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IMPACT OF TEMPEH FLOUR SUPPLEMENTATION ON THE PROPERTIES OF NON-GLUTEN PASTA PRODUCT

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ABSTRACT

Gluten-free products are needed by people with gluten allergy such as celiac disease and autism. The consumption of gluten-free products rises annually and, therefore, there is potential in the development of gluten-free products. Most of the non-gluten pasta products (NGP) contain a low amount of protein. In this study, NGP prepared from modified cassava flour (mocaf) (40%), rice flour (35%), and maize flour (25%), was supplemented with tempeh flour as a source of protein. In this research, NGP was prepared by extrusion. The cooked dough was extruded using a single screw extruder (screw diameter, 60 mm, locally manufactured by the Research Centre for Appropriate Technology-Indonesian Institute of Sciences, Subang, West Java Indonesia). The procedure of making NGP involved mixing all ingredients, steaming, extrusion, tempering, drying, and packaging. The effect of tempeh flour supplementation (0%, 2.5%, 5%, 7.5%, 10%, 12.5%, and 15% (w/w)) on the properties of NGP product was evaluated. The parameters of NGP that were evaluated included chemical properties, texture profile, elongation break, cooking properties, crystallinity structure, and morphological properties. The chemical properties included proximate and mineral content (iron (Fe) and zinc (Zn)) analysis. Results showed that adding tempeh flour significantly increased the protein, fat, fibre, iron, and zinc contents of NGP. The NGP had a moisture content of approximately 10%–12%. The higher tempeh flour addition resulted in the higher protein, lipid, Fe, and Zn contents of NGP. The highest protein and minerals (Fe and Zn) were obtained by 15% tempeh flour addition. Adding a higher amount of tempeh flour induced the higher percentage of V-type crystalline structure of amylose–lipid complex. Higher supplementation of tempeh flour resulted in higher cooking loss and decreased adhesiveness, springiness, and cohesiveness of the NGP product. The range of cooking time of NGP was between 5 min 25 sec and 6 min 50 sec. The supplementation of tempeh flour in the NGP reduced the cooking time. Observation of the morphological properties showed that starch of NGP ingredients had been fully gelatinized during the extrusion process as indicated by absence of intact starch granules. Based on the results, it is suggested to supplement NGP with tempeh flour up to 10% (w/w) to get the nutritional advantage of tempeh without depressing its textural and cooking qualities.

Key words: non-gluten pasta product, tempeh flour, modified cassava flour, maize flour ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 20 No. 7 December 2020 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

INTRODUCTION

Gluten-free pasta products were initially developed for a niche market of people with celiac disease. Nowadays, the consumption of gluten-free products has become a global trend even for those who do not have this metabolic syndrome. The amount of gluten-free products that are sold reaches 11,6 million USD and is predicted to increase in the future [1]. Developing NGP has a good opportunity in the global and local markets, especially using local ingredients such as tubers and cereals.

Pasta products made from wheat flour have springy and elastic textures which are due to the role of gluten. Therefore, the major challenges of the development of non-gluten pasta product (NGP) are ingredient formulation and process development such that the obtained pasta product will have a texture similar to gluten pasta product (GP) [2].

Wheat substitute ingredients used to prepare NGP should contain starch as their major component, for example, cassava, rice, and cornflour [3,4]. The proportion of starch components greatly influences the physicochemical and textural properties of NGP products. Moreover, temperatures for the cooking process and methods for pasta moulding are important factors to obtain NGP dough with springy and elastic characteristics.

Non-wheat flours usually contain a lower amount of protein and fibre than wheat flour. Therefore, the use of raw materials with high protein or fibre content is suggested in NGP formulation [5,6]. It has been reported that fat-free beans powder increases the protein content of rice pasta [6]. Soybean is one of the commonly consumed vegetable proteins among Asians. Soy derivatives are known to have potential benefits for disease prevention and health treatment such as children with protein deficiency, chronic diseases, common cancers and heart diseases [5]. However, beans with high protein content also contain phytic acid that can inhibit nutrient absorption, particularly minerals, in the digestive tract. Ratnawati *et al.* [7] reported that soybean has a high protein content (40.94%) and high phytic acid content (2.78%). Phytic acid can bind to essential minerals such as iron and zinc in the digestive tract and inhibit their absorption by the body [8].

