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This second supplement issue of the Indonesian Journal of Nutrition and Food features the presentations given at the 1st International Conference on Food, Nutrition and Health that was organized by Centre for Dietetics Studies, Faculty of Health Sciences, Universiti Teknologi MARA which was held virtually on 19 – 20 September 2023.

These papers were reviewed by the Scientific Committee of ICFNH 2023 before their presentation, but they did not undergo the conventional reviewing system of the Indonesian Journal of Nutrition and Food.

The Indonesian Journal of Nutrition and Food, Bogor, Indonesia

SCIENTIFIC COMMITTEE MESSAGE FROM 1st ICFNH 2023

The 1st International Conference on Food, Nutrition and Health (ICFNH) 2023 was organized virtually by Centre for Dietetics Studies, Faculty of Health Sciences, Universiti Teknologi MARA. The main objective of this conference is to disseminate the most recent advancements in the field of food, nutrition, and health. ICFNH 2023 provided a platform for researchers, practitioners, students, and enthusiasts to exchange their research findings and innovative ideas within this domain. Notably, the event witnessed lively discussions between young nutrition and dietetics students alongside senior researchers, professors, and influential figures in the global food and nutrition arena.

The organizing committee of the ICFNH 2023 had chosen to focus on "*Curating Health through Nutrition: A Shared Responsibilities*" as the theme of the conference. The articles presented in this second supplement issue are selected from the 22 oral presentations covering six themes of ICFNH 2023.

The publication of this second issue of ICFNH 2023 supplement is supported by the Indonesian Journal of Nutrition and Food. We trust that this supplementary edition will serve as a valuable source of scientific knowledge in the field of food, nutrition and health for our readers.

On behalf of the 1st ICFNH 2023,

Emmy Hainida Khairul Ikram, MSc., PhD

Head of Scientific Committee
Lead Guest Editor of 2nd Issue

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Body Image, Eating Behaviour, and Physical Activity among Students at National Defence University of Malaysia

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ABSTRACT

This study aimed to explore the relationship between body image, eating behaviour, and physical activity among students at the National Defence University of Malaysia (UPNM). A total of 114 students, aged between 19 to 31 years old, were requited from the National Defence University of Malaysia (UPNM). Data were collected using an online self-report questionnaire which consists of four sections; Sociodemographic Form, Body Image Avoidance Questionnaire (BIAQ), Eating Attitude Test (EAT-26), and the International Physical Activity Questionnaire (IPAQ). Almost half of the respondents have normal BMI, whereas 20.2% were underweight and 23.7% were overweight and obese. Mean body image avoidance scores for civilian students, Reserve Officer Training Unit (ROTU), and cadets were 38.88±12.39, 42.71±6.34, and 44.00±16.05, respectively. Furthermore, high physical activity level was seen the most among civilian students (72.3%) compared to (57.1%) and cadets (41.7%). Significant associations were found between body image and eating behaviour ($p<0.001$). No association was observed between body image with physical activity ($p>0.05$) and eating behaviour with physical activity ($p>0.05$). To conclude, the respondents with a risk of the eating disorder tend to have higher body image avoidance, and the physical activity level did not seem to be concerning body image and eating behaviour in this study.

Keywords: body Image, eating behaviour, military, physical activity

INTRODUCTION

Globally, about half of the adult population suffers from overweight and obesity which makes it one of the most widespread health issues in the world (WHO 2016). Among Malaysian adults, the prevalence of overweight and obesity increased by 1.0% and 4.6% respectively from the year 2011 to 2019 (NHMS 2019). Body image was observed to indirectly affect the body weight status of an individual due to its relationship with eating behaviour and physical activity. Negative body image or body dissatisfaction is a negative perception of a person toward their physical appearance (Heider *et al.* 2018). Body dissatisfaction was reported to be related to eating disorders such as restrictive eating and purging (Edlund *et al.* 2022). People with a high score on the Eating Attitude Test-26 (EAT-26) which indicates a high risk of eating disorders were stated to be prone to becoming obese (Rukavishnikov *et al.* 2021).

According to a recent study, half of the population of Malaysian adults were diagnosed with symptoms of unhealthy eating behaviour (Chua *et al.* 2022). Besides that, physical inactivity was also known to be related to body image dissatisfaction as the person with a negative

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body image perceived exercising as embarrassing and exhausting to themselves (More *et al.* 2019). Mortality and cardiovascular disease were also reported to be caused by insufficient physical activity worldwide (Katzmarzyk *et al.* 2022). These days, university students also experience low physical activity and nutritional consumption due to workload, excessive sleep deprivation, less physical activity, and social inactivity (Azli *et al.* 2023). It is renowned that the purpose of universities is for academic excellence and preparing the next generation of scholars as well as help students to build character physically and mentally to become future leaders of the nation (Jakiwa *et al.* 2022).

At the National Defence University of Malaysia (UPNM), the students were divided into three subcategories which are cadets, civilians and civilians that joined Reserve Officer Training Unit (ROTU). The cadets are the members of the military who are involved in military training and academics, meanwhile, the civilians were only engaging in academics study (Jakiwa *et al.* 2020). On the other hand, civilians in the Reserve Officer Training Unit (ROTU) are also involved in military drills. A study conducted at UPNM found that cadets were more actively engaging in physical activity compared to civilian students (Jakiwa *et al.* 2020). Although the cadets had a high level of physical activity, they were observed to have a negative body image and were on the verge of unhealthy eating behaviour (Smith *et al.* 2020). Not only cadets, but civilian students were also prone to the symptoms of eating disorders (Falvey *et al.* 2021).

There was limited study among UPNM students regarding their body image perception, eating behaviour and physical activity level as well as the relationship between them. Additionally, previous studies had reported negative body image and risk of eating disorders in both cadets and civilian students, therefore early identification of this harmful behaviour was important to prevent unhealthy lifestyle prolonged among the students. These unhealthy behaviours not only may affect their fitness performance in military training but also could give a negative impact on their academic studies. Hence, the purpose of this study was to determine the relationship between body image, eating behaviour, and physical activity among students at the national defence University of Malaysia

METHODS

Design, location, and time

This cross-sectional study was conducted from January to July 2023. Ethics Approval was obtained from the Faculty Ethics Reviews Committee, Faculty of Health Sciences, Universiti Teknologi MARA (UiTM). The participant information sheet was included along with the questionnaires to get consent from the respondents.

Sampling

The study used convenient sampling as the sampling method and the sample size was determined using Raosoft software with a sample size of 232 respondents. However, only 114 students were successfully surveyed in the study through an online survey (Google Form), with 73 males and 41 females. Out of these 114 respondents, 24 were cadets, 83 were civilians and the remaining 7 students were ROTU.

Data collection

The anthropometric measurements of body weight and height were self-reported by the respondents since this study was conducted through an online survey. Self-reported anthropometrics measurement can be used in this study since it is a valid measure (De Rubeis 2019). The Body Mass Index (BMI) of the respondents was then calculated using the formula, weight (kg) divided by height (m^2) to obtain their BMI status. The cut-off points of BMI were determined using the WHO Asian BMI classifications, which includes underweight (<18.5 kg/m^2), normal (18.5−22.9 kg/m^2), overweight (23−27.4 kg/m^2), and obesity (>27.5 kg/m^2).

The Body Image Avoidance Questionnaire (BIAQ) was used to assess the body avoidance behaviour among the participants. BIAQ was developed in 1991 by Rosen and his colleagues (Rosen *et al.* 1991). This questionnaire comprised 19 items which can be classified into four factors associated with the adopted behaviour such as clothing, social activity, eating restraint, and grooming and weighing. It is based on a 6-point scale, with each item having scores between 0 (never) to 5 (always). The higher the total BIAQ scores, the higher the risk of a person to body image avoidance (Zakaria 2022). The internal consistency reliability of BIAQ varies among

different studies, with Cronbach's g ranging from 0.64 to 0.89 whereas test-retest reliability is between 0.64 to 0.87 (Pellizzer *et al.* 2018).

The eating behaviour of participants was assessed using the Eating Attitude Test-26 (EAT-26). This questionnaire was developed by Garner, Olmstedt, Bohr and Garfinkel in 1982, which consists of 26 questions related to dieting, bulimia and food preoccupation, and oral control (Garner *et al.* 1982). Additional 5 questions were included to evaluate harmful behaviour like purging, binge eating, usage of diet pills, and laxatives. Using a 6-point scale, each item ranges from 'Never', 'Rarely', 'Sometimes', 'Often', 'Usually', to 'Always'. A score of 0 for 'Never', 'Rarely' and 'Sometimes', a score of 1 for 'Often', a score of 2 for 'Usually' and a score of 3 for 'Always'. Meanwhile, for item 25, the scoring system was different which is reversed. The scores may be totalled between 0 to 76. The participants' eating behaviour can be classified into two categories, 'no-risk' if the total scores are below 20, and 'at-risk' if more than 20.

The short International Physical Activity Questionnaire (IPAQ) was used to measure the physical activity level of participants. It was developed by International Consensus Group in 1998 which consists of 4 generic items regarding vigorous activity, moderate activity, walking and sitting concerning the total amount of time that was spent within the last seven days (Lavelle *et al.* 2020). The data obtained was then inserted in the IPAQ Microsoft Excel sheet to assess the physical activity level of the participants. The physical activity levels can be categorized into three categories low (<600 MET-min/week), moderate (600−2,999 MET-min/week), and high (>3,000 MET-min/week).

Data analysis

The Statistical Package for Social Sciences (SPSS) version 27 was used to analyse the data in this study. Descriptive statistics was used to describe the characteristics like age, gender, course, and Body Mass Index (BMI). An independent T-test was performed to examine the differences between the mean BIAQ scores of the two groups' variables such as gender and eating behaviours. Meanwhile, One-way ANOVA was used to observe the differences between mean BIAQ scores of more than two groups' variables like physical activity. Similarly, the Kruskal Wallis test was also used to compare the differences of the mean BIAQ score of more than two groups, however, it was applied for non-normal distributed data in this study which were BMI and course. Pearson Chi-Square test was performed to assess the association between these variables. The statistical significance was set at $p<0.05$ and $p<0.001$.

RESULTS AND DISCUSSION

Socio-demographic

Table 1 shows that 64.0% of the respondents were males and 36.0% were females. The age of all the respondents were ranging from 19 to 31 years old, and their mean age was 20.24±1.76 years. Most of the respondents were civilians (72.8%), cadets (21.1%) and the remaining are ROTU (6.1%). The male respondents had a mean BMI of 21.42±2.97 kg/m^2, whereas the female respondents had a mean BMI of 20.39±2.48 kg/m^2. The majority of respondents in both genders were observed to have a normal body weight status according to their BMI. About half of the study samples (56.1%) had a normal BMI category, 20.2% of them were underweight and 23.7% were overweight and obese. The males (28.8%) were more prevalent to overweight and obese than females (14.6%) in this study.

Body image avoidance

Table 2 presents the mean BIAQ scores of each characteristic as well as their associations. Overall, the average score of BIAQ among the students was 40.19±13.07. This can be considered higher compared to previous studies, in which the mean score of Spanish adolescents was 23.6±11.0 (Senín-Calderón *et al.* 2020). Meanwhile, Moroccan teenagers had an average score of 24.4±9.7 (Zakaria 2022). Based on these comparisons, the majority of UPNM students may have critical issues with their body image perception as they were prone to behavioural avoidance.

Although the females had a slightly higher mean BIAQ score than males, no significant differences were observed between these two genders ($p>0.05$). On the contrary, a previous study reported that females were more unsatisfied with their body image than males (Quittkat *et al.* 2019). In addition, a study conducted among university students found that females had greater

Table 1. Socio-demographic characteristics of UPNM students

Characteristics	Mean±SD or n (%)		
	Male n (%)	Female n (%)	Total n (%)
Gender	73 (64.0)	41 (36.0)	114 (100.0)
Age	20.44±1.99	19.88±1.21	20.24±1.76
Course			
Civilian	52 (71.2)	31 (75.6)	83 (72.8)
PALAPES	4 (5.5)	3 (7.3)	7 (6.1)
Cadet	17 (23.3)	7 (17.1)	24 (21.1)
BMI (kg/m^2)	21.42±2.97	20.39±2.48	21.05±2.84
BMI category			
Underweight	16 (21.9)	7 (17.1)	23 (20.2)
Normal	36 (49.3)	28 (68.3)	64 (56.1)
Overweight & Obesity	21 (28.8)	6 (14.6)	27 (23.7)

BMI: Body Mass Index; PALAPES: *Pasukan Latihan Pegawai Simpanan* ; SD: Standard Deviation
UPNM: National Defence University of Malaysia

Table 2. Mean scores of the BIAQ test according to gender, course, BMI category, physical activity and eating behaviour (n=114)

Characteristics	n	Mean±SD	*p*
Gender			
Male	73	39.96±14.85	0.774[a]
Female	41	40.61±9.21	
Course			
Civilian	83	38.88±12.39	0.348[c]
ROTU	7	42.71±6.34	
Cadet	24	44.00±16.05	
BMI category			
Underweight	23	41.65±14.42	0.604[c]
Normal	64	39.48±13.16	
Overweight & Obesity	27	40.63±11.97	
Physical activity level			
Low	14	41.93±9.90	0.141[b]
Moderate	26	44.15±15.08	
High	74	38.47±12.64	
Eating behaviour			
No risk	101	37.80±10.76	<0.001[a**]
At risk	13	58.77±14.86	

[a]Independent T-test; [b]One-way ANOVA; [c]Kruskal Walli's test; BIAQ: Body Image Avoidance Questionnaire; ROTU: Reserve Officer Training Unit; SD: Standard Deviation
[*]Significantly associated at p<0.05; [**]Significantly associated at p<0.001

body dissatisfaction than males (Radwan *et al.* 2019). It can be stated that females, especially among young adults were more prevalent to negative body image.

Between the three courses, no significant differences in BIAQ scores were found ($p>0.05$). However, all these three courses had high BIAQ mean scores, such that civilians (38.88), ROTU (42.71) and cadets (44.00). A study reported that Reserve Officer Training Corps (ROTC) cadets were unsatisfied with their body image (Smith *et al.* 2020). This is maybe due to cadets having to focus on both military training and their academics study (Smith *et al.* 2020). For civilians, it may be common because behavioural avoidance was prevalent even among university students (Radwan *et al.* 2019).

According to the weight status of respondents, there were no significant differences in BIAQ scores observed between these BMI categories ($p>0.05$). This finding contradicts another study which discovered that a person who is underweight and overweight was more likely to have body image dissatisfaction (Moehlecke 2020). However, other studies found that there was no correlation between body image and BMI (He *et al.* 2020). Based on these facts, body weight status may not affect all people's view of their body image because it depends on their perception towards their body (Radwan *et al.* 2019).

Among different levels of physical activity, no significant difference in BIAQ score was observed ($p>0.05$). Similarly, a study conducted among college students reported that there was no association between body image and physical activity (Han *et al.* 2023). But another study reported that high physical activity level was linked to positive body image (Sabiston *et al.* 2019). Therefore, as stated earlier body image perception depends on one own's view and it does not merely affect by another factor such as physical activity.

The current study found that there were significant differences in BIAQ scores between respondents with normal eating behaviour and those at risk of eating disorders ($p<0.001$). It was observed that respondents with a risk of eating disorders had mean BIAQ scores of 58.77, which is significantly higher than those with normal eating behaviour (37.80). Similarly, a study reported that emotional eating was related to high dissatisfaction with body image (Corno 2022). Moreover, university students who were engaging in unhealthy eating behaviour had negative perceptions towards their bodies (Santos *et al.* 2021). Thus, this clearly shows that body image had a strong relationship with eating behaviour.

Eating behaviour

Table 3 shows the distribution of eating behaviour according to gender, course, and BMI category. No significant association were found between eating behaviour and gender ($p>0.05$). This is consistent with findings from a study among students at the University of Malaysia, in which both genders were reported to have the same rate of eating disorders (Taib *et al.* 2021). However, another study found that female students in university were more prone to restrictive eating than males (Chin 2020). These contradicting findings indicate that eating behaviour may differ between genders, but it also depends on the location of the study, such that different universities had different environments and cultures.

The current study found that there was no significant association between eating behaviour and course ($p>0.05$). Correspondingly, no significant differences in eating disorders were observed between military-involved students and civilian students (Falvey *et al.* 2021). However, the current study observed that one in ten civilian students was at risk of eating disorder. It was stated that students in the Association of Southeast Asian Nations (ASEAN) countries were diagnosed with a risk of unhealthy eating habits, with Malaysia as one of the top countries (Pengpid 2018). Further, less than 20% of cadets in this study were at risk of eating disorders. Similarly, a study reported that 21.3% of military students were having the risk of unhealthy eating behaviour (Falvey *et al.* 2021). Besides that, due to small samples, all ROTU students were observed with normal eating behaviour. Nonetheless, a study found that ROTC cadets were prevalent in eating disorders, particularly females (Smith 2020). Thus, it is shown that only a few respondents in both the civilian and military-involved students were having the risk of eating disorders.

Further, there was a negative association between eating behaviour and BMI category ($p>0.05$). On the contrary, a study reported that

Table 3. Distribution of eating behaviour according to gender, course, and BMI category (n=114)

Characteristics	No risk n (%)	At risk n (%)	*p*
Gender			
Male	64 (87.7)	9 (12.3)	0.678
Female	37 (90.2)	4 (9.8)	
Course			
Civilian	74 (89.2)	9 (10.8)	0.453
ROTU	7 (100.0)	0 (0.0)	
Cadet	20 (83.3)	4 (16.7)	
BMI category			
Underweight	19 (82.6)	4 (17.4)	0.533
Normal	57 (89.1)	7 (10.9)	
Overweight & Obesity	25 (92.6)	2 (7.4)	

p-value obtained from Pearson Chi-Square Test; *Significantly associated at p<0.05; BMI; Body Mass Index
ROTU: Reserve Officer Training Unit

there was an association between BMI and eating disorders, where people with obesity had more risk of unhealthy eating habits (Ngan *et al.* 2017). In addition, underweight people were reported to be more prevalent in having eating restraints (Ralph-Nearman 2020). However, a study in a university setting found that students with normal BMI were more prone to eating disorders (Chan *et al.* 2020). Hence, this shows that the BMI of an individual does not precisely indicate the person's eating behaviour.

Physical activity

Table 4 presents the physical activity level among UPNM students by gender, course, BMI category, and eating behaviour. The current study found that there was no significant association between physical activity and gender (p>0.05). This contradicts other studies, a survey conducted among Malaysian adults observed that men had higher physical activity than women (NHMS 2019). In addition, male students were more actively engaging in physical activity than females (You *et al.* 2020; Emmy *et al.* 2023). Nevertheless, a study reported that there were no differences in strenuous physical activity among the gender (Craft *et al.* 2014). Thus, the level of physical activity among gender in this study was similar, maybe due to the fact that students in military universities were actively engaging in military training and sports.

There was a significant association between physical activity and course (p<0.05). The current study observed that civilians (72.3%) were the most active compared to ROTU (57.1%) and cadets (41.7%) under high physical activity level category. On the contrary, a study reported that cadets were more active than civilian students because they were regularly engaged in military training (Jakiwa *et al.* 2020). According to current findings, civilian students may be more active than cadets due to their frequent involvement in sports or exercise.

No significant association were found between physical activity and BMI category (p>0.05). Similarly, a study also reported a negative association between physical activity and BMI (Yousif *et al.* 2019). However, another study found that a person with a low BMI was more likely to engage in vigorous physical activity compared to an overweight person (Wu & He 2022). Thus, there were no differences in physical activity among the students in this study despite their body weight status, due to the environment or activity in the military university.

There was also no association between physical activity level and eating behaviour (p>0.05). However, current findings show that students with normal eating behaviour (68.3%) were more actively participating in the high physical activity level category than those with a risk of eating disorder (38.5%). A study

Table 4. Distribution of physical activity level according to gender, course, BMI category, and eating behaviour (n=114)

Characteristics	Low n (%)	Moderate n (%)	High n (%)	*p*
Gender				
Male	7 (9.6)	20 (27.4)	46 (63.0)	0.203
Female	7 (17.1)	6 (14.6)	28 (68.3)	
Course				
Civilian	7 (8.4)	16 (19.3)	60 (72.3)	0.042*
ROTU	1 (14.3)	2 (28.6)	4 (57.1)	
Cadet	6 (25.0)	8 (33.3)	10 (41.7)	
BMI category				
Underweight	6 (26.1)	4 (17.4)	13 (56.5)	0.153
Normal	4 (6.3)	15 (23.4)	45 (70.3)	
Overweight & Obesity	4 (14.8)	7 (25.9)	16 (59.3)	
Eating behaviour				
No risk	12 (11.9)	20 (19.8)	69 (68.3)	0.074
At risk	2 (15.4)	6 (46.2)	5 (38.5)	

P-value obtained from Pearson Chi-Square Test; *Significantly associated at $p<0.05$
BMI: Body Mass Index; ROTU: Reserve Officer Training Unit

reported that low physical activity level was linked to a higher appetite level (Shook *et al.* 2015). This implies that people who frequently engaged in physical activity were more likely to have normal eating habits due to their low appetite. Nevertheless, the physical activity level of UPNM students was the same regardless of their eating behaviour because it is a military university which involves regular engagement in military training.

CONCLUSION

In conclusion, this study suggests that body image was positively associated with eating behaviour. However, no association were found between physical activity with body image and eating behaviour. Future studies should recruit larger samples of military-involved students, particularly cadets and ROTU. Furthermore, it is recommended that future research conduct a non-virtual method to acquire more precise data. Strategies to promote healthier lifestyles in both civilian and military-involved students should include measures that prevent negative body image, unhealthy eating behaviour and physical inactivity. Thus, it is suggested that government and non-government agencies give more attention to military university students by carrying out programs to promote positive body image, healthy eating habits and high physical activity.

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DECLARATION OF CONFLICT OF INTERESTS

The author(s) declare no conflict of interest.

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Knowledge, Attitude, and Practices of Traditional Herbs and Spices Consumption among Adults in Malaysia

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ABSTRACT

This research aimed to assess knowledge, attitude, and practices regarding traditional herbs and spices consumption among Malaysian adults aged 18 to 60 years. A- 5-parts close-ended questionnaire was partially adapted and modified from articles and validated by 11 experts. Data collection was performed by using an online questionnaire (n=281). Most participants are female (75.4%) and Malay (85.1%), followed by Chinese (10.0%), Indian (2.1%), and other ethnicities (2.8%) such as Sabah natives, Iban, Dusun, and Javanese. Most respondents consumed traditional herbs and spices. *Centella asiatica* ('pegaga'), ginseng, *Labisia pumila* ('kacip fatimah'), and longjack ('tongkat ali') were the most consumed herbs whereas lemongrass, garlic, ginger, turmeric, and star anise were the most consumed spices. The study found good knowledge, fair attitude, and poor practice regarding traditional herbs and spices consumption. Knowledge was significantly associated with ethnicity, while consumption status was associated with attitude and practice levels. A moderate and positive correlation was observed between attitudes and practices. Enhancing public knowledge and promoting positive attitudes towards these traditional ingredients is essential for preserving cultural heritage and incorporating them into modern diets.

Keywords: attitude, consumption, knowledge, traditional herbs and spices

INTRODUCTION

Herbs and spices have diverse properties and are widely used in cooking, traditional medicine, and for various health purposes. They hold significant economic importance as essential ingredients in food, medicine, perfumery, and cosmetics (Jiang 2019). Research has highlighted their numerous health benefits, including immune system support, disease prevention, and cardiovascular health improvements, attributed to their rich content of polyphenols and other phytochemicals (Muchtaridi *et al.* 2022a; Ikram *et al.* 2022). For instance, garlic has been shown to lower cholesterol levels by up to 9% when consumed daily, and garlic extract can prevent blood clots and reduce blood pressure (Tapsell *et al.* 2006). Moreover, the flavor-enhancing properties of herbs and spices lead to reduced salt usage, providing additional cardiovascular health benefits (Anderson *et al.* 2015).

The historical use of herbs and spices dates back thousands of years in ancient civilizations like Egyptian, Chinese, and Indian cultures, valued for their medicinal properties, flavor enhancement, and food preservation (Ahmad *et al.* 2021). In Malaysia, traditional medicine systems, including Traditional Chinese Medicine (TCM), Ayurvedic medicine, traditional Malay medicine (e.g., *jamu*), and Islamic medical practices,

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reflect the nation's multi-racial and multicultural nature (Ikram *et al.* 2015; Williams 2021).

Herbs play a crucial role in all these traditional medicine systems. The study is driven by health concerns and knowledge about the benefits of herbs and spices, as observed in European studies (Szűcs *et al.* 2018). However, there is a paucity of research on the consumption of traditional herbs and spices in South Asian countries, particularly Malaysia. Previous research has mainly focused on the development of indigenous plants and herbal products (Muhammad *et al.* 2022; Arisanti *et al.* 2023; Muchtaridi *et al.* 2022b), but there is a limited understanding of the consumption patterns of traditional herbs and spices among Malaysian adults. Thus, this study aims to fill this research gap by investigating the knowledge, attitudes, and practices of traditional herbs and spices consumption among Malaysian adults.

METHODS

Design, location, and time

Cross-sectional non-experimental research was conducted in Malaysia to determine the knowledge, attitudes, and practices of traditional herbs and spices consumption among Malaysian adults aged 18 to 60 years old from December 2022 to July 2023. Ethical clearance for this study was received on 31st May 2023 from the Universiti Teknologi Mara (UiTM) Research Committee, with the reference number FERC/FSK/MR/2023/00126.

Sampling

The convenience purposive sampling method was used to select participants based on their availability to complete the questionnaire forms and adherence to the inclusion and exclusion criteria set for this study. Based on sample size calculation using Raosoft software calculator with a 95% confidence level, 5% margin of error, and 50% response distribution, the initial sample size (n) was 385. After data checking and cleaning, data for 281 respondents were proceeded for further analysis.

The eligibility criteria were: 1) Malaysian adults aged 18–60 years; 2) Ability to read and write in Bahasa Malaysia or English; 3) Able to provide informed consent; 4) Willing to take part in the study.

Data collection

Data collection was conducted by using the self-administered, close-ended questionnaire. All questionnaires provided were in English and Malay versions. Participants were invited to take part in the study through various communication channels, including email, WhatsApp, Telegram, Facebook, Twitter, and Instagram. An online questionnaire, including a consent form, was distributed via Google Forms. The questionnaire comprised 5 sections, covering socio-demographic data, a Food Frequency Questionnaire (FFQ) regarding traditional herbs and spices, knowledge, attitude, and practice about traditional herbs and spices consumption. Participation was voluntary, and participants were required to complete the questionnaire by answering all the questions. The average time required for completing the questionnaire was approximately 5 to 15 minutes.

Research instruments. A 5-part close-ended bilingual questionnaire was utilized to assess the participants' socio-demographic information, food frequency regarding traditional herbs and spices, as well as knowledge, attitude, and practices toward herbs and spices consumption. The questionnaire was partially adapted and modified from relevant studies (Zaidi *et al.* 2022; Jamaludin *et al.* 2022; Blanton, 2020; Teh *et al.* 2019; Szűcs *et al.* 2018; Othman *et al.* 2013) and translated into Malay. Eleven experts, with expertise in the field of study, evaluated each item for clarity, relevance, and appropriateness. The questionnaire's content validity was evaluated using the index of Content Validity (CVI), the Scale-level Content Validity Index based on the Average Method (S-CVI/Ave), and the Scale-level Content Validity index based on the Universal Agreement method (S-CVI/UA). Items that received a value of 0.78 or higher are accepted while some of the items that received lower values were eliminated or revised (Yusoff 2019). The validity test revealed 53 items received CVI values greater than 0.78, considered acceptable, except for item 10 with a CVI value of 0.64 was eliminated. A pilot test was conducted to ensure all participants understood the questions.

Food Frequency Questionnaire (FFQ) of traditional herbs and spices. There were 10 types of traditional herbs and 10 types of traditional spices that were included in the FFQ which was

chosen from the common traditional herbs and spices in Malaysia (Zakaria *et al.* 2019). The questionnaire provided clear instructions on how to use the FFQ and included visual illustrations for each item listed. Frequency of the consumption was recorded in six categories: 1) Daily; 2) Few times a week; 3) Once a week; 4) Two or three times per month; 5) Once a month; and 6) Do not know or never (Szűcs *et al.* 2018).

Knowledge, attitude, and practice of traditional herbs and spices consumption. All the questions were partially adapted and modified from several studies (Zaidi *et al.* 2022; Jamaludin *et al.* 2022; Blanton 2020; Teh *et al.* 2019; Szűcs *et al.* 2018; Othman *et al.* 2013). The total scores for each domain were calculated and categorized as poor (≤50% of total score), moderate (51% to 69%), and good (≥70% of total score) (Harrington 2016; Jamaludin *et al.* 2022; Ikram *et al.* 2023).

Knowledge domain. The third part focused on the participants' knowledge of herbs and spices consumption. This domain consisted of nine closed-ended statement questions regarding the general knowledge of traditional herbs and spices consumption. Each question was provided with two scales, 'yes' and 'no' with the marks 1 and 0 respectively. It gave a total score range of 0–9 for the knowledge section.

Attitude domain. In the fourth part, the consumers' attitudes towards herbs and spices consumption were measured. It consisted of 18 statements with five Likert scale answers provided. Likert scale answers were scored as follows: Strongly agree–5; Agree–4; Neutral–3, Disagree–2; Strongly disagree–1 with the total score range of 0–90. 'Strongly agree' indicated maximum adherence towards traditional herbs and spices consumption. The statement was overall related to their belief in the benefits of traditional herbs and spices consumption, preferences, and the availability of the products.

Practice domain. In the last part, participants' practices on traditional herbs and spices intake are evaluated. It consists of seven questions with three choice answers as follows: 'yes', 'no', and 'not sure'. Subjects were asked about their practice towards traditional herbs and spices consumption, such as their habits of taking traditional herbs and spices products during sickness. Each question regarding good practice was provided with a score of "1" for yes, while the lowest practice was given "0" for no or not sure.

Data analysis

The Statistical Package for the Social Sciences (SPSS) version 27.0 was used to analyze the data collected in this study.

RESULTS AND DISCUSSION

Socio-demographic characteristics

A total of 281 Malaysian adults aged 18 to 60 years were included in the data analysis. Among them, 75.4% were female and 24.6% were male. Participants were categorized into young adults (18–30 years), adults (31–50 years), and older adults (51–60 years), with 69.0% falling in the young adult category. Ethnically, the majority were Malay (85.1%), followed by Chinese (10.0%), Indian (2.1%), and other ethnicities (2.8%). Most participants held a Bachelor's degree (70.1%, n=197). Single status was more prevalent among female participants (64.5%) compared to males (76.8%). Socioeconomic status was assessed using monthly household income, categorized into low (<RM2,500–RM4,850), normal (RM4,851–RM10,970), and high (>RM10,971) according to Malaysian household income groups. Participants were predominantly in the bottom category (59.8%), followed by middle (28.1%, n=79), and top (12.1%, n=34) categories. Additionally, 68.7% were students (n=193), while 31.3% were currently not students (n=88).

Traditional herbs and spices consumption patterns among adults in Malaysia

The findings revealed that most participants (55.2%) consumed traditional herbs and spices, while 44.8% of participants did not consume them. This indicates that traditional herbs and spices hold a significant place in the dietary habits of the study population, with more than half of the respondents incorporating them into their daily meals. This might be due to Malaysia's diverse ethnic groups each bringing their unique culinary heritage, which heavily influences the consumption patterns of traditional herbs and spices (Ishak *et al.* 2019; Perry 2017).

Beyond culinary uses, traditional herbs and spices held importance in Malaysian traditional medicine practices. Various communities valued the medicinal properties of these elements, using them to address common ailments and enhance overall well-being (Tengku Mohamad

et al. 2019). Additionally, studies have reported varying consumption levels across different regions, with the highest in India, South Africa, and Latin America. European countries, however, exhibited lower consumption (Gajewska *et al.* 2020; Vázquez-Fresno *et al.* 2019).

The overall findings demonstrate none of the sociodemographic characteristics analyzed were significantly associated ($p>0.05$) with traditional herbs and spices consumption. Gender, age, socioeconomic status, ethnicity, educational level, and marital status did not appear to play a significant role in determining the participants' likelihood of consuming traditional herbs and spices (Table 1).

Common traditional herbs and spices consumption among adults in Malaysia

In this study, traditional herb and spice consumption was categorized as 'at least once per month' and 'do not know or never.' Among the listed traditional herbs, *Centella asiatica* ('pegaga') was the most commonly consumed (40.6%), followed by ginseng (31.7%), *Labisia pumila* ('kacip fatimah') (20.6%), and longjack (17.4%). However, a majority of respondents were unaware of listed herbs like *Orthosiphon* aristatus ('misai kucing'), *Morinda citrifolia* ('mengkudu'), *Andrographis paniculata* ('hempedu bumi'), *Ficus deltoidea* ('mas cotek'), and *Phyllanthus niruri* ('dukung anak'), highlighting a potential knowledge gap in the diverse range of traditional herbs available in Malaysia.

Regarding traditional spices, lemongrass was the most consumed spice (92.9%), likely due to its strong presence in Malaysian cuisine. Garlic (91.5%), ginger (90%), turmeric (89%), and star anise (87.5%) were also popular, enhancing flavors while offering potential health benefits. These consumption patterns reflect Malaysia's rich culinary and medicinal traditions.

These findings are consistent with prior research on the significance of traditional herbs and spices in Malaysian cuisine (Abas *et al.* 2006; Raji *et al.* 2017). In a different study, black pepper, garlic powder, and cinnamon were found to be the most commonly consumed herbs and spices among respondents (Blanton 2020).

Levels of knowledge, attitude, and practices of traditional herbs and spices consumption among adults in Malaysia

According to Szűcs *et al.* (2018), knowing the health benefits of herbs and spices can positively influence consumption habits. As presented in Table 2, the majority of the participants (81.1%) displayed a good level of knowledge, indicating a favorable understanding of traditional herbs and spices consumption. However, analyzing associations between knowledge and sociodemographic factors like gender, age, education, marital status, socioeconomic status, and student status, no significant differences were observed ($p>0.05$). This implies that these demographic factors did not significantly influence the participants' knowledge of traditional herbs and spices consumption. Yet, a statistically significant relationship ($p<0.05$) was observed on the association between knowledge and ethnicity ($p=0.033$), indicating varying knowledge levels among different ethnic backgrounds. This aligns with previous studies like Teh *et al.* (2019), where the results indicated no statistically significant difference in knowledge scores based on socio-demographic profiles such as gender, age, marital status, educational level, and employment ($p>0.05$). However, a significant difference in knowledge scores was observed between different racial groups ($p<0.05$). Similarly, Kim Sooi and Lean Keng (2013) reported no significant difference ($p>0.05$) in knowledge scores based on socio-demographic characteristics such as age, occupation, and education level.

In terms of attitude towards traditional herbs and spices consumption, most respondents (51.2%) had a fair attitude towards traditional herbs and spices, followed by 39.1% with a good attitude and 9.6% with a poor attitude. This variation in attitudes reflects the complexities of individuals' perceptions and beliefs surrounding traditional dietary practices in the context of modern lifestyles. Gender, age, socioeconomic status, and student status showed no significant associations with attitude levels ($p>0.05$), indicating the limited influence of these demographics on attitudes. However, a statistically significant association was observed between attitude and consumption status ($p<0.05$), that the participants' attitudes towards traditional herbs and spices consumption were linked to their actual consumption practices (Table 3). Similar patterns were observed in the study by Teh *et al.* (2019) on consumers' attitudes

Table 1. Association between consumption of traditional herbs and spices and socio-demographic characteristics

Characteristics	Consumption of traditional herbs and spices		Total (n=281) n (%)	*p*
	No (n=126) n (%)	Yes (n=155) n (%)		
Gender				0.589
Male	29 (23.0)	40 (25.8)	69 (24.6)	
Female	97 (77.0)	115 (74.2)	212 (75.4)	
Age group				0.694
Young adults	90 (71.4)	104 (67.1)	194 (69.0)	
Adults	30 (23.8)	41 (26.5)	71 (25.3)	
Older adults	6 (4.8)	10 (6.5)	16 (5.7)	
Ethnicity				0.135[a]
Malay	108 (85.7)	131 (84.5)	239 (85.1)	
Chinese	14 (11.1)	14 (9.0)	28 (10.0)	
Indian	0 (0.0)	6 (3.9)	6 (2.1)	
Others	4 (3.2)	4 (2.6)	8 (2.8)	
Education level				0.284[a]
Secondary school	2 (1.6)	2 (1.3)	4 (1.4)	
Certificate	2 (1.6)	1 (0.6)	3 (1.1)	
Pre-University (STPM, Matriculation, Foundation)	4 (3.2)	10 (6.5)	14 (5.0)	
Diploma	17 (13.5)	11 (7.1)	28 (10.0)	
Bachelor's degree	89 (70.6)	108 (69.7)	197 (70.1)	
Postgraduate (Master's degree, PhD)	12 (9.5)	22 (14.2)	34 (12.1)	
Others	0 (0.0)	1 (0.6)	1 (0.4)	
Marital status				0.781[a]
Single	89 (70.6)	101 (65.2)	190 (67.6)	
Married	35 (27.8)	52 (33.5)	87 (31.0)	
Divorced	1 (0.8)	1 (0.6)	2 (0.7)	
Widowed	1 (0.8)	1 (0.6)	2 (0.7)	
Socioeconomic status				0.108
Top	10 (7.9)	24 (15.5)	34 (12.1)	
Middle	34 (27.0)	45 (29.0)	79 (28.1)	
Bottom	82 (65.1)	86 (55.5)	168 (59.8)	
Student				0.095
Yes	93 (73.8)	100 (64.5)	193 (68.7)	
No	33 (26.2)	55 (35.5)	88 (31.3)	

[a]Fisher-Freeman-Halton Exact. Significant value at $p<0.05$; STPM: *Sijil Tinggi Persekolahan Malaysia*

Table 2. Association between level of knowledge regarding traditional herbs and spices consumption and socio-demographic characteristics (n=281)

Characteristics	Level of knowledge			Total (n=281)	*p*
	Poor (0–50) n (%)	Fair (51–69) n (%)	Good (70–100) n (%)		
Gender					0.330[a]
Male	0 (0.0)	9 (17.6)	60 (26.4)	69	
Female	3 (100.0)	42 (82.4)	167 (73.6)	212	
Age group					0.100[a]
Young adults	2 (66.7)	28 (54.9)	164 (72.2)	194	
Adults	1 (33.3)	20 (39.2)	50 (22.0)	71	
Older adults	0 (0.00	3 (5.9)	13 (5.7)	16	
Ethnicity					0.033[a]
Malay	1 (3.33)	42 (82.4)	196 (86.3)	239	
Chinese	2 (66.7)	4 (7.8)	22 (9.7)	28	
Indian	0 (0.0)	1 (2.0)	5 (2.2)	6	
Others	0 (0.0)	4 (7.8)	4 (1.8)	8	
Education level					0.384[a]
Secondary school	0 (0.0)	2 (3.9)	2 (5.3)	4	
Certificate	0 (0.0)	0 (0.0)	3 (1.3)	3	
Pre-University (STPM, Matriculation, Foundation)	0 (0.0)	2 (3.9)	12 (5.3)	14	
Diploma	0 (0.0)	9 (17.6)	19 (8.4)	28	
Bachelor's degree	2 (66.7)	33 (64.7)	162 (71.4)	197	
Postgraduate (Master's degree, PhD)	1 (33.3)	5 (9.8)	28 (12.3)	34	
Others	0 (0.0)	0 (0.0)	1 (0.4)	1	
Marital status					0.066[a]
Single	2 (66.7)	29 (56.9)	159 (70.0)	190	
Married	1 (33.3)	20 (39.2)	66 (29.1)	87	
Divorced	0 (0.0)	2 (3.9)	0 (0.0)	2	
Widowed	0 (0.0)	0 (0.0)	2 (0.9)	2	
Socioeconomic status					0.942[a]
Top	0 (0.0)	6 (11.8)	28 (12.3)	34	
Middle	1 (33.3)	16 (31.4)	62 (27.3)	79	
Bottom	2 (66.7)	29 (56.9)	137 (60.4)	168	
Student					0.180[a]
Yes	1 (33.3)	32 (62.7)	160 (70.5)	193	
No	2 (66.7)	19 (37.3)	67 (29.5)	88	
Consumption					0.579[a]
Yes	1 (33.3)	26 (51.0)	128 (56.4)	155	
No	2 (66.9)	25 (49.0)	99 (43.6)	126	

Chi-square test used unless otherwise noted; [a]Fisher-Freeman-Halton Exact. Significant value at $p<0.05$; STPM: *Sijil Tinggi Persekolahan* Malaysia

towards Chinese herbal tea, where gender, race, marital status, education, and employment did not show significant associations ($p>0.05$) while age groups showed significance ($p<0.05$). Such similarities across studies indicate that attitudes towards traditional herbs and spices consumption might be less influenced by sociodemographic factors.

Even though the majority of respondents showed good knowledge and fair attitude levels, they had poor practice levels (48.4%) towards traditional herbs and spices consumption which scored less than 50%. The poor practice level might be related to the availability of traditional herbs and spices at home and taste preferences toward healthy food (Jamaludin *et al.* 2022). Those who have easy access to these ingredients and a preference for healthier options are more likely to incorporate them into their meals. Furthermore, low Socioeconomic Status (SES) individuals may face challenges in accessing and affording traditional herbs and spices, which can impact their consumption practices. Limited financial resources may hinder their ability to use these ingredients (Dean & Sharkey 2011). Notably, a significant connection between consumption status and practice levels was identified ($p<0.05$), indicating that those consuming traditional herbs and spices tended to exhibit more favorable practices. Meanwhile, in a study conducted by Zaidi *et al.* (2022), only the educational status and gender of the respondents

Table 3. Association between level of attitude regarding traditional herbs and spices consumption and socio-demographic characteristics (n=281)

Characteristics	Level of knowledge			Total (n=281)	*p*
	Poor (0–50) n (%)	Fair (51–69) n (%)	Good (70–100) n (%)		
Gender					0.806
Male	7 (25.9)	33 (22.9)	29 (26.4)	69	
Female	20 (74.1)	111 (77.1)	81 (73.6)	212	
Age group					0.180
Young adults	19 (70.4)	102 (70.8)	73 (66.4)	194	
Adults	4 (14.8)	36 (25.0)	31 (28.2)	71	
Older adults	4 (14.8)	6 (4.2)	6 (5.5)	16	
Ethnicity					0.940[a]
Malay	25 (92.6)	119 (82.6)	95 (86.4)	239	
Chinese	2 (7.4)	17 (11.8)	9 (8.2)	28	
Indian	0 (0.0)	3 (2.1)	3 (2.7)	6	
Others	0 (0.0)	5 (3.5)	3 (2.7)	8	
Education level					0.690[a]
Secondary school	0 (0.0)	2 (1.4)	2 (1.8)	4	
Certificate	0 (0.0)	2 (1.4)	1 (0.9)	3	
Pre-University (STPM, Matriculation, Foundation)	1 (3.7)	8 (5.6)	5 (4.5)	14	
Diploma	1 (3.7)	18 (12.5)	9 (8.2)	28	
Bachelor's degree	24 (88.9)	93 (64.6)	80 (72.7)	197	
Postgraduate (Master's degree, PhD)	1 (3.7)	21 (14.6)	12 (10.9)	34	
Others	0 (0.0)	0 (0.0)	1 (0.9)	1	
Marital status					0.809[a]
Single	19 (70.4)	97 (67.4)	74 (67.3)	190	

Continue from Table 3

Characteristics	Level of knowledge			Total (n=281)	*p*
	Poor (0–50) n (%)	Fair (51–69) n (%)	Good (70–100) n (%)		
Married	8 (29.6)	43 (29.9)	36 (32.7)	87	
Divorced	0 (0.0)	2 (1.4)	0 (0.0)	2	
Divorced	0 (0.0)	2 (1.4)	0 (0.0)	2	
Widowed	0 (0.0)	2 (1.4)	0 (0.0)	2	
Socioeconomic status					0.546
Top	5 (18.5)	16 (11.1)	13 (11.8)	34	
Middle	10 (37.0)	39 (27.1)	30 (27.3)	79	
Bottom	12 (44.4)	89 (61.8)	67 (60.9)	168	
Student					0.728
Yes	18 (18.5)	102 (70.8)	73 (66.4)	193	
No	9 (33.3)	42 (29.2)	37 (33.6)	88	
Consumption					
Yes	10 (37.0)	70 (48.6)	75 (68.2)	155	
No	17 (63.0)	74 (51.4)	35 (31.8)	126	

Chi-square test used unless otherwise noted; [a]Fisher-Freeman-Halton Exact Test. Significant value at $p<0.05$

STPM: *Sijil Tinggi Persekolahan Malaysia*

were found to be significant ($p<0.05$) for an association of demographics with the practices of herbal medicines.

The analysis of correlation coefficients revealed that no statistically significant correlation existed between knowledge and attitude scores towards traditional herbs and spices intake ($r=0.001$, $p=0.985$), nor between knowledge and practice ($r=0.049$, $p=0.413$). These findings suggest that there is no significant linear relationship between these pairs of variables. However, a moderate and positive correlation was observed between attitude and practice scores ($r=0.456$) with a highly statistically significant association ($p<0.001$). This indicates that as attitudes towards traditional herbs and spices consumption increase, so does the level of actual practice.

Similarly, a study on Medicinal Plants (MPs) among Malaysian consumers found that consumers' attitudes have a stronger association with their practices compared to knowledge and practice, demonstrating moderate relationships (Arumugam 2019). This aligns with the findings of Ekor (2014), which also showed that the relationship between attitude and practice is stronger than that between knowledge and practice. Individuals are more likely to consume medicinal plants when they hold positive attitudes and beliefs about them. However, it's important to acknowledge that the knowledge, attitude, and practice of individuals may not be directly interlinked, as they can also be influenced by external factors such as socio-economic status or family lifestyle (Jamaludin *et al.* 2022).

CONCLUSION

Notably, *Centella asiatica* ('pegaga') was found to be the most consumed traditional herb, while lemongrass emerged as the most commonly consumed spice. Ethnicity showed a statistically significant association with knowledge level, while consumption status was associated with attitude and practice levels. A moderate and positive correlation was observed between attitudes and practices ($p<0.001$). This finding showed the importance of enhancing public knowledge and promoting positive attitudes towards these traditional ingredients

is essential for preserving cultural heritage and incorporating them into modern diets.

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DECLARATION OF CONFLICT OF INTERESTS

The author(s) declare no conflict of interest.

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Nutrition Knowledge and the use of Nutrition Labels among Undergraduate Students in UiTM Puncak Alam

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ABSTRACT

This study aimed to determine the relationship between socio-demographic factors, nutrition knowledge, and the use of nutrition information labels during food purchases among undergraduate students in UiTM Puncak Alam. In this cross-sectional study, 156 undergraduate students between 18 and 25 years old were recruited from different locations in UiTM Puncak Alam. Data collection involved a self-report questionnaire with five sections covering sociodemographic and anthropometric information, nutrition knowledge level, use of food and nutrition labels, factors influencing label usage, and preferences for nutrition information formats. The Fisher's Exact Test revealed no significant association between Body Mass Index (BMI) and nutrition knowledge or nutrition label usage ($p>0.05$). However, gender is significantly associated with nutrition knowledge ($p<0.05$). As for nutrition knowledge and nutrition label usage, there was no significant association between the level of nutrition knowledge and the use of nutrition labels during food purchases ($p>0.05$). To summarize, this research may determine the most recent data on general nutrition knowledge patterns among university students following the COVID-19 outbreak and underscores the importance of nutrition awareness in empowering students to make informed dietary choices, improving their health and well-being, necessitating targeted interventions and further research for a healthier, nutritionally aware generation.

Keywords: knowledge, nutrition label, sociodemographic, students

INTRODUCTION

Healthy eating habits are influenced by nutrition awareness and knowledge of nutrition labels (Rivera Medina *et al.* 2020; Murimi 2013). Consumers often get nutrition and health-related information about food items from nutrition labels because they provide crucial information and serve as interventions with unrivaled population-level reach (Campos *et al.* 2011). Miller & Cassady (2015) mentioned that nutrition knowledge refers to the knowledge and ideas connected to nutrition and health, including understanding diet and health, diet and illness, food as a primary source of nutrients, and dietary guidelines and recommendations. Most chronic illnesses begin early in life and proceed gradually over decades, making nutrition education necessary for young individuals to begin disease prevention sooner (Al-isa & Alfaddagh 2014). Due to the implementation of the Movement Control Order (MCO), overweight and obesity increased among young people in Malaysia. The psychological effects of lockdown and deviation from typical routines may lead to unhealthy food overconsumption, which may worsen obesity and increase the risk of cardiovascular and metabolic diseases (Bhutani & Cooper 2020; Martinez-Ferran *et al.* 2020; Emmy *et al.* 2023).

Most students are young adults categorizing them between the ages of 18 and 29 (Norimah *et al.* 2010), a time when significant life changes occur, particularly concerning dietary autonomy. Leaving home for an extended period is a new

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experience for many college students. There are notable distinctions in various aspects, such as food, individuals, and residential environments (Yasmin *et al.* 2020). Nonetheless, it has been discovered that providing nutritional information at the point of purchase in university settings, in conjunction with the appropriate teaching, improves food choices (Ab Hamid *et al.* 2021). In addition, it has been shown that subsidies for nutritious foods induce positive dietary practices in various settings (Roy *et al.* 2015). According to Norazmir *et al.* (2012), 53.6% of teenagers in Malaysia do not use nutrition labels, and 69.5% of them do not understand what is written on them. In the present society, the lockdown was undoubtedly connected to modifying food choice motives, which indicates that specific individuals are becoming more aware of the necessity of choosing sustainable food choices (Marty *et al.* 2021).

One strategy for combating unhealthy diets is encouraging people to read nutrition labels when buying products. The relationship between nutrition knowledge and label usage is a crucial aspect to explore as it has implications for promoting healthier dietary choices and overall public health. However, statistics on adopting nutrition information labels among Malaysians, especially after MCO and its influencing variables, remain sparse. Therefore, this research aimed to determine the nutrition knowledge and the use of nutrition labels among undergraduate students in UiTM Puncak Alam.

METHODS

Design, location, and time

This cross-sectional study was conducted using quantitative techniques among undergraduate students at UiTM Puncak Alam from June to July 2023. This research was carried out at the Selangor campus of the Universiti Teknologi MARA (UiTM) in Puncak Alam, Kuala Selangor, Malaysia. There were eight faculties till 2023, including the Faculty of Accountancy, Art and Design, Build Environment, Business, Education, Health Sciences, Hotel and Tourism Management, and Pharmacy. Ethical approval for this study was obtained from the UiTM Research Ethics Committee, Selangor, Puncak Alam Campus (FERC/FSK/MR/2023/00127) on May 31, 2023, before the study began.

Sampling

The students in UiTM Puncak Alam were randomly selected using the convenience sampling method. The population size is 18,721 students in UiTM Puncak Alam. Raosoft Sample Calculator is chosen to calculate the sample size with a margin error is 5% and a confidence level of 95%. Response distribution is 50% making the minimum (n=377) sample size required for this study. The eligibility criteria were: 1) A full-time undergraduate student; 2) from different faculties in UiTM Puncak Alam who are; 3) Aged 18–29 years old; 4) Able to read and understand the questionnaire. Students in a weight loss program or consuming weight loss supplements were excluded from the study.

Additionally, the participants' identities were kept confidential, ensuring their information remained anonymous and could not be linked back to them. Initially, only 161 students were successfully recruited throughout the data collection process due to time constraints. However, five respondents who are currently joining weight loss programs or consuming weight loss supplements were excluded making 156 respondents included in the final analysis. The exclusion process was performed to ensure that there would not be any potential risk of confounding factors.

Data collection

UiTM students who met all the eligibility criteria were invited to participate in the study through an online self-administered questionnaire. The data collection was carried out at various locations within UiTM Puncak Alam such as the faculties and the cafeterias of the hostels. Participants were given the questionnaire and consent form through Google Forms, prepared in a QR Code. Participants were given a short explanation of the research regarding the data collection method. The duration to complete the data collection was less than 10 minutes, including anthropometric measurement and answering the questionnaire for each participant.

Participants' weight and height were collected barefoot and measured twice, and the average was taken. The weight was measured using a digital flat scale (Model: SECA 813) and height using a stadiometer (Model: SECA 213). BMI-for-age is categorized according to the Asia-Pacific Body Mass Index Classification, which

classifies Underweight (<18.5 kg/m²), Normal (18.5–22.9 kg/m²), Overweight (23.0–27.4 kg/m²), and Obese (≥27.5 kg/m²).

Other than anthropometric and sociodemographic information, respondents answered a validated and modified self-administered questionnaire adapted from Nurliyana *et al.* (2011). The study used the Food Label Use Questionnaire (FLUQ) to determine the relationship between socio-demographic factors, nutrition knowledge, and the use of nutrition information labels during food purchases among undergraduate students in UiTM Puncak Alam, which comprises five primary parts. Section A compiles demographic data related to the students, including age, gender, year of study, faculty, and year of study. Section B comprises a set of eight concerns relating to the participant's knowledge in the field of nutrition. Five distinct answer choices accompany each question. The scores used to define each level were as follows: Low (0.0–2.0), Medium (3.0–5.0), and High (6.0–8.0).

Section C of the study evaluates the utilization of food and nutrition labels by students at UiTM. A 4-part Likert-type response set has been used to assess the frequency of label usage, with options including "often," "sometimes," "rarely," and "never." Furthermore, this component has an inquiry regarding the primary factor considered while making a food purchase, employing a Likert-type response scale consisting of four parts (most important, important, least important, and not important).

Section D of the survey has two inquiries that investigate the various determinants that impact the use of food labels during food purchases. Section E of the study examines the comprehension and preferences of students about multiple formats of nutrition information, specifically focusing on their preferred format for the nutrition information panel. However, it is essential to note that the questionnaire does not include specific inquiries concerning the frequency at which individuals read and analyze nutritional information on labels such as total fat content, the caloric contribution from fat, trans fat, saturated fat, cholesterol, carbohydrates, protein, dietary fiber, sugar, vitamins, and minerals.

Data analysis

The collected data was analyzed using Statistical Package for Social Sciences (SPSS), version 27.0. Descriptive analysis was used to calculate and categorize the subject's sociodemographic characteristics. Fisher's Exact test was utilized to determine whether there is a significant association between socio-demographic factors, nutrition knowledge, and the use of nutrition information labels during food purchases among undergraduate students in UiTM Puncak Alam. The statistical significance level was set at $p<0.05$. Categorical data are presented as frequency and percentage, while numerical data is shown as mean±SD.

RESULTS AND DISCUSSION

Table 1 shows the socio-demographic characteristics of the participants that are presented in frequency and percentage for the categorical variable and mean±SD for the numerical variable. The study included 156 participants aged 18–25 years, with a mean age of 21.97±1.13.

Based on Table 2, the participants' general nutrition knowledge levels were mainly categorized as high (56.4%), followed by medium (41.0%), and only a small proportion had a low level (2.6%) based on their scores. This finding aligns with previous research conducted in Malaysia targeting university students, which also supports the notion that most young adults have high nutrition knowledge (Norazlanshah *et al.* 2013). Interestingly, no female students in this study had a low level of nutrition knowledge. This observation aligns with previous research, as Yahia *et al.* (2016) reported, which also found that female students have more excellent nutrition knowledge than male students. Fisher's Exact test (with $\alpha<0.05$) was used to evaluate whether gender is related to or not with nutrition knowledge and the result was statistically significant ($p<0.001$). Therefore, it is concluded that there is an association between gender and nutrition knowledge level (Table 3).

Various factors might contribute to this gender-based difference in nutrition knowledge. Women are often more involved in food preparation and family health, leading to increased exposure to nutrition-related information and discussions (Spronk *et al.* 2014). Additionally, a study found that young adult women display a keen interest in calorie and fat information on nutrition labels. This can be attributed to their strong desire for

Table 1. Socio-demographic characteristics of participants (n=156)

	Total (n=156)	
	n (%)	Mean±SD
Age group		
18–25		21.97±1.13
Gender		
Male	41 (26.3)	
Female	115 (73.7)	
Faculty		
Accountancy	10 (6.4)	
Art & design	13 (8.3)	
Build environment	4 (2.6)	
Business	23 (14.7)	
Education	9 (5.8)	
Health science	69 (44.2)	
Hotel & tourism management	8 (5.1)	
Pharmacy	20 (12.8)	

SD: Standard Deviation

weight control, leading them to make informed food choices to regulate their energy and fat intake (Lim *et al.* 2015). This might support a study by AlHazmi & Aziz (2020) that reported the awareness of young females regarding their body weight, physical appearance, and the aspiration to be socially accepted within the context of beauty standards emerged as noteworthy aspects.

