ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

Development of Mojac noodle products incorporating modified cassava flour (MOCAF), konjac flour, and cassava leaf extract

[Pengembangan mi Mojac berbahan dasar tepung singkong termodifikasi (MOCAF), tepung konjac, dan ekstrak daun singkong]

Fitriyah Zulfa*, Yenny Febriana Ramadhan Abdi, Dininurilmi Putri Suleman, Alfi Nur Rochmah, Prakoso Adi, Rizka Mulyani, Dini Nadhilah, Prajwalita Rukmakharisma Rizki and Tri Nur Dewi Riyani

Agricultural Product Technology, Vocational School, Sebelas Maret University, Surakarta, Indonesia

*Correspondence email: fitriyahzulfa@staff.uns.ac.id

Received: 19 January 2025, Revised: 21 May 2025, Accepted: 20 October 2025, DOI: 10.23960/tip.v31i1. 12-21

ABSTRACT

Noodles are widely consumed across many countries, including Indonesia, and are typically made using wheat and rice flour as the primary ingredients. However, since Indonesia is not a major wheat producer, the country depends heavily on wheat imports. This reliance underscores the need to explore locally available food resources to reduce dependence on imported raw materials. One promising alternative is cassava, which can be processed into modified cassava flour (MOCAF). Despite its potential, a high proportion of MOCAF in noodle formulations tends to reduce product elasticity. To address this issue, konjac flour, a hydrocolloid-rich ingredient containing glucomannan known for its high viscosity, can be incorporated to improve texture. This study aimed to develop Mojac instant noodles, formulated using MOCAF, konjac flour, and cassava leaf extract as a natural antioxidant source. The Mojac noodle formulations consisted of four ingredients: wheat flour, MOCAF, konjac flour, and cassava leaf extract, combined in the following ratios: F1 (50:20:7:23), F2 (45:20:10:25), and F3 (40:20:13:27). Analyses performed included sensory evaluation, chemical composition testing (moisture, ash, protein, fat, carbohydrates, hydrogen cyanide [HCN], and antioxidant activity), and physical property assessment (color and elasticity). Sensory evaluation results indicated that the F1 formulation was the most preferred by panelists. The chemical composition of F1 noodles was as follows: 41.24% moisture, 2.74% ash, 5.74% protein, 7.59% fat, 42.69% carbohydrates, 4.07% antioxidant activity, and 18.72% HCN. In terms of physical properties, the color analysis of F1 noodles showed L, a*, and b* values of 58.42, -5.17, and 23.97, respectively.*

Keywords: cassava leaf extract, konjac flour, mocaf, noodles

ABSTRAK

Mie merupakan salah satu pangan yang banyak dikonsumsi di berbagai negara, termasuk Indonesia, umumnya diproduksi dengan menggunakan tepung terigu dan tepung beras sebagai bahan utama. Namun, Indonesia bukanlah negara penghasil gandum dan sangat bergantung pada impor dari negara lain. Ketergantungan ini menunjukkan pentingnya eksplorasi sumber pangan lokal untuk mengurangi ketergantungan terhadap pasokan luar negeri. Salah satu alternatif yang menjanjikan adalah singkong, yang dapat diolah menjadi tepung singkong termodifikasi (mocaf). Meskipun memiliki potensi besar, penggunaan mocaf dalam konsentrasi tinggi pada produk mi dapat menurunkan elastisitasnya. Tepung porang (konjac), yang memiliki viskositas tinggi karena kandungan glukomanannya, berpotensi dikombinasikan dengan mocaf untuk mengatasi keterbatasan tersebut. Penelitian ini bertujuan untuk menghasilkan mi instan berbahan dasar mocaf, tepung konjac, dan ekstrak daun singkong sebagai sumber antioksidan. Formulasi mi mojac (kombinasi mocaf, tepung konjac, dan ekstrak daun singkong) terdiri atas empat bahan utama: tepung terigu, mocaf, tepung konjac, dan ekstrak daun singkong, dengan kombinasi sebagai berikut: F1 (50:20:7:23), F2 (45:20:10:25), dan F3 (40:20:13:27). Analisis yang dilakukan meliputi uji sensoris, uji mutu kimia (kadar air, abu, protein, lemak, karbohidrat, HCN, dan aktivitas antioksidan), serta uji fisik (warna dan elastisitas). Hasil uji sensoris menunjukkan bahwa mi formulasi F1 paling disukai oleh panelis. Analisis mutu kimia menunjukkan komposisi mi F1 sebagai berikut: kadar air 41,24%, abu 2,74%, protein 5,74%, lemak 7,59%, karbohidrat 42,69%, aktivitas antioksidan 4,07%, dan HCN 18,72%. Hasil uji fisik, khususnya warna, menunjukkan nilai L*, a*, dan b* masing-masing sebesar 58,42; -5,17; dan 23,97.