Tempeh which is a fermented soybean product is popular in Asian countries. Mostly, it can be found on the daily menu of Southeast Asian families. Recently, it has also been consumed widely among Westerners [6]. Tempeh has been investigated to contain a lower amount of phytic acid and a higher percentage of amino acids than non-fermented beans [9]. Moreover, tempeh flour has higher bioavailability values of minerals and amino acids than soybean flour [10]. Aini *et al.* [9] reported that adding tempeh flour in a ratio of 8:2 for tempeh flour to corn flour increased the protein content of corn noodles up to 8.2%. Tempeh is also considered to be the best non-animal source of protein, and it contains vitamin B12, antioxidants, phytochemicals, and other bioactive substances [11]. Therefore, supplementation of tempeh flour in NGP is expected to provide additional nutritional benefits to the product.

It is expected that adding tempeh into NGP formula will increase its nutritional value, particularly protein content. However, the effect of tempeh flour supplementation on the properties of NGP has not yet been reported. Therefore, this study aimed to investigate the impact of tempeh flour supplementation on the properties of NGP including proximate and mineral (Fe and Zn) content, crystalline structure, morphological, and cooking properties.

MATERIAL AND METHODS

Materials

Modified cassava flour (mocaf) was purchased from Abah Cumid, a local mocaf producer in Subang, West Java, Indonesia. Rice flour (Rose Brand, Indonesia), and salt were obtained from a local market in Subang, West Java, Indonesia. Maize flour was prepared from a local corn variety of Pioneer 21. Fresh tempeh for tempeh flour preparation was purchased from a local tempeh producer in Subang West Java, Indonesia. Chemicals for analysis (n-hexane, hydrochloric acid, and nitric acid) were purchased from Merck (Germany).

Preparation of pasta product

Tempeh flour was prepared according to the method of Mursyid *et al.* [12] with slight modifications. The fresh tempeh was sliced, blanched, dried, milled, and filtered using a 40-mesh sieve. The maize flour was prepared according to the protocol of Bastidas *et al.* [13]. In brief, the corn kernel was coarsely chopped, separated from its pericarp, dried, milled, and finally filtered using a 40-mesh sieve. The NGP was prepared according to the previous method of Ratnawati and Afifah [14]. All the ingredients were weighed according to the formula in Table 1, mixed with a vertical mixer for 5 min, and steamed in a vertical steamer at 95°C for 30 min. The cooked dough was then extruded using a single screw extruder (screw diameter, 60 mm, locally manufactured by the Development Center for Appropriate Technology, Subang, West Java Indonesia). The barrel length was 45 mm. The extruder was operated at a screw speed of 50 rpm, and the setting temperature of the barrel was 60°C. The barrel was heated by an electrical heater of 1 kW. The heater temperature was controlled by a controller. The extruder driver was an AC motor (220 V, 3 HP) and operated at a speed of 1600 rpm. The motor and the screws were connected through a fixed gearbox of a ratio of 300:1. The subsequent process was slow drying using a circulating fan in an air-conditioned room. The wet pasta product was dried overnight in an air-conditioned room at a temperature of 22 °C. The air-circulating dryer was used to remove the remaining moisture from the product. The drying process was terminated when the product had moisture content of approximately 10%–12%, which was indicated by the breakability of NGP and transparency in the core of NGP. Before and after drying process, the moisture content of samples was determined.The experiment was carried out in triplicate. Prior to analysis, all samples were kept in a closed box at ambient temperature.

Determination of proximate and mineral (Fe and Zn) contents

The proximate content including moisture, ash, lipid, and carbohydrate was determined according to the method of Food and Beverage Analysis [15]. The protein content was determined using the Dumas method in Buchi Dumaster. The mineral contents (Fe and Zn) were determined by an inductively coupled plasma-optical emission spectrometry method (Agilent ICP OES 720, USA). Before the analysis, the sample was bashed in a furnace at 450°C for 12 h. The ash was then solubilized in a mixture of HNO_3 and water, filtered and injected into the instrument. All analyses were carried out in duplicate.