A study reported that students with higher nutritional knowledge tended to consume less unhealthy fats and cholesterol, implying the potential benefits of improved nutrition knowledge (Yahia *et al.* 2016). Individuals with limited nutrition knowledge may encounter challenges in making informed dietary choices, potentially leading to weight gain and a higher BMI. Remarkably, no students with low nutrition knowledge were observed among the underweight and obese BMI categories, indicating that higher awareness and nutrition knowledge may contribute to better nutrition-related decisions and more consistent body weight and BMI levels (Staśkiewicz *et al.* 2023).

From Table 4, majority of the students use nutrition information labels during food purchases which are about 89.7% (n=140). Gender was not statistically different among the categorized nutrition information label usage ($p>0.05$).

This observation is consistent with a previous study that found females more likely to practice using food labels than males. A local study emphasized the high awareness level of food labels among urban shoppers, and this awareness was associated with respondents' gender and income level. Notably, healthy males were less inclined to read food labels than healthy women, considering it time-consuming (Norazmir *et al.* 2012). Males are less attentive to food labels and less interested in their food decisions than their female counterparts, as females view food choices as a constant thought process.

Several theories link males' disinterest in food decisions to ideologies of masculinity, as dieting has often been associated with femininity (Nani 2016). Moreover, traditional gender roles may encourage women to be more meticulous about food selection. The study highlights that women are often responsible for grocery shopping, which may explain their heightened awareness and use of nutrition labels when buying groceries for the family (Ponnudurai *et al.* 2019). Additionally, females were more likely to be concerned about their body weight and motivated to change it through dietary adjustments, potentially contributing to their greater use of nutrition information labels during food purchases (Heiman & Olenik-Shemesh 2019).

Table 2. The frequency of nutrition knowledge according to gender (n=156)

Nutrition knowledge	Gender		Total n (%)
	Male (n=41) n (%)	Female (n=115) n (%)	
Low	4 (9.8)	0 (0.0)	4 (2.6)
Medium	24 (58.5)	40 (34.8)	64 (41.0)
High	13 (31.7)	75 (65.2)	88 (56.4)

Table 3. The association of gender and BMI with nutrition knowledge (n=156)

	Nutrition knowledge				*p*
	Low (%)	Medium (%)	High (%)	Total (%)	
Gender					
Male	4 (100.0)	24 (37.5)	13 (14.8)	41 (26.3)	<0.001[a*]
Female	0 (0.0)	40 (62.5)	75 (82.5)	115 (73.7)	
BMI					
Underweight	0 (0.0)	10 (15.6)	21 (23.9)	31 (19.9)	0.730[a]
Normal	3 (75.0)	28 (43.8)	33 (37.5)	64 (41.0)	
Overweight	1 (25.0)	18 (28.1)	26 (29.5)	45 (28.8)	
Obese	0 (0.0)	8 (12.5)	8 (9.1)	16 (10.3)	

[a]Fisher's Exact test; [*]Significant at p<0.05; BMI: Body Mass Index

Moreover, the data shows that among students who use the nutrition information label, 40.7% have a normal BMI. Similarly, among students who do not use the nutrition information label during food purchase, 43.8% belong to the normal BMI classification. This suggests that nutrition information label usage is prevalent among students with a normal BMI, regardless of whether they utilize the labels or not. However, a previous study found that young adults who regularly use the nutrition facts label have higher diet quality (Buyuktuncer *et al.* 2018). Based on BMI, more overweight students use nutrition information labels (29.3%) compared to underweight students (18.6%). This indicates that students who are overweight are more likely to utilize nutrition information labels during food purchases than underweight students. This is supported by a study that found many students read food labels to control energy intake (Norazmir *et al.* 2012).

Meanwhile, participants not using nutrition information labels are higher among underweight than overweight students, who are 31.1% and 25.0%, respectively. This might be due to a lack of awareness of basic dietary guidelines, as supported by a study in China reporting low overall dietary guideline awareness in both urban and rural areas (Jiang *et al.* 2023). Moreover, all students who are obese use nutrition information labels during food purchases (14.4%). However, a considerable proportion of consumers, especially those belonging to specific demographics like children, adolescents, and older adults who are obese, exhibit a notable lack of reliance on nutrition labels during their food purchasing decisions, raising concerns about their potential limited awareness of nutritional content and its implications (Jefrydin *et al.* 2019). Nevertheless, there was no significant association between BMI and nutrition information label usage among UiTM Puncak Alam students (p>0.05). This result suggests that body weight status may not be the primary factor driving students' engagement with nutrition information labels. Several factors could contribute to the absence of a significant association, such as diverse reasons for label usage. Students may use nutrition information labels for various purposes, including weight management, health consciousness, dietary preferences, and nutritional awareness. These motivations may vary widely among students, irrespective of their BMI.

As for nutrition knowledge, it is shown that students who use nutrition information labels during food purchases range from high (58.6%), medium (38.6%), and low (2.9%) levels of nutrition knowledge. This suggests that students with higher nutrition knowledge are more likely to utilize nutrition labels when making food choices. Previous studies have also found that knowledgeable consumers comprehend nutrition labels better than those with lower knowledge levels (Miller & Cassady 2015). In the study of Al-Barqi *et al.* (2020), 40.9% of the students stated lack of time as the primary reason for not

Table 4. The association between gender, BMI, and knowledge with nutrition information label usage (n=156)

	Nutrition information label usage			*p*
	Use (%)	Not use (%)	Total (n=151) (%)	
Gender				
Male	36 (25.7)	5 (31.3)	41 (26.3)	0.765[a]
Female	104 (74.3)	11 (68.8)	115 (73.7)	
BMI				
Underweight	26 (18.6)	5 (31.1)	31 (19.9)	0.425[a]
Normal	57 (40.7)	7 (43.8)	64 (41.0)	
Overweight	41 (29.3)	4 (25.0)	45 (28.8)	
Obese	16 (11.4)	0 (0.0)	16 (10.3)	
Nutrition knowledge				
Low	4 (2.9)	0 (0.0)	4 (2.6)	0.205[a]
Medium	54 (38.6)	10 (62.5)	64 (41.0)	
High	82 (58.6)	6 (37.5)	88 (56.4)	

[a]Fisher's Exact Test; *Significant at $p<0.05$; BMI: Body Mass Index

using food labels, with other reasons including no interest, no need, and difficulty in usage. This suggests that most students refrain from using food labels during purchases due to time constraints and a perception that they already know what to buy, making label usage seem unnecessary.

Additionally, attitudes significantly and positively influence consumers' food purchase intentions. The utilization of nutrition information labels during food purchases among students appears to be shaped by many factors encompassing psychological, economic, and social dimensions, all of which influence their behaviour (Jefrydin *et al.* 2019). Delving into the significance of using nutrition labels, it is evident that employing these informative labels in the process of food selection empowers consumers to make well-informed and sensible choices, thereby aligning their dietary practices with desirable nutritional behaviours, such as maintaining appropriate calorie or fat intake levels (Lim *et al.* 2015). Further research may be needed to understand better the complexities of these relationships and their impact on promoting healthier food habits among students.

CONCLUSION

In conclusion, the study highlights that nutrition awareness among university students can influence their dietary choices as well as overall health. Most students had high general nutrition knowledge levels followed by medium and only a small proportion had a low level based on their scores. Notably, between BMI and nutrition knowledge or nutrition label usage, there was no association found whereas gender showed a statistically significant association with nutrition knowledge level. This study contributes valuable insight into the relationship between nutrition knowledge level, nutrition label usage and BMI among students. It lays the groundwork for further research and intervention strategies to promote healthier eating habits and nutrition awareness among young adults.

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DECLARATION OF CONFLICT OF INTERESTS

The authors declared that they have no conflict of interest.

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Association Between Diabetes-Related Nutrition Knowledge and Weight Status among Cadet and Non-cadet Students at Universiti Pertahanan Nasional Malaysia (UPNM)

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ABSTRACT

The aim of this study is to investigate the association between diabetes-related nutrition knowledge and body weight status among non-diabetic young adults. This cross-sectional study utilized a questionnaire assessing socio-demographic and Diabetes-Related Nutrition Knowledge-Questionnaire (DRNK-Q). Weight, height, and waist circumference were measured using standard protocols, and body weight categories were established using the Body Mass Index (BMI). Data from 320 young adults, aged 18–26 years old, were collected from Universiti Pertahanan Nasional Malaysia (UPNM). Participants were divided into two categories based on their knowledge scores. Overall, the study's respondents exhibited low DRNK (52.8%) and high DRNK (47.2%). Majority of respondents have normal body weight (55.7%); nevertheless, there is no relationship between body weight and diabetes-related nutrition knowledge. To conclude, there is no knowledge difference between cadet and non-cadet. Therefore, public health initiatives must customize interventions suitable to support behavior and lifestyle changes based on the amount of diabetes awareness.

Keywords: diabetes-related nutrition knowledge, young adults

INTRODUCTION

Diabetes mellitus has emerged as one of the world's most pressing public health issues, exacting a massive worldwide toll on public health and socioeconomic development (Akhtar *et al.* 2022). Former Malaysia Health Minister Datuk Seri Dr. Dzulkefly Ahmad addressed that this is a concerning trend for diabetes that will result in a prevalence rate of 31.3% for adults who are 18 years of age and older (Bernama 2019). According to him, 3.6 million people in Malaysia today have the disease, making it one of the most common worldwide and the highest in Asia. Akhtar *et al.* (202) discovered a generally increasing trend in type 2 diabetes mellitus prevalence with age, ranging from 2.0% to the 18–19-year-old age, therefore type 2 diabetes is becoming much more common in teenagers and young people. Gupta and Bansal (2020) stated that having a higher Body Mass Index (BMI) increases the risk of developing both diabetes and prediabetes. Approximately 80–90% of type 2 diabetics are overweight or obese (Nianogo & Arah 2022). According to BMI, the prevalence of prediabetes varied; it was highest in those who were obese, intermediate in those who were overweight, and lowest in those who were normal weight or underweight (Andes *et al.* 2020).

A study by Schnurr *et al.* (2020) discovered that type 2 diabetes incidence is increased by obesity and poor lifestyle choices, regardless of genetic susceptibility. As a result, the global rise in obesity prevalence has coincided with an increase in Type-2 Diabetes Mellitus (T2DM) prevalence (Klein *et al.* 2022). According to the World Population Review 2019, Malaysia has the highest prevalence of adult obesity in Southeast

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Asia at 15.6%, followed by Brunei (14.1%), Thailand (10.0%), and Indonesia (6.9%). In 2014, Ho *et al.* mentioned that this expanding trend is caused by various factors, including population growth, population ageing, urbanization, rising rates of obesity, and physical inactivity. To classify adults as overweight or obese, the simple Weight-to-Height Ratio (BMI) is usually utilized (WHO 2021). It is calculated by multiplying the person's height in meters by the square of their weight in kilograms (kgm^{-2}). Weight gain and body mass also have a substantial influence on the development and rising prevalence of type 1 and type 2 diabetes, and there is a considerable relationship between diabetes, insulin resistance, and BMI (Al-Goblan *et al.* 2014). In both established and developing nations, obesity is one of the biggest challenges to public health in the twenty-first century (Zatońska *et al.* 2021).

The key to managing diabetes is proper nutrition (Mphasha *et al.*2021). Knowledge of nutrition also affects the dietary habits and nutrient consumption of an individual (Dallongeville *et al.* 2001; Sun *et al.* 2021). A study by Mazzochi *et al.* (2014) found that 56% of those surveyed believed that the lack of nutrition knowledge is a contributing factor to overweight and obesity. In another study, students who scored higher on nutrition knowledge had lower daily intakes of total fat, saturated fat, and cholesterol than students who scored lower on nutrition knowledge (Yahia *et al.* 2016). According to studies by Brandhorst and Longo (2019), having a solid understanding of nutrition is essential for encouraging eating behaviors that support a healthy weight. Since both obesity and being overweight have an impact on health and encourage the development of chronic diseases. The majority of studies assess the general population's diabetes knowledge. However, a few studies have been made to assess diabetes-related nutrition knowledge among diabetic patients. Unfortunately, studies assessing diabetes-related nutrition knowledge among non-diabetics are scarce as they usually focus on diabetic patients. This study conducted between cadet and non-cadet as we expected their body weight status might be different due to military training that should be enrolled by cadet. Therefore, this study focuses at assessing diabetes-related nutrition knowledge among young adults as it could help health practitioners, other researchers, and the authorities to construct effective initiatives and strategies to prevent diabetes from early adulthood. Hence, this study aims to assess weight status, diabetes-related nutrition knowledge and the association between diabetes-related nutrition knowledge and weight status among young adults.

METHODS

Design, location, and time

This cross-sectional observational study was conducted by distributing the Diabetes-Related Nutrition Knowledge Questionnaire (DRNK-Q) to young adults at Universiti Pertahanan Nasional Malaysia (UPNM), a military institute located at Sungai Besi Camp. The DRNK-Q is to measure their level of knowledge of diabetes-related nutrition. Bonnie *et al.* (2015) defines individuals between the ages of 18 and 26 are considered young adults. It was conducted from October 2022 to August 2023. The ethical clearance for this study was obtained from the Faculty Ethics Review Committee (FERC) of Universiti Teknologi MARA with the reference number FERC/FSK/MR/2023/00011.

Sampling

Convenience sampling was used to select individuals based on their availability. The population of this study were between the ages of 18 and 26 who are willing to join, did not be diagnosed with type 2 diabetes mellitus, active students status at UPNM and also understand Malay or English language. The study population consisted of 320 respondents who participated in the cross-sectional observational study from UPNM. Summarily the number of respondents from cadet (120) and non-cadet (200). In general, the students at UPNM are divided into two groups: cadet and non-cadet. A cadet is a student enrolled in both military training and academic studies simultaneously, as opposed to non-cadets who are not members of the military and are exclusively enrolled in academic studies. In terms of academic hours, cadets and non-cadets have agreed to study at the same periods from 8.00 a.m. to 5.00 p.m., with intervals for both groups of students to engage in physical activity from 5.00 to 6.30 p.m. During this time, cadets are obliged to partake in military physical training. However, non-cadets were free to partake in any extracurricular activities they chose, including

both individual and team sports. The diabetes-related nutrition knowledge questionnaire was distributed to participants of different ages, gender, race and education levels. A target sample size of 327 was calculated using the formula as shown below:

$$n= (Z1-\alpha/2\ 2\ SD2)/d2$$

n: abbreviation for sample size. Z1-α/2: standard normal variate (at 5% type 1 error, $p<0.05$ (1.96). SD: standard deviation of the variable from the previous study. d: absolute error or precision (50%). For estimation, the significance level is set at =0.05 (two-tailed), and the 95% CI is used. Therefore, the standard normal variate in this study is 1.96. Based on past research by Han *et al.* (2020) on "Development of a diabetes-related nutrition knowledge questionnaire for individuals with type 2 diabetes mellitus in Singapore", the average standard deviation of the DRNK-Q score in this study is (±4.4). The precision used in the study is 50% (0.5). Martínez-Mesa *et al.* (2016) stated to accommodate for predicted non-responses, refusals, or losses, sample sizes are increased by 10%. As a result, a sample size of n=327 was calculated.

Data collection

Participants were briefed on the study, which allowed them to consider participating. Participants should leave the briefing with a succinct explanation of the study, any potential harm, and knowledge of their rights. They are given the right of withdrawing from the study without penalty. Following an explanation of the study to the participants, they were given an informed consent form and freely participated in the study. The consent form is in English, and participants were guided to sign it in English or Malay if necessary. After collecting consent forms, participants' height and body weight were measured using stadiometers and weighing scales, respectively. The body mass index was then determined from the result. Finally, the Waist Circumference (WC) was measured with a SECA measuring tape. To take the measurement, the measuring tape is fastened to the housing and encircled the body. This enables the measurement result to be read accurately and simply. The questionnaire was finally circulated after all the necessary measurements were taken.

The validity and reliability of the DRNK-Q were established after it was implemented from a literature review in Singapore. The questionnaire was administered in person to the students at UPNM to gauge their understanding of diabetes-related diet. This could be approved for use in South-East Asian (SEA) nations with comparable multiethnic populations or in studies involving Chinese, Malays, and Indian populations of these ethnicities (Han *et al.* 2020). Socio-demographic data, such as age, gender, ethnicity, education, family history of diabetes mellitus and family history of overweight and obesity was self-reported by the participants first before answering DRNK-Q. The DRNK-Q composed of four sections and 27 questions related to the topics covered in dietetic therapy and education sessions for patients with T2DM: food portion and sizes; nutrition content of food; healthier food choices and safety; and food label reading. The score will vary from 0 to 100 depending on the population's knowledge. To categorize into poor and high knowledge, the median score needs to be calculated. If the DRNK-Q score below median, it is classified as poor while above median will be classified as high knowledge. Later, the information gathered through a self-administered questionnaire since Cella *et al.* (2015) stated it is less expensive and less susceptible to interviewer bias, and because it has historically been chosen.

Data analysis

The recorded data was analyzed using IBM SPSS Statistics for Windows (Version 27.0). The participant's sociodemographic, anthropometric, and diabetes-related nutrition knowledge were presented descriptively in mean and standard deviation. An independent t-test was used to dictate the significant difference in mean value between cadet and non-cadet participants for WC, BMI, and diabetes-related nutrition knowledge score. The Pearson Correlation Coefficient test was used to identify the association between body weight status and diabetes-related nutrition knowledge score.

RESULTS AND DISCUSSION

Socio-demographic characteristics

The socio-demographics of the study participants were shown in Table 1. The mean age was 20.76±1.12 years old. Most of the respondents were male (67.5%), non-cadet (62.5%) and were predominantly Malay (90.6%).

Table 1. Socio-demographic characteristics of respondents between cadet and non-cadet (n=320)

Socio-demographic	Cadet (n=120)		Non-cadet (n=200)		Total (n=320)
	n (%)	Mean±SD	n (%)	Mean±SD	n (%)
Age		21.12±0.68		20.54±1.26	
Gender					
Male	111 (92.5)		105 (52.5)		216 (67.5)
Female	9 (7.5)		95 (47.5)		104 (32.5)
Ethnicity					
Malay	107 (89.2)		183 (91.5)		290 (90.6)
Chinese	3 (2.5)		2 (1.0)		5 (1.6)
Indian	4 (3.3)		12 (6.0)		16 (5.0)
Bumiputera	6 (5.0)		3 (1.5)		9 (2.8)
Faculty					
Defense Science and Technology	44 (36.7)		16 (8.0)		60 (18.8)
Defense Studies and Management	53 (44.2)		13 (6.5)		66 (20.6)
Engineering	15 (12.5)		8 (4.0)		23 (7.2)
Medicine and Health Defense	5 (4.2)		47 (23.5)		52 (16.3)
Defense Fitness Academy			112 (56.0)		112 (35.0)
Others	3 (2.5)		4 (2.0)		7 (2.2)
Current education					
Diploma			80 (40.0)		80 (25.0)
Bachelor degree	120 (100.0)		120 (60.0)		240 (75.0)
Family history of diabetes mellitus					
Yes	18 (15.0)		44 (22.0)		62 (19.4)
No	90 (75.0)		137 (68.5)		227 (70.9)
I do not know	12 (10.0)		19 (9.5)		31 (9.7)
Family history of overweight/obesity					
Yes	17 (14.2)		39 (19.5)		56 (17.5)
No	99 (82.5)		140 (70.0)		239 (74.7)
I do not know	4 (3.3)		21 (10.5)		25 (7.8)

SD: Standard Devitation

Most of the respondents are from Defense Fitness Academy (35.0%) and are taking bachelor's degree (75.0%) and majority of them have no family history of diabetes mellitus (70.9%), and overweight or obesity (74.7%).

Table 2 shows the anthropometric data of the respondents. Their mean height was 166.47±7.97 cm, weight 62.13±7.97 kg, waist circumference 76.20±8.97 cm and BMI 22.38±3.25 kgm^{-2}. Most of the respondents have a normal BMI (55.7%) followed by overweight (29.1%), underweight (7.8%), obese I (5.0%) and obese II (2.2%). The finding shows the mean BMI of both groups are in normal classification however the mean BMI of non-cadets (22.70±3.77 kgm^{-2}) is higher than cadets (21.83±2.02 kgm^{-2}). Nevertheless, it was

Table 2. Anthropometric data of respondents between cadets and non-cadets' students in UPNM (n=320)

Anthropometric	Cadet (n=120)		Non-cadet (n=200)		Total (n=320)	*p*
	n (%)	Mean±SD	n (%)	Mean±SD	n (%)	
Height (cm)	-	170.20±5.93	-	164.23±8.20	-	-
Weight (kg)	-	63.35±7.50	-	61.40±11.91	-	-
Waist Circumference (cm)	-	75.22±4.72	-	76.79±10.71	-	0.008[a, b]
BMI (kgm^{-2})	-	21.83±2.02		22.70±3.77	-	0.073[a]
BMI Category						
Underweight	3 (2.5)	-	22 (11.0)	-	25 (7.8)	-
Normal	82 (68.3)	-	97 (48.5)	-	179 (55.9)	-
Overweight	34 (28.3)	-	59 (29.5)	-	93 (29.1)	-
Obese I	1 (0.8)	-	15 (7.5)	-	16 (5.0)	-
Obese II	-	-	7 (3.5)	-	7 (2.2)	-

BMI: Body Mass Index; SD: Standard Deviation; UPNM: Universiti Pertahanan Nasional Malaysia
[a]Independent sample t-test; [b]Significant at p<0.05

not statistically different (p=0.073). On the other hand, there is a statistically significant difference (p=0.008) in waist circumference between cadets (75.22±4.72 cm) and non-cadets (76.79±10.71 cm). This revealed that non-cadet has higher mean waist circumference than cadet. Hence, our result from this study is supported by Suwan *et al.* (2012) in which the mean BMI and WC of the medical cadet are 21.78 kgm^{-2} and 74.60 cm. While the mean BMI of University Putra Malaysia (UPM) students was 22.17±3.41 kgm^{-2} (Kamal *et al.* 2018), which was relatively similar to that of non-cadet respondents. However, this study found that both cadet and non-cadet respondents' mean BMI categories are normal. This could be because, while non-cadet students were not required to participate in military training, they were encouraged to participate in any type of activity to graduate.

There was a difference between the diabetes-related nutrition knowledge among UPNM cadets and non-cadets' students. It is worth mentioning that respondents had a wide range of DRNK from 0% to 72% and a median of 36%. Respondents in this study had overall poor DRNK (52.8%) while high DRNK (47.2%). Poor knowledge among non-cadet is 30%, while cadets are 22.8%. However, good knowledge among non-cadet is 32.5%, while cadets are 14.7%. As shown in Table 3, the results indicate that there was a significant (p=0.002) difference between the diabetes-related nutrition knowledge of cadets (32.89±14.50) and non-cadets (38.42±15.54) where the non-cadet scored higher DRNK compared to cadets.

Additionally, there is a statistically significant difference in diabetes-related nutrition knowledge in Section 1 on food and sizes portions between cadets (1.90±1.41) and non-cadets (2.31±1.37), (t (318)=2.573, p=0.011). This revealed that non-cadets have higher knowledge of the food and sizes portions than cadets. The mean difference was 0.41, with a 95% confidence interval of (0.10, 0.72). Meanwhile, there is a statistically significant difference in Section 2 on the nutrition content of food between cadets (2.81±1.68) and non-cadets (3.57±1.53), (318±4.127, p=<0.001). This revealed that non-cadets have higher knowledge of the nutrition content of food than cadets. The mean difference was 0.76, with a 95% confidence interval of (0.40, 1.12). Furthermore, the mean difference of Section 3 on healthier food choices and safety between cadets (1.29±1.02) and non-cadets (0.90±0.97) was statistically significant (318±3.47, p=<0.001). The mean difference was -0.40, with a 95% confidence interval of (-0.62, -0.17). It shows that non-cadets have

Table 3. Diabetes-related nutrition knowledge (DRNK) between cadets and non-cadets students in UPNM (n=320)

Variables	Cadets (n=120)	Non-cadets (n=200)	Mean diff (95% CI)	*p*
	Mean±SD	Mean±SD		
DRNK	32.89±14.50	38.42±15.54	5.54 (2.09, 8.98)	0.002
Food portion and sizes	1.90±1.41	2.31±1.37	0.41 (0.10, 0.72)	0.011
Nutrition content of food	2.81±1.68	3.57±1.53	0.76 (0.40, 1.12)	<0.001
Healthier food choices and safety	1.29±1.02	0.90±0.97	-0.40 (-0.62, -0.17)	<0.001
Food label reading	2.37±1.47	2.91±1.66	0.54 (0.19, 0.89)	0.003

DRNK: Diabetes-Related Nutrition Knowledge; SD: Standard Deviation; UPNM: Universiti Pertahanan Nasional Malaysia

more knowledge of healthier food choices and safety than cadets. While in Section 4 the mean difference in food label reading between cadets (2.37±1.47) and non-cadets (2.91±1.66) was statistically significant (273.80=3.02, p=0.003). This suggested that cadets have lesser knowledge of food label reading than non-cadets. The mean difference was 0.54, with a confidence interval of (95% CI:0.19, 0.89). In general, non-cadet respondents have high knowledge of three out of four sections of the diabetes-related nutrition knowledge questionnaire.

The results of diabetes-related nutrition knowledge among cadets are in line with the study by Bovill *et al.* (2003) results as they revealed that the mean nutrition knowledge score for soldiers was 48.5, meaning that less than half of the questions could be answered correctly by them. Another study by Belogianni *et al.* (2021) found students majoring in healthcare (41.1%) received higher knowledge scores than those majoring in non-healthcare fields (58.9%). Demographic research among the Danish discovered that despite being a somewhat well-educated demographic, there was a noticeable prevalence of poor health literacy. Therefore, having a higher education does not automatically equate to having better nutrition or health literacy (Svendsen *et al.* 2020). Unsatisfactory understanding may be exemplified by the fact that nutrition as a science is still in its early stages, with no formal nutrition education training being provided in schools. It is only studied at specific universities at the university level. As an outcome, properly developed nutrition education programmes must be provided early in life through school and then through the media to offset erroneous nutrition-related knowledge.

A Pearson correlation coefficient was performed to evaluate the relationship between body weight status and diabetes-related nutrition knowledge. The results r=0 indicate that there is no linear correlation between body weight status and diabetes-related nutrition knowledge. We can see in Figure 1 and Figure 2 that the data is widely scattered around the line. It is a fair correlation (0.25<r<0.50). Hence, the relationship between body weight status and diabetes-related nutrition knowledge was not statistically significant, r=0.46, p=0.411. In addition, no significant correlation was found between waist circumference and diabetes-related nutrition knowledge, r=-0.043, p=0.448. Therefore, we fail to reject the null hypothesis.

Nutritional knowledge affects diet quality because it influences people's decisions to choose a healthy diet (Ul Haq *et al.* 2018) and lead healthy lifestyles, particularly for young adults (El Ansari *et al.* 2015). This study demonstrates no significant correlation between both body weight status body mass index and waist circumference towards diabetes-related nutrition knowledge. A weak correlation existed between these two variables (p>0.05). This result was consistent with those of the research studies carried out by O'Brien and Davies (2007) who assessed the nutritional knowledge and body mass index as well as findings from Issahaku and Alhassan (2021) that overweight was not found to be significantly correlated with nutrition

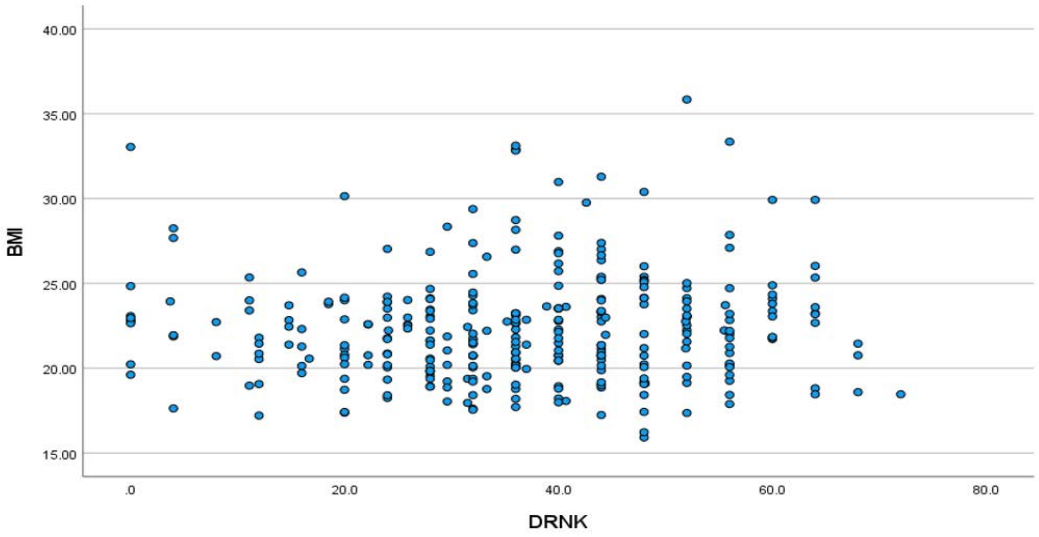

Figure 1. Correlation between Body Mass Index (BMI) and Diabetes-Related Nutrition Knowledge (DRNK)

knowledge. On the other hand, it is in contrast with the study by Valmórbida *et al.* (2017) where they conclude that respondents with lower knowledge scores had worse results in terms of BMI, waist circumference and waist-hip ratio and supported by Saintila *et al.* (2022) whereas they discovered that teachers with poor nutritional knowledge were more likely to be overweight. Although some findings do not corroborate with this study's result, they are still valuable data.

The Pearson correlation coefficient was used to examine the association between the DRNK and body weight status. First, the BMI-related DRNK exam revealed a positive association, with participants with lower BMIs scoring higher on the diabetes-related nutrition knowledge question. Conversely, there is a negative correlation between waist circumference and DRNK score, indicating that the two variables are moving in the opposing directions.

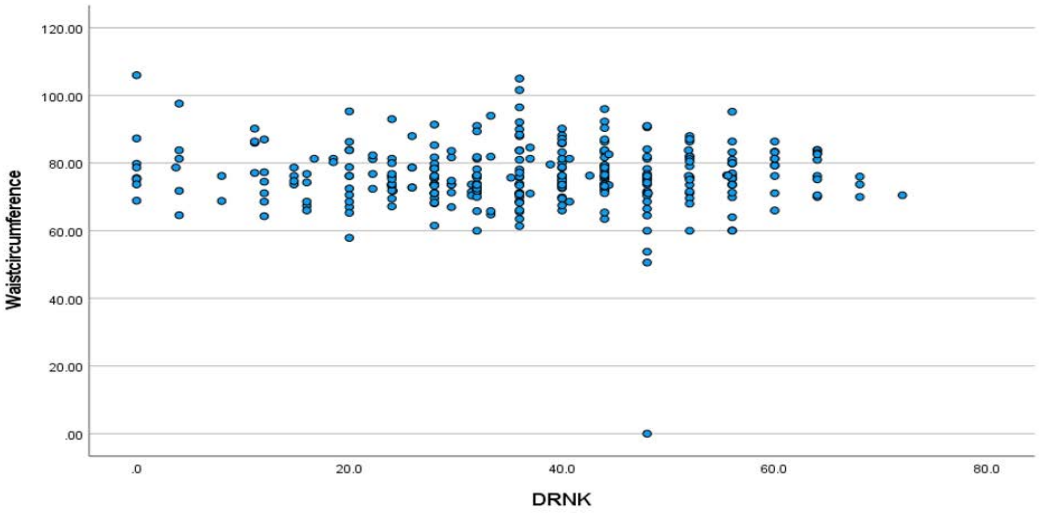

Figure 2. Correlation between Waist Circumference (WC) and Diabetes-Related Nutrition Knowledge (DRNK)

The participants' waist circumference increased with increasing DRNK score. This concludes that there is a relationship between body weight status and diabetes-related nutrition knowledge score, with lower BMI individuals demonstrating a greater level of nutrition knowledge.

CONCLUSION

We examined the relationships between body weight status and diabetes-related nutrition knowledge among young adults in UPNM. We found that the diabetes-related nutrition knowledge was poor among our participants. Furthermore, there was no significant association between body mass index and waist circumference to diabetes-related nutrition knowledge can be observed. It is advised to improve overall diet through nutrition education, which should set realistic healthy eating goals for each cadet's lifestyle and address motivational barriers to increase adherence.

The current findings should be interpreted in light of the following limitations such as the study was only carried out at UPNM, so it cannot give a comprehensive picture of the young adult population. We only consider university students in our study, which is also an inadequate representation of Malaysia's young adult population. The lack of prior study in the field is noteworthy because diabetes-related nutrition knowledge is employed frequently in the diabetic community to regulate and halt complications from the disease. Future research should link physical activity and dietary intake to cadets' knowledge of diabetes-related nutrition to gain a more complete picture of the variables that may affect this knowledge.

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DECLARATION OF CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

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Examining Factors in Preventing Foodborne Diseases among Food Handlers at Military Dining Hall

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ABSTRACT

This study aims to determine Food Safety (FS) knowledge, practice in preventing Foodborne Disease (FBD), and risk perception related to food handling among food handlers at military bases. An Optimistic Bias (OB) in preventing FBD were examined based on the risk perception responses. A set of questionnaires was sent to an officer at each military base in Malaysia. Later, the officer would conveniently distribute the questionnaire to approximately half of the targeted respondents. A total of 284 data were gathered and were analysed using SPSS version 20. The findings revealed that food handlers had good FS knowledge scores and practice to prevent FBD. However, it was found that different risk perception levels were present, indicating OB. The existence of OB was observed in all comparisons and situations except for the question about sanitising utensils. Hence, a conclusion can be made that there is a tendency that food handlers tend to neglect and overlook FS procedures, and can contaminate foods due to the presence of OB. This study will contribute significantly to military foodservice establishments in Malaysia regarding food hygiene and safety awareness.

Keywords: food contamination, food safety knowledge, optimistic bias, risk perceptions

INTRODUCTION

Knowledge, attitude and practice play a vital aspect in preventing the occurrence of FBD. In addition, it is crucial to know the risk perception, knowledge and optimistic bias and its relationship with FS risk (de Andrade *et al.* 2019). Food handlers are expected toll practise what they have learned during training. Enhancing education in FS through exercise is essential, but this does not indicate that the implementation would be appropriately commuted in practice (Sanlier *et al.* 2020). According to Hamade (2015), knowledge is essential in controlling FS, but it cannot guarantee the safety of the food being produced without proper practice. Hamade (2015) also stated that appropriate food handling knowledge and practices reflected the change of action on how food handlers prepare food. Food handlers with poor personal and food hygiene and inappropriate cleanliness at the premises will lead to FBD and the death of the consumer (Kamboj *et al.* 2020; Le *et al.* 2021).

Initially, food handlers' risk perceptions differ (Evans *et al.* 2020). In addition, increased cases of food poisoning will influence behaviour (Bolek 2020), which will further increase the knowledge of the risk associated with FBD among food handlers (Al-Mohaithef 2021). Meanwhile, Optimistic Bias (OB) is a situation where a person's level of self-confidence is subjected to the optimistic perception of their partner (de Andrade *et al.* 2019). An over-optimistic food handler inclines to ignore safety procedures which can result in food contamination (Rossi *et al.* 2017). In addition, Rowell *et al.* (2013) also mentioned that common barriers such as time constraints, poor communication, limited resources, and ineffective leadership are important limitations that lead the food handler to ignore good practices. OB causes the presence of these barriers among food handlers (da Cunha *et al.* 2015).

Concerning this matter, extensive studies have been conducted related to FBD in foodservice institutions where Knowledge, Attitude and Practice (KAP) measurement of food handlers were mostly emphasised (Mshelia *et al.* 2022; Izyan *et al.* 2019; Zaujan *et al.* 2021). Similarly, many studies have been carried out

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in conjunction with food optimism from food handlers and peer risk perception towards FBD in many parts of the countries (de Andrade *et al.* 2019; Evans *et al.* 2020; de Freitas *et al.* 2019; Evans & Redmond 2019; Fujisaki *et al.* 2019; Aschemann-Witzel & Grunert 2015).

de Andrade *et al.* (2019) reported that food handlers are more likely to believe that they are less risky than their peers in hazardous situations. It is because a person tends to be very optimistic about risk, especially people who think they are in control (de Freitas *et al.* 2019). A similar situation happened in the military food service in which the perception of food handlers on their co-workers or peers who have limitations in performing their duties will cause FBD. Lee *et al.* (2012) stated that the military foodservice establishment poorly practised designated temperature and time control. Furthermore, Mustafa *et al.* (2009) found that military personnel perceived it as easy for them to encounter food poisoning because of the food-handling culture assembled within the kitchen. Hence, this study is vital to examine factors leading to the practice of preventing FBD by food handlers at military camps.

METHODS

Design, location, and time

A cross-sectional survey was conducted among food handlers at military bases in Malaysia between October and November 2019. Before the study was conducted, approval was obtained from higher authority at every military base.

Sampling

There were 647 food handlers at military bases throughout Malaysia. According to Krejcie and Morgan (1970), a minimum sample size of 242 is needed. In this study, a purposive sampling method was adopted where approximately 50% of the food handlers at each military base were asked to complete the questionnaire. There was an informed consent statement at the beginning of the questionnaire.

Data collection

Items for questionnaires were adapted from Patah *et al.* 2009; Kamal *et al.* 2015; Abdullah 2015; Abd Lataf Dora-Liyana *et al.* 2018; Rossi *et al.* 2017; Food Standard Australia & New Zealand 2019. The questionnaire was segmented into four sections: demographic profiles, practice to prevent FBD, FS knowledge, and risk perception in handling food. The latter segment is to measure optimistic bias.

The practice to prevent FBD consists of 10 questions with a four-point Likert scale ranging from 1=never, 2=seldom, 3=sometimes and 4=always. A zero score was given to never (scale 1) response, while scale 2, scale 3 and scale 4 will get scores 1, 2 and 3, respectively. However, the FS knowledge consists of 15 items with three selections of answers: “true”, “false”, and “not sure”, where the correct answer would be given one mark, while incorrect and “not sure” answers would get zero marks. To facilitate score calculation, the practice and knowledge score points were transformed to 100 marks The practice to prevent FBD and the FS knowledge scores percentage were ranked based on the following: below 50% is poor, a score between 50%–79% is defined as average score; and a score 80% and above as good score (Sani & Siow 2014).

Meanwhile, the risk perception in handling food consists of 13 questions which were adapted from Rossi *et al.* (2017) with five-point Likert scale ranging from 1= not at all likely; 2= likely not to happen; 3=50% chance of happening; 4= likely to happen and; 5= extremely likely. However, no scores were calculated since this variable was used to identify optimistic bias. Questions were asked indirectly to the respondent to indicate the risk of causing OB and separate questions about risk to other individuals (peers, friends/others) that may cause FBD (de Freitas *et al.* 2019). The first eight questions were on the food handler’s self-risk perception (Q1–Q8), while the following five were on peer risk perception (Q9–Q13). To further determine the OB, the respondent’s total score was compared to the peer score of the other in the same situation (Rossi *et al.* 2017) (shown below). A significant score difference would indicate OB and the width of the difference would reflect its magnitude (Chock 2011).

1) Pair 1 (Q1 and Q9) - Food handlers compared themselves with colleagues working at other dining halls; 2) Pair 2 (Q1 and Q10) - Food handlers compared themselves with colleagues working at the same dining halls; 3) Pair 3 (Q3 and Q11) - Food handlers compared themselves with colleagues working at the same dining hall but for a specific practice hall; 4) Pair 4 (Q7 and

Q12) - Food handlers compared themselves with colleagues working at the same dining hall but for a specific practice; 5) Pair 5 (Q4 and Q13) - Food handlers compared themselves with colleagues working at other dining halls but for a specific practice.

The instrument was checked for reliability and consistency with Cronbach's alpha value above 0.90. Finally, the validated instrument was distributed among the food handlers at the respective military bases throughout Malaysia.

Data analysis

Data gathered were analysed using SPSS version 20 (SPSS Inc.) for descriptive statistics, while paired sample tests were conducted to examine the existence of OB (by comparing self-risk perception with peer risk perception).

RESULTS AND DISCUSSION

Demographic Profiles

A total of 284 data were analysed where most respondents were males (n=167, 58.8%) and aged between 26 and 35 (n=103, 36.3%). Approximately 200 (70%) of the respondents obtained secondary school qualifications. Most respondents had working experience of more than five years (n=136, 47.9%). As much as 264 (93%) of the respondents had attended the food handling courses conducted by either the Ministry of Health (MoH) (n=144, 50.7%), Malaysian Armed Forces (MAF) (n=64, 22.54%), or both (n=56, 19.72%). However, 20 (7%) did not attend any food handling course. Almost all food handlers had typhoid injections within the past three years (n=277, 97.5%).

Food safety knowledge

Food handlers had good FS knowledge, with an overall mean score of 86.85% (±19.169). The respondent has demonstrated excellent knowledge about food storage, the temperature of the chiller/freezer, wearing proper cloth and gloves and handwashing in handling food to reduce the risk of cross-contamination. The findings are consistent with Abdullah (2015). However, food handlers demonstrated inadequate knowledge of reheating food (69.7%). The finding is consistent with Martins *et al.* (2022) and Mbombo-Dweba *et al.* (2022). It is crucial to ensure that the food is reheated adequately since some toxins produced by microbes are resistant to the heating temperature of food (Zyoud *et al.* 2019).

In addition, poor knowledge related to typhoid injection was also observed (77.1%), which is consistent with Izyan *et al.* (2019). In Malaysia, all food handlers must have typhoid injections, and only those with the injections can participate in food safety courses organised by the government and the authorised agencies. This is clearly shown in Table 1 that more than 97% of the respondents had typhoid injections, but only 77% of them gave a correct answer related to the role of the injections. Hence, food handlers may take

Table 1. Characteristics of the respondents (n=284)

Characteristics	Frequency	%
Gender		
Male	167	58.80
Female	117	41.20
Age		
18–25 years	79	27.82
26–years	103	36.27
36–45 years	55	19.37
46 years and above	47	16.55
Educational level		
Primary school	11	3.87
Secondary school	200	70.42
Certificate	21	7.39
Diploma	35	12.32
Degree	11	3.87
Others	6	2.13
Working experience		
<1 years	34	11.97
1–2 years	63	22.18
3–5 years	51	17.96
>5 years	136	47.89
Typhoid injection within the past three years		
Yes	277	97.54
No	7	2.46

typhoid injections to fulfil specific requirements or to avoid being penalised by the authority without understanding the purpose of the injections.

Practice to prevent foodborne diseases

Most of the food handlers had good practices related to objects that can contaminate food (90.8%), food storing (93.3%), cleaning kitchen/serving utensils (92.6%), keep area clean (94.7%), storage of cleaning supplies (90.1%), ensure cleaning supplies stored separately from food (91.5%) (data not shown). However, the lowest score was obtained regarding wearing a hairnet (73.6%). It could be perceived that the food handlers feel uncomfortable wearing a hairnet or are not provided with enough hairnets. The finding was contradicted to Abd Lataf Dora-Liyana *et al.* (2018), where food handlers at the boarding schools were observed with a hairnet and clean uniforms.

Besides, hand washing practices have been claimed to be good (88%). This statement could be justified that the number of handwashing sinks is not enough, or they are difficult to wash their hand due to the location of the handwashing sink far from their working area. Similar findings were reported by Tan *et al.* (2013), where most food handlers in primary schools in the Hulu Langat area of Selangor neglected hand hygiene and did not properly wash their hands.

Self-risk perception in handling food

Table 2 summarises the self-risk perception in food handling. The food handlers perceived the slightest risk perception that customers would have food poisoning after eating the food they prepared (Q1), followed by the customer having severe/lethal risk after consuming contaminated food (Q2). Meanwhile, questions 3, 5, 6, 7 and 8 revealed that food handlers had moderate risk perception of FS, demonstrating that they were aware that food poisoning could occur if they did not comply with the correct FS practices. Conversely, the statement about preparing meals with expired ingredients (Q6) had the highest mean for risk perception (3.84±1.258). Da Cunha *et al.* (2015) mentioned that if the food handlers believed that FBD would not happen when preparing the food, it would be hard for them to take preventive measures, that is, to ensure good food handling practices. In addition, da Cunha *et al.* (2019) mentioned that self-reported

Table 2. Food handler's self-risk perception in handling food (n=284)

Statement	Mean±SD
Q1. What is the customer's risk of having a stomachache and/or vomiting (food poisoning) after eating a meal prepared by you?	1.77±1.00
Q2. If a customer consumes contaminated food that prepares/served by you, what is the risk of the disease he contracts being severe or lethal?	2.66±1.35
Q3. If you do not wash your hands, what is the customer's risk of having a stomach ache and/or vomiting (food poisoning) after consuming a meal prepared by you?	3.08±1.28
Q4. If you work while wearing earrings, jewellery, a watch or uncovered hair, what is the customer's risk of having a stomach ache and/or vomiting (food poisoning) after consuming a meal prepared by you?	2.98±1.19
Q5. What is the customer's risk of having a stomachache and/or vomiting (food poisoning) after consuming a hot meal that did not reach the temperature 70ºC that prepared/served by you?	3.23±1.24
Q6. If you provide your customer with a meal prepared with an expired ingredient, what is his risk of him having a stomachache/or vomiting (food poisoning) after consuming this meal?	3.84±1.26
Q7. If you do not properly sanitise a utensil, what is the customer's risk of having a stomachache and/or vomiting (food poisoning) after consuming a meal prepared by food handlers from the foodservice where you work?	3.76±1.24
Q8. If you prepare meat that has been improperly thawed, what is the customer's risk of having a stomachache and/or vomiting (food poisoning) after consuming the meal?	3.39±1.15

Q1, Q3, Q4 and Q7 will be paired with statements in Table 3 to determine OB (as presented in Table 4)

risk perception usually differed from actual or observed practices.

Peer risk perception in handling food

As can be seen in Table 3, questions 9 and 10 had lower scores than questions 11, 12 and 13. The respondents believe that their colleagues working at different halls but receiving the same amount of training or who worked in the same place have a low chance of causing food poisoning to their customers. One possible reason for the findings was probably because they recognised the food handlers and knew how their friends worked. The findings indicate that food handlers are confident that if their colleague/ co-worker handles food correctly with the correct FS procedures, it will prevent the customer from having food poisoning. It is known that improper food handling will lead to food contamination and allow the bacteria to multiply, resulting in an increasing number of patients receiving FBD (Kibret & Abera 2012). The overall mean score for risk perception was 3.0014±0.72. This result indicates that there is a moderate risk perception among food handlers in the military base in Malaysia.

Optimistic bias among food handlers

OB has been identified based on four situations: 1) Food handlers compared themselves to colleagues working at the same dining halls; 2) Food handlers compared themselves with colleagues working at other dining halls; 3) Food handlers compared themselves with colleagues working in the same dining room but for a specific practice; and 4) Food handlers distinguished themselves from colleagues working in the same dining room but for a particular practice.

To determine the presence of OB, an individual's score will be compared to the peer score of the other (Rossi *et al.* 2017). Positive results with significant differences demonstrate the presence of OB, and a high score indicates a high degree of tendency of OB (Chock 2011). OB is where a person feels that he or she is not doing/experiencing something negative and is always positive about him or herself (Rossi *et al.* 2017). Hence, the findings of this study revealed that food handlers feel that they are not at risk of doing anything harmful.

This result means that if the individual/ food handlers who score lower than their peers show a tendency existence of OB. Individual/ food handler senses and marks a lower response or scale than the peer/other people's question to determine the presence of OB. After comparison and if the negative result means OB.

As shown in Table 4, significant differences were observed for pair 1, 2, 3 and 4, where pair 1 (questions 1 and 9): -348, p=0.000; pair 2 (questions 1 and 10): -390, p=0.000; pair 3 (questions 3 and 11): -285, p=0.000; and

Table 3. Peer risk perception in handling food (n=284)

Statement	Mean±SD
Q9. What is the customer's risk of having a stomachache and/or vomiting (food poisoning) after eating a meal prepared by a food handler similar to you (who is a similar age and has participated in the same amount of training as you), but working at other dining hall?	2.11±1.13
Q10. What is the customer's risk of having a stomachache and/or vomiting (food poisoning) after consuming a meal prepared by a colleague (food handler working in the same place as you- at the same dining hall)?	2.16±1.14
Q11. If your co-worker does not wash his/her hands, what is the customer's risk of having a stomachache and/or vomiting (food poisoning) after consuming a meal prepared by him?	3.37±1.10
Q12. If your colleagues do not properly sanitise a utensil, what is the customer's risk of having a stomachache and/or vomiting (food poisoning) after consuming a meal prepared by him?	3.58±1.15
Q13. If your friends at other dining halls work while wearing earrings, jewellery, a watch or uncovered hair, what is the customer's risk of having a stomachache and/or vomiting (food poisoning) after consuming a meal prepared by him?	3.03±1.25

All statements in this table need to be paired with some statements in Table 2 to determine OB (as presented in Table 4)

Table 4. Paired independent t-test for risk perception (n=284)

Pair	Question†	Mean±SD	Mean difference±SD	*p*
1	Q1	1.771±1.006	-0.349±1.262	0.000*
	Q9	2.120±1.128		
2	Q1	1.771±1.006	-0.391±1.277	0.000*
	Q10	2.162±1.144		
3	Q3	3.088±1.276	-0.285±1.318	0.000*
	Q11	3.373±1.100		
4	Q7	3.761±1.235	0.176±0.896	0.001*
	Q12	3.585±1.148		
5	Q4	2.982±1.193	-0.053 (1.138)	0.435
	Q13	3.035±1.249		

*indicate a significant difference at p<0.05

†: The full statement for the respective question number can be found in Table 2 and 3

pair 4 (questions 7 and 12): 0.176, p=0.001. The p-values for each pair <0.05 indicate the existence of OB. However, no existence of OB was observed for pair 5 (questions 4 and 13): -0.052, p=0.435>0.05.

In addition, pair 2 was having larger mean value than pair 1 (Pair 2: -0.39085±1.277 > Pair 1: -0.34859±1.261). When a comparison is made with a known person, the individual is aware of and can evaluate the nature of his or her attitude, and this is different compared to other people even though both have similar characteristics. However, there were differences between pair 4 and 5, where pair 4 was smaller than pair 5. Pair 4 mean differences (Pair 4: 0.176±0.896 < Pair 5: 0.052±1.137). This result indicates that if the food handlers assess a known person rather than an unknown person under certain circumstances, then the rating is low, and they place a higher risk on the known person.

CONCLUSION

The findings of this study show that food handlers at the Malaysian military bases had good FS knowledge and practice in preventing FBD. Consumers perceived safety and hygiene of food as the most important attribute for their satisfaction, although many studies clarified that good FS knowledge does not guarantee good food handling practices and hygiene results. Hence, upholding the fact that food handling courses are a compulsory requirement for all food handlers in Malaysia, it is, therefore, a corporate way to increase knowledge on FS in preventing foodborne disease.

Lastly, this study's findings presented that food handlers' self-risk perception is always positive compared to their friends' understanding, and their perceptions also differ from known people and unknown people. Food handlers who are more likely to say they are better than their peers will then cause OB. OB occurs especially when the food handlers put judgements of themselves to other food handlers. Hence, OB is significantly good at assessing one's perceptions and risks. By knowing the level of perception respectively, the management will be able to determine what kind of training and courses to be provided to suit overall targets. In this way, continuous FS training, as well as suitable intervention programs, will help food handlers not to put judgement on others, hence reducing and preventing FBD from happening excessively.

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DECLARATION OF CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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Nutritional Values of *Artocarpus odoratissimus* (Terap) Fruit and its Antioxidant Capacity as Affected by Superheated-steam Treatment

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ABSTRACT

This study was carried out to evaluate the nutrient composition, Total Phenolic Content (TPC), Total Flavonoid Content (TFC) and antioxidant capacity of *Artocarpus odoratissimus* by using DPPH and FRAP assays. Results showed that nutrient compositions were quite similar to other reported studies. As for the antioxidant potential of the fruit, both the flesh and seed treated with Superheated-Steam (SHS) showed significantly higher TPC, TFC, 2,2-Diphenyl-1-picrylhydrazyl (DPPH) and Ferric Reducing Antioxidant Power (FRAP) (except the flesh showing no significant difference) values compared to the Freeze-Dried (FD) samples. The SHS-treated seed showed the highest values in all the assays conducted, exhibiting the superior antioxidant potential of the seed over the flesh. The seed also contained a higher composition of fat, protein, ash and carbohydrate than the flesh, while the flesh, on the other hand, showed higher moisture content and crude fibre compared to the seed ($p<0.05$). This study has demonstrated that SHS has the ability to enhance the polyphenolic compounds and antioxidant capacity of terap fruit.

Keywords: antioxidant capacity, *Artocarpus odoratissumus*, nutrient composition, superheated-steam treatment, terap

INTRODUCTION

Artocarpus odoratissimus or locally known as terap/tarap, is a popular seasonal fruit in Borneo. Belonging to the Moraceae family, it is native to Southeast Asia and is related to *A. integer* (cempedak), *A. altilis* (breadfruit) and *A. heterophyllus* (jackfruit). Its common name pingan (lban), pi-ien (Bidayuh), keiran (Kelabit), terap (Malaysia), marang (Sulu), madang (Lanao), loloi (Tagalog), and khanun sampal (Thailand) varies between different places. The fruit averaged about 16 cm in length, 13 cm in diameter and weighing about 1 kg. The fruit is round to oblong, regular and thickly studded with short, brittle, greenish-yellow spines. The fruit's skin is green and thick, similar to cempedak fruit, while the flesh is white, juicy and aromatic, attached to the central core where each segment contains a seed of 8 x 15 mm (Tang *et al.* 2013).

Among the Artocarpus, terap fruit is not widely exploited, especially on its phytochemical constituents. However, various parts of the plant have been studied, such as the flesh, seed, root and stem, to identify the approximate value of each part. It has been reported that terap fruit shows high antioxidant, phenolic and flavonoid content (Bakar *et al.* 2009). Peel shows the highest total phenolic content, followed by the seed and flesh (Bakar *et al.* 2015). According to Nyokat *et al.* (2017), terap fruit is rich in phenolic compounds, including flavonoids, stilbenoids and arylbenzofurons. However, very limited studies are available on the effect of treatments on this fruit, particularly superheated-steam application in the drying process.

Superheated-Steam (SHS) is a steam at a temperature higher than its vaporisation (boiling) point at the absolute pressure where the temperature is measured (Alfy *et al.* 2016). It is a drying method with high heat transfer capability, produces condensation heat when in contact with the food, provides no oxygen environment and can be obtained under normal pressure. It also can improve product quality, such as low shrinkage, high porosity and vitamin C retention (Abdulhameed *et al.* 2014). The potential of superheated-steam application in fruit has

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been presented, where superheated-steam dried avocado shows a significant increase in its polyphenolic content and antioxidant capacity (Husen *et al.* 2014). It also has been reported that the radical scavenging activity in black cumin seed was improved with increased exposure to superheated-steam (Liang *et al.* 2018). To date, there is no study reported on the effect of superheated-steam treatment on the antioxidant properties of terap fruit. In this study, the effect of superheated-steam treatment on the polyphenolic compound and antioxidant capacity of terap flesh and seed was evaluated and compared with their freeze-dried counterparts, which is a drying technique that has the ability to retain nutrients and the quality of food products and is generally recommended to dry samples with heat-sensitive compounds, especially antioxidants. The nutritional composition of this fruit was also measured in this study.

METHODS

Design, location, and time

Terap fruit sample was subjected to superheated-steam drying as a pre-treatment prior to freeze-drying, while another group was directly subjected to freeze-drying. Proximate analysis (moisture, carbohydrate, protein, fat, fibre, ash and minerals) and chemical analysis (TPC, TFC, DPPH and FRAP) were then performed on both groups. Superheated-steam drying was done at the Biomass Technology Centre at Universiti Putra Malaysia, Serdang, Selangor. All experimental works were conducted in the laboratories at the Faculty of Applied Sciences, Universiti Teknologi MARA. The study started in 2016 and was completed in 2017.

