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RESEARCH Open Access

Comparison of Total Bacterial Count in Contact Lenses with Different Treatments of Contact Lens Solutions

Hanna Nurul Husna[1,2a*], Dewi Veti Virgianti[3b], Sindiyani Wini Lestari[2c]

[1] Department of Science Education, Universitas Pendidikan Indonesia, Bandung, West Java, Indonesia
[2] Department of Optometry, Universitas Bakti Tunas Husada, Tasikmalaya, West Java, Indonesia
[3] Department of Medical Laboratory Technology, Universitas Bakti Tunas Husada, Tasikmalaya, West Java, Indonesia

[a] Email address: hannanurulhusna@upi.edu
[b] Email address: dewipeti@universitas-bth.ac.id
[c] Email address: sindiyaniwll14@gmail.com

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Abstract

The use of contact lenses continues to increase, raising attention to aspects of eye health because of their hygienic factors. The hygiene of contact lenses comes not only from the way they are treated but also from the soaking fluid. This study aimed to determine the total bacterial count on contact lenses with and without the use of immersion solutions. The research method used is a comparative descriptive research method that compares the two pairs of contact lenses with two different contact lens solutions. The total bacterial count was calculated using the total plate count (TPC) method. The number of bacterial colonies for contact lenses before being immersed in liquid A was found in dilution 10-2 with an amount of 4.4×103 CFU/mL, and after soaking, it was in dilution 10-1 with an amount of 8.5×102 CFU/mL. The number of bacterial colonies on contact lenses before being immersed in B liquid was found in 10-1 dilution with an amount of 1.3×103 CFU/mL, and after being soaked, the average colony was 3.9×104 CFU/mL. From these results, it can be seen that in contact lenses and liquid A, there is a decrease in the number of bacterial colonies, while on the other hand, in liquid B, there is an increase in the number of bacterial colonies. The causal factor is thought to originate from the composition of the solutions. However, do not rule out contamination from bottles and contact lens care. Therefore, this research can be used as a basis for hygiene education in contact lenses.

Keywords: Bacteria, Contact Lens, Solutions, Total Plate Count.

Corresponding Author:

Hanna Nurul Husna
Department of Science Education, Universitas Pendidikan Indonesia, Bandung, West Java, Indonesia
Email: hannanurulhusna@upi.edu

1. INTRODUCTION

Contact lenses are visual aids that are used with or instead of glasses. Contact lenses are visual aids that are placed on the surface of the cornea so they are efficient and comfortable to use in daily activities (Ibrahim et al., 2021). Aside from being a vision aid for people with refractive errors, contact lenses also have cosmetic and therapeutic functions (Centers for Disease Control and Prevention, 2022). These functions have made contact lenses continue to gain popularity.

Worldwide, there are approximately 125 million users of contact lenses which are used to correct common visual impairments such as myopia, hypermetropia, presbyopia, and astigmatism (ResearchAndMarkets.com, 2023; Waghmare & Jeria, 2022). Not only worldwide, the popularity of contact lenses in Indonesia continues to increase. This can be seen from the increasing demand for contact lenses, especially daily disposable lenses and cosmetic lenses (Statista Market Insight, 2022). Based on research conducted by Statista (Statista Market Insight, 2022), it was found that contact lenses are preferred by young people because of their ease of use. In addition, the weather conditions in Indonesia which tend to be humid make it comfortable to use contact lenses.

Some of the factors that are the focus of attention on eye health in the use of contact lenses are continuous use of contact lenses, unhygienic contact lenses, overnight use, and complications caused by contact lens fluids (Waghmare & Jeria, 2022). The use of contact lenses that are not good, and hygiene can cause bacterial infections in the eye. Bacterial colonies on contact lenses can cause inflammation and other complaints such as red, sore, itchy, and watery eyes (Szczotka-Flynn et al., 2010).

The gap in this study arises from the lack of comprehensive comparative data on the effectiveness of different contact lens solutions in inhibiting bacterial growth. Based on research conducted by Iguban and Nanagas (Iguban & Nanagas, 2016) found contamination of contact lens solutions by pathogenic bacteria. 9% of samples taken from contact lenses, 34% of samples from contact lens containers, and 11% of samples from contact lens solutions, were contaminated with pathogenic microorganisms such as Serratia sp, Staphylococcus aureus and coagulase-negative Staphylococci. In addition, Indrayati and Amelia (Indrayati & Amelia, 2019) found that contact lens solutions with disinfectant concentrations of 0%, 0.0001%, 0%, and 20% had no inhibitory power in inhibiting the growth of Staphylococcus aureus bacteria.

Referring to these problems, it can be seen that improper contact lens hygiene can lead to bacterial contamination and eye infections. It also revealed that not all contact lens solutions are equally effective in preventing this contamination. However, there is limited research comparing the total bacterial count across various contact lens solutions, which is crucial for educating the public on proper lens care and choosing the most effective solutions. This study aimed to determine the total bacterial count on contact lenses with and without the use of immersion solutions.

2. RESEARCH METHOD

The research method that will be used in this study is a comparative research method that aims to explain the relationship between different variables through comparison and hypothesis testing (Rizki et al., 2022). This study aims to see the comparison of contact lens swabs between two soaking solutions. The research samples taken were two pairs of used contact lenses. The contact lens solutions were chosen based on the popularity of the contact lens solution chosen by the contact lens users. From the previous observation and interview with the optician, there are two contact lens solutions that are popular among the users. Therefore, those types of contact lens solutions were used in this research. The independent variables in this study are contact lenses and solutions, while the dependent variable is the number of bacterial colonies.

The instruments used in this study were: test tubes, sterile petri dishes, watch glass, spatula, Erlenmeyer, stirring rod, cotton, gauze, paying paper, mattress thread, autoclave, dry

sterilizer, laminar air flow, test tube rack, technical balance, 1000 micron micropipette, blue tip, and spirit lamp. The media and reagents used were physiological NaCl (0.85%), distilled water, and plate count agar (PCA) media.

Calculation of the total value of bacteria using the Total Plate Count (TPC) method. The TPC test was carried out aseptically to prevent unwanted contamination and was done in duplo to increase the accuracy of the results obtained (Tapotubun et al., 2024). The total plate count was calculated in 1 ml of a sample by multiplying the average number of colonies in the dish with the dilution factor used (Jamilatun & Lukito, 2024). The number of bacteria is expressed as Colony Farming Units (CFU) (Rizki et al., 2022) with the equation:

$$\text{TPC} = \text{Number of coloni} \times \frac{1}{\text{dilution factor}} \quad (1)$$

Where the number of colonies counted is the number of colonies observed on the agar plate; the Dilution factor is the factor by which the sample was diluted before plating (e.g., for a 1:100 dilution, the dilution factor is 100). Due to multiple dilutions and plating for each sample, the average CFU was calculated to minimize variation. To evaluate the results, the CFU/mL between different treatments or groups was compared to analyze trends in microbial growth.

3. RESULTS AND DISCUSSION

The samples in this experiment included both used and new contact lenses. The contact lenses were swabbed with a sterile cotton swab, and the process was repeated three times to ensure adequate sample collection. Each swab was then introduced into a series of test tubes labeled 1, 2, and 3, corresponding to serial dilutions ranging from 10^{-1}, 10^{-2}, to 10^{-6}.

For each test tube, 9 ml of sterile physiological NaCl was prepared, and 1 ml of sample from the transport media tube was added to tube number 1 to create a 10^{-1} dilution. Subsequent dilutions were made by transferring 1 ml from one tube to the next, with a code of 10^{-2} dilution. The test tube was shaken so that the solution was homogeneous and a 10^{-2} dilution was obtained. From a test tube with a dilution of 10^{-2}, it was taken with a 1 ml pipette and put into a tube that was given the code of dilution 10^{-3}. Shake the test tube again so that the solution is homogeneous. The same thing was done up to the 10^{-6} dilution. This procedure allowed for a progressive dilution of the sample, reducing the bacterial concentration for easier enumeration

Following the dilution process, 1 ml of solution from each dilution level was transferred using a sterile pipette into pre-labeled sterile petri dishes. The petri dishes were then incubated at 37°C for 24-48 hours to allow bacterial colonies to develop. This method facilitated a comparative analysis of germ counts from swabs taken from contact lenses with and without immersion liquid, providing insight into potential differences in contamination levels. The germ counts were carefully recorded in a table, offering a clear view of bacterial growth across different dilutions. Through this process, the study aimed to evaluate the efficacy of contact lens immersion liquids in reducing microbial contamination on contact lenses. Calculation of the number of germs from contact lens swabs with and without immersion liquid can be seen in the table 1 below.

Table 1. Average TVC Number of Contact Lenses with and Without Solutions

Sample	Type	Dilutions	Colony number	Average TPC (CFU/mL)
1	CL without soaked solutions	10^{-2}	44	$4.4x10^{3}$
	CL with soaked A solutions	10^{-1}	85	$8.5x10^{2}$

Sample	Type	Dilutions	Colony number	Average TPC (CFU/mL)
2	CL without soaked solutions	10^{-1}	130	$1.3x10^3$
	CL with soaked A solutions	10^{-2} 10^{-3}	170 60	$3.9x10^4$

Dilution affects the number of bacterial colonies. Based on Table 1 above, it is known that most contact lens bacterial colonies are found in just one dilution. However, in contact lenses with B solutions, it was found that two groups of colonies were found at different dilutions even though the number was getting smaller. Dilution is done to reduce the density of bacteria with the consideration that to grow bacterial colonies on limited media it is not possible to count tens of thousands of bacteria (Laili et al., 2022).

Based on the table above, it can be seen that the highest number of bacterial colonies before immersion in contact lens A was found in the 10^{-2} dilution with an amount of 4.4×10^3 CFU/mL and after being soaked it was in the 10^{-1} dilution with the amount 8.5×10^2 CFU/mL. The highest number of bacterial colonies on contact lenses before soaking in B solutions was found in 10^{-1} dilution with an amount of 1.3×10^3 CFU/mL and after being soaked the average colony was 3.9×10^4 CFU/mL. From these results, it can be seen that in contact lenses and immersion liquid A, there is a decrease in the number of bacterial colonies, while in contrast, in immersion liquid B, there is an increase in the number of bacterial colonies.

Based on the interview results, contact lens users stated that the two liquids were obtained in new condition and had a long expiration date. It is possible that the presence of bacteria is due to the ineffectiveness of the solutions. The composition of the solutions will affect its effectiveness in inhibiting bacteria. Liquid with brand A has a buffered, isotonic, and sterile liquid composition with Sodium Hyaluronate, Poloxamer, EDTA, and Polyhexanide 0.0001%. Brand A liquid specifically states that their liquid can clean, moisturize, kill germs, clean protein impurities, and maintain the quality of contact lenses during storage. Whereas solutions with brand B have a composition of Sodium Chloride, Potassium Chloride, Disodium Edetate, Polyhexanide, Poloxamer, Hypromellose, and Sodium Phosphate Buffer. Liquid B claims to clean and moisturize.

The active ingredients for removing bacteria are usually contact lens solutions with compositions such as Polyhexamethylene biguanides (PHMB), quaternary ammonium compounds, hydrogen peroxide, alcohol, sorbic acid, and thimerosal (Eryılmaz, et al., 2018). From the composition of the two solutions, it can be seen that only brand A has a disinfectant/bacterial removal composition, while brand B does not. This explains why brand A has a decrease in the number of bacterial colonies, while brand B actually has an increase in the number of bacterial colonies.

In eyes, without contact lenses, the ocular surface would be considered sterile or have a normal microorganism biota (Willcox et al., 2002). The presence of microorganisms in the eye is important because they will produce antimicrobials that play a role in the defense of the ocular surface from infection. Contamination can come from existing bacteria from the contact lens itself and also transfer from the ocular surface of the eye (Szczotka-Flynn et al., 2010). The surface of the eye is very susceptible to bacterial contamination. Bacterial contamination in the eye will be cleaned by the eye itself as a form of eye defense mechanism. Although in very small amounts, namely under 5 to 10 CFU/lens (Szczotka-Flynn et al., 2010).

The presence of contact lenses on the ocular surface can increase bacterial contamination. This is due to protein deposits produced from contact lenses (Barr et al., 1988) whose amount depends on the contact lens material itself (Szczotka-Flynn et al., 2010). In addition, the oxygen level in contact lenses will also affect the number of bacteria. Increased oxygen levels in contact lenses can reduce bacterial bonding with the ocular surface (Waghmare & Jeria, 2022).

Based on the results of the interviews, it is known that contact lens care will have a significant effect on contact lens hygiene. The number of bacterial colony numbers found to be different in each contact lens can be caused by several factors. Holding contact lenses is the main factor causing bacterial contamination (Szczotka-Flynn et al., 2010). Other factors can also play a role, such as the lens case and immersion solutions.

Contamination can come from existing bacteria from the contact lens itself and also transfer from the ocular surface of the eye (Szczotka-Flynn et al., 2010). The surface of the eye is very susceptible to bacterial contamination. Bacterial contamination in the lens case was detectable even in the presence of liquid immersion, which consisted of a mixture of bacterial, fungal, and protozoan contaminants (Clark et al., 1994). The main cause of contamination even though there is immersion fluid is biofilm (Szczotka-Flynn et al., 2010). Bacterial contamination usually begins with the initial attachment of some bacteria to a surface followed by implantation, but later, develops to form a biofilm on the contact lens surface. This biofilm shows resistance to antibiotics in washing solutions and the immune system (Indrayati & Amelia, 2019).

Soaking solutions are used to clean, lubricate, and disinfect contact lenses (Waghmare & Jeria, 2022). Therefore soaking solutions usually consist of buffers, surfactants, preservatives, lubricants, and antimicrobial agents. Contact lens solutions use polymers as disinfectants, but the function of other contact lens cleaning solutions that is preferred is as a sterile storage medium as long as contact lenses are not used (Indrayati & Amelia, 2019).

The minimum amount of bacteria in contact lens fluid has been established by ISO standards. Contact lens fluid manufacturing processes are defined in ISO 14729 and ISO 18259 (McAnally et al., 2021). Based on ISO 14759, the minimum number of inoculum bacteria present is $1x10^5 – 1x10^6$. However, soaking fluids have varying effectiveness in dealing with the transfer of bacterial contamination. Research conducted by Indrayati (Indrayati & Amelia, 2019) found that contact lens cleaning fluids with disinfectant concentrations of 0%, 0.0001%, 0%, and 20% had no inhibitory power in inhibiting the growth of Staphylococcus aureus bacteria.

Soaking solutions packaged in bottles can easily become contaminated, and become a source of microbes that contaminate the lens case, stick to contact lenses, and cause inflammatory reactions and corneal infections (Szczotka-Flynn et al., 2010). All types of contact lens solutions, including those with hydrogen peroxide composition, are contaminated even if the bottle has not been opened (Szczotka-Flynn et al., 2010). Durban et al., (1996) found that Acanthamoeba organisms were almost always found in lens cases or lens solutions. Achantamoeba is a cause of keratitis (Waghmare & Jeria, 2022). Several studies have also found that contamination from solutions can occur due to the behavior of transferring lens fluid to the box through the bottle cap (Szczotka-Flynn et al., 2010). The length of time since the bottle was opened also affects bacterial contamination. Donzis (Donzis et al., 1987) found that bacteria can be acquired immediately after 5 days from opening the bottle cap, and the risk of contamination continues to increase the longer the bottle is opened.

Bacterial contamination found on contact lenses can come from the contact lenses themselves or from external factors such as contact lens cases and solutions. Contact lens wearers should pay great consideration to cleaning and disinfection practices to decrease bacterial growth, reduce chances of biofilm formation (Hadeel T AL-Hadithi & Zahira M AL-Khani, 2023). Most of the bacterial isolates obtained from contact lens wearers had the potential to produce biofilms (Raksha et al., 2020). This bacterial contamination will be a concern because it can cause infections such as keratitis (Szczotka-Flynn et al., 2010). One solution that can be done from contact lens manufacturing is contact lens formulation and contact lens cases with anti-microbial coatings such as silver polyquats, polymeric pyridium compounds, free-radical producing agents, quorum-sensing blockers, and anti-infective agents (Weisbarth et al., 2007). Preventive measures can be taken by increasing awareness about the importance of

contact lens hygiene so that contact lens users can adopt healthy habits such as cleaning contact lenses using a special liquid (not with water); periodically dispose of the liquid in the contact lens case; cleaning and changing contact lens cases every three months (Waghmare & Jeria, 2022). These actions can reduce the risk of bacterial infections in contact lenses such as keratitis.

4. CONCLUSION

From the results of the research on examining the number of bacterial colonies using the TPC method, it can be concluded that there was a decrease in the number of bacteria in the results of examining contact lenses with immersion liquid A, amounting to 4.4 x 103 CFU/mL sample to 8.5 x 102 CFU/mL sample. Meanwhile, when examining contact lenses and immersion liquid B, the number of germs increased, namely from 1.3 x 103 CFU/mL sample to 3.9 x 104 CFU/mL sample. Future research could focus on evaluating the effectiveness of various disinfectant concentrations in contact lens solutions to determine optimal bacterial inhibition, while also investigating the mechanisms of biofilm formation and resistance on lenses and in storage cases. Long-term contamination studies could explore how bacterial levels change over time after solution bottles are opened. Additionally, research into the impact of user behavior, such as cleaning and handling practices, could provide insights into reducing contamination. Further studies might examine the use of antimicrobial coatings on lenses and cases, as well as the development of new antimicrobial agents to enhance solution efficacy.

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RESEARCH Open Access

Career Ladder Professionalism in Nursing: A Concept Analysis

Haeril Amir[1,2a*], Rr. Tutik Sri Hariyati[1b], Enie Novieastari[1c], Trevino A. Pakasi[3d]

[1] Faculty of Nursing, Universitas Indonesia, Depok, West Java, Indonesia
[2] Faculty of Public Health, Universitas Muslim Indonesia, Makassar, South Sulawesi, Indonesia
[3] Faculty of Medicine, Universitas Indonesia, Depok, West Java, Indonesia

[a] Email address: haeril.amir@umi.ac.id
[b] Email address: tutik@ui.ac.id
[c] Email address: enie@ui.ac.id
[d] Email address: pakasitrevino@gmail.com

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Abstract
A defined career path for nurses is essential, as they constitute the largest segment of healthcare workers and hold strategic and leadership roles in determining the quality of patient care and overall hospital quality. This study aims to analyze the concept of professionalism in relation to the implementation of career paths for nurses within hospital settings. This concept analysis follows the steps outlined by Walker & Avant. A literature search was conducted using the PubMed, Scopus, ScienceDirect, and ProQuest databases to identify articles published between 2014 and 2024. After filtering, 9 articles were selected from various scientific disciplines such as nursing, medicine, education, and other health-related fields. This study identified three main attributes related to the clinical professional ladder: 1) integrity, 2) justice, and 3) beneficence. Antecedents include education, workshops/conferences, experience, and professional identity. Consequences include ethics, patient outcomes, nursing outcomes, future career opportunities, job satisfaction, retention, salary, and organizational commitment. This concept analysis enhances our understanding of the three attributes of the career ladder and professionalism (CLp) and provides insights into future development and uncertainties in nursing management. This concept is highly valuable for nurse management settings, particularly in enhancing professionalism through career path programs. Ultimately, this concept analysis approach encourages both new and experienced nurses to maintain professionalism in the delivery of nursing care.