Crystalline structure

The crystalline structure of samples was assayed using the WAXS technique. The WAXS analysis was carried out at the 1.3 WAXS station, Synchrotron Light Research Institute, Nakhon Ratchasima, Thailand. The beamline was set according to the report of Soontaranon *et al.* [16] with some modifications. The sample to detect distance was set at 203.9 mm, and an X-ray energy of 9 keV was used. The WAXS measurement was recorded using a MAR-CCD (SX165) detector with a detecting radius of 82.5 mm. The moisture content of the samples was equilibrated in a closed chamber filled with a saturated LiCl solution for 7 days. The WAXS data from the scattering angle at 2θ of 3 to 30° was normalized to give an area under the curve of 100. The crystalline peaks were refined from the amorphous part by an in-house developed software called SAXSIT (https://www.slri.or.th/en/bl13w-saxs.html). The relative crystallinity was determined according to the following equation (i):

$$\text{Relative Crystallinity [\%]} = \frac{\text{area of crystalline peaks}}{\text{total area of diffractogram}} \text{ x } 100\% \quad \text{.....................(i)}$$

Morphological properties

The morphological property of samples was observed by a Field Emission-Scanning Electron Microscope (Auriga^{Tm}-Carl Zeiss, Jena, Germany). Before the analysis, the sample was milled and filtered through a 60-mesh sieve. The sample was mounted on a metal stub which was previously covered with double-sided adhesive tape. The excess sample was removed by spraying it with nitrogen. Then, it was coated with gold and examined with an accelerating voltage of 2 kV.

Elongation break and texture profile analysis

A texture analyzer (TA. XT plus C, Stable Micro System®, Vienna Court, Surrey, UK) was employed to determine the texture profile of samples including elongation break, springiness, adhesiveness, and cohesiveness values. A modified method of Ratnawati and Afifah [14] was used to prepare the samples. Spaghetti was prepared by cooking in the boiling water for several minutes (based on the cooking time of each sample). A spaghetti tensile grip rig probe (A/SPR) was utilized to measure the elongation break. The measurement settings were as follows: pre-test at the speed of 1 mm/s, test at the speed of 3 mm/s, and post-test at the speed of 10 mm/s with the initial distance between the clampers at 20 mm. Then, the elongation break was determined as follow (ii):

$$\text{Elongation break} = \frac{\text{s x probe speed } \left(\frac{\text{mm}}{\text{s}}\right)}{\text{probe distance (mm)}} \text{ x } 100\% \quad \text{......................................(ii)}$$

Where *s* is the time to break.

The hardness, adhesiveness, and cohesiveness values of the samples were obtained using a P/36R cylinder probe. The test mode was trigger type where the force was 0.5 g; pre-test speed, 2 mm/s; test speed, 2 mm/s; post-test speed, 10 mm/s; and strain, 75%. The unit of hardness is gram force (gf) while the unit of adhesiveness is the gram second (gs). All measurements were performed in five replicates.

Cooking properties
The cooking time of the sample was determined by the method of Phongthai *et al.* [17] with some modifications. Sample (5g) was cooked in 100 ml of boiling water. The cooking time was determined according to the time taken for the complete gelatinization of the product, which was indicated by the disappearance of the white core of the pasta sample when it was squeezed between two glass plates. The cooking water and cooked pasta samples were dried in a hot air oven at 105°C for 5 h. The cooking loss of the sample was calculated using the following equation (iii):

$$\text{Cooking loss [\%]} = \frac{\text{Ws [gram]}}{\text{Wf [gram]}} \times 100\% \qquad \text{.....(iii)}$$

Where W_s is the weight of the sediment in the cooking water after drying and W_f is the weight of the cooked pasta after drying.

Sensory evaluation
In order to evaluate the effect of tempeh flour on sensory acceptance, the two samples were selected. The sample K did not contain tempeh flour and sample M6 contained tempeh flour at the highest percentage. These samples were evaluated for their sensory acceptability through six sensory evaluation parameters, namely color, flavor, adhesiveness, springiness, taste, and overall acceptability using the hedonic scale from 1 to 7 in which 1 represents "extremely dislike," 7 indicates "extremely like," and 4 signifies "not liked nor disliked" values. The sensory perception of the samples was evaluated by 33 respondents aged 17–60 years. The mean and modus values of each sensory parameter were reported.