Material and tools

Chemical and reagents. Aluminium chloride hexahydrate, sodium acetate trihydrate, acetic acid, petroleum ether, Trolox, gallic acid and rutin standards, and DPPH (2,2-diphenyl-2-picrylhydrazyl) were purchased from Sigma-Aldrich, Germany. Ninety percent (95%) ethanol was purchased from Merck, Germany. Hydrogen peroxide, sulphuric acid, nitric acid, boric acid, hydrochloric acid, acetone and Folin-Ciocalteu reagent were purchased from R & M Chemicals, United Kingdom. Sodium carbonate was purchased from Ajax, New Zealand. TPTZ (2,4,6-tripyridyl-s-triazine) were purchased from Fluka, Germany. Ferric chloride hexahydrate and hexane were purchased from HmbG GmbH, Denmark.

Procedures

Physical characteristics of fruit samples. Six terap fruits were obtained from Kuching, Sarawak, Malaysia, at their ripe stage. The diameter, height, width (mm) and weight (g) of all the fruits were measured.

Drying method. The fruits were cleaned and separated into flesh and seed. The flesh and seed samples were divided into two groups. The drying method was conducted according to Husen *et al.* (2014) with slight modifications. One group was subjected to SHS treatment using a SHS oven (DC Quto QF-5200C, Naomoto, Japan) at 170°C for 30 minutes, followed by lyophilisation for two weeks at -60°C by using a freeze dryer (Alpha 1-4 LD plus, Martin Christ, Germany), while the other group was freeze-dried (control). Both groups of flesh and seed were then finely ground, sieved, sealed in a normal polypropylene plastic bag and kept at -30°C until further analysis.

Extraction. Referring to the method by Shaharuddin (2021) with slight modification, 50 g and 20 g of flesh and seed samples respectively were extracted with 70% ethanol in a 1:10 wt/vol ratio. The sample was then incubated in the incubator shaker (Innova 40, Eppendorf, Germany) for 2 hours at 200 rpm at 27°C. The sample was filtered using Whatman filter paper No.1 and evaporated under vacuum at 27°C for 2–3 hours using Rotavapor (RE21, Büchi, Switzerland). The liquid extract was then lyophilised at -60°C in a freeze dryer. The dried extracts were sealed in an airtight plastic container and kept at -30°C until further analysis.

Nutritional properties. The proximate composition of terap fruit, including carbohydrate, protein, fat, moisture, ash and crude fibre, was determined according to the AOAC method (AOAC 2012). Mineral contents were determined using a method by Kumaravel and Alagusundaram (2014) with slight modification using an Atomic Absorption Spectrophotometer (Shimadzu AA-7000, Japan).

Total Phenolic Content (TPC). Total phenolic content was measured by using Folin-Ciocalteu reagent as described by Othman *et al.* (2016). Two hundred microliter (200

µL) extracts were mixed with 1,500 µL Folin-Ciocalteu reagent (diluted 10-fold with distilled water). The mixture was vortexed for 15 seconds and allowed to stand at room temperature for 5 minutes. 1,500 µL 0.56 M sodium carbonate solution was added and left to stand for another 90 minutes. The absorbance was measured using a UV-Vis Thermo Spectrophotometer (Thermo Scientific, Thermo Fisher Scientific, USA) at 725 nm. The result was expressed as mg gallic acid equivalent (GAE) per 1 g edible portion.

Total Flavonoid Content (TFC). Total flavonoid content was measured using the colourimetric method as described by Djeridane *et al.* (2006). 1 ml of sample extract was mixed with 1 ml of 2% aluminium chloride solution and allowed to stand at room temperature for 15 mins. The absorbance was then measured using a UV-Vis Thermo Spectrophotometer at 430 nm. The result was expressed as mg rutin equivalent (RE) per 1 g edible portion.

DPPH Radical Scavenging Activity. The extract's scavenging activity was estimated using 1,1-diphenyl-2-pycrylhydrazyl (DPPH) as described by Othman *et al.* (2016). 1 ml of extract (or ascorbic acid) was mixed with 2 mL 0.15 mM DPPH and allowed to stand for 30 mins at room temperature in the dark. After the incubation period, the absorbance was measured at 517 nm using a UV-Vis Thermo Spectrophotometer. Antioxidant activity was expressed as the percentage of scavenging activity, calculated below:

Percentage of scavenging activity (%) =

$$\frac{(A_{control} - A_{sample/standard})}{A_{control}} \times 100$$

Ferric Reducing Antioxidant Power (FRAP). FRAP was measured as described by Tang *et al.* (2013). FRAP solution was freshly prepared using 300 mM acetate buffer, 30 mM Tris(2-pyridyl)-s-Triazine (TPTZ) solution in 40 mM HCl, 30 mM ferric chloride hexahydrate with a 10:1:1 ratio. It was then incubated at 37°C for 10 minutes in an incubator shaker. 100 µL extract was mixed with 8.9 ml FRAP solution and allowed to react for 1 hour in the dark. Absorbance was measured at 593 nm using a UV-Vis Thermo Spectrophotometer. The result was expressed as mg Trolox Equivalent (TE) per 1 g edible portion.

Data analysis

All experiments were carried out in triplicates. Results were presented as mean±SD (Standard Deviation). Statistical analysis was done using analysis of variance (ANOVA), SPSS version 23 (SPSS Inc., Chicago, Illinois, USA). A significant difference between means was defined as $p<0.05$.

RESULTS AND DISCUSSION

Physical characteristics of terap fruit

Terap fruit is an underutilized fruit which is well known among the local people in the region but not widely known or consumed outside of the area. The physical measurement of the fruits can give a better idea of the fruit size, especially to those who are not familiar with the fruit. In this study, the diameter, height, width and weight were given in Table 1. Tang *et al.* (2013) also reported that the weight of terap fruit is around 0.5–1 kg depending on its size.

As given in Table 2, the moisture content of terap flesh was 72.65%, while the seed was 38.17%. These values were within the range reported by Tang *et al.* (2013), where the flesh and seed were between 67.9–73.4% and 31.0–55.0%, respectively on a wet basis. Terap flesh also showed moisture content which was within the range of the moisture content found in *A. integer* (chempedak), *A. altilis* (breadfruit), and *A. heterophyllus* (jackfruit) (67–83%) (Tang *et al.* 2013).

Fat is very important in a diet, and it helps to promote the absorption of fat-soluble vitamins. Fat content in the flesh and seed of terap was 0.36% and 3.54%, respectively. However, this value was lower compared to previously reported, which are 10.1%–28.1% (Tang *et al.* 2013) and 15.60% (Noorfarahzilah *et al.* 2017), but higher than unripe terap flour (1.89%) (Masri *et al.* 2012).

Table 1. Physical characteristics of terap fruit

Parameter	Values
Weight (g)	868.70–1402
Diameter (mm)	380–700
Height (mm)	185–250
Width (mm)	150–160

n=6

Table 2. Nutrient composition of terap fruit

	Flesh	Seed
Moisture (%)	72.65±0.43	38.17±0.47
Fat (%)	0.36±0.02	3.54±0.29
Protein (%)	0.39±0.01	7.49±0.13
Carbohydrate (%)	26.25±0.48	50.29±0.81
Ash (%)	0.34±0.03	0.50±0.00
Crude fibre (%)	1.08±0.01	0.33±0.01
Na (mg/100 g)	12.93±6.70	N/A
Ca (mg/100 g)	21.91±3.99	N/A
Mg (mg/100 g)	39.41±1.01	N/A
Zn (mg/100 g)	1.15±0.07	N/A
Fe (mg/100 g)	1.31±0.19	N/A
Cu (mg/100 g)	0.3±0.08	N/A

Data expressed as mean±SD
N/A: Data not available

Protein plays a part in food's organoleptic properties and is a source of amino acids. The protein content of terap fruit was found to be high in the seed (7.49%) and low in the flesh (0.39%). This was in agreement with Tang *et al.* (2013), where lower protein content in the flesh is 1.2–1.5% and higher in the seed at 5.1–6.6%. The protein content in the seed measured in this study was slightly lower than previously reported by Noorfarahzilah *et al.* (2017) on terap seed flour, with a value of 8.78%. The stage of maturity and growing environment commonly affect the protein content in the fruit (Noorfarahzilah *et al.* 2017). In pineapple (*Ananas comosis)* for example, total protein content increases with the increase in the days of maturity stage, while in sweet pepper (*Capsicum annuum* L.) seeds show an increase in albumin, globulin and prolamins content as a function of the fruit maturation stage (Sabahelkhier *et al.* 2010; Colombari *et al.* 2022).

Ash represents the total mineral content in food. In this study, the ash content in the seed (0.50%) was slightly higher than in the flesh (0.34%). This result was lower compared with Tang *et al.* (2013), which shows that ash content for seed and flesh are in the range of 1.0–1.5% and 0.6–0.8%, respectively. The ash content in the seed is higher than in the flesh could be due to the seeds having higher concentrations of minerals than flesh because they are the reproductive organs and therefore need more nutrients for germination and growth. Terap has less ash content compared to other Artocarpus, where *A. heterophyllus* (jackfruit) and *A. integer* (chempedak) showed 2.2% and 1.2% of ash content respectively in their flesh (Morton 1987). Nevertheless, terap flour possessed higher ash content with a value of 2.84% (Masri *et al.* 2012) and 1.17% for terap seed flour (Noorfarahzilah *et al.* 2017).

Total carbohydrate content includes fibre and other components such as organic acids. Energy from fruits comes mainly from carbohydrates. In this study, total carbohydrates in the flesh and seed were 26.25% and 50.29% respectively. The carbohydrate content in the flesh reported by Tang *et al.* (2013) is lower than this study (12.0–25.2%,) while in the seed, the carbohydrate content was similar with terap seed flour (49.65%) (Noorfarahzilah *et al.* 2017).

Crude fibre helps maintain normal peristaltic movement of the intestinal tract. A diet containing high fibre is important to prevent constipation, which in turn could be helpful in order to prevent other chronic diseases. As reported by Tang *et al.* (2013), the fibre content in the flesh and seed of terap is 2.8–4.2% and 5.5–10.0% respectively. The seed flour contains 12.30% crude fibre (Noorfarahzilah *et al.* 2017), and terap flour contains 2.65% crude fibre (Masri *et al.* 2012). In this study however, the crude fibre content in terap fruit was found to be lower, which was 1.08% and 0.33% in the flesh and seed, respectively. Generally, seeds have higher fibre content than flesh due to the higher content of complex carbohydrates that are resistant to digestion, such as cellulose, hemicellulose, and lignin. These substances provide structural support and protection for the seeds, as well as a source of energy and nutrients for germination and seedling growth (Oso & Ashafa 2021).

Potassium was found to be the most abundant mineral in terap flesh (Masri *et al.* 2012; Tang *et al.* 2013; Noorfarahzilah *et al.* 2017), where Tang *et al.* (2013) shows 176–298 mg/100 g potassium content. The mineral content of terap flesh in this study is given in Table 2. In this study, magnesium gave the highest value (39.41 mg/100 g), followed by calcium (21.91 mg/100 g) and sodium (12.93 mg/100 g). Tang *et al.* (2013) reported lower magnesium, calcium and sodium content (15–31 mg/100 g, 0.5–1.4

mg/100 g and 1.1–1.7 mg/100 g respectively). Iron (1.31 mg/100 g) and zinc (1.15 mg/100 g) measured in this study were also higher than the reported values (0.3–0.5 mg/100 g and 0.17–0.45 mg/100 g for iron and zinc respectively) (Tang *et al.* 2013). Among all the minerals analysed, copper content was the lowest (0.3 mg/100 g), which gave a similar value as previously reported (Tang *et al.* 2013). No lead was found in both the flesh and seed of the fruit. Hence, it is safe for consumption (Tang *et al.* 2013).

Antioxidant properties

Total Phenolic Content (TPC). Table 3 shows the result of the TPC of terap flesh and seed dried with superheated steam treatment and freeze-drying. SHS-treated terap seed gave the highest TPC at 4.69 mgGAE/g, which was significantly higher than the FD seed (4.10 mgGAE/g). For the flesh, TPC values were significantly lower than the seed, with the SHS-treated sample being significantly higher (0.72 mgGAE/g) than the FD counterpart (0.65 mgGAE/g).

This increase in TPC was possibly due to the matrix liberation of phenolic compounds and/or inactivation of polyphenol oxidase during the superheated steam treatment process. According to Tomás-Barberán and Espín (2001), fruit subjected to stress conditions may increase the level of phenolic compounds. Stress conditions include UV radiation, infection by pathogens and parasites, wounding, air pollution, and exposure to extreme temperatures. Therefore, SHS might cause structure damage to fruit cells, resulting in increased liberation of phenolic compounds from the flesh and seed of the terap samples. A study by Bakar *et al.* (2009) reported that the seed contained higher TPC than the flesh, with values of 14.67 mgGAE/g and 4.39 mgGAE/g respectively. Another part of terap fruit, the peel, shows even higher phenolic content (42.38 mgGAE/g) (Bakar *et al.* 2015). TPC of terap fruit seed is lower when compared to A. heterophyllus (jackfruit) at 27.7 mgGAE/g (Soong & Barlow 2004). According to Soong and Barlow (2004), gallic acid, ellagic acid, coumarin, cinnamic acid, ferulic acid and caffeic acid might contribute to the total phenolic acid in the seed. Phenolic compounds found in the seed are responsible during seed germination to act as antioxidants to avoid internal damage.

Total Flavonoid Content (TFC). The total flavonoid content in terap seed was also higher compared to the flesh (Table 3). Similar to the TPC result, TFC in SHS-treated seed and flesh were significantly higher (2.12 mgRE/g and 0.43 mgRE/g respectively) compared to their FD counterparts (1.10 mgRE/ g and 0.28 mgRE/g respectively). Bakar *et al.* (2009) also showed higher TFC in terap seed (3.65 mgRE/g) compared to the flesh (1.08 mgRE/g) ($p<0.05$). Flavonoids are found at high levels in most plant seeds as they offer vital roles in defence against pathogens and predators and contribute to physiological functions such as seed maturation and dormancy (Shirley 1998).

Flavonoids are the most common and extensively distributed group of plant phenolic compounds. They are ubiquitously present in fruits and vegetables. Flavonoids have high pharmacological activities as radical scavengers, making them essential for human health to avoid oxidation (Baliga *et al.* 2011). A. odoratissimus consists of artosimmin, a phytochemical compound derived from the flavonoid group. It displays cytotoxicity activity against breast cancer and promyelocytic leukaemia (CL kEe *et al.* 2010).

Table 3. Total phenolic content, total flavonoid content and antioxidant activity of terap fruit

Sample	TPC (mgRE/ g)	TFC (mgGAE/ g)	Antioxidant activity	
			DPPH (%)	FRAP (mgTE/ g)
Flesh Superheated-Steam (SHS)	0.72±0.00[a]	0.43±0.01[a]	11.24±0.37[a]	1.55±0.01[a]
Flesh Freeze-Dried (FD)	0.65±0.00[b]	0.28±0.00[b]	8.46±0.28[b]	1.60±0.08[a]
Seed Superheated-Steam (SHS)	4.69±0.00[a]	2.12±0.01[a]	90.52±0.15[a]	129.81±1.95[a]
Seed Freeze-Dried (FD)	4.10±0.00[b]	1.10±0.00[b]	89.19±0.16[b]	59.75±1.27[b]

DPPH: 2,2-Diphenyl-1-picrylhydrazyl; FRAP: Ferric Reducing Antioxidant Power

Results expressed as mean±S.D; (n=3); Different letters in the same group indicate a significant difference ($p<0.05$)

Polyphenols and flavonoids are powerful free radical scavengers. Phenolic compounds generally occur as soluble conjugated and insoluble forms, while flavonoids present as glycosides with single or multiple sugar molecules linked through an OH group (O-glycoside) or Carbon-Carbon Bond (C-glycoside) (Acosta-Estrada *et al.* 2014). Phenolic phytochemicals are a group of compounds that play an important role in determining antioxidant properties in plants (Minatel *et al.* 2017).

DPPH radical scavenging activity. DPPH radical scavenging activity is a method to measure antioxidant activity in food and has a broad absorption band in the visible region at 517 nm. It is protonated by an antiradical compound by losing this property (Scalzo 2008). In this study, the highest percentage of scavenging activity was observed in the SHS-treated seed, followed by the FD seed, SHS-treated flesh and FD flesh, with values of 90.52%, 89.19%, 11.24% and 8.46% respectively (Table 3). Similar to the previously described results on TPC and TFC, higher radical scavenging activity was observed in the seed than in the flesh. Bakar *et al.* (2009) also reported that the seed of terap fruit contains higher scavenging activity (13.69 mgAEAC/g) compared to the flesh (2.44 mgAEAC/g). The radical scavenging activity was also significantly higher when SHS treatment was applied in both seed and flesh. The SHS may have caused the inactivation of oxidative enzymes and contributed to better preservation of phenolic compounds which can increase antioxidant activity (Samoticha *et al.* 2016).

Ferric Reducing Antioxidant Power (FRAP). FRAP assay was also performed to determine the antioxidant capacity of the samples. It measures the ability of phytochemicals to reduce ferric ions (Fe^{3+}) to ferrous ions (Fe^{2+}) through electron donation (Benzie & Strain 1996). The result also showed that terap seed gave significantly higher FRAP values than flesh (Table 3). When treated with SHS, the antioxidant activity doubled in the treated seed, at 129.81 mgTE/g, significantly higher than the FD sample (59.75 mgTE/g). The flesh, however, showed no significant difference when treated with superheated steam.

Fruits and vegetables have higher biological activities due to chemical changes during heat treatment (Dewanto *et al.* 2002). The effect of the high temperature of SHS might be one cause for the significant increase in antioxidant activity (Husen *et al.* 2014). Citrus pomace extract treated with SHS at 300˚C exhibited higher scavenging activity with IC_{50} values ranging from 0.13 to 0.20 mg/mL (Wang *et al.* 2018), while black cumin seed treated with SHS for 30 min resulted in higher scavenging activity compared with conventional hot air drying (Liang *et al.* 2018). It was thought that any materials treated with high temperatures would most likely lose their antioxidant activity. However, this is not necessarily the case, as shown by the application of SHS in food processing. SHS process has the advantage of heating at high temperatures within a short period of time. The steam temperature of SHS is over its boiling point at an absolute pressure in a closed system that may cause strong penetrability and solvency, which effectively enrich the antioxidant without destroying relevant compounds in a short period of time (Wang *et al.* 2018). Moreover, SHS can enhance the amount of phenolic and flavonoid compounds compared to FD. SHS works in the absence of oxygen, where steam is generated and is given additional heat to raise its temperature above the saturation temperature under normal pressure. Therefore, because of the absence of oxygen in the SHS system, there is less oxidation and, in turn, higher antioxidant properties in both samples. Research has shown that SHS-heated food retains antioxidants, vitamins, and other essential nutrients due to the absence of oxygen (Pronyk *et al.* 2004).

Relationship between antioxidant compounds and antioxidant activities in terap fruit. The correlation between antioxidant compounds and antioxidant activities of terap fruit was also evaluated. TPC gave a strong positive correlation ($p<0.01$) with both DPPH and FRAP antioxidant activities, with r2 values at 0.953 and 0.960, respectively. TFC on the other hand, only showed a strong positive correlation with FRAP with r^2 at 0.970. These strong positive correlations indicated that antioxidant activities in terap fruit were attributed to the presence of both phenolic and flavonoid compounds in the fruit.

CONCLUSION

Terap is a nutritious fruit which can provide a certain amount of both macro and

micronutrients. Terap fruit dried using SHS exhibited significantly higher TPC, TFC, DPPH and FRAP values than that of freeze dried. Generally, food materials processed at high temperatures are likely to lose their nutrients and antioxidant properties. However, the application of SHS in this study has demonstrated its advantage over freeze-drying as a method which can be applied in food processing due to its ability to enhance the antioxidant capacity. Furthermore, a significant increase especially shown in the seed of terap fruit treated with SHS shows the potential of this fruit to be developed into functional food products such as seed flour and powders. For future studies, it is recommended that terap fruit seed be used to develop food or functional food products.

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DECLARATION OF CONFLICT OF INTERESTS

The authors have no conflict of interest.

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Physicochemical and Functional Properties of Bario Rice Varieties as Potential Gluten-Free Food Ingredients

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ABSTRACT

This study aimed to analyse the proximate composition, physical characteristics, and functional attributes of flour of four selected varieties of Bario rice (*Oryza sativa* L. Opaceae.): Bario Adan, Bario Padan, Bario Hitam, and Bario Kulit Merah. The rice flour was prepared using a semi-wet grinding method. The results on proximate composition showed that the moisture content ranged from 12.56% to 13.87%. All flours were high in crude fibre and low in fat content ranged 23.07 to 25.30% and 2.46 to 2.69%, respectively. Bario Padan exhibited the highest amount of crude fibre and protein ($p<0.05$). There were significant differences ($p<0.05$) observed for L, a*, and b* values, Bario Hitam shows the lowest L* (5.29) and b* (4.96) value ($p<0.05$). The functional properties among flour variety differ significantly ($p<0.05$) with a range of 1.160 to 1.257 g/g for water absorption capacity and oil holding capacity ranged from 0.970 to 1.158 g/g. Highest swelling power was obtained in Bario Adan (5.594 g/g) while Bario Padan possessed highest water solubility index (0.099%). In conclusion, Bario rice varieties showcased favourable nutritional and functional traits, indicating their potential as gluten-free ingredients in the formulation of food products.

Keywords: bario rice, functional properties, proximate

INTRODUCTION

Gluten-related disorders, such as celiac disease, are increasing globally. Celiac disease impacts around 0.5% to 1% of the world's population (Hosseini *et al.* 2018). Gluten-free diets are the primary treatment for celiac disease, sparking interest from researchers and consumers. Rice flour has become a popular gluten-free alternative to wheat flour due to its availability, neutral effectiveness, hypoallergenic properties, neutral taste, and minimal impact on final products (Ronie *et al.* 2022; Burešová *et al.* 2023).

Rice (*Oryza sativa* L.) is the second most important crop after wheat, and Asia takes up to 90.6% of the consumer region, making it the world's largest producer and consumer (Rajamoorthy *et al.* 2015). Indigenous crops of Malaysia hold significant promise for the future, playing a vital role in ensuring both food security and health. Research indicate that the composition and properties of rice vary based on variety and location of rice production (Abera *et al.* 2021). Among the local potential crops are the Bario rice varieties. According to Khazanah Research Institute (2018), these rice varieties, known for their fine and elongated grains, gentle and pleasant fragrance, and exceptional flavour. Bario rice is primarily grown in the Bario highland of Sarawak, cultivated by the local ethnic community using traditional methods and without artificial fertilisers (Thomas *et al.* 2014a). Bario Adan, Bario Padan, Bario Kulit Merah, Bario Merah, and Bario Hitam are notable varieties of Bario rice. Bario Adan, Bario Padan, and Bario Kulit Merah are white rice with 10–18% amylose content, while Bario Merah and Bario Hitam are pigmented rice with red and black bran layers, respectively (Nicholas *et al.* 2014). The diverse attributes of Bario rice offer valuable benefits for future use.

Currently, there is limited new scientific research regarding the nutritional value and functional properties of these cultivars. Therefore, the objective of this paper is to determine the physicochemical and functional properties of four different types of Bario rice. Additionally, it is envisaged that the results generated from this study will be useful to popularise these exotic rice varieties as an alternative for gluten-free ingredients for better marketability at international levels.

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METHODS

Design, location, and time

The research was conducted in the Food Analysis Laboratory, Faculty of Applied Sciences, Universiti Teknologi MARA and Paddy and Rice Research Centre, Malaysian Agricultural Research and Development Institute, Selangor, Malaysia. The study was carried out from November 2022 to June 2023.

Material and tools

Bario Adan, Bario Padan, Bario Kulit Merah, and Bario Hitam were obtained from local farmers in Pa' Dalih, Bario, Sarawak. These rice varieties were harvested at the ripening stage. The paddy was dried until it reached below 14% of moisture content and dehulled using Satake Rice Machine THUS35B (Satake Engineering Co. Ltd, Japan).

The tools used in this study were a Kjedahl digestion and distillation unit (C. Gerhardt GmbH & Co. KG, Germany), Soxhlet extractor unit (Favorit S.p.A Hamelin Group, Italy), water bath, muffle furnace, drying oven, tabletop centrifuge, and colour spectrophotometer. Kjedahl selenium catalyst tablets, boric acid, sulphuric acid, sodium hydroxide, phenolphthalein, and petroleum ether used in this research were analytical grade.

Procedures

Semi-wet grinding of rice grains. The rice samples were grounded through the application of a semi-wet grinding method, which was adapted from Asmeda *et al.* (2016). The rice grains were soaked in water for 8 hr at a 1:1 rice-to-water ratio (w/v). Then, the excess water was drained, and the rice grains were allowed to dry at 30°C for removal of surface moisture before being ground using the multifunctional grinder (Ormismart Multifunctional Grinder Machine, ALX Sdn.Bhd, Malaysia).

Proximate analysis. The proximate composition includes total carbohydrates, moisture, protein, crude fat, crude fibre, and ash. Moisture, ash, and crude fibre were determined using standard AOAC methods (AOAC 2000). According to AOAC International (2000), the determination of total carbohydrates in foods can be performed using the enzymatic gravimetric method (Method 985.29).

Colour analysis. The colour profile of the rice was assessed using Chromameter (CR400, Konica Minolta, Japan). A 5g of rice flour sample was placed in a petri dish and pressed firmly to ensure complete coverage of the dish's bottom surface. The colour profiles were represented by L*, a*, and b* values. The L* value corresponds to the brightness level (L=100) or darkness level (L=0), the a* value signifies the presence of redness (+a) or greenness (−a), and the b* value indicates the presence of yellowness (+b) or blueness (−b).

Bulk density. A 5 g sample was filled into a 10 mL graduated cylinder and their weight was noted. The cylinder was tapped continuously until there was no further change in volume. The weight and final volume of the starch in the cylinder were noted, and the difference in weight and volume was determined. Bulk density was calculated as gram per millilitre (g/mL).

Functional properties analysis. Water and oil absorption, swelling capacity, and water solubility index were determined according to Ronie *et al.* (2022) and Falade *et al.* (2014) with slight modifications.

Approximately 1.00±0.02 g of the sample was weighed and recorded as w_0. The sample was then placed into a 15 mL centrifugal tube and re-weighed, recorded as w_1. Subsequently, 10 mL of distilled water or refined oil was introduced into the centrifugal tube. The mixtures were vortexed for 30 seconds at 5-mins intervals over a 30 mins period at room temperature. Following this, centrifugation was performed for 10 mins at 2,000 rpm. The resulting supernatant was weighed and recorded as w_2. The quantity of water or oil absorbed by the flour was calculated as the difference and presented as the weight of water absorbed by 100 g of dry flour. Water and oil absorption capacity was calculated as below:

$$\textbf{Water / Oil absorption capacity} = (w_2 - w_1) / w_0$$

For swelling properties, 1 g (w_1) of the rice flour sample was initially moistened with 30 mL of distilled water in a centrifuge tube. Subsequently, the tubes containing the sample were subjected to continuous shaking and heat at 80°C in the water bath. Following the cooling phase, the samples underwent centrifugation at 2,200 rpm for 15 mins. The supernatant was then removed from the centrifuge tube, and the residue weight was recorded (w_2). The swelling capacity (g/g) was determined using below equation:

Swelling power (g/g)=w_2 / w_1

The supernatant obtained after the swelling power procedure was employed to assess the rice flour's water solubility index. Initially, the empty crucibles were weighed and noted as w_4. Subsequently, the supernatant was cautiously transferred into the pre-weighed crucible. Following this, the supernatant was subjected to oven drying at 105°C for an overnight period. On a subsequent day, the desiccated supernatant was cooled to room temperature within a desiccator and then weighed as w_3. The water solubility index was calculated using below equation:

Water solubility index, %=((w_3 – w_4) / w_1) x 100

Data analysis

All experimental data were performed in triplicate and analysed using IBM SPSS Statistics Version 28.0 (SPSS Inc., Chicago, USA) in a completely randomised study design. All experimental values were presented as mean±standard deviation (mean±SD). In general, a one-way analysis of variance (ANOVA) was employed to determine the significant differences in data among the experimental units. Duncan's Multiple Range test was utilised for multiple comparisons. Statistical significance was established at $p<0.05$.

RESULTS AND DISCUSSION

Table 1 outlines the physicochemical properties of rice flour, showing variability in proximate composition due to factors like rice variety, growth conditions, and post harvest procedures. Notably, Bario Kulit Merah stood out with the highest carbohydrate concentration, accounting for 52.75%. It is observed that there is a significant difference ($p<0.05$) in carbohydrate levels between Bario Kulit Merah and Bario Padan (48.77%). According to prior research by Oppong *et al.* (2021), brown rice typically features a lower carbohydrate content compared to white rice. This discrepancy can be attributed to the fact that brown rice encompasses the bran and germ, which are the most nutrient-rich segments of the grain. Consequently, brown rice boasts a more comprehensive nutritional profile than its white counterpart, encompassing attributes such as fibre, magnesium, and a spectrum of other vital nutrients (Oppong *et al.* 2021; Ronie *et al.* 2022; Nicholas *et al.* 2014).

The moisture content of rice flour in the current study falls within the range of 12.56% to 13.87%, consistent with findings by Nicholas *et al*. (2014) for Bario cultivars. As outlined by the United States Department of Agriculture (USDA) Foreign Agricultural Service (2017),

Table 1. Physicochemical composition of Bario Rice

Parameter	Variety			
	B.Adan	B.Padan	B.Kulit Merah	B.Hitam
Proximate composition (%)				
Carbohydrate	51.00±0.73^{b}	48.77±0.96^{c}	52.75±0.74^{a}	50.16±0.10^{b}
Moisture	13.87±0.17^{a}	13.16±0.05^{ab}	12.56±0.62^{b}	13.58±0.58^{a}
Protein	7.46±0.08^{c}	9.68±0.25^{a}	7.58±0.27^{c}	8.65±0.30^{b}
Crude fat	2.56±0.08^{ab}	2.46±0.20^{ab}	2.69±0.04^{a}	2.26±0.32^{b}
Crude fiber	23.90±0.60^{b}	25.30±0.50^{a}	23.10±0.55^{b}	24.00±0.50^{b}
Ash	1.20±0.04^{a}	0.64±0.18^{b}	1.35±0.03^{a}	1.36±0.03^{a}
Physical properties colour				
L*	82.76±0.13^{b}	84.20±0.11^{a}	80.85±0.09^{c}	60.47±0.30^{d}
a*	1.75±0.10^{b}	1.30±0.03^{c}	1.79±0.05^{b}	5.29±0.04^{a}
b*	12.22±0.17^{b}	11.74±0.08^{c}	12.62±0.07^{a}	4.96±0.05^{d}
Bulk density (g/mL)	0.81±0.00^{b}	0.83±0.01^{a}	0.81±0.00^{b}	0.84±0.01^{a}

Data is expressed as means±standard deviations (n=3)

Means carrying different alphabets in a row differ significantly ($p<0.05$)

rice flour production standards indicate that the moisture content of rice can fall within the range of over 10% and under 15%. In general, moisture content below 14% is considered optimal for extended storage, particularly when dealing with cereals and cereal products (Hamel *et al.* 2020). Maintaining a moisture level below 14% serves to mitigate the risk of insect infestation and the proliferation of microorganisms, both of which can lead to a decrease in the shelf life of food products (Nicholas *et al.* 2013).

The protein content in all the Bario varieties was in the range of the average value of protein in unmilled rice (Juliano & Tuaño 2019), except in Bario Padan and Bario Hitam. Notably, the protein content in question meets the criteria to be classified as a noteworthy protein source, exceeding 5 g per 100 g, as stipulated by the Nutrient Reference Value in the 18C Act, Table II of the Food Regulations 1985 (MOH 2023). The highest crude protein content was 9.68% in Bario Padan, followed by Bario Hitam (8.65%). Ronie *et al.* (2022) investigated that milled Bario rice flour's protein content was between 6% to 9%. On the contrary, Nicholas *et al.* (2014) reported that the protein content of milled Bario rice flour ranges from 5.85% to 7.30%. Variations in crude protein content are primarily attributed to external factors, encompassing environmental parameters and storage conditions. Incorporating high-protein rice flour into food development endeavours can yield benefits by diminishing carbohydrate content, consequently reducing the glycaemic load during the absorption and digestion processes within the human body.

The fat content of Bario rice variaties ranged from 2.26% to 2.69%. This contrasts with findings by Ronie *et al.* (2022) suggesting that black-pigmented rice typically has higher fat content. The rationale behind this phenomenon lies in the outer bran layer, which is known to contain around 20% lipids or fats on a dry basis (Rathna Priya *et al.* 2019). The fat composition can exhibit slight variations depending on factors like specific rice variety, growth conditions, and processing techniques, including the presence of oils within the bran layer and the extent to which the bran layer is retained during processing (Ronie *et al.* 2022).

The crude fibre content exhibited variation from 23.07% to 25.30%, with Bario Padan having the highest amount and Bario Kulit Merah the lowest. The quantity of crude fibre in brown rice. Brown rice generally contains 1 to 3 g more fibre per cup than white rice, signifying its high dietary fibre content. While previous research (Ronie *et al.* 2022; Nicholas *et al.* 2014) reported the crude fibre content of polished Bario rice ranging from 0.21% to 2.05%, this study reveals that unmilled Bario rice possesses more than tenfold the amount of crude fibre, ranging from 23.07% to 25.30%, potentially du e to the bran fraction retained on unmilled rice (Nicholas *et al.* 2014; Ronnie *et al.* 2022).

According to the Food Regulation of Malaysia 1985, the ash content shall not yield more than 1.5%. Bario Padan has significantly lower ash content (0.637%) and conversely, Bario Hitam has higher ash content compared to other Bario rice varieties ($p>0.05$). These results are consistent with findings by Oppong *et al.* (2021) indicating higher ash content in pigmented rice flour compared to white rice flour. The ash concentration in different rice flours is dependent on the chemical composition within the bran layers of the caryopsis, and variations within commodities are further shaped by agricultural factors like soil and irrigation sources.

Food colour enhances visual appeal, influencing consumer preference (Phimolsiripol *et al.* 2012; Popov-Raljić *et al.* 2013). The degree of brightness of rice varieties in this study spans from 60.743 to 84.203 (Table 1). Among these, Bario Padan stands out with the highest brightness, followed by Bario Adan and Bario Kulit Merah. These varieties exhibit elevated L* values owing to their pristine white appearance (Figure 1). Conversely, Bario Hitam rice flour had the lowest L* values, attributable to the purple-hued outer layers of its rice grains. A positive a* value represents redness, whereas a positive b* value represents yellowness. The a* and b* values ranged between 1.303 and 5.290 and between 4.96 and 12.62, respectively. The a* values, with all measurements above zero, confirmed that the red tone dominates over the green in the rice flour. Additionally, the positive a* value for Bario Hitam was significantly high ($p<0.01$) compared to the other varieties due to the colour pigmentation of the rice bran. On the other hand, the b* value was significantly high ($p<0.01$) in Bario Kulit Merah. The colour characteristics of rice flour samples are linked to the pigments found in the rice bran (Loan *et al.* 2022). Rice

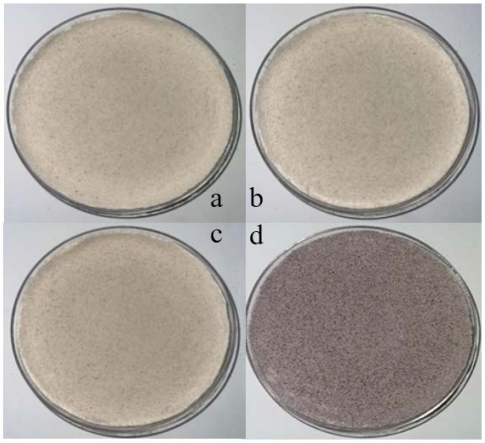

Figure 1. Colour diversity of Bario rice flour: (a) Bario Adan; (b) Bario Padan; (c) Bario Kulit Merah; (d) Bario Hitam

grains with a brownish-red pigment are termed red rice and are characterized by the presence of proanthocyanidins or condensed tannins, whereas purple pigmentation is identified as black rice is known for containing anthocyanins (Limtrakul *et al.* 2019).

The bulk densities of the rice flours ranged from 0.81 g/mL to 0.84 g/mL. Bulk density plays a crucial role in determining compressibility and cohesiveness, thereby preventing the formation of air gaps. The composition and particle size of flour are commonly recognised as influential factors impacting bulk density (Nkurikiye *et al.* 2023). Notably, both starch and fat contents display a positive correlation with the bulk density of flour. Bario Padan and Bario Hitam exhibit higher bulk densities, signifying their potential suitability as effective thickening agents in food preparations.

The Water Absorption Capacity (WAC) of food products refers to the ability of the flour to interact with water (Awuchi *et al.* 2019). WAC holds a pivotal role in the advancement of cereal-based food products, as it effectively enhances cohesiveness and consistency, and imparts body to the food (Atuna *et al.* 2022). As outlined in Table 2, the WAC of all samples ranged from 1.16 g/g to 1.26 g/g, with significant differences among samples ($p<0.05$). Rice flour derived from Bario Adan and Bario Kulit Merah demonstrated the highest WAC value, each registering at 1.26 g/g. The levels observed in this investigation are below those observed by Thomas *et al.* (2014b). However, results from Ronie *et al.* (2022) corroborated current findings, reporting WAC contents within the range of 1.21 g/g to 1.26 g/g, with the peak value found in Bario Adan. The substantial presence of hydrophilic groups within starch molecules contributes to the velvety texture, pliancy, and viscosity of the resulting food product. Rice flour with lower WAC levels is well-suited for making rice bread, while those with high WAC can be used in bakery products, effectively averting moisture loss, and preserving the delectability of bread, cakes, sausages, and even serving as a soup thickener (Han *et al.* 2012).

Oil Absorption Capacity (OAC) represents the physical entrapment of oil by protein through its non-polar side chains (Lira *et al.* 2023). The OAC of the rice flours ranged from 0.97 g/g to 1.16 g/g. The highest OAC is presented in Bario Padan, followed by Bario Adan and Bario Kulit Merah which has no significant difference ($p>0.05$) from each other but has a significant difference ($p<0.05$) from Bario Hitam. OAC is a key feature that elevates the shelf life and mouthfeel while preserving flavour in food products (Atuna *et al.* 2022). The notable high OAC value indicates its suitability for incorporation into lipid-rich foods, such as cakes. More pronounced hydrophobic

Table 2. Water absorption capacity, swelling power, and water solubility index of Bario rice

Parameter	Variety			
	B. Adan	B. Padan	B. Kulit Merah	B. Hitam
Water absorption capacity (g/g)	1.26±0.02^{a}	1.17±0.02^{b}	1.26±0.02^{a}	1.16±0.02^{b}
Oil absorption capacity (g/g)	1.11±0.02^{a}	1.16±0.10^{a}	1.05±0.07^{ab}	0.97±0.06^{b}
Swelling power (g/g)	5.59±0.07^{a}	4.40±0.15^{c}	5.20±0.12^{b}	5.21±0.06^{b}
Water solubility index (%)	0.05±0.00^{b}	0.10±0.01^{a}	0.05±0.02^{b}	0.04±0.00^{b}

Data is expressed as means±standard deviations (n=3)

Means carrying different alphabets in a row differ significantly ($p<0.05$)

proteins tend to expose a greater number of non-polar amino acids to fats, consequently enhancing the efficacy of lipid binding processes (Oppong *et al.* 2021).

The swelling of starch granules occurs during gelatinisation because the hydroxyl groups within the starch granules formed new hydrogen bonds with water molecules due to the disruption of hydrogen bonds between the hydroxyl group in the double helices of starch molecules (Zhou *et al.* 2021). The swelling capacity range in this study was between 4.40 g/g and 5.59 g/g. Generally, Bario Adan exhibited the highest swelling capacity value whilst Bario Padan presented the lowest value. The outer bran of the pigmented rice grains is said to delay water penetration into the starch granules, consequently lowering the swelling capacity of the flour. Hence, the post-harvest operations of this rice play a crucial part in managing the swelling capacity (Awuchi *et al.* 2019). Swelling capacity is depicted as an important functional property that can impact the quality of food products such as hydration capacity which measures the ability of the substance to absorb water and form a gel-like substance. This property is important in many food products, such as bread, cakes, and pastries, where the dough or batter needs to hold its shape and texture during baking (Huang *et al.* 2019). Besides that, swelling capacity can also affect the emulsification properties of flour, which is essential in many food products, such as sauces, dressings, and mayonnaise. The flour's ability to absorb water and form a gel-like substance can help stabilise the emulsion and prevent separation.

The Water Solubility Index (WSI) is a crucial parameter indicating the amount of solute dissolved in a solvent at equilibrium, often used to measure starch conversion during extrusion and the release of soluble polysaccharides from the starch granule (Taverna *et al.* 2012). Low WSI in flour implies lower adhesiveness and stickiness in food products but a higher structural preservation (Kraithong *et al.* 2018). Bario Padan (0.10%) exhibited a significantly higher WSI value ($p<0.05$) compared to other varieties, influenced by compounds like starch and fibre. Research by Ronie *et al.* (2022) stated that pigmented rice usually elucidated higher WSI but lower SP than white rice flour due to the leached phenolic compounds during processing. The inverse relationship between swelling power and WSI in rice flour is influenced by the ratio of soluble to insoluble amylose content, molecular weight and shape of amylopectin, and granule size of starch (Lan *et al.* 2015, Zhang *et al.* 2023). Although amylose and amylopectin ratios influence swelling and solubility, stronger intermolecular interactions and higher hydrophobicity contribute significantly to the variance in swelling power and solubility (Aidoo *et al.* 2022).

CONCLUSION

Bario rice flour demonstrates notable protein and fibre content. The pigmentation of the rice bran influences the colour profiles of Bario rice flour. The swelling capacity displayed a high level across all Bario rice flour types. Notably, Bario Padan rice flour exhibited a high WSI, potentially attributed to elevated phenolic compound concentrations released during processing. However, further research should focus on investigating Bario rice's nutrient bioavailability and compatibility in various food processing methods. Such investigations would deepen our understanding of Bario rice flour varieties and encourage the utilisation of indigenous crops to create gluten-free products.

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DECLARATION OF CONFLICT OF INTERESTS

The authors state that they have no conflict of interest.

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Unveiling Determinants in Rice Supply Chain Studies: A Bibliometric Analysis on Food Security

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ABSTRACT

This paper seeks to provide an overview of the characteristics of the Rice Supply Chain (RSC) as studied across various research areas related to food security concerns. In agriculture, Rice Self-Sufficiency (RSS) level is an indicator of food security. However, food security encompasses broader factors such as availability, accessibility, stability, and utilisation. Given that rice holds significant importance as one of the world's staple foods, addressing the increasing demand for rice is seen as a crucial strategy to enhance national resilience against food insecurity. Inefficiencies in the rice supply chain can negatively impact production, storage, and distribution, consequently diminishing the RSS. In line with the growing attention to food security, there is a need to better understand the importance of sustaining the production of rice to cater to food security issues within broader academic research. Thus, this study has two main objectives: 1) to examine the characteristics and development of literature related to the RSC and, 2) to identify the thematic areas related to the RSC research and their connections to specific disciplines. To achieve this, a Systematic Literature Review (SLR) and bibliometric analysis of 165 journal articles listed in the Web of Science (WoS) and SCOPUS databases was conducted. This analysis revealed significant findings in research activity, highlighting the extensive and multidisciplinary nature of the studies. Study results indicate a gap in relational bibliometric studies within the field of RSC. Nevertheless, there is still potential for increased collaboration across disciplines and further investigation into how diverse RSC studies touch on food security issues for future reference.

Keywords: food security, food supply chain, rice supply chain

INTRODUCTION

Addressing food security issues has increased attention on improving the Food Supply Chain (FSC) (Rejeb *et al.* 2022). However, there's limited research on shortages in food supply, a significant challenge for poor and developing countries. Efficiency in the food supply relies on the entire food system, from cultivation to consumption (Lautala *et al.* 2015). To address challenges, a comprehensive and efficient FSC process is crucial. With the global rise in food security concerns, studies are investigating FSC issues (Durán-Sandoval *et al.* 2023).

Food security involves access to safe and nutritious food, defined by the UN as consistent access to sufficient and nutritious food (Peng & Berry 2019). Criteria for food security include availability, accessibility, utilisation, and stability (Mutungi *et al.* 2023). Achieving optimal food security requires a consistent food supply and access, emphasising the need to tackle issues like food shortages (Addai *et al.* 2022).

Food supply challenges contribute to a crisis, with high natural gas prices impacting food prices globally (Liboreiro & Vigneron 2023). Shortages affect poor nations, leading to high inflation of food prices worldwide (The World Bank 2023). A substantial portion of global food production never reaches consumption, highlighting the need for action plans to address supply shortages (Dou *et al.* 2016).

The importance of food security necessitates significant changes in agri-food systems (Yusriadi & Cahaya 2022). Rice, a global staple, faces challenges in its supply chain, identified as a critical area for improvement due to high-risk factors (Rath *et al.* 2022). To enhance

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rice production and address food security, a robust RSC system is needed.

Imbalances in global rice production, increasing rice imports, and rising consumption pose challenges to achieving self-sufficiency (Arshad *et al.* 2011). However, bibliometric analysis studies on RSC are lacking, and this research aims to fill that gap by conducting a bibliometric analysis of RSC literature, identifying clusters and relationships in the study areas (Erboz *et al.* 2023; Chopin *et al.* 2023).

This Systematic Literature Review (SLR) focused on RSC issues and utilized bibliometric analysis to confirm SLR findings. It covered publications from 2018 to 2024 in Google Scholar, SCOPUS, and Web of Science databases. The study aims to highlight RSC issues, analyse keywords, and identify common challenges using bibliometric techniques and VosViewer software (Gan *et al.* 2022). This approach provides a fair, factual, and useful way to identify networks and summarize literature findings on RSC development and characteristics. The goal is to aggregate literature findings and suggest improvements to address overall RSC issues.

Recent research on Food Supply Chains (FSC) has highlighted drawbacks, with factors such as food quality and security becoming significant concerns. Meanwhile, Rice Supply Chain (RSC) studies, particularly in Southeast Asian countries like Malaysia, Indonesia, Thailand, and Vietnam, reveal challenges due to insufficient rice production, leading to the need for imports.

John and Fielding (2014) identified the top constraints to rice production, emphasizing total rice yield losses accounting for half of the production. Rigorous searches in RSC studies have categorised factors into internal (managerial) aspects investigated by Peng *et al.* (2022) and Cheraghalipour *et al.* (2019), and external (technical) factors explored by Tao *et al.* (2023), Jifroudi *et al.* (2020), and Kakkar and Ruchi (2020). Suryani *et al.* (2022) recommended addressing both internal and external factors to enhance RSC value, emphasizing the importance of strengthening managerial and technical aspects for rice quality and safety.

As scientific information on food security increases, it becomes crucial to categorise and study current research areas. To address rice production issues, tables summarising publications in Google Scholar, WOS, and SCOPUS databases were created. Utilising SLR as the first step helps in understanding the scope of RSC studies, with papers classified based on publication numbers, providing an initial insight into the field.

METHODS

The number of publications was examined by three different types of databases which are Google Scholar, Web of Science (WoS) and SCOPUS. Based on all databases show increasing trends for the number of publications. This indicates that the prevailing trend reflects an interest in RSC studies that are associated with food security issues. At this stage, all studies that are found related and touch on RSC are included. All retrieved studies were screened to ensure no duplications.

Data collection

Considering the high quality and characteristics of impactful studies, extracting information from every publication included in this study enables this study to come out with several RSC classifications. These studies were found to have similar focus areas in their RSC research. From the SLR conducted, five classifications were identified which consist of the determinants in RSC studies. These classifications are: 1) product quality; 2) product quantity; (3) process of product flow (distribution and logistics) namely as the operational aspect known as the external factors; 4) process of information flow (organization, community, policy, person or people, and behaviour) which namely as the managerial aspect known as the internal factors; 5) technology application. Results from the findings indicate most of the studies look into product quality which has been identified in Google Scholar (15), WoS (18) and SCOPUS (21) databases for the recent years in 2023. However, publications in the year 2020 expanded more studies focusing on the process of information flows that focus on the managerial aspect of RSC. These internal factors were found to have impacts on their RSC performance. Due to current issues that touch on food security problems, recent studies were most likely to shift their focus to look into product quality rather than focusing on the other aspects of RSC.

To attain the study's objectives, inclusion and exclusion criteria are employed to screen pertinent studies. Focusing on RSC studies, an in-depth analysis was conducted. There are five main components in RSC studies which consist of: 1) raw materials; 2) supplier or producer; 3) distributor; 4) retailer; 5) consumer or customer. However, an additional component was the studies focusing on the network-related aspects of RSC between other parties were found to be of the highest interest to researchers. This emphasises that studies on RSC not only encompassed its entire supply chain but also addressed various components either by combining them or solely focusing on individual components of the RSC. Findings indicate that it is relevant to study the entire supply chain to enhance the performance of RSC. Even though the last component is highlighted in the studies of RSC network, it does not cover the entire RSC. Previous studies only touched on networks between two or three components but not all the components involved in RSC. These findings are relevant to help future studies explore further details which cover the entire supply chain that includes all five main components in RSC.

Upon reviewing the literature on the topic, it is evident that there exists a gap that needs to be addressed. Most of the studies discover only the specific related issues in terms of its key areas and Supply Chain Management (SCM) components. From this finding, there are two key areas highlighted which are the determinants of RSC and RSC components. Lists of RSC classifications which consist of the determinants found in this research findings are: 1) product quality; 2) product quantity; 3) process of product flow (distribution, logistics-external); 4) process of information flow (managerial aspect on decision making: organisation, community, policy, person or people, behavior-internal) and 5) technology application. As for the RSC listed components, there are six identified in the literature: 1) raw material; 2) supplier or producer (farmer); 3) distributor; 4) retailer; 5) consumer or customer, and vi) RSC network (between RSC parties or more than 1 party) where these components have been studied separately.

The determinants of RSC studies

This study recognised the importance of RSC determinants to improve rice production which helps to promote food security issues as it has become one of the world's main concerns recently. As rice is the staple food for Malaysia, it is important to examine the causes and drawbacks of RSC to overcome issues related to RSC. The determinants highlighted in this study are:

Product quality. Food quality is the most basic aspect that was being measured as a state of excellence. Gershwin (2018) defined product quality is about how well it is made, and how much it is made well. Most of the previous studies found that technology helps in maintaining product quality (Peng *et al.* 2022; Tao *et al.* 2023).

Product quantity. As defined by Gershwin (2018), quantity is about how much is produced, when it is produced, and what resources are required. Previous studies related to measuring product quantity were driven by many factors such as technology (Harun *et al.* 2021), cultivation system (Kumar *et al.* 2021), organisation initiative (Libriyanto *et al.* 2022) and many more.

Process of product flow. A supply chain needs to maintain and improve its product flow. In the supply chain, the process flow shows the activities and steps taken in delivering products. One of the process flows discovered is the external factors which look into the outside activities in transferring the product externally such as the distribution process and logistics. Zając and Swieboda (2023) explained that logistics processes are most often considered in the context of the correct flow of materials.

Process of information flow. The challenge facing the current supply chains is ensuring the continuity of supply reliability based on available information (Zając & Swieboda 2023). Zając and Swieboda (2023) stated that the unreliability of a process is not a physical or technical issue but results from insufficient reliability of the information. It has been mentioned by Ahmad and Sanjog (2023) that the information is very important for proper coordination between the stakeholders through the supply chain.

Technology application. Advancements in technology are occurring at a faster pace in various areas of human activities. New technologies such as the Internet of Things (IoT), blockchain, and Big Data Analytics (BDA) can help gather real-time information about product demand, stock levels, and location. Additional technology has been agreed by most researchers and industry professionals to help overcome the

prevailing issues related to improper product flows, disruptions, fragmentations, poor product traceability, food contamination, and food recall (Mastilović *et al.* 2023). However, implementing these technologies successfully can be challenging. In the present study, we sought to gain insight into the technology trends in the field of current technology applications in RSC.

Data analysis

This analysis aims to show whether the research area for this study is in line with the current issues in improving food security. The bibliometric analysis carried out in this research is based on the academic literature found in WOS and SCOPUS databases as it is one of the most restrictive for indexing works. From SLR analysis conducted shows publications that are available online during the exact search time. Additionally, this analysis, helps to track the papers which are "on a given subject" which gives an absolute number to show the evolution of studies on RSC.

Data retrieved from Google Scholar is used to support both databases as it covers large areas of study. For the Google Scholar database, the number of publications provides a wide range of databases which includes indexed and non-indexed databases. The results are useful as an overview of the study. However, Google Scholar is not suitable to be referred to as a scholarly article which has low in quality of the papers included. Thus, other indexed journal such as WoS and SCOPUS was included in this study. Focusing on WOS and SCOPUS, both of these databases have been established by worldwide to be useful as the most systematic and dynamic method of journal selection. Also, using Boolean (""; AND) and phrase search (rice supply chain) helps to limit the selection and the results are of sufficient scientific quality (Martínez-Falcó *et al.* 2023).

After refining the selection of the database search platform, the selection of papers has been focused on the issues related to the rice supply chain only as the main interest in this study. It was determined that the best search equation among those considered as the following:

Search = (("rice supply chain") AND PUBYEAR > 2018 AND PUBYEAR < 2024)

Analysing the algorithm, it can be seen that the search covers the related paper regarding RSC between the years 2017 and 2024. The usage of the Boolean operator "" for the phrase search of the RSC ("rice supply chain") and AND to limit the scope and searching for the related papers. These parameters were applied to the topic, which includes the title and the abstract of the papers in both databases until 2024.

Following the application of the search algorithm on 4th April 2023, a total of 111 documents were displayed. However, limitations were used in limiting the selection year which reduced the number to 86 papers. Further, PRISMA guidelines for systematic review were applied through this methodology. As mentioned by Martínez-Falcó *et al.* (2023), by following the PRISMA guidelines, the reliability and reproducibility of reviews can be enhanced due to the comprehensive methodology it employs, as well as its widespread use in conducting bibliometric analyses. In a study by (Şalvarlı & Griffiths 2021), there is a four-phase flow diagram in PRISMA guidelines that describes the identification, screening, eligibility, and inclusion criteria of the reports that fall under the scope of a review. By referring to Şalvarlı and Griffiths (2021) this study follows as in Figure 1.

After filtering and refining the data according to the scope of this study, the number of documents was reduced from a total of 165 overall to 132 items. All of these data fall under the categories of Agricultural and Biological Sciences, Computer Science, Environmental Science, Business, Management and Accounting, Engineering, Social Sciences, Economics, Econometrics and Finance, Decision Sciences, Earth and Planetary Sciences, and Energy. It shows that this study had gone through an extensive view of the scope of rice supply chain studies which covers the overall categories and areas.

