JFSP Vol.10, No.2, May-August 2024, Page: 141-149
pISSN: 2549-9068, eISSN: 2579-4558
Jurnal Farmasi Sains dan Praktis
(JFSP)
http://journal.unimma.ac.id/index.php/pharmacy

USE D-OPTIMAL MIXTURE DESIGN IN FORMULATION OF ONCHIDIID SLUG (ONCHIDIUM TYPHAE) INSTANT POWDER AS FUNCTIONAL FOODS

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https://doi.org/10.31603/pharmacy.v10i2.11107

Article info:

Submitted : 27-02-2024

Revised : 22-04-2024

Accepted : 05-07-2024

Publisher:
Universitas Muhammadiyah Magelang

ABSTRACT

Onchidiid slug (*Onchidium typhae*) is an animal with bioactive compounds with high nutritional value and the potential to be used as a functional food product. The study aimed to optimize the onchidiid slug instant powder formula, analyze its proximate content, and determine its hedonic level. The formula of instant powder was made with a comparison of the composition of maltodextrin and dextrose based on the run in the D-Optimal Mixture Design (DMD) program, namely run 1 (20%:10%), run 2 (10%:20%), run 3 (13.33%: 16.67%), run 4 (16.67%:13.33%), run 5 (15%:15%), run 6 (12.5%:17.5%), run 7 (10%: 20%), run 8 (20%:10%). The powder is tested for water content and dissolution time, and the optimal formula is analyzed using One Sample T-Test in SPSS. The results showed that the composition of maltodextrin and dextrose significantly affected the characteristics of instant powder. The optimal instant powder formula combines 18.690% maltodextrin and 11.310% dextrose with a water content of 4.892% and a soluble time of 118.052 seconds. The results of statistical analysis in verifying the optimal formula show a p-value > 0.05 (not significant). The results of the proximate content test were 8.21% water content, 0.42% ash content, 0.85% crude fiber, 3.54% protein, and 1.54%. They had a preference level in the like and acceptable in terms of color, taste, texture, and scent.

Keywords: *Onchidium typhae*; Functional food; D-Optimal Mixture Design; Hedonic Assay

1. INTRODUCTION

West Kalimantan is a province that boasts diverse biological resources with potential for use as food sources and bioactive compounds with significant economic value. However, research on marine biological resources as food ingredients has been minimal compared to terrestrial biological resources, even though marine biological resources have been proven to contain various potential active ingredients (Faulkner, 2002; Lordan et al., 2011). Aquatic organisms are a rich source of secondary metabolites that exhibit pharmacological activity and can be used to develop healthy food products (Karthikeyan et al., 2022; Pringgenies, 2010). One such organism is the onchidiid slug from the genus Onchidium.

The Onchidium genus is a marine biota that contains bioactive compounds with high nutritional value. One species of this genus is the onchidid slug (*Onchidium typhae*) (Wang et al., 2021). Previous research shows that onchidid slug chloroform extract contains alkaloids, steroids, saponins, and free amino acids. Proximate analysis shows that onchidiid slug meat simplicia powder is protein-rich (67.88%) (Wijianto, et al., 2022). This high protein value makes onchidiid slugs have the potential to be used as health food products that function well as a source of energy, building blocks in the body, and forming antibodies (Budiyanto, 2015; Hayes & Mora, 2021).

Nowadays, food products widely consumed by the public are practical health drinks that do not require much time to prepare but can have a good effect on health. The method used to extend the shelf life related to product storage is processing it into an instant powdered functional drink (Ariska & Utomo, 2020). Instant powdered drinks are food products in the form of practical powders to serve and dissolve easily in water.

Instant powder has problems, namely the loss of several vital substances due to inappropriate drying techniques (Utomo & Ariska, 2020). Foam mat drying is a technique for drying liquid and heat-resistant materials through foaming techniques with the addition of foaming agents. The foam mat drying method is relatively simple and cheap and is carried out at low temperatures ranging from 50-80 °C to retain essential substances. Fillers and foaming agents influence the quality of instant powder using the foam mat drying method (Purbasari, 2019). Fillers and foaming materials commonly used in the foam mat drying method are maltodextrin and tween 80. Another filler that is also useful as a sweetener is dextrose. Apart from playing a role in adding taste, dextrose sweetener also plays a role in creating the texture of a food product (Rahmawati & Sutrisno, 2015).