Keywords: Career Ladder Professional, Nursing, Concept Analysis.

Corresponding Author:

Haeril Amir
Faculty of Nursing, Universitas Indonesia, Depok, West Java, Indonesia
Email: haeril.amir@umi.ac.id

1. INTRODUCTION

Nurses are providers of professional nursing services (Blais & Hayes, 2015). Professionalism in nursing encompasses values and ethics, including altruism, autonomy, dignity, integrity, honesty, and justice (Karami et al., 2017; Poorchangizi et al., 2019; van der Wath & van Wyk, 2020). The integration and implementation of these professional values are crucial to ensuring the future of nursing as the frontline of patient care in hospitals (Karami et al., 2017). Thus, nursing is not merely a profession but also prioritizes compassion and empathy in the delivery of nursing care (Yi et al., 2022).

The World Health Organization (WHO) emphasizes the importance of strengthening nursing professionalism and requires countries to report on their efforts (WHO, 2016), Professionalism in nurses is cultivated during their education. A study by Gilvari at Semnan University, involving 196 nursing students, found that a high A Grade point Average (GPA) and practical experience are key factors in shaping nurse professionalism (Gilvari et al., 2022; Zeng et al., 2022). This underscores the vital role of educators in fostering student professionalism (Tang et al., 2022).

Professionalism continues to develop as nurses enter the workforce, becoming ingrained as a social response (Su et al., 2021) New nurses require learning opportunities and recognition, which can be achieved through a structured career path that includes continuing professional development (Kim et al., 2017; Lee et al., 2017; Pertiwi et al., 2021; Rahmah et al., 2021). A career path serves as an assessment system to evaluate skills, competencies, and experience in nursing practice (Ahn & Choi, 2023) Career paths facilitate the mapping of nurses according to their competencies (Sandehang et al., 2019), and support career advancement, rewards, duty awareness, and skills development (Pertiwi & Hariyati, 2019). Thus, the career ladder and professionalism (CLp) are intrinsically linked and inseparable. Study aim is reviewing career ladder and professionalism through concept analysis is essential to promote clarity while providing mutual understanding within nursing.

2. RESEARCH METHOD

This concept analysis was conducted using the Walker and Avant method to interpret dimensions, attributes, antecedents, consequences, cases, and empirical references (Walker & Avan, 2019). This approach involves selecting a concept, determining the objectives of the analysis, identifying all uses of the concept, determining the defining characteristics of the concept, creating a model case, developing borderline, conflicting, and imaginary cases, identifying the antecedents and consequences of the concept, and determining empirical references for the concept. A literature search was conducted online by reviewing articles closely related to career paths and professional nursing. The databases used were PubMed, Scopus, and ProQuest. The keywords used were "Career path," "career ladder," "nursing," "nurse," and "professional." The search included articles published in the last 10 years and written in English.

3. RESULTS AND DISCUSSION

According to Walker and Avan (2019), the best concept is one that aligns with our interests and is significant for advancing the field. The selection of this concept aims to provide clarity that will help nurses become more professional and enhance the quality of practice in hospitals. The chosen concept is the career ladder and professionalism. According to the Oxford Learner's Dictionaries, professionalism refers to the high standards expected of someone trained in a particular job (University of Oxford, 2024).

The second step in this concept analysis is determining the purpose of the concept (Walker & Avant, 2019). This concept aims to assist in focusing analytical attention on how professionalism is closely related to the implementation of career paths for nurses within hospital settings.

The process of identifying attributes starts with a literature search. For this concept analysis, several databases were used, including PubMed, Scopus, ScienceDirect, and ProQuest. The search included articles published in the last 10 years and written in English. The literature was not limited to nursing but included other disciplines such as psychology, economics, medicine, and other scientific fields (Walker & Avant, 2019). A total of 9 articles were found and analyzed: six from nursing, one from education, one from medicine, and one from the broader health field. The keywords and search process are detailed in Table 1.

Determining the Defining Attributes. Walker and Avant stated that attributes are identified based on the largest clusters to provide broader insight (Walker & Avant, 2019). The authors found 10 articles related to professionalism, highlighting attributes such as integrity, justice, beneficence, and respect (Table 2).

Integrity originates from the Latin words "integritas" and "atis," meaning the condition of being truthful and not manipulated, and is synonymous with honor (Stigger et al., 2022) This attribute pertains to nurses genuinely serving patients, providing accurate diagnoses, and conducting intervention processes to the best of their abilities. Integrity forms the framework and basic foundation of nursing science, encompassing personal values, moral, and professional ethics (Seidlein & Kuhn, 2023).

Justice refers to the fair and impartial treatment of all patients, ensuring equitable decision-making in reporting and implementation (Correia & Almeida, 2020; Haghighinezhad et al., 2019; Hashish, 2020) Justice should be upheld not only by nurses but also by organizations, patient families, and coworkers (Correia & Almeida, 2020). Nursing has a long history of advocating for social justice, focusing on addressing the social root causes of poor health, as well as ensuring patient safety and fairness (Ibrahim, 2024; Rudner, 2021) There is a consensus on the need to include social justice issues in nursing education to empower nurses to address health disparities (Abu & Moorley, 2023).

Beneficence is defined as the practice of doing good and helping patients (Beauchamp & Childress, 2019) Fundamentally, beneficence aims to protect patients' rights, prevent harm, and provide care for those at risk (Cummings & Mercurio, 2010).

Table 1. Career Ladder and Professionalism (CLp) Concept definitions

Authors (Years)	Fields	Definition
(Kim et al., 2017)	Nursing	Human resource management system to manage nurses by building nursing knowledge and management.
(Li et al., 2022)	Nursing	A level of clinical practice that recognizes and values nurses' contributions to quality, evidence-based care that positively influences patient care.
(Vilendrer et al., 2022)	Medicine	Process to reduce job burnout, turnover, skepticism, and obtain additional education.
(Coleman & Desai, 2019)	Nursing	A structured system to advance nurses' careers while remaining in a clinical environment by placing nurses based on their professional skills.
(Xenakis, 2018)	Health	The advancement process encourages workers to engage in critical reflective thinking, summarize their work carefully, and relate their practice to theoretical foundations.
(Ghamrawi & Abu-Tineh, 2023)	Education	Structures frequently used to support the development and alignment of teacher recruitment, pre-service and in-service training,

		assessment procedures, and career advancement opportunities.
(Pertiwi & Hariyati, 2019)	Nursing	Programs that influence nurse satisfaction and turnover rates
(Filani et al., 2019)	Nursing	Used to differentiate the implementation of nursing practice at each level to facilitate professional development, improve staff relationships, appreciation, and competence, and increase work motivation.
(Slagle et al., 2023)	Nursing	The program promotes best clinical practices, professional development, increased satisfaction, recognition of expertise, and efforts to reduce retention.

Concept definition is an explanation and definition of concepts from various fields of science, these definitions are then described according to table 1 and between one definition and another, similarities are sought so that they can be grouped.

Table 2. Attributes of Career Ladder and Professionalism (CLp)

Keyword clusters	**Sources**	**Attributes**
- It is the state or characteristic of being full and complete - Ethics - Personal morality - Sense of personal, professional, and social wholeness - Maintain dignity as human beings - Be recognized as individuals	(Stigger et al., 2022)	Integrity
- Does not differentiate - Balanced decision - Fair regarding implementation - Not racist	(Chandler et al., 2022; Correia & Almeida, 2020; Haghighinezhad et al., 2019; Hashish, 2020)	Justice
- Beneficial - Help - Mercy - Protect patient rights - Prevent loss - Help those at risk - Generosity	(Beauchamp & Childress, 2019; Cheraghi et al., 2023; Cummings & Mercurio, 2010; Ivanov & Oden, 2013)	Beneficence

Cases

Model Case

This case involves Nurse Maria, who has 10 years of work experience and is confident in all her activities in providing nursing care to her patients. Nurse Maria is committed to providing the best service in accordance with nursing professional standards. Her patients often praise her, and it is not uncommon for patients and their families to respect her for her integrity, sense of fairness, and selfless assistance to patients and their families.

Borderline Case

This case involves Nurse Ani, who works in the emergency room of a private hospital. On Mondays, she is on night duty from 20:00 to 08:00 the next day. During her shift at around 22:00, Patient B is admitted to the ER with complaints of chest pain and difficulty breathing. Patient B happens to be a close family member who lives next door to her. However, 5 minutes later, another patient is admitted to the ER due to a traffic accident and is unconscious. Nurse Ani, without hesitation, leaves Patient B, her family member, to immediately treat the traffic accident patient. Nurse Ani acts fairly in this situation by prioritizing the patient in greater need, even though her family member also requires treatment.

Contrary Case

This case involves Nurse Ani, who works as the head of the emergency unit in a hospital. During working hours, the ER is full of patients with various complaints. Despite the busy environment, Nurse Ani is not assisting in treating patients but is seen playing with her cell phone. Occasionally, she greets patients she knows and instructs her subordinate nurses to prioritize these familiar patients.

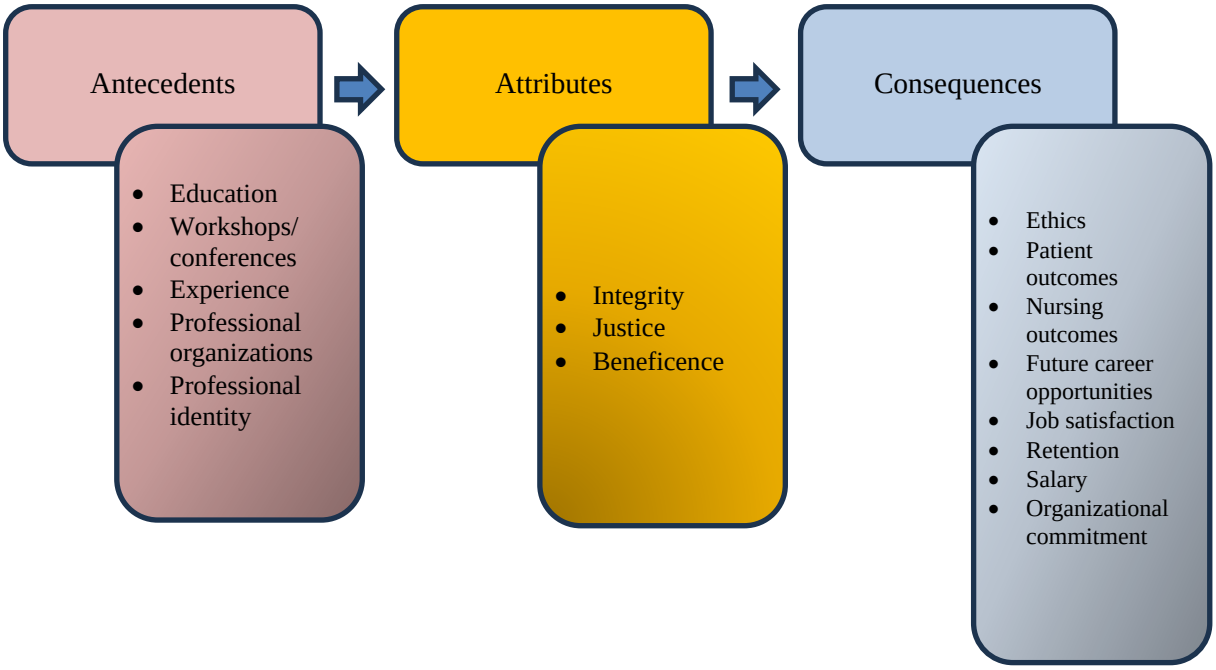

Figure 1. Antecedents, Attributes, and Consequences

Antecedents are events preceding the concept that contribute to refining its attributes (Walker & Avant, 2019). The career ladder and professionalism is shaped by the nurse's personal values manifested through education, training, and certification. The following antecedents have been identified for the professional nursing career ladder:

a. Education
b. Workshop or conferences
c. Experience
d. Professional organizations
e. Professional identity

Based on the framework outlined by Walker and Avant (2019), consequences arise as a result of a concept. When discussing the consequences of a career ladder and professionalism, it is essential to consider the role of ethics and formal standards. The following consequences have been identified for the professional nursing career ladder:

a. Ethics
b. Patient outcomes
c. Nursing outcomes
d. Future career opportunities/success
e. Job satisfaction
f. Retention
g. Salary
h. Organizational commitment

Empirical references are phenomena observed directly and are directly connected with the attributes defining the concept, or in other words, they provide opportunities to measure the career ladder and professionalism (Walker & Avant, 2019). The career ladder and professionalism can be assessed using screening tools such as the Nursing Professionalism Evaluation Model in a Career Ladder System (NPEM-CLs) (Kim et al., 2017) and the Career Growth Scale for Nurses (CGSN) (Ni et al., 2023).

4. CONCLUSION

This concept analysis has identified three critical attributes in the career ladder and professionalism: integrity, justice, and beneficence. The insights gained from this conceptual analysis can inform the development of career path programs for nurses. Additionally, these findings emphasize the importance for nurses to actively engage in and adhere to career path initiatives within hospital settings.

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RESEARCH **Open Access**

Diabetes Self-Management Education on Dietary Compliance in Indonesia: A Descriptive Literature Review

Meigi Rompas[1a*], Dwi Indah Iswanti[2b], Julvainda Eka Priya Utama[2c]

[1] Master of Nursing Study Program, Faculty of Nursing and Health, Universitas Karya Husada Semarang, Semarang, Central Java, Indonesia
[2] Faculty of Nursing and Health, Universitas Karya Husada Semarang, Semarang, Central Java, Indonesia

[a] Email address: rompasmeigi@gmail.com
[b] Email address: dwi.indah.iswanti@unkaha.ac.id
[c] Email address: julvaindaeka@gmail.com

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Abstract
Diabetes Mellitus (DM) is a condition that is becoming more common worldwide, affecting both industrialized and developing countries. The objective of this study was to do a comprehensive analysis of the available literature in order to investigate the impact of Diabetes Self-Management Education (DSME) on adherence to dietary guidelines among individuals with diabetes in Indonesia. This study employed a method of descriptive literature review. Relevant keywords were used to conduct literature searches on academic databases including PubMed, Scopus, and Google Scholar. Relevant articles were picked based on specific criteria, and data were collected from them. The initial studies found from databases were 1,730 and after applied inclusion and exclusion criteria, the final studies included to this study was nine studies (2012 – 2024). The gathered data were subsequently examined through three distinct stages: data reduction, data presentation, and generating conclusions that was done by all authors. The results indicated that Diabetes Self-Management Education (DSME) programs had a notable effect on the degree of adherence to dietary guidelines in individuals with Diabetes Mellitus (DM). Patients who engaged in the DSME program exhibited greater adherence to the prescribed diet, in contrast to those who did not partake in the program.

Keywords: Diabetes, Self-Management Education, Diet Compliance.

Corresponding Author:

Meigi Rompas
Master of Nursing Study Program, Faculty of Nursing and Health, Universitas Karya Husada Semarang, Semarang, Central Java, Indonesia
Email: rompasmeigi@gmail.com

1. INTRODUCTION

Diabetes Mellitus (DM) is a disease that is increasingly common throughout the world, both in developed and developing countries. This condition shows that DM has become a significant global health problem for society at large (Arokiasamy et al., 2021; Lovic et al., 2020; Mukhtar et al., 2020). Number of diabetes sufferers worldwide in 2021 reached 537 million people. IDF projections show that this figure will continue to increase to around 643 million in 2030, and even reach 783 million in 2045. IDF also noted that Indonesia ranks fifth among countries with the largest number of diabetes sufferers, with 19.5 million sufferers in 2021 (Magliano & Boyko, 2022).

Diabetes Mellitus is a metabolic disorder characterized by increased blood glucose levels, caused by abnormalities in insulin secretion, insulin function, or both (Kumar et al., 2020; Rachdaoui, 2020). Therefore, to keep blood sugar levels under control, people with diabetes must follow five main pillars in managing their condition, namely education, diet management, physical activity, use of drugs, and self-monitoring of blood sugar levels (Ibrahim et al., 2020; Prabawati & Natalia, 2020; Soep & Agussalim, 2020). Diet in diabetes management, also known as medical nutrition therapy, aims to help individuals with diabetes improve their diet and exercise habits in order to achieve optimal metabolic control (Evert et al., 2019; Tamura et al., 2020). The basic principle of regulating diet in people with diabetes is to choose foods that are balanced and in accordance with the calorie and nutrient needs needed (Salvia & Quatromoni, 2023).

Education is an integral part of efforts to promote a healthy lifestyle that must continue to be carried out. In the management of diabetes mellitus, education plays a key role in efforts to prevent and holistically manage this disease (Lambrinou et al., 2019; Świątoniowska et al., 2019). This includes knowledge about healthy eating patterns, proper physical activity patterns, regularity in taking oral diabetes medication (OAD) or insulin, and good foot care (Mirahmadizadeh et al., 2020). The effectiveness of efforts to prevent complications is highly dependent on the level of knowledge of individuals with diabetes about their condition (Nazir et al., 2018). This knowledge can be influenced by various factors, such as age, education level, type of work, personal experience, access to information, and social, cultural, and economic factors (Hill-Briggs et al., 2021).

This educational effort can be done, one of which is through Diabetes Self-Management Education (DSME). DSME is a process that provides knowledge to individuals with diabetes mellitus (DM) regarding self-care strategies to improve metabolic control, prevent complications, and improve their quality of life (Ernawati et al., 2021). The main goal of DSME is to assist individuals in making decisions regarding self-care, improving health behaviors, resolving problems related to their condition, and actively collaborating with the health team to improve clinical outcomes, health status, and quality of life (Kolb, 2021). However, based on the background description, researchers are interested in conducting research on diabetes self-management education on dietary compliance. There are existing studies related to DSME such as the study in China, Ethiopia, and India (Hailu et al., 2019; Srinath et al., 2017; Zheng et al., 2019). The findings from those three studies revealed that diabetes mellitus with self-management education found effective to reduce the morbidity among DM patients. These findings can contribute to a theoretical understanding of the effectiveness of educational interventions in the context of chronic disease management, such as diabetes. In addition, this study can also encourage the development of more comprehensive theories and models in describing the relationship between education, compliance, and health outcomes. The purpose of this study was to conduct a descriptive literature review of the existing literature to evaluate the effect of Diabetes Self-Management Education (DSME) on dietary compliance in people with diabetes in Indonesia.