Kata kunci: ekstrak daun singkong, tepung konjac, mocaf, mie

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

Introduction

Noodles are processed food products typically made from flour, salt, water, and eggs. These products hold a significant position in Southeast Asian cuisine, particularly in Indonesia, where they serve as viable alternatives to rice. According to the World Instant Noodles Association, global noodle consumption reaches 121.2 billion packs annually. Indonesia is the second-largest consumer of instant noodles, with 14.26 billion packs consumed each year (Hidayah, 2023). Several studies have highlighted the diverse variations of noodles, which are distinguished by unique processing methods and ingredient compositions. These variations include fresh wet, dry, semi-dry, cooked, and fried instant noodles (Chen et al., 2023). Among these, dry noodles and fried instant noodles are particularly popular due to their favorable qualities and stable preservative content. Instant noodles have become a convenient and satisfying substitute for rice in Indonesia, driving the exploration of innovative processing methods within the food industry.

Noodles are rich in carbohydrates, as wheat flour is the primary ingredient. Wheat flour is often sourced from imported wheat seeds, contributing to the products' carbohydrate content and relatively high glycemic index (Sihmawati et al., 2017). Data from the Central Statistics Agency indicates a rising trend in wheat seed imports, with figures increasing from 10,287 tons in 2020 to 11,172 tons in 2021. This underscores the importance of wheat imports for noodle production. Given this, there is a pressing need to explore local natural resources to reduce dependency. Indonesia is home to a wealth of plants that can serve as viable sources of carbohydrates, such as cereals like rice and corn, as well as tubers like cassava, sweet potato, and konjac (Budijanto & Yuliana, 2015). Utilizing these indigenous resources could help alleviate the nation's reliance on imported wheat and promote sustainability within the noodle industry. Among these alternative resources, cassava is a versatile tuber that serves as an important source of industrial raw materials in the food industry. In Indonesia, cassava is the most abundant source of carbohydrates when compared to other sources. It can be processed into a variety of industrial raw components used in the food industry. It offers a range of products, including tape, cassava flour, modified cassava flour (Mocaf), tapioca flour, and other food items, with Mocaf being the most significant. The primary method of producing mocaf involves fermenting cassava cells using lactic acid bacteria, which transforms the material to have properties similar to wheat flour (Agustia et al., 2019a). Several studies have reported similarities between Mocaf and wheat flour (Afiyah and Sarbini, 2021). Mocaf is soft, white, and odorless, but typically has a coarser texture compared to wheat flour. While wheat flour contains 60-68% starch, Mocaf has an impressive starch content of approximately 87% (Dewi et al., 2020). This similarity in starch content makes Mocaf a promising substitute in various applications. Previous studies have shown that mocaf can be incorporated into noodle production as a substitute for wheat flour or as a blend ranging from 30% to 100% (Yuliyandjaja et al., 2020). Some papers reported that Mocaf might produce a range of wheat-based goods, including high-iron biscuits (Sari et al., 2018), brownies (Prayitno et al., 2018), and instant tiwul (Agustia et al., 2018). Additionally, mocaf and maize can be used to make mocatilla chips (Asmoro et al., 2017). However, excessive incorporation can affect the quality of the final product, as high concentrations of mocaf often reduce elasticity and increase brittleness (Tuhumury et al., 2020). Despite its potential, Mocaf cannot fully replace wheat flour in noodle production due to its inability to undergo gelatinization, a critical process in noodle production. An essential avenue for advancing noodle processing methods comprises leveraging local food commodities, such as konjac flour and mocaf, supplemented with color from cassava leaf extract. The use of these commodities introduces nutrients beneficial for overall health.