Research on the use of onchidid slugs as a raw material in the formulation of functional drinks has never been carried out, thus encouraging this research to find the optimal formula for preparations in the form of instant powdered functional drinks that utilize fine flesh filtrate of onchidiid slugs using the foam mat drying method. The formulation of the onchidiid slug instant powder functional drink was optimized using the Design Expert 13 software and the D-Optimal Mixture Design method to obtain the optimal formula. The Design Expert program, the D-Optimal Mixture Design method, was chosen because of its high flexibility and high accuracy in determining a suitable mathematical model for optimization (Usman et al., 2023). The optimized factor is a filler consisting of a combination of maltodextrin and dextrose based on the physical characteristics of the powder, including water content and dissolution time. Maltodextrin and dextrose in this study are combined because they have the largest proportions in the formulation that can affect the characteristics and quality of the functional drinks. Maltodextrin and dextrose, besides serving as fillers, also function as sweetening agents, thus affecting the hedonic acceptance and testing by respondents. In order to determine the nutritional value of a product, a proximate analysis is conducted to measure the content of water, ash, crude fiber, protein, fat, and carbohydrates. A liking level (hedonic test) is also performed to assess the level of acceptability and preference for the instant powder. This test aims to create instant powder functional drink products that are both popular and high-quality, with good nutritional value and instant powder characteristics that meet the required standards.

2. METHODS

2.1. Material

Onchidiid slug fresh meat (*Onchidium typhae*), Design Expert 13.0.0 Trial software, ginger, lime, maltodextrin (LIHUA food grade brand, batch no. 20171015), dextrose (LIHUA food grade brand, batch no. 20220409), tween 80 (Chemical Nitra, COA, batch no. 38133). Another supporting instrument in this study consisted of a computer Intel Core i-5, blender (Mitochiba CH-200), mixer (Philips HR1530), food dehydrator (PAPALOLO), analytical balance (Ohaus Pioneer PX224/e), 60 mesh sieve, glassware (iwaki), pH meter (HANNA), Kern Moisture Balance DLB 160-30A.

2.2. Research Stages

2.2.1. Sample Preparation

Onchidid slug samples were washed and cleaned of dirt and mud until clean. Onchidid slugs are separated from the flesh and innards; then, the flesh is rewashed until it contains no mucus. Next, the clean onchidiid slug meat is mashed using a blender for 10-30 minutes to a smaller size by adding water in a ratio of 1:1 (w/v), then boiled at 90 °C for 8-10 minutes and filtered to take the filtrate (Wijianto, et al., 2022) .

2.2.2. Instant Powder Formulation Stage

In order to create instant powder, the essence of the ingredients must be extracted through a multi-stage process involving drying or evaporation to remove any water content. For this research, foam or mat drying is the preferred method for instant powder formulation. Mix primary and additional ingredients, and dry using a foam mat at 70-80 °C for 15-20 mins per formula. The mixture is then refined using a blender and sifted through a 60 mesh, resulting in the ideal instant powder. Packaging is the final step in the process (Purbasari, 2019).

2.2.3. Physical Characteristics Evaluation Stage

Water Content Test - The Kern Moisture Balance DLB 160-30A was used to determine the percentage of water content in the powder as part of this study's water content testing.

Soluble Time Test - To conduct the dissolution time test, we start by weighing 5 grams of powder and dissolving it in 100 ml of cold water (25-28 °C) while continuously stirring. Using a stopwatch, we record the time for the sample to dissolve fully. An ideal completion time for this process is less than 5 minutes. This methodology was established by Husni et al., 2020.

2.2.4. Proximate Analysis

A proximate analysis was carried out to determine the water and ash content through the gravimetric method. The fat content was determined using the Weibull-modified Soxhlet method, while the protein content was tested using the Kjeldahl method. The carbohydrate content was calculated by difference, and the crude fiber content was tested according to SNI 01-2891-1992, which is related to food and drink testing (Wijianto, et al., 2022).

2.2.5. Hedonic Assay

The hedonic assay is a method used to evaluate product acceptance or liking. It considers various factors, including color, taste, texture, and aroma. In a recent study, 20 panelists were selected for the assay. Although trained, the panelists required further expertise in identifying the organoleptic characteristics of the products. They were provided with preparations formulated with the ideal ingredients and asked to rate them on a questionnaire using a hedonic scale from 1 to 4, which included options like "immensely dislike," "do not like," "like," and "really like" (Apandi & Restuhadi, 2016).