2. RESEARCH METHOD

This study uses a descriptive literature review method. The review method is a research method that involves a series of systematic processes, to collect, identify, assess, and interpret evidence from the results of research that has been conducted. Literature searches were conducted through academic databases such as PubMed, Scopus, and Google Scholar using relevant keywords. The keywords used were "diabetes self-management education", "diet adherence", and "diabetes mellitus". The data used in this study has several inclusion criteria and exclusion criteria.

Inclusion Criteria: Language: Articles published in English or Indonesian. Publication Year: Articles published in 2012 or after 2024 and only in the Indonesia setting. Study Type: Original research studies, including observational studies, clinical trials, or meta-analyses. Studies that specifically address diabetes self-management education (DSME) and dietary compliance among individuals with diabetes mellitus. Study Population: Research involving individuals diagnosed with diabetes mellitus, either type 1 or type 2. Accessibility: Articles available in full text and accessible through databases such as PubMed, Scopus, or Google Scholar. There is no limit of the participants aged in the study. According to PICO (Population, Intervention, Comparison, and Outcome), this review study did not limit the selected studies based on type of patients, intervention, comparisons, and outcome. The main point is diabetes self-management education.

Exclusion Criteria: Language: Articles published in languages other than English or Indonesian. Publication Year: Articles published before 2012 or after 2024. Publication Type: Review articles, commentaries, editorials, or case reports that do not present primary research data. Studies focusing on aspects of diabetes unrelated to self-management education or dietary compliance, such as complications of diabetes or pharmacological therapy without including DSME. Non-Relevant Populations: Articles focusing on non-diabetic populations or other health conditions not relevant to diabetes mellitus. Accessibility: Articles available only in abstract form or those not accessible in full text. Based on the established criteria, the flow and results of the research that will be used in this study are described in the following PRISMA diagram:

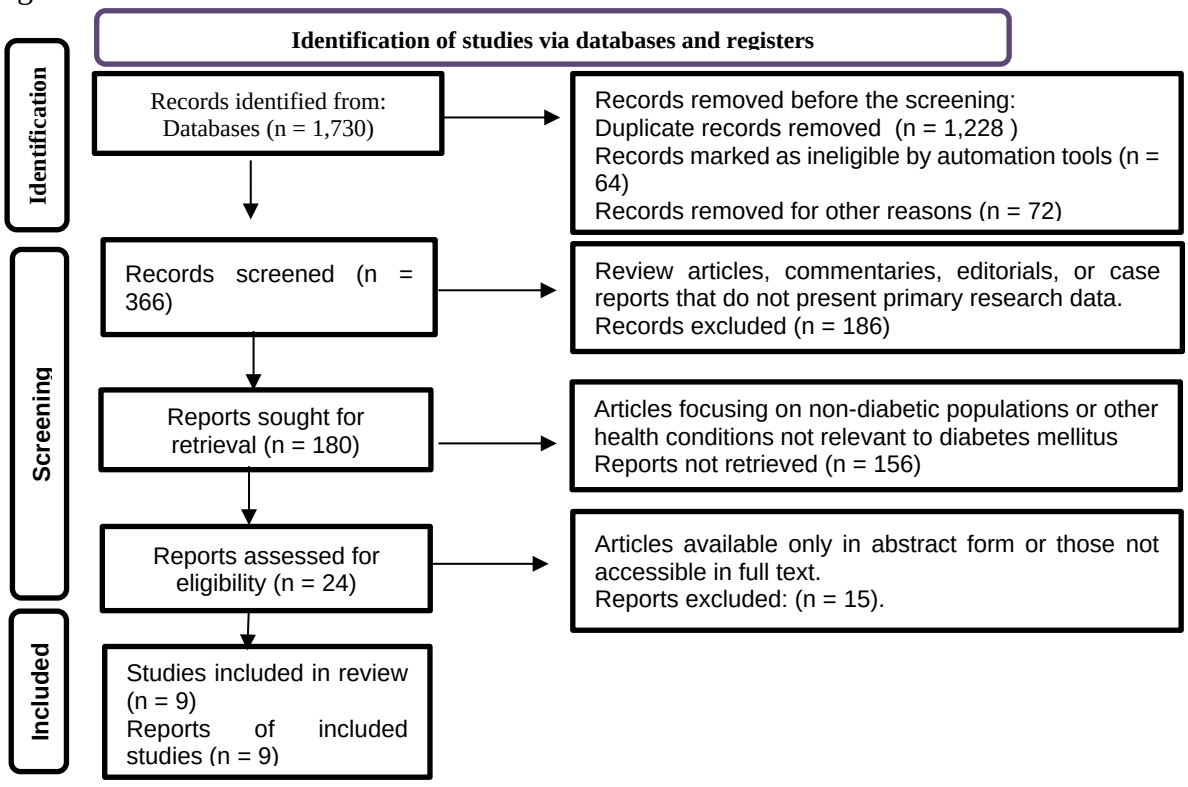

Figure 1. PRISMA Diagram

The final studies included in this study was nine studies from Indonesia. The collected data was then analyzed in three stages, namely data reduction, data presentation and drawing conclusions. All the data processes were responsible to all authors.

3. RESULTS AND DISCUSSION

The following is a critical analysis of nine research articles that were sampled in the literature review that focused on the role of Diabetes Self-Management Education (DSME) and other diabetes education on dietary compliance of DM patients, which is presented in the following table 1:

Table 1. Tabulation and descriptive literature review used

No	Authors, year, and country	Patient's information	Methods and Interventions (duration)	Results
1	(Aminah et al., 2022) Cimahi, Indonesia	Involved 16 respondents (aged 35-65 years old) with duration September to October 2021.	Pre-Experimental with One Group Pretest Posttest design. The sampling technique used was purposive sampling with 16 respondents. With booklet media.	The Self-Management Education program reduced the percentage of respondents not compliant with their diet from 81.3% to 81.3%, a statistically significant result with a p-value of 0.006, indicating a positive effect.
2	(Laili et al., 2019) Semarang, Indonesia	Involved 100 patients with DM type 2 (not mentioned age and duration of the study)	Quasi-experimental using purposive sampling and divided into two groups, namely the treatment group and the control group. With a structured questionnaire and daily food recording for seven days.	Diabetes Self-Management Education (DSME) is a patient-centered approach that enhances dietary adherence in type 2 Diabetes Mellitus patients. It involves patient empowerment and behavioral strategies, aiming to improve their understanding and skills in managing their condition. Ongoing support maintains progress and strengthens adherence behavior.
3	(Restuning, 2015) Yogyakarta, Indonesia	Involved 82 respondents who mostly aged >45 years old. The duration of study was September to October 2014.	Quasi experimental pre–posttest without control group design and conducted in Wirogunan and Brontokusuman sub-districts. There is 41 intervention groups	The study found that diabetes education significantly impacts the level of diet compliance in type 2 diabetes patients. The intervention group showed a significant difference in diet management

			and 41 control groups.	compliance before and after diabetes education, while the control group showed no significant difference. The Mann Whitney difference test also showed a significant difference in diet compliance before and after diabetes education.
4	(Harwadi et al., 2015) Padang, Indonesia	Involved 15 respondents (not mentioned age and study duration)	Quasi-experimental with One Group Pre-Post Test Design, involving 15 people as samples selected using the Purposive Sampling method.	Health education significantly improved Diabetes Mellitus patients' compliance with the right diet in terms of quantity, type, and schedule (p = 0.002). This suggests that providing diet education can enhance treatment compliance among patients with Diabetes Mellitus.
5	(Syaftriani et al., 2021) Medan, Indonesia	Involved 63 patients who were aged 56-65 years old. However, not mentioned the study duration.	Community Service was carried out on Friday, April 1, 2022, in Dusun 1B Wampu, Pantai Gemi Village, Stabat District, Langkat Regency, North Sumatra. The process of implementing this service is divided into three stages, namely preparation, implementation, and closing.	Parents with Diabetes Mellitus can enhance their self-care skills and manage their condition more effectively by regularly monitoring blood sugar levels, maintaining a healthy diet, engaging in physical activities, taking prescribed medication, and managing stress related to DM.
6	(Widayati, 2021) Kediri, Indonesia	Involved 16 respondents age 30-60 years old.	The pre-experiment involving 16 samples was selected intentionally through purposive sampling.	Peer-led education can boost adherence to diet and self-care in individuals with Diabetes Mellitus (DM) by creating a sense of connection and support among those experiencing the same condition.

7	(Damhudi et al., 2021) Singkawang, Indonesia	Involved 60 patients aged 19 to 65 years old.	A quasi-experimental study in Indonesia compared the effects of modified DSMES on 60 patients. The modified curriculum included culturally appropriate nature similarities, photos, and eating habits. Intention-to-treat analyses were conducted to determine the modified DSMES' effect on self-care, DFU severity, and QoL in a total of 60 patients.	The study found that the DSMES program was more effective than standard care in improving self-care behaviors, quality of life, and the degree of diabetic foot ulcers among Indonesians with DFU, both immediately after the intervention and three months later. This suggests that DSMES is a valuable intervention for managing diabetes and its complications.
8	(Aklima et al., 2012) Indonesia	Review article	An analytical literature review was undertaken by examining papers pertaining to evidence-based procedures. Exclusively articles written in English and Indonesian were examined. The search yielded eleven published empirical papers pertaining to the subject matter.	The review suggests that a family-based dietary self-management support program could significantly improve dietary behaviors in type 2 diabetes patients. This program, guided by Funnell and Anderson's self-management theory, would empower patients and their families through reflective listening, emotional support, active problem-solving, and structured goal-setting. Further studies are needed to integrate family support into routine diabetes care.
9	(Sugiharto et al., 2017) Pekalongan, Indonesia	Involved 41 participants (not mentioned the duration of study)	The Joanna Briggs Institute implemented a three-phase project to enhance evidence utilization and improve community health settings, involving stakeholder	Baseline audit revealed poor compliance with 12 criteria, but strategies implemented during phase 2 (diabetes educator training, curriculum development, patient logbook) led to 100% compliance, indicating improved

	engagement, baseline audits, identification of barriers, and follow-up audits.	evidence-based compliance.

Diabetes Self-Management Education (DSME) plays a critical role in enhancing dietary compliance among individuals with diabetes in Indonesia. The integration of effective educational strategies tailored to the local context is essential for improving dietary habits and managing diabetes effectively. Studies indicate that educational interventions significantly influence dietary practices and overall diabetes management (Butayeva et al., 2023; Mikhael et al., 2020).

One of the primary challenges in diabetes management is adherence to dietary recommendations. Research shows that a substantial portion of diabetic patients struggle with dietary compliance, often due to a lack of adequate nutritional education and support from healthcare providers. For instance, a study conducted in Ethiopia found that only 44.3% of participants adhered to dietary recommendations, highlighting the necessity for ongoing educational efforts to promote better dietary management among diabetes patients (Mohammed & Sharew, 2019). Similarly, the absence of proper nutritional education in clinical settings has been linked to poor dietary practices, emphasizing the need for healthcare systems to prioritize diabetes education (Cristello Sarteau et al., 2024).

Moreover, the effectiveness of DSME is enhanced when it incorporates diverse educational methods. For example, emphasize the importance of flexible strategies that align with patients' real-life situations, suggesting that educational content should not only focus on glucose monitoring and medication adherence but also on practical dietary changes, such as reducing salt intake (Weller et al., 2017). This aligns with findings from, who demonstrated that a multifaceted approach to nutritional education, including community activities and media outreach, significantly improved dietary knowledge and practices among diabetic patients (Jarvandi et al., 2023). Such comprehensive educational frameworks can empower patients to make informed dietary choices that align with their health goals.

Peer education and community support also emerge as vital components of effective DSME. propose a framework for peer education that fosters shared learning and support among individuals with diabetes, which can enhance dietary compliance (Eu et al., 2019). This approach is supported by evidence that social support from family and peers significantly influences dietary habits and adherence to diabetes management plans (Busebaia et al., 2023). The role of family dynamics in shaping dietary practices cannot be overlooked, as participants in various studies have reported that family members often influence their dietary choices, either positively or negatively (Tshiswaka et al., 2017).

Furthermore, the integration of psychosocial theories into DSME can enhance its effectiveness. Research indicates that understanding the psychological and social factors influencing dietary behaviors is crucial for developing effective educational interventions (Chiang et al., 2021). For instance, a study highlighted that individuals with a higher level of diabetes knowledge were more likely to adhere to dietary recommendations, suggesting that education must address both knowledge and the underlying beliefs and attitudes towards diabetes management (Elafros et al., 2023).

Providing proper education through DSME allows patients to gain a better understanding of their diabetes. Education about diabetes is considered crucial to prevent complications and undesirable outcomes. When patients are provided with comprehensive information about their disease and how to properly treat it, they tend to show more positive results in managing their condition. Accurate knowledge about diabetes allows patients to make better decisions based on the information they have (Ferreira et al., 2024). After the implementation of education with the Diabetes Self-Management Education (DSME)

approach, patients who participated in the DSME program tended to show higher levels of adherence to the recommended diet, compared to those who did not participate in the program (Shahabi et al., 2024). There is potential bias of the study selection because the studies selected to this review study were only from Indonesian context.

These findings suggest that DSME has an important role in helping patients with Diabetes Mellitus (DM) to better manage their diet. By increasing the level of adherence to the recommended diet, patients can achieve better blood sugar control and reduce the risk of long-term complications associated with diabetes. Thus, the results of this study confirm that the DSME approach not only improves patients' knowledge about diabetes, but also helps them to implement healthy dietary practices to effectively manage their condition. This study overcome the insight of DSME which understudied in developing countries such as Indonesia. However, additional literatures from developed countries could be better comparison. Future studies could examine the long-term effect of DSME for patients' health by using cohort study for ensuring effectiveness of the program.

4. CONCLUSION

The results of the analysis of nine studies that met the inclusion and exclusion criteria showed that Diabetes Self-Management Education (DSME) has a significant impact on the level of dietary compliance in Diabetes Mellitus (DM) patients. Patients who actively participate in the DSME program tend to show a higher level of compliance with the diet recommended by medical personnel, compared to those who do not participate in the program. These findings indicate that DSME has an important role in helping DM patients to better manage their diet, thereby improving blood sugar control and reducing the risk of long-term complications associated with diabetes.

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Comparison of Lipid Profiles among Vegan Vegetarians, Lacto-Ovo Vegetarians and Non-Vegetarians

Dessy Ikasartika Sineri[1a], Ida Nurwati[2,3b*], Sumardiyono[4c]

[1] Postgraduate in Nutrition Sciences, Universitas Sebelas Maret, Surakarta, Central Java, Indonesia
[2] Department of Biochemistry, Faculty of Medical, Universitas Sebelas Maret, Surakarta, Central Java, Indonesia
[3] Doctoral Program of Medical Sciences, Faculty of Medicine, Universitas Sebelas Maret, Surakarta, Central Java, Indonesia
[4] Department of Occupational Safety and Health, Vocational School, Universitas Sebelas Maret, Surakarta, Central Java, Indonesia

[a] Email address: ddessysineri@gmail.com
[b] Email address: idanurwati@staff.uns.ac.id
[c] Email address: sumardiyono@staff.uns.ac.id

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Abstract

The lipid profile is a crucial indicator of cardiovascular disease risk, with elevated levels often influenced by dietary patterns. Nutrient intake and physical activity can help regulate cholesterol by reducing total cholesterol, HDL, LDL and triglyceride levels. This study aims to compare the lipid profiles among vegan vegetarians, lacto-ovo vegetarians, and non-vegetarians. This research uses a cross-sectional study design. The study population includes 60 participants from IVS and the Yogyakarta community, selected based on inclusion and exclusion criteria. The research examines diet type as the independent variable, lipid profile as the dependent variable, and physical activity as a confounding variable. Data collection involves respondent identity and a physical activity questionnaire using IPAQ. Statistical analyses include one-way ANOVA, Post Hoc tests and multivariate analysis with one-way MANCOVA. The research results show that the total cholesterol level for vegan (173.10±21.04), lacto-ovo (169.45±44.84), and non-vegetarians (194.55±31.40). HDL levels for vegan are (55.25±10.79), lacto-ovo (49.00±9.12), and non-vegetarians (45.49±9.11). LDL levels for vegan are (111.90±19.80), lacto-ovo (114.85±44.39), and non-vegetarians (134.90±30.37), showing no significant difference $p>0.05$. Triglyceride levels for vegan are (103.15±57.06), lacto-ovo (100.65±60.07), and non-vegetarians (154.15±88.63) with significant differences p-value <0.05. When controlling for physical activity, differences in total cholesterol, HDL, and triglycerides persist between diet groups. Notably, HDL levels differ significantly between vegans and lacto-ovo ($p<0.05$). The conclusion is that both vegan and lacto-ovo diets have lipid profiles within the normal range compared to non-vegetarian diets. A vegetarian diet and regular physical activity contribute to a healthier lipid profile.

Keywords: Lipid Profile, Vegan Vegetarian, Lacto-Ovo Vegetarian, Non-Vegetarian.

Corresponding Author:

Ida Nurwati
Department of Biochemistry, Faculty of Medical, Universitas Sebelas Maret, Surakarta, Central Java, Indonesia
Email: idanurwati@staff.uns.ac.id

1. INTRODUCTION

The lipid profile is a representation of fat levels in the blood. Lipid profile testing can be done by measuring total cholesterol, HDL, LDL, and triglyceride levels. The results of a lipid profile test are one of the indicators for detecting the risk of cardiovascular diseases (Perkeni, 2021). Research by Utama et al., (2021) states that in individuals with coronary heart disease, there is an increase in the lipid profile ratio caused by elevated levels of LDL, triglycerides, and total cholesterol, as well as a decrease in HDL levels in the body. Risk factors for dyslipidemia may be caused by lifestyle changes such as unhealthy eating habits, high job stress, and lack of physical activity (Qi et al., 2015).

Dietary patterns are one of the factors that influence lipid profiles. The habit of consuming fatty foods is also a factor contributing to high total cholesterol levels in the blood. Foods that contain saturated fats can cause cholesterol levels to rise, as there are two sources of cholesterol: endogenous cholesterol, which is produced within the body's cells, particularly in the liver, and exogenous cholesterol, which comes from the foods consumed daily (Syarfaini et al., 2020). A vegan vegetarian diet focuses on consuming plant-based foods and vegetables, while limiting or avoiding products derived from animal. On the other hand, a lacto-ovo vegetarian diet permits the consumption of animal products such as dairy and eggs. Conversely, a non-vegetarian diet encompasses a diverse range of foods from both plant and animal-based sources (Pritasari et al., 2017).

A vegetarian diet is thought to offer health advantages, aiding in the prevention of risk factors for degenerative diseases like hypertension, cancer, diabetes mellitus, and coronary artery disease (Pritasari et al., 2017; Richter et al., 2016). Study conducted by Antoniazzi et al., (2022) states that the vegetarian group has lower LDL and triglyceride levels as well as a normal body mass index compared to the non-vegetarian group. This is related to the intake of unsaturated fats, fiber, antioxidants, and low cholesterol in the vegetarian group, which contributes to reducing cardiovascular risk factors compared to the non-vegetarian group.