Mocaf and konjac flour have been reported to have a rich nutrient profile that supports bodily health. Furthermore, adding cassava leaf extract contributes to enhanced antioxidant activity, further enriching the nutritional value of the processed noodles. A total of 100 g of cassava leaves contains approximately

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

90 calories, 6.8 g of protein, 1.2 g of fat, 13 g of carbohydrates, 165 g of potassium, and 2 g of iron (Subeki et al., 2018). Rachmawati and Ramdanawati (2020) showed that cassava leaves harvested at 3 months of plant age, and from the third order of leaves, shoots have a relatively high chlorophyll content, measuring approximately 27.162 µm/mL. This shows the importance of strategic selection to maximize chlorophyll content, thereby enhancing the coloration potential of cassava leaf extract on noodle formulation. In addition, other ingredients, such as konjac flour, must be added to produce more elastic Mocaf noodles. Several studies have shown that konjac flour contains high glucomannan content, with significant water-holding capacity (Witoyo et al., 2020). During noodle production, various ingredients, such as mung bean flour with 1.8% (db) protein (Agustia et al., 2019) and sago starch with 10.47% dry basis/db protein, can also be used (Yuliani et al., 2015). This study investigated noodles produced using a blend of wheat flour, mocaf, konjac flour, and cassava leaf extract.

Noodles substituted with mocaf and konjac flour, along with the addition of natural antioxidants from cassava leaves, which is around 31-50% (Simão et al., 2013), offer an alternative solution to reduce dependence on wheat flour in society and serve as a functional food. Therefore, this study aims to determine the best formulation for mocaf and konjac (mojac) wet noodle production based on sensory quality and physicochemical characteristics. The results are expected to facilitate the development of studies on Indonesian local flour commodities and increase public interest in consuming instant noodles with good nutritional content.

Materials and methods

Materials and tools

The equipment used includes noodle-making machines (ETON DZM-200C, Indonesia), blenders (Cosmos), desiccators (Duran), ovens (Kirin), analytical scales (Radwag AS 220), spectrophotometers UV VIS (B-one DA 100), and a water bath (Memmert). The ingredients used for noodle production are mocaf (Mocafine, Indonesia), konjac flour (Lels Organic Foods, Indonesia), eggs (Farmer Eggs, Indonesia), cassava leaves (traditional market, Indonesia), and salt (Dolpin, Indonesia). The chemicals used for analysis are distilled water (ONEMED, Indonesia), HCl (Merck, Germany), HgO (Merck, Germany), K_2SO_4 (Merck, Germany), H_2SO_4 (Merck, Germany), and HBO_3 (Merck, Germany).

Preparation of cassava leaves extract

Cassava leaf extraction was performed through several steps, starting with sorting the leaves and washing them with running water. The process continued with blanching, where the samples were soaked in water at 100°C for 1 min to inhibit the activity of the chlorophyllase enzyme. Next, the cassava leaves were drained, cut into uniform sizes, and pureed in a blender (chopper) at medium speed until slightly smooth. While extracting chlorophyll, the refined cassava leaves were mixed with water at a 1:2 ratio, with the addition of a 1% NaCl concentration. The mixture was then extracted using the maceration method and left at room temperature (27°C) for 3 h, followed by filtration to obtain the extract (Aryanti et al., 2016).

Preparation of mojac noodles

The process of making wet mojac noodles followed the method proposed by Faridah and Widjanarko (2014), starting with determining the formulation, as shown in Table 1. Each formula consisted of varying proportions of wheat flour, mocaf, konjac flour, and cassava leaf extract.

Table 1. Mojac-noodles formulas

Formula	Wheat flour		MOCAF		Konjac flour		Extract cassava	
	%	**gr**	**%**	**gr**	**%**	**gr**	**%**	**gr**
F1	55	77	15	21	7	10	23	32
F2	45	63	20	28	10	14	25	35
F3	35	49	25	35	13	18	27	38

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

The first step was preparing the konjac gel by mixing the konjac flour with water and stirring to achieve homogeneity. The mixture was then allowed to stand at room temperature for 10 minutes. The next step involved preparing the mojac noodles dough, where wheat flour, mocaf, and other additional ingredients (10 g of eggs, 10 g of cooking oil, and 2 g of salt) were added according to the specified formula ratios and mixed until even. Konjac gel was added to the mixture and stirred until homogeneous, followed by the gradual addition of cassava leaf extract until fully incorporated. The dough was then flattened using a rolling machine and molded into noodle strands using a noodle maker. The final step involved drying the noodles in a cabinet dryer.