3. RESULTS AND DISCUSSION

This research involved the development of an instant powder preparation formula using the Design Expert 13 software program. The study aimed to find the optimal combination of maltodextrin, dextrose, fillers, and sweeteners to produce a high-quality powder. Eight formulations were created with varying amounts of maltodextrin and dextrose. The fillers and sweeteners used in the formulations included various options to produce a sound and favorable powder for consumption. The correct number of fillers and sweeteners was determined based on the instant powder's water content and dissolution time. The instant powder was produced using the Foam Mat Drying method, which uses a foaming agent to shorten the drying process. This method proved to be effective in reducing the drying time and resulted in a high-quality instant powder. Overall, this research provides valuable insights into the development of instant powder preparation formulas that are both effective and easy to produce. The results of 8 runs of D-Optimal Mixture Design are shown in **Figure 1**.

3.1. Evaluation of Instant Powder Characteristics

3.1.1. DMD Analysis Water Content Test

The tests that were carried out revealed the moisture content of the instant powder to range between 5.2% and 10.51%. A low percentage of water content is critical in producing high-quality powder that can be stored for a long duration without compromising quality. Upon evaluation, the results indicated that the water content in each formula was below 10%, which is in line with the standard requirements of the Regulation of the Head of the Food and Drug Supervisory Agency. The analysis of the water content response is expressed in equation 1, providing a clear understanding of the moisture level present in the instant powder. ANOVA Cubic Model Water Content Response and the equations can be seen in **Table 1** and Eq. (1).

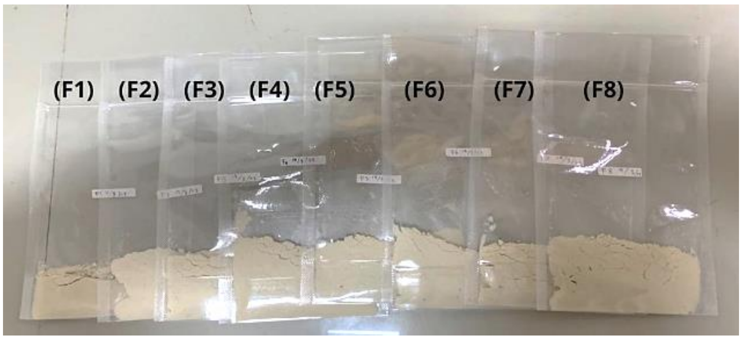

Figure 1. Onchidiid slug instant powder from 8 runs of D-Optimal Mixture Design: F1 combination Maltodextrin:Dextrose (20%:10%); F2 Maltodextrin:Dextrose (10%:20%); F3 Maltodextrin:Dextrose (13.33%:16.67%); F4 Maltodextrin:Dextrose (16.67%:13.33%); F5 Maltodextrin:Dextrose (15%:15%); F6 Maltodextrin:Dextrose (12.5%:17.5%); F7 Maltodextrin:Dextrose (10%:20%); F8 Maltodextrin:Dextrose (20%:10%)

Table 1. ANOVA cubic model water content response

No	Source	P value	Result
1	*Model Cubic*	0.0452	Sig.
2	*Lack of Fit*	0.1160	Not Sig.

The model equation or polynomial for water content response analysis is contained in the following Eq. (1).

$$Y = 3.21825\ A - 3.46023\ B + 0.0501421\ AB \qquad (1)$$

Where: Y = Water content (%); A = Maltodextrin; B = Dextrose; AB = Combination of Maltodextrin and Dextrose Proportions

According to Eq. (1), the component that affects the water content in instant powder is the interaction coefficient A, which represents maltodextrin and has a positive value. This means that the more maltodextrin is added during production, the higher the water content will be. On the other hand, the coefficient B, which represents dextrose, has a negative value, indicating that it has a more negligible impact on increasing water content than maltodextrin. The AB coefficient value is positive, meaning that the combination of maltodextrin and dextrose has a negligible effect on increasing water content. A graph showing the results of the normality of the water content test from research conducted using the D-Optimal Mixture Design method can be found in **Figure 2**.