Excessive carbohydrate consumption in vegetarians occurs because carbohydrates are used as the primary energy source to replace the fat found in animal products. Excess carbohydrates are converted by the body into fat in the blood, which can affect the lipid profile. According to Sukmawati et al., (2021) lacto-ovo vegetarians have total cholesterol levels above 200 mg/dL due to their continued consumption of animal products, while vegans have total cholesterol levels below 200 mg/dL as they avoid animal products and meet their fat needs through plant-based sources such as corn oil and olive oil, which are used to prepare food.

Aside from providing health benefits, there are still many perceptions that a vegetarian diet is prone to nutrient deficiencies, often accompanied by an unhealthy lifestyle, such as low physical activity, which can lead to obesity. This is related to the fact that nutrient intake, combined with physical activity, can help regulate cholesterol by lowering total cholesterol, LDL, and triglyceride levels in the blood. A lack of physical activity and the consumption of simple carbohydrates can lead to quicker feelings of hunger, which may increase the risk of elevated lipid profiles (Kemala et al., 2021). According to Chang et al., (2020) a vegetarian diet combined with regular physical activity results in increased HDL levels compared to a non-vegetarian diet. This is linked to the unsaturated fatty acids found in plant-based foods, which affect HDL levels. Meanwhile, saturated fats are known to be unhealthy for the body because they can increase LDL levels in the blood. Intake of saturated fats can lead to a decrease in HDL levels.

Research on vegetarian and non-vegetarian groups has been widely conducted; however, there have not been many studies specifically examining lipid profiles compared between vegan vegetarians, lacto-ovo vegetarians, and non-vegetarians, as well as investigating the impact of physical activity on lipid profiles, particularly in Yogyakarta within the Indonesian Vegetarian Society (IVS). Thus, this study aimed to compare the lipid profiles among vegan vegetarians, lacto-ovo vegetarians, and non-vegetarians, as well as the influence of physical activity factors.

2. RESEARCH METHOD

This study employs a cross-sectional research design to identify differences in lipid profiles among vegan vegetarians, lacto-ovo vegetarians and non-vegetarians, while also evaluating lipid profile comparisons by controlling for physical activity variables. The research was conducted within the Indonesian Vegetarian Society in Yogyakarta from January to March 2024. The population for this study consists of members of the IVS (Indonesian Vegetarian Society) in Yogyakarta and residents living in Yogyakarta. The sampling method uses non-probability sampling, specifically consecutive sampling. The estimated calculation for the minimum sample size used in this study follows the unpaired analytical formula (Probandari et al., 2020):

$$n = 2\left(\frac{(Z\alpha + Z\beta)s}{x^1 - x^2}\right)^2$$

Information:
N : Sample size
Zα : Confidence level at 95% significance level (1.96)
Zβ : Power test 20% (0.84)
S : Standard deviation of the difference between group values (56.54)(Nudhar et al., 2020).

Based on the calculations, a minimum sample size of 15.9, which was rounded up to 16 samples. To ensure the study had sufficient data, the total sample size for three groups was set at 48. To account for a 10% loss to follow-up, the sample size was increased to 60. These 60 samples were then evenly distributed among the three groups, resulting in 20 samples per group.

Data collection was carried out by researchers and enumerators who had undergone training and aligned perceptions. Data were collected using questionnaires to obtain information on respondents' identities and the outcomes of lipid profile tests including total cholesterol, HDL, LDL, and triglycerides. The physical activity assessment was conducted using the International Physical Activity Questionnaire (IPAQ), consisting of 7 items related to heavy, moderate, walking, and sitting activities performed in the past 7 days. The IPAQ questionnaire has been translated into Indonesian following the guidelines provided by its developers, ensuring that it retains its original meaning and remains relevant to the local cultural context. Furthermore, the Indonesian version has undergone validity and reliability testing in various previous studies conducted in Indonesia. Additionally, a blood sample of 3 cc was taken through a venous blood vessel in the morning by a laboratory analyst.

Bivariate data analysis was conducted to analyze the differences in total cholesterol, HDL, LDL, and triglyceride levels among vegan vegetarians, lacto-ovo vegetarians, and non-vegetarians. Data with a normal distribution were analyzed using one-way ANOVA, and the results indicated a significant difference, further analysis was performed using Post Hoc tests. The analysis of the differences in age, education, and occupation on total cholesterol, HDL, LDL, and triglyceride levels was conducted using the Kruskal-Wallis test, while the difference in gender was analyzed using the Mann-Whitney test. Additionally, multivariate data analysis using one-way MANCOVA was employed to analyze differences in lipid profiles among vegan vegetarians, lacto-ovo vegetarians, and non-vegetarians while controlling for physical activity. This study was conducted after obtaining ethical approval from the Research Ethics Commission of the Faculty of Medicine, Universitas Sebelas Maret (no. 12/UN27.06.11/KEP/EC/2024).

3. RESULTS AND DISCUSSION

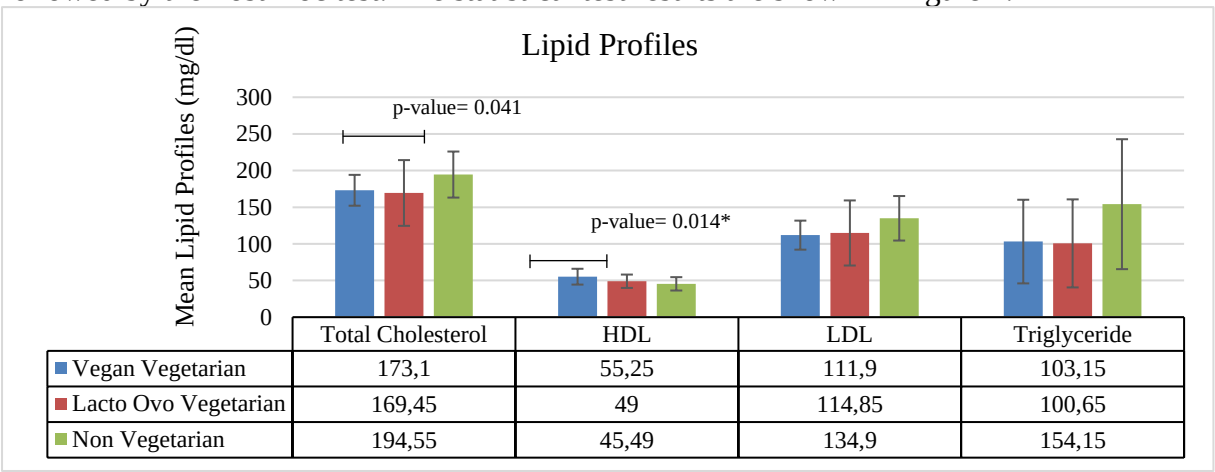
The analysis results present the characteristics of the study subjects, including gender, age, occupation, and education background. The characteristics of the study subjects are displayed in Table 1.

Table 1. Characteristics of Study Subjects (N=60)

Subject	Total Cholesterol	HDL	LDL	Triglyceride
				Mean Rank
Gender				
Male (18)	33.25	22.97	36.56	34.03
Female (42)	29.32	33.73	27.90	28.99
p-value	0.425	0.029*	0.079	0.306
Age (years)				
19-20 (39)	28.37	34.00	27.17	25.81
30-49 (20)	33.63	23.08	36.13	38.48
50-64 (1)	51.00	42.50	48.00	54.00
p-value	0.273	0.059	0.105	0.012*
Occupation				
Housewife (6)	40.42	34.75	38.58	41.17
Government Employe (2)	29.75	16.75	40.75	32.00
Private Employee (24)	31.04	29.90	31.33	29.75
Student (25)	27.20	32.04	26.76	26.62
Others (3)	34.33	23.17	32.00	46.50
p-value	0.558	0.671	0.525	0.195
Education				
Grade school (3)	0.0	0.0	0.0	0.0
Intermediate school (1)	8.00	37.00	8.50	9.00
High school (5)	38.60	33.20	36.30	43.00
University (54)	30.17	30.13	30.37	29.74
p-value	0.252	0.868	0.343	0.124

Based on Table 1, the number of female subjects is higher than that of male subjects, with a p-value of 0.029 for HDL levels, indicating a significant difference in HDL levels between genders. The most common age range is 19-29 years, with a p-value of 0.012 for triglyceride levels, indicating a significant difference in triglyceride levels based on age. The majority of the study subjects are students, while the most common level of education is university.

The statistical test to determine the differences in total cholesterol, HDL, LDL and trygliseride between vegan, lacto-ovo and non-vegetarians is the one-way ANOVA test, followed by the Post Hoc test. The statistical test results are shown in Figure 1.



(*)p-value<0,05 between vegan vegetarian and non-vegetarian

Figure 1. Differences in Mean Lipid Profiles among Vegan, Lacto-Ovo, and Non-Vegetarians

Figure 1 shows a significant difference in total cholesterol and HDL levels, with a p-value of <0.05. In contrast, no significant differences were observed in LDL and triglyceride levels across the three groups. Based on Figure 1, the mean total cholesterol levels for vegan vegetarians, lacto-ovo vegetarians, and non-vegetarians fall within the normal category (<200 mg/dl) according to the classification of plasma lipid levels by Perkeni, (2021). The mean total cholesterol levels for each group are as follows: vegan 173.10 ± 21.04 mg/dl, lacto-ovo 169.45 ± 44.84 mg/dl, and non-vegetarians 194.55 ± 31.40 mg/dl. These results indicate that the non-vegetarian group has a higher total cholesterol level compared to both the vegan vegetarian and lacto-ovo vegetarian groups. The difference in total cholesterol between vegetarian and non-vegetarian groups is due to vegetarian diets, which is typically low in cholesterol, total fat, and saturated fatty acids, thus reducing cholesterol absorption in the blood (Matsumoto et al., 2019; Saintila et al., 2021).

Based on the post hoc test, the difference in total cholesterol levels between the vegan vegetarian group and the non-vegetarian group is statistically significant (p=0.041). The mean total cholesterol level in vegan vegetarians is lower compared to non-vegetarians. The vegan vegetarian diet tends to be high in fiber, which plays an important role in reducing total cholesterol levels in the body (Müller et al., 2018). The lower the total cholesterol value, the stricter the vegan vegetarian diet (Jedut et al., 2023).

The mean HDL levels in all three groups fall within the normal range (40-59 mg/dl), with the mean HDL level for vegan vegetarians (55.25 ± 10.79 mg/dl) being higher than that of lacto-ovo vegetarians (49.00 ± 9.12 mg/dl) and non-vegetarians (45.49 ± 9.11 mg/dl), as shown in Figure 1. This is linked to vegetarian diets being rich in fiber and unsaturated fats, resulting in higher HDL levels. This result is backed by the study conducted by Gogga et al., (2021), which states that high HDL levels are influenced by diets rich in unsaturated fatty acids, such as nuts, fiber, and antioxidants that contribute to increased HDL levels.

Based on the post hoc test, the difference in HDL levels between the vegan vegetarian group and the non-vegetarian group was statistically significant (p=0.014). The mean HDL level in vegan vegetarians was higher compared to non-vegetarians, indicating that the vegan vegetarian diet positively contributes to lipid profiles. Increased HDL levels are associated with a reduced risk of cardiovascular disease, as HDL facilitates the transport of cholesterol from the arteries to the liver, where it is processed and removed from the body (Perkeni, 2021; Pritasari et al., 2017). The findings of this study are consistent with research by Dybvik et al., (2023), which shows that vegan vegetarians consume low-saturated fat foods that can help maintain heart health. This is further supported by Pimentel et al., (2019), who state that high HDL levels in vegetarian groups are linked to regular exercise and a lack of smoking habits.

This study found no significant difference in LDL levels between vegan vegetarians, lacto-ovo vegetarians, and non-vegetarians (p=0.066). The mean LDL levels for vegan vegetarians (111.90 ± 19.80 mg/dl) and lacto-ovo vegetarians (114.85 ± 44.39 mg/dl) fall within the near-optimal category (100-129 mg/dl), as illustrated in Figure 1. In contrast, the mean LDL level for non-vegetarians (134.90 ± 30.37 mg/dl) is slightly elevated (130-159 mg/dl). This finding relates to the vegetarian diet, which tends to be high in fiber and low in saturated fats, contributing to the management of cholesterol levels.

However, the results of this study differ from those of Jedut et al., (2023), which indicated that LDL levels were higher in the vegetarian group compared to the non-vegetarian group. This discrepancy was attributed to the vegetarian diet being high in carbohydrates, which can lead to increased triglyceride levels. High triglyceride levels are often associated with elevated LDL levels (Jo & Park., 2023). Conversely, the findings of this study align with those of Dawczynski et al., (2022), which reported that LDL levels were higher in the non-vegetarian group compared to vegetarians, attributed to a fiber-rich diet. Consuming high-fiber foods can directly bind LDL cholesterol and inhibit its absorption in the intestines, leading to lower

plasma cholesterol levels. Fiber also binds bile acids, facilitating the excretion of LDL through feces, resulting in decreased LDL levels (Kwiatkowska et al., 2023)

The mean triglyceride levels for vegan vegetarians (103.15 ± 57.06 mg/dl) and lacto-ovo vegetarians (100.65 ± 60.07 mg/dl) fall within the normal range (<150 mg/dl), as illustrated in Figure 1. In contrast, the mean triglyceride level for non-vegetarians (154.15 ± 88.63 mg/dl) is slightly elevated (150-199 mg/dl). This indicates that vegan vegetarians and lacto-ovo vegetarians have a positive effect on triglyceride levels compared to non-vegetarians. This study also included a multivariate analysis to evaluate differences in total cholesterol, HDL, LDL, and triglyceride levels after controlling for physical activity among vegan vegetarians, lacto-ovo vegetarians, and non-vegetarians, as shown in Table 2.

Table 2. Results of One-Way MANCOVA Test

Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	p-value
Types of Diets	Wilks' Lambda	0.655	3.116	8	106	0.003*

Based on Table 2, there are significant differences in total cholesterol, HDL, LDL, and triglycerides among the vegan, lacto-ovo, and non-vegetarian groups after controlling for physical activity variables (p=0.003). Further analysis using the Test of Between-Subject Effects was conducted to determine which variables are responsible for the differences between the vegan, lacto-ovo, and non-vegetarian groups, as shown in Table 3.

Table 3. Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum Of Squares	df	Mean Square	Partial Eta Squared	Power	Sig
Types of Diets	Total Cholesterol	7739.894	2	3869.947	0.108	0.618	0.040*
	HDL	908.414	2	454.207	0.146	0.776	0.012*
	LDL	6396.562	2	3198.281	0.094	0.543	0.064
	Triglyceride	40447.498	2	20223.749	0.144	0.768	0.013*

Based on Table 3, there are significant differences in total cholesterol levels (p=0.040), HDL levels (p=0.012), and triglyceride levels (p=0.013) among the vegan, lacto-ovo, and non-vegetarian groups. Subsequently, Post Hoc Pairwise Comparisons were conducted on the total cholesterol, HDL, and triglyceride variables to identify which groups differ significantly, as shown in Table 4.

Table 4. Post Hoc Pairwise Comparisons Test

Group 1 (n)	Group 2 (n)	Mean1-Mean2	SE	p-value
Total Cholesterol				
Vegan (20)	Lacto Ovo (20)	4.412	10.678	0.681
Vegan (20)	N Vegetarian (20)	-21.622	10.661	0.047*
Lacto Ovo (20)	N Vegetarian (20)	-26.034	10.687	0.018*
HDL				
Vegan (20)	Lacto Ovo (20)	6.407	3.080	0.042*
Vegan (20)	N Vegetarian (20)	9.314	3.075	0.004*
Lacto Ovo (20)	N Vegetarian (20)	2.907	3.083	0.350
Triglyceride				
Vegan (20)	Lacto Ovo (20)	6.149	20.736	0.768

Group 1 (n)	Group 2 (n)	Mean1-Mean2	SE	p-value
Vegan (20)	N Vegetarian (20)	-51.825	20.704	0.015*
Lacto Ovo (20)	N Vegetarian (20)	-57.975	20.754	0.007*

Based on Table 4, the Post Hoc Pairwise Comparisons between the vegan vegetarian and lacto-ovo vegetarian groups indicate a significant difference in HDL levels (p=0.042). Additionally, comparisons between the vegan vegetarian and non-vegetarian groups show significant differences in total cholesterol levels (p=0.047), HDL levels (p=0.004), and triglyceride levels (p=0.015). Furthermore, there are significant differences between the lacto-ovo vegetarian and non-vegetarian groups regarding total cholesterol levels (p=0.018) and triglyceride levels (p=0.007).

Physical activity is one of the factors that influences lipid profiles. Nutrient intake in a vegetarian diet combined with physical activity can aid in regulating cholesterol by reducing total cholesterol, LDL, and triglyceride levels in the blood (Kemala et al., 2021). According to Table 3, there is no significant difference in LDL levels (p=0.064) among the vegan vegetarian, lacto-ovo vegetarian, and non-vegetarian groups. This indicates that in this study, diet type does not affect LDL levels after controlling for physical activity variables. Insufficient physical activity and excessive energy intake can lead to nutritional problems. The more active a person is in physical activities, the more energy is expended (Khoerunisa & Istianah, 2021). Moreover, the combination of consistent physical activity and a balanced diet is associated with a reduced risk of developing metabolic syndrome (Lee et al., 2022).

There are significant differences in total cholesterol levels (p=0.040), HDL levels (p=0.012), and triglyceride levels (p=0.013) among the vegan vegetarian, lacto-ovo vegetarian, and non-vegetarian groups, as shown in Table 3. This indicates that diet type affects total cholesterol, HDL, and triglyceride levels. Vegetarian diets typically emphasize complex carbohydrates, especially from plant-based sources like legumes, whole grains, vegetables, and fruits. In contrast, non-vegetarian diets tend to include simple carbohydrate sources from processed foods (Segovia-Siapco et al., 2019). Additionally, regular physical activity has a positive impact on lipid metabolism (total cholesterol, HDL, and triglycerides) (Storz et al., 2023). This is further supported by research from Lombardo et al., (2024), which indicates that a vegetarian diet combined with endurance exercises such as jogging, cycling, and swimming can influence the reduction of body fat percentage.

Based on Table 4, there is a significant difference in the average HDL levels (p=0.042) between the vegan vegetarian and lacto-ovo vegetarian groups after controlling for physical activity through post hoc pairwise comparisons. The average HDL level in vegan vegetarians is significantly higher than that in lacto-ovo vegetarians. The impact of physical activity on the vegan vegetarian group is more favorable in terms of increasing HDL levels compared to the non-vegetarian group. In this study, the vegetarian diet, particularly that of vegan vegetarians, regularly includes vegetables in the form of legumes and analog meats made from mung beans. Analog meats contain protein, fiber, and several vitamins and minerals essential for health (Mentari et al., 2016). In contrast, the lacto-ovo vegetarian group generally includes animal protein in their diet, mainly from milk and eggs, consuming these foods about 4 to 5 times a week.