Sensory evaluation

Sensory evaluation of the noodle products was conducted using a hedonic test, also known as a preference test. An analysis was carried out to assess the panelists' acceptance of the noodle products. The hedonic test involved 30 panelists, who were asked to provide personal assessments. The parameters evaluated included color, aroma, texture, and taste. The assessment used a 5-point scale: 1 (dislike very much), 2 (dislike), 3 (neutral), 4 (like), and 5 (like very much) (Pontolulli et al., 2017). The data collected were tabulated, and the treatment was analyzed using the De Garmo method. Quantitative analysis was performed using IBM SPSS version 25 software with the One-Way ANOVA method, at a 95% confidence level. If significant results were obtained, further analysis was conducted using the DMRT (Duncan Multiple Range Test).

Physicochemical analysis

The physicochemical characteristics of the noodle products were tested three times and included colorimetry, water content (AOAC, 2016), ash content (Aditya, 2023), protein content (AOAC, 2016), fat content (Angelia, 2016), carbohydrate content, antioxidants used DPPH (Tristantini et al., 2016), chlorophyll content (AOAC, 2016), and HCN content (AOAC, 2016).

Results and discussion

Sensory evaluation of instant mojac noodles

Sensory analysis was conducted on Mojac noodles to assess the panelists' preferences for specific parameters and to identify the most favored formulation in this study. Each formulation contained varying proportions of konjac flour and cassava extract, while the proportion of mocaf remained consistent. The results of the sensory evaluation regarding the favorability of the mojac noodles are presented in Table 2.

Table 2. Sensory evaluation result of Mojac noodles

Sample	Sensory parametric			
	Color	Flavor	Texture	Taste
F1[1)]	$3.74^{b} \pm 0.67$	$3.48^{b} \pm 0.71$	$4.03^{b} \pm 0.59$	$3.65^{b} \pm 0.74$
F2[2)]	$3.61^{b} \pm 0.87$	$3.42^{ab} \pm 0.75$	$3.71^{b} \pm 0.92$	$3.55^{b} \pm 0.87$
F3[3)]	$2.65^{a} \pm 0.70$	$3.06^{a} \pm 0.62$	$2.42^{a} \pm 0.66$	$3.03^{a} \pm 0.78$

Note: [1)]F1: 55% wheat flour, 15% mocaf, 7% konjac flour, 23% extract leaf cassava; [2)]F2: 45% wheat flour, 20% mocaf, 10% konjac flour, 25% extract leaf cassava; [3)]F3: 35% wheat flour, 25% mocaf, 13% konjac flour, 27% extract leaf cassava. Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different ($p<0.05$).

The findings indicate that F1 received higher preference scores from the panelists than F2 and F3 for color, texture, and taste. This suggests that the differing proportions of konjac flour in the mojac noodles influenced their color, texture, and taste. Specifically, increasing the amount of konjac flour resulted in lower acceptance by the panelists. Konjac flour typically has a brownish color, which may affect the final product's appearance (Widjanarko et al., 2011). The texture of the mojac noodles was also affected by the addition of konjac flour. (Hasni et al. 2022) noted that high levels of konjac flour tend to produce a softer, less chewy product due to a reduction in gluten content. In contrast, noodles made primarily from wheat

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

flour generally exhibit a better texture due to the presence of gluten. (Umri et al., 2017) emphasized that the amount of gluten in noodle dough plays a significant role in the noodle's breaking strength and texture. (Faridah., 2013) also found that panelists were less favorable toward noodles containing 6% konjac flour due to their sandy texture. Among the sensory evaluation parameters, taste is crucial in determining the acceptability of food products. Table 2 indicates that panelists preferred the taste of F1 noodles. As more konjac flour was added to the noodle dough, resulting in a rougher texture, the panelists' assessment of the taste also declined. (Rahmawati et al., 2021) reported that adding 5% konjac flour did not significantly alter the taste of food products.