Furthermore, to enhance the analysis, a network map was created using version 1.6.18 of the VOSviewer tool. This tool is a software application for constructing and visualising bibliometric network (Martínez-Falcó *et al.* 2023). More specifically, a network map was generated to visualize the co-occurrence of keywords. The keywords that appeared at least ten times in the analysed records were included, and clusters were identified based on predetermined parameters. The networks included in this study to create a term co-occurrence map are based on text data and individual publications counting known as authorship. It was agreed by Martínez-Falcó *et al.* (2023) that authorship was one of

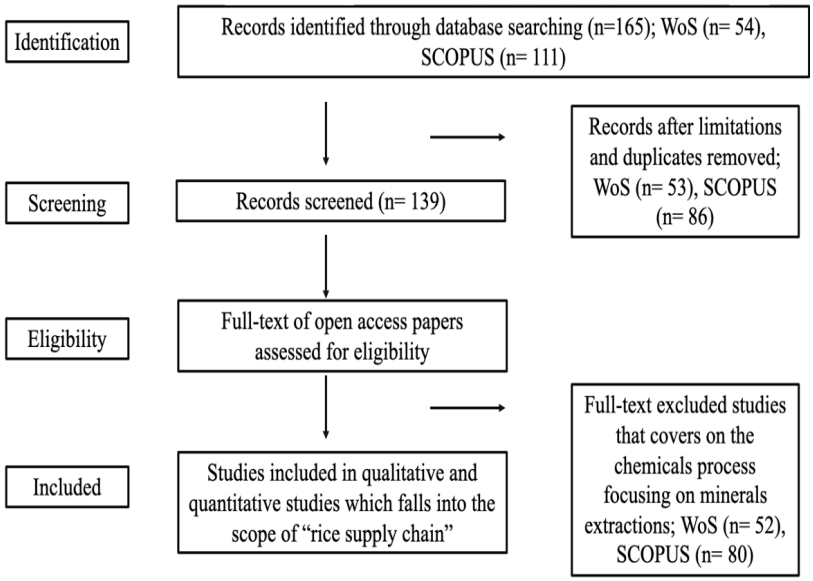


Figure 1. PRISMA flow diagram of the paper selection process used in the present study

the most important variables to be considered in bibliometric analysis. This analysis helps to identify the clusters involved and thus distinguish the leading research areas in this study field. Also, this map displays the connections between each keyword and co-authorship that have connectivity between them.

RESULTS AND DISCUSSION

Referring to the study by Guo *et al.* (2019) bibliometric analysis was applied to analyse and visualise the relationships among the authors, countries, journals, co-citations, and terms. Every pattern that is displayed has its meaning. The size of the circles represents the occurrence of keywords with the larger circle reflecting that more a keyword has been co-selected in the rice supply chain publications. Additionally, the distance between each keyword demonstrated relative strength and topic similarity. From the visual of bibliometric, different colours reflects different cluster which discussed a similar topic among these publications with the connection of link. Each link has its strength where the higher the value, the stronger the link. The total link strength under the item displayed indicates the number of publications in which two keywords occur together.

Bibliometric analysis on keyword terms of the rice supply chain in Web of Science (WOS) database

In reference to the data sorted and analysed in the WoS database, a table of verified selected terms is displayed in Table 1. From this table, the number of occurrences for each keyword was displayed.

Table 1. Number of occurrences by keywords in WoS database from 2018–2023

Term	Occurrence	Total link strength
Chain	172	675
Data	38	234
Farmer	37	145
Efficiency	25	171
Blockchain	24	157
CSC	12	228
Green investment level	12	228
SCRA	12	228
Cooperative	10	46

CSC: Construction Supply Chain
SCRA: Supply Chain Risk Assessment

Scientific studies show a large number of research areas, which highlight the top five highest keywords listed as a chain (172), data (38), farmer (37), efficiency (25), and blockchain (24). These keywords reflect the number of studies conducted in the rice supply chain, mostly related, and highlight this area of study. Unfortunately, it is seen that limited studies touch on cooperative aspects, which have the least number of 10 shown.

As a result, from the WoS database, details on related rice supply chain studies a network visualisation shows the trends and patterns of its relationships between each item in scientific literature. In addition, this analysis also helps to understand aspects of knowledge that fall in the scope of the rice supply chain. The analysis serves two purposes: first, to investigate the development of knowledge in the academic discipline, and second, to analyze the linkages between each item. To visually demonstrate the connections and linkages between these items, a keyword occurrence analysis was conducted. Figure 2 enabled the identification of the relationships between the keywords.

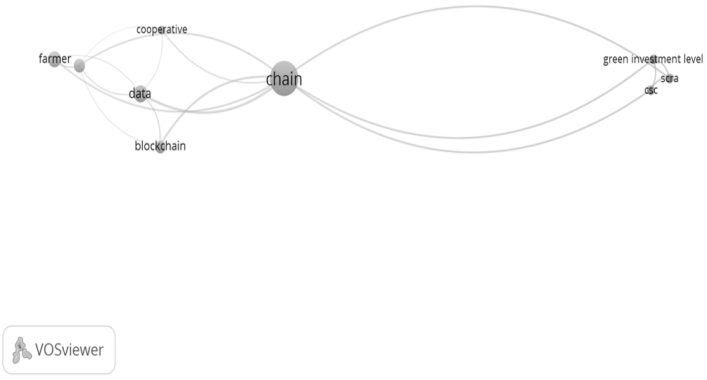
As can be seen from Figure 2, there is a strong connection between each keyword with other items: total link strength for chain (675), data (234), efficiency (171), blockchain (157), farmer (145), supply chain risk assessment (scra) (84), and cooperative (46). Furthermore, these keywords are linked with each other. Among others, the cooperative keyword reflects the lowest occurrence value which reflects that few studies focus on this aspect. It can be concluded that not many studies have explored the cooperative aspects of rice supply chain studies.

Bibliometric analysis on keyword terms of the rice supply chain in the SCOPUS database

On the other hand, in reference to the data sorted and analysed in the SCOPUS database, a table of verified selected terms is displayed in Table 2. From this table, the number of occurrences for each keyword was displayed.

Scientific studies have revealed numerous research areas in the field of the rice supply chain in the SCOPUS database, with the top five highest keywords being model (118), farmer (76), cost (49), price (45), and performance (39). These keywords reflect the extensive research conducted in the rice supply chain, predominantly related to these areas, highlighting the importance of this field of study. However, a lack of study was found focusing on trust aspects which shows the lowest value in the area of the rice supply chain. From this, it can be concluded that there has been limited exploration of the trust aspects of rice supply chain studies.

In order to gain a deeper understanding of the knowledge boundaries within the rice supply chain field, a network visualisation was generated using data obtained from the SCOPUS database. This visualization allowed for an examination of the trends and patterns of relationships between each item in the scientific literature. Additionally,



Note: For practical reasons, we have included those keywords that appear at least 10 times in the records considered (unit of analysis: all keywords) but excluded keywords which have not related to the study area. The size of the nodes is proportional to the number of times keywords appear

Figure 2. Network map of the occurrence of keywords in WoS database

Table 2. Number of occurrences by keywords in SCOPUS database from 2018–2023

Term	Occurrence	Total link strength
Model	118	865
Farmer	76	642
Cost	49	454
Price	45	437
Performance	39	296
Problem	37	267
Information	36	410
Market	36	374
Production	32	258
Actor	31	272
Blockchain	30	263
Risk	30	172
Activity	28	263
Demand	28	362
Framework	28	253
Policy	25	337
Stakeholder	24	158
Smart Contract	22	325
Effect	19	174
Use	19	141
Loss	18	151
Rice Production	18	152
Safety	18	190
Grain	16	145
Government	15	179
Supply chain performance	15	118
Profitability	14	156
Rice Mill	14	122
Covid	13	139
Cooperative	11	110
Rice Industry	11	109
Trust	10	53

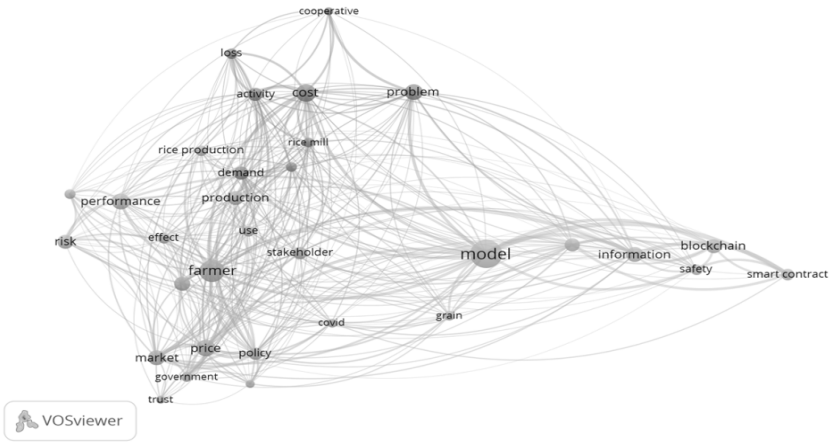
a keyword occurrence analysis was conducted to illustrate the connections and linkages between these items in a graphical format. The resulting Figure 2 facilitated the identification of relationships between the various keywords.

Figure 3 displays a significant correlation between each keyword and other items, with the farmer (455) having the highest value of total link strength followed by cost (345), price (329), market (293), information (251), and performance (210). Even though the item has a high occurrence, it does not mean that it also has a high value of link strength. These keywords exhibit connections with each other where high link strength indicates the number of publications in which two keywords occur together. From this analysis, most studies looked into the perspective of a supplier which specifically relates to the farmer who is the main provider in the rice supply chain. There are a lot of improvements that need to be made in moving towards reliable access to a sufficient food supply by looking into the overall component in a holistic view of the rice supply chain. In achieving a high level of food security in the rice supply chain, it must be considered the entire supply chain which was being measured by the four pillars of food security; availability, access, utilisation, and stability.

CONCLUSION

This study has explored the overall studies related to the rice supply chain, covering indexed databases such as WoS and SCOPUS, which contain high-quality research studies from around the world. Analyzing the current and recent studies in this area provides insightful views and information for future improvements. The astounding number of keywords identified in the indexed databases highlights potential research areas and their occurrence and total link strength, which identifies the most common study area. Additionally, authorship emphasizes the same interests as this study's objectives.

Thus far, this paper concludes that despite the current trends that look into food security issues, improvements in the RSC can be made toward more sustainable practices that consider social and economic aspects. New strategies and improvements in practices among stakeholders can lead to more sustainable practices that align with the SDGs agenda.



Note: For practical reasons, we have included those keywords that appear at least 10 times in the records considered (unit of analysis: all keywords) but excluded keywords which have not related to the study area. The size of the nodes is proportional to the number of times keywords appear.

Figure 3. Network map of the occurrence of keywords in the SCOPUS database

The analysis concludes that the majority of researchers who have the same interest in rice supply chain studies still need more improvement related to their contribution to the overall RSC performance. Both internal factors, which cover the managerial side, and external factors on the technical side such as material distribution activities, must be viewed holistically. Both the internal and external factors must be considered without dismissing any.

As food security issues continue to increase all over the world, improvements in RSC studies must not be overlooked. As rice is known as the staple food for most countries in the Asia region, it may help reduce the shortages of food supply that have recently been highlighted. Further study is required for future review, which can help improve RSC performance, thus reducing food security issues.

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DECLARATION OF CONFLICT OF INTERESTS

The authors have no conflict of interest.

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The Proximate Analysis and Sensory Hedonic Evaluation of Energy Drink (Agarbomb)

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ABSTRACT

The main purposes of this study are to assess the consumers' acceptance of the sensory attributes of energy powder made from guarana as caffeine and to determine the nutritional values of energy powder made from guarana as a substitute for coffee. The method used to conduct this research is measuring proximate analysis of ash, moisture, protein, fat, and crude fibre to identify energy powder's nutrient content. Besides, it discovers the acceptance of energy drinks towards potential consumers by undergoing a 7-point hedonic sensory evaluation test of 25 semi-panels. The outcomes gained from this research are low protein, low fat, and high minerals due to the high ash content, presenting that it is acceptable for energy drinks since it usually focuses on total energy and sugar for energy boost. The panellist's acceptance is concentrated in viscosity and colour, which might concern Agarbomb's improvement in aroma, taste, and overall acceptability.

Keywords: energy drink, guarana, hedonic sensory, proximate analysis

INTRODUCTION

In Malaysia, the consumption of energy drinks is increasing due to the need for instant energy boosts for the body. Most consumers depend on energy drinks for activities such as staying up for work, driving, avoiding fatigue, or for athletes (Aguilar-Raymundo *et al.* 2019). To attract consumers, creating unique marketing strategies and tools is significant to the evolution of industries (Hussain *et al.* 2021). In the last few years, businesses have reached customers more successfully because of new methods of acquiring consumer data via cutting-edge marketing initiatives and technologies, which include improvising the products to appear unique and become the main highlight of attraction (Amiruddin *et al.* 2022).

The statistics show that young generations consume more energy drinks as they are much needed for driving, playing, studying, and other physical activities (Hasan *et al.* 2019). Consuming energy drinks has highly stimulating effects as it pushes the body to function more than it should to give high cognitive performance. Latest statistics from Statista (2020) in 2019 show that energy-boosting drinks with a combination of high caffeine and guarana content compared to other functional beverages such as functional water, 'detox' drinks, fermented and probiotic drinks promoting gut health, and others. Consumption of energy drinks was the highest among 25 to 34-year-old Malaysians, which is 49.91%, followed by 16 to 24-year-olds (49.29%) and 35 to 44-year-olds (43.78%). It concludes that 16 to 44 years old are the top three highest age ranges that consume energy drinks frequently as functional beverages.

According to Chen and Voigt (2020), nutrients are needed to follow modernisation and boost the food and beverage industry. Discovering nutrient values in the products can help expand their acceptability. It will indirectly encourage consumers to purchase the products, especially when they match their nutritional needs (Wong *et al.* 2023). As Vandenbrink *et al.* (2020) mentioned, nutrition evaluation is performed in the laboratory to observe and determine the presence of protein, potassium, sodium, and carbohydrates in the products.

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This research mainly focused on determining the nutritional values of energy drinks made from guarana and assessing consumers' acceptance of the sensory attributes of energy drinks.

METHODS

Design, location, and time

The research proposal employed an experimental design and a quantitative technique. Both proximate analysis and sensory evaluation tests were conducted in different settings at Universiti Teknologi MARA, Puncak Alam Campus. Proximate analysis was conducted at the Food Analysis Laboratory, and the sensory evaluation test was held in the Food Sensory Laboratory. Ethical approval was obtained from the Faculty Research Ethics Committee (REC) ref. no: REC/06/2023 (MR/396).

Materials and tools

Twenty-five semi-panelists participated in a 7-point Hedonic sensory evaluation of the Agarbomb powder, Refeul, and Isotonic Energy brands. This sample selection method allowed for diverse feedback on the tested products' sensory attributes.

Procedures

Proximate analysis

Analysis of moisture content. AOAC (1990) and Dhankhar and Techs (2013) methods have been applied to analyse the moisture content of energy powder. A small amount of energy powder, about 5 grams, will be initially dried at 98°C to 100°C, cooled in the dryer, and then precisely weighed in a weighing container as soon as it reaches room temperature. The lid was removed and heated at 110°C in a hot air oven for two hours. After the bowl lid had reached room temperature, it was promptly squeezed, put in the dryer, and weighed. On a dry basis, the weight loss was computed as a percentage of the moisture content.

Determination of ash. Ash content was assessed using the AOAC (1990) and Dhankhar and Tech methods (2013). A shallow aluminium dish spends three hours being dried in an oven set to 105°C. Once it reached room temperature, it was chilled in a desiccator and weighed. The homogenised food sample was accurately weighed at 5 grams and placed in an aluminium dish. The sample was precisely weighed in a container when it reached room temperature after being accurately dried in an oven at 110°C for three hours. The lid was removed and heated at 110°C in a hot air oven for two hours. Up to yellowish or greyish ash was collected, and the sample was ashed. After reaching room temperature, the dish was removed, chilled in a desiccator, and weighed.

Determination of carbohydrate. The carbohydrate content for energy drinks was calculated based on AOAC (1990). Total carbohydrates were calculated based on the following formula (Dhankhar & Tech 2013):

Total carbohydrates = 100 – (Fat + Fiber + Ash + Protein)

Determination of crude protein. The crude protein content of the sample was analysed using two steps which are digestion and determination using the Kjeltec auto analyser with AACC (2000) method No. 46-10 according to the following statement (Dhankhar & Tech, 201Tor to oxidize Noxidizerm ammonium sulfate, 1 g of well-ground food sample was put to the digestion tube along with 2 K2SO4 (3.5g) catalyst tablets and 12 mL of sulphuric acid. When the mixture was clear, the digestion tube was placed in the rack and digested at 420°C for 45 minutes. The digested sample was then chilled until it reached room temperature.

The digestion tube containing the sample was attached to the distillation unit in the second stage. It has 50 mL of 40% NaOH and 75 mL of water. 25 mL of H3BO3 solution was added to the receiver flask for the distillation. The equipment eventually performs automatic titration.

Determination of crude fiber. The crude fiber was estimated according to the procedure outlined in the 32–10 AOAC (1995) method. The first energy drink sample was digested with 1.25% H2O-SO-4, a 3g sample. It was digested with a solution of 1.25% NaOH, rinsed with distilled water, and filtered once more. The digested sample was heated and placed in a muffle furnace that was kept at 550–650°C for 3–5 hours to obtain grey or white ash.

Sensory evaluation

A panel of 25 semi-trained subjects were chosen for this research. This type of panel should be selected from individuals who are familiar

with the quality of beverages and different classes of products. Panellists must be capable of recognising the differences and communicating their reactions, though they may not formally be trained. Semi-panel individual variations are balanced by involving more panellists (Selahvarzi *et al.* 2021). About 25–30 members are required and should be used as a preliminary screening programme to select a few products for large-scale consumer trials. All of the variables were calculated using a hedonic scale of nine points, from "very like" to "extremely dislike" (Nguyen & Chuyen 2020). The semi-trained panellists were given a pencil, plain water, a hedonic scale evaluation form, and three Agarbomb, ReFeul, and Isotonic Energy samples.

Drinking filtered water was performed for the mouth of beverage particles. As a result, it can stop mistakes from happening. Barylko Pikielna and Matuszewska (2014) state that panellists must consume water between each sample test to prevent errors. The panellists were required to rate the samples using a 7-point hedonic sensory evaluation scale based on their personal preferences after testing them.

Data analysis

All the obtained data was imported into SPSS version 27.0 (Statistical Package for Social Sciences) for data analysis. A study of Variance (ANOVA) and descriptive statistics was performed in the statistical analysis to investigate any significant differences in the acceptances between three types of energy powder concentrations. Excel was used to obtain spider web or sensory evaluations between three different products.

RESULTS AND DISCUSSION

Table 1 shows the proximate analysis of the Agarbomb energy drink. The proximate analysis includes moisture, ash, protein, crude fibre, fat, and carbohydrate content. For energy drinks, proximate analysis is used to determine their composition and analyse how different elements, such as the contents and consumption habits of the beverage, affect their physical characteristics and colour stability (Choi *et al.* 2019). The moisture content attained from the analysis of the Agarbomb energy drink is 7.09±0.02. This shows that the moisture content in the energy drink powder is in the ideal range as, according to research by Akhter *et al.* (2020), dried food products such as energy powder drinks should attain a moisture content of less than 10%. Compare this to the moisture content in instant mango drinks by Akhter *et al.* (2020). Agarbomb energy drinks contain a higher moisture content than mango instant drinks, with a 4.6 to 0.2% moisture content.

Low moisture content in products can determine the extended shelf life (El Wakeel 2007). Moisture can encourage various chemical processes, microbiological development, and enzymatic degradation, resulting in product deterioration and decreased quality. The powder has a longer shelf life since it is less likely to deteriorate over time with a lower moisture content reading. Besides that, the chance of caking or clumping of products, which can happen when the powder particles absorb water, is lowered with less moisture.

Besides, ash content was analysed with the results of 90.56±0.62, showing that high mineral content such as calcium, magnesium, potassium, and sodium are discovered in the energy drink. Based on the Akhter *et al.* (2020) study, the importance of determining the minerals in the ash is that having high mineral content would help in hydration support, which can improve the capacity of the human body to absorb and hold onto water. The drink of instant mango powder is lower (Mohammed *et al.* 2017) than the Agarbomb energy drink. Higher ash-content energy drinks could help the body remain hydrated, which is important for general health

Table 1. Subject distribution based on research variables

Proximate composition	(Mean±SD)
Moisture content (%)	7.09±0.02
Ash content (%)	90.56±0.62
Protein (%)	0.07±0.04
Crude fibre (%)	16.95±0.00
Fat (%)	0.00±0.00
Carbohydrate (%)	0.66±0.00

SD: Standard Deviation

and performance. Moreover, it has many minerals in muscle function and bone health.

Besides that, the proximate protein analysis for the Agarbomb energy drink is 0.07±0.04. Although protein is an essential macronutrient in diets, there are a few unique reasons for types of beverages, such as energy drinks, to apply a lesser amount of protein. In their study, Akhter *et al.* (2010) mentioned that low protein is found in fruits and vegetables as it is proved that Agarbomb and mango instant drinks attained the same protein content, which is 0.07±0.04. The concrete reason for low protein is rapid absorption and digestion. Frequently, individuals devote themselves to energy drinks to get a quick increase in energy, alertness, and determination. A low-protein energy drink might be beneficial when quick absorption and digestion are required. Proteins typically take longer to digest than carbohydrates, which can hinder the absorption of the beverage's other nutrients and active substances (Hamilton *et al.* 2020).

Meanwhile, 16.95±0.00 was attained for proximate analysis of Agarbomb crude fibre. The concept of "crude fiber" refers to the indigestible portion of dietary fibre in non-plant-based meals. The significance of crude fiber in the needs of energy drinks is less concerning than other nutrients, and most energy drinks would exclude the large levels of fibre. Energy drinks focus on introducing consumers to an immediate boost in energy, concentration, and alertness (McWhirter *et al.* 2020). Adding carbs, caffeine, and other stimulants would be the most concerning components in every energy drink. In other words, the primary goal of energy drinks is to focus more quickly on obtaining energy rather than dietary fiber.

Next, the fat contained in the Agarbomb energy drink is 0 g. The presence of fat in energy drinks is frequently not significant, and almost all the ones available are made to be either fat-free or minimal in fat. Since fatty acids take longer to digest and metabolise than carbs, fats provide an unsteady and enduring energy source. Fats would be out of place in energy drinks because the idea is to provide consumers with an immediate energy boost. When the body's supply of carbohydrates runs out, it might use the concentrated energy in fat. Some of the fat's crucial purposes are as a cushion and protector for internal organs such as the heart, kidneys, lungs, and intestine. (Mohammed *et al.* 2017)

Lastly, the carbohydrate content in Agarbomb is 0.66±0.00, meaning it only consists of 0.66 g of carbs per serving. The energy drink offers an ideal alternative for any individual who favours low-calorie or low-carbohydrate drinks because 0.66 g are considered low-carbohydrate since typical carbohydrates contained in energy drinks are 11% to 12%. It is tempting for those on a strict diet or attempting to consume fewer carbohydrates. While a low-carb energy drink may offer a small amount of increase in energy from carbohydrates, it still contains other stimulants like caffeine from guarana and B vitamins, which help with alertness and focus (Nowak & Goslinski 2020). A low-carb energy drink could prove a better option for consumers with certain medical conditions, such as diabetes or insulin resistance, to help control blood sugar levels.

A study of the developed Agarbomb energy drink shows that most characteristics outperformed those of the existing instant drink powder. The instant drink powder's proximate analysis shows it is safe for human ingestion. Proximate analysis is crucial in producing commercial food because businesses must ensure that the final goods are safe and nutritious and comply with all applicable laws and legal regulations. It continues to be the only method for preserving and observing food products' quality and remaining shelf life.

Sensory evaluation

Table 2 shows significant differences in acceptability of colour, aroma, taste, viscosity, and overall acceptance (Okokon & Okokon 2019) between Agarbomb, ReFeul and Isotonic Energy as the p-value was less than 0.05. All the samples had significant differences due to the different main focus of attributes for each energy drink. Agarbomb is moderately accepted for colour with the mean of 5.481.09 followed by Isotonic Energy (4.32±1.65) and ReFeul (4.24±1.88). For aroma, ReFeul gained the highest mean (5.64±1.60), assuring that most of the panellists agreed ReFeul had the likeable aroma, followed by Agarbomb with the mean of 4.84±1.72 and Isotonic Energy with the mean of 4.08±1.85. Besides, there is a huge gap between the three energy drinks for the taste attribute. ReFuel attained the highest figure, which is 6.00±1.38 go around with Agarbomb (3.96±1.95) and Isotonic Energy (2.76±1.56).

Table 2. Descriptive table of energy drinks

Samples	Colour (Mean±SD)	Aroma (Mean±SD)	Taste (Mean±SD)	Viscosity (Mean±SD)	Overall acceptance (Mean±SD)
Agar bomb	5.48±1.09	4.84±1.72	3.96±1.95	4.92±1.15	4.40±1.60
Refeul	4.24±1.88	5.64±1.60	6.00±1.38	4.24±1.99	5.36±1.38
Isotonic energy	4.32±1.65	4.08±1.85	2.76±1.56	3.16±1.72	2.80±1.44

SD;: Standard Deviation

Next for viscosity, Agarbomb hit the uppermost reading, which is 4.92±1.15, followed by ReFuel (4.24±1.99) and Isotonic Energy (3.16±1.72). Lastly, the overall acceptability of the energy drink by the panellists through hedonic scale evaluation is attained by ReFuel with the reading of 5.36±1.38 followed by Agarbomb (4.40±1.61) and Isotonic Energy (2.80±1.44).

Based on Table 2, there are significant differences in acceptability of colour, aroma, taste, viscosity, and overall acceptance between Agarbomb, ReFeul, and Isotonic Energy as the p-value was less than 0.05, which is similar to the previous study of functional energy drink by Selahvarzi *et al.* (2021). All the samples had significant differences due to the different main focus of attributes for each energy drink.

Figure 1 shows the level of sensory evaluation result acceptance for three energy drinks: Agarbomb, ReFeul, and Isotonic Energy. Agarbomb represented the blue line, ReFeul represented the orange line, and lastly, the grey line was represented by the Isotonic Energy drink.

Based on the results, ReFeul conquered the most attributes: aroma, taste, and overall acceptability. Agarbomb attained high colour and viscosity attributes, while Isotonic Energy was the lowest. Figure 1 of the spider web sensory evaluation acceptance test result, Agarbomb has been compared with two other sample products, ReFuel and Isotonic Energy. The mentioned attributes include colour, aroma, taste, viscosity, and overall acceptability of the panellists as measured by a 7-point hedonic scale evaluation (Chonpracha *et al.* 2019). ReFeul scored the highest attributes for aroma, taste, and overall acceptability, while Agarbomb scored in colour and viscosity. This makes Isotonic Energy the lowest of all.

The panellist might favour the aroma of ReFeul more than others because of the total mean of 5.64±1.60. This product has a strong and sweet aroma, allowing the brain cells to activate more positively (Al-Shawyeh 2019) and hype the

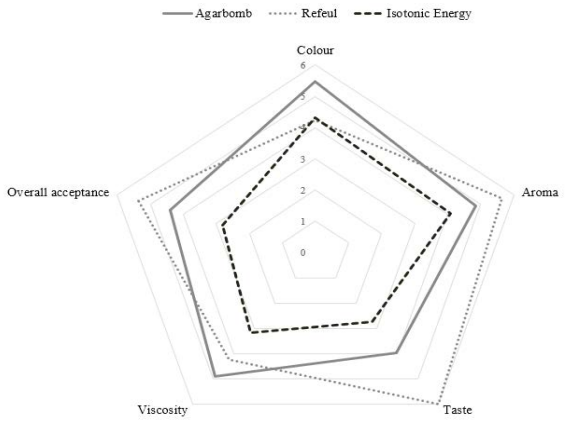

Figure 1. Sensory evaluation acceptance test result

panellist to choose ReFeul as the most favoured aroma choice among the three. In Figure 1, the aroma attribute shows that each product has a significant difference because the spider webs of each product do not overlap.

As for taste, ReFeul proves that it tastes better than the other two, with a mean of 6.00±1.38. The panellist is most likely to pick the sweetest taste of all. Moreover, refuel shows a big difference in taste from other products. Refuel's spider web is near the attribute in Figure 1.

Next, Agarbomb lead in attributes of colour with 5.48±1.09, which is acceptable because, among all the sample products, Agarbomb has the most attractive appearance and shows significant differences compared to Refuel and Isotonic Energy products in Figure 1. Both refuel and isotonic energy products have no significant difference as the spider web of Refuel and isotonic energy overlap each other. The berry-like colour of the liquid makes the panellist fascinated with choosing Agarbomb over others.

Besides, Agarbomb also attained the highest viscosity with a total mean of 4.92±1.15, proving that Agarbomb has the most stable fluid resistance. Agarbomb also shows the nearest viscosity attribute through the spiderweb, addressing a significant difference between Agarbomb, Refuel, and Isotonic Energy. Agarbomb have an average middle viscosity level that is highly likeable among all.

Moreover, the overall acceptance attribute chosen from the mean result of panellists is ReFeul with a reading of 5.36±1.38. This is understandable due to three out of five attributes the ReFeul energy drink attained. All the products significantly differ in acceptance, with Refuel leading, followed by Agarbomb and isotonic drink.

Agarbomb is recommended to improve aroma, taste, and overall acceptance attributes. This product aims to attract more consumers and increase market demand (Seninde & Chambers 2020). According to Mostafa (2022), adding caffeine (up to 320 mg/L) improved the taste and scent but had a detrimental effect on the colour. Throughout this research, consumers are more attracted to the aroma of energy drinks with mild original berries instead of plain or nearly non-aroma as Akubor and Obasi (2019) mentioned that to attract the taste of energy drinks using flavoured fruit formulations which served as the study's base is preferable for enriching the beverage. The potential consumer might refer to energy drinks as delicious and tasteful with a compact taste and benefits in a small packet.

CONCLUSION

This study was carried out to measure the nutrient content in Agarbomb and to determine consumers' acceptability through a 7-point sensory hedonic evaluation. The guarana-based energy drink's nutritional research has shed important light on its makeup. The presence of important macronutrients, such as carbs, proteins, and lipids, as well as the amount of moisture and ash, were identified by proximate analysis. The analysis' findings help better understand the energy drink's nutritional composition and give consumers, medical experts, and regulatory bodies crucial information.

Additional investigation is required to examine additional bioactive substances and micronutrients in the energy drink and confirm the labelling data's veracity. Future studies should investigate the effects of context, cultural variations, and repeated exposure on consumer acceptability to further advance our understanding of sensory appeal. As a result, efforts to develop an energy drink that complies with consumers' taste preferences and expectations were guided by the insights provided by the sensory hedonic evaluation. In the next research study, it is highly recommended that the correlation between physical activities and different percentages of guarana as caffeine in energy drinks be determined.

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DECLARATION OF CONFLICT OF INTERESTS

The authors have no conflict of interest.

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The Proximate Analysis and Sensory Evaluation of Super Seed Cookies

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ABSTRACT

This study aimed to determine the nutritional content and assess the consumers' acceptance of the sensory attributes of the Super Seed Cookies, which contained sacha inchi nuts, pumpkin seeds, almonds, and oats as added ingredients. The cookie was developed by a company named Mad About Cake. The cookie was analysed by measuring its proximate composition, such as moisture, ash, crude protein, crude fiber, crude fat, and carbohydrate content. This research also discovered the consumers' acceptance of the cookies by undergoing a 7-point hedonic sensory evaluation test among 30 semi-trained panelists. The proximate analysis results revealed that the Super Seed Cookies contained 4.06±0.07% of moisture, 1.80±0.04% of ash, 0.31±0.01% of protein, 3.16±0.00% of crude fiber, 7.67±0.00% of crude fat, and 83.00±0.00% of carbohydrates. In addition, the sensory evaluation results found that the consumers neither liked nor disliked all the sensory attributes of the cookies. In conclusion, improvement of the Super Seed Cookie's nutrient contents and sensory attributes is needed to make the cookies a healthy food product choice and meet the consumer's preferences before the cookies are commercialised to the market.

Keywords: almonds, cookies, oats, pumpkin seeds, sacha inchi nuts

INTRODUCTION

Nowadays, the availability of healthy foods around the world is increasing. It is because people are trying to maintain their health by monitoring their food intake since many researches have shown that daily dietary intake can influence an individual's health status. A diet can be assumed as healthy when it contains all types of nutrients that are required by the body in the appropriate amount, based on the Recommended Dietary Intake (RNI). The nutrients that should be in the diet are carbohydrates, protein, fat, fiber, water, minerals, and vitamins. According to the World Health Organization (WHO 2020), a healthy diet helps to protect against malnutrition and Non-Communicable Diseases (NCDs), such as diabetes, heart disease, stroke, and cancer. Fruits, vegetables, legumes such as beans, and nuts, and whole grains such as millet and oats are all components of a healthy diet (WHO 2020). However, the National Health Morbidity Survey 2019 found about 95% of Malaysian adults do not eat the recommended daily amount of fruits and vegetables (IHSR 2020). At the same time, the National Health Morbidity Survey 2017 showed that 2 in 3 adolescents in Malaysia ate inadequate fruits, while 23 in 25 Malaysian adolescents ate inadequate vegetables (IPH 2017). Besides, about 1 in 2 Malaysian adolescents ate inadequate amounts of legumes daily, and 1 in 3 of them consumed inadequate cereals and grains-related products daily. This problem may be a significant public health concern since the inadequate dietary intake of these foods can lead to an imbalanced diet, which may increase the risk of certain diseases, such as cardiovascular diseases, and cancers. Therefore, there is a need to have an alternative to increasing the daily dietary intake, especially involving grains, legumes, and fiber to ensure that Malaysians get sufficient nutrients, which can improve their health status. Sacha inchi nut (*Plukenetia volubilis*) has a high content of fatty acids (45–50%), protein (22–30%), and antioxidant properties (Kodahl & Sørensen 2021). Apart from that, oat is one of the

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top 10 superfoods in the world, which is high in protein, dietary fiber, lipids, vitamins, minerals, and antioxidants (Kim *et al.* 2021). Beta-glucan is a type of dietary fiber in oats that has cholesterol-lowering and antidiabetic effects (Paudel *et al.* 2021). According to the study conducted by Paudel *et al.* (2021) eating beta-glucan-rich oats or oat-based products in the daily diet can lower blood pressure and the lipid profile in people with mild hypercholesterolemia. Besides, almond (*Prunus dulcis*) belongs to the Rosaceae family and is a good source of protein, monosaturated fatty acids, dietary fiber, vitamin E, riboflavin, and essential minerals such as manganese, magnesium, copper, and phosphorus (Barreca *et al.* 2020). In a study done by Kamil and Chen (2012), they found that a standard 28 g serving of almonds provides 36.4% of α-tocopherol and 36% of manganese, 19.5% of magnesium, 16.0% of copper, 13.4% of phosphorus, 13.2% of fiber, 13.5% of riboflavin, and 12.1% of protein. However, in another study done by Barreca *et al.* (2020), they found that approximately 50% of an almond's weight is made up of fat, which is mostly Monounsaturated Fatty Acid (MUFA). The high content of MUFA can reduce the Low-Density Lipoprotein Cholesterol (LDL-c), which can help to improve cardiovascular health. Other than that, pumpkin seeds (*Cucurbita sp.*) from the *Cucurbitaceae* family have become a popular functional food due to their nutrient content and health-promoting properties. The pumpkin seeds can promote anthelmintic, antidiabetic, antidepressant, antioxidant, antitumor, and cytoprotective properties (Dotto & Chacha 2020). It is rich in fibers, protein, Polyunsaturated Fatty Acids (PUFA), minerals, phytosterol, carotenoids, and tocopherols (Syed 2019). The mineral contents of pumpkin seeds are iron, zinc, calcium, magnesium, manganese, copper, and sodium. Moreover, pumpkin seed is also a good source of phenolic compounds, which can act as antioxidants (Dotto & Chacha 2020; Amin *et al.* 2019; Koh *et al.* 2018). In addition, the cookie is a type of snack, which has a sale value of 2.34 billion Malaysian Ringgit in 2021 in Malaysia (Statista Research Department 2023). Many manufacturers have begun to add nutritious ingredients to the cookies and market the cookies as functional foods (Brown 585). For example, to reduce fat content in cookies, beta-glucan can be used to replace shortening in the batter. To improve the nutritional profile of cookies, dietary fiber, vitamin E, and omega-3 fatty acids can be used as additives in cookie preparation (Brown 585).

The aim of this study is to determine the nutrient contents of the developed cookie, which is known as Super Seed Cookies that are made from sacha inchi nuts, oats, almonds, and pumpkin seeds. The nutritional content of the cookies should be known and labeled on the packaging of the food product so that the customer can refer to the label, and it may help the customer to make a good choice whenever they want to look for foods that contain more nutrients. Besides, this study also wants to assess the consumers' acceptance of the sensory attributes of Super Seed Cookies. The results of the consumers' acceptance can be used as a reference to improve the sensory attributes of the cookies.

METHODS

Design, location, and time

The design of this research was experimental, which involved proximate analysis and 7-point hedonic sensory evaluation. The proximate analysis was conducted at the Food Analysis Laboratory, while the hedonic sensory evaluation test was conducted in the Food Sensory Laboratory at Universiti Teknologi MARA, Puncak Alam campus. The experiment was conducted from June to July 2023. Ethical approval was obtained from the Faculty Ethics Review Committee (ref. no: REC/06/2023 (MR/397).

Materials and tools

The ingredients used in the preparation of Super Seed Cookies were 432 g of butter, 500 g of brown sugar, 4 eggs, 528 g of oats, 588 g of wheat flour, 1 tablespoon of baking soda, 1 tablespoon of baking powder, 120 g of almonds, 200 g of raisins, 50 g of pumpkin seeds, and 30 g of Sacha Inchi seeds.

Catalyst tablets, Sulphuric Acid (H_2SO_4), hydrogen peroxide, deionized water, methyl red solution, bromocresol green solution, concentrated boric acid solution, Sodium Hydroxide Solution (NaOH), 1% of Hydrochloric Acid (HCl), celite 545, n- Octanol, acetone, desiccator, air oven, aluminium dish with lid, muffle furnace, electric hotplate with thermostatic

control, Silica crucible: diameter 3.5 cm, depth 4 cm, desiccators with silica gel desiccant, beakers, analytical balance, Kdejahl digestion unit, Kdejahl distillation apparatus, burette, conical flask, digestion tube, Fibertec hot extraction unit, Fibertec cold extraction unit, boiling stone were used to conduct proximate analysis.

Data collection

Proximate analysis. Proximate composition was determined according to standard procedures of AOAC International. In particular, moisture content was determined by heating 5–6 g of the sample at 105°C in an oven until constant weight measurements (AOAC 1984). Ash was determined by using the dry ashing method, in which the sample was placed in a muffle furnace at 550°C overnight (AOAC 1984). The nitrogen content of the sample was determined by using the Kjeldahl method (AOAC 1984). The crude protein content was calculated by using the conversion factor 6.25. The crude fiber was determined by using Wijkstrom fast method, in which the sample needed to undergo cold extraction, hot extraction, cold extraction, drying, and ashing process. Crude fat was determined by using the Nutritionist Pro Software and the data from the USDA databases. The carbohydrate content of the cookies was determined by subtracting 100% from the percentage of moisture, ash, crude protein, crude fat, and crude fiber.

Sensory evaluation. 30 semi-trained panelists from the Health Science Faculty were selected to evaluate the sensory attributes of the cookies. The selection of semi-trained panelists based on the inclusion and exclusion criteria for the sensory evaluation test. The inclusion criteria were healthy individuals and ages between 19–30 years old, and the exclusion criteria were smokers, individuals with hyposmia, and individuals with ageusia. The Mc Oaty Raisin Oat Cookies, and HM Cookies were used to compare the sensory attributes of the Super Seed Cookies. Besides, plain water was needed to rinse the mouth between each sample test.

The 7-point Hedonic Scale was used to measure whether the consumer liked or disliked the Super Seed Cookies. Each panelist was randomly served three different cookies: the Super Seed Cookies, the Mc Oaty Raisin Oat Cookies, and the HM Cookies. The panelists needed to rinse their mouths with water before trying each sample. After testing the samples, the panelists recorded their scores on the 7-point hedonic sensory evaluation scale based on their preferences.

Data analysis

The sensory evaluation data was analyzed by using Statistical Package for Social Sciences (SPSS) version 27.0. Analysis of variance (ANOVA) and descriptive statistics were used to investigate the significant differences in the acceptances between 3 types of different cookie brands. Besides, the Spiderweb chart is also used to compare the sensory attributes data between the three samples.

RESULTS AND DISCUSSION

The results of the proximate analysis of Super Seed Cookies are summarised in Table 1. The moisture content of the cookies was 4.06±0.07%, which was low moisture content. The low moisture content in the cookies contributes to the crunchiness of the cookies (Carter *et al.* 2015). If the moisture content of the cookies is high, it can reduce the cookie's crunchiness and lead to sogginess. According to the Food Data Central of USDA, soft oatmeal cookies with raisins had 8.85% of water content. Besides, cookies with low moisture content normally have a longer shelf life (Varghese *et al.* 2023). Apart from that, another factor that can contribute to the cookies' moisture is the ingredients used in making the cookies. The ingredients that contributed to the moisture of the Super Seed Cookies were brown sugar, raisins, butter, and eggs. Brown sugar had a higher moisture content (0.15%) than refined

Table 1. Proximate composition of super seed cookies

Proximate composition	(Mean±SD)*
Moisture content (%)	4.06±0.07
Ash content (%)	1.80±0.04
Crude Protein (%)	0.31±0.01
Crude fiber (%)	3.16±0.00
Fat (%)	7.67±0.00
Carbohydrate (%)	83.00±0.00

*Data in duplicates; SD: Standard Deviation

sugar (0.1%) and minimally refined brown sugar (0.11%) (Azlan *et al.* 2020). The high moisture content of brown sugar is due to the presence of molasses, which is a type of syrup. Besides, dark raisins are also high in moisture. It contained about 15.46 g of water per 100 g of raisins (Olmo-Cunillera *et al.* 2019). Other than that, butter is a type of fat, which contributes to the tenderness, moistness, and smooth mouthfeel of baked goods (Lauterbach & Albrecht 1994). According to Food Data Central of USDA, butter contained about 16.2 g of water per 100 g of butter.

Besides, the ash content of the cookies was 1.80±0.04%. Ash refers to the inorganic residue remaining after the complete oxidation of organic materials of food and it represents the mineral content of the foods (Nielsen 2003). In another study conducted by Desai & Bodhankar (2023) which analyzed gluten-free water chestnut flour cookies fortified with almond flour, the ash content of the cookies was 1.119%. Besides, based on the USDA database, the ash content of soft oatmeal cookies with raisins was 1.44%. Thus, the ash content of Super Seed Cookies was higher than the two cookies mentioned before, which indicated Super Seed Cookies contained more minerals than the two cookies. According to the USDA database, the ingredients that contributed to the ash content of Super Seed Cookies were pumpkin seed (4.77%), almond (3.16%), butter (2.1%), raisin (1.9%), oat (1.8%), wheat flour (1.6%), and egg (0.85%). The high value of ash content in pumpkin seeds is due to its mineral content, which is iron, zinc, calcium, magnesium, manganese, copper, and sodium (Syed 2019).

Other than that, the crude protein content of the cookies was 0.31±0.01%. The value of crude protein in Super Seed Cookies was considered as low. According to the research conducted by Megeri *et al.* (2022) protein content of multigrain cookies made from a combination of whole wheat flour, finger millet flour, and oats flour ranged between 11.5–13.8%. In another research conducted by Salazar *et al.* (2018) the crude protein content found in oatmeal cookies that used sucrose as the sugar was 9.75%±0.07. Besides, according to the USDA database, soft oatmeal cookies with raisins contain 5.79% of crude protein. Based on the comparison of crude protein content with other cookies of previous studies, the Super Seed Cookies contained a low percentage of crude protein. Even though the ingredients such as almonds, oats, sacha inchi nuts, eggs, and pumpkin seeds used in making Super Seed Cookies were known as good sources of protein, the crude protein content of the cookies was still low. Small amounts of sacha inchi nuts (30 g), pumpkin seeds (50 g), and almonds (120 g) used in making the cookies might be the reason for the low crude protein content. Another factor that might contribute to the low crude protein content was due to heat effect during the baking process. According to the study conducted by Runyon *et al.* (2015) heat treatment on oat led to a reduction in the amount of soluble proteins, which was approximately 50%. He explained that the reduced amount of soluble protein in oat during heat treatment might be due to the denaturation of soluble protein.

The percentage of the crude fiber content of the cookies was 3.16%. The fiber content of Super Seed Cookies was nearly the same as the fiber content of soft oatmeal cookies with raisins recorded on the USDA database (3.3%). The ingredients that might contribute to the fiber content of the Super Seed Cookies were oats, sacha inchi nuts, pumpkin seeds, and brown sugar. According to the studies on the nutritional compositions of sacha inchi seeds conducted by Kyaw *et al.* (2019), the fiber content of sacha inchi seeds was 8.63%, which was high. In other studies, the fiber content of sacha inchi seeds was found between the range of 6.61–11.30% (Goyal *et al.* 2022; Muangrat *et al.* 2018). However, a study conducted by Muangrat *et al.* (2018) found that the drying process of sacha inchi nut decreased its fiber content. Apart from that, another ingredient that contributed to the fiber content of the cookies was oat, which was known as a good source of β-glucan, a type of soluble dietary fiber (Sang & Chu 2017). Based on the USDA database, oats contained about 12% of total fiber. In the study conducted by Devi *et al.* (2018), the fiber content in pumpkin seeds was 4.59%. Research conducted by Azlan *et al.* (2020) found that brown sugar had higher fiber content than refined sugar, which was 2.38%.

Based on the data obtained from Nutritionist Pro Software and the USDA database, the crude fat content in the Super Seed Cookies was 7.67%. Almonds contributed to the highest content of fat, which was 2.16%, followed by oats (1.39%), butter (1.32%), pumpkin seeds (1.03%), eggs

(0.74%), sacha inchi seeds (0.56%), wheat flour (0.41%), and raisins (0.03%). Even though almond is high in fat, it contains high MUFA, and PUFA, which is good for health (Kalita *et al.* 2018). MUFA and PUFA in almonds help to reduce the LDL levels and maintain and increase the High-Density Lipoprotein (HDL) cholesterols levels (Kalita *et al.* 2018; Phung *et al.* 2009; Tey *et al.* 2015). Besides, oats, a type of cereal, are also high in unsaturated fats, which contain 34–37% of oleic acids and 36–39% of linoleic acids (Biel *et al.* 2020). Butter, an essential ingredient in baking, contained high saturated fatty acids, which was 2.4 grams of saturated fatty acids that can be obtained in one teaspoon of butter (USDA 2000). Apart from that, a study conducted by Kim *et al.* (2012) found that the major fatty acids in pumpkin seeds were palmitic acids, oleic acids, linoleic acids, and stearic acids. Besides, egg yolk is the part of the egg which contains high fat. The fatty acids found in egg yolk were oleic acids (about 40%), palmitic acids (about 30%), and linoleic acids (about 13%) (Xiao *et al.* 2020). In addition, Arachidonic Acid (AA) and Docosahexaenoic Acid (DHA), known as omega-3 also can be found in egg yolk. Oleic acid is a monounsaturated fatty acid, while linoleic acid, arachidonic acid, and docosahexaenoic acid are polyunsaturated fatty acids.

The carbohydrate content in Super Seed Cookies was 83.00%. Based on the USDA food database, soft oatmeal cookies with raisins contained 69.6% of carbohydrates, lower than the carbohydrate content in Super Seed Cookies. The difference in carbohydrate content might be due to a few factors, such as different types and quantities of ingredients used in making the cookies. The ingredients that contributed to the high carbohydrate content of Super Seed Cookies were wheat flour, brown sugar, and oat. Research conducted by Kumari and Sindhu (2019) found that carbohydrate content in cookies made from a combination of refined wheat flour and germinated pumpkin seed flour was within the range of 45.04% to 60.04%. The result of the study showed that the germinated pumpkin seed flour contributed to a lower carbohydrate content in the cookies. Wheat flour contributed to a high carbohydrate percentage because it contains starch, a type of complex carbohydrate. According to the USDA database, the carbohydrate content in 100 g of wheat flour is about 72 g, while 69.8 g in 100 g of oats. In addition, brown sugar also contributed to the high carbohydrate percentage of Super Seed Cookies, as it primarily contained sucrose, a type of simple sugar.

Sensory characteristics of cookies. The summary of colour, aroma, taste, crunchiness, and overall acceptability of the cookies is shown in Table 2 and Figure 1. HM cookies had the highest score in color, aroma, taste, crunchiness, and overall acceptability, while the Super Seed Cookies had the lowest score for all attributes. The HM cookies had the highest score for color due to the appearance of red cherry in the cookies, which made the cookies look attractive. In comparison, MC Oaty Crunch and Super Seed Cookies contained raisins instead of cherries.

Apart from that, in terms of taste, the Super Seed Cookies had the lowest score, while the HM cookies had the highest score. The difference in taste score might be due to some different ingredients used in making the cookies. Chocolate chip and cherry, which were contained in the HM cookies, made the cookies taste sweet, while the sacha inchi seed, almond, and pumpkin seed, which were contained in the Super Seed Cookies, made the cookies taste nutty. A study that was conducted by Espinosa-Páez *et al.* (2021) also showed that panellists preferred cookies with

Table 2. Comparing the mean score per attribute with the standard deviation between the cookie samples (n=30)

Sample	Color	Aroma	Taste	Crunchiness	Overall acceptability
Super seed cookies	5.03±1.13	4.20±1.50$^{\alpha}$	4.50±1.87$^{\alpha}$	5.23±1.41$^{\alpha}$	4.63±1.30$^{\alpha}$
Mc Oaty Crunch	5.47±1.14	4.53±1.33$^{\alpha}$	4.87±1.28$^{\alpha}$	5.27±1.26$^{\alpha}$	5.13±1.17$^{\alpha}$
HM Cookies	5.67±1.18	5.40±1.50$^{\alpha}$	6.00±1.44$^{\alpha}$	6.20±0.89$^{\alpha}$	6.03±1.10$^{\alpha}$

*Mean score per attribute with standard deviation are indicated as (±)

**Significance levels are indicated as α=($p<0.05$). P-value was calculated via analysis of variance test (ANOVA)

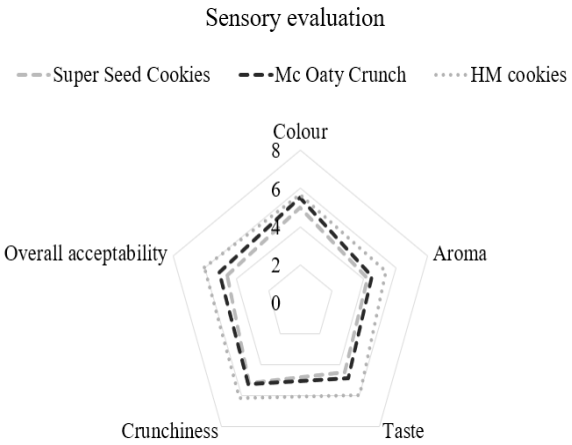

Figure 1. Spiderweb chart for the sensory data of the Super Seed Cookies, Mc Oaty Crunch Cookies and HM Cookies

cocoa flavours. Another factor contributing to the lowest taste score for Super Seed Cookies was the aftertaste of the cookies, which came from sacha inchi nuts. Besides, the food's aroma is closely related to the taste of the food. The food's aroma would influence the taste of the food. The HM cookies had the highest score, while the Super Seed Cookies had the lowest score for the aroma attribute. The lowest aroma score in Super Seed Cookies might be due to the nutty and earthy aroma, which came from sacha inchi nuts and pumpkin seeds. However, a study conducted by Alshehry (2020) showed that the panellists preferred the cookie's flavour with high percentage content of pumpkin seed. The highest aroma score in HM Cookies might be due to the cocoa aroma, which came from chocolate chips. The crunchiness score for Super Seed Cookies and Mc Oaty Crunch were nearly identical, while the crunchiness score for HM cookies was the highest. The cookies' crunchiness is related to the sugar types used in making the cookies. The Super Seed Cookies and Mc Oaty Crunch were nearly identical because they are made from brown sugar, while the HM cookie is made from white sugar. Since brown sugar contains more moisture than white sugar, it causes the cookies made from brown sugar less crunchy than the cookies made from white sugar. Since the HM cookies had the highest score for all attributes, it is good to make the HM cookies the benchmark to improve the quality of the Super Seed Cookies in the future.

CONCLUSION

This research aimed to determine the moisture, ash, crude protein, crude fiber, and crude fat and carbohydrate content of the Super Seed Cookies and also to determine the consumer acceptance of the cookies. Based on the proximate analysis and sensory evaluation results, it can be concluded that the Super Seed Cookies contained 4.06% of moisture, 1.80% of ash, 0.31% of crude protein, 3.16% of crude fiber, 7.67% of crude fat and 83% of carbohydrates, and consumer was neither like nor dislike all the sensory attributes of the cookies. The results indicate improvement of the Super Seed Cookie's sensory attributes is needed before the cookies are commercialized to meet the consumer's preferences. The recommendation for future research was to analyze the cookies' calories, water activity, and trace elements.

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DECLARATION OF CONFLICT OF INTERESTS

The authors declare that they have no competing interests.

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Development and Validation of Postnatal Diet, Lactation, and Emotion Management (LEDies) Module

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ABSTRACT

This study aims to develop and validate a module on managing diet, lactation, and emotion for postnatal mothers. This cross-sectional study involves three phases: needs assessment, module development, and module validation. About 37 mothers aged 18 to 49 years old with infants less than 6 months were recruited, and information on postnatal care practices, lactation knowledge, and emotion were obtained for module development. The guidelines from the Ministry of Health Malaysia and literature served as the foundation for the module that was developed following the requirements assessment utilizing the Health Belief Model (HBM). Content and face validity of the module is carried out to validate the developed module. The validation form used was adapted from Silveira de Castro (2007) which consists of seven criteria, two criteria related to content validity and another five criteria related to face validity. The content validity was assessed using a Content Validity Index (CVI). CVI was calculated using two different formulas: I-CVI and S-CVI. Meanwhile, a level of agreement was used in the data for the module's face. From the need assessment, most mothers with restricted seafood and nuts intake struggled to breastfeed and about 21.6% of them experienced postpartum depression. The developed module has been validated with both mean I-CVI and S-CVI more than 0.78 and 0.80, respectively. Meanwhile, five face validation components achieved 75% agreement, confirming the validity. In conclusion, the developed module named The LEDies has good validity and can serve as teaching material for postnatal mothers caring for themselves and their infants during the postpartum period.

Keywords: emotion, lactation, postnatal diet, traditional practices

INTRODUCTION

A postpartum period usually lasts six weeks after giving birth, mothers experience physiological, psychological, and social changes. The Malaysian postpartum period involves formalities, ceremonies, and cultural habits. Traditional practices, particularly dietary, can harm postpartum mothers, restricting nutritious food intake (Jusoh & Tengku Ismail 2022). Food restrictions may reduce the source of protein and other essential nutrients needed for healing.

The mother's health could suffer from the reduction of various key nutrients. According to Recommended Nutrient Intake Malaysia 2017, breastfeeding mothers need an additional 500 calories, but traditional practices may not meet postpartum needs. Maternal vitamin insufficiency decreases breast milk's fat and water-soluble vitamin levels, and cultural practices impact intake (Nurrachmawati *et al.* 2019). Mother needs adequate water during breastfeeding to produce sufficient milk. Meanwhile, postpartum depression can be avoided with a healthy diet that includes enough Docosahexaenoic Acid (DHA). Depression can also be impacted by low Polyunsaturated Fatty Acid (PUFA) consumption, insufficient folate, and vitamin B12 intake, and decreased mother-child bonds (Mughal *et al.* 2022).

Studies on the effects of nutrient insufficiency on postpartum mothers which may impact breastfeeding outcomes and contribute to postpartum depression are lacking in Malaysia. Thus, this study is conducted to develop a module that will serve as a medium for mothers

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to manage their dietary intake, lactation practices, and emotion control. Moreover, developing a postnatal management module is crucial as it may reduce malnutrition, enhance the health of mothers, and avert future problems.

METHODS

Design, location, and time

Module design, development, and validation began from December 2022 until August 2023. There were three phases in conducting this study: Phase 1: needs assessment, Phase 2: module development, and Phase 3: module validation. In Phase 1, 37 mothers aged 18 to 49 years old with infants less than 6 months were recruited to observe the postnatal care practices, lactation knowledge, and emotional control obtained for module development purposes. Meanwhile, in Phase 2, The LEDies module developed using the Health Belief Model (HBM), was based on guidelines from the Ministry of Health Malaysia, literature, and needs assessments. Phase 3 involved an expert team comprised of a lecturer from Center for Dietetics Studies, a dietitian from the Diet Care Centre at UiTM Puncak Alam, and a dietitian from Hospital Melaka. The experts were consulted through email and the questionnaire needs to be answered in Google Forms. The needs assessment was conducted in a health facility which is in Klinik Kesihatan Meru, Klang, Selangor while the validation process that involved both expert and target users was conducted online through Google Forms. The Medical Research & Ethics Committee approved this study with reference number NNMR-19-4204-52471 (IIR).