There is a significant difference in the average levels of total cholesterol (p=0.047), HDL (p=0.004), and triglycerides (p=0.015) between the vegan vegetarian and non-vegetarian groups after controlling for physical activity through post hoc pairwise comparisons. The average total cholesterol and triglyceride levels in vegan vegetarians are significantly lower than those in non-vegetarians, while the HDL level in vegan vegetarians is higher compared to non-vegetarians. Research by Zaki et al., (2023) Indicates that moderate to high-intensity physical activity can boost HDL levels and reduce triglyceride levels. This is supported by findings from Bondge et al., (2021), which indicate that total cholesterol levels tend to be lower in individuals

who engage in regular physical activity. Physical activity plays a crucial role in lipid metabolism, and insufficient activity can result in elevated LDL levels and reduced HDL levels, increasing the risk of cardiovascular diseases (Widiastuti et al., 2023). Additionally, dietary factors also contribute to cholesterol regulation. Foods rich in fiber, such as fruits, vegetables, and whole grains can lower cholesterol levels by attaching to cholesterol in the digestive system, thereby reducing its absorption into the bloodstream (Fontes et al., 2024). The combination of between physical activity and dietary habits can have a beneficial effect on total cholesterol and triglyceride levels (Bondge et al., 2021).

There are significant differences in the average levels of total cholesterol (p=0.018) and triglycerides (p=0.007) between the lacto-ovo vegetarian and non-vegetarian groups after controlling for physical activity through post hoc pairwise comparisons. The average levels of total cholesterol and triglycerides in lacto-ovo vegetarians are significantly lower than those in non-vegetarians. This is related to the lacto-ovo vegetarian diet, which tends to include foods high in fiber and lower in simple carbohydrates (Wang et al., 2023). This is further supported by Ramadhani et al., (2022), which states that the quality of carbohydrates from fruits, vegetables, and whole grains provides more energy and is rich in fiber, vitamins, and minerals. Conversely, carbohydrate intake from processed sources, such as added sugars and fast food, can cause energy fluctuations and affect physical performance. Moreover, research by Kemala et al., (2021) indicates that triglyceride levels are affected by insufficient physical activity and the consumption of foods high in simple carbohydrates from fruits and vegetables. However, high levels of physical activity combined with a balanced diet that includes low saturated fat and high fiber foods can positively affect lipid profiles in the blood, including triglyceride levels (Chang et al., 2020).

4. CONCLUSION

This study found that both vegan vegetarians and lacto-ovo vegetarians have lipid profiles within the normal range, compared to non-vegetarians. In general, a vegetarian diet combined with regular physical activity leads to a healthier lipid profile. The results of this study are expected to serve as input for both vegetarian and non-vegetarian groups to always pay attention to the type and amount of nutrients that positively affect the body. Furthermore, additional research can be conducted on the influence of other factors on the lipid profiles between vegetarians and non-vegetarians.

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Energy Intake, Protein Intake, and Toddler Hygiene with the Incidence of Stunting in 24-59 Months Toddlers in Mentawai Islands

Fatia Ilmiati[1a], Ahmad Syauqy[2b*], Etika Ratna Noer[2c], Ani Margawati[2d], Apoina Kartini[3e]

[1] Postgraduate of Nutrition Science Program, Faculty of Medicine, Diponegoro University, Central Java, Indonesia
[2] Department of Nutrition Science, Faculty of Medicine, Diponegoro University, Central Java, Indonesia
[3] Department of Nutrition Science, Faculty of Public Health, Diponegoro University, Central Java, Indonesia

[a] Email address: fatiailmiati18@gmail.com
[b] Email address: syauqy@fk.undip.ac.id
[c] Email address: etikaratna@fk.undip.ac.id
[d] Email address: amargawati@lecturer.undip.ac.id
[e] Email address: apoinakartini@lecturer.undip.ac.id

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Abstract
Toddlerhood is an important period in human growth and development; during that period, if the nutrition is not adequate, they risk stunting. Some factors that cause this are energy intake, protein intake, parenting, and food security. In 2022, the prevalence of stunting is around 148 million (22.3%), most coming from Asia and Africa; according to WHO, in Indonesia, the prevalence of stunting is 21.6%. The incidence of stunting in Mentawai Islands Regency is 32%, the second highest rate below the national rate. According to the author's knowledge, this research is the first study to analyze the relationship between independent and dependent variables as well as the determinants of stunting in toddlers in the Sarereiket Health Centre using questionnaire data, direct observation, and interviews that have gone through a validation and reliability process from experts through the laboratory. The research aims to analyze the relationship between energy intake, protein intake, and hygiene of toddlers and the incidence of stunting in toddlers aged 24-59 months in South Siberut District, Mentawai Islands Regency. The method used the observational method. The subjects of analysis were 393 toddlers aged 24-59 months in the Sarereiket Health Centre who were involved in this study. Multivariate regression was performed to identify the relationship between dependent and independent variables. The results indicate that toddlers' energy intake, protein intake, and hygiene are associated with stunting. The results of the multivariate analysis in this study indicate that protein intake and toddler hygiene influence stunting and contribute to increasing the incidence of stunting in toddlers. The conclusion is there is a significant relationship between energy intake, protein intake, and hygiene of toddlers and the incidence of stunting in the Sarereiket Community Health Centre, Mentawai Islands.

Keywords: Energy Intake, Protein Intake, Toddler Hygiene.

Corresponding Author:

Ahmad Syauqy
Department of Nutrition Science, Faculty of Medicine, Diponegoro University, Central Java, Indonesia
Email: syauqy@fk.undip.ac.id

1. INTRODUCTION

Stunting is a condition of chronic or prolonged malnutrition that leads to impaired growth characterized by inappropriate or substandard height for age. Toddlers with diverse food consumption have better nutritional status (Hadi et al., 2022). However, the level of food consumption among toddlers in Indonesia is still not diverse. This affects the quality of nutrients consumed by toddlers and can result in a lack of nutrient intake. Lack of nutrient intake will inhibit growth and lead to undernutrition, which will increase the chance of stunting (Raiten & Bremer, 2020a).

Globally, the prevalence of stunted children under five in 2022 will be around 148 million (22.3%) (UNICEF/WHO/World Bank Group, 2022). Most of the stunting problems come from Asia and Africa. The prevalence of stunting in Asia has decreased from 81.7 million (54.8%) in 2020 to 76.6 million (22.3%) in 2022 (UNICEF/WHO/World Bank Group, 2022). While the prevalence of stunting in Indonesia, according to WHO (2022), is (21.6%) (UNICEF/WHO/World Bank Group, 2022). The incidence of stunting in Mentawai Islands Regency is 32%, which is the second highest rate below the national rate (Fitriani & Oktobriariani, 2017).

Therefore, adequate energy intake and protein intake patterns are needed to prevent the increase of stunting in Indonesia. Adequate energy intake is needed to support body activities and child growth, while protein plays an important role in body tissue formation, cell growth, and brain development (Fikawati et al., 2021). Lack of energy and protein intake can cause delays in children's physical growth and cognitive development, impacting their future quality of life (Fikawati et al., 2020). In Mentawai, socioeconomic conditions that do not support access to nutritious food, as well as limited nutrition knowledge, exacerbate the problem of stunting (Raiten & Bremer, 2020). Therefore, proper nutrition intervention, including the provision of nutritious food with adequate energy and protein sources such as fish, meat, and beans, is needed to break the stunting cycle (Simamora et al., 2019).

The Mentawai people have a traditional speciality food known as sago. Carbohydrate sources that the Mentawai people often consume include taro, sago, sweet potato, and banana. Protein sources such as sago worms, eggs, fish, tempeh and tofu are available because the location of the market is far away and the purchasing power is quite expensive, so only people who have a middle to upper economy can afford it. A diverse and age-appropriate intake is needed to fulfill various nutrients. At the age of 0-6 months, babies only need intake from breast milk; after 6 months, they are given complementary foods (MP-ASI) (Aritonang, et. al., 2021; Anggraeni, et al, 2022; Tyas, Sa'danoer, & Silvia, 2024). Inadequate intake risks malnutrition, making them susceptible to diseases, especially infectious diseases.

In addition, under-five hygiene also plays an important role in preventing stunting in Mentawai communities. Unhygienic environments, such as limited access to clean water and poor sanitation, increase the risk of infectious diseases such as diarrhea and parasitic infections, which can undermine the nutritional status of under-fives (Aisyah & Yunianto, 2021). Toddlers who are often sick will have difficulty absorbing nutrients properly, thus hindering their growth. Then, maintaining hygiene, such as washing hands with soap, maintaining environmental sanitation, and ensuring access to clean water, can prevent infections that interfere with the growth process (Endrinikapoulos et al., 2023). In Mentawai, geographical challenges increase the problem of access to hygiene, so education to the community and improvement of sanitation infrastructure are key (Sari et al., 2020).

South Siberut sub-district is located at an altitude of 2,000 meters above sea level. The area of the South Siberut sub-district is 328 km^2. The majority of livelihoods are as farmers. South Siberut sub-district still needs a place to accommodate garbage and waste management, so people often throw garbage into the river or the garden. The population lives in hilly areas where there are still houses that do not have bathrooms, so they dispose of feces carelessly or go into the river. In addition, it is also known that children under five years old have a habit of

not wearing footwear and not washing their hands after playing. This can increase the risk of infection transmission. Based on the description above, the researcher aims to analyze toddler hygiene, energy intake, and protein intake about the incidence of stunting.

2. RESEARCH METHOD

This cross-sectional study was conducted at the Sarereiket Community Health Centre in South Siberut and focused on children aged 24-59 months within the health center's area, with a total population of 393 toddlers. A sample of 130 toddlers was selected using purposive sampling. Data was collected through questionnaire interviews covering parent and toddler demographics, dietary diversity, hygiene, environmental sanitation, food intake, exclusive breastfeeding history, complementary feeding, family size, health service utilization, and low birth weight (LBW) data. Soil-transmitted helminth (STH) infections were identified by collecting fecal samples and analyzing them at the Faculty of Medicine Laboratory, Andalas University, using the Kato Katz method. Anthropometric measurements of weight and height were also taken to confirm the toddlers' nutritional status. The data was univariately analyzed using frequency distribution and bivariate analysis with the Fisher Exact test at a 95% significance level to understand the relationship between independent and dependent variables. Additionally, multivariate analysis, specifically multiple logistic regression, was employed to examine the relationship between several independent variables and stunting, determining which independent variable had the greatest influence on the dependent variable. This study was approved by the Ethical Committee with Approval No. 037/EC/KEPK/FK-UNDIP/II/2024.

3. RESULTS AND DISCUSSION

Table 1. Subject Characteristics (N=130)

Variables	**N**	**%**
Nutritional status		
Stunting	76	58,5
Normal	54	41,5
Gender		
Women	64	49,2
Male	66	50,8
Age		
24-36	52	40
37-59	78	60
Birth Weight (g)		
No LBW	110	84,6
LBW	20	15,4
Energy Intake (kcal)		
Less	75	57,7
Simply	55	42,3
Protein Intake (g)		
Less	77	59,2
Simply	53	40,8
Food Diversity (IDDS)		
Not Diverse	108	83,1
Various	22	16,9
Exclusive breastfeeding		
No	100	76,9
Yes	30	23,1

Variables	N	%
Complementary Foods		
Not good	113	86,9
Good	17	13,1
STH infection		
Positive	57	48,3
Negative	73	56,2
Toddler Hygiene		
Not good	73	56,2
Good	57	43,6
Maternal Hygiene		
Not good	20	15,4
Good	110	84,6
Mother's education		
Low	89	86,5
High	41	31,5
Father's education		
Low	80	61,5
High	50	38,5
Number of Family Members		
A little	13	10,0
Many	117	90,0
Food Diversity (HDDS)		
Not Diverse	105	80,8
Various	25	19,2
Environmental Sanitation		
Not good	11	8,5
Good	119	91,5
Health Services		
Home	49	37,7
Fakes	81	62,3
Parents' Income		
Low	120	92,3
High	10	7,7

Table 1 shows that 130 children aged 24-59 months were involved in this study. Most children were identified as having stunted (58,5%). A slight difference according to gender, where slightly higher males than females with 60% aged 37-59 months. Children who were LBW or born normal (15.4%) and not LBW (84.6%). Children with low energy (57.7%) and low protein (59.2%) had a high probability of stunting. IDDS (83.1%) and HDDS (80.8%) food conditions that were not diverse had a higher percentage. In addition, children who did not receive exclusive breastfeeding (86.9%) and did not receive complementary feeding (13.1%) had a high probability of stunting. Then toddlers with a level of hygiene are not good (56.2%) and good (43.6%). There are toddlers infected with STH (48.3%) who have a high percentage of stunting in toddlers. Regarding households, about (91.5%) had good environmental sanitation. Low mother's education (86.5%) and low father's education (61.5%) have a higher probability of stunting. A high percentage of stunting was also found in large families (90.0%) and low parental income (92.3%). Table 1 summarizes the results of the frequency of subjects' characteristics.

Table 2. Logistic Analysis of Stunted Children 24-59 Months of Age

Characteristics	Bivariate		Multivariate	
	OR (95% CI)	p-value	OR (CI95%)	p-value
Gender				
Women	1	-	-	-
Male	1,26 (0,62-2.53	0,515	-	-
Age				
37-59	1	-	-	-
24-36	1,85 (0,89-3,85)	0,416	-	-
IDDS				
Various	1	-	1	-
Not Diverse	1,88 (0,74-4,75)	0,179	0,37 (0,01-8,16)	0,535
HDDS				
Various	1	-	-	-
Not Diverse	1,38 (0,57-3,32)	0,467	-	-
Environmental Sanitation				
Good	1	-	1	-
Not good	3,49 (0,73-16,86)	0,119	8,97 (0,10-776,52)	0,335
Toddler Hygiene				
Good	1	-	1	-
Not good	17,31 (7,17-41,74	0,000	14,98(2,17-103,04)	0,006
Maternal Hygiene				
Good	1	-	1	-
Not good	2,41(0,81-7,09)	0,110	0,27 (0,10-7,79)	0,447
STH				
Negative	1	-	1	-
Positive	0,46 (0,22-0,978)	0,043	1,36 (0,78-23,95)	0,830
Energy Intake				
Simply	1	-	1	-
Less	78,85 (24,94-249,28)	0,000	105(10,01-1113,59)	0,000
Protein Intake				
Simply	1	-	1	-
Less	113,60 (32,80-393,36)	0,000	94 (9,79-920,56)	0,000
Exclusive breastfeeding history				
Exclusive breastfeeding	1	-	-	-
Not exclusively breastfed	0,92 (0,40-2,11)	0,845	-	-
Complementary Foods				
Good	1	-	-	-
Not good	1,70 (0,61-4,734)	0,310	-	-
Birth Weight				
LBW	1	-	1	-
Not LBW	0,41 (0,14-1,22)	0,110	1,64 (0,07-36,56	0,754
Number of Family Members				
Many	1	-	-	-
A little	0,81 (0,25-2,56)	0,722	-	-
Parents' Income				
High	1	-	1	-

Characteristics	Bivariate		Multivariate	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Low	2,25 (0,60-8,39)	0,227	0,239 (0,01-5,20)	0,363
Health Services				
Fakes	1	-	-	-
Shamans	0,70 (0,34-1,43)	0,332	-	-
Father's education				
High	1	-	-	-
Low	1,33 (0,63-2,81)	0,451	-	-
Mother's education				
High	1	-	1	-
Low	1,53 (0,75-3,14)	0,238	0,37 (0,01-8,16)	0,700

Table 2 presents bivariate and multivariate analyses of stunting in children aged 24-59 months. Bivariate analysis showed that children with poor hygiene (p=0,000), infected by STH (p= 0,043), lack of energy (p=0,000), and protein intake (p=0,000) are more likely to be stunted children. The results of multivariate analysis strengthen that poor toddler hygiene variable (OR = 14.98; 95% CI = 2.17-103.04), lack of energy intake (OR =105; 95% CI =10.01-1113.59), and lack of protein intake (OR =94; 95% CI =9.79-920.56) influence the incidence of stunting.

DISCUSSION

Relationship between Energy Intake and Incidence of Stunting. The results of the bivariate analysis in Table 2 show that the energy intake variable has a p-value of 0.000, which has a value smaller than 0.05. This can be interpreted that there is an association between energy intake and the incidence of stunting, with an OR value (OR = 78.85; 95% CI = 24.94-249.28). The results of this study are in line with research conducted by (Aisyah & Yunianto, 2021), which states that the lack of ideal energy intake can increase the incidence of stunting in toddlers. Stunting in toddlers is a chronic condition caused by a lack of nutritional intake in the long term, especially in the first 1,000 days of life. One of the main factors affecting the incidence of stunting is insufficient energy intake (Morales et al., 2024). Energy obtained from daily food is very important for the growth and development of toddlers. When energy intake is inadequate, a child's body does not have enough fuel to support vital functions and optimal growth processes (Djuardi et al., 2021). This leads to impaired physical development, including age-inappropriate length or height. In addition, energy deficiency also affects the immune system, increasing the risk of infections that can worsen nutritional conditions and accelerate stunting (Sari et al., 2020).

The relationship between energy intake and the incidence of stunting is also influenced by other factors such as diet quality, meal frequency, and family socioeconomic conditions. Toddlers from families with low economic status tend to have limited access to nutritious food, resulting in low intake of energy and other nutrients (Pitoyo et al., 2022). In addition, inappropriate feeding practices, such as inadequate complementary feeding, can lead to deficiencies in energy and other essential nutrients. Overall, stunting is the result of complex interactions between inadequate energy intake, poor diet quality, and environmental and social factors that affect the ability of families to provide adequate and quality food for their children (Pitoyo et al., 2022).

Relationship between protein intake and the incidence of stunting. The results of the bivariate analysis in Table 2 show that the protein intake variable has a p-value of 0.000, which has a value smaller than 0.05. This can be interpreted that there is an association between protein intake and the incidence of stunting, with an OR value (OR =113.60; 95% CI =32.80-393.36). The results of this study are in line with research conducted by (Fikawati et al., 2021), who stated that the lack of protein intake needed in toddlers can increase the incidence of

stunting in toddlers. Protein is one of the important components in child growth and development, especially during toddlerhood. Adequate protein intake is needed to build and repair body tissues, including muscles and bones (Fikawati et al., 2021). Protein also plays an important role in the synthesis of enzymes and hormones that regulate metabolic processes and growth. When protein intake is inadequate, a child's linear growth can be disrupted, leading to a decrease in growth rate and, ultimately, a risk of stunting (Endrinikapoulos et al., 2023). In addition, high-quality protein containing essential amino acids is required to support brain development and cognitive function, which can also be affected when children experience long-term protein deficiency.