Colorimetric characteristics of Mojac noodles

Table 3 shows the highest L* values in sample F1. The higher L* value indicates the similarity of the product's color to white. According to Wulantika and Supriyanto (2022), L* values ranging from 0 to 50 represent dark colors, while values between 51 and 100 indicate lighter colors. The concentration of konjac flour and cassava leaf extract influenced the brightness of the instant noodles. As the amount of konjac flour and cassava leaf extract increased, the brightness (L*) decreased. The* values for all samples were negative, indicating that the color of the instant noodles was green/greenish. Samples F2 and F3 exhibited lower values, suggesting that these samples were greener in color. The addition of cassava leaf extract, which contains chlorophyll, was a key factor influencing the green color of the noodles (Dharmadewi, 2020). According to (Kamsiati et al., 2020), cassava leaves contain chlorophyll pigments, which are known to be stable in basic pH conditions. As a result, cassava leaf extract is considered a good-quality natural food coloring agent.

Table 3. Colorimetric analysis of Mojac noodles

Sample	Colorimetric analysis		
	L	a	b
F1[1)]	57.16	-4.75	29.32
F2[2)]	54.30	-4.83	28.05
F3[3)]	52.56	-5.15	27.37

Note: [1)]F1: 55% wheat flour, 15% mocaf, 7% konjac flour, 23% extract leaf cassava; [2)]F2: 45% wheat flour, 20% mocaf, 10% konjac flour, 25% extract leaf cassava; [3)]F3: 35% wheat flour, 25% mocaf, 13% konjac flour, 27% extract leaf cassava.

The b* value reflects the intensity of the yellow color. F1 (29.32) displayed a higher b* value compared to F2 (28.05) and F3 (27.37). Enzymatic and non-enzymatic bleaching reactions contributed to the addition of brown-colored flour. The enzymatic bleaching reaction occurred due to the presence of polyphenol oxidase and tannins in the flour, which can easily react and cause the color to change to brown. The non-enzymatic reaction, primarily the Maillard reaction, occurs when the reduced sugar content increases during the drying and heating of flour, thereby facilitating color change (Widjanarko et al., 2011). The combination of cassava leaf extract, konjac flour, and mocaf resulted in noodles with a slightly brownish-yellow hue.

Chemical characteristics of Mojac noodles

The results of chemical characteristics are presented in Table 4. The results of the water content ranged from 37.5 – 39.3%. The F3 shows a higher water content than F1 and F2, indicating that the higher konjac flour affects the higher water content in noodles. Analysis of the ash content shows that F3 (3.03%) was higher than F1 (2.5%) and F2 (2.6%). This parameter also increased along with the increment in konjac flour and cassava leaf extract. The protein content results show the highest value on F1. This value is also suitable for the minimum protein value in noodles, which is at least 9% (w/w). The fat content results showed that F3 significantly differed from F1 and F2. The value obtained for F3 was higher (6.3%^{b}) compared to other samples. This could be influenced by adding cassava leaf extract, which has a high-fat content. Wet noodles' carbohydrate content ranged from 44.9% to 45.7%. F3 showed a significant difference compared

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

to F1 and F2. This carbohydrate content was lower than the standard needs for noodle products, which is 86.9%. The antioxidant content of F1, F2, and F3 was 22.6%, 26%, and 30.9%, respectively, and all differed significantly. The addition of konjac flour, mocaf, and cassava leaf chlorophyll extract in the production of instant noodles resulted in a water content that complies with SNI. Based on SNI 2987:2015, noodles have a maximum water content of 65%.

Table 4. Chemical characteristics of Mojac noodles

Sample	Formulas		
	F1[1)]	F2[2)]	F3[3)]
Water content (%)	37.50^{a}±0.07	37.31^{a}±0.11	39.30^{b}±0.25
Ash content (%)	2.56^{b}±0.01	2.49^{a}±0.01	3.03^{c}±0.03
Protein (%)	9.24^{c}±0.06	8.80^{b}±0.07	7.19^{a}± 0.13
Lipid (%)	5.73^{a}±0.03	5.70^{a}±0.09	6.29^{b}± 0.07
Carbohydrate (%)	44.94^{b}±0.68	44.18^{a}±0.25	45.69^{c}± 0.26
Antioxidant (%)	22.57^{a}±0.19	25.93^{b}±0.17	30.92^{c}± 0.17
Chlorophyll (%)	3.45^{ab}±0.30	3.34^{a}±0.31	3.84^{b}± 0.04
Cyanide acid (%)	101.19^{a}±0.01	104.37^{b}±0.37	109.06^{c}± 0.95

Note: [1)]F1: 55% wheat flour, 15% mocaf, 7% konjac flour, 23% extract leaf cassava; [2)]F2: 45% wheat flour, 20% mocaf, 10% konjac flour, 25% extract leaf cassava; [3)]F3: 35% wheat flour, 25% mocaf, 13% konjac flour, 27% extract leaf cassava. Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different ($p<0.05$).