Sampling

This study used purposive sampling with inclusion criteria which are the mothers of infants under the age six months who are between the ages of 18 and 49, have a singleton baby, are healthy, can communicate in English and Bahasa Melayu effectively, and live in the Klang areas. A study by Nurrachmawati *et al.* (2019) utilized 27 samples for the needs assessment, therefore, with additional of 40% for attrition rate, this study recruited 37 respondents for needs assessment. The needs assessment required the respondents to answer socio-demographic information, confinement practices knowledge, lactation practice and knowledge, and the Edinburgh Postnatal Depression Scale (EPDS). Three experts were chose to validate the content of this module. According to Polit *et al.* (2007), the involvement of three or more experts is indicative of significant content validity. The panelists provided diverse suggestions from various specializations (Lau *et al.* 2019). Meanwhile, a study by Shuhaimi *et al.* (2023) demonstrates 16 samples of the target audience were used for face validation while Hazaha *et al.* (2023) used 30 samples. Thus, this study recruited 18 postnatal mothers who have been followed up from the Needs Assessment conducted in Klinik Kesihatan Meru.

Data collection

The sample collected from the mothers who visited public health facility, Klinik Kesihatan Meru, and passed the inclusion criteria. The study permission and an informed consent were obtained from the participants. The needs assessment questionnaire was categorized into four categories which were socio-demographic information, confinement practices knowledge, lactation practice and knowledge, and Edinburgh Postnatal Depression Scale (EPDS). The postnatal care practices questionnaire was adapted from (Ghani & Salehudin *et al.* 2018) which consists of 13 questions assessing food restriction during confinement using dichotomous and open-ended methods. Meanwhile, the CDC Postnatal Questionnaire used the Likert scale and 9 multiple-choice questions to assess breastfeeding and infant formula feeding practices (CDC 2023). Lastly, the validated Malay version of EPDS consisting of 10 questions was used to screen postnatal depression among the mothers. A score of 12 or higher was used as the cut-off point for positive screening of depression (Kadir *et al.* 2004).

The validation form derived from an instrument proposed by Silveira de Castro *et al.* (2007) was used in this study. It consists of 7 criteria where two criteria (scientific accuracy and content) are related to content validity and another five criteria (literary presentation, illustrations, sufficiently specific and understandable material, legibility and printing characteristics, and quality information) related to face validity. The validation form consists both of closed and open-ended questions. The content validity requires the experts to rate the items based on relevance using

a scale of 1 (no relevance), 2 (revision needed), 3 (relevant but minor revision), and 4 (very relevant). Meanwhile, face validity requires both the experts and the target user to answer "yes" or "no" since it uses close-ended dichotomous questions.

Data analysis

The analysis of the need assessment was performed using the statistical program International Business Machines (IBM) Statistical Package for the Social Sciences (SPSS) version 27. Descriptive statistics are used to present the results, which include mean or average, standard deviation, frequency, and percentages of data obtained.

The content validity was calculated using Content Validity Index (CVI) which is divided into I-CVI (Item-Level Content Validity Index) and S-CVI (Scale-Level Content Validity Index). In this study, there were three experts validated the module content validity. A score of I-CVI must be at least 0.78 and S-CVI must be at least 0.80 in a study with three to five experts to demonstrate good content validity (Polit *et al.* 2007). Next, face validity implies the level of agreement based on the five criteria which include literary presentation, illustrations, sufficiently specific and comprehensive material, legibility, printing characteristics, and quality of information. Items were considered validated if they had at least 75% positive responses (Lau *et al.* 2019).

RESULTS AND DISCUSSION

Phase 1: Needs assessment

Figure 1 demonstrates that most mothers restrict seafood intake, with 45.9% agreement, as it may cause itchiness, pus, and slow wound recovery. Besides, they also strongly agreed (27%) to restrict bean and nuts consumption due to gassy, discomfort, allergies, and itchiness concerns during the confinement. Meanwhile, most mothers breastfeed their babies from both breasts in the first week, lasting 20–29 minutes. About 23 (62.2%) of the mothers feed their children with formula milk or other foods in less than 1 month, 6 (16.2%) at 1 to 2 months, 1 (2.7%) at 3–4 months, 3 (8.1%) at 5–6 months, and 1 (2.7%) at 9 months, respectively (Table 1). This suggests that most mothers faced difficulties in meeting the six-month exclusive breastfeeding recommendation by WHO. Next, the mean EPDS score of postnatal women participating in the study was 6.86±5.21. This study finds that 21.6% (n=37) of mothers have experienced postnatal depression which suggests that there is a need to develop an educational module for the purpose of providing knowledge on healthy postnatal diet, lactation, and stress management.

Phase 2: Module development

This module is named "The LEDies" (pronounced as ladies). Lactation, emotion, and diet were denoted by capital letters L, E, and D, respectively. It was designed using Canva, a graphic design software that allows anyone to design anything. This module consists of 42 pages including the covers, and is written in English to allow postnatal mothers of all ethnicities to understand this module easily. The content and pages are used in a variety of color pallets to enhance the visual search of the mothers. Besides, infographics and diagrams were also implied to convey the information effectively. This module includes three main chapters:

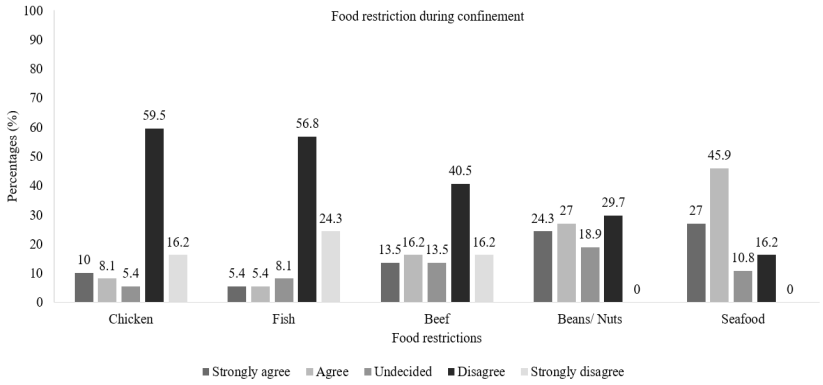


Figure 1. Level of agreement on food restriction during confinement among the study population

Table 1. Lactation practice and knowledge (n=37)

Lactation practice & knowledge	Number (n)	Percentage (%)
Method of breastfeeding a newborn baby in the first weeks		
Breastfeed only	27	73.0
Formula feed only	1	2.7
Both breast and formula feed	9	24.3
Baby typically feeds from both breasts		
Yes	32	86.5
No	5	13.5
Baby typically releases breasts after feeding		
Both breast	30	81.1
First breast only	4	10.8
No	3	8.1
Average duration of breastfeeding		
<10 minutes	8	21.6
10–19 minutes	8	21.6
20–29 minutes	13	35.1
30–39 minutes	8	21.6
Baby's age when first feeding formula or other foods		
<1 month	23	62.2
1–2 months	6	16.2
3–4 months	1	2.7
5–6 months	3	8.1
7–9 months	3	8.1
>9 months	1	2.7
Frequency with which babies finish formula bottles		
Never	13	35.2
Rarely	2	5.4
Sometimes	8	21.6
Most of the time	7	18.9
Always	7	18.9
Baby's age to stop breastfeeding		
<1 year old	15	13.5
1–2 years old	19	51.4
2–3 years old	12	32.4
Depends on the milk supply	1	2.7
The best method to feed a baby		
Breastfeeding	32	86.5
Both breastfeeding and formula feeding	3	8.1
Breastfeeding and formula are equally good	2	5.4

Diet Management, Lactation Management, and Emotion Management, each with a message, overview, content, and expected output. In Diet Management, it covers on educating the importance of healthy diet management for postnatal mothers, together with suggestion menu for breastfeeding mothers. Meanwhile, mothers will be exposed on the benefits of breastfeeding for both babies and mothers, techniques, and tips in ensuring a successful breastfeeding in Lactation Management. Finally, in Emotion Management, special topics on educating mothers on stress management during postpartum.

Phase 3: Module validation

Based on Table 2, "Scientific Accuracy" received an I-CVI of 1.00 for each item in the module's content, whereas "Content" received an I-CVI of 1.00. Moreover, experts highly agree on content validity using the S-CVI formula, where the score obtained is 1.00. The I-CVI and S-CVI results show more than 0.78 and 0.80 respectively, thus, this module is declared content validated. Meanwhile, for face validity, five evaluation criteria including literary presentation, illustration, the material is sufficiently specific and understandable, legibility and printing characteristics, and quality of information, were calculated by the level of agreement. Figure 2 revealed the experts agree on the module's face validity, with 93% to 100% agreement, exceeding 75%. They recommend improving content with graphics and sentences. Meanwhile, Figure 3 demonstrates the target user which involved the postnatal mothers from the need assessment had a strong agreement on face validity criteria, with range percentages of 96% to 100%. Thus, the module achieved face validity for postnatal mothers.

According to various research conducted in Malaysia, traditional postpartum practices are frequently followed by mothers after giving

Table 2. Content validity index for "The LEDies" module by expert panels (n=3)

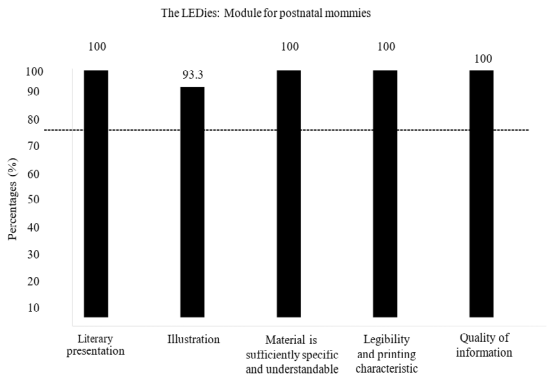
Criteria	Item description	Relevant (Rating 3 or 4)	Not relevant (Rating 1 or 2)	I-CVI[a]	Interpretation[b]
Scientific accuracy	Contents are in agreement with current knowledge	3	0	1.00	Relevant
	Recommendation is necessary and correctly approached	3	0	1.00	
Average CVI				1.00	
Content	There is no unnecessary information	3	0	1.00	Relevant
	Recommendation about the desired behavior is satisfactory	3	0	1.00	Relevant
	There is no unnecessary information	3	0	1.00	Relevant
	Important points are reviewed	3	0	1.00	Relevant
Average CVI				1.00	
S-CVI/Ave[c]				1.00	Excellent

[a]Item-level Content Validity Index (I-CVI); The number of expert panels that agreed with the items by ranking them as relevant (rating 3 or 4) divided by the total number of expert panels (n=3)

[b]I-CVI is greater than 0.78, indicating that the items are relevant

[c]S-CVI/Ave (Scale-level Content Validity) index based on the average method)

The sum of I-CVI scores divided by the number of items; The value of S-CVI is exceed 0.80; Thus, it has an excellent content validity; CVI: Contet Validity Index



-------: An item must have at least 75% positive responses to be certified validated

Figure 2. Level of agreement among experts for face validity

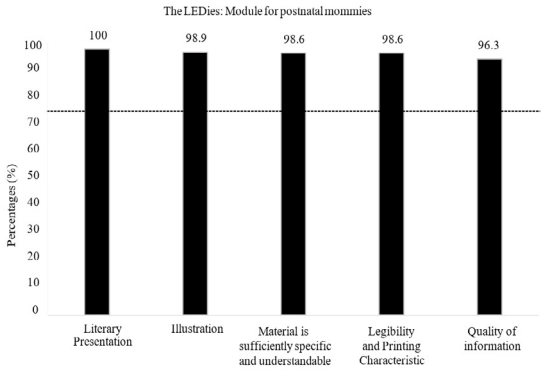


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Figure 3. Level of agreement among postnatal mothers for face validity

birth. It is well known that Asian cultures have a higher prevalence of confinement practices. Malaysian women use traditional practices to recover postpartum health (Myint *et al.* 2019). Moreover, dietary adjustments help to balance the cold states of pregnancy and delivery (Basir *et al.* 2019). Most mothers in this study restrict seafood and nuts intake during confinement due to concerns about wound healing, itching, and potential allergic reactions in newborns. Based on the study by Basir *et al.* (2019) in Penang, Malaysia also found that mothers restrict nut intake for bloating. Women worldwide avoid certain foods such as coconut milk and yam post-birth due to blood loss during delivery (Poh *et al.* 2005). Thus, the mother needs to follow guidelines to improve health and breastmilk production whether by forbidding or encouraging the consumption of particular foods.

This present study demonstrates that most mothers were unable to comply with the WHO recommendations to exclusively breastfeed their infants for at least six months. Many mothers introduce their infants to formula milk or other foods when they are younger than 6 months old. Moreover, even though the percentage of mothers who may be diagnosed with postpartum depression is small, it nevertheless suggests that the mothers need assistance and support in managing their emotions during the critical period of postpartum. According to Schiller *et al.* (2015), Postpartum Depression (PPD) is still a common disorder, and its causes are still unknown, despite decades of research into the disorder. However, PPD is a treatable, complex mood illness that is frequently misdiagnosed. Numerous studies have shown that various foods and nutrients have antidepressant properties via several pathways (Rupanagunta *et al.* 2023). Increased levels of DHA in breast milk and higher seafood intake have been associated with lower PPD rates (Chatzi *et al.* 2011). Thus, this study aims to develop a tool for mothers to understand a healthy diet's impact on emotions and lactation. Generally, breast milk contains numerous proteins, PUFAs, and a complex microbiome (Kim & Yi 2020). It promotes microbial colonization in infants, aids digestion, protects against pathogens, and increases mucine production, improving intestinal barrier functions. Breast milk provides essential microbiota, immune components, and supports the infant's immune system development (Mikšić *et al.* 2020). Besides, breastfeeding may reduce postpartum depression and improve maternal mood. Comparatively, to mothers who did not exclusively breastfeed, prenatally depressed mothers who breastfed exclusively reported fewer symptoms and reduced rates of postpartum depression (Dias & Figueiredo 2015).

This module was developed using Canva and given the name “The LEDies”. It is printed in an A5 format booklet, which reduces eye strain compared to reading online material. Besides, the module was designed for diverse mother learning styles. Graphic representation is believed to cater to most learning styles effectively. Bušljeta (2013) state that the best visual representations are paintings, caricatures, maps, sketches,

timelines, and diagrams. Hence, this module uses a variety of pictures and diagrams to grasp the mother's attention. The LEDies module also implies colorful content and pages which may help the mothers with visual search. Colorful modules enhance reader concentration, enhancing information retention in short- and long-term memory (Diachenko *et al.* 2022) Finally, the module included infographics to convey the information efficiently and improve memory retention. According to Dunlap and Lowenthal (2016), infographics enhance reader comprehension and retention of information through visual appeal.

One of the study's strengths is the developed module's adaptation to the needs of postnatal mothers in Malaysia. The recommendations used in this module were based on the Malaysian Dietary Guidelines 2020 and integrated into Malaysian culture. Besides, the module also has been validated by experts, content improvement enhances effectiveness in the intervention study. However, the study's limitation is the small number of validation experts, with most recommendations of six to ten (Yusoff 2019). Thus, future research requires a larger expert sample size for better control over the chance agreement. The module also recommends being translated into Malay to overcome the language barriers.

CONCLUSION

A module on controlling diet, lactation, and emotions was developed especially for this study to reduce the risk of malnutrition, which can lead to postpartum depression and early nursing cessation. The module has been validated by experts and faces validated by postnatal mothers. All two content validity criteria were successfully obtained, indicating that the module had good content validity. Furthermore, five components of face validation received more than 75% agreement. In conclusion, the module can be used to improve the breastfeeding approaches, emotional control, and nutrition understanding of postpartum women.

ACKNOWLEDGEMENT

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DECLARATION OF CONFLICT OF INTERESTS

The authors have no conflicts of interest.

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Effect of *Kappaphycus alvarezii* and Overripe Banana Sweetener Addition on the Nutritional Composition and Palatability of Cookies

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ABSTRACT

This study aimed to assess the qualities of butter biscuits made with seaweed flour (*Kappaphycus alvarezii,* (KA) (0, 4, and 8%) and Overripe Banana Sweetener (ORBS) (0, 50, and 100%) as a partial replacement for wheat flour and table sugar. A.O.A.C. and hedonic methodologies have been used to analyze the nutritional composition, color, and sensory evaluation of butter cookies. The increase in ORBS in cookie formulation resulted in a significant rise in the nutritional qualities of butter cookies, according to the result. Butter cookies with 4% seaweed flour and 100% ORBS had higher total dietary fiber (19.6%) and ash (3.07%) values. Sensory scores for the control (0%) and 4% seaweed flour-incorporated cookies did not differ substantially across all sensory qualities. However, the addition of 4% seaweed flour and 50% ORBS resulted in the highest scores for aroma, flavor, and overall acceptance. In conclusion, substituting 4% seaweed flour for wheat flour and 50% ORBS for table sugar could be an effective combination to make nutritious and tasty butter cookies.

Keywords: banana sweetener, cookies, *kappaphycus alvarezii*

INTRODUCTION

Knowledge and prevention of chronic diseases are the most significant issues that need attention in the twenty-first century. As the name implies, a chronic condition lasts a long time and is challenging to treat. Chronic illness development can be influenced by lifestyle factors like stress, imbalanced diet intake, and physical inactivity, according to research conducted in the last ten years (Barber *et al.* 2020). For most people, food is the most essential thing. Healthy eating has entered the mainstream in the current context, where life quality has increased (Timper & Brüning 2017). Foods low in fat, carbohydrates, and dietary fiber have sparked widespread concern and interest (Harcombe 2016; Hinde 2019) among the public. Many studies are now being conducted to develop nutritious and healthful foods.

Among nutrients, dietary fiber has a significant impact on health benefits (Weickert & Pfeiffer 2018). The European Food Safety Authority (EFSA) defines dietary fiber as nondigestible carbohydrates plus lignin (Hijová *et al.* 2019). The EFSA classifies dietary fiber as ingredients such as cellulose, fructooligosaccharides, hydrocolloids, pectins, and resistant starch (Hijová *et al.* 2019). Dietary fiber comes in two types: soluble and insoluble. Grains and whole grain products include insoluble fiber, whereas fruits and vegetables have soluble fiber. According to research, soluble fiber is more likely than insoluble fiber to ferment (Prasad & Bondy 2019). As a result, incorporating grains into diets can provide health benefits such as protection against long-term illnesses such as diabetes, obesity, and colon cancer (Xiong *et al.* 2019).

As a functional food, seaweed can be consumed since it is high in dietary fiber, which is very beneficial to human health (Huang *et al.* 2022). Seaweed is categorized into three categories: red, green, and brown. Red seaweed is the most commonly used seaweed in carrageenan, followed by green and brown seaweed (Torres *et al.* 2019). The red seaweed like *Kappaphycus alvarezii* (KA), Chondrus crispus, and Sarcothalia crispate are often employed as the primary sources in the carrageenan production. It

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is extensively utilized throughout many different industries, particularly the food sector (Naseri *et al.* 2019). The KA is straightforward to cultivate and proliferate (Gereniu *et al.* 2017). According to related studies, soluble dietary fiber found in the seaweed KA. may be a useful food that helps prevent or reduce colon cancer (Raman & Doble 2015). Reduced reliance on wheat flour imports can be achieved by using seaweed flour of KA, which is recognized as an alternative local ingredient with good nutritional value (Munandar *et al.* 2019).

Banana (*Musa sp.*) highly available in the tropical countries of Malaysia. It is one of the most popular fruits in the market due to its rich nutritional value and wide planting area (Clement *et al.* 2019). Because of the unappealing/ darkening color of its skin, it is often abandoned due to its high yield and ease of degeneration during maturation. As a result, when processing functional foods, it makes sense to use overripe bananas to produce Overripe Banana Sweeteners (ORBS); on the other hand, it is more natural and healthier because it is prepared from overripe bananas rather than refined sugar (Kumar 2022). The ORBS has a low glycemic index Ng *et al.* (2020b) and can be used as a natural sweetener to replace refined crystal sugar in the production of low GI foods.

The flavor, texture, and color of butter cookies make them a particularly popular bakery item in Malaysia. Flour, sugar, butter, egg, and other ingredients are the main ingredients of butter cookies (Hu *et al.* 2022). Regular consumption of butter cookies may increase the risk of developing chronic diseases due to their high sugar, fat, and dietary fiber content. Consequently, a statement that shows KA flour rather than regular flour and ORBS made from overripe bananas rather than regular sugar are a good combination to improve the nutrient quality of butter cookies. The purpose of this research was to elucidate the nutritional value, color, and sensory evaluation of cookies made from KA powder and ORBS.

METHODS

Design, location, and time

In this study, two experimental samples and one control sample were used. The experimental samples were butter cookies mixed with 0, 4, and 8% seaweed flour and 0, 50, and 100% ORBS to partially replace wheat flour and sugar, respectively. The control was a butter cookie made without the inclusion of seaweed flour (0%) and ORBS (0%). The sensory evaluation, Total Dietary Fiber (TDF), color analysis, and proximate analyses of the control and experiments were compared.

The study was carried out at the Food Preparation Laboratory and Analytical Laboratory, Health Campus of Universiti Sains Malaysia (USM). The study was conducted from September 2023 to March 2024. Before this studied was carried out the ethical approval for this study was acquired from the Human Research Ethnics Committee (HREC) USM with study protocol code of USM/JEPeM/KK/23050423.

Materials and tools

The fully ripened of the Musa acuminata cv. Berangan banana were purchased at a local supermarket in Kubang Kerian, Kelantan, Malaysia. Mainly color changes in banana during ripening are based on the peel color rather than the pulp color.

A color chart and physical inspection were used to compare the peel's color and hardness to assess the stage of ripening. Stages 1 through 3 of a banana peel's development are when it is hard and green in color; stages 4 and 5 are when the peel is flexible and entirely yellow with a growing number of brown patches (Karim *et al.* 2018).

Banana extraction was carried out with a few minor modifications by (Ng *et al.* 2020a). The banana pulps were blended in a 1:3 water to banana pulp ratio and then centrifuged at 4°C for 25 min at 15,000 g. To extract the clear top banana juice, filter paper Whatman No. 4 was used. To eliminate the moisture, 50 g of banana juice was dehydrated at 60°C for 16 hours in a thermal dehydrator (Anywin FD770, China). After that, the concentrated syrup was maintained at 4°C in a screw-top bottle for later analysis and usage. A hand refractometer (Atago 3851 PAL-BX/RI, Japan) and a microprocessor pH meter (HANNA. pH 211, USA) were used to test the syrup's Total Soluble Solids (TSS) °Brix and pH, respectively.

Butter cookies were made with wheat flour, corn flour butter, margarine, castor sugar, baking powder, and eggs as the primary ingredients. The recipe was adopted with slight modifications (Ng *et al.* 2020b). Imtanomic Sdn Bhd is the supplier

of seaweed flour (KA). Butter and castor sugar were mixed in a bowl with an electric hand mixer. The egg was then gradually added, beating the mixture until it had a creamy consistency. The mixture was stirred for five min after adding all of the dry ingredients before being refrigerated for two hours. With a 5 cm diameter mold, the cold dough was gently molded into a 3 mm thick disc. After that, they were put on a baking pan and baked for ten minutes at 170°C. After a half-hour of cooling at room temperature, the cookies were crushed into flour and kept at 4°C until additional nutritional analysis was conducted.

Previously, an optimization experiment was carried out to select the two most optimized formulas based on texture profiles analysis data analyzed from 16 treatments utilizing Response Surface Methodology (RSM). Three variables were set with varied combinations of KA. powder: wheat flour, ORBS: table sugar, and butter: margarine. In this optimization study, wheat flour was partially substituted with seaweed flour at percentages of 0, 4, and 8%, while ORBS and butter were used to partially substitute sugar and margarine at percentages of 0, 50, and 100%. Both treatment-12 and treatment-14 are the most optimal formulae obtained from our preliminary study (Ali *et al* 2014). For treatment-12, 41 g of ORBS, 3 g of KA and 40 g butter were added into the butter cookies. As for treatment-14, 20.5 g of ORBS, 3 g of KA, 20.5 g sugar and 20 g margarine were added.

Procedures

The analysis of moisture, total ash, fat content, and protein was conducted by AOAC (2020). The proximate composition of butter cookies was determined using an air-oven method for moisture, a dry-ashing method for total ash, a Kjeldahl method for protein, and a Soxhlet method for fat. Furthermore, Eq. 1 was used to compute the carbohydrate content:

Total carbohydrate = 100-(moisture+ash+ protein+fat+dietary fiber) (Eq.1)

The Total Dietary Fiber (TDF) was measured using the TDF kit from Sigma Chemical Company and an enzymatic method based on AOAC (2020) (St-Louis, MO).

Sensory evaluation of butter cookies was performed by 30 untrained panels involving staff and students at the School of Health Sciences, Universiti Sains Malaysia Health Campus. The samples were coded with a three-digit permuted number and evaluated using the seven-point hedonic scale method. Aroma, color, appearance, crispiness, flavor, and general acceptance were the sensory characteristics studied (1 being the most disliked and seven being the most liked) according to Sharif *et al.* (2017).

According to (Gat & Ananthanarayan 2015), Hunter color characteristics (L*, a*, b*) were measured for cookies formulated with added seaweed flour and ORBS. Color measurement was carried out using a Hunter Lab colorimeter (LabScan XE, Hunter Associates Laboratory, Reston, VA, USA) and the Easy Match QC programmer. The color points in this color space are identified by three color coordinates. L* is the brightness coordinate, a* is the redness coordinate to greenness coordinate, b* is the yellowness coordinate to blueness coordinate. From no reflection for black (L*=0) to perfect diffuse reflection for white (L*=100). The 'redness' coordinate, a*, ranges from a negative value for green to a positive value for red. 'Yellowness' coordinate (b*) ranges from positive values for yellow to negative values for blue. The reported values for each sample were the three replicates' average values (Gat & Ananthanarayan 2016).

Data analysis

All data were analyzed using one-way repeated measure Analysis of Variance (ANOVA), Tukey's posthoc test, and Design-Expert software (v.7.0.0, State-Ease, Inc., Minneapolis, USA). For data analysis, SPSS, version 24.0, was employed. Founded in Chicago, Illinois, SPSS. Inc. Three batches of cookies prepared with seaweed flour and OBS butter were created for all measurements. Except for sensory evaluation (n=30), results were reported as the mean of three replicates and the $p<0.05$ significance level was chosen.

RESULTS AND DISCUSSION

Proximate compositions

Table 1 shows the nutritional information for butter cookies made with varied amounts of seaweed flour as a partial substitution for wheat flour. The results showed that when the amounts of ORBS increased, the ash and moisture levels of butter biscuits increased from experiment-14 to experiment-12. Treatment-12 cookies had

Table 1. Nutritional composition of butter cookies formulated with KA flour and ORBS

Nutritional analysis	Control (%)	Experiment 12 (%)	Experiment 14 (%)
Moisture	4.57±0.04[a]	15.09±0.11[b]	8.02±0.10[c]
Ash	0.82±0.06[a]	3.07±0.05[b]	2.53±0.05[c]
Fat	20.01±0.26[b]	20.38±0.16[b]	20.92±0.08[a]
Protein	6.89±0.28[a]	6.79±0.06[a]	6.88±0.11[a]
Carbohydrate	67.73±0.57[a]	54.67±0.20[c]	62.00±0.57[b]
Total Dietary Fiber (TDF)	14.70±0.03[c]	19.62±0.06[a]	16.61±0.05[b]

The analysis was replicated three times (n=3) and was expressed in Mean±SD

[a-b]: Mean±SD with different superscript letters within the same row indicate significant difference ($p<0.05$)

KA: *Kappaphycus alvarezii*; ORBS: Overripe Banana Sweetener

the highest moisture content (15.09%) when compared to treatment-14 and the control group (8.02 and 4.57%, respectively). The increased moisture content could be attributed to the fact that treatment-12 was produced with 100% ORBS and zero% table sugar. In actuality, ORBS contains soluble fibers and pectin, which trap more moisture than in experiment-14, in which cookies are baked with 50% ORBS and 50% table sugar.

The different rates at which sugar dissolves when mixed impact how much the moisture content rises. Dryer cookies are baked when crystalline sucrose evaporates more easily because it interacts with water less frequently. Conversely, high glucose and fructose moisture absorption in ORBS leads to increased hydrogen bonding interactions with water and decreased evaporation during baking, resulted in the chocolate cookies being studied containing a higher moisture content (Ng *et al.* 2020a). The moisture content of control cookies made with 100% table sugar was the lowest. Because table sugar lacks dietary fiber, it is incapable of retaining moisture during cookie preparation and baking.

The high Dietary Fiber (DF) content of ORBS and KA may absorb a substantial amount of water, causing a rise in the moisture content of cookies after baking. Ng *et al.* (2020b) found a similar finding, noting that cookies created with ORBS had a higher moisture content than cookies made with lower quantities of ORBS. Furthermore, KA seaweed has a good water-holding capacity during preparation and baking (Mohammad *et al.* 2019). As a result, it enhances the water content of cookies (experiment-12 and experiment-14).

Experiment-14 also revealed a statistically significant ($p<0.05$) increase in moisture and ash content when compared to the control. When ORBS was added to all formulations, there was a significant difference ($p<0.05$) in the ash concentration which increased from 2.53% to 3.07% as ORBS increased from 50% in Experiment 14 to 100% in Experiment 12. The high ash concentration of ORBS and KA powder was primarily responsible for this increment. The increased level of ash in experiment-12 (3.07%) was attributable to the high concentration of ORBS (100% ORBS and zero% table sugar) utilized in the formulation. Both cookies (experiments 12 and 14) had considerably greater ($p<0.05$) ash concentrations (2.53 and 3.07%) than the control (0.82%). The increased concentration of ash in experiments 12 and 14 is attributable to the fact that the dehydrated KA used in the cookies had a higher ash content (48%) (Neoh *et al.* 2016), whereas the control cookie was not formulated with dehydrated KA They discovered that the ORBS has a higher ash content and a significant proportion of TDF.

The inclusion of KA. results in the highest value of TDF in cookies for both experiment-12 (19.6%) and experiment-14 (16.6%) but not in control cookies (14.7%). The higher TDF content in cookies from experiment-12 compared to cookies from experiment-14 is due to the addition of 100% ORBS replacing table sugar in experiment-12, but only 50% ORBS was used to replace table sugar in cookies from experiment-14. Ng *et al.* (2020b) also reported that the addition of ORBS to cholate cookies increase the TDF value compared to the control. This information

accurately reflects the nutritional value of ORBS.

In terms of fat content, there was a significant difference ($p>0.05$) between experiment-12 and experiment-14 (20.38% and 20.92%). However, the fat content of experiment-12 and the control were not significantly different ($p>0.05$), with fat contents of 20.38% and 20.01%, respectively, owing to the reduced fat content in ORBS and seaweed flour, which were employed as key ingredients in this study. The KA seaweed powder used in this study, supplied by Imtanomic Sdn Bhd, has a lower fat content (1.10%) and can replace wheat flour to reduce fat intake, creating a healthy effect (Munandar *et al.* 2019). Ng *et al.* (2020a) discovered a similar result when they added overripe banana sweetener (ORBS) and Overripe Banana Residue (OBR) to chocolate biscuits. Meanwhile, protein content was not significantly different ($p>0.05$) for experiment-12, experiment-14, and control cookies, ranging from 6.79% to 6.89%. This is because the protein level of wheat flour and KA powder is similar, ranging from 8.00 to 10.00% (Neoh *et al.* 2016). Despite this, an inverse link between carbohydrate content and moisture content was identified in butter cookies.

Sensory acceptability

Making fiber-enriched goods with acceptable sensory qualities is one of the issues that the food sector has in meeting consumer expectations. In the current study, 30 panelists evaluated the sensory attributes of seaweed flour cookies vs. butter cookies as the control. The sensory evaluations for butter cookies baked with varying amounts of seaweed flour and ORBS are shown in Table 2.

The control butter cookie had higher scores for appearance (5.20) and color (5.27) qualities than the other treatments, but the difference was not significant ($p>0.05$). However, when the crispness and overall acceptance of the control group were compared with the sensory scores of experiment-14, although the significant difference was not obvious, due to the addition of ORBS and seaweed flour to the butter cookies in experiment-14, the taste of experiment-14 compared with the butter cookies in the control group, they were more popular with sensory consumers. Thus experiment-14 had higher crispness scores (4.60) and overall acceptance scores (5.43) than the control scores (3.90 and 5.20, respectively). This could be due to the intense flavor and aroma of overripe bananas, which the panelist prefers. A similar study on overripe bananas found that bananas can be utilized practically and that many consumers enjoy the flavor and aroma of bananas (Soto-Maldonado *et al.* 2020). In comparison to the control, it is believed that a small amount of ORBS can improve the aroma, flavor, and crispiness. Higher ORBS in butter cookie inclusion, on the other hand, will result in an unpleasant taste.

In terms of appearance and color qualities, the experiment-14 butter cookie did not differ significantly ($p>0.05$) from the control and experiment-12 butter cookies. The sensory results also demonstrate that using 50% ORBS and 4% seaweed flour in place of table sugar and wheat flour can produce a butter cookie high in dietary fiber without sacrificing the desirable sensory attributes.

Previous research has shown that the sensory properties of gluten-free cookies made

Table 2. Sensory acceptability of optimized butter cookies incorporated with KA flour and ORBS

Properties	Control	Experiment-12	Experiment-14
Appearance	5.20±1.47[a]	4.60±1.50[a]	4.97±1.65[a]
Color	5.27±1.41[a]	4.40±1.77[a]	5.20±1.47[a]
Aroma	5.40±1.22[a]	4.30±1.90[b]	5.00±1.53[a]
Flavor	5.33±1.24[a]	3.70±1.80[b]	5.20±1.45[a]
Crispiness	3.90±1.67[a]	2.67±1.73[b]	4.60±1.61[a]
Overall Acceptance	5.20±1.06[a]	3.93±1.53[b]	5.43±1.25[a]

[a-b]: Mean±SD with different superscript letters within the same row indicate significant difference ($p<0.05$)

KA: *Kappaphycus alvarezii*; ORBS: Overripe Banana Sweetener

with banana flour and starch are equivalent to those of regular biscuits (Olawoye *et al.* 2020). Shahzad *et al.* (2021) identified a similar tendency when substituting 7.5% Lotus Seed Flour (LSF) for wheat flour in the production of cookies. The sensory evaluation score of overall approval is the highest due to the impact of L.S.F. integration on texture, color, appearance, and taste. This study found that when there was more flour in baked goods, consumers were less satisfied, and replacing foods high in dietary fiber with flour in baked goods can further endow consumer items with functional and health-promoting features.

Color analysis

The L*, a*, and b* values of control butter cookies were compared to cookies with seaweed flour and ORBS (Table 3). The effect of adding seaweed flour and ORBS can be easily noticed by comparing the values of control butter cookies, seaweed flour, and ORBS-added butter cookies. Table 3 shows that as the percentage of seaweed flour increased from 0% to 4% (experiments 12 and 14) while the lightness (L* value) of butter biscuits decreased significantly ($p<0.05$). Meanwhile, the redness (a* value) of seaweed flour added to cookies was dramatically increased ($p<0.05$). Control-butter cookies with no seaweed flour or ORBS had the highest lightness (L* value) and the lowest redness (a* value). This result indicated that when seaweed flour was added to butter cookies, the color turned darker and redder compared to the control butter cookies. The more the level of seaweed flour added, the darker and redder they became. Besides, control butter cookies, without any additives, recorded the lightest and the least reddish in color.

Table 3. Color analysis of butter cookies incorporated with KA flour and ORBS

Properties	Control*	Experiment 12**	Experiment 14***
L*	79.92±0.13[a]	67.25±0.86[b]	65.80±0.19[c]
a*	5.58±0.17[c]	7.34±0.17[b]	8.04±0.17[a]
b*	22.09±1.81[a]	21.14±0.17[a]	21.17±0.3[4a]

[a-b]: Mean+SD with different superscript letters within the same row indicate significant difference. ($p<0.05$)
*Control-butter cookies samples containing 0% seaweed flour, 0% ORBS, 50% butter
**Experiment 12-butter cookies samples containing 4% seaweed flour, 100% ORBS, 100% butter
***Experiment 14-butter cookies samples containing 4% seaweed flour, 50% ORBS, 50% butter
KA: *Kappaphycus alvarezii*; ORBS: Overripe Banana Sweetener

As previously noted, the overall acceptability of the sensory scores obtained was 5.20 (control), 3.93 (experiment-12), and 5.43 (experiment-14), which may be related to the L*, a*, and b* values (Table 3). According to these findings, the control and experiment-14 scores are greater than experiment-12. The reason for this could be that adding butter to the control cookies (without adding KA powder) makes the butter cookies taste more flavorful, which customers prefer. When KA and ORBS were added at 4% and 50%, respectively (in experiment-14), the butter cookies had a greater nutritional value and a crisper flavor but were substantially darker in color. Experiment-14 has a higher sensory assessment score than experiment-12, which may be attributed to experiment-12 containing too much ORBS, which impairs the taste of butter cookies. As a result, the cookies sample made with 4% seaweed flour and 50% ORBS were the most acceptable in terms of color and overall acceptance. Adding ORBS in concentrations greater than 50% resulted in darkening (lower intensity of L* values at 65.80 and 67.25, respectively) of butter cookies, which affected or lowered their overall appeal. The outcome is the same as the previously reported color difference when combining capsicum extract and rice flour under varied circumstances and concentrations. The higher the concentration of chili oil used, the lower the intensity of lightness (L* value), while the intensity of redness (a* value) grew dramatically, namely more of chili oil made things darker and redder (Gat & Ananthanarayan 2016).

CONCLUSION

The current study showed that adding the right amount of seaweed flour and ORBS to butter cookies enhanced crispiness, lowering their moisture and ash content but not affecting fat and protein content. The butter cookie from experiment-14 had the highest sensory ratings, although it performed worse than experiment-12 regarding moisture and ash. This might be because experiment-12 had added half as much ORBS as experiment-14, which resulted in lower

moisture content and more ash in the butter cookies. Experiment-14 also had a higher degree of crispiness than experiment-12. In conclusion, experiment-14, which contains 4% seaweed flour and 50% ORBS, is the best choice to replace some of the wheat flour and maybe a successful method to increase the nutritious content while maintaining acceptable physical and sensory qualities. The potential of dehydrated seaweed (KA powder) as a partial replacement for wheat flour and in-depth research is needed which emphasizes the role of cookies developed with DF in impacting glycemic responses in healthy individuals. It is also recommended that the low glycemic index cookies developed from KA powder (rich in dietary fiber) can be used for a natural regiment interventional diet for a reduction of diabetic complications among diabetes individuals.

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DECLARATION OF CONFLICT OF INTERESTS

The researchers have declared that they have no competing interests.

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Infant Feeding Practices among Mothers with a History of Gestational Diabetes Mellitus in Selangor

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ABSTRACT

This study aims to determine infant feeding practices including breastfeeding initiation, exclusive breastfeeding, duration of breastfeeding and complementary feeding, feeding practices related factors among mothers with Gestational Diabetes Mellitus (GDM) history, and the association between Infant and Young Child Feeding indicators and GDM status. A cross-sectional study (n=130) was conducted from February to June 2023 in Meru and Bandar Botanic health clinics. Data on infant feeding practices were gathered from GDM mothers and children aged below two years. Findings showed that 43.8% (n=57) of the mothers had initiated breastfeeding within an hour, 57.7% (n=75) infants were exclusively breastfed, 30.0% (n=39) continued breastfeeding for one year and 81.9% (n=68) had an appropriate time of complementary feeding. Mothers who had caesarean-section delivery and GDM were more likely to initiate breastfeeding after an hour of delivery, $p<0.05$. Exclusive breastfeeding was highly practiced by older, multiparous, and higher education mothers. Unemployed mothers were more likely to continue breastfeeding for one year. GDM mothers were more inclined to delay breastfeeding initiation and introduced complementary feeding appropriately, $p<0.05$. This study's findings bridge the gap in providing information on infant feeding practices among mothers with a history of GDM and therefore might be beneficial for related personnel to figure out how to overcome this concerning issue in the future.

Keywords: complementary feeding, exclusive breastfeeding, gestational diabetes mellitus, infant feeding practices

INTRODUCTION

The World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) (2021) defined Infant and Young Child Feeding (IYCF) practices that precisely influence children below the age of 2 years' health, growth, and status of nutrition as well as the effect on their survival. The optimal child feeding process is an essential component in a child's development, growth, and overall health in the years of childhood. Inappropriate feeding practices can lead to many risk factors for developing stunting (Birungi & Ejalu 2022) and obesity (Tulpule *et al.* 2022). About 45% of children's death is at the age of five and below due to lack of nutrition (WHO 2019).

According to the National Health and Morbidity Survey (NHMS) 2019 the childhood obesity prevalence in Malaysia is 14.8% which is the highest in recent years. Enhancing feeding practices of newborns specifically for children under the age of two, should therefore be the world's leading top concern. The WHO and UNICEF have outline recommendations for infant feeding which includes breastfeeding initiation within an hour of delivery, exclusively breastfeeding before the age of six months, breastfeeding continued up to two years and more, introducing solid, semi-solid, and soft food at six to eight months, minimum dietary diversity, minimum meal frequency, and minimum acceptable diet. The guidelines include the recommendation of breastfeeding initiation within an hour of delivery, exclusively breastfeeding before the age of six months, breastfeeding continued up to two years and more, introducing solid, semi-solid, and soft food at six to eight months, minimum dietary diversity, minimum meal frequency, and minimum acceptable diet.

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However, a meta-analysis of Gestational Diabetes Mellitus (GDM) pooled prevalence in Malaysia is approximately 21.5%, which seems to be higher than other Asian countries accounting for 10.1 to 11.5% (Teng *et al.* 2022). Most earlier studies listed that GDM prevalence is indeed rising in Malaysia, which could be due to interactions between sociodemographic, variables and lifestyle (Dualis *et al.* 2020). GDM imposes an enormous health burden in the short and long term, putting both mother and baby at higher risk of complications during pregnancy and delivery (Teng *et al.* 2022). At six months following delivery, the exclusive breastfeeding prevalence was 23% among Thai women with GDM (Jirakittidul *et al.* 2019).

Although numerous studies on infant feeding practices and their associated characteristics have been undertaken, information is still limited, particularly among targeted participants in the desired location. There were no studies in Malaysia on infant feeding practices and factors associated with feeding practices among GDM history mothers. Therefore, this study aims to determine infant feeding practices including breastfeeding initiation, exclusive breastfeeding, duration of breastfeeding and complementary feeding, feeding practices related factors among mothers with GDM history.

METHODS

Design, location, and time

This cross-sectional study was conducted in Bandar Botanic and Meru Health Clinic. Data was gathered from postpartum mothers with children under the age of 24 months between February and June 2023. This research has been registered in the National Medical Research Register (NMRR) and has been approved by the Medical Research and Ethics Committee (REC) under Research ID:NMRR-19-4204-52471 (IIR).

Sampling

Purposive sampling was used in line with predetermined requirements to select the study's target participants. Raosoft software was utilized to calculate the sample size of 287 participants, with a total population of 2,000 subjects for the study. Raosoft software was used to calculate the respondents, with a 90% confidence level, 5% margin of error, 50% response distribution, and 20% sample size was set aside to account for research dropouts.

GDM and non-GDM postpartum mothers aged 18 to 45 years with children below the age of 24 months who lived in Selangor and visited Bandar Botanic or Meru Health Clinic and can understand English and Malay language were eligible to participate in this study. However, pregnant, non-Malaysian, with psychotic disorders diagnosed and having severe pre-existing health conditions mothers have been excluded from participating.

Data collection

The participants were approached and briefly explained about the study. Then, the participants were given the consent form and need to sign the form if they are willing to participate in this study without any compulsion. The data for this study was collected using a structured questionnaire that participants self-administered. This study utilized a validated Infant Feeding Practices questionnaire adapted from Emmanuel and Clow (2017); Leow *et al.* (2017); WHO & UNICEF (2021). The collected information includes maternal age, race, educational level, residential area, employment status, number of children, marital, smoking, GDM status, child's age, gender, weight, feeding planning before born, skin-to-skin contact, breastfeeding intention, breastfeeding initiation, breastfeeding duration, feeding frequency, exclusive breastfeeding, previous children feeding experience, weaning off breastfeeding, breastfeeding encouragement from husband, family, and friends, and bed-sharing practices. Furthermore, the questionnaire addresses if any of the stated food groups have been introduced into the child's diet, introductory age, and consumption frequency.

Data analysis

The data gathered was transferred to the Statistical Package for the Social Sciences (SPSS) Version 27 for numerical data statistical analysis. The mean, standard deviation, frequency, and percentage have been utilized to present descriptive results. The chi-square test was used to determine the association between infant feeding practices and socio-demographic factors, along with GDM status and infant feeding practices.

RESULTS AND DISCUSSION

The sociodemographic profile of the participants is presented in Table 1. About 130 participants who completed the survey were recruited in this study. One participant had been excluded due to an incomplete response survey. All participants had a mean age of 30.89±5.5 years. Many participants were Malay (n=124, 95.4%). The most common educational level among participants is college/bachelor (n=75, 57.7%). There were about 69 (n=53.1%). All participants were married and did not smoke. Most of the participants had two to three children (n=67, 51.5%), had vaginal birth (n=100, 76.9%). About 90 (70%) were non-GDM and 39 (30%) had GDM

Table 2 shows the profile of the child participants. The child's mean age and standard deviation are 9.70±7.1 months. Most common child's age is 0 to 6 months (n=58, 44.6%). About 77 of the child were female (59.2%) and 53 were male (40.8%). The mean and standard deviation of birth weight is 2.96±0.5 kg. Most of the children weighed 2,500 g or more at birth (n=114, 87.7%), have less than average weight-for-length (n=57, 43.8%). Majority of the children have less than average weight (n=73, 56.2%), normal stature (n=49, 37.7%) and normal BMI-for-age (n=61, 46.9%).

The infant feeding practices were shown in Table 3. Most of the mothers have intention to feed breast milk (n=103, 79.2%). NGDM mother intent to feed breast milk solely (n=76, 73.8%) before delivery, whereas GDM mothers intent to feed breast milk only (n=27, 26.2%). About 93 mothers (71.5%) had skin-to-skin contact with the child within the first hour after birth, with 71 were NGDM (76.3%) and 22 were GDM (23.7%) mothers. Most mothers (n=108, 83.1%) choose breast milk during the child's first feeding. Approximately 81 (75.0%) were NGDM and 27 (25.0%) were GDM mothers gave their infant breast milk as the first feeding.

About 57 (43.8%) mothers have initiated breastfeeding within an hour with 47 (82.5%) were NGDM and 10 (17.5%) were GDM mothers. Sandhi et al. (2020) discovered that mothers who had skin-to-skin contact had greater confidence in breastfeeding and better-expressed milk supplies, but not early breastfeeding initiation. In one case series study, their findings demonstrated a delay in the first attempt to breastfeed, delayed secretory activation, and lower milk production in GDM mothers (Suwaydi et al. 2022). The mean and standard deviation of duration first attached to the breast for total participants, NGDM and GDM were 16.88±14.7 minutes, 17.68±15.7 minutes, and 14.95±11.9 minutes. Most of the participants fed breast milk 8 to 11 times (40.0%, n=52) per day. More NGDM mothers fed breast milk more than 11 times (80.4%, n=37) while GDM mothers fed breast milk more than 11 times and less than 8 times having the same number (71.0%, n=22).

Exclusive breastfeeding requires that newborns be given only their mother's milk, with no other food or drink, including water. The rate of exclusive breastfeeding in Malaysia was 47.1% (IPH 2016). Our present study found that 57.7% of mothers have practiced exclusive breastfeeding with 74.7% are NGDM mothers and 25.3% GDM mothers. Oza-Frank *et al.* (2016), discovered that GDM mothers reported feeding their infants formula within the first two days of life which is more than 75%. It is acknowledged that this might be related to shorter breastfeeding duration among mothers who commence breastfeeding. Several strategies must be implemented to extend breastfeeding duration and delay the introduction of formula. Jirakittidul *et al.* (2019) revealed that approximately 23% of GDM mothers exclusively breastfed for 6 months after birth, which was lower than our results in this present study (25.3% at 6 months). Individualized instruction on breastfeeding during postnatal appointments has been found to enhance breastfeeding rate and confidence among women with history of GDM (Shuhaimi & Abd Hamid 2023).

About 42 (71.2%) of NGDM and 17 (28.8%) of GDM mothers had exclusively breastfed their older children. Most participants still breastfeeding. About 61 (72.6%) of NGDM and 23 (27.4%) of GDM mothers have not stopped breastfeeding yet. Our study findings presented 30.0% of the mothers who continued breastfeeding for one year with 25.3% NGDM and 41.0% GDM. According to Oza-Frank *et al.* (2016), the overall breastfeeding duration in women with GDM is declining.

Almost all participants' husbands and families support the mothers to breastfeed (98.5%, n=128), with 70.3% (n=90) of NGDM and 29.7% (n=38) of GDM mothers. About 58.4% (n=76) of participants had started their child on solid, semi-solid, or soft food. Regardless of GDM status,

Table 1. Sociodemographic profile of participants (n=130)

Sociodemographic data	Total (n=130) n (%)	NGDM (n=91)	GDM (n=39)
Age (years)	30.89±5.5	30.37±5.8	32.1±4.6
Race			
Malay	124 (95.4)	87 (95.6)	37 (94.9)
Chinese	1 (0.8)	0 (0.0)	1 (2.6)
Indian	5 (3.8)	4 (4.4)	1 (2.6)
Education level			
Primary school	1 (0.8)	0 (0.0)	1 (2.6)
Secondary school	52 (40.0)	36 (39.6)	16 (41.0)
Tertiary education	77 (59.2)	55 (60.4)	22 (56.4)
Residential area			
Urban	11 (8.5)	7 (7.7)	4 (10.3)
Suburban	119 (91.5)	84 (92.3)	35 (89.7)
Employment status			
Employed	69 (53.1)	48 (52.7)	21 (53.8)
Unemployed	61 (46.9)	43 (47.3)	18 (4.2)
No. of children			
1	45 (34.6)	29 (31.9)	16 (41.0)
2−3	67 (51.5)	50 (54.9)	17 (43.6)
4+	18 (13.8)	12 (13.2)	6 (15.4)
Delivery types			
Vaginal	102 (78.4)	77 (84.6)	25 (64.1)
Cesarean	28 (21.5)	14 (15.4)	14 (35.9)
Health complications			
No	125 (96.2)	87 (95.6)	38 (97.4)
Yes	5 (3.9)	4 (4.4)	1 (2.6)

*NGDM: Women without GDM; GDM: Women with GDM

more than half of them had introduced solid, semi-solid, or soft food into their child's diet; NGDM (52.8%, n=48) and GDM (71.8%, n=28).

About 79.5% of mothers had achieved minimum dietary diversity with NGDM (80.4%) and GDM (78.1%) in this present study. Morover, (41.0%) of the children met minimum meal frequency and 81.9% met the minimum acceptable diet. In contrast with a study by Bong *et al.* (2018) on Penan children in Sarawak, reported 76.4% of them had minimum dietary diversity, high minimum meal frequency (83.0%) and 55.3% achieved a minimum accepatable diet, which is slightly higher than Malaysia's (53.1%) achievement (IPH 2016).

The relationship between sociodemographic factors and infant feeding practices were presented in Table 4. Half of the vaginal delivery mothers (50.5%) initiated breastfeeding within an hour of birth, while 78.6% of cesarean delivery mothers had initiated breastfeeding after an hour of birth, with a significant association between delivery types and breastfeeding initiation, $p<0.05$. Based on Gedefaw *et al.* (2020), their study is consistent with our present study in which cesarean-delivery

Table 2. Profile of the youngest child (n=130)

	Mean±SD	n (%)
Age, months	9.70±7.1	
0−6		58 (44.6)
7−11		19 (14.6)
12 and above		53 (40.8)
Gender		
Male		53 (40.8)
Female		77 (59.2)
Birth weight (g)	2.96±0.5	
≥2,500		114 (87.7)
<2,500		16 (12.3)
Weight-for-length		
Low		18 (13.8)
Less than average		57 (43.8)
Average		11 (8.5)
Above average		30 (23.1)
High		14 (10.8)
Weight-for-age		
Low		19 (14.6)
Less than average		73 (56.2)
Average		19 (14.6)
Above average-High		19 (14.6)
Length/height-for-age		
Short		18 (13.8)
Moderate short		41 (31.5)
Normal		49 (37.7)
Moderate-High		22 (16.9)
BMI-for-age		
Severely thin		44 (33.9)
Normal		61 (46.9)
Overweight		13 (10.0)
Obese		12 (9.2)

BMI: Body Mass Index; SD: Standard Deviation

mothers were four times more likely to delay breastfeeding initiation than vaginal-delivery mothers. Vaginal birth mothers were significantly more likely to begin early breastfeeding than cesarean birth mothers (Yılmaz *et al.* 2017).

This present study found that GDM mothers are more susceptible to initiate breastfeeding after an hour of birth (73.7%) compared to half of non-GDM mothers who initiated breastfeeding within an hour of birth, with a significant association between GDM status and breastfeeding initiation, $p<0.05$. This present study's findings are consistent with a study from Suwaydi *et al.* (2022) which concluded that GDM mothers are more susceptible to having a poor start to breastfeeding due to multiple factors and may require extra assistance to breastfeed within an hour of delivery or to express milk when breastfeeding is not feasible. Compared to non-GDM women, about 12% more GDM women reported difficulty producing enough milk (Oza-Frank *et al.* 2016).

Older mothers tend to exclusively breastfeed than younger mothers, with a significant association between age and exclusive breastfeeding practices, $p<0.05$. There is a study underpinned that 25 to 34-year-old mothers (26%) are more inclined to exclusive breastfeeding during the first eight months of their lives (Parnis *et al.* 2020). The breastfeeding knowledge and experience influenced exclusive breastfeeding (Shohaimi *et al.* 2022) as older mothers may have more knowledge and experience in infant feeding and hence practice exclusive breasfeeding more than younger and inexperienced mothers. However, our findings are supported by another study where older women with longer breastfeeding duration have a reduced likelihood of having another child and need to continue breastfeeding compared to younger mothers who have another child, requiring them to stop breastfeeding earlier (Mulugeta *et al.* 2022).

Mothers that have higher educational levels tend to practice exclusive breastfeeding than mothers that have lower educational levels, with a significant association between educational level and exclusive breastfeeding practices, $p<0.05$. Our present findings are in line with the study from Indonesia which revealed that a higher level of education increases the chances of exclusive breastfeeding (Laksono *et al.* 2021). The association between mothers' education and breastfeeding practices has positive consequences since education increases the likelihood that mothers acknowledge the advantages of exclusive breastfeeding and thus

Table 3. Infant feeding practices among mothers with and without GDM (n=130)

	Total (n=130) n (%)	NGDM (n=91)	GDM (n=39)
Intention to feed before delivery			
Breast milk	103 (79.2)	76 (73.8)	27 (26.2)
Formula	2 (1.5)	0 (0.0)	2 (100.0)
Combination of breast milk and formula	25 (19.2)	15 (60.0)	10 (40.0)
Skin-to-skin contact (in the first hour after birth)			
Yes	93 (71.5)	71 (76.3)	22 (23.7)
No	37 (28.5)	20 (54.1)	17 (45.9)
First feeding			
Breast milk	108 (83.1)	81 (75.0)	27 (25.0)
Formula	22 (16.9)	10 (45.5)	12 (54.5)
Timepoint when breastfeeding started			
Within an hour	57 (43.8)	47 (82.5)	10 (17.5)
Within 24 hours	49 (37.7)	30 (61.2)	19 (38.8)
After 1 day	23 (17.7)	14 (60.9)	9 (39.1)
Duration first put to the breast (minutes)	16.88±14.7	17.68±15.7	14.95±11.9
Frequency fed breast milk a day			
<8 times	31 (23.8)	22 (71.0)	9 (29.0)
8−11 times	52 (40.0)	32 (61.5)	20 (38.5)
>11 times	46 (35.4)	37 (80.4)	9 (19.6)
Exclusive breastfeeding for 6 months			
Yes	75 (57.7)	56 (74.7)	19 (25.3)
No	55 (42.3)	35 (63.6)	20 (36.4)
Previous child feeding in first 6 months			
Breast milk	59 (45.4)	42 (71.2)	17 (28.8)
Formula	0 (0.0)	0 (0.0)	0 (0.0)
Combination of breast milk and formula	28 (21.5)	21 (75.0)	7 (25.0)
Not related	43 (33.1)	28 (65.1)	15 (34.9)
Age weaned off breastfeeding, months	9.11±8.2	8.1±7.7	11.0±8.9
Have not stopped	84 (64.6)	61 (72.6)	23 (27.4)
0−6	24 (18.5)	17 (70.8)	7 (29.2)
7−11	8 (6.2)	5 (62.5)	3 (37.5)
12 and above	14 (10.8)	8 (57.1)	6 (42.9)
Introduction of solid/semi-solid/soft food			
No	54 (41.5)	43 (47.3)	11 (28.2)
Yes	76 (58.4)	48 (52.8)	28 (71.8)
Minimum dietary diversity			
<3 food types	11 (13.3)	6 (11.8)	5 (15.6)

Continur from Table 3

	Total (n=130) n (%)	NGDM (n=91)	GDM (n=39)
3 food types	6 (7.2)	4 (7.8)	2 (6.3)
>3 food types	66 (79.5)	41 (80.4)	25 (78.1)
Minimum meal frequency			
No food taken	5 (6.0)	1 (2.0)	4 (12.5)
1–2 times	44 (53.0)	29 (56.9)	15 (46.9)
3 or more times	34 (41.0)	21 (41.2)	13 (40.6)
Minimum acceptable diet			
No	15 (18.1)	9 (17.6)	6 (18.8)
Yes	68 (81.9)	42 (82.4)	26 (81.3)

*NGDM: Women without GDM; GDM: Women with GDM

implement it (Pilus *et al.* 2019).