Statistical Analysis
A one-way analysis of variance test was employed to determine the mean variation between the samples. The least significant differences test was performed to compare the mean values of samples at a confidence level of 95% ($p \leq 0.05$). Statistical Package for the Social Sciences (SPSS) software version 17.0 (https://www.ibm.com/analytics/spss-statistics-software) was used to perform the statistical analysis.

RESULTS AND DISCUSSION

Proximate and mineral (Fe and Zn) contents
The proximate composition, iron, and zinc content of samples are presented in Table 2. Moisture content was not significantly influenced by the addition of tempeh flour. The NGP showed high moisture content (35%-37%) when it came out from the extruder. The moisture content of NGP obtained by this process was lower than the maximum moisture content of noodles according to the Indonesian Quality Standards (SNI 8217:2015), which is 13%. The pasta product with low moisture content has longer shelf life than those with high moisture content as stated in the the Indonesian Quality Standards [18]. The ash of all samples was not significantly different. Although tempeh flour showed

higher ash content than other flour [19, 20], the result of this study indicated that the addition of 2.5%-15% of tempeh flour could not increase the ash of NGP significantly.

Tempeh flour prepared from non-defatted soybean contains a high amount of protein and lipid. As expected, tempeh flour supplementation significantly increased the protein and lipid content of samples but decreased the carbohydrate content in NGP. Tempeh flour increased the protein content of NGP significantly from 5.72% to 10.27% or 1.79 fold. Therefore, adding tempeh flour into the NGP formula increased the protein and lipid content of the NGP products. This result is in line with a previous report [21] which stated that adding tempeh flour into the gluten-free cereal bar product with an amount of 15% increased the protein content of the product from 6.24% up to 11.02% or 1.77 fold. Adding tempeh flour to corn noodles also enriched the protein and fat contents of the products [9]. Tempeh flour contains a protein of 45.43% [20], therefore, tempeh could be the main contributor to increase the protein content of NGP.

The iron and zinc content of the NGP products increased significantly by the addition of tempeh flour which are 6.94 (mg/100g) and 1.2 (mg/100g) (Table 2), respectively. A previous study has shown that tempeh flour contains 0.011% and 0.0046% iron and zinc, respectively [19]. Non-gluten pasta enriched with tempeh flour may be beneficial for people with iron and zinc deficiencies. Consuming the NGP supplemented with tempeh flour will help people to obtain adequate amounts of iron and zinc as mentioned in the Indonesian regulation for labeling the nutrient intake from processed food which is 22 mg/day and 13 mg/day, respectively [23].

Crystalline structure

The diffractograms and the relative crystallinity of the NGP products are shown in Figure 1 and Table 3, respectively. All samples did not show the identity peaks of native starch which indicated that starch granules in the NGP ingredients have been gelatinized [24]. The crystal structure of native starch probably was destroyed during the extrusion process. The result showed that all NGP products exhibited the identity peaks of V-type crystalline structure including peaks at 2θ of 7.5°, 12.9°, and 19.8° (Figure 1)[25]. Generally, the percentage of V-type crystallinity of the control sample (K) was lower than that of the treated samples (Table 3). These results suggested that tempeh flour supplementation increased the percentage of amylose–lipid complex. The complex of amylose with lipid may be formed during the extrusion cooking. The lipid might have originated from tempeh flour (Table 2) or maize flour since both contain indigenous lipids [26].