The increase in konjac flour proportion could influence the water content, as noted by Faridah (2014), who found that the greater the addition of this ingredient, the higher the water absorption capacity. Consequently, the water content was higher due to konjac flour's inherent ability to absorb water. This property is attributed to glucomannan, a compound in konjac flour, which has a high solubility in both hot and cold water. Glucomannan can absorb water up to 200 times its weight, contributing significantly to the water content (Hasni et al., 2022). As a soluble fiber, glucomannan exhibits excellent water-binding properties, meaning that a higher fiber content leads to an increase in water retention (Panjaitan et al., 2017). (Widjanarko et al., 2014) also stated that the addition of konjac flour is directly proportional to the water content in noodle dough. For example, adding 2% konjac flour resulted in a water content of 25%, while a 4% addition raised it to 31%. Other materials that cause an increase in water content in the formula are extracted leaf cassava. According to Trisnawati and Nisa (2015), leaves contain protein. Proteins have various functional groups (NH_2, NH, OH, CO) contained in protein structure, thus causing the protein to be able to bind water molecules through hydrogen bonds. Mocaf flour was another factor contributing to the elevated water content in wet noodles, due to its high amylopectin content (83.78%). According to Manganti (2021), raw materials rich in amylopectin tend to have increased water absorption, which is reflected in the higher water content of the product. Furthermore, the addition of cassava leaf extract increased the moisture levels in the wet noodles, as cassava leaves themselves have a high water content, approximately 70.36% (Syarif et al., 2007).

The incorporation of konjac flour and cassava leaf extract also influenced the ash content in the noodles. (Rahmawati et al., 2021) reported that konjac flour has a relatively high ash content of 4.612%, which impacts the final product. Factors affecting this parameter in noodles include the mineral content of the soil in which the raw materials are cultivated, as well as the mineral content in the cassava leaves themselves. (Putri et al., 2017) suggested that the ash content in plants is influenced by soil mineral contamination during cultivation and by temperature and air conditions during processing. (Kamsiati et al., 2020) noted that cassava leaf extract, obtained through blanching with a 1% NaCl solution and maceration for 3 h, contained 8.56% ash.

The protein content of cassava leaf chlorophyll extract was 68% (Kamsiati et al., 2020). Konjac flour contains protein which is very low at 3.34% (Rahmawati et al., 2021). The content of protein in mocaf flour

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

is 1.0% (Gusriani et al., 2021), while wheat flour has a protein content of 12% (Makmur, 2018). Based on the protein content of each flour, konjac flour and mocaf flour have a lower protein content than wheat flour protein content, therefore the higher the konjac flour or mocaf flour added, the lower the protein content in the wet noodles. According to Umri & Wikanastri (2017), the more mocaf flour added, the lower the protein content in the wet noodles. The protein content also could decrease due to the absorption process, particularly when konjac flour is added. This absorption leads to the hydrolysis of protein, which may reduce its concentration. As cassava leaf extract is in liquid form, it is readily absorbed by konjac flour, promoting hydrolysis and thereby decreasing the protein content of the wet noodles.

Cassava leaf extract, produced via blanching in a 1% NaCl solution for 1 minute and maceration for 3 hours, was found to have a fat content of 5.17% (Kamsiati et al., 2020). This fat content is relatively high compared to Faridah's (2013) findings, where wet noodles consisting of 75% wheat flour, 25% mocaf flour, and 4% konjac flour contained only 2.13% fat. The innovation in this study was the use of cassava leaf chlorophyll extract as a coloring agent. The results indicated that the primary ingredients, such as the flour, had minimal impact on the fat content. Several studies have shown that konjac, wheat, and mocaf flours contain minimal fat (0.02% for konjac, 0.3% for wheat, and 0.4–0.8% for mocaf) (Santoso et al., 2019; Gusriani et al., 2021; Rahmawati et al., 2021). In contrast, other ingredients, such as cassava leaf extract, eggs (31.06%) (Wulandari and Arief, 2022), and cooking oil (0.22% free fatty acids) (Mahmudah and Nopiyanti, 2019), contributed more to the fat content. The concentration of eggs and oil was kept constant across treatments, while the amount of cassava leaf extract varied. As expected, higher concentrations of cassava leaf chlorophyll extract led to higher fat content in the final product.

