JOURNAL OF NUTRITION COLLEGE
Volume 14, Nomor 2, Tahun 2025, Halaman 156-164
Received: 10 September 2024, Revised: 13 Desember 2024
Accepted: 21 Desember 2024, Published: 30 April 2025
Online di: http://ejournal3.undip.ac.id/index.php/jnc/ , DOI:10.14710/jnc.v14i2.46497

OPTIMIZATION OF SHIRATAKI NOODLES FORMULA PREPARED FROM PORANG FLOUR ENRICHED WITH MORINGA LEAVES AND OYSTER MUSHROOM POWDER

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ABSTRACT

This study aimed to determine the optimum formula for shirataki noodles prepared from pouring flour enriched with moringa leaves and oyster mushroom powder. The D-Optimal Mixture Method of Design Expert Software was employed to design the experiment in which 18 different formulas were evaluated during the study. The observed characteristics include the chemical contents (ash and protein contents) and the physical characteristics (elongation, hardness, adhesiveness, and springiness). The results showed the optimum formula of shirataki noodles consisting of 3.88 grams of porang flour, 0.10 grams of Moringa leaves powder, and 0.02 grams of oyster mushrooms flour, provided the desirability value of 0.761.

Keywords*: Shirataki noodles; porang flour; moringa leaves and oyster mushroom powder; optimization*

INTRODUCTION

Noodles are a string-shaped food product made from wheat flour, which is a very popular staple food for Asian people. Indonesia produces more than 13.27 billion packs of instant noodles in 2021 (WINA, 2021). Moreover, Indonesia must import up to 10.3 million tons of wheat flour to fulfil the needs of the noodle and bakery industry (Assa, Koapaha, & Boangmanalu, 2022). Generally, there are two types of noodle products in the market: dry noodles and wet noodles. Since noodles are mostly made from white wheat flour, they contain low fiber (Untari, Herdiana, & Inke, 2021). Sajdakowska, Gębski, Jeżewska-Zychowicz, Jeznach, and Kosicka-Gębska (2021) reported that consumers agreed that fiber addition is necessary for noodles products, however, the presence of fiber deteriorated the sensory acceptance of the noodle's product. Therefore, noodles containing high fiber acceptable for consumers are in demand, particularly for niche market noodles such as noodles for people on a diet (Khorasaniha et al., 2023) and diabetics (Saboo et al., 2022).

Porang flour is made from porang tuber (Amorphophallus muelleri blume). The flour contains a high percentage of glucomannan. Glucomannan is a soluble fibre that can form a thick solution in water (Faridah, 2011). Glucomannan solution will expand its volume when agitated at high speed (Untari et al., 2021). The expansion is because the air is entrapped within the matrix of glucomannan. Glucomannan solution also can form a hard gel when mixed with alkali solutions (Luo, He, & Lin, 2013). Glucomannan undergoes complex reactions, including deacetylation, self-aggregation, entanglement, and local and continuous gel network structure, forming an irreversible hard gel. Based on this principle, glucomannan has been widely used as the main ingredient of Japanese glucomannan noodles, known as shirataki noodles (Impaprasert et al., 2016).

Moringa is a native plant to the tropical and subtropical regions of South Asia countries such as Indonesia and Malaysia. Moringa leaves have been utilized as food and medicine for centuries. Moringa leaves can be processed to be powder; therefore, they can be added with another ingredient for food products. Moringa leaves contain high nutritional values, such as essential amino acids and minerals (Gopalakrishnan, Doriya, & Kumar, 2016). Moringa

leaves contain a high proportion of iron; therefore, it can be applied to overcome iron deficiency in anemia patients (Kasri, 2022). Oyster mushrooms are one type of mushroom that is widely cultivated in Indonesia. Commonly, it is consumed as a vegetable. It has also been used as an ingredient in various types of food, such as nuggets, sausages and mushroom pudding. Dried oyster mushrooms contain protein up to 19-35% (Wang & Zhao, 2023). Since oyster mushroom protein has a high glutamic acid content, oyster mushroom powder is widely used as a natural umami ingredient in Chinese restaurants (Nurainy, Sugiharto, & Sari, 2015). Enrichment of moringa leaves and oyster mushroom powder in shirataki noodles products might increase the product's nutritional values and protein content. This study was intended to optimize the addition of moringa leaves, oyster mushrooms powder, and porang flour in the shirataki noodles formula by using Mixture D-Optimal Modul in the Design Expert Software. The software was selected as the most used software in the process optimization. The optimized characteristics include chemical contents (ash and protein contents) and physical characteristics (elongation, hardness, adhesiveness, and springiness).