Uniparous (60.0%) mothers do not practice exclusive breastfeeding, but multiparous (67.1%) mothers do, with the association between number of children and exclusive breastfeeding practices is significant, p<0.05. According to the research (Theodorah & Mc'Deline 2021), their findings are consistent with our results that uniparous mothers lack experience and experience other common breastfeeding difficulties. Based on their qualitative study, the problems that first-time mothers have are a lack of needed assistance, an inability to initially attach and place the infant during breastfeeding, and a lack of breast milk production. According to Al-Jawaldeh and Abul-Fadl (2018); Rollins *et al.* (2016), intervention programs to encourage breastfeeding and raise women's confidence in supplying adequate milk for their children have been established which include counseling sessions, instant assistance with breastfeeding after delivery, and managing lactation.

Furthermore, half of the employed mothers continued to breastfeed for one year while unemployed mothers having a high percentage continued to breastfeed for one year (89.3%) with a significant association between occupation and continued breastfeeding at one year, p<0.05. This study is supported by Inano *et al.* (2021) study, who stated that working mothers leaving their infant to another's care are more likely to cease breastfeeding earlier since the mother needs to get back to work. According to research by Al-Jawaldeh & Abul-Fadl (2018); Rollins *et al.* (2016), the primary challenge to exclusive breastfeeding is the mothers' employment status, which is due to short periods of leave, lack of parental care, unsupportive employer, the flexibility of time and inadequate facilities for expressing breast milk at the workplace.

About 61.5% (n=56) NGDM and 48.7% (n=19) GDM mothers had exclusively breastfed their child, with no significant association between exclusive breastfeeding practices and GDM status, p>0.05 (Table 5). Mothers without GDM have a higher percentage of initiating breastfeeding within one hour of birth, with a significant association between breastfeeding initiation within one hour of birth and GDM status, p<0.05. This study's findings are consistent with the study of Suwaydi *et al.* (2022) which concluded that GDM mothers are more susceptible to having a poor start to breastfeeding due to multiple factors and may require extra assistance to breastfeed within an hour of delivery or to express milk. Compared to non-GDM women, about 12% more GDM women reported difficulty producing enough milk (Oza-Frank *et al.* 2016). More than half of NGDM (71.9%, n=23) and GDM (69.6%, n=16) had continued breastfeeding for one year. The association is not significant between continued breastfeeding at one year and GDM status, p>0.05.

CONCLUSION

This present study concludes that there is no significant difference in infant feeding

Table 4. Relationship between sociodemographic factors and infant feeding practices (n=130)

Socio-demographic data	Breastfeeding initiation		*p*	Exclusive breastfeeding		*p*	Continued breastfeeding at 1 year		*p*	Complementary feeding		*p*
	Within an hour	After an hour		Yes	No		Yes	No		Appropriate	Not appropriate	
Age												
<25 years	8 (14.0)	8 (11.1)	0.725	5 (29.4)	12 (70.6)	**0.034***	2 (40.0)	3 (60.0)	0.179	5 (71.4)	2 (28.6)	0.611
25−35 years	38 (66.7)	47 (65.3)		54 (63.5)	31 (36.0)		28 (77.8)	8 (22.2)		49 (84.5)	9 (15.5)	
>35 years	11 (19.3)	17 (23.6)		16 (57.1)	12 (42.9)		9 (64.3)	5 (35.7)		14 (77.8)	4 (22.2)	
Education level												
<12 years	26 (50.0)	26 (50.0)	0.275	24 (45.3)	29 (54.7)	**0.018***	14 (60.9)	9 (39.1)	0.165	29 (82.9)	6 (17.1)	0.851
>12 years	31 (40.3)	46 (59.7)		51 (66.2)	26 (33.8)		25 (78.1)	7 (21.9)		39 (81.3)	9 (18.8)	
Employment status												
Employed	29 (42.6)	39 (57.4)	0.710	35 (50.7)	34 (49.3)	0.087	14 (51.9)	13 (48.1)	**0.002***	35 (83.3)	7 (16.7)	0.736
Unemployed	28 (45.9)	33 (54.1)		40 (65.6)	21 (34.4)		25 (89.3)	3 (10.7)		33 (80.5)	8 (19.5)	
No. of children												
One	15 (43.1)	29 (65.9)	0.097	18 (40.0)	27 (60.0)	**0.003***	13 (61.9)	8 (38.1)	0.248	22 (78.6)	6 (21.4)	0.571
More than one	42 (49.4)	43 (50.6)		57 (67.1)	28 (32.9)		26 (76.5)	8 (23.5)		46 (83.6)	9 (16.4)	
Delivery types												
Vaginal	51 (50.5)	50 (49.5)	**0.006***	63 (63.0)	39 (38.2)	0.073	31 (73.8)	11 (26.2)	0.489[a]	53 (82.8)	11 (17.2)	0.738[a]
Cesarean	6 (21.4)	22 (78.6)		12 (42.9)	16 (57.1)		8 (61.5)	5 (38.5)		15 (78.9)	4 (21.1)	
GDM status												
GDM	10 (26.3)	28 (73.7)	**0.008***	19 (48.7)	20 (51.3)	0.175	16 (69.6)	7 (30.4)	0.852	26 (81.3)	6 (18.8)	0.899
Non-GDM	47 (51.6)	44 (48.4)		56 (61.5)	35 (38.5)		23 (71.9)	9 (28.1)		42 (82.4)	9 (17.6)	

*Significant value (p<0.05)

NGDM: Women without GDM; GDM:Women with GDM; p-value from chi-square and Fisher's exact test with significant association (p<0.05)

[a]: Fisher's exact test

Table 5. Associations between the Infant and IYCF indicators and GDM status (n=130)

IYCF indicator	NGDM (n=91) n (%)	GDM (n=39) n (%)	*p*
Exclusively breastfed	56 (61.5)	19 (48.7)	0.175
Breastfeeding initiation within one hour of birth	47 (51.6)	10 (26.3)	**0.008**
Continued breastfeeding at one year	23 (71.9)	16 (69.6)	0.852
Introduction of solid, semi-solid, or soft foods	48 (52.7)	28 (71.8)	**0.043**
Minimum dietary diversity	41 (62.1)	25 (37.9)	1.000[a]
Minimum meal frequency	21 (61.8)	13 (38.2)	0.813[a]
Minimum acceptable diet	42 (82.4)	26 (81.3)	0.899

NGDM: Women without GDM; GDM:Women with GDM; IYCF: Young Child Feeding

*p-value from chi-square and Fisher's exact test with significant association (p<0.05)

[a] :Fisher's exact test; *Significant value (p<0.05)

practices among mothers with and without a history of GDM. Cesarean section delivery and GDM mothers were more likely to initiate breastfeeding after an hour of delivery. Mothers' age, education level, and number of children are closely associated with exclusive breastfeeding. The status of GDM has been associated with the initiation of breastfeeding within one hour of birth and the introduction of solid, semi-solid, or soft foods.

Future research with a bigger scale of participation can investigate the cultural traditions and perceptions of infant feeding practices including breastfeeding initiation, exclusive breastfeeding, duration of breastfeeding, and complementary feeding across ethnicity in Malaysia. This may assist in investigating the cultural differences of infant feeding practices following local culture, beliefs, and family perceptions towards infant feeding practices support.

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DECLARATION OF CONFLICT OF INTERESTS

The authors declare that there are no conflicts of interest.

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Sociodemographics and Dietary Intake Associations with Gestational Weight Gain Rates Among Gestational Diabetes Mellitus Mothers

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ABSTRACT

This study aims to assess the rates of Gestational Weight Gain (GWG) among pregnant mothers with and without Gestational Diabetes Mellitus (GDM) and to investigate the sociodemographic and dietary intake factors associated with the rates of GWG. This cross-sectional study involved 77 pregnant mothers visiting selected government clinics. Sociodemographics, medical records, and dietary intake were obtained through a self-administered questionnaire. The mean age of the participants was 30.48±5.0 years old with 48.1% (n=37) of them were GDM diagnosed. Moreover, 27 (73.0%) of GDM mothers experienced abnormal GWG. Their mean intakes were 1,481±389 kcal/day, macronutrients such as carbohydrate, protein, and fat were 199.9±59.3 g/day, 75.5±23.9 g/day, 44.1±15.3 g/day accordingly, fiber was 6.9±7.0 g/day and followed by micronutrients such as folate, calcium, iron, and zinc were 137.4±78.9 µg/day, 738.6±335.3 mg/day, 16.8±7.1 mg/day, and 6.0±2.6 mg/day respectively. This study reported no significant association between GDM status and GWG rates but there was a significant association between pre-pregnancy BMI and zinc intake with rates of GWG among pregnant mothers ($p<0.05$). In conclusion, the latest guidelines of GWG rates should include GDM status among pregnant mothers according to the specific pre-pregnancy Body Mass Index (BMI) to ensure, they can adhere to the new recommendations and lower the risk of pregnancy complications that may occur due to abnormal rates of GWG.

Keywords: gestational diabetes mellitus, gestational weight gain, pregnant women

INTRODUCTION

Pregnant mothers with Gestational Diabetes Mellitus (GDM) commonly gain excessive GWG. Sixty percent of pregnant women that were overweight and had GDM experienced excessive Gestational Weight Gain (GWG) and pre-pregnancy Body Mass Index (BMI), dietary intake pattern, and level of physical activity are correlated with GWG rates (Xie *et al.* 2020; Wu, *et al.* 2019). A study in Portugal also showed more than 50 % of obese GDM mothers gained gestational weight excessively (Ferreira *et al.* 2021).

GDM defined as the emergence of the glucose-intolerant occurs during pregnancy. International Diabetes Federation (IDF) mentioned GDM was prevalent in low to middle-income countries may be due to the limitation in accessing proper and developed maternal care (IDF 2020). The complications of GDM were potentially lethal to both mother and her child (IDF 2020).

GDM etiologies including in increased age among pregnant mothers, higher pre-pregnancy BMI, excessive GWG, sedentary lifestyle, and unhealthy dietary intake (Lewandowska *et al.* 2020; Yong *et al.* 2020; Hashim *et al.* 2019; Suliga *et al.* 2018; Viecceli *et al.* 2017; Horosz *et al.* 2013). To highlight, the complications of GDM are miscarriage, preterm delivery, pregnancy-induced hypertension, pre-eclampsia, cesarean delivery, and postpartum diabetes for mothers and macrosomia, and infant metabolic syndrome that may cause them to become susceptible to develop diabetes and cardiovascular disease later

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in the adulthood (Lewandowska *et al.* 2020; Xie *et al.* 2020; Zhuang *et al.* 2020; Mastella *et al.* 2018).

International of Medicine (IOM) has revealed an endorsement of GWG in 2009 by the latest version (Gilmore & Redman 2015). The latest version considers re-examining and re-assessing the impact of different rates of GWG on the pregnancy's outcome (Gilmore & Redman 2015). Current IOM GWG recommendation demonstrated the pre-pregnancy BMI was classified according to the World Health Organization (WHO) BMI cut off poitns. The classifications are underweight (<18.5 kg/m²), normal weight (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²), and obese (≥30.0 kg/m²) (Martínez-Hortelano *et al.* 2020). The suggested range of GWG recommendation throughout pregnancies were 5–18.0 kg, 11.5–16.0 kg, 7.0–11.5 kg, and 5.0–9.0 kg for underweight, normal, overweight, and obese BMI, respectively (Martínez-Hortelano *et al.* 2020).

The prevalence rates of GWG globally are still worrying as most acquired abnormal rates include insufficient and excessive. A 21%, 18%, and 31% of pregnant mothers experiencing inadequate of GWG in the USA, Europe, and Asia, respectively, while 51% population in the USA and Europe, and 37% of population in Asia gain excessive GWG (Goldstein *et al.* 2018). In developed Asian countries such as Singapore and Japan, nearly half population gained gestational weight excessively (Chee *et al.* 2019). Furthermore, in developing Asian countries like China and Malaysia, nearly half population of mothers had excessive GWG records (Chee *et al.* 2019).

The common factors influencing GWG are sociodemographic factors; maternal age, ethnicity, education level, household income, obstetrical histories; pre-pregnancy BMI and parity, and behavioral factors; dietary intake, and physical activity (Ferreira *et al.* 2021; Chee *et al.* 2019; Hashim *et al.* 2019; Suliga *et al.* 2018; Tan *et al.* 2011). Previous study shown a significant association between primiparous women, younger age, lower education level, higher household income level, high pre-pregnancy BMI, unhealthy dietary pattern, and not being physically active to experience excessive rates of GWG (Almeida *et al.* 2021; Ferreira *et al.* 2021; Rugină *et al.* 2020; Chee *et al.* 2019; Hashim *et al.* 2019; Suliga *et al.* 2018; Yong *et al.* 2016). Moreover, in Malaysia, higher pre-pregnancy BMI is also common among Indian mothers as the Indian population has metabolic syndrome that causes central obesity compared to the Malay and Chinese mothers population (Tan *et al.* 2011).

The implications of abnormal GWG have been explained extensively. For instance, mothers with excessive GWG will increase risk to develop GDM, delivery complications such as cesarean delivery, macrosomia baby, and pre-eclampsia and also postpartum weight retention which may lead to repetition of the vicious cycle of higher pre-pregnancy BMI incidence (Martínez-Hortelano *et al.* 2020; Chee *et al.* 2019; Hashim *et al.* 2019). Moreover, excessive GWG also cause the mother and her child to be susceptible to obese-related cardiometabolic as it related to mothers' insulin sensitivity, and their child's beta cell pancreas functions (Tam *et al.* 2018). Furthermore, insufficient weight gain also have complications which include growth retardation, preterm delivery, low birth weight, and neurocognitive degradation later in life (Xie *et al.* 2020; Chee *et al.* 2019; Tran *et al.* 2019)

At present time, there is a limited study on the associations between sociodemographic and dietary intakes with the rates of GWG among pregnant mothers with and without GDM in Selangor, Malaysia. Hence, the objectives of this study are to assess the GWG rates and the association of sociodemographics and dietary intake with GDM status among pregnant mothers.

METHODS

Design, location, and time

This cross-sectional study was conducted among pregnant mothers from two selected government clinics, Klinik Kesihatan Meru and Bandar Botanik, Selangor from February until July 2023. Seventy-seven participants involved in this study.

Ethical approval was obtained from UiTM Research Ethics Committee (REC/08/2021 (MR/678)) and Ministry of Health Medical Research Ethics Committee National Medical Research and Registry (NMRR) (Reference No: NMRR-19-4204-52471). The participants were well-informed and obtained a signed consent form prior to their recruitment. All data was kept confidentially and anonymous.

Sampling

Convenient sampling design was applied in this study. The sample size was calculated based census of pregnant mothers at second trimester and above, visiting antenatal appoitments in both clinics thus leading to only 156 samples after calculated using Raosoft Calculator Software. Inclusion criteria for participants were mothers in their second to third trimesters, age 20 to 45 years old, singleton pregnancy, and without chronic health history and conditions.

Data collection

Pregnant mothers' characteristics. The mother's age, ethnicity, educational level, monthly household income, parity, current gestational week, and the presence of the GDM status were self-administered.

Anthropometric measurements. Height, pre-pregnancy weight, and current weight were obtained from their antenatal records. Then, pre-pregnancy BMI and GWG rates were calculated and categorized accordingly (Martínez-Hortelano *et al.* 2020).

Dietary intake. The Frequency Food Questionnaire (FFQ) was used to determine mother's dietary intake. The frequency and portion size of each food item were taken with the researcher's guidance. The nutrients observed include energy, macronutrients (carbohydrates, protein, and fat), fiber, and micronutrients (folate, iron, calcium, and zinc). Nutrient intake was calculated using Nutritionist Pro Software by calculating the coefficient of intake frequency for one day on every food item and multiplied the coefficient with the nutrient content for one portion for one time eating over one day.

Data analysis

The data were analyzed using IBM SPSS 27. Categorical data was presented as frequency and percentages whereas for numerical data underwent descriptive analysis and was presented in mean and standard deviation or median and interquartile range depending on the normality distributions of the data. Independent t-test and Chi-Square or the Karl Fischer test were applied to achieve both objectives in this study. Not normally distributed variables were analysed using the Mann – Whiteney test. The statistical significance for this study was $p<0.05$.

RESULTS AND DISCUSSION

Characteristic and sociodemographic of mothers

Table 1 shows the characteristics of the study participants with a total of 77 mothers. About 48.1% (n=37) of the mothers were diagnosed with GDM. Meanwhile, mean pre-pregnancy BMI among mothers in this study was 24.9±6.1 kg/m^2, about 11.7% (n=9), 48.1% (n=37), 23.4% (n=18) and 16.9% (n=13) of them were underweight, normal, overweight, and obese, respectively. Mean GWG was 7.1±5.1 kg/week. About 39.0 % (n=30) of them had indequate GWG and 32.5% (n=25) had excessive GWG. Their mean was 30.5±5.0 years old with an average of 27.3±7.1 weeks of gestation, respectively. Majority were Malays with 89.6% (n=69). All 77 mothers in this study were married and most of them had more than one child, 68.9% (n=53). They received second (35.1%, n=27) and tertiary (62.3%, n=48) education. Lastly, 62.3% (n=48) of them had lowest monthly household income of less than RM4,850.

Meanwhile, their dietary intake were as follows; mean energy intake 1,481.3±388.9 kcal/day, carbohydrate 199.9±59.3 g/day, protein 75.5±23.9 g/day, and fat 44.1±15.3 g/day. Lastly, the mean micronutrients intake daily for folate, calcium, iron, and zinc were 137.4±78.9 µg/d, 738.6±335.3 mg/d, 16.8±7.1 mg/d, and 6.0±2.6 mg/d respectively.

The present study has shown the prevalence of inadequate GWG among mothers was the highest, 39.0 % (n=30) followed by the excessive and normal rates of GWG.This aligned with the findings from a study in conducted in Malaysia and Poland which reported high prevalence of indequate GWG (Chee *et al.* 2019; Suliga *et al.* 2018). However, most of the other studies found the prevalance of mothers experiencing excessive GWG was the highest compared to the other category, normal and inadequate rates of GWG (Chee *et al.* 2019; Suliga *et al.* 2018).

The associations between rates of GWG among mothers with and without GDM

Based on Table 2, it shows that there is no significant association between the GWG rates and GDM status among mothers.

Previous study shown that mothers with GDM have a higher tendency to excessively

Table 1. Characteristic of the participants and mothers (n=77)

Characteristics	Mean±SD	n (%)
Age (years)	30.5±5.0	
Ethnicity		
Malay		69 (89.6)
Chinese		1 (1.3)
Indian		7 (9.1)
Marital status		
Married		77 (100)
Not married		-
Parity		
1		24 (31.2)
2		32 (41.6)
3		15 (19.5)
4		6 (7.8)
Educational level		
No formal education		2 (2.6)
Primary education		-
Secondary education		27 (35.1)
Tertiary education		48 (62.3)
Monthly household income (RM)		
Less than RM4,850		48 (62.3)
RM4,850–RM10,959		28 (36.4)
More than RM10,960		1 (1.3)
Current gestational week (week)	27.3±7.1	
GDM Status		
Yes		37 (48.1)
No		40 (51.9)
Pre-pregnancy BMI (kg/m^{-2})[1]	24.9±6.1	
Underweight		9 (11.7)
Normal		37 (48.1)
Overweight		18 (23.4)
Obese		13 (16.9)
Rates of GWG (kg/week)[2]	7.1±5.1	
Inadequate		30 (39.0)
Normal		22 (28.6)
Excessive		25 (32.5)
Energy intake (kcal/day)	1,481.3±388.9	
Carbohydrate intake (g/day)	199.9±59.3	

Continue from Table 1

Characteristics	Mean±SD	n (%)
Protein intake (g/day)	75.5±23.9	
Fat intake (g/day)	44.1±15.3	
Fiber intake (g/day)	6.9±7.0	
Folate intake (µg/day)	137.4±78.9	
Calcium intake (mg/day)	738.6±335.3	
Iron intake (mg/day)	16.8±7.1	
Zinc intake (mg/day)	6.0±2.6	

BMI: Body Mass Index; GDM: Gestational Diabetes Mellitus; GWG: Gestational Weight Gain; RM: Ringgit Malaysia
SD: Standard Deviation
[1]Pre-pregnancy BMI was classified according to WHO 1995 cut-off points
[2]Rates of GWG are determined based on the 2009 International Of Medicine classification

gain gestational weight, especially if the mothers were obese in pre-pragnancy BMI (Ferreira *et al.* 2021). Moreover, in a study by Viecceli *et al.* (2017) among Chinese pregnant mothers, 57%of mothers with GDM also excessively gained gestational weight. The reason behind the phenomenon of excessive GWG rates was due to the infants' rapid growth and development, which may lead 15 to 45% of higher risk to deliver macrosomia baby (Gou *et al*. 2019; Hashim *et al.* 2019). In contrast, a study by Xie *et al.* (2020), reported 50% of mothers with GDM were more likely to experience inadequate rates GWG.

The associations of sociodemographics, dietary intake, and GWG rates

Based on Table 3, a chi-square test was performed to determine the associations between the sociodemographics, dietary intake and the GWG rates This present study found only pre-pregnancy BMI showed a significant association with the GWG rates, with regards to GDM status.

In a study in Batu Pahat, Johor, Malaysia also showed overweight and obese mothers has three times odds in experiencing excessive GWG rates as compared to normal weight mothers (Chee *et al.* 2019). It was suggested that pre-pregnancy BMI was an indicator for excessive GWG rates and development of the GDM (Xie *et al.* 2020; Hashim *et al.* 2019).

Association between sociodemographic and dietary intake factors with rates of GWG among mothers with and without GDM independently

Table 4 presented comparison of associated sociodemographic and dietary intake factors with the rates of GWG among pregnant mothers with and without GDM.

This finding has limited literature to support the significant association as most of the study only found the association of energy and macronutrient intakes among mothers with and without GDM where the author stated that the intakes for energy and macronutrients could be seen higher among GDM mothers (Hasbullah *et al.* 2019). As mentioned in an overview related with nutrients consumption during gestation, zinc

Table 2. The association between rates of GWG among pregnant mothers with and without GDM (n=77)

Characteristics	Rates GWG		X^2 statistic (df)	*p*
	Abnormal	Normal		
GDM, n (%)[1]			0.083 (1)	0.773
Yes	27 (73)	10 (27)		
No	28 (70)	12 (30)		

[1]Significance was determined using Pearson's Chi-Square statistical analysis; GWG: Gestational Weight Gain
GDM: Gestational Diabetes Mellitus

Table 3. Sociodemographic and dietary intake associated with the GWG rates (n=77)

Characteristics	Rates GWG		X^2 statistic (df)	t-stats (df)	*p*
	Abnormal	Normal			
Age (years)[1]				-0.02 (75)	0.983
Mean±SD	30.47±4.9	30.5±5.4			
Ethnicity, n (%)[3]			-		1.000
Malay	49 (89.1)	20 (90.9)			
Non-Malay	6 (10.9)	2 (9.1)			
Parity, n (%)[2]			1.362 (1)		0.243
Uniparous	15 (27.3)	9 (40.9)			
Multiparous	40 (72.7)	13 (59.1)			
Educational level, n (%)[2]			0.022 (1)		0.882
Lower education	21 (38.2)	8 (36.4)			
Higher education	34 (61.8)	14 (63.6)			
Monthly household income (RM), n (%)[2]			0.022 (1)		0.882
Lower-income	34 (61.8)	14 (63.6)			
Higher-income	21 (38.2)	8 (36.4)			
GDM status, n (%)[2]			0.083 (1)		0.773
Yes	27 (49.1)	10 (54.5)			
No	28 (50.9)	12 (45.5)			
Pre-pregnancy BMI[2] (kg/m^{-2}), n (%)			5.000 (1)		**0.025***
Normal (18.5–24.9)	22 (40)	7 (31.8)			
Abnormal (<18.5 & >24.9)	33 (60)	15 (68.2)			
Energy intake (kcal/day)[4]				0.25 (75)	0.800
Mean±SD	1,488.4±403.9	1,463.3±357.1			
Carbohydrate intake (g/day)[4]					0.471
Median±IQR	193.1±86.9	179.8±85.4			
Protein intake (g/day)[1]				-0.19 (75)	0.852
Mean±SD	75.2±25	76.3±21.6			
Fat intake (g/day)[1]				0.69 (75)	0.495
Mean±SD	44.9±16.5	42.2±11.7			
Fiber intake (g/day)[4]					0.554
Median±IQR	5.2±6.2	4.75±5.8			
Folate intake (µg)[4]					0.259
Median±IQR	121.1±64	84.3±117.1			
Calcium intake (mg)[1]				0.41 (75)	0.683
Mean±SD	748.6±353.5	713.8±290.9			
Iron intake (mg)[4]					0.506
Median±IQR	15.6±8.5	15.0±10.4			

Continue from Table 3

Characteristics	Rates GWG		X^2 statistic (df)	t-stats (df)	*p*
	Abnormal	Normal			
Median±IQR	15.6±8.5	15.0±10.4			
Zinc intake (mg)[4]					0.62
Median±IQR	5.8±3.1	5.25±2.8			

BMI: Body Mass Index; GDM: Gestational Diabetes Mellitus; GWG: Gestational Weight Gain; IQR: Interquartile Range; SD: Standard Deviation; Statistically significant p<0.05

[1]Significance was determined using Independent T-test; [2]Significance was determined using Pearson's Chi-Square test

[3]Significance was determined using the Karl Fischer test; [4]Significance was determined using Mann Whiteney test

Table 4. The comparison of associated sociodemographic and dietary intake factors with the rates of GWG among pregnant mothers with and without GDM independently (n=77)

Characteristics	Pregnant mothers with GDM (n=37)		*p*	Pregnant mothers without GDM (n=40)		*p*
	Abnormal GWG rates	Normal GWG rates		Abnormal GWG rates	Normal GWG rates	
Age (years)[1]			0.951			0.953
Mean±SD	31.6±4.3	31.7±5.6		29.4±5.2	29.5±5.1	
Ethnicity, n (%)[2]			1.000			1.000
Malay	25 (92.6)	10 (100.0)		24 (85.7)	10 (83.3)	
Non-Malay	2 (7.4)	0 (0)		4 (14.3)	2 (16.7)	
Parity, n (%)2			0.407			0.720
Uniparous	6 (22.2)	4 (40.0)		9 (32.1)	5 (41.7)	
Multiparous	21 (77.8)	6 (60.0)		19 (67.9)	7 (58.3)	
Educational level, n (%)[2]			1.000			1.000
Lower education	10 (37)	4 (40.0)		11 (39.3)	4 (33.3)	
Higher education	17 (63.0)	6 (60.0)	0.481	17 (60.7)	8 (66.7)	0.720
Monthly household income (RM), n (%)[2]						
Lower-income	15 (55.6)	7 (70.0)		19 (67.9)	7 (58.3)	
Higher-income	12 (44.4)	3 (30.0)	0.275	9 (32.1)	5 (41.7)	0.079
Pre-pregnancy BMI (kg/m^{-2}), n (%)[2]						
Normal (18.5–24.9)	8 (29.6)	5 (50.0)		14 (50.0)	2 (16.7)	
Abnormal (<18.5 & >24.9)	19 (70.4)	5 (50.0)		14 (50.0)	10 (83.3)	
Energy intake (kcal/day)[1]			0.356			0.562
Mean±SD	1,598.5±401.0	1,466.5±318.0		1,382.2±384.0	1,460.7±400.9	
Carbohydrate intake (g/day)[1]			0.598			0.949
Mean±SD	208.1±67.9	195.4±53.5		195.1±50.7	196.3±67.0	
Protein intake (g/day)[1]			0.219			0.105
Mean±SD	84.6±25.9	73.4±17.9		66.1±20.7	78.7±24.8	
Fat intake (g/day)[1]			0.388			0.929

Continue from Table 4

Characteristics	Pregnant mothers with GDM (n=37)		*p*	Pregnant mothers without GDM (n=40)		*p*
	Abnormal GWG rates	Normal GWG rates		Abnormal GWG rates	Normal GWG rates	
Mean±SD	48.3±15.6	43.6±11.0		41.6±17.0	41.1±12.6	
Fiber intake (g/day)[3]			0.96			0.358
Median±IQR	3.9±6.9	4.9±5.7		5.9±5.4	4.8±7.1	
Folate intake (µg/day)[1]			0.714			0.672
Mean±SD	156.4±84.4	143.0±127.9		156.4±84.4	143.0±127.9	
Calcium intake (mg/day)[1]			0.701			0.899
Mean±SD	807.4±356.8	757.2±331.3		807.4±356.8	757.2±331.3	
Iron intake (mg/day)[1]			0.798			0.911
Mean±SD	17.3±6.3	16.7±7.8		17.3±6.3	16.7±7.8	
Zinc intake (mg/day)[1]			0.024*			0.488
Mean±SD	6.8±2.4	4.9±1.5		6.8±2.4	4.9±1.5	

BMI: Body Mass Index; GDM: Gestational Diabetes Mellitus; GWG: Gestational Weight Gain; IQR: Interquartile Range; RM: Ringgit Malaysia; SD: Standard Deviation; *Statistically significant p< 0.05

1Significance was determined using Independent T-test; 2Significance was determined using the Karl Fischer test; 3Significance was determined using Mann Whiteney test

functioned to aid in biochemical functions such as involved in cellular division, expressing genes, and others that were associated with the infant's growth (Mousa *et al.* 2019). To compare, our study participants showed insufficient zinc intake when compared to Malaysian Recommended Nutrient Intake (MoH 2017).

CONCLUSION

In conclusion, most of the mothers in this study had inadequate GWG rates. Pre-pregnancy BMI was associated with the rates of GWG , however, in present study, there were no associations found between pre-pregnancy BMI and GDM status. Therefore, it is notable that pre-pregnancy BMI should be highlighted during early antenatal appointments, meanwhile, GWG pattern also should be monitored throughout the pregnancy to prevent the occurence of GDM.

This study has several limitations such as a limited participants involved therefore, could affect the findings. This might be due to the complications of administering FFQ as it was very time consuming and had higher risk of over- and under-estimate the intake of every food items listed.

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DECLARATION OF CONFLICT OF INTERESTS

The author has no conflict of interest when conducting this study.

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Correlation Between Diet History and Nutritional Status of Children Aged 24–59 Months in Tarumajaya, Bekasi in 2019

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ABSTRACT

This study aimed to analyze the correlation between diet history and the nutritional status of pre-school children. This was an analytical observational study using a cross-sectional design. Sam-ples were 96 children aged 24–59 months in Tarumajaya, Bekasi, West Java. Diet history was obtained from questionnaires containing history of breastfeeding and diet since the infancy period. The children's heights were measured using a microtoise stature meter. Subjects were considered stunted if their Height-for-Age Z-score was minus 2 or lower according to WHO Child Growth Standard. Data was analyzed using Fisher's exact test. Out of the 96 children, 16 (16.7%) were stunted. There were 80 (83.3%) children who received exclusive breastfeeding, 51 (53.1%) who received an appropriate frequency of meals, 78 (81.3%) who met the minimum dietary diversity, and 29 (30.2%) who had a minimum acceptable diet. Fisher's exact test showed that dietary diversity was a significant factor for stunted children ($p<0.001$).

Keywords: child nutrition, exclusive breastfeeding, stunted growth, dietary diversity, minimum acceptable diet

INTRODUCTION

Stunting is a complex condition that impaired growth and development of children due to poor nutrition, repeated infection, and inadequate psychosocial stimulation that happened in their first 1,000 days of life. Studies show there is a strong association between stunting and non-communicable diseases later in life, low learning capacity, low productivity, higher morbidity and mortality risks (Leroy & Frongillo 2019).

Children are defined as stunted if their height-for-age is more than two standard deviations below the WHO Child Growth Standards median (WHO 2017). The incidence of stunting is related to many factors, including the inadequacy of the quality and quantity of the child's diet chronically (Aguayo & Menon 2016).

The World Health Organization (WHO) and the Indonesian Paediatric Society (IDAI) recommend giving a child exclusive breastfeeding for the first 6 months of life, which means no other food or drink except breast milk, with the exception of rehydration solutions, drops and syrups (vitamins, minerals and medicines). Breast milk contains all the nutrients that a growing infant needs, and also increase its immune system (WHO 2017; IDAI 2018).

After the infant reaches the age of 6 months, their nutrient requirements start to go beyond what breast milk contains. At this point, parents need to start introducing food and drink that is nutritionally adequate and safe, while still feeding them breastmilk up to the age of two years or beyond. Supplementary foods should be added to the diet and there is a gradual progression in the variety, quantity, and the consistency of foods (Bégin & Aguayo 2017). At the age of 6–8 months, infants should be given these additional meals 2–3 times a day. As they get older up to 24 months, they should be fed 3–4 times a day, supplemented with healthy snacks once or twice a day as needed. These meals need to be nutritious enough to meet their daily requirements (WHO 2003).

Foods can be grouped into 7 standard groups, those are: 1) grains, roots and tubers; 2) legumes and nuts; 3) dairy products; 4) flesh foods, 5) eggs; 6) vitamin-A rich fruits and

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vegetables; 7) other fruits and vegetables. A diverse diet is important for children to meet their dietary requirements. Dietary diversity ensures adequate nutrient intakes that could reflect the children's nutritional status (Sealey-Potts & Potts 2014). A "minimum dietary diversity" of the complementary feeding should contain 4 or more food groups (WHO 2003; IDAI 2018).

Children are considered to receive a Minimum Acceptable Diet (MAD) if they meet both the minimum meal frequency and minimum dietary diversity. The prevalence of MAD is still concerningly low in low and middle income countries, such as in North West Ethiopia (12.6%) (Birie *et al.* 2021), Nepal, India (30.1%) (Sapkota *et al.* 2022) and Indonesia (61.8%) (Pranita *et al.* 2023).

The 6–23 months of age period is very important for long-term health. Inappropriate feeding can affect growth, organ development, and metabolism, which can have long-term programming effects on development and health (Bégin & Aguayo 2017). There is now broad agreement that most stunting happens from conception through the first two years of life, although additional linear growth faltering may still happen after the first two years of life (Aguayo & Menon 2016). Complementary feeding plays a major role in this period, so it is a critical opportunity to prevent all forms of malnutrition, including stunting, by improving the quality of complementary feeding (Beal *et al.* 2018). Because of this rapid growth period, these first 2 years of life are more vulnerable to nutritional inadequacies than other age groups. Chronic or persistent nutritional deprivation in this period causes a disruption in a child's linear growth, which will become clearly visible as the child reaches 2 years of age. That is why in this study we used height-for-age z-score to assess the nutritional status of children aged 24–59 months.

Apart from being clearly visible manifesting in the form of a short stature, stunting can be formally detected using the height-for-age z-score. This parameter allows us to detect nutritional deprivation in a way that is applicable for chronic or persistent nutritional deprivation.

The prevalence of stunting among children under five years old has declined gradually from 33.0% in 2000 to 22.3% in 2022 (UNICEF 2022). However, even if the current trend continues, there would be 30 million stunted children above the global WHO target by 2025 (WHO 2017). According to recent data published by Indonesian Health Status Survey (*Survei Status Gizi Indonesia,* SSGI), the number of stunted children in Indonesia is 21.6%, while the prevalence in the province of West Java is 20.2% (SSGI 2022). Nowadays, Indonesia is the country with the third highest prevalence of child stunting in Southeast Asia (Aditianti *et al.* 2020).

Identifying a child's diet history and investigating its relation to the child's nutritional status is crucial and can play a big role in improving the child's quality of health and avoid incidences of malnutrition, including stunting.

This study aimed to investigate the diet history, including the breastfeeding practices, meals frequency, dietary diversity, and minimum acceptable diet, and their relation to the nutritional status of children aged 24–59 months in Tarumajaya, Bekasi, West Java, Indonesia.

METHODS

Design, location, and time

This was an analytical observational study with a cross-sectional design. It was carried out in Tarumajaya subdistrict, Bekasi Regency, West Java in December 2019. Children aged 24–59 months and their mothers or guardians were involved in this study. The study was approved by the institutional Ethics Committee of the Faculty of Medicine and Health, Universitas Muhammadiyah Jakarta letter number 139A/PE/KE/FKK-UMJ/XI/2019.

Sampling

Using the cluster sampling technique, children aged 24–59 months old with their mothers/guardians who lived in 4 (out of 8) villages in Tarumajaya subdistrict, Bekasi Regency, West Java, were chosen. Sample size was determined using the Lemeshow formulation (Sastroasmoro 2022). The sample size was 96 children. The inclusion criteria were children 24–59 months of age residing in the area, without physical and mental disorders, with mothers or guardians who were willing to participate in the study and sign the informed consent form. Respondents are excluded if they didn't follow through the entire study, such as not filling in the questionnaire completely or not participating in the anthropometric measurements.

Data collection

The materials and tools involved in this study are: 1) Microtoise Stature Meter to measure the children's height; 2) Questionnaire on the identity of the mother and child, their history of breastfeeding practices, the earliest age of complementary feeding to breast milk; 3) The Food Frequency Questionnaire (FFQ) consisting of a list of foods from 7 standard food groups and a scale indicating the frequency of consumption of that food, that is never, less than once per month, 1–3 times per month, 1–2 times per week, 3–4 times per week, 1–2 times per day, and 3 times per day; 4) The WHO Child Growth Standard for girls/ boys: birth to 5 years (Z-scores).

Height measurement for each participant was determined using standardized techniques. The subject should stand erect, without shoes, with weight equally distributed on both feet and heels together and touching the vertical board. The subject should stand up as straight as possible with the heels, back, shoulders, and head all touching the wall. Their arms should hang freely at the sides of the trunk with palms facing the thighs. Looking straight ahead so that the line of vision is perpendicular to the body, the subject should take a deep breath and hold that position while the horizontal headboard is brought down firmly on the top of the head. Their stature is recorded to the nearest 0.1 cm (Mitchell 2003). Their height was compared to age using WHO Child Growth Standard to determine nutritional status of children. A child was considered stunted when their Height-for-Age Z-score is minus 2 or lower (WHO 2009).

The history of the participant's breastfeeding practices and their earliest age of complementary feeding were retrieved through a questionnaire given to the mother. The frequency and diversity of the supplementary feeding were retrieved through a Food Frequency Questionnaire (FFQ).

The child is considered to have had exclusive breastfeeding if they had consumed only breast milk for their first 6 months of life. The child is considered to have received the Minimum Meal Frequency (MMF) if they had a minimum number of meals as recommended by WHO and IDAI, according to the child's age. The child is considered to have had the Minimum Dietary Diversity (MDD) if the complementary feeding contained 4 out 7 standard food groups. The child is considered to have had a Minimum Acceptable Diet (MAD) if they had both minimum meal frequency and minimum dietary diversity.

Data analysis

Univariate analyses were conducted to obtain an overview of the frequency distribution of each variable studied. The correlationships between variables were analysed with Fisher's exact test. Results were presented in tables. Statistical analyses were conducted using R version 3.2.1. The differences were considered significant when $p<0.05$.

RESULTS AND DISCUSSION

Characteristics from the study participants can be seen in Table 1 and the characteristics of children based on the nutritional status can be seen in Table 2.

There were 96 children who participated in this study consisting of 49 boys (51%) and 47 girls (49%). They ranged between 30–50 months of age. The majority of the respondents (83.3%) were not stunted and 16.7% were stunted. Amongst the stunted children there were 9 boys and 7 girls and there were no difference between the genders ($p=0.648$) and there is no difference. This prevalence rate is higher than the one included in Bekasi Health Profile in 2021, which is 4.2% (DKK Bekasi 2022). However, this value is close to the published prevalence rate of stunting children in West Java in 2022, 20.2%, and the national rate of 21.6% (SSGI 2022). According to the WHO, a child stunting prevalence of over 20% qualifies it as a health problem in a particular region (WHO 2017)

Out of 96 respondents, 80 children (83.3%) were claimed to have had exclusive breastfeeding. This achievement was beyond WHO's Global Nutrition Monitoring Framework target of over 50% of under-6-month infants receiving exclusive breastfeeding (WHO 2017). Out of the 80 children, 13 (16.7%) children were stunted. Meanwhile, 15 from 18 (83.3%) children that did not have exclusive breastfeeding were not stunted. Based on Fisher's exact test, there was not a significant correlation between exclusive breastfeeding history and nutritional status of children aged 24–59 months old ($p=1.000$). Children who were not exclusively breastfed were 3.1 times more at risk of stunting than those

Table 1. Characteristics of the study participants (n=96)

Variable	n (%)
Sex of the child	
Male	49 (51)
Female	47 (49)
Age (months) (median [IQR])	38.5 [30–50]
Nutritional status	
Stunted	16 (16.7)
Not-stunted	80 (83.3)
Exclusive breastfeeding history	
Yes	80 (83.3)
No	16 (16.7)
Minimum meal frequency	
Yes	51 (53.1)
No	45 (46.9)
Minimum dietary diversity	
Yes	78 (81.2)
No	18 (18.2)
Minimum acceptable diet	
Yes	29 (30.2)
No	67 (69.8)

exclusively breastfed (Sari *et al.* 2021). Exclusive breastfeeding is one of the frameworks for action to reduce stunting (WHO 2014).

Out of 96 respondents, 51 (53.1%) children met the minimum meal frequency. Data published by WHO shows that half of all children in low and middle-income countries are not receiving the minimum meal frequency (WHO 2003). Meeting the nutrient demands for an infant in this complementary feeding period requires some strategizing, because while their nutrient needs reach a lifetime peak, their small stature can only ingest a small amount (WHO 2003). Out of the 51 children that met the minimum meal frequency, 5 (9.8%) were stunted. Meanwhile, 34 from 45 (75.5%) children who did not meet the minimum meal frequency were not stunted. We found that there was no significant correlation between children who met the minimum meal frequency to the incidence of stunting (p=0.403).

Most of the children (81.2%) consumed food items from 4 food groups from 6 until 24 months old, indicating that they met the minimum dietary diversity. This result is in line with a previous study conducted in Trinidad and Tobago in which the majority (80.38%) of their respondents met a minimum dietary diversity by consuming a minimum of 4 food groups. Fruits, vegetables and legumes were the food groups least consumed by the children, while the most consumed by the participants were staples, dairy

Table 2. Characteristics of children aged 24–59 months who were stunted based on nutritional status (n=96)

Variable	Stunted (n=16)	Not-stunted (n=80)	*p*
Total	n (%)	n (%)	
Sex			0.648
Male	9 (18.4)	40 (81.6)	
Female	7 (14.9)	40 (85.1)	
Exclusive breastfeeding history			1.000
Yes	13 (16.7)	65 (83.3)	
No	3 (16.7)	15 (83.3)	
Minimum meal frequency			0.403
Yes	5 (9.8)	46 (90.2)	
No	11 (24.4)	34 (75.6)	
Minimum dietary diversity			0.001*
Yes	7 (9.0)	71 (91.0)	
No	9 (50.0)	9 (50.0)	
Minimum acceptable diet			0.136
Yes	2 (6.9)	27 (93.1)	
No	14 (20.9)	53 (79.1)	

*p<0.05

and meat products (Sealey-Potts & Potts 2014). Within the 78 children that meet the minimum dietary diversity, 7 were stunted. Meanwhile, 9 out of 18 children that did not meet the minimum dietary diversity were not stunted. We found a significant correlation between these two variables ($p<0.001$). A higher variety of food being consumed leads to a more complete set of nutrients being ingested.

Out of 96 respondents, only 29 (30.2%) children met both the minimum meal frequency and the minimum dietary diversity (minimum acceptable diet). However, 2 out of 29 (6.9%) children that met the minimum acceptable diet and 53 out of 67 children (79.1%) that did not meet the minimum acceptable diet were found to be in good nutritional status. We did not find a significant correlation between these two variables ($p=0.136$).

A study carried out in Central Jakarta in 2019 found the prevalence of stunting children aged 6–23 months to be 26.0% and a minimum acceptable diet was only met by 31.6% of samples. This study revealed that minimum acceptable diet and family income were significant factors for stunting among children aged 6–23 months. (Andina & Achadi 2021). Another study conducted in Odisha, India, found only 8.4% children aged 6–23 months were fed MAD, and children whose mother was exposed to any mass media had a higher chance of MAD feeding (Acharya *et al.* 2021).

Recently published data showed that five out of six children are not receiving a minimum acceptable diet. The quality of the diet is so closely associated with children's nutritional status that children who are fed at least a minimum acceptable diet are less likely to be stunted or underweight (UNICEF 2022). That being said, nutrition is not the only factor that might affect the growth of a child. Hereditary factors, hormones, and a child's environment are also important factors to analyse.

There were some limitations to this study. This is a descriptive study, meaning it does not analyse cause and effect. The usage of FFQ heavily relies on each respondent's memory on what kind of diet was given to the child. Finally, the sample is children of 24–59 months of age, which is a large range. This might cause the respondents to have forgotten what kind of diet they provided during the infant's earlier stages.

CONCLUSION

The number of children who received exclusive breastfeeding is high but only a small number of children received a minimum acceptable diet. From bivariate analysis, dietary diversity is a significant factor in the prevalence of stunting.

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DECLARATION OF CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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Determinant of Non-pregnant Women's Anemia in Banggai Regency

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ABSTRACT

This study purpose is to seek the determinant factors of anemia in non-pregnant women in Banggai Regency. With a cross-sectional design, we collect data from 308 non-pregnant women through non-probability sampling. Variables collected were age, Body Mass Index (BMI), Middle Upper Arm Circumference (MUAC), abdominal circumference, education, ownership of a healthy latrine, water source for cooking, and daily consumption of iron-source food such as legumes, green vegetables, also fish or meat. Bivariate and logistic regression was used to identify variables that correlate with anemia. The mean age and hemoglobin levels were 30±6.2 years and 12.7±1.5 g/dL, respectively. About 80 (25.97%) of the subjects were anemic. Bivariate analysis shows that water from standardized sources/ facilities for cooking, ownership of a healthy latrine, MUAC, daily consumption of legumes, and daily consumption of fish or meat were variables that significantly correlated with anemia ($p<0.05$). Moreover, after we performed logistic regression, non-pregnant women who did not use standardized clean water for cooking (OR 2.19; $p=0.09$) and did not consume fish or meat daily (OR 2.28; $p=0.02$) were at higher risk of having anemia. Determinant factors that significantly correlate with anemia in Banggai Regency's non-pregnant women were water utilization from not-standardized sources/facilities for cooking and not consuming of fish or meat daily. Local governments should include these variables in their new reformulated and innovative stunting-reducing programs. Thus, perhaps they can achieve their expected targets, such as non-anemic pregnant women, which, in the long run, can reduce stunting.

Keywords:anemia, Banggai Regency, non-pregnant women

INTRODUCTION

Stunting in Indonesia is called "*pendek*" or "kerdil". This is one form of malnutrition caused by repeated illness/infection and or inadequate nutrition for a long time, usually from early life. Stunting not only can burden billions to a nation's economy (Renyoet *et al.* 2016; Akseer *et al.* 2022) but also has a long-term effect on the individual such as increasing morbidity and mortality due to the elevated risk of non-communicable diseases in later life and lower productivity, thus in the end will affect their family's welfare and health (Soliman *et al.* 2021).

According to a previous study, the prominent determinants of stunting in Indonesia are unexclusive breastfeeding, preterm delivery, short birth length, being born in a family with low socio-economic status, and maternal factors such as having short stature and low educational level. The risk of stunting also increases when the family living in a rural area do not have optimal access to health facilities and poor access to improved latrine and drinking water (Beal *et al.* 2018). In addition to that, maternal anemia is also reportedly leads to poor pregnancy outcomes such as preterm labor, incidence of caesarian section, low birth weight, small for gestational age (Shah *et al.* 2022), and short birth length (WHO 2020). The risk factors of anemia itself are multifactorial (Owais *et al.* 2021).

For years, Indonesia has been struggling with stunting problems. Indonesia even ranks 108th out of 132 countries in stunting prevalence by the Global Nutrition Report in 2016 (IFPRI 2016). Basic Health Research 2018 shows that

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the national prevalence of stunting was 30.8%, and in Banggai Regency was 31.9%. However, preventing stunting has always been a challenging task. From 2007 to 2013, only a 6% reduction in National stunting prevalence. It seems that doing business as usual did not tremendously affect stunting reduction.

Therefore, in 2017, Indonesia's Government launched a program to accelerate the stunting prevalence reduction called National Strategy to Accelerate Stunting Prevention (TP2AK 2020). The goal is to reduce stunting prevalence by up to 14% by the year 2024 in children under 5 years of age (Peraturan Presiden Republik Indonesia 2020). For that purpose, in 2018, Indonesia's Government appointed 10 villages within 100 regencies/cities as a focus-location (locus), and Banggai Regency was among the 100 regencies/ cities.

The National Strategy to Accelerate Stunting Prevention assign the focus location must integrate nutrition-specific and nutrition-sensitive intervention programs. Responding to the national strategy, in late 2018, they established a multisectoral task force focusing on 1,000 first days of life, held stunting seminars to raise awareness about stunting, and signed a memorandum of understanding with universities in research about stunting. The activities resulted in a plan to reformulate and converge the existing programs with new programs. In consequences, studies about health determinants must be conducted before establishing new reformulated and innovative programs in focus-location villages.

Similarly for anemia, efforts in reducing anemia prevalence have been accelerated globally and locally. Data analyzes on determinants and anemia prevalence, research on innovative prevention and intervention, collaboration with all sectors at all levels, commitment strengthening in anemia reduction (WHO 2023), and providing health service with life-course approach (Sungkar *et al.* 2022), are the key programs in anemia reduction acceleration. Regarding this and since anemia in non-pregnant women could affect the outcome of pregnancy, a study about the determinant of anemia is important. This study aims to determine the risk factors correlating with anemia in non-pregnant women in Banggai Regency.

METHODS

Design, location, and time

This study is a cross-sectional study held in April 2019 in Banggai Regency at 10 Community Health Center (CHC) areas, with recruitment focusing on respondents from 10 stunting prevention locus villages. The 10 CHCs are Pagimana, Lobu, Toima, Simpang Raya, Bunta, Nuhon, Saiti, Hunduhon, Tangeban and Teku. These are all located in rural areas of Banggai Regency, with the closest CHC being 1.5 hours away from the regency's capital. Data collection approval was obtained from Banggai Regency Health Office (Letter of Approval's number:400/2742/Dinkes) on 8 April 2019.

Sampling

With non-probability sampling method, 308 non-pregnant women were chosen from 450 women in childbearing age. These 308 respondents are the total number of women who met the study's criteria: bride-to-be, women in pregnancy program, domiciled in mentioned CHCs, also willing to participate in the study. The non-pregnant women were chosen to be the respondents because the Government needs information about health determinants of this group. This group's health and nutritional status are believed to significantly affect the success of the Government's 1,000 Days of Life program.

The respondents were recruited through an announcement in the CHCs and disseminated in villages by midwives and health cadres. Non-pregnant women who were married and responding to the announcement were then asked about their utilization of contraceptives in the last month. They are then included if they did not use contraceptives at least 1 month before the study. The 1 month cut-off point were chosen because ovulation could begin shortly after contraceptive cessation (Britton *et al.* 2020) and due to conception can happen within 12 month after contraceptive cessation (Girum & Wasie 2018). This 1-month cut-off point not only can confirm their readiness in pregnancy programming, but also can give mother-to-be a chance to improve their nutritional status and knowledge about healthy pregnancy by participating in preconception program held by CHC. As for the exclusion criteria were women who were sick at the time of the study.

Data collection

We use a questionnaire and perform an anthropometric measurement to collect independent variables. Anthropometric measurement was conducted using microtoise to measure height in centimeters, SECA flat scale to measure weight in kilograms and SECA 201 measuring tape to measure the respondent's MUAC in centimeters. And for the dependent variable, anemia status as determined by hemoglobin level, we use HemoCue Hb 301 to measure it. The outcome of independents variables was categorized into two categories. The age of respondents was categorized as teenagers (≤21 years old) and adults. The last education completed by respondents was categorized as completed 12 years of compulsory education. Ownership of healthy latrine was categorized as YES for respondents who have a healthy latrine and NO for respondents who did not. Water sources/facilities for cooking activities from protected dug well, public piped water into yards or houses, tube well, protected springs, refilled drinking water, and protected rainwater collection are classified as standardized. Other than that, are categorized as not standardized.

Moreover, daily consumption of iron-source food, such as legumes, green vegetables, and fish or meat, was categorized as daily and non-daily consumption for those who consume less than 7 days a week. Body Mass Index (BMI) and Middle Upper Arm Circumference (MUAC) are categorized as normal and not normal for those who have BMI or MUAC under or above the normal range.

Before we conducted the study, we trained college students from a local university as enumerators to use the questionnaire and to perform anthropometric measurements. In contrast, the hemoglobin level was measured by nurses from the CHCs. As for the consent from respondents, we collected the informed consent between the time the research was announced and before it began, with the help of health workers in CHC.

Data analysis

Each location of the study was supervised by one of the researchers. Every questionnaire was checked the completeness and entered in Microsoft Excel, then transferred to a statistical software to perform the statistical analyses. Bivariate analysis using chi-square was employed to validate the effect between the dependent and independent variables. Variables with a significancy level of $p<0.25$ were then included in logistic regression. The results were presented as Odds Ratio (OR) and 95% Confidence Interval (95% CI).

RESULTS AND DISCUSSION

Characteristic of respondents

Banggai Regency is located in the eastern part of Central Sulawesi Province and is divided into 23 subdistricts and 337 villages. Twenty-seven Community Health Centers (CHCs) were built and operated in all 23 subdistricts for health services. Only 3 subdistricts can be categorized as urban areas, while the rest are in rural areas in which the study areas are located.

Table 1 displays the characteristic of respondents. About 80 (25.97%) of the respondents were anemic. The mean age and hemoglobin levels were 30±6.2 years and 12.7±1.5 g/dL, respectively. The majority of respondents were adults (n=224, 74.4%), had not completed the 12 years of compulsory education (n=159, 51.6%), had abdominal circumference above 80 cm (n=208, 67.5%), have BMI under and above the normal range (n=240, 77.9%) but have normal range of MUAC (n=165, 53.5%). Most of them consume legumes less than 7 days a week (n=240, 77.9%) and consume green vegetables (n=188, 61%) and fish or meat daily (n=178, 57.8%). The majority also have their own healthy latrine (n=159, 51.6%) but use water from not-standardized sources/facilities for cooking activity (n=200, 64.9%).