When added to a substance, maltodextrin can significantly impact the water content. This is due to the unique hygroscopic properties of maltodextrin, which allow it to absorb water and increase the overall water content of the substance. Research has shown that the ability of maltodextrin to bind OH groups from water makes it such an effective water-absorbing agent (Hui, 1992).

In order to provide more insight into this matter, numerous studies have been conducted on various powders that contain varying levels of maltodextrin. For example, research by Corie et al. (2023) found that powders with 20% maltodextrin had a higher water content of 3.31%, compared to powders with 10% and 15% maltodextrin, which had lower water contents of 3.13% and 3.33%, respectively. This suggests that the amount of maltodextrin added can significantly impact a substance's overall water content.

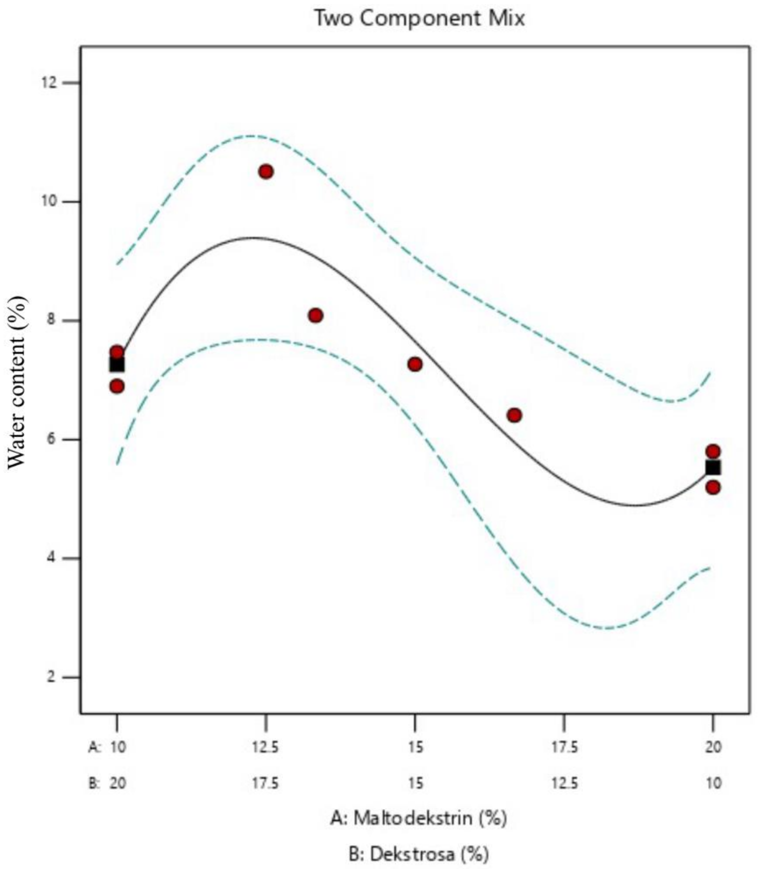

Figure 2. Two-component mix maltodextrin and dextrose on water content

3.1.2. DMD Analysis of Soluble Time Test

The results of the tests revealed that the instant powder for onchidiid slug's dissolves quickly, within a range of 120.22 – 138.45 seconds, making it easy to consume. The evaluation results concluded that all formulas dissolve entirely within five minutes, meeting the instant dissolving time requirements. The analysis of the dissolving time response recommended using a cubic polynomial model for the dissolving time test, according to the Design Expert 13 program. This means that the dissolving time of the instant powder for onchidiid slugs is in line with the recommended industry standards for the instant dissolving time. The response time of the ANOVA cubic model is listed in **Table 2**.

Table 2. ANOVA soluble time response cubic model

No	Source	P value	Result
1	*Model Cubic*	0,0060	Sig.
2	*Lack of Fit*	0,4826	Not Sig.

The mathematical model equation or polynomial for soluble time response analysis is contained in the following Eq. (2).

$$Y = 16.9565\ A - 9.9703\ B + 0.109326\ AB \quad (2)$$

Where: Y = Soluble Time (seconds); A = Maltodextrin; B = Dextrose; AB = Combination of Maltodextrin and Dextrose Proportions

Based on the equation obtained above, the component that significantly influences the dissolving time is the interaction coefficient A because its value is positive (+) 16.9565. The higher the addition of maltodextrin in making instant powder, the more the powder's dissolution time increases. The coefficient B value has a negative value (-) 9.9703, which means that the ability of dextrose to increase the speed of dissolution time is not greater than maltodextrin. The AB coefficient value is positive (+) 0.109326, which states that the combination of maltodextrin and dextrose affects the dissolution time of instant powder. Result of component Mix between Maltodextrin and Dextrose on Soluble Time Test are shown in **Figure 3**.