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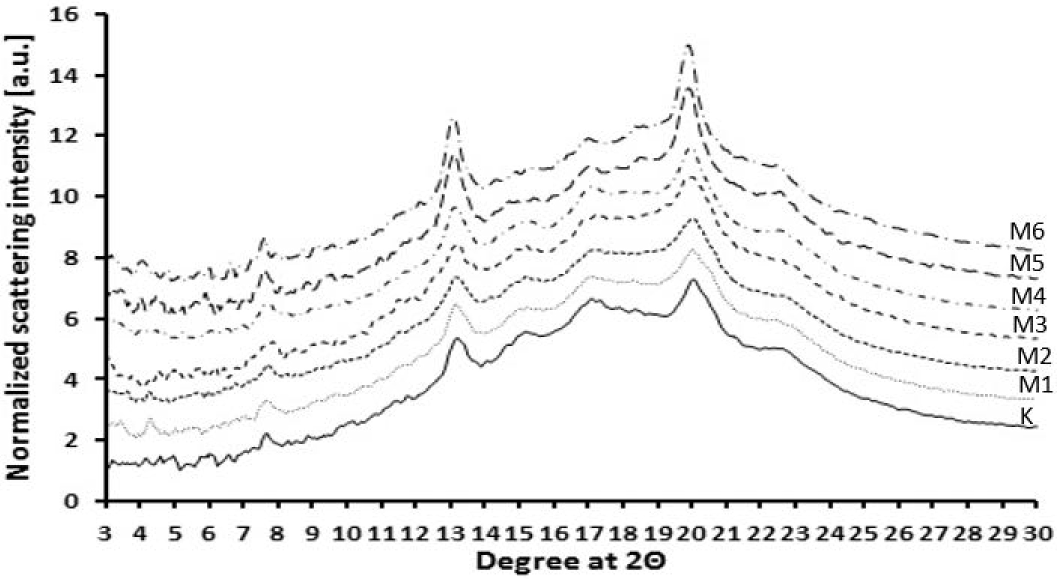

Figure 1: X-ray diffraction pattern of non-gluten pasta (NGP) products supplemented with tempeh flour (K: 0%, M1: 2.5%, M2: 5%, M3: 7.5%, M4: 10%, M5: 12.5%, and M6: 15%)

Morphological properties

Figure 2 shows the morphological properties of the NGP and the control sample. It can be confirmed from the figure that starches from NGP ingredients including tempeh, mocaf, rice, and corn flours have been fully gelatinized, as no starch granules exist in the samples. The starch underwent the gelatinization process during steaming and extrusion cooking processes. Both processes involved high temperatures and shearing effects that are sufficient to gelatinize starch in the NGP ingredients [27]. The figure also indicates that the starch granules have melted and well blended with other NGP ingredients. The supplemented protein from tempeh flour might entangle with the starch components, resulting in the rougher surface of NGP samples. The presence of protein changes the microstructure of pasta products [28]. Other food constituents from tempeh flour supplementation such as fat might also be trapped within or covered the microstructure of melted starch granules. The starch components of NGP including amylose and amylopectin may undergo retrogradation during storage. These induce stiffness, reduces stickiness, and prevents weight losses of pasta when it is cooked. The result showed that NGP with higher tempeh flour supplementation produced a higher number of smaller debris particles (Figure 2). This might be because the starch-protein matrix of NGP supplemented with tempeh flour are more fragile than the starch-starch matrix of NGP without tempeh flour supplementation. The result of Wójtowicz *et al.* [25], indicated that the matrix of NGP built by starch and protein is not homogenized in size, therefore its enrichment caused roughness and corrugation on the surface of pasta product.