The relationship between protein intake and stunting is influenced by the quality and quantity of protein consumed. Children who consume protein from animal sources, such as meat, fish, eggs, and milk, tend to have better growth compared to those who rely on plant-based proteins with lower biological value. However, adequate protein intake must be balanced with calorie and other nutrient intake, as energy-protein malnutrition often occurs together (Komang et al., 2023). In addition, other factors such as recurrent infections, poor sanitation, and socioeconomic conditions can also exacerbate the impact of protein deficiency on stunting. Therefore, a holistic approach is needed to ensure adequate protein intake as part of efforts to prevent stunting in children under the age of five.

Relationship Between Toddler Hygiene and the Incidence of Stunting. The results of the bivariate analysis in Table 2 show that the toddler hygiene variable has a p-value of 0.000, which has a value smaller than 0.05. This can be interpreted that there is a relationship between toddler hygiene and the incidence of stunting, with an OR value (OR =17.31; 95% CI =7.17-41.74). The results of this study are in line with research conducted by (Adani & Nindya, 2017), which found that a low level of hygiene habit formation in toddlers can result in an increased likelihood of stunting in toddlers. Toddler hygiene has an important role in preventing stunting, which is a condition of growth failure in children due to a lack of nutritional intake and repeated infections (Silva et al., 2023). When hygiene standards are not met, children under five are more susceptible to infectious diseases, especially gastrointestinal infections such as diarrhea. Recurrent diarrhea causes malabsorption of nutrients, so the child's body cannot utilize the food consumed optimally (Raiten & Bremer, 2020). This results in insufficient intake of nutrients necessary for growth, which contributes to stunting (Ahmed et al., 2022; Raiten & Bremer, 2020). In addition, unsanitary environments increase the risk of exposure to pathogens, which can trigger chronic inflammation and inhibit the growth process (Manalu et al., 2023).

Other contributing hygiene factors are unhygienic feeding practices and lack of access to clean water and sanitation (Das et al., 2021). For example, using contaminated water to prepare food or formula can be a source of infection. In addition, a lack of personal hygiene, such as not washing hands with soap before touching food or breastfeeding, can also increase the risk of disease transmission. As a result, toddlers living in poor sanitation conditions have a higher risk of developing recurrent infections, which negatively impacts their nutritional status and increases the likelihood of stunting (Manalu et al., 2023). Therefore, improving the environmental hygiene of under-fives through public health interventions and health education is an important step in stunting prevention efforts (Nuzhat et al., 2020).

Effect of Energy Intake on the Incidence of Stunting. The results of multivariate analysis in Table 2 show that the energy intake variable has a p-value of 0.000, which has a value smaller than 0.05 with an OR value (OR =105; 95% CI =10.01-1113.59). This means that energy intake can influence the incidence of stunting. The results of this study are in line with research conducted by (Fikawati et al., 2021), who stated that inadequate energy intake is one of the main causes of stunting in toddlers. Energy obtained from food is the main source for the body to carry out various metabolic functions that support the growth and development of children (Fikawati et al., 2021). When energy intake is insufficient, the body will prioritise the use of energy to maintain vital functions such as brain and heart activity, while growth functions will

be neglected. As a result, children who experience chronic energy deficits cannot reach their optimal growth potential, resulting in stunting. In addition, lack of energy intake is also often associated with deficiencies in other nutrients, such as protein and micronutrients, that are important for bone and tissue development (Kwami et al., 2019).

Inadequate energy intake can also worsen the risk of infection, which in turn worsens the nutritional status of children under five. Children who lack energy have weaker immune systems, making them more susceptible to infections, especially gastrointestinal infections such as diarrhoea. These infections interfere with the absorption of essential nutrients needed for growth (Kwami et al., 2019). In addition, children who experience frequent illnesses tend to have decreased appetite, which further decreases energy intake and creates a continuous cycle that increases the risk of stunting. Therefore, ensuring adequate energy intake is crucial in preventing stunting in children under five.

Effect of Protein Intake on the Incidence of Stunting. The results of multivariate analysis in Table 2 show that the protein intake variable has a p-value of 0.000, which has a value smaller than 0.05 with an OR value (OR =94; 95% CI =9.79 -920.56). The results of this study are in line with research conducted by (Endrinikapoulos et al., 2023), which states that lack of protein intake in toddlers is one of the factors that can increase the likelihood of stunting in toddlers. Lack of protein intake is one of the main factors that can increase the likelihood of stunting in toddlers. Protein is an essential nutrient that plays an important role in various biological processes, including body tissue growth, brain development, and immune system function (Endrinikapoulos et al., 2023). Protein deficiency results in the disruption of enzyme synthesis, hormones, and body structure, which directly impacts a child's linear growth. When protein intake is insufficient, the body is unable to build and repair tissues optimally, resulting in stunted height growth (Xiong et al., 2023). Protein deficiency can also weaken the immune system, making children more susceptible to infections. Recurrent infections, especially in the digestive tract, can result in malabsorption of nutrients, which further worsens the stunting condition (Nuzhat et al., 2020).

In addition, the quality of the protein consumed also plays an important role. Animal proteins usually contain all the essential amino acids the body needs, while plant proteins often lack one or more essential amino acids (Fikawati et al., 2020). Toddlers who eat a diet low in high-quality protein, especially from animal sources, are at higher risk of protein deficiency. Furthermore, protein deficiency often occurs alongside energy and other micronutrient deficiencies, synergistically increasing the risk of stunting. Ensuring adequate intake of high-quality protein is therefore key in stunting prevention, especially in under-five populations in developing countries where access to animal protein may be limited (Xiong et al., 2023).

The Effect of Toddler Hygiene on the Incidence of Stunting. The results of multivariate analysis in Table 2 show that the toddler hygiene variable has a p-value of 0.006, which has a value smaller than 0.05 with an OR value (OR = 14.98; 95% CI = 2.17-103.04). This means that toddler hygiene can influence the incidence of stunting. The results of this study are in line with research conducted by (Krisnana et al., 2020), who stated that toddler hygiene, such as poor toddler care, is one of the factors that can increase the likelihood of stunting in toddlers. Low hygiene in toddlers is one of the main factors that increase the likelihood of stunting. When hygiene standards are not maintained, toddlers become more vulnerable to various infections, especially gastrointestinal infections such as diarrhea (Nuzhat et al., 2020). Recurrent diarrhea causes nutrient malabsorption, where the nutrients consumed cannot be absorbed properly by the body. As a result, the child's body lacks the nutrients necessary for optimal growth and development, which directly contributes to stunting. In addition, dirty environments and poor sanitation increase a child's exposure to pathogens, which can trigger chronic inflammation in the gut and inhibit nutrient absorption, thus worsening a child's nutritional status (Fikawati et al., 2021).

In addition, poor hygiene is often associated with a lack of access to clean water and proper sanitation (Emerson et al., 2020; Mock et al., 2017). This increases the risk of contamination of food and water consumed by under-fives, which can lead to intestinal infections and other illnesses. Unhygienic feeding practices, such as not washing hands before preparing food or breastfeeding, can also increase the risk of disease transmission (Silva et al., 2023). In addition, the risk of transmitting infectious diseases may increase when toddlers do not wear sandals. Toddlers who do not wear footwear are more susceptible to cuts or injuries to the feet, which can be an entry point for various pathogens, including bacteria and parasites (Wang et al., 2023). All these factors cumulatively lead to an increased risk of stunting, as a toddler's body that is constantly fighting infection cannot focus on the growth process. Therefore, improving hygiene through education and the provision of adequate sanitation facilities is crucial in the effort to prevent stunting in children under five (Das et al., 2021).

From the results of this study, several factors contribute to insurgency in Indonesia, so various strategies are needed to solve the problem. The government should prioritize equitable health and nutrition policies to achieve the country's medium-term development goals. This study stands out for being the first to assess the prevalence and causes of non-adherence in Indonesian children. The study used a representative sample and data collected by trained interviewers. However, the cross-sectional research design limits its ability to establish causality. Factors such as location and age group may influence the results and should be considered. It is also important to recognize potential biases, such as recollection or negative news, that may affect the study findings.

4. CONCLUSION

Judging from the results of the research and discussion of this study, it can be concluded that several variables can increase the likelihood of stunting, namely low IDDS and HDDS scores, poor environmental sanitation, low toddler and maternal hygiene, STH infection, minimal energy and protein intake, absence of exclusive breastfeeding and lack of complementary foods, inappropriate LBW methods and minimal health facilities, as well as low parental income and low parental education. When viewed from bivariate analysis, the results of this study can be concluded that energy intake, protein intake and toddler hygiene have a relationship with the incidence of stunting in toddlers. The results of multivariate analysis in this study indicate that energy intake, protein intake and toddler hygiene have an influence on the incidence of stunting in toddlers and are contributing factors to the increase in the incidence of stunting in toddlers in the Mentawai Islands.

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RESEARCH Open Access

The Role of Ergonomic Interventions in Enhancing Employee Well-being: A Case Study from the Hospitality Industry

Ni Ketut Dewi Irwanti[1a*], I Putu Gede Adiatmika[2b], I Made Muliarta[2c], Dahlan Abdullah[3d]

[1] Faculty of Health, Triatma Mulya University, Badung, Bali, Indonesia
[2] Faculty of Medicine, Udayana University, Denpasar, Bali, Indonesia
[3] Faculty of Hotel and Tourism Management, Universiti Teknologi MARA Cawangan Pulau Pinang, Malaysia

[a] Email address : dewi.irwanti@triatmamulya.ac.id
[b] Email address : ipgadiatmika@unud.ac.id
[c] Email address : muliarta26@gmail.com
[d] Email address : dahla707@uitm.edu.my

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Abstract

The impact of ergonomic interventions and multitasking on employee well-being, particularly in high-demand hospitality settings, explores how these factors interact with perceived organizational support, an essential mediator that could influence employee satisfaction, health, and productivity. This study aims to discover the relationships among ergonomic interventions, multitasking, perceived organizational support, and employee well-being, focusing on employees of the Puri Saron Hotel Group in Bali. The study employs a quantitative methodology, utilizing SEM SmartPLS 3 software. Data was collected over questionnaires spread to a sample of 100 employees, following Slovin's formula. The findings contribute to the growing field of workplace ergonomics by demonstrating that both physical ergonomic interventions positively, with the with the highest significant impact, and followed by multitasking for employee well-being, enhance the conceptual understanding of how organizational culture can amplify the benefits of ergonomic interventions. It is focused on a single hospitality group, this may impair the ability to be generalized of the results. that enhancing ergonomic conditions and multitasking abilities, coupled with strong organizational support, can significantly improve employee well-being, particularly in industries with high physical and cognitive demands. this offering valuable insights into the role of perceived organizational support in mediating these relationships.

Keywords: Ergonomic Interventions, Employee Well-Being, Multitasking, Hospitality Industry.

Corresponding Author:

Ni Ketut Dewi Irwanti
Faculty of Health, Triatma Mulya University, Badung, Bali, Indonesia
Email: dewi.irwanti@triatmamulya.ac.id

1. INTRODUCTION

Maintaining good health is crucial for overall well-being and quality of life. It encompasses physical, mental, and social dimensions, extending beyond the mere absence of disease (WHO, 1948). Prioritizing Maintaining a healthy way of life through a healthy diet, consistent exercise, enough sleep, and stress reduction can suggestively reduce the risk of chronic diseases and promote longevity (CDC, 2024). Furthermore, fostering positive mental health through mindfulness, social connections, and seeking support when needed enhances emotional resilience and overall life satisfaction (Keng et al., 2011). Recognizing the interconnectedness of these aspects empowers individuals to make informed choices and take proactive steps towards leading a healthier and more fulfilling life (Ryan & Deci, 2000). Furthermore, ergonomics is particularly relevant in modern workplaces where physical and mental demands are high, such as in healthcare, hospitality, and manufacturing industries (Castaño Cardenas, 2023; Marková & Škurková, 2023). In these high-stress environments, poor ergonomic conditions are often linked to musculoskeletal disorders (MSDs), fatigue, and cognitive overload, which negatively impact employee performance and well-being (Soares et al., 2019; Zhang et al., 2024).

The Occupational Safety and Health Administration (OSHA) states that musculoskeletal problems related to the workplace are responsible for approximately 33% of all work-related injuries (Reddy et al., 2016). Moreover, the rapid increase in sedentary office work and repetitive tasks has exacerbated these issues in sectors that traditionally might not have experienced high levels of physical strain (Chinedu et al., 2020). Additionally, in industries with high multitasking demands, such as hospitality and healthcare, ergonomics can play a critical role in enhancing cognitive well-being by minimizing distractions and optimizing workflows (Koirala & Maharjan, 2022). In the context of modern workplace challenges, where the rise of remote work, longer working hours, and higher multitasking demands are dominant (Countouris et al., 2023). Ergonomic interventions are not just optional but essential (Santos & Skiavan, 2023). Poor ergonomic conditions can lead to long-term health issues like chronic pain, burnout, and decreased job satisfaction (Santos & Reis, 2021).

Consequently, organizations that prioritize ergonomics tend to experience better employee retention rates, lower healthcare costs, and higher overall organizational performance (Huang et al., 2016). Given the increasing awareness of workplace health, exploring the link between ergonomic interventions and employee well-being is crucial for creating safer and more productive workplaces, especially in industries with high job demands and multitasking pressures (Shiri et al., 2023). Most ergonomic intervention studies are short-term and focus on specific industries like office environments or manufacturing. Most existing studies tend to focus on the reduction of musculoskeletal disorders (MSDs) and absenteeism as indicators of successful ergonomic interventions (Yazdani & Wells, 2018). And other research has mainly focused on physical ergonomics, such as workstation adjustments and equipment improvements. However, cognitive ergonomics, which deals with mental workload and multitasking capacity, is underexplored (Wollter Bergman et al., 2021). Though other research has indicated that perceived organizational support mediates the relationship between ergonomic interventions and employee outcomes like job satisfaction (Maan et al., 2020). This mediator has not been rigorously tested in the context of well-being metrics, other empirical research is needed to explore whether employees who perceive higher organizational support experience greater benefits from ergonomic interventions, and how these dynamic impacts their physical and mental health over time (Worley et al., 2009).

Given the physically demanding and multitasking-intensive nature of the hospitality industry, work organization variables have a negative and significant influence on the work stress of hotel front office employees in Bali (Irwanti & Wisnawa, 2023). Puri Saron Hotel Group faces challenges related to employee well-being, including potential musculoskeletal disorders (MSDs), stress, and burnout, A study at Puri Saron Hotel Group revealed significant challenges related to employee well-being, with the analysis of the RULA method in the lifting activity using this trolley, a score of 7 (seven) was obtained which indicates that the room attendants have a high level of risk (Irwanti, 2018). Stress and physical work environment were also key factors, contributing to 87.40% of the variation in employee performance (Mariani & Kartika, 2018). Poor lighting and locker space further worsened work conditions (Prabawa et al., 2023). There is a need to investigate how ergonomic interventions can enhance employee well-being by reducing physical strain and improving cognitive performance, especially in a high-demand environment in Puri Saron Hotel Group Bali. The principal goal of this study is to investigate the impact of ergonomic interventions on the overall well-being of hotel

employees, with a focus on mitigating the negative effects of multitasking, it will explore whether perceived organizational support mediates the connection among these interventions and employee well-being results. This study aims to discover the relationships among ergonomic interventions, multitasking, perceived organizational support, and employee well-being, focusing on employees of the Puri Saron Hotel Group in Bali.

2. RESEARCH METHOD

Explanatory research within the framework of quantitative research aims to describe the relationships among variables and often seeks to establish cause-and-effect connections. It goes beyond simply describing phenomena (descriptive research) by focusing on understanding how and why certain factors influence each other (George & Merkus., 2023). This study is using explanatory research to examine the impact of ergonomic interventions on employee well-being, using a statistical model.

The inhabitants of this study is all employees of Puri Saron Hotel Group. By using Slovin's formula (Ryan, 2013; Yamane, 1976), this is how the sample size was determined.: Sample size:

n = N/(1+N (e))

= 133/ 1+ (133 (0.05)

= 133/.56 = 99.84 => 100 margin of error, E = 0.05, and response rate, p = 50%, researchers discovered that the estimated sample size was 100.

Tabel 1. Demographic Information (N=100)

Variable	Subcategory	Frequency	Percentage (%)
Gender	Males (M)	41	41
	Females (F)	59	59
Age	17-24 years	20	20
	25-34 years	35	35
	35-44 years	25	25
	45 years and above	20	20
Job Tenure	Less than 1 year	15	15
	1-3 years	30	30
	3-5 years	25	25
	More than 5 years	30	30
Departments	Housekeeping	25	25
	Front Office	20	20
	Food & Beverage	35	35
	Management/Administrative	20	20

The location of the study is Puri Saron Hotel Group Bali, which consists of 4 (four) hotels: Badung, Denpasar, Gianyar, and Singaraja. Puri Saron Hotel Group was chosen as the case study location due to its relevance in the hospitality industry, diverse operations, consistent standards, and potential for generalizing findings. This choice allows for a comprehensive analysis of ergonomic interventions within the hospitality context.

` The study's variables consist of exogenous variables (X) and endogenous variables (Y), with Z representing the mediation variable. This study employs two independent variables: X1 Ergonomic Intervention (EI) 3 items and X2 Multitasking (M) 4 items, while the dependent variable is Employee Well-Being (EWB) 4 items as Y. Additionally, Perceived Organizational Support (POS) 5 items are used as a mediator, altering the link between both the dependent and independent variables. In essence, ergonomic interventions and multitasking are assumed to impact employee well-being directly or indirectly through employees' perceptions of organizational support.

Data collection methods include observations, interviews using questionnaires, and literature studies such as books, literature, and scientific publications that aim to enrich and analyze data (Hollweck, 2015). To achieve the objectives validly, the researcher used A Likert scale is a statement to which respondents rate their level of agreement. A five-point scale of agreement like the following is used: 1 = strongly disagree; 2 = disagree. 3. Neutral 4=Agree 5 = strongly agree (Tullis & Albert, 2013).

The information used in this study were gathered from employees of the Puri Saron Hotel Group in Bali, employed online questionnaires using Google Forms in coordination with the HRD department to ensure smooth data collection. If there is incomplete data, the best approach is to attempt to gather the missing information by following up with the respondents. However, if this is not possible, the incomplete data may need to be excluded to maintain the integrity and reliability of the analysis. The sampling of this study is based on the needs of SmartPLS SEM analysis version 3.0 (Hair & Alamer, 2022). Where the requirement for the number of samples is between 30 and 100-200 (Hair et al., 2010). PLS-SEM is suitable for complex models with many indicators and structural paths, as is the case with this study. It also accommodates both common factor and composite-based models, providing flexibility in model specification. Additionally, PLS-SEM prioritizes prediction, which aligns with the study's objective of understanding the predictive relationships between ergonomic interventions, multitasking, perceived organizational support, and employee well-being.