Factors associated with anemia in non-pregnant women

Respondents of this study are non-pregnant women who are in the state of preparing to be a mother, or in another term, they are preconception women. Women's health and nutritional status in this period significantly affect maternal nutritional status and even the pregnancy outcome (Stephenson *et al.* 2018). Specifically, anemia status could determine the anthropometric of newborns via intrauterine growth restriction led by chronic hypoxia due to low level of hemoglobin which then cause restriction of oxygen amount in body circulation (Naoko *et al.* 2012; Ganju

Table 1. Characteristic of respondents

Variable	n	%
Age*	30	6.2
Hemoglobin level, g/dL*	12.7	1.5
Anemia status		
Anemia	80	25.97
Non-anemia	228	74.03
Education		
≥12 years	149	48.4
<12 years	159	51.6
Abdominal circumference		
>80 cm	208	67.5
≤80 cm	100	32.5
Age		
Teenager	79	25.6
Adult	229	74.4
BMI		
Normal	68	22.1
Not-normal	240	77.9
Legumes consumption		
Daily	68	22.1
Non-daily	240	77.9
Fish and or meat consumption		
Daily	178	57.8
Non-daily	130	42.2
Green Vegetables		
Daily	188	61
Non-daily	120	39
MUAC		
Normal	165	53.5
Not-normal	143	46.4
Healthy latrine ownership		
Yes	159	51.6
No	149	48.4
Standardized water utilization for cooking		
Yes	108	35.1
No	200	64.9

*Value presented as (X±SD)
MUAC: Middle Upper Arm Circumference
BMI: Body Mass Index

2020). Moreover, nutritional status, especially anemia status in non-pregnant women, is affected by various factors such as age, anthropometric markers, food consumption and sanitation.

Table 2 describes the bivariate analysis results using chi-square. Independent variables that had a significant association with anemia status in non-pregnant women were consumption of fish or meat, legumes consumption, MUAC, and water utilization for cooking ($p<0.05$). Meanwhile, the signification level of the other independent variable, such as the last completed education level, abdominal circumference, age, and BMI, did not report any association with anemia status.

Based on the bivariate analysis, we included variables that had a significance level of $p<0.25$ in logistic regression analysis (Table 3). Variables that seemingly could decrease anemia are non-daily consumption of legumes (COR=0.54, 95% CI:0.29–1.00; p=0.05) also under and above the normal range of MUAC (COR=0.55, 95% CI:0.32–0.96; p=0.03). Conversely, non-daily consumption of fish and or meat increases the risk of anemia (COR=2.16, 95% CI:1.25–3.71; p=0.00). This increased risk was also shown in respondents who did not use clean water from standardized facilities/sources for cooking (COR=2.13, 95% CI:1.17–3.89; p=0.01).

After adjustment using stepwise regression with backward elimination (Table 3), elevated odds of anemia were significantly associated with non-daily consumption of fish or meat (AOR=2.27, 95% CI:1.34–3.85; p=0.002) and utilization of water from non-standardized sources/facilities for cooking (AOR=2.19, 95% CI:1.21–3.95; p=0.009).

Many studies explored the correlation of anthropometric markers with anemia status with various results (Qin *et al.* 2013; Choma *et al.* 2015; Virginia & Fenty 2017; Cepeda-Lopez & Baye 2020; Kerkadi *et al.* 2021; Jeong *et al.* 2022). Among three anthropometric markers measured in this study, only MUAC significantly correlates with anemia status. Respondents who have MUAC fall under and above the normal range (53.5%) are less likely to be anemic (COR=0.55, 95% CI:0.32–0.96; p=0.03) compared to those who have normal nutritional status. The findings here do not align with those of a prior study in Indonesia that report higher odds of anemia in women who are underweight

Table 2. Bivariate analysis of independent variables based on respondents' anemia status

Variable	Anemia status		X^2	*p*
	Non-anemia 228 (74.02%)	Anemia 80 (25.97%)		
Legumes consumption				
Daily	44	24	3.94	0.047*
≤6 times/week	184	56		
Fish and or meat consumption				
Daily	143	35	8.73	0.003*
≤6 times/week	85	45		
Green vegetables				
Daily	139	49		
≤6 times/week	89	31	0.53	0.76
MUAC				
Normal	114	51	4.5	0.034*
Not-normal	114	29		
Healthy latrine ownership				
Yes	124	35	2.68	0.101
No	104	45		
Standardized water utilization for cooking				
Yes	89	19	6.07	0.014*
No	139	61		
Education				
≥12 years	118	41	0.006	0.938
<12 years	110	39		
Abdominal circumference				
>80 cm	156	52	0.31	0.574
≤80 cm	72	28		
Age				
Teenager	59	20	0.02	0.877
Adult	169	60		
BMI				
Normal	48	20	0.53	0.464
Not-normal	180	60		

*significant value ($p<0.05$); BMI: Body Mass Index; MUAC:Middle Upper Arm Circumference

Table 3. Logistic regression

Variable	Anemia status		COR (95% CI)	*p*	AOR (95% CI)	*p*
	Non-anemia	Anemia				
Legumes consumption						
Daily	44	24	1		1	
≤6 times/week	184	56	0.54 (0.29–1.00)	0.05*	2.27 (1.34–3.85)	0.002*
Fish and or meat consumption						
Daily	143	35	1			
≤6 times/week	85	45	2.16 (1.25–3.71)	0.00*		
MUAC						
Normal	114	51	1			
Not-normal	114	29	0.55 (0.32–0.96)	0.03*		
Healthy latrine ownership						
Yes	124	35	1			
No	104	45	1.50 (0.87–2.59)	0.14		
Standardized water utilization for cooking						
Yes	89	19	1		1	
No	139	61	2.13 (1.17–3.89)	0.01*	2.19 (1.21–3.95)	0.009*

*significant value ($p<0.05$); MUAC: Middle Upper Arm Circumference

or have low MUAC scores (Nainggolan *et al.* 2022) but in accordance with another study (Sari *et al.* 2022). The categorization of MUAC's group in this study variable might be the reason for the opposite result in another study. In this study, the group of respondents who were categorized as not having a normal range of MUAC consisted of those who were underweight and those who were overweight, even obese. Obese women tend to have a lower risk of anemia, as reported in a previous study (Utami *et al.* 2020), due to the allegedly biological mechanism which is hypoferremia led by the elevation of low-grade chronic inflammation and hepcidin level (Alshwaiyat *et al.* 2021), and given the complexity of anemia etiology, this contradictive result is unsurprising.

Iron-deficiency anemia is the most common anemia in the world in all age groups, including in Indonesia (WHO 2015; Manikam 2021). However, other nutrient deficiencies such as zinc (Jeng & Chen 2022), folate, vitamin B12, vitamin A (Finkelstein *et al.* 2020), and protein (Brittenham *et al.* 2023) also contribute to anemia. Legumes and green vegetables are iron and other micronutrients source of food. However, iron from this plant-based food is non-heme iron which is only absorbed 10%, and the absorption is highly affected by dietary factors such as the consumption of coffee, tea, and phytates (Piskin *et al.* 2022). This bioavailability of iron from plant-based food might be the reason why no significant correlation between the consumption of legumes and green vegetables with anemia can be found in this study.

Fish and meats are food rich in iron and protein and contain other nutrients such as zinc and riboflavin that affect the hemoglobin level.

The odds of anemia in non-pregnant women who did not consume fish or meat daily in this study are higher compared to women who did (AOR=2.27, 95% CI:1.34–3.85; p=0.002). Considering the nutrient content of fish and meat, it is inevitable that consumption in sufficient amount will prevent anemia, as shown in a study of Japan's elderly (Imai & Nakade 2019). However, the irony of this result is that most of these research locations are coastal areas, and the main source of protein in Banggai Regency is fish (BPS-Statistic of Banggai Regency 2020), yet not everyone consumes fish daily.

According to Robert N. *et al.* (2022), in a fishing community, fish from open-water fishing only consumed about 5–10% of the total catch, and the rest of it was sold to the market. The high fish price in certain seasons also makes the community prefer to sell the catch than consume it directly (Roberts *et al.* 2022). This condition also may occur in our research community. Even though many of the respondents are consumers, high prices in certain seasons can be an obstacle to fish consumption (Fiandari *et al.* 2019). Meat (beef, goat, and poultry) consumption is less frequent than fish consumption in Banggai's rural area, especially in low-economic families, because of the price and the culture. Thus, make meat is often only consumed on certain occasions. Data from Banggai's Central Statistical Agency (BPS) confirmed that people at the bottom 40% of the economic level do not consume adequate calories and protein and only spend about 52,000 Rupiah of meat per capita per month (BPS-Statistic of Banggai Regency 2018; 2020).

World Health Organization (WHO) pointed out that inadequate access to Water, Sanitation and Hygiene (WASH) is among the intermediate determinants of anemia in women of reproductive age (WHO 2020). The adjusted OR in non-pregnant women who did not use water from standardized facilities/sources to suffer from anemia is two times higher compared to those who did. This comes in agreement with previous studies in other parts of the world (Teshale *et al.* 2020; Talukder *et al.* 2022) and the odds of anemia being elevated if access to healthy latrine is limited (Kothari *et al.* 2019). The direct pathways between not-standardized water to anemia are diarrhea, intestinal parasitic infection (WHO/USAID/UNICEF 2015) and environmental enteropathy (Regassa *et al.* 2023).

This study has limitations. Consumption of all food groups only assessed using food frequency weekly. We planned to use 24hr recall method to assess the consumption, but due to the lack of preparation times, we could not train the enumerator to perform the method as well as it should.

Another limitation is the characteristic homogeneity of the community where respondents belong to. To give perspective, the common characteristic of rural areas in Banggai District is that people in one village or even subdistrict usually come from the same ethnic group, farmer and fisherman are the main occupations, with fewer people being civil servants and traders, the majority of women are housewives and did not have permanent work. Moreover, traditional markets in most rural areas did not operate 7 days a week, so the community relied on greengrocer peddlers daily. This homogeneity is more visible because the stunting locus areas are close to each other. Therefore, the results might be generalized to only some parts of the regency

CONCLUSION

Not using water from standardized sources/ facilities for cooking activity and not consuming fish or meat daily are the determinant factors that significantly correlate with anemia in Banggai Regency's non-pregnant women. However, further research, especially about the quantity of iron-source food consumption and its inhibitor, together with individual access to a healthy latrine, and infection frequency, is needed to gain a deeper understanding of the incidence of maternal anemia in Banggai Regency.

Local governments should include these variables in their new reformulated and innovative stunting-reducing programs, thus perhaps they can achieve their expected targets such as reducing anemia in pregnant women and reducing stunting in the long run.

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DECLARATION OF CONFLICT OF INTERESTS

The authors have no conflict of interest.

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Parental Feeding Styles Related to the Stunting in Sleman, Indonesia

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ABSTRACT

The study aimed to determine the correlation between parental feeding style and stunting in toddlers. This study was an observational method with a cross-sectional design. The population of this study were all mothers of toddlers who were in the Minggir Puskesmas (Public Health Center) working area. The sample size in this study was 114 mothers of toddlers, and the sample was chosen using the cluster random sampling technique. Determination of parenting style variables based on demandingness and responsiveness scores. There are four categories of parental feeding styles, namely democratic, authoritarian, permissive, and neglect parenting. Anthropometric measurements of toddlers were carried out directly, and interviews using the parental feeding style questionnaire that had been tested for validation and reliability. That the data was analyzed with Fisher's Exact test. The Fisher's Exact test revealed that there was a correlation between parental feeding styles approaches to the stunting incidence with the value of $p=0.000$ ($p<0.05$). The parental feeding style that mostly applied to cause stunting is the neglect-feeding style (8.8%). Parents should further improve their parenting patterns by always paying attention to food intake, especially the amount, frequency of feeding, and type of food.

Keywords: feeding style, parenting style, stunted, toddler

INTRODUCTION

Stunting is a chronic nutritional problem in children under five years old characterized by a low ratio of length or height to age according to a z-score of -3 SD to <-2 SD (stunted) and <-3 SD (severely stunted) (MoH RI 2020a). According to WHO (World Health Organization), the prevalence of stunting in toddlers was as high as 22% or as many as 149.2 million of children in 2020 (WHO 2020). South-East Asia Regional (SEAR) was ranked sixth in the world in the prevalence of stunting in toddlers, as much as 27.3% or as many as 15.3 million in 2020 (WHO 2020). Based on the Survey of Toddlers' Nutritional Status in Indonesia (*Survey Status Gizi Balita Indonesia*-SSGBI), the prevalence of stunting in Indonesia is as much as 26.2%. This figure is relatively high because it passes the threshold of stunting from (WHO 2020) which is less than 20% (MoH RI 2020b). The result from the data of Nutritional Status Monitoring (*Pemantauan Status Gizi*-PSG) showed that the prevalence of stunting in toddlers in Sleman Regency reached 11.9% in 2017, lowered to 11.0% in 2018 and again, lowered to 8.4% in 2019. Although there was a decline in the percentage of the prevalence of stunting in 2019, the number of toddlers in monitoring was still high, which was as many as 58,521 toddlers, compared to 55,055 toddlers in 2018. One of the *Puskesmas* (Public Health Centre) in Sleman Regency, namely *Puskesmas* Minggir, had a prevalence of stunting in toddlers as much as 15.8%, which can be categorized as high seen from the strategic plan of Sleman Regency, which is 11.5% (Dinkes Sleman 2020).

It is proven from the research that the lack of food intake, inadequate parenting style, short-stature genetics, failure to exclusively breastfed, failure to get early breastfeeding initiation (*Inisiasi Menyusu Dini*-IMD), inadequate sanitation, low birth weight (*Berat Badan Lahir Rendah*-BBLR), and anemic pregnant mothers are the factors which lead to stunting (Ernawati 2020).

Nutritional status is also indirectly influenced by various factors, such as food availability, parenting style, parental education level, and healthcare (Bella *et al.* 2020). Based on the finding of one of the researches in Sleman Regency, there was a significant correlation between parenting style on feeding and stunting

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status (Melcita *et al.* 2016). Based on the finding of the research from Harahap & Handayani (2022) in Riau, one of the factors which became the risk factor of stunting occurrence was parenting style on feeding (Harahap & Handayani 2022). This is in line with the finding of the research conducted by Lailayah in the work area of *Puskesmas* Dapet in Gresik, showing a significant corellation between parenting style in feeding and stunting occurrence on toddlers aged 2–5 years (Lailiyah *et al.* 2021).

Parental style of feeding has the aspects of demandingness and responsiveness. Democratic parenting describes a balance of high demandingness and responsiveness, where mothers are active in encouraging children to eat while still providing good responsiveness by providing affection and warmth. Authoritarian parenting has a high demandingness aspect but low responsiveness, indicating that mothers who demand or invite children are high but mothers are less responsive in meeting children's food needs. Permissive parenting has low demandingness and high responsiveness. This shows that the mother is less demanding for the child to eat but the mother gives the opportunity and freedom to the child to choose their own food. A neglectful parenting style is a combination of low demandingness aspect and low responsiveness aspect. Low demand demonstrates that the mother neglects the children and frees the children to consume food without any demand, while low response demonstrates that the mother is not responsive enough in fulfilling children's intake needs. Based on Baurmind theory, there are four types of parenting styles employed by parents to their children, namely democratic, authoritarian, permissive, and neglectful (Gafoor & Kurukkan 2014).

Based on the elaboration above, one of the factors leading to stunting is the parenting style of feeding. Parenting style on feeding is the behaviour of mothers in caretaking the children: feeding daily meals that can affect children's nutrition. This study used Fisher's exact test to determine the corellation between two categorical variables.

METHODS

Design, location, and time

The design of the research was cross-sectional. This research was conducted in *Posyandu* (Integrated Health Care) in the work area of *Puskesmas* (Public Health Center) Minggir, Sleman Regency. There are five villages in the area, namely Desa Sendang Agung, Sendang Mulyo, Sendang Arum, Sendang Sari, and Sendang Rejo. This research was conducted in March 2023. This research has been granted ethical feasibility from the Research Ethics Committee of the Faculty of Health, 'Aisyiyah University Yogyakarta (2627/KEP-UNISA/III/2023).

Sampling

The population in this study were all mothers who had children under five in the working area of the *Puskesmas*. The sample size in this study used the proportion estimation formula and then added 10%, so the sample of this study was 114 mothers of toddlers. The sampling technique used in this study was cluster random sampling, namely sampling by taking representatives from each village taken randomly. The inclusion criteria in this study were mothers who had toddlers in the work area of the *Puskesmas* Sleman Regency and mothers who had toddlers aged 1–5 years. Exclusion criteria in this study were toddlers who had a history of genetic diseases.

The questionnaire on parenting style on feeding has been through validity and reliability test using the product moment formula with a total of 24 questions. The result was pronounced valid with a score of 0.04 and pronounced reliable with Cronbach's Alpha score of 0.90. The instruments were pronounced valid and reliable. The "favorable" statement "always" was given the score of 4, "often" was given the score of 3, "sometimes" was given the score of 2, and "never" was given the score of 0. For "unfavorable" statement, "always" was given the score of 0, "sometimes" was given the score of 2, "seldom" was given the score of 3, and "never" was given the score of 4. The calculation of Demandingness (D) and Responsiveness (R) answers from each respondent yielded the total questionnaire score. The total score from the entire respondents was counted for their median. Then, based on the median value, each respondent's answer score was classified into four categories: democratic parenting style (D value>median and R>median), authoritarian parenting style (D value>median and R<median), permissive parenting style (D

value<median and R>median), and neglectful parenting style (D and R-value<median) (Astuti 2014). The free variable in this research was parenting style on feeding with an ordinal measurement scale, while the bound variable in this research was stunting occurrence on toddlers with a nominal measurement scale. Determining the variable of parenting style on feeding was based on the demandingness and responsiveness scores. The categories of parenting styles feeding were divided into four kinds, namely democratic parenting style, authoritarian parenting style, permissive parenting style, and neglectful parenting style. The tool to measure the variable was the questionnaire of parenting style on feeding, consisting of 17 demandingness questions and 7 responsiveness questions, in which the questionnaire would be filled according to the result of the interview with the toddlers' mothers. The variable of stunting occurrence in toddlers was a bound variable measured based on the result of anthropometric measurement of the toddlers, which then was interpreted based on the indicator of height/age (height according to age) employing WHO-Anthro application. This variable was grouped into two categories, namely stunting and normal. According to the WHO anthropometric classification, nutritional status is categorized if the z-score value is <-3 SD (severely stunted), -3 SD to <-2 SD (stunted), -2 SD to +3 SD (normal) and >+3 SD (high).

Data collection

The data source in this study is primary data, which is data found in the field. The primary data collection process began with explaining the purpose and objectives of the study to the participants. Anthropometric measurements were assisted by *Posyandu* cadres in each village and two enumerators. Anthropometric measurements were assisted by *Posyandu* cadres in each village and two enumerators. The data collected included mother's education level, mother's occupation, feeding parenting style, and the incidence of stunting in the Minggir *Puskesmas* working area.

Data analysis

Categorical data analysis is presented in the form of numbers and frequencies. Fisher's Exact test used to determine the association between parental feeding style and stunting showed a significant correlation if the p-value was 0.005 measured by licensed statistic software stata version 13. The requirements of the Fisher's Exact test requires are that the Expected value is less than 5 and the data scale is categorical. Fisher's exact test was employed to observe the relationship between parenting style on feeding and stunting occurrence.

RESULTS AND DISCUSSION

This research was conducted in *Posyandu* (Integrated Health Care) in the work area of *Puskesmas* (Public Health Center) Minggir, Sleman Regency. From the research conducted, the data obtained from 114 respondents were explained. Based on Table 1, it can be seen that the majority of mothers who are senior high school/ equal graduates (n=47, 41.2%) and mothers who are housewives (n=74, 64.9%).

Based on Table 2 about the characteristics of the toddlers, it can be seen that there were 58 male (50.9%), and majority of the toddlers have normal nutritional status (n=90, 78.9%). However, these were 24 toddlers who were stunting (21.1%).

The aspect of parenting style on feeding

Among stunting children, parental feeding style of low demandingness was greater than those with parental feeding style high demandingness (Table 3).

The result of the statistical test employing Fisher's Exact shows a significant degree as much as p=0.000 by determining a significant degree p<0.05. The result of the analysis illustrates a significant correlation between parenting style on feeding and stunting occurrence in toddlers in the work area of *Puskesmas* Minggir (Table 4).

Stunting is a condition where toddlers have less length or height when compared to age due to chronic malnutrition (long-term malnutrition) caused by insufficient nutritional intake as a result of feeding that is not in accordance with nutritional needs (MoH RI 2020b).

According to Diana Baumrind's theory, parenting is parents educating, caring for, guiding, and protecting children in achieving the maturity process. The most important parenting has good behavior, especially infulfillment of nutrition. Inadequate feeding leads to inadequate food intake. Nutrient deficiencies, especially energy and protein nutrients, are a direct factor because

Table 1. The characteristics of the mothers of the toddlers

Variable	n	%
Mother's education		
Elementary school/equal	4	3.5
Junior high school/equal	42	36.8
Senior high school/equal	47	41.2
Associate's/Bachelor's degree	21	18.4
Mother's occupation		
Housewive	74	64.9
Farmer	9	7.9
Entrepreneur	25	21.9
Civil servants	6	5.3
Total	114	100.0

physical growth in children will be inhibited (Pratama *et al.* 2019).Another research showed the correlation between parenting style on feeding with stunting occurrence with a p value of 0.001 (Wibowo *et al.* 2023). This research is in line with the research conducted by Syafei (2022), stating that there was a significant correlation between parenting style on feeding with stunting.

Based on the results of the study, the majority of toddlers who experienced stunting (8.8%) had mothers with neglectful parenting, while the majority of toddlers who did normal (58.8%) had mothers with democratic parenting. A Neglectful parenting style is a combination of low demandingness aspect and low responsiveness aspect. Low demand demonstrates that the mother neglects the children and frees the children to consume food without any demand, while low response demonstrates that the mother is not responsive enough in fulfilling children's intake needs. Thus, they can influence the children's nutritional status. The research from Gunawan stated that the parenting style for feeding children with stunting was mostly neglectful (as many 39.2%). Gunawan stated that neglectful parenting style was shown in the form of mothers who neglected their children while eating at any time and neglected the children when the children did not want to eat, which caused unfulfilled nutritional needs in children (Gunawan *et al.* 2020). The research from Wardani stated that the majority of toddlers with stunting had a neglectful parenting style (44.4%), with p-value of 0.003, meaning that there was a significant correlation between parenting style on feeding with stunting occurrence. In the research data, it was found that there was a lack of maternal role in demanding children to eat (Wardani & Andari 2022).

The questionnaire on parental style of feeding has the aspects of demandingness and responsiveness. The aspect of demandingness is the tendency of parents to demand, control, and monitor childcare. In contrast, the aspect of responsiveness is the tendency of parents to demonstrate warmth, acceptance, and involvement in childcare.

Based on the finding of this research, mothers who employ a democratic parenting style, as many 58.8% and have proven to have children without stunting. The democratic parenting style found in this research illustrates that there is balance in the aspect of high demandingness and responsiveness where the mothers actively encourage the children to eat. At the same time, still providing good responses towards children's intake needs by giving love and warmth. This study is in line with previous research stating that most democratic parenting patterns were found in as many (60.0%) in toddlers with good nutritional status (Rahmiati & Yuliati 2023). For toddlers with non-stunting, this research is in line with the previous research where (86.7%) implemented a

Table 2. The characteristics of the toddlers

Variable	n	%
Sex		
Male	58	50.9
Female	56	49.1
Nutritional status		
Stunting	24	21.1
Normal	90	78.9
Total	114	100.00

Table 3. The distribution of the frequency in the aspect of parenting style on feeding

Parenting style aspect	Nutritional status				Total	
	Stunting		Normal			
	n	%	n	%	n	%
Demandingness						
Low	13	11.4	12	10.5	25	21.9
High	11	9.7	78	68.4	89	78.1
Responsiveness						
Low	13	11.4	16	14	29	25.4
High	11	9.7	74	64.9	85	74.6
Total	24	21.1	90	78.9	114	100

democratic parenting style. Based on the research finding, mothers who demanded their children to eat while balancing it with high responsiveness made toddlers finish their meals without stress (Ramadhani & Novera 2022). Mothers who implement a democratic parenting style have 5.1 times more potential to have toddlers without stunting (Rahman 2018).

Based on the analysis, this research finds that the prevalence of authoritarian parenting style is as much as 2.6% in toddlers with stunting with p=0.000. Authoritarian parenting style happens when mothers are too demanding to the children but are not responsive enough to the children's needs, thus affecting their children's nutritional status. In another research, it was even found that authoritarian parenting style had in an even bigger prevalence, which was 46.8% with p=0.005 (Rifdi *et al.* 2021). Another research also found that authoritarian parenting style was 34.1% proven to be significant to stunting in toddlers, with p=0.019 (Darussalam *et al.* 2023). Those researches explain that the authoritarian parenting style is prone to causing stunting in toddlers. It is due to high demand (which shows the mothers' demand for the children to eat is very high) and low responsiveness, which shows that the mothers are not responsive enough to fulfill

Table 4. The correlation between parenting style on feeding and stunting occurrence in the work area of *Puskesmas* Minggir

Parenting style on feeding	Nutritional status				Total		*p*
	Stunting		Normal				
	n	%	n	%	n	%	
Neglectful	10	8.8	2	1.8	12	10.5	0.000*
Permissive	4	3.5	6	5.3	10	8.8	
Autoritarian	3	2.6	15	13.2	18	15.8	
Democratic	7	6.1	67	58.8	74	64.9	
Total	24	21.1	90	79.1	114	100	

*Significant value (p<0.05)

the children's intake needs because the mothers do not push for a balanced meal to the children.

Meanwhile, in the permissive parenting style, it found that 3.5% of toddlers with stunting. In several previous researches, in toddlers with stunting, it was found that the mothers implemented a permissive parenting style (62%) (Christiana *et al.* 2022). In line with the previous research, toddlers with stunting had mothers with permissive parenting styles as much as 67.3% (Luarsih *et al.* 2023). The research explains that a permissive parenting style might lead to stunting because, in this parenting style, there is a combination of low demandingness and high responsiveness. The low aspect of demandingness shows that the mothers are not enough to force and demanding the children to eat, while the high responsiveness shows that the mothers give a chance and freedom to the children to choose their food.

Stunting occurrence in toddlers is directly caused by food intake, which is influenced by the mother's parenting style. This research proves that parenting style affects toddlers' nutritional status, such as being underweight, stunting, and wasting in the first year (Mongkolchati & Phuphaibul 2016). In line with the research from Hidayati & Pratiwi (2022), there is a significant correlation between parenting style on feeding and stunting occurrences by stating, that a good parenting style on feeding depends on the skill of the mothers in arranging the menu to fulfil toddler's nutritional needs (Hidayati & Pratiwi 2022).

In daily life, the parenting style implemented by parents is multidimensional, meaning that parents can implement a democratic parenting style on particular occasions. However, parents can also use authoritarian, permissive, and even neglectful parenting style. The implementation of parenting styles by the parents can be influenced by various factors, social and environmental (Yıldız & Duru 2020). Sometimes, parents need to be authoritarian to increase their demands towards their children for adequate feeding. In different atmosphere, parents are needed to be permissive when children need a more fun feeding atmospheres and need warmth from the parents. Therefore, parents must adapt to the kind of parenting style which is adapted to the condition so that they can maintain their children's normal nutritional status.

CONCLUSION

Based on the objectives of the study, it can be concluded that there is a significant relationship between the two variables, namely parenting patterns in feeding with the incidence of stunting in the Minggir *Puskesmas* working area.

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DECLARATION OF CONFLICT OF INTERESTS

The authors have no conflict of interest.

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An Online Cross-Sectional Survey: Changes in Food Group Consumption on Complementary Feeding during COVID-19 Pandemic in Indonesia

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ABSTRACT

This study aimed to assess the impact of COVID-19 pandemic on food group consumption of complementary feeding in Indonesia. Data were collected using online self-administered questionnaires on Indonesian mothers of children aged 6–23 months. The result showed that households with decreased ability to provide food during the COVID-19 pandemic tended to choose unhealthy food groups on complementary feeding. There were higher odds of unhealthy food consumption, such as sweetened beverages, including fruit juice (OR=3.181; 95% CI:1.788−5.657) and homemade drink with sweeteners (OR=1.652; 95% CI:1.034−2.641); sugar confection (OR=2.066; 95% CI:1.240−3.444); frozen treats (OR=2.270; 95% CI:1.400−3.681), baked or fried confection (OR=2.154; 95% CI:1.435−3.235); fried and salty foods (OR=1.633; 95% CI:1.059−2.517). Meanwhile, the odds of food group consumption which lower during COVID-19 pandemic mostly are animal source foods group, including yogurt (OR=0.297; 95% CI:0.161−0.548); yogurt drink (OR=0.253; 95% CI:0.138−0.464); cheese (OR=0.355; 95% CI:0.230−0.549); eggs (OR=0.675; 95% CI:0.461−0.991); fish or seafood (OR=0.409; 95% CI:0.279−0.600); organ meats (OR=0.304; 95% CI:0.180−0.512); meats (OR=0.339; 95% CI:0.225−0.511); and poultry (OR=0.339; 95% CI:0.225−0.511). However, effective strategy for enhancing complementary feeding quality during pandemic should be formulated.

Keywords: complementary feeding, COVID-19, food group, unhealthy food

INTRODUCTION

The COVID-19 pandemic was declared by WHO on March 2020 and has spread to many countries, including Indonesia in 2020. The spread of COVID-19 is very fast and is transmitted through droplets (Setiadi *et al.* 2022; WHO 2020). The rapid transmission of COVID-19 has led to government policies such as large-scale social restrictions, including stay-at-home regulations, school-from-home, and restrictions on public and private gatherings (Laborde *et al.* 2021; Picchioni *et al.* 2022). The large-scale social restrictions policy impacted the household economic, including the decrease in production, wage cuts, and termination of employment (Syafiq *et al.* 2022).

Child nutrition and health issues have been negatively affected by the COVID-19 pandemic (Ntambara & Chu 2021). Low household economic level due to COVID-19 pandemic lead to decreasing purchasing power for nutritious and varied food, as well as access to health facilities. Children with poor dietary practices are more susceptible to illness, and if it persists for a long time, it will lead to malnutrition. (Kundu *et al.* 2021). Providing complementary foods that are timely, appropriate (frequency, amount, and consistency), safe, and responsive feeding is one strategy to improve children's health. Infant and Young Child Feeding guidelines suggest that children aged 6–23 months should be provided various foods to ensure that nutrient needs are met (UNICEF 2020).

There were eight food groups should provide during complementary feeding, including grains, roots, tubers, and plantains; pulses; nuts and seeds; dairy products; flesh foods; eggs; vitamin-A rich fruits and vegetables; and other fruits and vegetables (Binns *et al.* 2020). On the other hand, it is crucial to limit the consumption of unhealthy food groups such as sugar-sweetened beverages, sweet food, and fried or salty food (WHO & UNICEF 2021).

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During the COVID-19 pandemic, the practice of providing complementary feeding was quite challenging, this was due to socioeconomic changes, including restrictions on social activities and decreased household income (Widyaningrum *et al.* 2021). Low household income influences the type and amount of food given to children (Lovelace & Rabiee-Khan 2015). Furthermore, socioeconomic changes impacted the choice of food group ingredients for complementary feeding (French *et al.* 2019).

Currently, there are limited studies analysing the complementary feeding practice in Indonesia during the COVID-19 pandemic. This study aimed to assess the impact of COVID-19 pandemic on household ability to provide adequate complementary feeding practice in Indonesia.

METHODS

Design, location, and time

The research used a cross-sectional study. This study was conducted through an online self-administered questionnaire from April−May 2022 during the COVID-19 pandemic in Indonesia. The ethical clearance was obtained from the ethical committee of the Faculty of Health Sciences, Universitas Alma Ata (with the number KE/ AA/ VI/ 10832/ EC/ 2022). Participants in this study gave their informed consent after filling out a voluntary consent form.

Sampling

The population for this study was mothers of child who had a healthy child aged 6 to 23 months and currently living in Indonesia. The sampling technique used was convenience sampling where participation was open to all mothers who had been introduced to solid foods to their child. For practical reasons, only participants with access to the internet and a computer or smartphone were invited to participate.

Data collection

For timing and clarity, the questionnaire was piloted with three researchers and two mothers. Minor changes were made following comments on the phrasing and flow. The survey was created on the online platform Google Form. An online survey was chosen as the format due to the pandemic situation and COVID-19 physical restrictions. Several target groups in Indonesia received links to the online survey through social media, including Instagram, Whatsapp, Line, Facebook, and Twitter. For a quick and effective way to reach respondents, data was gathered from nearby communities by *Asosiasi Ibu Menyusui Indonesia* (AIMI). Total 630 sample participate in this study. Of the total sample, we excluded 56 participants for incomplete data, resulting in 574 participants.

The self-administered questionnaire collects information related to sociodemographic data, food group consumption on complementary feeding, and the impact of the COVID-19 pandemic on household economic aspects. Sociodemographic data include area of residence, household income level (low or IDR <1,500,000, middle or IDR 1,500,000−2,500,000, high or IDR >2,500,000), child's age, child's gender, maternal educational status (low or junior high school and below, middle or senior high school, high or the college or above), maternal and father's occupation (formal worker like civil servants, army, police, private sectors, infomal worker like labourer, entrepreneur, farmers). Data related to the impact of the COVID-19 pandemic on household economic aspects include the impact on the household's ability to provide food, the impact on mother's employment status, and the impact on father's employment status.

Food group consumption in complementary feeding is defined as children 6−23 months who consumed each food group on the previous day. Food group recommendations based on Infant and Young Child Feeding from UNICEF and WHO 2021 guidelines (WHO & UNICEF 2021). The type of food group including (1) Breastmilk; (2) Grains; (3) Starchy tubers or starchy tuberous roots; (4) Legumes, nuts, and seeds etc.; (5) Infant formula; (6) Milk from animals, such as fresh, tinned, or powdered milk; (7) Yoghurt; (8) Yoghurt drink; (9) Cheese; (10) Eggs; (11) Fish, seafood, or shellfish; (12) Organ meats; (13) Meats; (14) Poultry; (15) Processed meats; (16) Vitamin A-rich deep yellow and orange fleshed vegetable; (17) Dark green leafy vegetables; (18) Vitamin A-rich fruits; (19) Any other vegetables; (20) Any other fruits.

Furthermore, the consumption of other types of food groups that are recommended to limit their consumption in complementary feeding are also analysed, including sweetened beverages

and unhealthy foods. Sweetened beverage group including (1) Commercially produced and packaged; (2) Fruit juice; (3) Homemade drinks added with any kind of sweeteners. Unhealthy food groups included (1) Sugar confections; (2) Frozen treats; (3) Baked or fried confections; (4) Sentinel fried and salty foods.

Data analysis

Food group consumption and sociodemographic data were analysed using a descriptive analysis for frequency distribution. Pearson's Chi-Square test ($p<0.05$) was used to conduct a bivariate analysis of food group consumption and the impact of COVID-19 pandemic on household ability to provide food. To determine the adjusted odds ratios and 95% confidence intervals for the association between sociodemographic factors and unhealthy food and beverage consumption, multinominal logistic regression analysis was employed for adjusted analyses. Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) 26 Software.

RESULTS AND DISCUSSION

The total respondents of this study were 574 mothers of children aged 6−23 months. Majority of respondents are residents in Java 403 (70.21%), high-income level 229 (39.9%), the middle level of educational status 361 (62.89%), and unemployed/housewife 350 (60.98%). Most children were aged 12−17, and the child's gender was half boys and half girls. COVID-19 pandemic had an impact on household economic aspects, including decreased household ability to provide food 422 (73.52%) (Table 1).

Figure 1 reports the percentage of each food group's consumption on complementary feeding the previous day. Almost all children consumed grains such as rice 521 (90.77%) on their complementary feeding. The consumption of formula milk was higher 327 (56.97%) than breastmilk 327 (56.97%). Among all animal source food, organ meat was most consumed 419 (73.17%). Most children consumed any other fruits 324 (56.45%) and vegetables 206 (35.89%) rather than vitamin A rich fruits 175 (30.49%)and vegetables 111 (19.34%) Yogurt 460 (80.14%) was the most consumed dairy food group. Consumption of commercially produced and packaged food 507 (88.33%) and sugar confections 448 (78.05%) was high among the unhealthy food groups.

Table 2 shows the odds of healthy food groups consumption on complementary feeding were lower compared to unhealthy food groups if their household ability to provide food during COVID-19 pandemic had been affected. Healthy food group consumption that was statistically significant and lowering the odds during COVID-19 pandemic were dairy and animal source foods group. Dairy foods were significant, including yoghurt, yoghurt drink, and cheese. Animal source foods groups were significant including eggs, fish or seafood, organ meats, meats and poultry.

Meanwhile, the consumption of most plant-based food groups were higher in household that affected the ability to provide food during COVID-19 pandemic, including vitamin A-rich deep yellow and orange fleshed vegetable, dark green leafy vegetables, vitamin A-rich fruits any other vegetables, and any other fruits.

There were higher odds of unhealthy food groups consumption on complementary feeding shown in Table 3 on households that affected their ability to provide food during COVID-19 pandemic. Among sweetened beverage consumption, fruit juice and homemade drinks with sweeteners were high. Consumption of unhealthy food group were also have high odds, such as sugar confections, frozen treats, baked or fried confections, fried and salty foods.

The consumption of unhealthy food and sugar-sweetened beverages tended to have higher odds in households with a decreased ability to provide food. During the pandemic there was an increase in food prices on the market, generally healthy foods have a higher price than unhealthy food groups. This condition is related to consumer demand for healthy food due to panic buying behaviour during a pandemic (Sobaih & Moustafa 2022). As a result of these high food prices, there has been a shift in food choices, due to higher levels of stress, fewer resources, and less access to food (Laborde *et al.* 2021).

Household with food insecurity will tend to choose food with cheap sources of calories and generally non-perishable ingredients or food that can be stored on shelves to deal with food supply disruptions and social distancing policies and depend on high energy density for a longer

Table 1. Respondent characteristics

Characteristic	Frequency (n)	Percentage (%)
Area of residence		
Java	403	70.21
Outside Java	171	29.79
Income Level		
High	229	39.90
Middle	203	35.37
Low	142	24.73
Child's age (months)		
6−11	235	40.92
12−17	236	41.21
18−23	102	17.77
Child's gender		
Male	287	50.00
Female	287	50.00
Maternal educational status		
High	201	35.02
Middle	361	62.89
Low	12	2.09
Maternal employment status		
Housewife/Unemployed	350	60.98
Formal worker	102	17.77
Informal worker	122	21.25
Father's occupation		
Unemployed	5	0.87
Formal worker	179	31.18
Informal worker	390	67.95
COVID-19 pandemic impacts on the household ability to provide food		
Not affected	152	26.48
Decrease	422	73.52
COVID-19 pandemic impacts on mother's employment status		
No	319	55.57
Yes	255	44.43
COVID-19 pandemic impacts on father's employment status		
No	135	23.52
Yes	439	76.48

period of time (Adams *et al.* 2020). Compared to food-secure households, food-insecure households tend to choose higher intake of added sugar food and beverage which is also liked by children because of its taste (Landry *et al.* 2019). Based on this research, it is known that the types of unhealthy foods that are widely consumed in this study are long-shelf life foods, such as frozen food and other packaged snacks. As well as the majority of respondents in this study are domiciled in Java island (urban area), which is a location where many packaged food products are sold around the neighbourhood compared to outside Java island (rural areas).

Based on multivariate analysis (Table 4), it is known that the consumption of sugar-sweetened beverages were higher on older children, primarily aged 18−23 months (AOR=1.296;

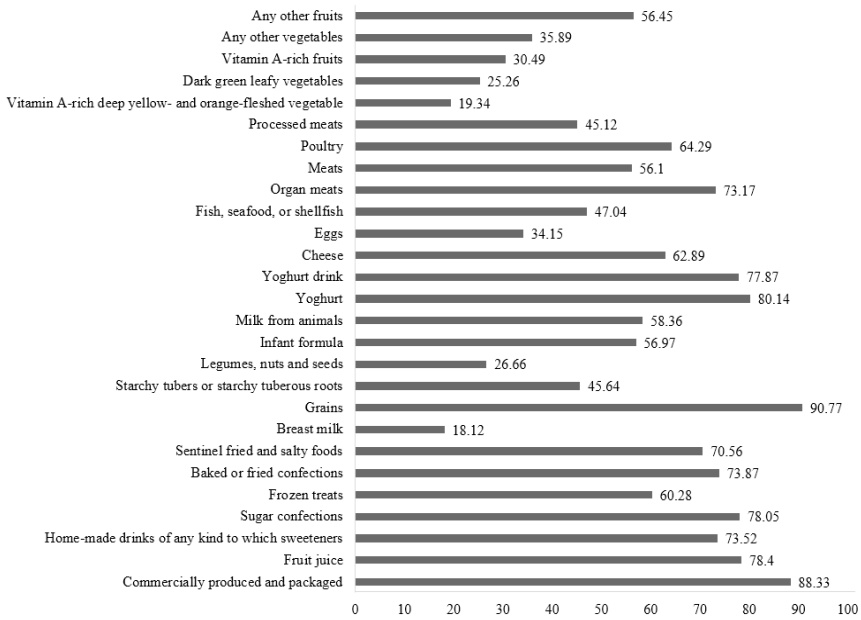

Figure 1. Consumption of several food groups on complementary feeding during the previous day

Table 2. Impacts COVID-19 pandemic related to household ability to provide food of several healthy food group consumption on complementary feeding

Variables	Food group consumption				OR	95% CI	*p*
	Yes		No				
	n	%	n	%			
Breast milk							
Decreased	73	17.3	349	82.7	0.816	0.511−1.304	0.396
Not affected	31	20.39	121	79.61	1		
Grains							
Decreased	379	89.81	43	10.19	1.611	0.788−3.292	0.191
Not affected	142	93.42	10	6.58	1		
Starchy tubers or starchy tuberous roots							
Decreased	160	37.91	262	62.09	0.299	0.202−0.443	<0.001
Not affected	102	67.11	50	32.89	1		
Legumes, nuts, and seeds							
Decreased	82	19.52	338	80.48	0.284	0.190−0.422	<0.001
Not affected	71	46.71	81	53.29	1		
Infant formula							
Decreased	250	59.24	172	40.76	0.816	0.511−1.304	0.396
Not affected	77	30.92	172	69.08	1		
Milk from animals							
Decreased	238	56.4	184	43.6	0.733	0.500−1.075	0.112
Not affected	97	63.82	55	36.18	1		
Yogurt							
Decreased	321	76.07	101	23.93	0.297	0.161−0.548	<0.001
Not affected	139	91.45	13	8.55	1		

Continue from Table 2

Variables	Food group consumption				OR	95% CI	*p*
	Yes		No				
	n	%	n	%			
Yogurt							
Decreased	321	76.07	101	23.93	0.297	0.161−0.548	<0.001*
Not affected	139	91.45	13	8.55	1		
Yogurt drink							
Decreased	308	72.99	114	27.01	0.253	0.138−0.464	<0.001*
Not affected	139	91.45	13	8.55	1		
Cheese							
Decreased	241	57.11	181	42.89	0.355	0.230−0.549	<0.001*
Not affected	120	78.95	32	21.05	1		
Eggs							
Decreased	134	31.75	288	68.25	0.675	0.461−0.991	0.045
Not affected	62	40.79	90	59.21	1		
Fish, seafood, or shellfish							
Decreased	174	41.23	248	58.77	0.409	0.279−0.600	<0.001*
Not affected	96	63.16	56	36.84	1		
Organ meats							
Decreased	287	68.01	135	31.99	0.304	0.180−0.512	<0.001*
Not affected	133	87.5	19	12.5	1		
Meats							
Decreased	209	49.53	213	50.47	0.339	0.225−0.511	<0.001*
Not affected	113	74.34	39	25.66	1		
Poultry							
Decreased	245	58.06	177	41.94	0.313	0.199-0.492	<0.001*
Not affected	124	81.58	28	18.42	1		
Processed meats							
Decreased	177	41.94	245	58.06	0.617	0.425-0.896	0.011*
Not affected	82	53.95	70	46.05	1		
Vitamin A-rich deep yellow and orange-fleshed vegetable							
Decreased	66	15.64	356	84.36	2.268	1.467−3.509	<0.001*
Not affected	45	29.61	107	70.39	1		
Dark green leafy vegetables							
Decreased	86	20.38	336	79.62	2.479	0.656−3.709	0.066
Not affected	59	38.82	93	61.18	1		
Vitamin A-rich fruits							
Decreased	109	25.83	313	74.17	2.204	0.495−3.248	0.121
Not affected	66	43.42	86	56.58	1		
Any other vegetables							
Decreased	120	28.44	302	71.56	3.275	2.233−4.815	<0.001*
Not affected	86	56.58	66	43.42	1		
Any other fruits							
Decreased	217	51.42	205	48.58	2.246	1.510−3.341	<0.001*
Not affected	107	70.39	45	29.61	1		

*Pearson's Chi-square Test, significant if p<0.05

95% CI:1.179−1.491) and children with working mothers (AOR=1.854; 95% CI:1.235−2.786). Meanwhile, the consumption of unhealthy food were also higher in older children, especially aged 18−23 months (AOR=1.235; 95% CI:1.140−1.393) and children who live in Java (AOR=1.708; 95% CI :1.486−1.830).

Consumption of sugar-sweetened beverages and unhealthy food or mostly defined as Ultra-Processed Food (UPF), both are influenced by the child's age, the odds of consumption increased in children aged 18−23 months. Consumption of ultra-processed food increases as children get older, this is associated with reduced breastfeeding as children get older, so parents provide other food on complementary feeding (Masztalerz-Kozubek *et al.* 2020). Furthermore, child preference and demand was a prominent factor in older children (Green *et al.* 2019).

Guidance regarding the selection of types of food in complementary feeding for parents is still needed, especially in relation to limiting added sugar consumption. Consumption of UPF in the first 2 years of life is not recommended due to high level of energy density, added sugar, fat, sodium and additives (Dunford & Popkin 2023; Murray 2017). UPF can also affect a child's future food preferences. Consumption of UPF is also associated with a higher prevalence of obesity, chronic disease, and nutritional deficiencies in the first years of life and may also interfere with child growth and development (Calcaterra *et al.* 2023).

Whereas in this study, the consumption of sugar sweetened beverages and unhealthy food were high accompanied by a low consumption of ASFs and dairy food. However, people will tend to reduce portions or even not consume ASFs due to economic reasons (Headey *et al.* 2018; Jafri *et al.* 2021). In general, the price of ASFs is quite expensive compared to other foodstuffs, especially during the pandemic due to the lockdown which caused problems in the food supply chain and also because of the

Table 3. Impacts COVID-19 pandemic related to household ability to provide food on sweetened beverage and unhealthy food consumption

Variables	Food group consumption				OR	95% CI	*p*
	Yes		No				
	n	%	n	%			
Commercially produced and packaged							
Decreased	367	86.97	55	13.03	0.572	0.297−1.00	0.094
Not affected	140	92.11	12	7.89	1		
Fruit juice							
Decreased	313	74.17	109	25.83	3.181	1.788−5.657	<0.001*
Not affected	137	90.13	15	9.87	1		
Homemade drinks added with sweeteners							
Decreased	311	71.33	125	28.67	1.652	1.034−2.641	0.032
Not affected	111	80.43	27	19.57	1		
Sugar confections							
Decreased	317	75.12	105	24.88	2.066	1.240−3.444	0.005
Not affected	131	86.18	21	13.82	1		
Frozen treats							
Decreased	235	55.69	187	44.31	2.27	1.400−3.681	0.001*
Not affected	111	73.03	41	26.97	1		
Baked or fried confections							
Decreased	296	70.14	126	29.86	2.154	1.435−3.235	<0.001*
Not affected	128	84.21	24	15.79	1		
Sentinel fried and salty foods							
Decreased	287	68.01	135	31. 99	1.633	1.059−2.517	0.026*
Not affected	118	77.63	34	22.37	1		

*Pearson's Chi-square Test, significant if p<0.05

Table 4. Multivariable logistic regression of factors associated with sugar-sweetened beverages and unhealthy food consumption on complementary feeding during COVID-19 pandemic

Characteristic	Sugar sweetened beverage		Unhealthy food	
	COR (95% CI)	AOR (95% CI)	COR (95% CI)	AOR (95% CI)
Area of residence				
Java	1.049 (0.700−1.571)		1.735 (1.499−1.820)	1.708* (1.486−1.830)
Outside Java	1		1	1
Income Level				
High	0.838 (0.469−1.496)		0.589 (0.314−1.104)	
Middle	0.809 (0.426−1.534)		0.728 (0.412−1.285)	
Low	1		1	
Child's age				
18−23 months	1.273 (1.163−1.457)	1.296* (1.179−1.491)	1.353 (1.240−1.520)	1.235* (1.140−1.393)
12−17 months	0.296 (0.195−0.450)	0.918 (0.574−1.470)	0.218 (0.129−0.369)	0.629 (0.373−1.059)
6−11 months	1	1	1	1
Child's gender				
Female	1.021 (0.711−1466)		1.124 (0.791−1.596)	
Male	1		1	
Maternal educational status				
Low	1.360 (0.381−4.862)		0.594 (0.177−1.992)	
Middle	1.037 (0.309−3.479)		0.838 (0.236−2.974)	
High	1		1	
Maternal employment status				
Work	1.960 (0.978−3.928)	1.854* (1.235−2.786)	1.180 (0.620−2.244)	
Housewife	1	1	1	
Father's occupation				
Unemployed	1.430 (0.906−2.256)		1.008 (0.650−1.562)	
Informal worker	1.027 (0.139−7.589)		1.762 (0.266−11.663)	
Formal worker	1		1	
COVID-19 pandemic impacts on the household ability to provide food				
Decrease	1.573 (1.055−2.344)		1.361 (1.112−1.975)	
Not affected	1		1	

*Pearson's Chi-square Test, significant if p<0.05

long production process (Rahimi *et al.* 2022). According to the study's findings, the proportion of ASFs consumed is higher when compared to other types of food and beverage, particularly sugar sweetened beverages and unhealthy foods. To ensure price stability for ASFs on the market, further policies are required. In order to meet the consumption of ASFs in CF, a safety net is

also required for families who experience food insecurity.

As a limitation of this study the we used convenience sampling, which may have been representative of the general population of Indonesian mothers of children aged 6−23 months. The respondents were recruited through social media and a community group, which that cause selection bias and affect the generalizability of the findings. The study relied on online self-administered questionnaires, which may be subject to recall bias, social desirability bias, and measurement error.

CONCLUSION

The result showed that households with decreased ability to provide food during the COVID-19 pandemic tended to choose unhealthy foods for complementary feeding. There was a higher odd of unhealthy food such as sweetened beverage consumption, including fruit juice and homemade drink with sweeteners. Meanwhile, the odds of food group consumption were low mostly are animal source foods and dairy. To improve nutritional quality on complementary feeding during pandemic, effective strategy for enhancing complementary feeding quality should be taken into account.

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DECLARATION OF CONFLICT OF INTERESTS

The authors declare no conflicts of interest.

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Genetic Variation's Impact on Weight: Systematic Review and Meta-Analysis

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ABSTRACT

This study investigates the genetic factors influencing precision weight management, contributing insights to the enduring debate on hereditary versus environmental influences on obesity. The primary objective is to identify genetic variations as predictive markers for weight management and evaluate their impact on weight control. Following the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guideline, this research systematically reviews articles that meet specific criteria, with no specific timeline due to limited research on genetic variation in this context. Inclusion criteria mandate the provision of weight and BMI data at the beginning and end of interventions, demonstrating weight reduction. Exclusions cover animal studies, non-English papers, and articles lacking baseline or pre/post-intervention data. The review incorporates comprehensive searches on Scopus, Medline, PubMed, and Web of Science, employing Review Manager for meta-analysis. The study concentrates on Single Nucleotide Polymorphisms (SNPs) rs9939609, rs10830963, and rs1052700 across 10 investigations. Despite lacking statistical significance, the findings suggest that these genetic polymorphisms enhance weight loss potential for recessive genotypes. A discernible preference for non-risk genotypes in weight loss efforts emerges. For instance, individuals with the non-risk A allele of rs9939609 experience weight loss with a Polyunsaturated Fatty Acid (PUFA) diet, while those with the non-risk G allele of rs10830963 effectively manage weight with a low-fat diet. Similarly, rs1052700 indicates that individuals with the T allele shed more weight by consuming meals earlier during the day. Although statistically insignificant, the non-risk genotype for all three SNPs demonstrates potential for weight loss. This suggests that participants possessing the non-risk allele can effectively manage their weight through interventions provided by weight loss programs.

Keywords: genetic, nutrigenomics, obesity, weight management program

INTRODUCTION

Obesity is a major global health concern that impacts developed and developing nations (Nutter *et al.* 2024). Its prevalence has reached unprecedented levels, overshadowing malnutrition and infections as a leading health issue (Nutter *et al.* 2024). Notably, the rise in obesity has been most pronounced in the highest weight categories, underscoring the urgency of the issue (Shi *et al.* 2024). Amidst this, genetic diversity within the population plays a backdrop role (Jin *et al.* 2024), contributing to varying responses to obesity treatment (Heitkamp *et al.* 2021).

In the past two decades, obesity gene research has swiftly evolved, uncovering the genetic underpinnings of energy balance (Lee 2009). Traditional approaches, including genome-wide scans, linkage, and association studies, have identified obesity-related genes (Lee 2009). Genetic predisposition continues to influence susceptibility to obesity significantly (Snyder *et al.* 2004). There has been a debate regarding the cause of obesity, genetics or the environment. Studies have shown that identical twins tend to be more similar in body weight compared to non-identical twins (Elks *et al.* 2012). The study suggests that there is a genetic element which is the cause of obesity.

Weight management programs, incorporating tailored exercise and behaviour therapy, aim to empower individuals for

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sustainable weight loss (Liu *et al.* 2024). Weight loss programmes are among the most crucial preventative health measures to lower the occurrence of obesity (Sharifi *et al.* 2013). Many seek ongoing support post-program (Hall & Kahan 2018), as even modest weight loss can yield positive health outcomes (Mertens *et al.* 2012). While weight-loss initiatives in developing nations emphasise nutrition and exercise, the study demonstrates that most perceived obstacles are linked to lifestyle and behaviour (Vranešić Bender & Krznarić 2012).

A research gap persists in systematic reviews and meta-analyses exploring the influence of specific genetic variants on weight management through programs. This is evident in a review article conducted by Jeanne McCaffery in 2018, where it is affirmed that there is currently inadequate evidence to utilise genetics or genomics for enhancing obesity treatment. A 2013 review by El-Sayed Moustafa and Froguel also explores the relationship between genetic variation and environmental elements, including diet, highlighting the need for more research on this topic. The review aims to pinpoint predictive genetic markers and determine the impact of genetic variants on weight management, addressing a crucial gap in current knowledge.

METHODS

Design, location, and time

This study followed the guidelines of the "Preferred Reporting Items for Systematic Review and Meta-Analyses" (PRISMA). The systematic review and meta-analysis, which will be conducted in the research, have already been submitted to the International Prospective Register of Systematic Reviews (PROSPERO). The review is registered under identification CRD42022371341. The research obtains ethical clearance with approval no REC/04/2023 (ST/EX/7) by the University Technology Mara (UiTM) Research Ethics Committee.

Materials and tools

Four databases' titles, abstracts, keywords, and full texts of documents were thoroughly searched in October 2022, including PubMed, Medline, Scopus, and Web of Science (WoS). Terms used in the search algorithm included genetic variation (e.g., genetics, gene expressions), weight management terms (e.g., nutrigenomics, weight management), and population-setting terms (e.g., overweight, obese participants). In addition, a manual snowballing search of the reference lists of the studies that were included was conducted to locate and incorporate pertinent publications that the database search had not previously turned up.

Inclusion and exclusion criteria. Studies included in the analysis had to fulfil several eligibility criteria. First, the article must conduct a genomic study to be included. Secondly, it must contain genetics or polymorphism, which studies the effect of weight reduction on obese participants. Next, the participant needed to undergo a weight management program. The article also needed to be open access with the document in English. There is no restriction on the document type. The participant also needed to be overweight and obese or with a Body Mass Index (BMI) above 24.9 kg/m^2 squared. There is no restriction on the age of the subjects, time, and study design. The weight/BMI must have data before and after the intervention so that we can measure the weight loss of the participant. Lastly, the genotype data must be associated with weight/BMI before and after the intervention to ensure a direct weight change in the genotype.