The carbohydrate levels in the wet noodles met the established quality standards. According to SNI 01-3451-1994, the maximum allowable carbohydrate content in wet noodles is 86.9%. The observed carbohydrate content aligns with the Indonesian National Standard (SNI). The relatively lower carbohydrate content in these noodles can be attributed to several factors, such as the proportion of ingredients used. Additionally, the fat, water, and ash contents of the ingredients during noodle production also influenced the carbohydrate levels (Oktarini et al., 2022). The reduction in carbohydrate content in the wet noodles was primarily due to the increased water, ash, fat, and protein content, which impacted the carbohydrate calculation using the by-difference method in this study. This finding supports (Fatkurahman et al., 2012), who noted that the balance of other nutritional components can significantly affect carbohydrate levels.

These results can largely be attributed to the use of natural dyes derived from cassava leaf extract. The extraction process, which included blanching with NaCl for 1 minute, may have impacted the antioxidant activity, resulting in relatively low levels. (Hasim et al., 2016) found that boiled cassava leaf extract had low antioxidant activity (170.77 mg/L). Additionally, (Kurniati et al., 2019) suggested that the temperature during the extraction process can significantly influence antioxidant activity, with higher temperatures leading to the degradation of bioactive compounds. This observation aligns with the short blanching time (1 minute) used in this study.

Cassava leaves themselves are rich in nutrients, with 100 grams providing 90 calories, 6.8 grams of protein, 77 grams of water, 1.2 grams of fat, 13 grams of carbohydrates, 165 mg of calcium, 54 mg of phosphorus, 2 grams of iron, 3300 mg of retinol, 0.12 mg of thiamine, and 275 mg of ascorbic acid (Subeki et al., 2018). The antioxidant activity of cassava leaf extract is attributed to the phenolic and flavonoid compounds it contains. (Tsumbu et al., 2011) identified rutin in cassava leaves as a key compound responsible for its antioxidant effects. Rutin, a flavonoid, is a secondary metabolite produced by plants and is known for its antioxidant activity (Hasim et al., 2016). The inclusion of cassava leaf chlorophyll extract in the wet noodles aims to enhance their nutritional value.

CONCLUSION

In conclusion, the organoleptic test results showed that F1 was more preferred by the panelists in terms of the attributes of color, aroma, texture, and flavor compared to the other 2 samples. Meanwhile, the results of the physical-chemical characteristic test showed that F3 had increased water, ash, fat, and chlorophyll content compared to F1 and F2. The F3 mojac noodle had color characteristics of L: 52.56, a: -5.15, b: 27.37, and chemical characteristics 39.3% of water content, 3.0% ash content, 7.2% protein content, 6.3% lipid, 45.7% carbohydrate, 30.9% antioxidant, and 3.8% chlorophyll. This result has been in accordance with the standard quality of noodles in Indonesia based on SNI 2987:2015, which has a water content of no more than 35%, and a protein content maximum 9%.

Acknowledgement

This study was supported financially by the grants scheme of research of the group research, as the grant number: 228/UN27.22/PT.01.03/2023 of University Sebelas Maret, Indonesia.

References

Aditya, S., Bahutala, M. B., Hibatullah, D. N., Pourazad, P., Wahyono, T., Qumar, M., Penagos-Tabares, F., & Wulansari, N. (2023). Evaluation of milk yield and composition, feed intake, chewing activities, and clinical variables in dairy cows under a hot-humid climate of tropical zone. *Journal of Thermal Biology*, 114, 103608. https://doi.org/10.1016/j.jtherbio.2023.103608

Afiyah, D. N., & Sarbini, R. N. (2021). The effect of mocaf substitution on crispness and organoleptic quality of milk sticks. Jurnal Ternak (Animal Science Journal), 12(2), 49-53. https://doi.org/10.30736/jt.v12i2.100

Agustia, F. C., Rukmini, H. S., & Naufalin, R. (2018). Formulation of high protein-instant tiwul made from cassava flour, substituted jack bean flour, and skimmed milk. *Jurnal Aplikasi Teknologi Pangan,* 7(1), 15-20. https://doi.org/10.17728/jatp.2132