3. RESULTS AND DISCUSSION

There are various steps involved in the research data analysis technique, which include the following: a) Frequency tables are used in descriptive analysis to provide an overview of the data results. b) Validity and reliability testing using Average Variance Extracted (AVE), This involves examining how effectively the individual questions in the survey capture the core concept being measured. A higher AVE indicates that all questions accurately measure this concept. Cronbach's alpha measures how closely related the questions are. A higher Cronbach's alpha value means that everyone is measuring the same item, establish whether the questions work together to accurately assess the topic. Composite Reliability measures the internal consistency of a set of items (all survey questions) that are supposed to measure the same underlying concept (latent variable). Basically, Composite Reliability indicates how reliably the items work together to measure the concept. A high Composite Reliability indicates that the items are highly related and consistently measure the same thing. This gives confidence that the measurement is reliable and not just capturing random variation. and Outer Loading to assess the questionnaire's quality, indicate the strength of the association between each individual item and the latent variable it is designed to assess. Consider it as a correlation. Every indicator is legitimate and suitable for usage with latent variables and reflective indicators. Minimum score of 0.70 (or 0.60 for preliminary study) The factor model is correct and appropriate, with a maximum of 0.95 to prevent indicator redundancy, which would undermine content validity, recommended 0.70-0.9, and convergence validity AVE > 0.50 (Hair et al., 2019).

Table 1. Results of Model Constructs

Construct/Indicator	Outer Loading	Alpha	CR	AVE
Ergonomic Intervention (EI)				
Modifications to the workspace to improve posture and reduce strain	0.802			
Availability and use of tools designed to minimize physical discomfort	0.886	0.799	0.882	0.714

Construct/Indicator	Outer Loading	Alpha	CR	AVE
Education and interventions provided to workers on ergonomics	0.845			
Multitasking (M)				
The mental effort required to handle multiple tasks simultaneously	0.767	0.777	0.857	0.600
Number of times an employee switches between tasks within a certain period	0.847			
The relationship between multitasking and increased stress or fatigue	0.765			
Efficiency in handling various tasks without significant postponements	0.715			
Employee Well-Being (EWB)				
Employees' contentment with their work environment and duties	0.776	0.829	0.886	0.661
Presence or absence of work-related health issues, such as musculoskeletal disorders	0.850			
Degree of stress experienced by employees, particularly from multitasking or poor ergonomic conditions	0.789			
The capacity to sustain a sound equilibrium between obligations in one's personal and professional lives	0.836			
Perceived Organizational Support (POS)				
How much the organization supports and implements ergonomic improvements	0.878	0.874	0.909	0.668
Availability of emotional and logistical support from the organization	0.860			
Provision of resources that facilitate job performance and reduce stress	0.809			
The extent to which employees feel recognized and valued for their contributions	0.756			
The extent to which the organization provides ongoing training and development opportunities, particularly regarding ergonomic practices and employee well-being	0.775			

Table 1 presents the validity and reliability of variables measured in the study. For the ergonomic intervention variable, three items had outer loading values ranging from 0.802 to 0.886, indicating a strong correlation. The composite reliability score of 0.882, Cronbach's alpha of 0.799 (>0.7), and AVE of 0.714 (>0.50) confirm the variable's validity. Key indicators included the availability of tools to reduce physical discomfort (0.886) and worker education (0.845).The multitasking variable was assessed using four items with outer loading values between 0.715 and 0.847, showing strong relevance. Its composite reliability of 0.857, Cronbach's alpha of 0.770 (>0.7), and AVE of 0.600 (>0.50) indicate validity. Key contributors were task-switching frequency (0.847) and mental effort for multitasking (0.767). For employee well-being, four items had outer loadings of 0.776–0.850, with composite reliability of 0.886, Cronbach's alpha of 0.829 (>0.7), and AVE of 0.661 (>0.50). Significant indicators included the absence of work-related health issues, like musculoskeletal disorders (0.850), and the ability to maintain work-life balance (0.836). Perceived organizational support (POS) was measured with five items, having outer loadings of 0.756–0.878. Composite reliability was

0.909, Cronbach's alpha 0.874 (>0.7), and AVE 0.668 (>0.50), confirming validity. The strongest indicators were the organization's execution of ergonomic changes (0.878) and provision of emotional and logistical support. These results demonstrate that all variables are both reliable and valid, meeting required statistical thresholds.

Overall, the two strongest variables, based on their outer loading values, are that ergonomic intervention was seen to be stronger as reflected by the availability and use of tools designed to minimize physical discomfort (outer loading = 0.886) and variable how much the organization supports and implements ergonomic improvements (outer loading = 0.878). Both ergonomic interventions and perceived organizational support are vital factors in understanding the impact of ergonomic interventions. A supportive organizational environment coupled with a focus on employee physical and mental health creates a synergistic effect, leading to greater well-being and overall positive outcomes for both employees and the organization.

Discriminant Validity Evaluation. An assessment of a measurement model's discriminant validity verifies that its variables are theoretically distinct and subjected to empirical or statistical testing. The method utilized is the Fornell and Lacker criterion as well as the HTMT (heterotrait-monotrait ratio). The square root of the AVE variable must have a higher correlation across variables in order to meet the Furnell and Larcker requirements (Hair et al., 2019).

Table 2. Discriminant Validity of Constructs

Variable	EWB	EI	MLT	POS
Discriminant Validity Fornell-Larcker Criterion				
EWB	**0.813**			
EI	0.642	**0.845**		
M	0.698	0.520	**0.775**	
POS	0.705	0.679	0.607	**0.817**
Heterotrait–Monotrait Criterion				
EWB				
EI	0.785			
MLT	0.866	0.651		
POS	0.828	0.809	0.732	

Table 2 presents that the square root of the variable employee well-being is AVE 0.813, higher than the correlations with ergonomic intervention (0.642), multitasking (0.698), and perceived organizational support (0.705). Additionally, ergonomic intervention has a square root of AVE 0.845, higher than the correlations with multitasking (0.520) and perceived organizational support (0.679). as well as multitasking having a square root of AVE 0.775 bigger than perceived organizational support 0.607. These findings demonstrate that there is validation for discrimination based on employee well-being. Consequently, multitasking where the square root of the AVE is larger than the correlation between variables has been validated as an ergonomic solution. When it comes to identifying discriminant validity, the measure of the discriminant validity result is thought to be more sensitive or accurate. HTMT values less than 0.90 are advised (Hair et al., 2019). The findings demonstrate that discriminant validity is attained when the HTMT value for variable pairings is less than 0.9. Rather than dividing the variants on other variable items, variables divide the variables of the measurement item against the item that measures them more strongly.

Structural Model Evaluation. Testing the hypothesis regarding the influence link between the study's variables is the goal of the structural model evaluation. Hair et al., (2019) state that the following are part of the structural model evaluation examination: a) using the inner VIF (Variance Inflated Factor) measure to check for multicollinearity and make sure there is not any between the variables. b) The inner VIF number needs to be less than 5. Testing for

hypotheses: to test for hypotheses and obtain a 95% confidence interval for the predicted path coefficient parameters. c) Direct influence: The size f square is used to examine the direct influence of factors at the structural level. Low influence is indicated by a f square value of 0.02.

A moderate influence is indicated by the f square value of 0.15. F square's value of 0.35 suggests a strong influence. The statistical measure of upsilon v, which is obtained by squaring the mediation coefficient, is used to examine the mediation effect. According to Lachowicz et al., (2018) and Ogbeibu et al.,(2022) is that if upsilon v = 0.02, the mediation effect is minimal. If upsilon v = 0.075, the mediation effect is considered moderate. If v = 0.175, the mediation effect is high. Using the R Square method, the model's overall assessment was completed (Chin, 1988). Chin, (1988) 0.19 indicates low influence, 0.33 indicates a moderate influence, and 0.66 indicates a high influence. The Q-Square needs to be greater than zero. Significant values are those greater than zero. Higher values than 0 suggest that the PLS path model's small, medium, and large predictive accuracy are represented by values of 0.25 and 0.50. (Hair et al., 2019). By contrasting the PLS model's RMSE (Root Mean Square Error) and MAE (Mean Absolute Error) results with those of the linear regression (LM) model, PLS Predict evaluates the PLS model's capacity for prediction. If the PLS model's RMSE or MAE values are lower than those of the LM model, it is regarded as superior (Hair et al., 2019). A healthy SRMR is less than 0.08 (Hair et al., 2017). According to a different standard, SRMR levels between 0.08 and 0.10 are nevertheless considered acceptable. (Schermelleh-Engel et al., 2003).

Table 3. Hypothesis and Path Coefficients Significance Testing Results

Hypothesis	Path Coefficient (β)	p-value	95% confidence path interval		Sig/ supported	VIF	F Square/Upsilon V	R^2	Q^2
			Upper Limit	Lower Limit					
Direct Effect									
E I -> EWB	0.224	0.022	0.422	0.036	Yes	1.923	0.072		
E I -> POS	0.499	0.00000	0.634	0.318	Yes	1.371	0.403	0.639	0.405
M -> EWB	0.390	0.00014	0.588	0.189	Yes	1.639	0.257		
M -> POS	0.347	0.00002	0.506	0.187	Yes	1.371	0.195	0.549	0.338
POS->EWB	0.316	0.00611	0.553	0.102	Yes	2.219	0.125		
Indirect Effect									
E I -> POS -> EWB	0.158	0.0017	0,299	0.043	Yes	-	0.025	-	-
M -> POS-> EWB	0.110	0.033	0.229	0.029	Yes	-	0.014	-	-

Table 3 presents the significance of employee well-being in fostering a productive and positive work environment. This study examines how ergonomic interventions and multitasking influence employee well-being, with perceived organizational support (POS) as a mediator. Hypothesis 1 confirms that ergonomic interventions positively impact employee well-being, with Path Coefficient (β) = 0.224, p-value = 0.022 (<0.05), and 95% CI [0.036, 0.422]. Despite a low effect size (f^2 = 0.072), the R^2 = 0.639 and Q^2 = 0.405 indicate medium predictive accuracy. Hypothesis 2 shows ergonomic interventions significantly enhance POS (β = 0.499, p-value < 0.001), with 95% CI [0.318, 0.634]. The effect size is high (f^2 = 0.402), with strong predictive accuracy (R^2 = 0.639, Q^2 = 0.405). Hypothesis 3 reveals multitasking positively impacts employee well-being (β = 0.390, p-value < 0.001), 95% CI [0.189, 0.588], with moderate influence (f^2 = 0.257). R^2 = 0.549 and Q^2 = 0.338 reflect medium predictive accuracy. Hypothesis 4 establishes multitasking also enhances POS (β = 0.347, P-value <

0.001), 95% CI [0.187, 0.506], with moderate effect size (f^2 = 0.195). The model shows moderate predictive accuracy (R^2 = 0.549, Q^2 = 0.338). Hypothesis 5 confirms POS positively impacts employee well-being (β = 0.316, p-value = 0.006), 95% CI [0.102, 0.553], with moderate effect size (f^2 = 0.125). The model maintains medium predictive accuracy (R^2 = 0.549, Q^2 = 0.338). Hypothesis 6 indicates ergonomic interventions improve well-being indirectly through POS (β = 0.158, p-value = 0.0017), 95% CI [0.043, 0.299]. The mediation effect size is low (Upsilon V = 0.025). Hypothesis 7 finds multitasking indirectly enhances well-being via POS (β = 0.110, p-value = 0.033), 95% CI [0.029, 0.229]. The mediation effect size is low (Upsilon V = 0.014). The strongest relationship was between ergonomic interventions and POS (β = 0.499, p-value < 0.001), highlighting the critical role of ergonomic improvements in enhancing perceived support. Multitasking also significantly improved employee well-being (β = 0.390, p-value < 0.001). Overall, ergonomic measures and POS are vital for promoting employee well-being, with POS acting as a key mediator.

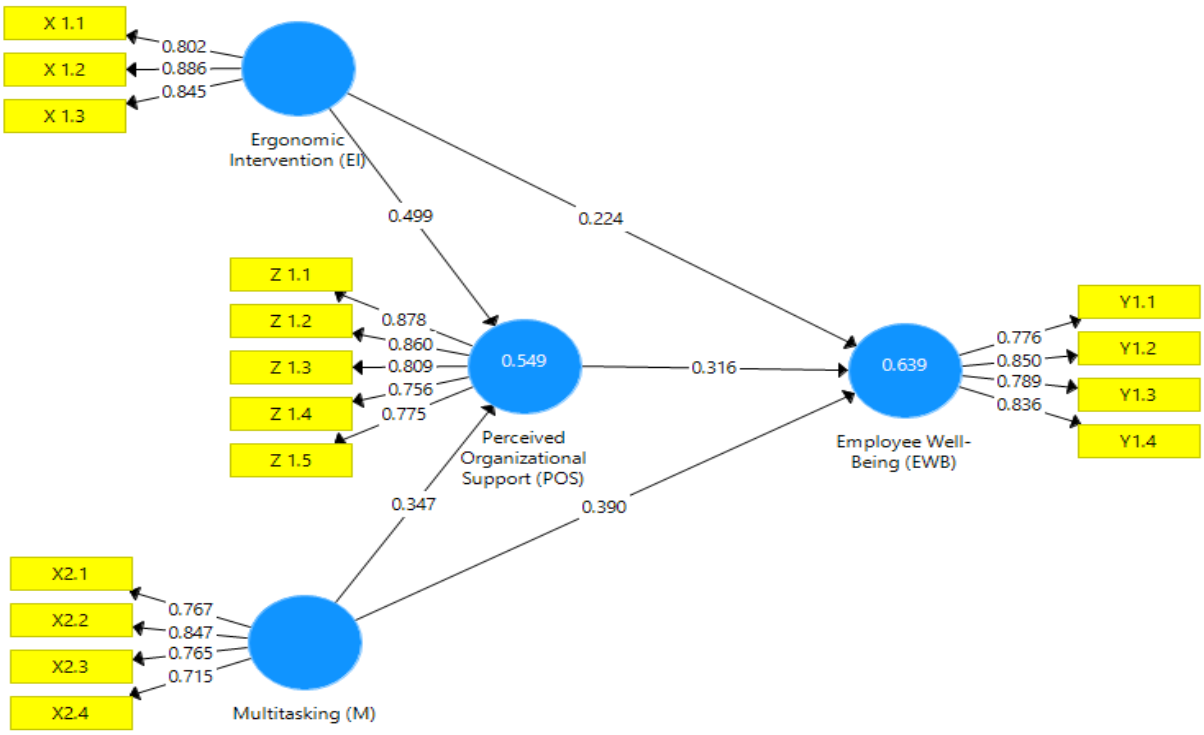

Figure 1. PLS Algorithm Path Coefficient and Outer Weight/Loading (Final Model)

Figure 1 shows that the PLS algorithm path coefficients and outer weights/loadings for a final model assessing the relationships between ergonomic interventions (EI), multitasking (M), perceived organizational support (POS), and employee well-being (EWB). The model shows direct paths from EI and multitasking to EWB, indirect paths with POS mediating the relationship between EI and EWB, and relationship between M and EWB.

Table 4. Out-of-Sample Predictive Power Analysis

Item	PLS Model		LM Model	$RMSE_{PLS}$—$RMSE_{LM}$
	Q^2_predict	RMSE	RMSE	
EWB.1	0.268	0.617	0.656	-0.039
EWB.2	0.379	0.767	0.816	-0.049
EWB.3	0.416	0.685	0.529	0.156
EWB.4	0.403	0.646	0.675	-0.029

Item	PLS Model		LM Model	$RMSE_{PLS}$—$RMSE_{LM}$
	Q^2_predict	RMSE	RMSE	
POS.1	0.357	0.496	0.503	-0.007
POS.2	0.285	0.507	0.515	-0.008
POS.3	0.283	0.611	0.618	-0.007
POS.4	0.343	0.833	0.871	-0.038
POS.5	0.316	0.673	0.677	-0.004

Table 4 presents that PLS, a method for modeling structural equations, was developed to bridge the gap between explaining and predicting phenomena. Despite the emphasis on prediction in PLS-SEM. this is a powerful statistical method for understanding complex relationships like those between ergonomics, organizational support, and employee well-being. It's particularly useful when dealing with new or evolving theories and situations with many interconnected factors. While qualitative methods like interviews can provide valuable context and depth, PLS-SEM offers a strong foundation for testing predictions, measuring abstract concepts, and identifying the most influential factors for improving employee well-being. the evaluation of these models has traditionally focused on metrics that assess their explanatory power. Recent work has introduced PLSpredict is a method that generates item- or construct-level predictions using a holdout sample, providing a direct means of evaluating the predictive validity of PLS path models. (Hair et al., 2019). while analyzing predictive power outside of a sample. The suggested PLS model has medium predictive potential if its RMSE value is less than that of the LM (linear regression) model. While the PLS model outperforms a simple linear regression model in terms of prediction accuracy, the statement suggests.

Table 5. Model Fit SRMR

	Saturated Model	Estimated Model
SRMR	0,086	0,086

Table 5 present that SRMR is the Standardized Root mean square residual which is a measure of model fit (model fit). The requirement used is that the SRMR value below 0.08 indicates a fit model (suitable), while the SRMR value between 0.08 and 0.10 is still acceptable (Schermelleh-Engel et al., 2003). The model estimate result is 0.086 which means that the empirical data acceptable fit model can explain the influence of variables between models

4. CONCLUSION

This study highlights the significance of ergonomic interventions and multitasking in enhancing employee well-being within the high-demand hospitality industry of the Puri Saron Hotel Group in Bali. Ergonomic interventions, such as workspace modifications and ergonomic training, were shown to have a statistically significant positive impact on employee well-being, with perceived organizational support acting as a crucial mediator. Multitasking, when managed effectively, also contributed to better well-being, indicating the role of cognitive adaptability in maintaining performance and satisfaction. The findings emphasize that fostering organizational support amplifies the benefits of ergonomic measures and helps mitigate stress and fatigue associated with multitasking. Overall, the results demonstrate that improving ergonomic conditions and providing organizational support are essential strategies for enhancing employee well-being in demanding industries. By addressing physical and psychological stressors, organizations can create a balanced work environment, boosting productivity and employee satisfaction. These insights offer valuable guidance for hospitality businesses aiming to optimize workplace practices and foster a healthier, more supportive organizational culture.