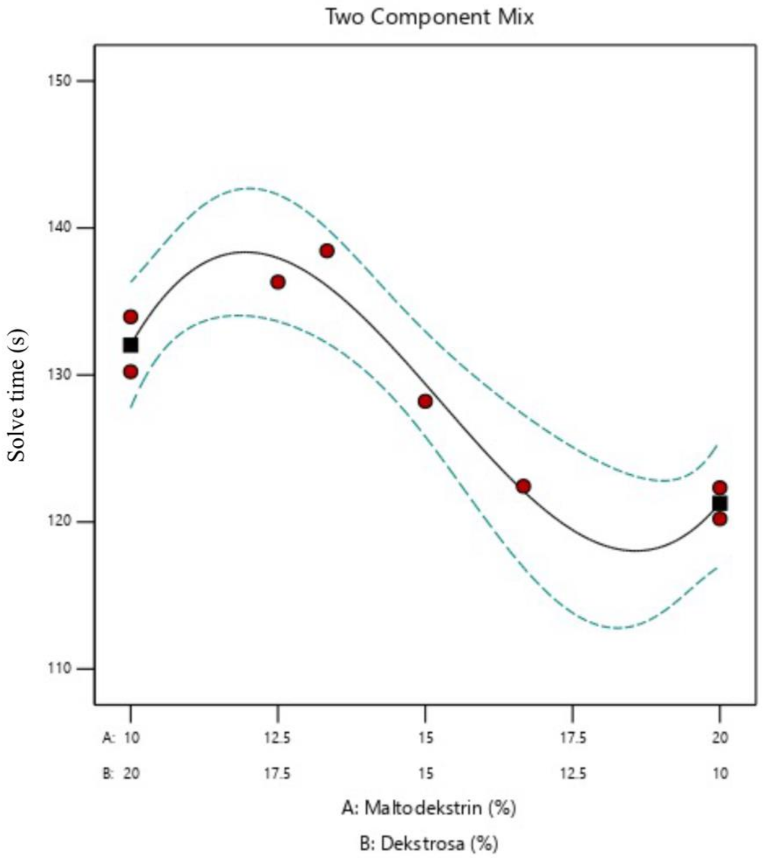

Figure 3. Two-component mix maltodextrin and dextrose on soluble time test

According to the results of a recent study, the addition of maltodextrin can have a significant impact on the dissolution time of instant powder drinks. As pointed out by Corie et al., 2023 the water content of a material is a crucial factor that influences the dissolution time. Instant powdered drinks with a higher water content take longer to dissolve due to the formation of lumps, which require more time to dissolve. This statement is further supported by the research conducted by Kaljannah et al. (2018), who found that noni-powder drinks with high water content take longer to dissolve than powders with low water content. Therefore, the water content of a material is a crucial factor that must be considered when determining the dissolution time of instant powder drinks.

3.1.3. D-optimal Mixture Design (DMD) Analysis

As per the findings of Adhayanti & Ahmad (2021), the most effective blend to predict outcomes involves a mixture of 18.690% Maltodextrin and 11.310% Dextrose, resulting in a desirable outcome score of 0.932. This formula is expected to maintain a water content of 4.892% and dissolve within 118.052 seconds. A desirability score closer to one indicates that the formula performs optimally according to the test variable. Graph of desirability can be seen in **Figure 4**.

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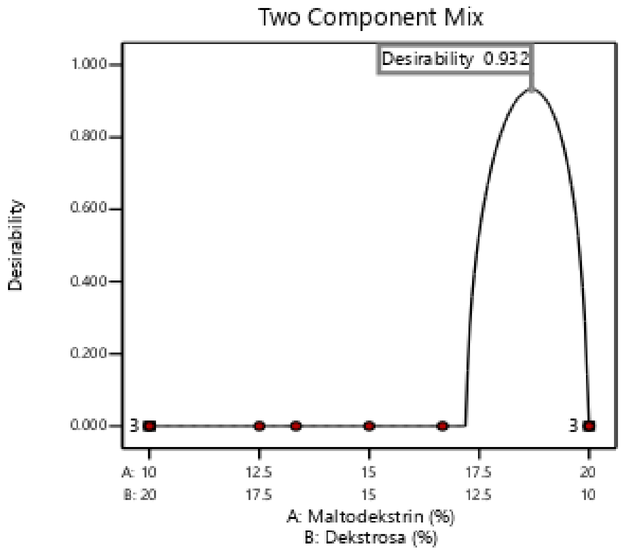