Study selection. After eliminating duplicate data, the titles and abstracts were checked against the inclusion criteria. When the abstracts of papers didn't include enough details to select determination, the full texts of those articles were read. Figure 1 showed the PRISMA diagram illustrating the selection process of the articles.

Procedures

The qualitative data were extracted in each study included in terms of the study's characteristic genetic variation (SNP ID), study location, population, study design, age group, risk allele, allele, and intervention. Mean and standard deviation of BMI/weight loss before and after intervention were collected for subgroup analyses. Subgroups were defined based on statistical, sensitivity, and stratified analyses.

Data analysis

Calculations were done as the initial stage in the analysis to standardise the data from various research. In this review, all included studies

reported the outcomes where the effect measure of interest through mean difference and standard deviation before and after the intervention. The difference is used to estimate the amount by which the participant loses weight. For each study, group-specific Standard Deviation (SD) was used to calculate the mean difference for each group. The Review Manager calculator was also used to calculate the correlation between the studies for stratified analysis.

RESULTS AND DISCUSSION

Study characteristics: Qualitative review

Ten investigations underpinning the systematic review and meta-analysis spanned 2008 to 2021 across various countries, as detailed in Table 1 (10 papers/investigations in PRISMA and, focused on 9 Genetic Variation, SNP ID). The total analysis included 4,094 study participants with sample sizes ranging from 30 to 1,287. Geographical distribution comprised six European countries, two from the United States and two from South America. Participant ages ranged from 10 to 70 years, with baseline BMI varying between 25 and 40 kg/m^2. Gender representation was mixed, with one study exclusively female. Most studies focused on adults, except one involving children and adolescents. Eight studies employed diet modifications, while two used distinct strategies like low-impact aerobics and High-Intensity Interval Training (HIIT) combined with dietary restrictions. Intervention durations ranged from 4 weeks to 2 years, with a median of 12 weeks.

Across the ten trials, 1,603 participants bore non-risk alleles, while 2,491 carried risk alleles. A correlation between nine SNP IDs and weight reduction emerged in weight management programs, with each SNP's risk allele influencing weight management. Most studies adjusted their results for BMI, gender, and sex. Refer to Table 1 of the study characteristics.

Meta-analysis results

rs9939609 analysis. Figure 2 portrays a meta-analysis involving four studies (666 subjects) focusing on rs9939609 genotypes (TT

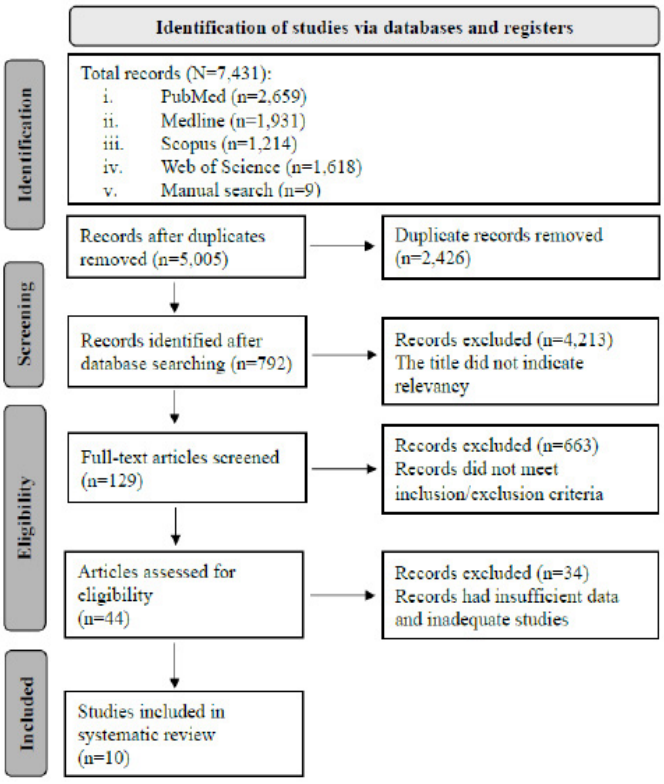

Figure 1. PRISMA diagram illustrating the selection process

Table 1. Baseline characteristics of studies included in the qualitative analysis

Genetic Variation, SNP ID	First Authors, publication year	Study location, Population	Study design	Age group	Number of risk/non-risk allele in participant	Risk allele	Alleles	Intervention	NOS score
rs9939609	Leońska-Duniec *et al.* 2018	Poland, Polish	Randomise controlled trials	Adults	146/55	A	A/T	12 weeks program of low and high impact aerobics	7
	de Luis *et al.* 2015	Spain, Spanish	Randomise controlled trials	Adults	119/114	A	A/T	3 months of diet in-tervention Diet M & Diet P	7
	de Luis *et al.* 2020a	Spain, Spanish	Non-randomise controlled trials	Adults	16/28	A	A/T	12 weeks partial meal replacement hypocaloric diet (pMRHD)	6
	Di Renzo *et al.* 2018	Italy, Italian	Randomise controlled trials	Adults	37/151	A	A/T	4 weeks nutritional intervention Mediterranean diet (MeD)	6
rs10830963	Goni *et al.* 2018	USA, Americans	Randomise controlled trials	Adults	146/55	G	C/G	2 years randomise clinica trial	7
	de Luis *et al.* 2020b	Finland, Finnish	Clinical Trial	Adults	119/114	G	C/G	3 months of diet in-tervention Diet M & Diet P	8
	Mirzaei *et al.* 2014	USA, Americans	Randomise controlled trials	Adults	721/722	G	C/G	2 years randomise weight loss diet intervention trial	8
rs1052700	Andrade-Mayorga *et al.* 2021	Chile, Chileans	Non-randomise controlled trials	Adults	13/17	T	T/A	12 weeks HIIT training & dietary energy restriction	6
	Deram *et al.* 2008	Brazil, Brazilian	Non-randomise controlled trials	Children & Adolescent	116/118	T	T/A	20 week lifestyle and weight loss program	6
	Garaulet *et al.* 2016	Spain, Spanish	Non-randomise controlled trials	Adults	1,058/229	T	T/A	28 weeks of treatment of ONTIME study	8
rs2289487	Garaulet *et al.* 2016	Spain, Spanish	Non-randomise controlled trials	Adults	1,058/229	T	T/A	28 weeks of treatment of ONTIME study	8
	Deram *et al.* 2008	Brazil, Brazilian	Non-randomise controlled trials	Children & Adolescent	116/118	T	T/A	20 weeks lifestyle and weight loss program	6

Continue from Table 1

Genetic Variation, SNP ID	First Authors, publication year	Study location, Population	Study design	Age group	Number of risk/non-risk allele in participant	Risk allele	Alleles	Intervention	NOS score
rs2304795	Garaulet *et al.* 2016	Spain, Spanish	Non-randomise controlled trials	Adults	1,058/229	T	T/A	28 weeks of treatment of ONTIME study	8
	Deram *et al.* 2008	Brazil, Brazilian	Non-randomise controlled trials	Children & Adolescent	116/118	T	T/A	20 weeks life-style and weight loss program	6
	Andrade-Mayorga *et al.* 2021	Chile, Chileans	Non-randomise controlled trials	Adults	13/17	T	T/A	12 weeks HIIT training & dietary energy restriction	6
rs894160	Deram *et al.* 2008	Brazil, Brazilian	Non-randomise controlled trials	Children & Adolescent	116/118	T	T/A	20 weeks lifestyle and weight loss program	6
	Garaulet *et al.*2016	Spain, Spanish	Non-randomise controlled trials	Adults	1,058/229	T	T/A	28 weeks of treatment of ONTIME study	8
rs11605924	Mirzaei *et al.* 2014	USA, Americans	Randomise controlled trials	Adults	721/722	G	C/G	2 years randomise weight loss diet intervention trial	8
rs283	Andrade-Mayorga *et al.* 2021	Chile, Chileans	Non-randomise controlled trials	Adults	13/17	T	T/A	12 weeks HIIT training & dietary energy restriction	6
rs4994	Andrade-Mayorga *et al.* 2021	Chile , Chileans	Non-randomise controlled trials	Adults	13/17	T	T/A	12 weeks HIIT training & dietary energy restriction	6

FTO: Fat Mass and Obesity-associated; SNP: Single Nucleotide Polymorphism; HIIT: High-Intensity Interval Training,
Diet M: Monosaturated Fatty Acid; Diet P: Polyunsaturated Fatty Acid; BMI: Body Mass Index; NOS: Newcastle-Ottawa Scale

vs TA + AA). Although not significantly different, the (TA + AA) genotype groups demonstrated greater weight loss (MD=0.51, 95% CI:-0.38, 0.95, p=0.40), favouring the FTO gene. Standard deviations for certain studies were imputed from Corr values. de Luis *et al.* (2015) had two interventions combined for the analysis.

rs10830963 analysis. Figure 3 illustrates a meta-analysis encompassing three studies (1,905 subjects) examining rs10830963 genotypes (CC vs CG + GG). Despite no significant difference, the (CG + GG) genotype group exhibited favourable weight loss (MD=0.24, 95% CI: -0.57, 1.04, p=0.56). Substitutions for missing data were made where needed.

rs1052700 analysis. Figure 4 presents an analysis of rs1052700 across three studies (1,551 subjects). Genotypes (AA vs AT+TT) showed the AT +TT genotype group favouring weight loss (MD=0.56, 95% CI:-0.74, 1.86, P=0.40).

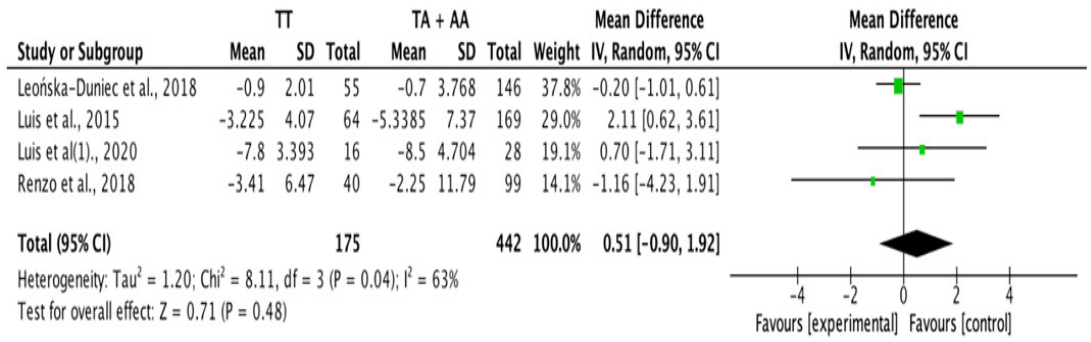

Figure 2. The result of forest plot of rs9939609, where the graph favours recessive genotype (TA + AA).

Substitutions were made to address data gaps and the correlation coefficient influenced calculations.

Sensitivity analysis

Sensitivity analysis of rs9939609. Sensitivity analysis for rs9939609 assessed the effect by excluding specific studies. Eliminating Leónka-Duniec *et al.* (2018) showed no significant difference (MD=0.93, 95% CI:-0.86, 2.73; p=0.31, I^2=48%). The removal of de Luis *et al.* (2015) and de Luis *et al.* (2020a) also had no substantial impact (MD=-0.17, 95% CI:-0.92, 0.57; p=0.65, I^2=0% and MD=0.44, 95% CI:-1.38, 2.26; p=0.64, I^2=75%, respectively). Similarly, excluding Di Renzo *et al.* (2018) yielded no significant weight loss (MD=0.80, 95% CI:-0.82, 2.41; p=0.33, I^2= 72%). Despite individual eliminations, rs9939609 still did not associate significantly with weight loss.

Sensitivity analysis of rs10830963. Sensitivity analysis for rs10830963 excluded Goni *et al.* (2018) and Mirzaei *et al.* (2014), revealing no significant weight loss for allele (CG + GG) (MD=-0.03, 95% CI:-2.27, 2.22; p=0.98, I^2=99%).

Sensitivity analysis of rs1052700. Sensitivity analysis for rs1052700 removed Andrade-Mayorga *et al.* (2021) and Deram *et al.* (2008), with no significant influence due to lower overall weight compared to Garaulet *et al.* (2016). Removing Garaulet *et al.* (2016) emphasised significant weight loss for allele (AT + TT) (MD=1.28, 95% CI:0.45, 2.11; p=0.003, I^2=0%).

Stratified analysis

Stratified analysis of rs9939609. Studies were stratified based on mean BMI and program duration. Studies with mean BMI<30 kg/m^2 showed no significant weight loss (MD=-0.26, 95% CI:1.05, 0.52; p=0.51), while those with mean BMI>30 kg/m^2 exhibited significant weight loss (MD=1.72, 95% CI:0.45, 2.99; p=0.008). Duration-based stratification showed no significant weight loss for both 4-week (MD=-1.16, 95% CI:-4.23, 1.91; p=0.46, I^2=0.00) and 12-week programs (MD=0.80, 95% CI:-0.82,

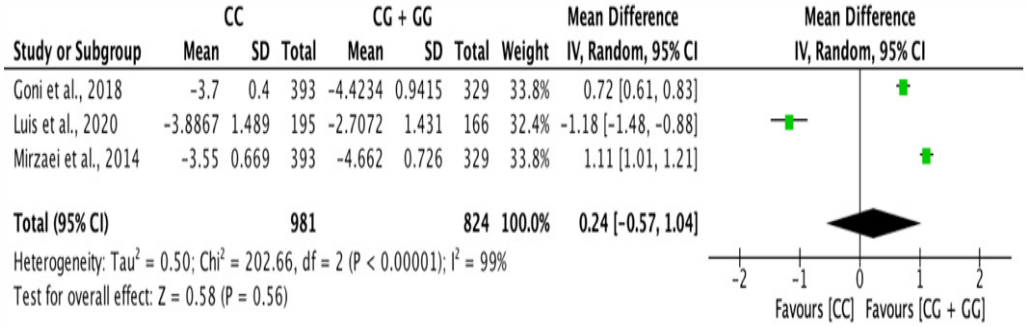

Figure 3. The result of forest plot of rs10830963, where the graph favours recessive genotype (CG + GG)

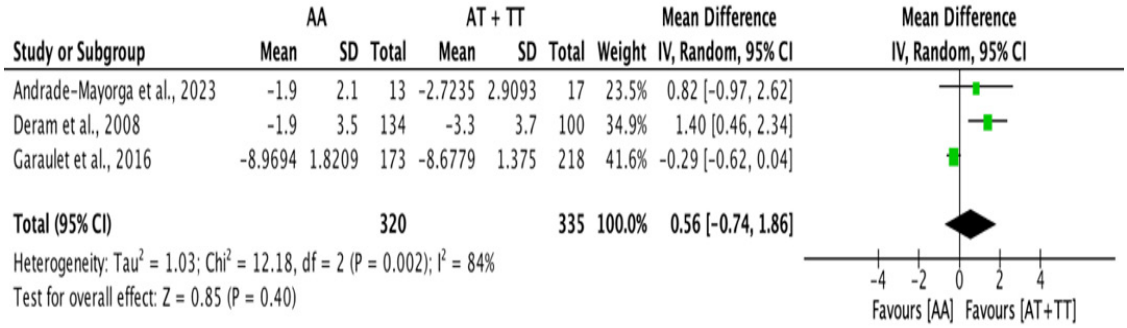

Figure 4. The result of forest plot of rs1052700, where the graph favours recessive genotype (AT + TT)

2.41; p=0.33, I^2=0.72). Diet-focused studies also didn't yield significant weight loss (MD=-0.20, 95% CI:-1.01, 0.61; p=0.63, I^2=0.00). Additionally, studies exploring low and high-impact aerobics (MD=0.93, 95% CI:-0.86, 2.73; p=0.31, I^2=0.48) indicated no significant weight loss regardless of intervention type.

Stratified analysis of rs10830963. Two studies had a mean BMI<35 kg/m^2 (Goni *et al.* 2018 & Mirzaei *et al.* 2014) with significant weight loss (MD=0.92, 95% CI:0.54, 1.30), p<0.00001, I^2=0. Another study had a mean BMI>35 kg/m^2 (de Luis *et al.* 2020b) with substantial weight loss (MD=-1.18, 95% CI:-1.48, -0.88), p<0.00001, I^2=0.96. The p-value between groups was <0.00001, signifying significant weight loss in both BMI categories. For program duration, one study had a 3-month program (de Luis *et al.* 2020b) showing substantial weight loss (MD=-1.18, 95% CI:-1.48, -0.88), p<0.0001, I^2=0.00. Conversely, the other three studies with 2-year programs (Goni *et al.* 2018 & Mirzaei *et al.* 2014) indicated noteworthy weight loss (MD=0.92, 95% CI:0.54, 1.30), p<0.00001, I^2=0.96. The p-value between groups underlined significant weight loss across participants. All three articles investigating diet effects showcased significant weight loss (MD=-0.26, 95% CI:-0.94, 0.42), p=0.0, I^2=0.00, highlighting intervention-based distinctions.

Stratified analysis of rs1052700. There is insufficient data in the listed papers for rs1052700 for a stratified analysis.

Summary of evidence

Weight loss is linked to the rs9939609 polymorphism (SNP ID), especially in those with the TA + AA genotype. In the study, four papers were reviewed. Leónska-Deuniec (2018) and Di Renzo *et al.* (2018) observed in two investigations that FTO did not result in weight reduction and carriers of the A allele had larger body mass. However, two more investigations by de Luis *et al.* (2015) and de Luis *et al.* (2020a) demonstrated that individuals with the A allele lost weight when eating a diet high in polyunsaturated fats (PUFA). According to Leónska-Deuniec *et al.* participants with the TA and AA genotypes consistently had higher BMIs and average body mass increases from 1.2 kg to 3.0 kg.

Di Renzo *et al.* (2018) also supported the idea that allele A carriers had higher BMI than the TT genotype. The other two articles also confirmed that carriers of the A allele had higher initial body weight. Still, they emphasised that these subjects experienced lower body weight gain when following a Mediterranean-style diet. de Luis *et al.* (2020b) found that TT and AT + AA genotype participants benefited from a low-calorie diet. However, A allele carriers had the most significant weight loss and improved metabolic outcomes when consuming a high PUFA, low-calorie diet. The interplay between dietary fat content and the FTO SNP variation may explain these benefits for A allele carriers. Two research studies supported weight reduction among A allele carriers, and two studies refuted this conclusion, according to the overall impact estimate from the forest plot.

The rs10830963 was analysed in three studies. Goni *et al.* (2018) found that the G genotype, associated with a 2 to 4-fold increase in MTNR1B mRNA expression, improved lipid profiles on a low-fat diet. However, weight loss may not significantly impact total cholesterol and LDL cholesterol concentration

despite its positive effects on the lipid profile in general. This study was the first to analyse the interaction between the MTNR1B genetic variant and dietary fat intake, showing that the G allele may benefit more from a low-fat diet to improve the lipid profile. On the other hand, de Luis *et al.* (2020b) contradicted these findings by stating that the G allele is associated with less weight loss. The forest plot suggested that the CC genotype may experience more weight loss than the recessive genotype. Mirzaei *et al.* (2014) investigated energy expenditure with Respiratory Quotient (RQ). They found that the G allele was significantly associated with a higher increase in RQ on a low-fat diet during the 2-year intervention. The relationship between RQ and weight loss suggests that the G allele may increase RQ, which could lead to more weight loss in individuals with obesity when following a low-fat diet (Weinsier *et al.* 1995). The overall effect estimate from the forest plot was not significant, mainly due to conflicting results between studies. However, after removing de Luis *et al.* (2020b) from the analysis, sensitivity analysis showed a significant result favouring the CG + GG genotype for weight loss.

In three investigations, the rs1052700 was examined. Both Andrade-Mayorga *et al.* (2021) and Aller *et al.* (2017) discovered that after treatments in overweight/obese participants, bearers of the TT genotype reported higher reductions in absolute fat mass and body mass, respectively. A PLIN1 x food timing interaction was seen in a different study by Garaulet *et al.* (2016), which revealed that those with the AA genotype had more difficulties losing weight, particularly when eating later in the day. The forest plot showed that the rs1052700 polymorphism had no significant overall effect. However, the AT + TT genotype favoured higher weight reduction, indicating that the T allele would be more advantageous for weight loss.

The study has strengths, including a comprehensive literature review identifying nine relevant SNPs related to weight control in obese individuals. Careful data retrieval of BMI/weight, mean difference, and standard deviation from selected papers enhanced methodological rigour. The strict inclusion criteria focused on three SNPs for meta-analysis, increasing its validity. The stratified analysis provided detailed insights into genetic variations' influence on weight control in various subgroups. Sensitivity analysis assessed the reliability of findings and the impact of different investigations on conclusions.

Investigating how these genetic variants interact with different weight-management therapies, such as dietary and lifestyle modifications, can lead to personalised approaches for more effective results.

CONCLUSION

In conclusion, our study establishes a correlation between genetic variation and weight management in obese subjects undergoing weight loss programs. We identified SNP IDs rs9939609, rs10830963, and rs1052700 as predictive markers for weight loss. Participants with recessive alleles (A for rs9939609, G for rs10830963, and T for rs1052700) are likelier to lose weight. The effect of genetic variants on weight management was observed with specific dietary interventions. For rs9939609, the A allele showed lower weight gain with a Mediterranean diet. rs10830963 non-risk allele G led to significant weight loss with a low-fat diet. rs1052700 T allele was associated with successful weight reduction when eating earlier meals. Participants with these genetic makeup and recessive alleles are more likely to benefit from diet and lifestyle change programs to reduce obesity.

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DECLARATION OF CONFLICT OF INTERESTS

The authors have no conflict of interest.

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Prebiotic Activity of Plants from *Cucurbitaceae* Family and In Vitro Fermentation by Gut Microbiota

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ABSTRACT

This study aims to examine the effect of Freeze-Dried Pumpkin Powder (FDPP), Freeze-Dried Winter Melon Powder (FDWMP), Freeze-Dried Rock Melon Powder (FDRMP), inulin, and D glucose on prebiotic activity score by in vitro fermentation. We also elucidate the changes in bacterial populations through batch culture fermentation using fecal samples from 5 healthy volunteers and In vitro fecal fermentation using batch culture and analyses of Short-Chain Fatty Acids (SCFAs). The growth of *Bifidobacterium* has significantly increased from 0 (8.90±0.05 $\log^{10}$ cells/mL) and 72h (8.83±0.14 $\log^{10}$ cells/mL) for D glucose and FDWMP (8.75±0.07 $\log^{10}$ cells/mL (0h) and 8.87±0.12 $\log^{10}$ cells/mL (72h)). However, the increase in population was not significant for inulin (9.15±0.06 log10 cells/mL), FDPP (9.04±0.12 $\log^{10}$ cells/mL), and FDRMP (8.67±0.08 $\log^{10}$ cells/mL). The number of *Lactobacili* significantly increased at 6h for FDPP (9.11±0.07 $\log^{10}$ cells/mL) and 24h for FDWMP (8.88±0.07 $\log^{10}$ cells/mL) and FDRMP (8.80±0.09 $\log^{10}$ cells/mL). Acetic acid was detected in all samples, and the concentration increased in all vessels at any given time except for the FDWMP fermentation, which decreased after 0h and increased after 6h. Overall, FDWMP has increased the probiotic growth of *L. plantarum* TISTR 1465 and exhibit the highest prebiotic index. As a result, it is suggested that the FDWMP be potentially used as a healthy raw material in developing varieties of functional prebiotic food products.

Keywords: fecal samples, freeze-dried, gas production, gut microbiota

INTRODUCTION

The *Cucurbitaceae* family is one of the most genetically distinct food plants widely planted in tropical areas (Karam *et al.* 2016). Cucurbit fruits are edible, and the taste of this pericarp is usually sweet and can be grown worldwide, with over 130 genera and 800 species (Duan *et al.* 2016).

Pumpkins in Malaysia are derived from the *Cucurbita moschata* (Men *et al.* 2021). Because it benefits the lungs and spleen, *Cucurbita moschata* has been used as a traditional medicine and healthy food in China (Bergantin *et al.* 2018). Proteins, polysaccharides, para-aminobenzoic acid, and sterols are the bioactive molecules in the seeds, leaves, and flesh. Pumpkin pulp is high in polysaccharides (60−80%), has anti-tumor, anti-diabetic, and immune-stimulating properties (Men *et al.* 2021).

The winter melon (*Benincasa hispida*) is a Southeast Asian native cultivated for over 2,000 years (Karam *et al.* 2016). This cucurbit plant is also known as Kundur (Malaysia), Kushamanda (India), Dnggu (China), and Bleego (Indonesia) (Mohammad *et al.* 2019). Winter melon has an antioxidative capacity and has been shown to benefit a variety of tissues, including the brain and liver (Islam *et al.* 2021). Rock melon (*Cucumis melo L.*), is a popular summer fruit due to its sweet, juicy flesh and pleasant aroma. Rock melon is high in nutritional value, and the seeds are high in fat and protein (Adams *et al.* 2014). These cucurbit plants are among the most popular fruits and are thought to have some prebiotic properties.

Prebiotics are fermented ingredients selectively used by host microorganisms for good health (Sommer & Bäckhed 2013). In addition,

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the consumption of prebiotics increases the population of beneficial bacteria in the gut colon and, consequently, prevents the establishment of pathogenic bacteria. Thus, it helps to prevent allergies and infections (Thursby & Juge 2017). Following ingestion, gut microbiota ferments the prebiotic constituents in the colon to produce Short-Chain Fatty Acids (SCFAs), namely acetic, propionic, and butyric acid. These acid productions improve several health physiological effects such as bowel function, regulation of lipids, mineral absorption, glucose metabolism, and decreasing the risk of colorectal cancer development (Thursby & Juge 2017).

Drying is a standard method for preserving food items over time by lowering water activity (a_w). The a_w below than 0.3 provides a longer shelf life because less free water is accessible for biochemistry activities. The aw must be kept to a minimum for living organisms to survive during manufacturing, storage, and consumption (Wang *et al.* 2020).

Previous investigations have established freeze-drying to dehydrate various fruits and vegetables, including guava, strawberries, pumpkin, tomatoes, and maple syrup (Bhatta *et al.* 2020). Several studies have shown various beneficial impacts of freeze-drying processes on the physicochemical characteristics, bioactive constituents, and antioxidant potential of fruits and some plants (Kittibunchakul *et al.* 2023; Borges *et al.* 2023). However, no study has investigated and compared the prebiotic properties of freeze-dried pumpkins, winter melons, and rockmelons. To the best of our knowledge, there is scarce information on the investigation of the cucurbit plant on prebiotic activity and in vitro fermentation by gut microbiota. The purpose of this study was to determine the effects of the freeze-drying method on nutrient composition, evaluate bacterial growth modulation of primarily beneficial bacteria using Fluorescence in Situ Hybridization (FISH), investigate the SCFAs, and calculate the Prebiotic Index (PI) to assess the prebiotic effects of selected cucurbit plants on microbial populations.

METHODS

Design, location, and time

The study was an experimental design. The research was conducted at the NFF Laboratory, Prince of Songkla University, Thailand. This study was carried out between March 2018 and May 2019. For taking fecal samples, we have received a consent from the donors which approved by the ethical committees of USM (USM/JEPeM/19030181).

Materials and tools

Pumpkin, winter melon, and rock melon were purchased from a local supermarket in the Kota Bharu district of Kelantan state, Malaysia. Their skins and seeds were removed, and the flesh was manually cut into small, thin pieces (0.5cm). The materials were frozen in a freezer (National NR-B53FE, Malaysia) at -20°C for 48h. The materials were freeze-dried for 36h in a freeze-dry (-40°C, vacuum speed 0.92 mbar, Christ-Alpha 1-4 LO, Germany). The samples were then finely ground using an electric grinder (National MX-895M, Malaysia) at low speed (1) for 10 min and sieved using a mechanical sieve (Retsch AS 200, Germany) to obtain standardized small particle powder. Each freeze-dried sample was labeled as FDPP (Freeze-Dried Pumpkin Powder), FDWMP (Freeze-Dried Winter Melon Powder), and FDRMP (Freeze-Dried Rockmelon Powder). The powder was stored in sealed airtight laboratory containers (Schott DURAN, Germany) at 4°C.

Artificial saliva, Simulated Gastric Fluid (SGF), and bile salt were purchased from Sigma-Aldrich, USA. Enzymes (alpha-amylase, pepsin, and pancreatin) were bought from Sigma-Aldrich, USA. Probes of DNA (Bif164, Lab158, Cris150, Bac303, and Eub338) used for the FISH method were purchased from Sigma-Aldrich, USA.

Procedures

Proximate composition. The AOAC (2000) method was used to calculate the proximate parameters of the FDPP, FDWMP, and FDRMP (ash, moisture, fat, protein, and total dietary fiber) including the carbohydrate.

Simulated gastrointestinal conditions of cucurbit fruits. The simulation of upper gut digestion was carried out according to the protocols of (Frank & Pace 2008) with some modifications.

Fecal sample preparation. Fresh fecal samples were provided by five healthy donors (3 women and two men, ages 25 to 35) who met the inclusion and exclusion criteria for batch culture

fermentations. The storage conditions of feces were followed (AOAC 2020). The preparations of fecal slurry were followed according to Ying *et al.* (2018) with modifications.

The inclusion and exclusion criteria for subjects; included age between 20 to 60 years old, no antibiotics for at least 3 months before entering the study, no history of Gastrointestinal (GI) diseases, no consumption of products containing high levels of inulin or oligofructose (chicory, onion, banana, Jerusalem artichoke, and dragon fruit) 1 week before and during this treatment period (Liu *et al.* 2014).

Prebiotic index (PI) determination. The PI of cucurbit samples was computed based on the equation as described below:

$$PI = \left(\frac{Bif}{Total}\right) - \left(\frac{Bac}{Total}\right) + \left(\frac{Lac}{Total}\right) - \left(\frac{Clos}{Total}\right)$$

FISH analysis. The protocols for assessing bacterial population were followed according to Adeleke & Odedeji (2010).

SCFAs determination by HPLC. Short-Chain Fatty Acids (SCFAs) were analyzed by High-Performance Liquid Chromatography (HPLC) according to Alfilasari *et al.* (2021).

Data analysis

All statistical analyses were implemented using SPSS software version 27 (SPSS Inc., USA). The data were statistically analyzed for ANOVA, and mean values were assessed for statistical significance ($p<0.05$) by Duncan's multiple range test (95% Confidence Interval (CI)). The post hoc Tukey's test, at 95% CI, was assessed to differentiate between the mean values in the results proximate composition of all samples.

RESULTS AND DISCUSSION

Proximate compositions of selected cucurbit plants.

After freeze-drying, the moisture content of FDPP is significantly ($p<0.05$) lower at 7.39% than that of FDWMP and FDRMP, which are 9.83% and 9.84% (Table 1), respectively. Sun-dried pumpkin powder has a moisture level of 11.72% (Kiharason *et al.* 2017), which is higher than the FDPP produced in this investigation. High moisture content of a fresh sample reduces the quality of the stored sample due to water content, which might contribute to microbial development (Dávila *et al.* 2019). The food product's low moisture content ensures a long shelf life, minimizes perishability and boosts the food's value and shelf life (Promjiam *et al.* 2017).

The sample FDWMP had the greatest ash content, with 10.86%, compared to FDPP (8.50%) and FDRMP (5.22%), respectively. According to Kiharason *et al.* (2017), the ash level of pumpkin flour is lower than FDPP, at 5.29%. This lower value is due to the different technique of drying process performed by them as compared to our study where the cucurbit samples are underwent freeze-drying process. The samples had a considerable increase in ash composition after drying due to water removal, which increased nutrient concentration (Siti Mahirah *et al.* 2018). Furthermore, a rise in ash content during dehydration might be explained by low mineral volatility, which is unaffected by heating. A high ash content indicates a higher mineral concentration in particular food items (Ng *et al.* 2020).

In terms of other nutrients, the fat levels of FDPP, FDWMP, and FDRMP differed significantly ($p<0.05$), with 1.52%, 0.49%, and 0.22%, respectively. FDPP had the highest fat level, at 1.52%. This is advantageous because a high-fat diet has been linked to a variety of health problems. Low-fat diets may benefit from gourd fruits (Men *et al.* 2021).

The protein compositions of FDPP, FDWMP, and FDRMP differed considerably ($p<0.05$), with 8.78%, 10.51%, and 7.00%, respectively. Sample FDWMP has the greatest protein content (10.51%). The protein level of several cultivars of *Benincasa hispida* (oven-dried) ranged from 9.30% to 24.6% (Islam *et al.* 2021). These values are slightly different as compared to our study because of the different drying processes perfomed by Islam *et al.* (2021). Proteins are required in the human body to repair and replace worn-out tissues, to act as antibodies, and as a building block of cellular protein (Promjiam *et al.* 2017).

The carbohydrate contents of FDPP, FDWMP, and FDRMP differed significantly ($p<0.05$) by 73.86%, 69.61%, and 77.51%, respectively. The sample FDRMP had the greatest carbohydrate content, at 77.51%. According to Ojo *et al.* (2014) the carbohydrate content of cucumber (*Cucurbitaceae genus* was 76.13 g/100 g).

Table 1. The nutritional compositions of FDPP, FDWMP, and FDRMP

Proximate composition parameters	Samples		
	FDPP	FDWMP	FDRMP
Moisture (%)	7.39±0.25^{j}	9.83±0.24^{i}	9.84±0.28^{i}
Ash (%)	8.50±0.10^{j}	10.86±0.13^{i}	5.22±0.02^{k}
Fat (%)	1.52±0.03^{i}	0.49±0.08^{j}	0.22±0.04^{k}
Protein (%)	8.78±0.05^{j}	10.51±0.12^{i}	7.00±0.17^{k}
Total carbohydrate (%)	73.86±0.49^{j}	69.61±0.24^{k}	77.51±0.34^{i}
Total Dietary Fiber (TDF) (g/100 g)	9.96±0.33^{j}	31.28±0.26^{i}	7.62±0.27^{k}

The values are expressed as the mean and standard deviation of three determinations

$^{i-l}$Means differed significantly (p 0.05) in the same rows with different letters

FDPP: Freeze-Dried Pumpkin Powder; FDWMP: Freeze-Dried Winter Melon Powder; FDRMP: Freeze-Dried Rock Melon Powder

The TDF of the FDWMP was significantly ($p<0.05$) higher (31.28 g) than that of the FDPP (9.96 g) and the FDRMP (7.62 g). The TDF concentration of winter melon juice was quite high (27.5%) due to bioactive characteristics (Mohammad *et al.* 2019), which validated the total dietary fibre (TDF) of FDWMP found in this investigation. The TDF content of FDPP and FDRMP was significantly different ($p<0.05$), with 9.96 g and 7.62 g, respectively.

Population changes of Bifidobacterial (Bif164) analyzed by FISH technique

The populations of *Bifidobacterium* in the D glucose and FDPP increased for fermentation times up to 24h, with significant differences from the population at 0, 6, 12, and 24h ($p<0.05$), respectively (Table 2). The highest population of *Bifidobacterium* at 24h was found in FDPP with 9.25±0.06 $\log^{10}$ cells/mL. The positive control (inulin) *Bifidobacterium* was higher with significantly different ($p<0.05$) (9.35±0.05 $\log^{10}$ cells/mL) at 12h than the population in the D glucose at 24h (9.07±0.07 $\log^{10}$ cells/mL). In addition, the number of Bifidobacteria stayed elevated significantly until 12h fermentation, particularly on inulin and FDRMP, while for D glucose and FDPP, the Bifidobacterial population increased until 24h fermentation but was not significant ($p>0.05$).

During 12h fermentation, D glucose (9.04±0.04 $\log^{10}$ cells/mL), inulin (9.35±0.05 $\log^{10}$ cells/mL), FDPP (9.22±0.07 $\log^{10}$ cells/mL), FDWMP (8.80±0.09 log10 cells/mL), and FDRMP (8.96±0.19 $\log^{10}$ cells/mL) were significantly increased ($p<0.05$) in Bifidobacteria population except for FDWMP. The findings were correlated to Zhou *et al.* (2016) where, the Bifidobacteria population increased during 12h fermentation in the substrates of control, FOS, and Grape Polyphenols (GP). Also, FDPP, FDWMP, and FDRMP have shown a Bifidogenic effect (stimulate the growth of Bifidobacteria) in short time of fermentation. Among tested cucurbit samples, FDPP showed the highest growth support of Bifidobacteria. All cucurbits (FDPP, FDWMP, and FDRMP) have promoted the growth of Bifidobacteria.

Population changes of *Lactobacillus* (Lab158) analyzed by FISH technique

The *Lactobacillus* population increased after 6h of FDPP fermentation (9.11±0.07 $\log 1^{0}$ cell/mL), 24h of FDWMP fermentation (8.88±0.07 $\log^{10}$ cell/mL), and 12h of FDRMP fermentation (8.89±0.10 $\log^{10}$ cell/mL, Table 3). Furthermore, the number of *Lactobacillus* of D glucose was significantly increased ($p<0.05$) after 12h fermentation (8.38±0.06 log10 cell/mL) and inulin (9.40±0.04 $\log^{10}$ cell/mL), which has the highest *Lactobacillus* growth. The difference in the number of *Lactobacillus* growth among all freeze-dried samples is may because of differences in carbohydrate metabolism resulting from the metabolic and genomic diversity of *Lactobacillus* (de Andrade *et al.* 2020).

The bacteria population of *Lactobacillus* reached 8.26±0.06 (D glucose), 8.88±0.07 (FDWMP), 8.80±0.09 (FDRMP), 9.29±0.07 (inulin) and 9.23±0.11 (FDPP) $\log^{10}$ cells/mL after 24h fermentation then slightly decreased after 48h fermentation. Extending the growing period to 48h did not increase the number of viable cells in any of the starters studied (except

Table 2. Bifidobacterial faecal bacteria populations on cucurbit samples in batch culture fermentation

Bacterial count (log^{10} cells/mL); Bif164; Samples					
Time (hour)	D glucose	Inulin	FDPP	FDWMP	FDRMP
0	8.90 ± 0.05^{dj}	8.95 ± 0.11^{dj}	9.03 ± 0.08^{ci}	8.75 ± 0.07^{dk}	8.20 ± 0.08^{cl}
6	8.95 ± 0.08^{cdj}	9.12 ± 0.05^{ci}	9.13 ± 0.05^{bi}	8.91 ± 0.08^{abjk}	8.86 ± 0.13^{ak}
12	9.04 ± 0.04^{abk}	9.35 ± 0.05^{ai}	9.22 ± 0.07^{aj}	8.80 ± 0.09^{cdm}	8.96 ± 0.19^{al}
24	9.07 ± 0.07^{aj}	9.29 ± 0.08^{bi}	9.25 ± 0.06^{ai}	8.84 ± 0.06^{bck}	8.71 ± 0.15^{bl}
48	8.99 ± 0.05^{bcj}	9.30 ± 0.04^{bi}	9.24 ± 0.11^{ai}	8.93 ± 0.15^{aj}	8.92 ± 0.31^{aj}
72	8.83 ± 0.14^{ek}	9.15 ± 0.06^{ci}	9.04 ± 0.12^{cj}	8.87 ± 0.12^{abck}	8.67 ± 0.08^{bl}

The data present as log CFU/mL average standard deviations

[a-d]Means in the same columns with different letters differed significantly ($p<0.05$)

[i-m]Means in the similar rows with different letters showed significant differences ($p<0.05$)

FDPP: Freeze-Dried Pumpkin Powder; FDWMP: Freeze-Dried Winter Melon Powder; FDRMP: Freeze-Dried Rock Melon Powder

D glucose), but it did decrease cell viability (Do & Fan 2019). Scientists recommended that the minimum probiotic organism level in probiotic food products should be ranging from 10^6−10^7 CFU/mL at the time of ingestion for the best health benefits (Do & Fan 2019).

As well as having a rich dietary fiber composition, FDWMP also presented a higher protein content (10.51%) as compared to other samples (8.78% for FDPP and 7.00 for FDRMP as tabulated in Table 1). The fiber-bound polyphenols in the food matrix can reach the gastrointestinal tract and being metabolized by the gut microbiota, thus contributing to the health-related properties of dietary fiber and its impact on gut microbiota modulation (Tomas-Barberan *et al.* 2016).

Population changes of *Bacteroides* (Bac303) and *Clostridia* (Clos150) analyzed by FISH technique.

The *Bacteroides* population (Table 4) has significantly reduced ($p<0.05$) after 12h fermentation (8.75±0.06 log cell/mL) for D glucose, 9.20±0.09 for FDPP, and 8.56±0.25 log^{10} cell/mL for FDWMP and 8.98±0.03 log^{10} cell/mL for FDRMP, while 24h fermentation (9.29±0.14 log^{10} cell/mL) for inulin. After 24h of fermentation, the *Bacteroides* populations of D glucose (8.83±0.13 log^{10} cell/mL), FDPP (9.52±0.04 log^{10} cell/mL), FDWMP (8.86±0.11 log^{10} cell/mL), and FDRMP (9.16±0.03 log^{10} cell/mL) were significantly ($p<0.05$) increased. *Bacteroides* are the main bacterial genus in the large intestine that produces propionate when it ferments food fibers like oats and barley (Sreenivas & Lele 2013).

Clostridia population trends were similar to *Bacteroides* population trends. The *Clostridia* population was significantly reduced ($p<0.05$) after 6h of fermentation (7.9±20.11 log^{10} cell/mL) for D glucose, 12h of fermentation (8.80±0.09 log^{10} cell/mL) for FDPP, and 9h of fermentation (9.05±0.06 log^{10} cell/mL) for FDRMP (not significant, ($p>0.05$)). However, a significant ($p<0.05$) reduction in the *Clostridia* population on FDWMP was observed at 24h fermentation (8.53±0.20 log^{10} cell/mL) but not for inulin (9.00±0.10 log^{10} cell/mL). During the incubation hours, the *Clostridia* population of each substrate gradually decreased. This result implicates the potential of prebiotic properties among the tested samples. The decrease in both *Bacteroides* and *Clostridia* population with an increase in Bifidobacteria and *Lactobacillus* bacteria indicates the beneficial effects and prebiotic quality of the cucurbit samples. Based on our observation, it can be suggested that both fibers and cleaved sugars from polyphenolic glycosides may impede bacterial growth selectivity, decreasing *Bacteroides* and total bacteria (Zhou *et al.* 2016).

Prebiotic Index (PI)

The highest prebiotic effect was found in commercial prebiotic inulin, with 1.50, respectively. Ariestanti *et al.* (2019) reported that the PI of batch culture fermentation of inulin was slighly lower at 0.97 as compared to our finding. The PIs of D glucose, inulin, FDPP, FDWMP, and FDRMP were 1.33, 1.50, 1.75, 1.90, and 1.44, respectively. The FDWM sample had the highest PI among selected cucurbit samples, with a

Table 3. Lactobacillus fecal bacteria populations on cucurbit samples in batch culture fermentation

Bacterial count (log^{10} cells/mL); Lab158; Samples					
Time (hour)	D glucose	Inulin	FDPP	FDWMP	FDRMP
0	8.20±0.11^{cl}	9.01±0.04^{ei}	8.90±0.08^{dj}	8.72±0.09^{bk}	7.67± 0.27^{dm}
6	8.19±0.22^{ck}	9.14±0.04^{di}	9.11±0.07^{bi}	8.77±0.12^{bj}	8.72± 0.09^{bcj}
12	8.38±0.06^{al}	9.40±0.04^{ai}	8.92±0.08^{dj}	8.78±0.08^{bk}	8.89± 0.10^{aj}
24	8.26±0.06^{bcm}	9.29±0.07^{bi}	9.23±0.11^{aj}	8.88±0.07^{ak}	8.80±0.09^{abl}
48	8.38±0.05^{al}	9.26±0.07^{ci}	9.00±0.14^{cj}	8.75±0.11^{bk}	8.68± 0.09^{ck}
72	8.35±0.18^{abl}	9.13±0.03^{di}	8.92±0.12^{dj}	8.73±0.11^{bk}	8.66± 0.08^{ck}

The data are presented as log CFU/mL average standard deviations

[a-e]Means differed significantly (p 0.05) in the same columns with different letters

[i-m]Means differed significantly (p 0.05) in similar rows with different letters

FDPP: Freeze-Dried Pumpkin Powder; FDWMP: Freeze-Dried Winter Melon Powder; FDRMP: Freeze-Dried Rock Melon Powder

positive prebiotic effect of 1.90 and fermentation increasing the bacterial population of beneficial bacteria. A PI more than one indicates that the polysaccharide significantly affects probiotic development (Ahire *et al.* 2022). If the PI is nearly one, the evaluated carbohydrate is poor quality. In this study, all samples analysed for PI calculation yielded results of more than one, implying that the values are positive PI, equivalent to the prebiotic effect. In short, the fecal batch culture showed that FDPP, FDWMP and FDRMP showed a prebiotic potential comparable with commercial inulin.

Production of SCFAs

The AA concentration increased in all vessels at any given time except for the FDWMP fermentation, which decreased after 0h and increased after 6h (Table 5). This SCFA demonstrated a significant ($p<0.05$) difference

Table 4. Bacteroides and Clostridia faecal bacteria populations on cucurbit samples in batch culture fermentation

Cucurbit samples					
Bacterial count (log^{10} cells/mL) for Bacteroides (Bac303)					
Time (hour)	D glucose	Inulin	FDPP	FDWMP	FDRMP
0	8.74±0.07^{cl}	8.89±0.12^{dk}	9.20^{bi} ±0.09	9.11^{aj}±0.07	8.57^{dm}±0.02
6	8.82±0.11^{abm}	9.28±0.13^{bj}	9.46^{ai}±0.08	8.94^{bl}±0.18	9.07^{bk}±0.07
12	8.75±0.06^{bcl}	9.31±0.12^{abi}	9.20^{bj}±0.09	8.56^{em}±0.25	8.98^{ck}±0.03
24	8.83±0.13^{al}	9.28±0.14^{bj}	9.52$^{ai±}$0.04	8.86^{bcl}±0.11	9.16^{ak}±0.02
48	8.83±0.03^{al}	9.40±0.16^{aj}	9.49$^{ai±}$0.05	8.83^{cl}±0.12	9.16^{ak}±0.03
72	8.59±0.08^{dk}	9.06±0.19^{ci}	8.75$^{cj±}$0.26	8.72^{dj}±0.08	8.98^{ci}±0.03
Bacterial count (log^{10} cells/mL) for Clostridia (Clos150)					
0	8.18±0.09^{bk}	8.71±0.07^{ci}	8.77±0.13^{ci}	8.61±0.07^{dej}	8.17±0.08^{ek}
6	7.92±0.11^{cl}	8.76±0.05^{bcj}	9.14±0.08^{ai}	8.66±0.23^{cdk}	9.11±0.03^{ai}
12	8.40±0.12^{ak}	9.02±0.0^{7ai}	8.80±0.09^{cj}	9.05ai±0.08^{ai}	9.05±0.06^{bi}
24	8.24±0.17^{bl}	9.00 ±0.10^{ai}	9.00±0.10^{bi}	8.53±0.20^{ek}	8.82±0.12^{dj}
48	8.17±0.10^{bl}	8.83±0.21^{bk}	9.10±0.09^{ai}	8.93±0.14^{bj}	8.98±0.04^{cj}
72	8.14±0.23^{bk}	8.77±0.23^{bcj}	8.84±0.09^{cj}	8.75±0.05^{cj}	8.98±0.04^{ci}

The data are presented as log CFU/mL average standard deviations

[a-e]Means differed significantly (p 0.05) in the same columns with different letters

[i-m]Means differed significantly (p 0.05) in similar rows with different letters

FDPP: Freeze-Dried Pumpkin Powder; FDWMP: Freeze-Dried Winter Melon Powder; FDRMP: Freeze-Dried Rock Melon Powder

Table 5. Short-chain fatty acids (SCFAs) production in selected cucurbit plants

		Concentration (mM); Samples				
SCFA	Time (Hour)	D glucose	Inulin	FDPP	FDWMP	FDRMP
Acetic	0	7.32±0.20^{fi}	5.96±0.15^{fi}	9.84±6.36^{fi}	3.16±0.18^{ei}	2.59±0.0^{1fi}
	6	16.88±0.03^{ej}	26.21±0.07^{ei}	18.42±0.28^{ej}	2.47±3.49^{fk}	15.58±0.73^{ej}
	12	18.73±0.16^{dj}	33.60±4.36^{di}	23.13±0.14^{dj}	8.20±11.59^{dj}	17.08±0.34^{dj}
	24	20.13±0.07^{ck}	33.75±0.09^{ci}	27.61±0.25^{cj}	20.35±0.35^{ck}	20.24±1.15^{ck}
	48	21.62±0.06^{bl}	40.02±0.62^{bi}	28.94±0.80^{bj}	23.64±0.52^{bk}	22.79±0.27^{bkl}
	72	23.37±0.20^{ak}	53.77±2.74^{ai}	31.23±0.06^{aj}	24.19±0.54^{ak}	24.14±0.6^{1ak}
Propionic	0	3.64±0.11^{fj}	7.12±0.29^{ei}	8.06±1.06^{ei}	3.84±0.18^{fj}	3.89±0.10^{fj}
	6	5.82 ±1.39^{eij}	4.60±0.02^{fj}	5.69±0.24^{fij}	4.28±0.10^{ej}	6.73±0.50^{ei}
	12	10.06±0.07^{di}	9.16±0.18^{di}	8.59±0.11^{di}	11.10±5.02^{ai}	7.66±0.41^{di}
	24	10.21±0.06^{cj}	10.20±0.04^{cj}	11.61±0.01^{ai}	8.71±0.06^{ck}	10.13±1.01^{cj}
	48	10.84±0.06^{aj}	11.88±0.13^{bi}	10.65±0.14^{cj}	8.77±0.11^{bk}	11.03±0.71^{bij}
	72	10.73±0.56^{bj}	16.58±0.22^{ai}	10.87±0.26^{bj}	7.73±0.01^{dk}	11.38±0.13^{aj}
Butyric	0	2.28±0.64^{fi}	ND	ND	ND	ND
	6	3.15±0.17^{ei}	ND	ND	ND	ND
	12	5.07 ±0.01^{ci}	2.73±0.24^{ci}	ND	4.37±6.18^{ai}	ND
	24	5.12±0.21^{bi}	3.45±0.04^{bj}	ND	ND	ND
	48	5.59 ±0.12^{ai}	2.72±3.85^{dj}	ND	ND	ND
	72	3.86±0.60^{dj}	6.73±0.16^{ai}	1.00±0.41^{ak}	ND	ND

The values are expressed as mean standard deviations (n=2); Mean= mM concentration; ND: Not Detected

$^{a-f}$Means in the same columns with different letters showed a significant difference ($p<0.05$)

$^{i-m}$Means in the same rows with different letters showed a significant difference ($p<0.05$)

FDPP: Freeze-Dried Pumpkin Powder; FDWMP: Freeze-Dried Winter Melon Powder; FDRMP: Freeze-Dried Rock Melon Powder

in inulin (6, 12, 24, 48, and 72h), FDPP (24, 48, and 72h), FDWMP (6 and 48h), D glucose (6 and 48h), and FDRMP (48h). After 72h of AA treatment, only inulin and FDPP fermentations showed a significant ($p<0.05$) different, whereas D glucose, FDWMP, and FDRMP did not. Inulin fermentation in vitro produced the most AA ($p>0.05$) with 53.77±2.74 mM, followed by FDPP (31.23±0.06 mM), FDWMP (24.19±0.54 mM), FDRMP (24.14±0.61 mM), and D glucose (23.37±0.20 mM). *Bacteroides* produce AA, while Eubacterium-Clostridium subgroups, Fusobacterium, and Roseburia produce butyric acid (Alfilasari *et al.* 2021). Acetic acid is required for inflammation control, pathogen resistance, and tissue function (Wang *et al.* 2019).

Propionic acid resulted in a significant ($p<0.05$) difference in inulin during (48 and 72h), FDPP (24h), FDWMP (24, 48, and 72h), and FDRMP (24, 48, and 72h) (6 and 48h) of fermentation. At 72h, In vitro inulin fermentation produced the highest population of propionic acid ($p<0.05$) with 16.58±0.22 mM, followed by FDRMP (11.38±0.13 mM), FDPP (10.87±0.26 mM), D glucose (10.73±0.56 mM), and FDWMP (7.73±0.01 mM). Except for inulin, FDPP, and FDWMP, propionic concentrations increased significantly ($p<0.05$) with substrates D glucose and FDRMP.

On the other SCFA, butyric acid concentrations increased significantly ($p<0.05$) for D glucose fermentation, while inulin concentrations being the highest; however, at some points it was not detected (0 and 6h). The highest concentration of butyric acid among cucurbit plants was found in FDWMP, detected during 12h fermentation with 4.37±6.18 mM. A high butyric acid concentration is colonocytes' most crucial energy source and plays an essential role in proliferation and differentiation (Zhou *et al.* 2016). Butyric acid is helpful to humans because it delivers energy to the colonic epithelium (Rios-Covian *et al.* 2016), regulates the progression and apoptosis of epithelial and immune cells, and

prevents colitis and colon cancer (Furusawa *et al.* 2013). Acetate, followed by propionate then butyrate, were the major organic acids produced in the fermentation systems which is similar to what happens in vivo during carbohydrate degradation (Wang *et al.* 2019). Our findings also show that the cucurbit samples produced the highest concentration of acetate followed by propionate and butyrate which in line with Wang *et al.* (2019).

CONCLUSION

There are variation in results on the nutritional content and the prebiotic activity score by in vitro fermentation exhibited by Freeze-Dried Pumpkin Powder (FDPP), Freeze-Dried Winter Melon Powder (FDWMP), Freeze-Dried Rock Melon Powder (FDRMP), inulin, and D glucose. Beneficial bacteria selectively ferment FDWMP and can increase acetic and propionic acid production during faecal fermentation. *Bifidobacterium* growth increased significantly between 0 and 72h for D glucose and FDWMP but not for inulin, FDPP, or FDRMP. The increase in both Bifidobacteria and *Lactobacillus* bacteria but the decrease in both *Bacteroides* and *Clostridia* indicates the beneficial effects and prebiotic quality of the cucurbit samples used in this study. The FDWMP increased the probiotic growth of *L. plantarum* TISTR 1465 and was the highest PI among selected cucurbit plants in the study. Among all cucurbits analyzed, it is proposed that the FDWMP be used as a healthy raw material in the production of a variety of functional food products.

Future works are recommended to explore the ability of food products developed with FDWMP in emeliorating the regularity and defecation behaviour among healthy individuals. It is also recommended to investigate in vitro antimicrobial activity and elucidate mechanistic action on how fiber-bound polyphenols and polysaccharides exhibit pre- and probiotic properties from cucurbit plant.

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DECLARATION OF CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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Sukandar D, Khomsan A, Herawati T. 2009. Kajian program pemberdayaan ekonomi keluarga untuk peningkatan akses pangan. J Gizi Pangan 4(3):157−166

Tuan NT, Nicklas TA. 2009. Age, sex, and ethnic differences in the prevalence of underweight and overweight, defined by using the CDC and IOTF cut points in Asian children. Eur J Clin Nutr 63(11):1305–1312. http://dx.doi.org/10.1038/ejcn.2009.90

Books:

Gibson RS. 2005. Principles of Nutritional Assessment. 3rd Edition. New York (USA): Oxford University Press.

Sherwood L. 2011. Fisiologi Manusia dari Sel ke Sistem (Brahm UP, penerjemah). Jakarta (ID): EGC.

[MoH RI] Ministry of Health Republic of Indonesia. 2013. Riset Kesehatan Dasar. Jakarta (ID): MoH RI.

Articles in Proceedings:

Muhilal & Hardinsyah. 2004. Penentuan Kebutuhan Gizi dan Kesepakatan Harmonisasi di Asia Tenggara dalam Soekirman dkk (Eds.), Ketahanan pangan dan Gizi di Era Otonomi Daerah dan Globalisasi. Prosiding Widyakarya Nasional Pangan dan Gizi VIII (page 302−307), 17−19th May. Jakarta (ID): LIPI.

Final project (Undergraduate Thesis, Thesis, Dissertation)

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Internet:

[WHO] World Health Organization. 2009. Key strategies for promotion of breastfeeding: Facts and Figures. World Health Organization Western Pacific Region http://www.wpro.who.int/internet/resources.ashx/NUT/Global+Facts+and+Figures.pdf [Accessed 9th April 2011].

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