MATERIALS AND METHODS

MATERIAL

Porang tuber was supplied by a local farmer (Jalan Cagak, Subang, West Java). Moringa leaves, and oyster mushrooms (Jamur Tiram Organic Flour, Iels Organic, Sleman, Yogyakarta) powder were purchased from the Tokopedia online market. Glucose syrup with a brix of 75 was obtained from a local food producer (Sweet Food Supply, Bekasi, West Java). Technical-grade sodium hydroxide was purchased from a local chemical store (Rofa Laboratorium, Indonesia). Ethanol used for porang flour preparation was technical grade (Cloger Shop, Indonesia).

Preparation Of Porang Flour

Porang flour was prepared according to the method of Sarifudin et al. (2022) with modifications. Dry powder of porang tuber (100 g) was mixed with 500 ml of ethanol solution (40 %v/v) for 1 min. The mix was then filtered using a lab-scale separator machine (Madato Vitamax Food Processor Double Tube, Bandung, Indonesia) with screen of 100 mesh. The retentate was remixed with 500 ml of ethanol solution (40 %v/v) and then filtered again. This separation process was repeated three times. Lastly, the retentate was washed with absolute ethanol and dried in an oven (Memmert UFB-500, Schwabach, Germany) at 50 °C for 12 hrs. The dried porang flour was then ground and sieved with an aperture size of 150 µm.

Sample Preparation Of Shirataki Noodles

The method of Impaprasert et al. (2016) was modified in preparing the shirataki noodles sample. Porang flour, moringa leaves, and oyster mushroom powder with a specific weight were drily mixed. The formula for shirataki noodles, which was designed using Design Expert Software, is presented in Table 1.

Table 1. Formula of shirataki noodles

Formula	Weight of ingredients (grams)			
	Porang Flour (A)	Oyster Mushroom Powder (B)	Moringa Leaves Powder (C)	Total weight (grams)
1	3.96	0.02	0.02	4
2	3.84	0.06	0.10	4
3	3.88	0.02	0.10	4
4	3.80	0.10	0.10	4
5	3.92	0.02	0.06	4
6	3.92	0.06	0.02	4
7	3.80	0.10	0.10	4
8	3.88	0.02	0.10	4
9	3.88	0.06	0.06	4
10	3.96	0.02	0.02	4
11	3.92	0.02	0.06	4
12	3.88	0.10	0.02	4
13	3.84	0.10	0.06	4
14	3.88	0.10	0.02	4
15	3.92	0.06	0.02	4
16	3.84	0.06	0.10	4
17	3.84	0.10	0.06	4
18	3.88	0.06	0.06	4

Water of 96 grams was added to the dry ingredients and mixed well. The batter then was allowed to firm for 30 min. Then, the dough was injected into the noodles molding machine to form noodles strands. The noodle strands were cooked in a boiled NaOH solution of pH 12 for 2 min. Then, the noodle strands were soaked in a glucose solution of 70% for 5 hrs. Finally, the wet noodles were dried in an oven at 50 oC for 6 hrs. Before analysis, the samples were sealed in plastic bags and stored at room temperature.

ASH AND PROTEIN CONTENT ANALYSIS

ASH CONTENT

Ash content analysis was carried out according to AOAC (2005). The pre-weighted sample was placed in a porcelain cup and then heated in a furnace at 350 °C for 2 hours. The furnace temperature was raised to 550 °C, and the sample was continuously heated for four hours until the ashing process was completed. The sample was placed in a desiccator for three hours and then weighed. The ash content is calculated using the following formula.

$$\text{Ash content (\%)} = \frac{weight\ of\ ash}{initial\ weight\ of\ sample} \times 100\%$$

Protein Content

The protein content of the sample was determined according to the Dumas combustion method (Serrano, Rincón, & García-Olmo, 2013). A sample of 200 mg was crushed and placed in tin foil. The sample was placed in the holder inside the Dumas protein analyzer (DuMaster D-480, Buchi, Switzerland). The amount of nitrogen released from the combustion process was then multiplied with a conversion factor (5.75) to obtain the protein content of the sample.