Figure 4. Optimal instant powder desirability graph

3.2. Proximate Analysis of Optimal Formula Instant Powder

The optimal formula of instant onchidiid slug powder was subjected to a proximate analysis test at the Food and Nutrition Center Study Laboratory of Universitas Gajahmada (UGM). The protein content in the powder was found to be 3.54%, which is relatively low compared to previous research on onchidiid slug simplicia powder, which had a protein content of 67.88% (Wijianto et al., 2022). The reduced protein content in the instant onchidiid slug powder is attributed to the cooking process of the filtrate of fresh ground onchidiid slug meat at a temperature of 90 °C for 10 minutes, which causes protein denaturation and amino acid damage. Research by Putri & Amrizal (2020) suggests that minimizing the drying process during powder production can help maintain higher protein levels. Widyanti et al. (2019) also found that protein levels in egg powder can be well maintained at 12.8-13.4% with low drying at 44 °C. The results of the approximate test analysis based on the test parameters can be seen in **Table 3**.

Table 3. Results of proximate analysis

Sample	Result (%)					
	Water	Ash	Fat	Protein	Carbohydrate	fiber
Powder Instant	8,21	0,42	1,54	3,54	86,3	0,85

3.3. Hedonic Test (Level of Likeability)

The study conducted to evaluate the preference level of the onchidiid slug instant powder functional drink sample for various parameters such as color, aroma, taste, and texture has yielded significant results. The results indicate that the sample has a high preference level for each hedonic test parameter. Upon analyzing the results in detail, it can be concluded that the functional drink sample containing onchidiid slug instant powder, ginger, and lime has an excellent acceptance value and is suitable for consumption. The unique combination of these ingredients offers a distinctive flavor and texture that satisfies the taste buds and provides functional benefits. The results of the hedonic test can be seen in **Figure 5**.

The extent of the research is confined to developing and evaluating its efficacy as a functional food for wound healing support therapy. Additional tests are necessary to assess the stability of the preparation, followed by clinical trials on human subjects.

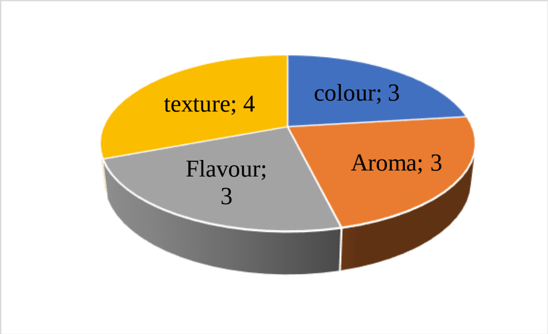

Figure 5. Graph of likeability level for hedonic test factors

4. CONCLUSION

The optimal DMD formula for instant powder is 18.690% maltodextrin and 11.310% dextrose with a water content of 4.892% and a dissolving time of 118.052 seconds. Onchidid slug instant powder contains 8.21% water, 0.42% ash, 0.85% crude fiber, 3.54% protein, 1.54% fat, and 86.3% carbohydrates. Optimization of maltodextrin and dextrose in the onchidiid slug instant powder formula can produce good characteristics of instant powder, with increased dissolution time and more exciting color. Hedonic test result Onchidid slug instant powder is shown as an attractive, functional drink with a great taste, texture, aroma, and color that is widely liked.

5. ACKNOWLEDGMENT

The author would like to thank the Pharmacy Study Program, Faculty of Medicine, Tanjungpura University; Food and Nutrition Center Study Laboratory, Universitas Gadjah Mada, which has supported this research.

6. AUTHOR DECLARATION

Authors' Contributions and Responsibilities

The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation, and discussion of results. The authors read and approved the final manuscript.

Funding

No funding information from the authors.

Availability of Data and Materials

All data are available from the authors.

Competing Interests

The authors declare no competing interest.

Additional Information

No additional information from the authors.

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