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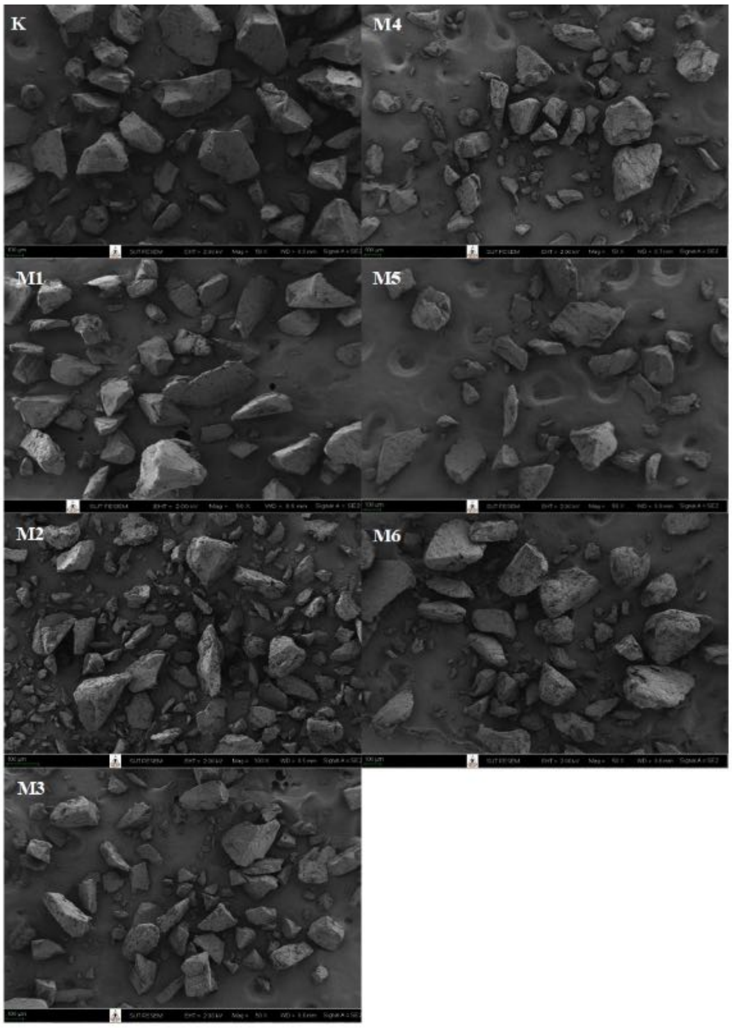

Figure 2: Morphological properties of non-gluten pasta (NGP) products supplemented with tempeh flour (K: 0%, M1: 2.5%, M2: 5%, M3: 7.5%, M4: 10%, M5: 12.5%, and M6: 15%)

Texture profile analysis

The texture profile of the NGP is summarized in Table 4. The results showed that tempeh flour supplementation did not significantly alter the elongation break of the NGP. Even though many factors influence the elongation break of pasta products, the parameter mainly is built by the interaction among the starch chains. The presence of gluten which is rich in sulphur amino acids in wheat-based pasta products increases the elongation break of the products [29]. For NGP, amylose contributes to the hardness, gumminess, and chewiness of the product. Meanwhile, the presence of protein in NGP tends to increase the product elasticity [30].

The results showed that tempeh flour supplementation tended to decrease the values of adhesiveness, springiness, and cohesiveness of NGP (Table 4). Since the amount of starchy ingredients in NGP formula decreased as the tempeh flour supplementation increased (Table 1), the amount of entanglement between starch components decreased in NGP product resulting in the lower adhesiveness, springiness, and cohesiveness values [30]. Moreover, adding tempeh flour into the NGP formula increased the protein and fat contents in the NGP (Table 2). Interactions of starch components with protein and fat in noodles tend to lower the cohesiveness, adhesiveness, and springiness values of the product, resulting in a stiffer noodle [31].

Cooking properties

The cooking properties of NGP are presented in Table 5. The range of cooking time of NGP was between 5 min 25 sec and 6 min 50 sec. M5 exhibited the longest cooking time of 6 min 50 sec, which was close to that of the control, whereas M2 showed the shortest cooking time of 5 min 25 sec. Cooking time is the main parameter for instant pasta products, which can be influenced by the chemical composition and the nutritional and calorie value of a product. However, adding raw materials with a high protein content may increase or decrease the cooking time of NGP, depending on the product preparation [32]. Adding tempeh flour as high as 10% significantly decreased the cooking time of NGP (Table 5). This indicated that the presence of tempeh flour enhanced the diffusion of water into the product, resulting in instant starch gelatinization. Tempeh flour has protein content higher than 46% [20]. The protein of tempeh flour might form a starch-protein matrix, resulting in the enlargement between starch components, making it easier for water to penetrate the NGP product, as evidenced by the morphology of NGP (Figure 2).

The results suggest that tempeh flour supplementation decreased the cooking loss of NGP (Table 5). The starch components of NGP entangle with protein and lipid from tempeh flour preventing the loss of starch components during cooking [31]. The presence of amylose-lipid complex in NGP (Figure 1) might also inhibit the leaching of starch components during cooking. The NGP with lower cooking loss indicates that the amount of soluble solids that leache out of the NGP is low. This implies that NGP with low cooking loss value is higher in textural and sensory qualities than those with high cooking loss value.