Elongation Analysis

Elongation analysis of the shirataki noodles sample was conducted following Sholichah, Indrianti, Yulianti, Sarifudin, and Kiatponglarp (2020) with modifications. A texture analyzer (TA.XT Plus Stable Microsystem, Surrey, UK) was employed for the elongation analysis. The dry shirataki noodles were soaked in boiled water for 2 min, then drained at room temperature for 3 min. The rehydrated shirataki noodles elongation analysis was performed immediately after the rehydration process. Noodles tensile grip (A/SPR) was used during the analysis. The analysis was performed using the following parameters: rig pre-test of 1 mm/s, test speed of 3 mm/s, post-test speed of 10 mm/s and initial distance clamps of 2 cm. The percent of elongation was calculated by the following equation:

$$\text{Percent of elongation (\%)} = \frac{(\text{break up distance} \times \text{probe speed})}{\text{probe distance}} \times 100\%$$

Texture Profile Analysis (Tpa)

The texture profile analysis (TPA) of the shirataki noodles sample was analyzed by following the method of Sholichah et al. (2020). A texture analyzer (TA.XT Plus Stable Microsystem, Surrey, UK) with a P/36R cylinder probe was employed during the texture profile analysis of the sample. The TPA test mode was operated in trigger type in which the force was 0.5 g, pretest speed of 2 mm/s, test speed of 2 mm/s, post-test speed of 10 mm/s, and strain was 75%. Three major texture profile parameters were reported, including hardness, adhesiveness and springiness values.

Experimental Design And Statistical Analysis

The number of experiments to obtain the optimal formula of shirataki noodles prepared from porang flour enriched with moringa leaves and oyster mushrooms powder was performed by Design Expert 7 in the module of Mixture D-Optimal. The shirataki noodles' characteristics, including the chemical contents (as and protein contents) and physical characteristics (elongation, hardness, adhesiveness, and springiness), were observed in triplicate.

RESULTS AND DISCUSSION

Response of ash and protein content

Ash content

The ash content of shirataki noodles prepared from porang flour enriched with moringa leaves and oyster mushroom powder is displayed in Figure 1. The value of ash content was ranged from 0.73% to 0.94%. The ash content of the sample comprised of minerals contained in the ingredient. Ardiansyah and Astuti (2014) reported that oyster mushrooms and moringa leaves contain many essential minerals such as Fe, Ca, and K. Moreover, the ash content in the shirataki noodles might also come from the calcium oxalate, which naturally exists in the porang flour (Sarifudin et al., 2022). Therefore, the ash content in the shirataki noodles should be limited. The ash content of shirataki noodles obtained in this study fulfilled the maximum ash content stated in the national standard of wet noodles (maximum of 3%) (Standard), 1992) also

vermicelli noodles (maximum of 2%) (Standard), 1995).

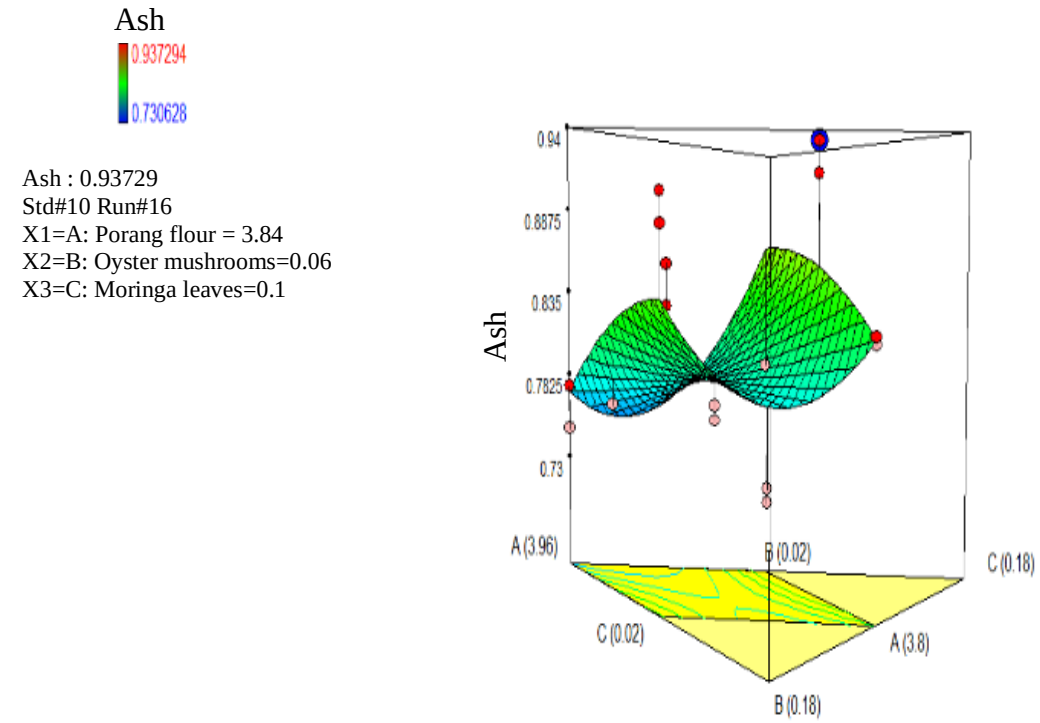

Figure 1. Response surface graph of ash content of shirataki noodles from porang flour enriched with moringa leaves and oyster mushrooms powder.