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RESEARCH Open Access

The Effect of Contact Time Variations of Activated Carbon from Coconut Shell on The Peroxide Value in Used Cooking Oil

Herlinda Djohan[1a], Hendra Budi Sungkawa[1b], Fara Chitra[2c*], Nur Reza Ningsih[2d]

[1] Department of Medical Laboratory Technology, Poltekkes Kemenkes Pontianak, Pontianak, West Kalimantan, Indonesia
[2] Department of Enviromental Health, Poltekkes Kemenkes Pontianak, Pontianak, West Kalimantan, Indonesia

[a] Email address: herlinda.dj@gmail.com
[b] Email address: hendrabudis.budis@gmail.com
[c] Email address: chitrafara@gmail.com
[d] Email address: nurrezaningsih@gmail.com

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Abstract
Cooking oil is a commonly used food product in daily life, both in households and commercially, especially for frying purposes. The repeated use of cooking oil can lead to an increase in peroxide value, which may pose health risks. High peroxide values are carcinogenic and can trigger various health problems, such as elevated cholesterol levels and heart disease. One method to reduce peroxide value is by using activated carbon, such as activated carbon derived from coconut shells. This study aims to analyze the effect of contact time variations of activated carbon from coconut shells on the reduction of peroxide value in used cooking oil. The research design used was a quasi-experiment with an iodometric testing method. A total of 24 samples of used cooking oil were treated with activated carbon from coconut shells for different contact times: 20 minutes, 30 minutes, and 40 minutes. The peroxide value was then measured. The results showed that varying the contact time with activated carbon from coconut shells resulted in the following average peroxide values: 15.57 meq O2/kg, 7.57 meq O2/kg, 6.58 meq O2/kg, and 5.82 meq O2/kg. The percentage reduction in peroxide value was 0%, 51.41%, 57.06%, and 62.64%, respectively. In conclusion, the study found a significant effect of contact time variations of activated carbon from coconut shells on the reduction of peroxide value in used cooking oil, with a probability value of 0.000 < 0.05.

Keywords: Peroxide Value, Activated Carbon, Used Oil, Cooking Oil.

Corresponding Author:

Fara Chitra
Department of Enviromental Health, Poltekkes Kemenkes Pontianak, Pontianak, West Kalimantan, Indonesia
Email: chitrafara@gmail.com

1. INTRODUCTION

Snacks have become an inseparable part of people's daily lives, both in urban and rural areas (Upreti, et al., 2020; Roy, et al., 2021; Bhattacharya, 2022). Snacks are food and beverage products produced by small-scale informal sector entrepreneurs, sold in crowded places, along the streets, in residential areas, or through a combination of both mobile and stationary methods (Menes, et al., 2019; World Health Organization, 2019; Mbwana, & Mwinuka, 2024). Snacks can be either main dishes or side dishes, commonly consumed during daily activities.

Heavy snacks, or main meals, are foods that consist of staple foods, side dishes, and vegetables, typically consumed on a daily basis. On the other hand, light snacks, often referred to as side dishes, are foods consumed outside of main meal times, such as various treats and traditional market snacks. These light snacks are usually eaten between breakfast and lunch, providing additional calories and energy to the body (Emilia & Akmal, 2021).

One of the most popular types of snacks in Indonesia is fried foods. Fried snacks are favored by many people due to their savory taste and crispy texture. Additionally, fried foods contain high-calorie content due to the cooking oil used. Frying food is not an issue as long as it is done at the right temperature. If the cooking oil becomes too hot, signs of degradation appear, such as smoke, indicating that the oil is breaking down (Bow, et al, 2019; Hanum, 2016).

Cooking oil is derived from plant or animal fats that are refined and liquid at room temperature (Awogbemi, Onuh, & Inambao, 2019; Mannu, et al., 2020; Suzihaque, et al., 2022; Foo, et al., 2022; Gharby, 2022). One type of oil commonly used in food processing is palm oil, chosen for its relatively low cost, availability, and high oxidation stability (Kaniapan, et al., 2021; Sulaiman, et al., 2022). However, repeated use of cooking oil, especially at high temperatures, can damage its quality, causing the oil to smoke, foam, and change color (Mishra, et al., 2023; Machado, et al., 2023). Moreover, unsaturated fatty acids in the oil oxidize and turn into saturated fatty acids, which are accompanied by the formation of harmful free radicals.

One indicator of cooking oil deterioration is the peroxide value, which is a parameter used to measure oil quality (Mariana, et al., 2020; Dewi, & Ulfah, 2021; Zhang, et al., 2021). According to SNI-01-3741-2013, a high peroxide value indicates that the oil has undergone oxidation and has become toxic. Therefore, efforts to reduce the peroxide value of used cooking oil are necessary. One such method is the use of activated carbon from coconut shells. Coconut shells, which have previously been considered waste, actually have high potential as a raw material for activated charcoal that functions as an adsorbent to reduce the peroxide content in used cooking oil. Based on previous research, refining used cooking oil with activated carbon from coconut shells at 100˚C for 20 minutes has been shown to improve the quality of the used oil, reducing free fatty acids to 0.79% (from 1.19%) and peroxide value by 21.46% (from 26.27%) (Paputungan, 2018).

This research focus on the use of activated carbon from coconut shells as an innovative and sustainable method to reduce the peroxide value in used cooking oil. While there has been prior research into refining cooking oil and the use of activated carbon, this study explores the effect of varying contact times on the peroxide value, which has not been extensively investigated in the context of coconut shell-derived activated carbon. The study's novelty is further highlighted by the potential for using coconut shells, typically considered waste, as a valuable resource to improve oil quality. The purpose of this study is to investigate the effect of varying contact times of activated carbon from coconut shells on the peroxide value in used cooking oil.

2. RESEARCH METHOD

The research design used is a Quasi-Experimental Design. This design involves a control group; however, it cannot fully control the external variables that may affect the implementation of the experiment (Sugiyono, 2019). The population in this study consists of

used cooking oil. The sample used in this study consists of 24 groups of used cooking oil purchased from fried food vendors on Jalan Panglima A'im, East Pontianak District, with 4 variations of treatment. The sampling technique employed is purposive sampling. The sample criteria for this study include used cooking oil that has turned brown in color and is made from bulk oil. The criteria for the coconut shell used are coconut shells that are free from husks and are dry. This research was conducted at the Chemistry Laboratory of Poltekkes Kemenkes Pontianak from March to August 2022.

The primary data in this study was obtained directly after testing the samples, by measuring the peroxide value of the used cooking oil before and after it was treated with activated coconut shell charcoal. Data collection was carried out after measuring the peroxide value of the used cooking oil that had been in contact with the activated coconut shell charcoal (0.25 grams) for varying contact times of 20 minutes, 30 minutes, and 40 minutes. The peroxide value measurement was carried out using the iodometric titration method, in which the amount of iodine released was titrated with a standard sodium thiosulfate solution using starch as an indicator (Anconi, 2022; Ghohestani, Tashkhourian, & Hemmateenejad, 2023).

The instruments used in this study include an analytical balance, watch glass, burette, stand, Erlenmeyer flask, volumetric flask, measuring cylinder, dropper pipette, volumetric pipette, funnel, beaker glass, stirring rod, black plastic, flocculation, rubber suction bulb, oven, furnace, desiccator, Whatman 42 filter paper, and 200 mesh sieve. The materials and reagents used in this study include used cooking oil, activated coconut shell charcoal, secondary standard Na2S2O3 0.01 N solution, 4 N HCl solution, distilled water/aquadest, primary KIO3 0.01 N solution, 20% KI solution, saturated KI solution, 1% starch indicator, and acetic acid-chloroform solution. Data analysis was conducted to test the hypothesis by determining the relationship between variables using linear regression analysis. This study has also received ethical approval from the ethics commission of the Pontianak Health Polytechnic Ministry of Health with ethical number: 201/KEPK-PK.PKP/VIII/2022 and conducted in accordance with the Declaration of Helsinki.

3. RESULTS AND DISCUSSION

Table 1. Data from the calculation of peroxide content in used cooking oil

Replication	**Peroxide Numbers Before and After Treatment (Meq O2/kg)**			
	Before	**20 minutes**	**30 minutes**	**40 minutes**
1	16,24	6,68	5,87	5,36
2	15,58	7,61	7,36	5,71
3	15,09	5,16	5,13	4,94
4	15,67	10,06	9,49	8,42
5	15,49	7,32	5,93	4,65
6	15,38	8,61	6,35	5,86

In table 1, it can be seen that the best reduction in peroxide number levels is in the contact time of 40 minutes of active coconut shell kabon, which is 5.82 Meq O2/kg.

Table 2. Organoleptic Test on Used Cooking Oil Before and After Contacting Coconut Shell Activated Carbon

Cooking Oil	**Colour**	**Aroma**	**Taste**
Used cooking oil before contact with coconut shell-activated charcoal	Brownish-yellow	Slightly rancid	Slightly bitter
Used cooking oil after coconut shell activated charcoal contact with 20 minutes contact time	Yellow	Rancidity gone	Normal

Cooking Oil	Colour	Aroma	Taste
Used cooking oil after contact with coconut shell activated charcoal with 30 minutes contact time	Yellow	Rancidity gone	Normal
Used cooking oil after contacted with coconut shell activated charcoal with 40 minutes contact time	Light yellow	Rancidity gone	Normal

In Table 2, used cooking oil after contact with coconut shell activated charcoal affects the colour, aroma and taste of the oil. The longer the contact time of coconut shell activated carbon, the more light-coloured the oil, the rancid aromas disappear and the taste becomes normal.

Table 3. Descriptive Test of the Effect of Contact Time Variations of Coconut Shell Activated Carbon on Peroxide Numbers in Used Cooking Oil

Variable	N	Mean	Standard Deviasi	Rate Minimum	Rate Maximum
Activated Carbon Contact Time 0 minutes	6	15,57	0,38256	15,09	16,24
Activated Carbon Contact Time 20 minutes	6	7,57	1,67009	5,16	10,06
Activated Carbon Contact Time 30 minutes	6	6,58	1.55487	5,13	9,49
Activated Carbon Contact Time 40 minutes	6	5,82	1.35119	4,65	8,42

Table 3 shows that the lowest average peroxide number in used cooking oil is after contacting coconut shell activated carbon for 40 minutes with a peroxide number of 5.82 meq O2/Kg.

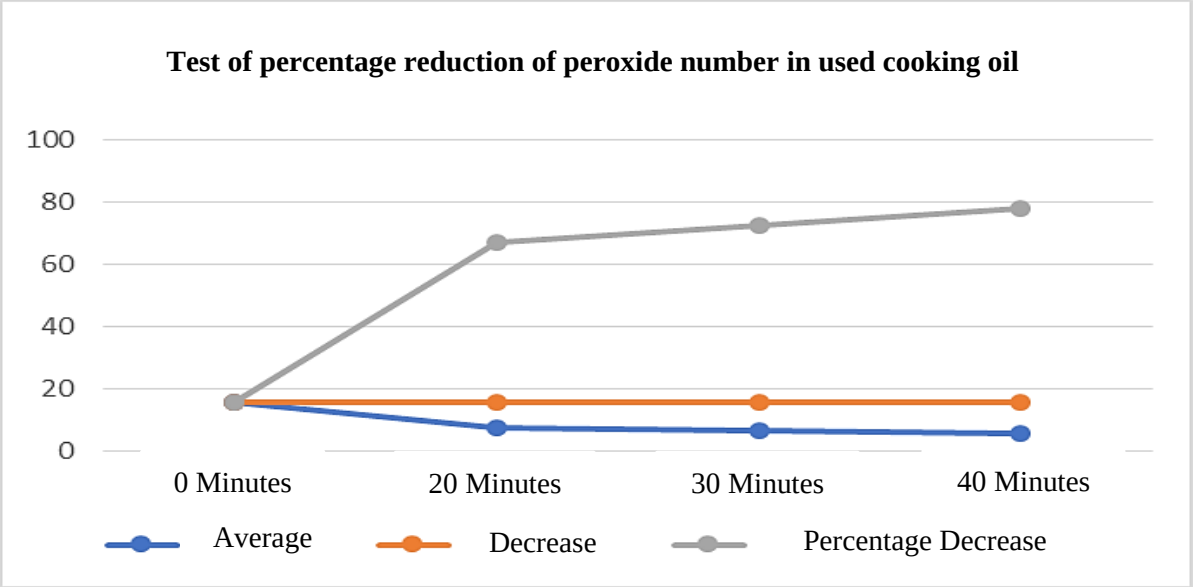

Figure 1. Test of Percentage Reduction of Peroxide Numbers in Used Cooking Oil

Figure 1 can be seen the largest percentage decrease in peroxide number levels in used cooking oil in coconut shell activated carbon contact time for 40 minutes, which is 62.64%.

Table 4. Pearson correlation analysis results of the effect of contact time variation of coconut shell activated carbon on peroxide number levels in used cooking oil.

Correlation Analysis	Activated Carbon Contact Time	Peroxide Numbers
Pearson Correlation	1,000	-0,825
Sig. (1-tailed)		0,000
N	24	24

Based on table 4, the correlation p-value is -0.825, which means that there is a very strong relationship between the two variables. The negative sign shows the direction of the correlation

between the two variables. The negative sign means that the correlation relationship between contact time with coconut shell activated charcoal and peroxide number in used cooking oil is inversely proportional, the longer the contact time with coconut shell activated charcoal, the smaller the peroxide number in used cooking oil. The sig (1- tailed) value of 0.000 <0.05 means that there is a significant relationship between the independent variable contact time with coconut shell activated charcoal (X) with the dependent variable peroxide number in used cooking oil (Y).

Table 5. Model Summary of Linear Regression Test of Contact Time Variation of Coconut Shell Activated Carbon on Peroxide Numbers in Used Cooking Oil

Model	R	R Squared	Adjust R Squared
1	-0,825[a]	0,681	0,667

In table 5, the R-value column explains the magnitude of the correlation or influence between the contact time of coconut shell activated charcoal and the peroxide number in used cooking oil which is 0.825 which means there is a very strong influence. The R square value is 0.681, so the influence of the variation in contact time of coconut shell activated charcoal on the peroxide number in used cooking oil is 0.825.

Table 6. ANOVA Test of Variation of Contact Time of Coconut Shell Activated Carbon on Peroxide Numbers in Used Cooking Oil

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	272.526	1	272.526	47.061	.000[b]
Residual	127.401	22	5.791		
Total	399.927	23			

Based on table 6, the significance value of 0.000 <0.05, the simple regression model can be used to predict the effect of variations in contact time of coconut shell activated carbon on peroxide number levels in used cooking oil.

Table 7. Output Coefficient of Contact Time Variation of Coconut Shell Activated Carbon on Peroxide Numbers in Beka Cooking Oils

Model	Unstandardized Coefficients		Standardized Coefficients	T
	B	Std. Error	Beta	
Constant	16.450	1.203		13.672
Contact Time	-3.014	.439	-.825	-6.860

Table 7 above shows that the value of t table 1.71714 < t count 6.860, so there is an effect of variation in contact time of coconut shell activated charcoal on peroxide number in used cooking oil. The longer the contact time with coconut shell activated charcoal, the lower the peroxide number in used cooking oil. So it is concluded that coconut shell activated charcoal can reduce peroxide number levels in used cooking oil.

DISCUSSION

Used cooking oil is oil that has been reused multiple times (up to four times), leading to a degradation in its quality. One of the key indicators of this degradation is an increase in the peroxide value of the oil. Therefore, an adsorbent, such as activated coconut shell charcoal, is required to reduce the peroxide value. In this study, variations in the contact time of activated coconut shell charcoal with used cooking oil were tested to reduce the peroxide value.

As shown in Table 1, the greatest reduction in peroxide value was observed with a contact time of 40 minutes, where the peroxide value decreased to 5.82 meq O2/kg, compared to the value before contact, which was 15.58 meq O2/kg. This finding is consistent with the study by Zunifer & Ayu (2020), which showed that as the contact time of activated charcoal with oil increased, the peroxide value decreased. The data in Table 1 also demonstrate a reduction in peroxide values for all sample replications. However, in the fourth replication, the peroxide value was 10.06 meq O2/kg, which was significantly different from the previous value of 5.16 meq O2/kg. This discrepancy may be due to factors beyond control, such as temperature, the duration of frying, and the duration of contact between the charcoal and oil.

Table 3 shows the average peroxide values of used cooking oil. Before contact with activated charcoal, the peroxide value was 15.57 meq O2/kg. After contact with activated coconut shell charcoal for 20 minutes, the average peroxide value decreased to 7.57 meq O2/kg; after 30 minutes of contact, it dropped to 6.58 meq O2/kg; and after 40 minutes of contact, the average peroxide value was reduced to 5.82 meq O2/kg. This reduction occurs because the activated charcoal reacts with the functional groups in the used oil. The cellulose in coconut shell contains -OH groups, which can bind with the free fatty acids present in the oil, thereby reducing the peroxide value. The cellulose content in coconut shell charcoal plays a significant role in lowering the peroxide value in used oil.

As shown in Figure 1, the peroxide value of the used cooking oil decreased by 0%, 51.41%, 57.06%, and 62.64% after contact with activated coconut shell charcoal for 0, 20, 30, and 40 minutes, respectively. This reduction occurs because coconut shells possess a good hardness and a high carbon content. The shells also have a tough layer rich in silica (SiO2) and contain 34% cellulose, which helps absorb peroxide compounds in the used oil, making them suitable as an adsorbent.

An adsorbent is a solid substance that can absorb specific components from a fluid phase (Pourhakkak, et al., 2021; Rathi, & Kumar, 2021; Pellenz, et al., 2023). The process of adsorption refers to the separation of components from a liquid phase, which attach to the surface of the solid. Small particles, as adsorbents, can release these components, forming strong bonds between the adsorbent and the adsorbed components (Zhou, 2019). This study uses powdered activated charcoal because the smaller the adsorbent particles, the larger the surface area, which increases the adsorption capacity. A larger surface area allows for greater adsorption efficiency, as confirmed by Zunifer & Ayu (2020), who found that a larger surface area results in a higher adsorption rate. The agitation during the adsorption process also affects the adsorption rate. In this study, a flocculator was used to stir the oil at 150 rpm for 20, 30, and 40 minutes, which increased the adsorption rate.

Based on the Pearson correlation test in Table 4, a correlation of -0.825 was obtained, indicating a very strong inverse relationship between the contact time of activated coconut shell charcoal and the peroxide value of used cooking oil. This means that the longer the contact time, the lower the peroxide value. The linear regression test results show an R-squared value of 68.1%, with the remaining 31.9% influenced by other variables. One potential factor is the temperature during frying, as higher temperatures can accelerate the oxidation process, causing further degradation of the oil and increasing its volatility (Erickson, Yevtushenko, & Lu, 2023).

The study also included organoleptic testing of the used cooking oil before and after treatment with activated coconut shell charcoal for 20, 30, and 40 minutes. The results showed that the activated charcoal influenced the oil's color, aroma, and taste. Initially, the oil was a yellowish-brown color, but after 20 and 30 minutes of contact, it became yellow, and after 40 minutes, it was a lighter yellow. In terms of aroma, the oil, which initially had a rancid smell, lost this odor after treatment with activated charcoal. Furthermore, a taste test using tempeh showed that the oil, which had a slightly bitter taste before treatment, regained a more neutral taste after the charcoal treatment.

4. CONCLUSION

It is concluded that there is an effect of variation in contact time of coconut shell activated carbon on peroxide number levels in used cooking oil. It is suggested that further researchers can examine the effect of coconut shell activated carbon on used cooking oil with different variables such as length of stirring and temperature variations when making activated carbon.

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