The cooking times of M1, M2, and M3 were significantly different from that of the control sample (Table 2). Good quality pasta should have a cooking loss value of less than 10% [33]. All samples resulted in conformable cooking loss value (<10%) except the NGP without tempeh flour supplementation (K). The K sample showed the highest cooking loss among all NGP products. This result is reasonable because a longer cooking time usually results in a higher cooking loss. Thus, adding tempeh flour reduced the cooking loss of the product. Tempeh flour contains protein and fat, which interact with the starch components of NGP which creates a strong matrix, preserving the product integrity by preventing the release of starch components during cooking [31].

Sensory analysis

The results of the hedonic test of one NGP sample (M6) and the control sample (K) are presented in Figure 3. It can be seen that according to the panelist, NGP was superior to the control product in terms of its springiness and adhesiveness. However, the panelists gave the lowest hedonic score for the flavor attribute. Leite *et al.* [34] also reported that cookies with tempeh flour also obtained lower acceptance from the panelist on the flavor attribute. The distinctive aroma of tempeh is quite strong that the odor of tempeh needs to be eliminated from the NGP product.

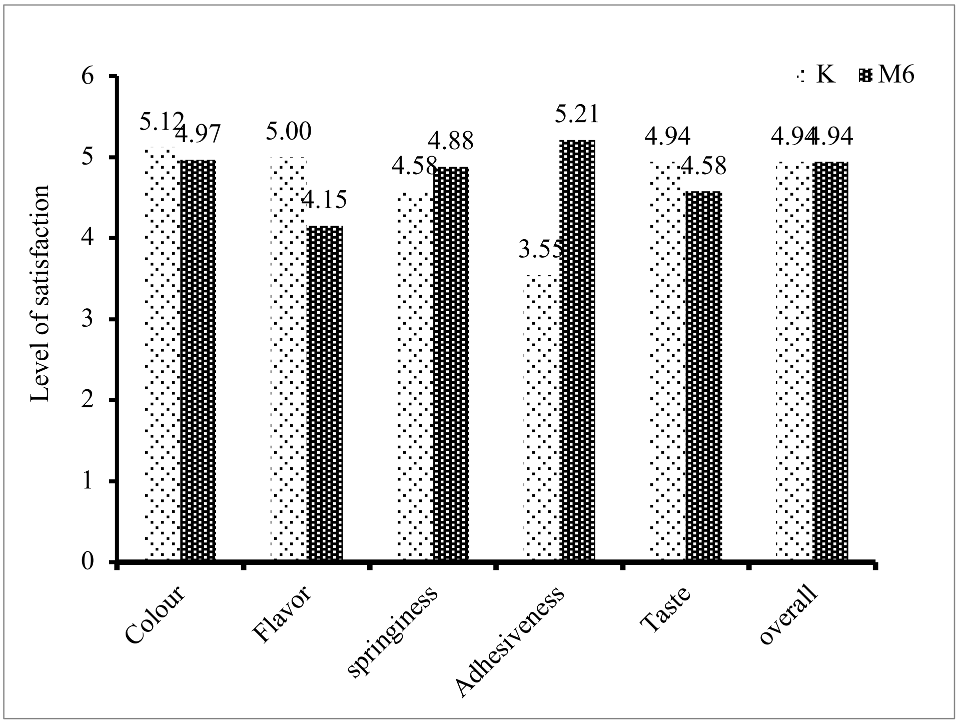

Figure 3: Results of the hedonic test for NGP (M6) and the control sample (K)

CONCLUSION

Tempeh flour supplementation enhanced the nutrient content of NGP, particularly protein, iron, and zinc contents. The highest protein and minerals (Fe and Zn) were obtained by 15% tempeh flour addition. Adding tempeh flour also increased the percentage of V-crystalline structures of the amylose-lipid complex in the NGP products. The adhesiveness and springiness values of NGP were reduced as the amount of supplemented tempeh flour was increased. Adding tempeh flour reduced the cooking loss of NGP. The more supplementation with tempeh flour, the more cooking loss of NGP. The lowest cooking loss was obtained with 7,5% and 10% supplementation of tempeh flour. NGP can be supplemented with tempeh flour up to 10% (w/w) to get the nutritional advantages of tempeh without decreasing its textural and cooking qualities.