Protein content

Figure 2 displayed the protein content of shirataki noodles from porang flour enriched with moringa leaves and oyster mushrooms powder. The maximum protein content achieved was 0.40%. Meanwhile, the minimum value was 0.21%. This result suggested that the protein content in the shirataki noodles prepared in this study was relatively low. The low protein content might be because the amount of moringa leaves and oyster mushroom powder added to the shirataki noodles formula was very low. Sumadi, Subrata, and Sutrisno (2017) reported that moringa leaves and oyster mushroom powder can be used as protein sources in many food products since they contain high protein. However, the protein content in the shirataki noodles prepared in this study fulfilled the national standard of wet noodles (maximum of 3%) (Standard), 1992).

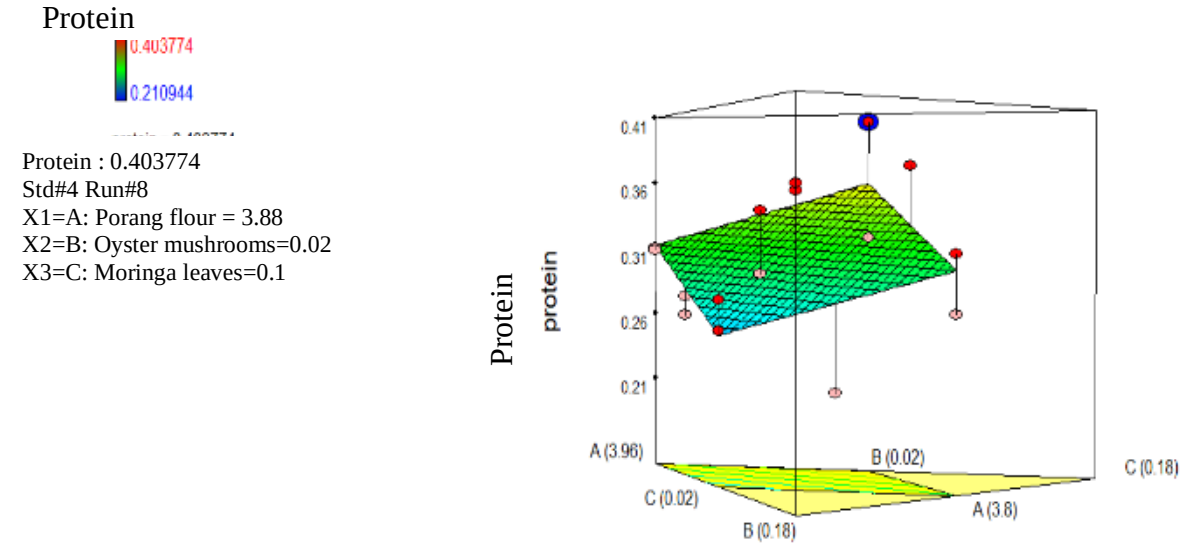

Figure 2. Response surface graph of protein content of shirataki noodles from porang flour enriched with moringa leaves and oyster mushrooms powder.

Response of elongation value

Results showed that the elongation value of shirataki noodles from porang flour enriched with moringa leaves and oyster mushroom powder ranged from 12.07% to 36.03% (Figure 3). Elongation is one of the parameters used to determine noodles' quality. According to strength, if the low tensile strength proves that the noodles are very brittle, the quality will also decrease (Sholichah et al., 2020). Therefore, it is necessary to obtain noodles with optimum elongation value. This study showed that Formula 7 was the formula to obtain shirataki noodles with an optimum elongation value of 36.03%.

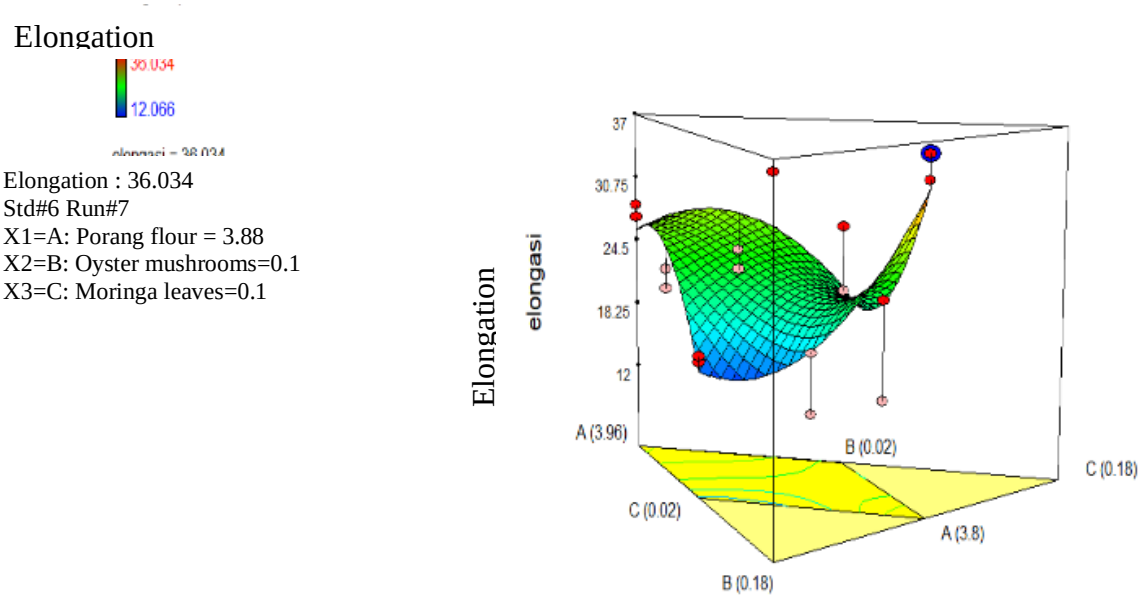

Figure 3. Response surface graph of elongation of shirataki noodles from porang flour enriched with moringa leaves and oyster mushrooms powder.

Response of texture profile parameters

Hardness

The hardness profile of shirataki noodles from porang flour enriched with moringa leaves and oyster mushrooms powder can be seen in Figure 4. Results showed that the hardness values ranged from 83.50 gf to 1800.33 gf. The optimum hardness value is required so the consumer obtains a unique feeling when chewing the product. Consumers have different expectations regarding the hardness of different types of products. Therefore, hardness can be defined as the amount of compressive force to break down a food product. Hardness is expressed from the maximum force in the first compression with the unit grams force (GF). The value obtained indicates the required force (Haliza, Kailaku, & Yuliani, 2017). Noodles with high hardness values indicate that the formula contains more ingredients that induce high hardness values (Ila, 2012). Glucomannan is a significant component in porang flour that can form a hard gel by reaction with calcium (Impaprasert et al., 2016). Formula six, which is composed of porang flour of 3.92 g, oyster mushrooms powder of 0.06 g, and moringa leaves powder of 0.02 g, provided the highest hardness value of shirataki noodles.