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Table 1: Formula of non-gluten pasta (NGP) products supplemented with tempeh flour (g/600 g)

Sample code	Mocaf [g]	Rice Flour [g]	Maize Flour [g]	Tempeh Flour [g]	Salt [g]	Water [g]
K	240	210	150	0	0.6	210
M1	240	210	150	15	0.6	210
M2	240	210	150	30	0.6	210
M3	240	210	150	45	0.6	210
M4	240	210	150	60	0.6	210
M5	240	210	150	75	0.6	210
M6	240	210	150	90	0.6	210

Table 2: Proximate and mineral content of non-gluten pasta (NGP) products supplemented with tempeh flour (g/100g)

Parameters	K*	M1	M2	M3	M4	M5	M6
Moisture	12.30^{a**}	11.57^{a}	11.23^{a}	11.80^{a}	10.13^{a}	11.22^{a}	12.35^{a}
Ash	1.63^{a}	1.61^{a}	1.47^{a}	1.53^{a}	1.57^{a}	1.44^{a}	1.51^{a}
Protein	5.72^{a}	6.34^{b}	7.23^{c}	8.36^{d}	9.19^{e}	9.40^{e}	10.27^{f}
Lipid	4.52^{a}	5.74^{ab}	5.77^{ab}	6.64^{bc}	7.04^{bc}	7.01^{bc}	7.71^{c}
Carbohydrate	75.83	74.74	74.31	71.67	72.06	70.93	68.16
Fe [mg/100g]	ND***	ND	ND	4.94^{a}	7.31^{b}	5.39^{a}	6.94^{b}
Zn [mg/100g]	ND	ND	ND	1.01^{a}	1.17^{b}	1.15^{c}	1.20^{d}

***K: 0%, M1: 2.5%, M2: 5%, M3: 7.5%, M4: 10%, M5: 12.5%, and M6: 15%**
** Same letters signify that samples are not statistically different (p>0.05)
***ND: not detected

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Table 3: Relative crystallinity of non-gluten pasta (NGP) products supplemented with tempeh flour

Sample	Relative crystallinity [%]	Relative crystallinity contributed by each crystalline type [%]	
		A-type crystalline	V-type crystalline
K	19.7	7.7	12.0
M1	18.9	7.3	11.6
M2	19.1	7.2	11.9
M3	18.9	6.2	12.7
M4	18.1	5.7	12.5
M5	18.2	5.6	12.6
M6	18.3	5.7	12.6

Table 4: Textural properties of non-gluten pasta (NGP) products supplemented with tempeh flour

Textural parameters	K	M1	M2	M3	M4	M5	M6
Elongation break [%]	128.81^{a}	100.5^{a}	122.50^{a}	132.99^{a}	133.23^{a}	142.35^{a}	118.27^{a}
Adhesiveness [gs]	−31.64^{a}	−22.33^{b}	−12.50^{c}	−11.81^{c}	−8.74^{c}	−7.70^{c}	−7.60^{c}
Springiness	0.24^{a}	0.22^{ab}	0.14^{cd}	0.14^{d}	0.16^{d}	0.15^{d}	0.10^{d}
Cohesiveness	0.97^{a}	0.88^{b}	0.92^{ab}	0.88^{b}	0.87^{b}	0.86^{b}	0.87^{b}

* Same letters indicate that samples are not statistically different ($p>0.05$)

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Table 5: Cooking properties of non-gluten pasta (NGP) products supplemented with tempeh flour

Cooking parameters	**K**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**
Cooking time [min]	6.9 [a*]	5.5[b]	5.4[b]	5.6 [b]	6.6 [a]	6.8 [a]	6.6 [a]
Cooking loss [%]	11.8[a]	6.2[b]	6.8[bc]	6.0 [b]	6.1 [b]	7.7 [c]	7.6 [c]

* Same letters represent that samples are not statistically different (p>0.05)

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