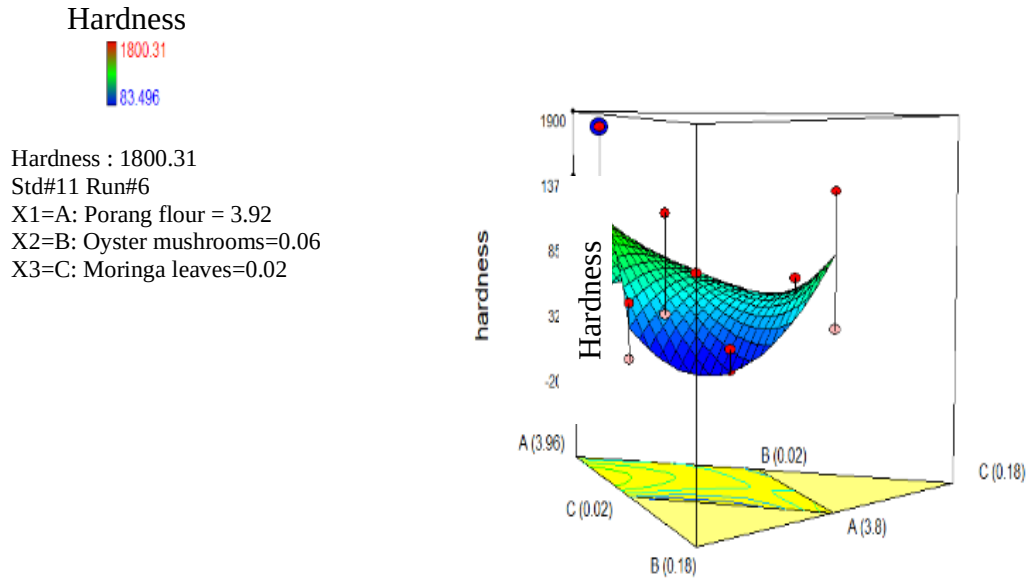

Figure 4. Response surface graph of hardness of shirataki noodles from porang flour enriched with moringa leaves and oyster mushrooms powder.

Adhesiveness

Figure 5 displays the adhesiveness profile of shirataki noodles from pouring flour enriched with moringa leaf and oyster mushroom powder. Some shirataki noodle samples showed adhesiveness properties, as indicated by the negative value of adhesiveness. Meanwhile, some others did not exhibit adhesiveness properties, as indicated by a zero-adhesiveness value. Texture (adhesiveness) is the force required to pull food off the surface. The adhesiveness value is the area between the first and second compression areas. In texture measurements, the adhesiveness is obtained from the curve area below the line and is usually negative; the greater the negative value, the greater the adhesiveness value of the measured product (Haliza et al., 2017). Most noodle consumers prefer noodles with a low adhesiveness value (close to zero). In this study, the optimum formula to obtain a low adhesiveness value was formula 11, composed of 3.92 g of porang flour, 0.02 g of oyster mushrooms powder, and 0.06 g of moringa leaves powder.

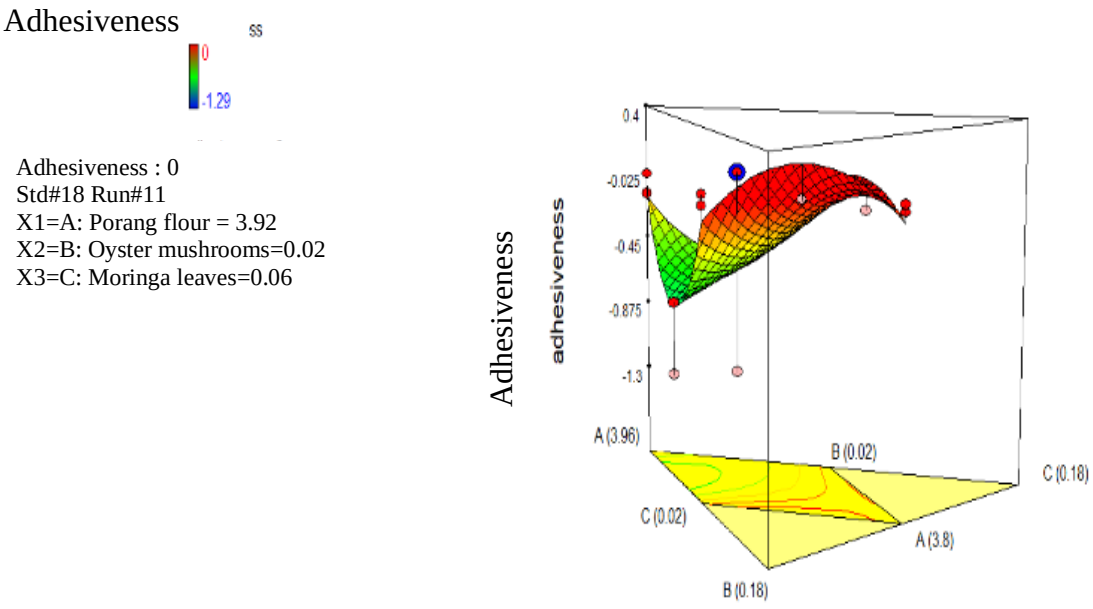

Figure 5. Response surface graph of adhesiveness of shirataki noodles from porang flour enriched with moringa leaves and oyster mushrooms powder.

Springiness

The springiness value of shirataki noodles from porang flour enriched with moringa leaves and oyster mushrooms powder can be seen in Figure 6. The springiness value ranged from 0.78 to 0.95 gf. Good noodles need to have high springiness value to get good acceptance from the consumer. The springiness describes the product's ability to return to its initial position after the first bite (Haliza et al., 2017). Glucomannan can create a matrix between all ingredients components, improving the springiness properties of shirataki noodles (Ila, 2012). Results of this study suggested the third formula, including 3.88 g of porang flour, 0.02 g of oyster mushrooms powder, and 0.1 g of Moringa leaves powder, as the best formula to obtain shirataki noodles with optimum springiness value.

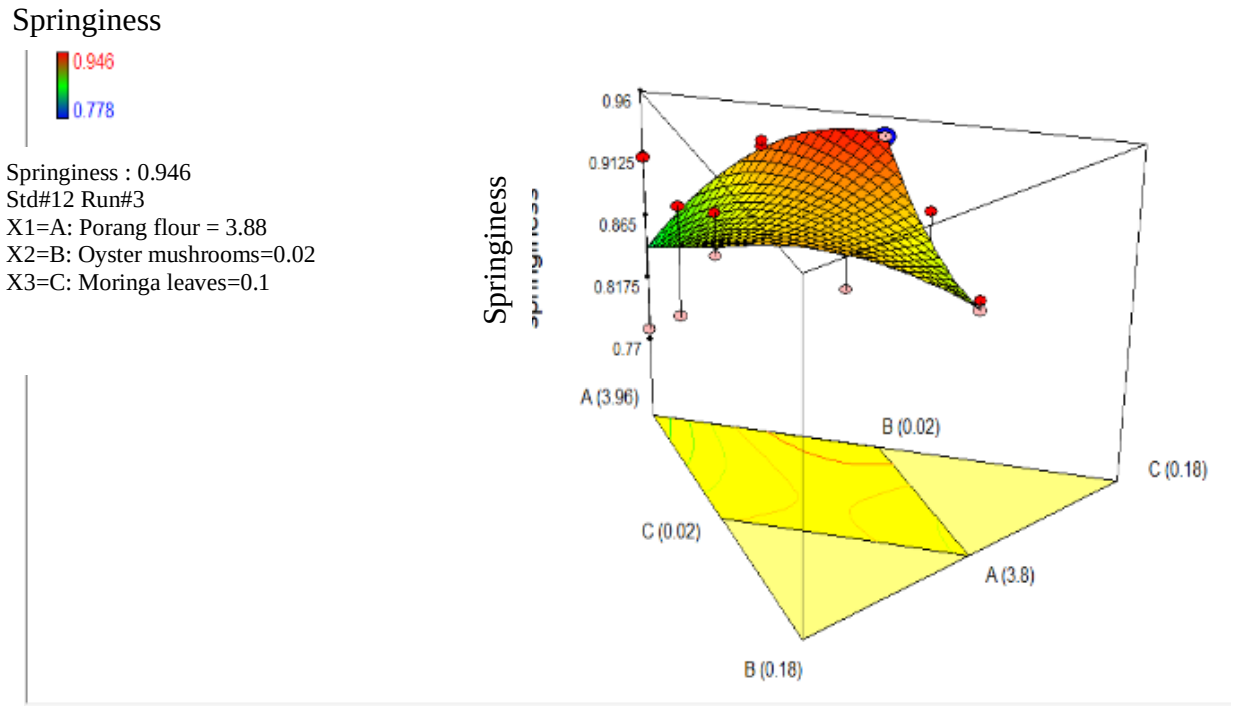

Figure 6. Response surface graph of springiness of shirataki noodles from porang flour enriched with moringa leaves and oyster mushrooms powder.

Selection of the best shirataki noodle formula

The result of the selection of parameters of shirataki noodles based on the chemical response (ash content and protein content) and physical response (elongation, texture (hardness, adhesiveness and springiness) is presented in Table 2. Results indicated that the protein content was the only significant parameter influencing the shirataki noodles ($p<0.05$). The predicted models still provided low R2 values, which might be due to the narrow range of experiments (Table 1).

Table 2. Result of Anova analysis and predicted value of shirataki noodles quality parameters.

Response	The model	p-value of model	p-value lack of fit	R^2	Adjusted R^2	Predicted R^2	Adequate precise
Ash	Quadratic	0.3561	< *0.0001*	0.3378	0.0619	-0.4622	2.762
Protein	Linear	0.0075	*0.4384*	0.4788	0.4093	0.2851	7.339
Elongation	Special cubic	0.1233	*0.0031*	0.5443	0.2957	-0.0762	4.836
Hardness	Special cubic	0.2063	*0.6347*	0.4839	0.2025	-0.4311	4.168
Adhesiveness	Special cubic	0.1831	*0.1391*	0.4990	0.2257	-0.2077	4.294
Springiness	Special cubic	0.1922	*0.7585*	0.4930	0.2164	-0.6255	4.510

The selection of the best formula for shirataki noodles based on desirability value using the Design Expert program is presented in Figure 7. The program selected formula 3, with a desirability value of 0.761, as the best formula to obtain shirataki noodles with optimum protein content. The formula consi r mixed with 4 grams of flour 88 grams of porang flour, 0.02 grams of oyster mushrooms powder, and 0.10 grams of Moringa leaves powder.

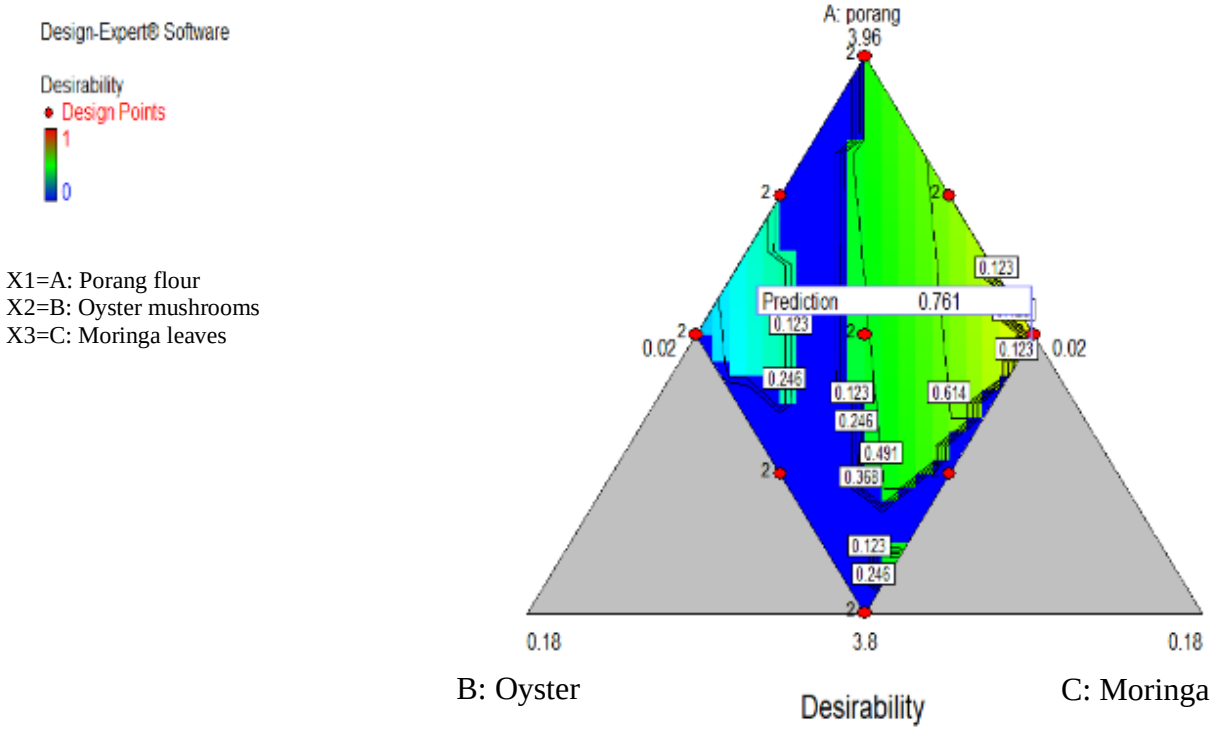

Figure 7. Desirability chart of shirataki shirataki noodles from porang flour enriched with moringa leaves and oyster mushrooms powder.

CONCLUSION

Moringa leaves, and oyster mushroom powder was successfully incorporated into shirataki noodles prepared from porang flour. The obtained shirataki noodles showed relatively low ash content (<3%) and protein content (<0.21%). Shirataki noodles also showed good elongation properties (>36.03%). However, the hardness values of the shirataki noodles were high (>1800.33 gf) and good springiness (<0.95), which could be the impact of glucomannan content. Formula 3, which consisted of 96 ml of water mixed with 4 grams of flour formula including 3.88 grams of porang flour, 0.02 grams of oyster mushrooms powder, and 0.10 grams of Moringa leaves powder, was selected as the best formula with a desirability value of 0.761.

ACKNWLEDGEMENTS

The authors acknowledged the WAITRO Innovation Award 2021 and the Research Organization for Food and Agriculture through Programme House of Appropriate Technology 2022 for funding the research.

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