Agustia, F. C., Subardjo, Y. P., & Ramadhan, G. R. (2019a). Development of mocap-wheat noodle product with the addition of catfish and egg-white flours as an alternative for high-animal-protein noodles. *Jurnal Aplikasi Teknologi Pangan,* 8(2), 47-51. https://doi.org/10.17728/jatp.2714

Agustia, F. C., Subardjo, Y. P., Ramadhan, G. R., & Betaditya, D. (2019b). Formulasi flake mohiro dari MOCAF-beras hitam dengan penambahan kacang koro pedang sebagai alternatif sarapan tinggi protein dan serat. *Jurnal Aplikasi Teknologi Pangan,* 8(4), 130-136. https://doi.org/10.17728/jatp.3009

Angelia, I. O. (2016). Analisis kadar lemak pada tepung ampas kelapa. *Jurnal Technopreneur,* 4(1), 19–23. https://doi.org/10.30869/jtech.v4i1.42

[AOAC] Association of the Official Analytical Collaboration International. (2016). Official methods of analysis of AOAC International. 20th ed. Gaithersburg, USA: AOAC.

Aryanti, N., Nafiunisa, A., & Willis, F. M. (2016). Ekstraksi dan karakterisasi klorofil dari daun suji (*Pleomele angustifolia*) sebagai pewarna pangan alami. *Jurnal Aplikasi Teknologi Pangan,* 5(3). https://doi.org/10.17728/jatp.183

Asmoro, N. W., Hartati, S., & Handayani, C. B. (2017). Karakteristik fisik dan organoleptik produk mocatilla chips dari tepung mocaf dan jagung. *Jurnal Ilmu Pangan dan Hasil Pertanian*, 1(1), 63-70. https://10.26877/jiphp.v1i1.1354

Budijanto, S. & Yuliana, N. D. (2015). Development of rice analog as a food diversification vehicle in Indonesia. *Journal of Developments in Sustainable Agriculture*, 10(1), 7-14. https://doi.org/10.11178/jdsa.10.7

Chen, H., Guo, X. N., & Zhu, K. X. (2023). The effect of chitosan oligosaccharides on the shelf-life and quality of fresh wet noodles. *Carbohydrate Polymers,* 309(120704), 1-9. https://10.1016/j.carbpol.2023.120704

Dewi, S. S., Hastutik, S. T., & Setiawan, C. K. (2020). Mocaf characteristic test of different varieties of cassava in Gunung Kidul. *IOP Conference Series: Earth and Environmental Science*. 458(1), 012009. https://10.1088/1755-1315/458/1/012009

Faridah, A. (2013). Uji organoleptik mi basah substitusi mocaf (modified cassava flour) pengaruh tepung porang dan air. Thesis. Universitas Negeri Padang.

Faridah, A., & Widjanarko, S. B. (2014). Penambahan tepung porang pada pembuatan mi dengan substitusi tepung mocaf (Modified cassava flour). *Journal of Food Technology & Industry,* 25(1), 98–105. https://doi.org/10.6066/jtip.2014.25.1.98

Hasni, D., Nilda, C., & Amalia, J. (2022). Kajian pembuatan mie basah tinggi serat dengan substitusi tepung konjac dan pewarna alami. *Jurnal Teknologi & Industri Hasil Pertanian,* 27(1), 31–41. http://dx.doi.org/10.23960/jtihp.v27i1.31-41

Hidayah, Fitri. (2023). Negara dengan konsumsi mie instan terbanyak. Retretive https://data.goodstats.id/statistic/negara-dengan-konsumsi-mie-instan-terbanyak-yHFXf.

Gusriani, I., Koto, H., & Dany, Y. (2021). Aplikasi pemanfaatan tepung mocaf (modified cassava flour) pada beberapa produk pangan di madrasah aliyah mambaul ulum kabupaten bengkulu tengah. *Jurnal Inovasi Pengabdian Masyarakat Pendidikan,* 2(1), 57-73. https://doi.org/10.33369/jurnalinovasi.v2i1.19142

Kamsiati, E., Rahayu, E., & Herawati, H. (2020). Pengaruh blanching terhadap karakteristik daun ubi kayu instan. *METANA*, 16(1), 39-46. https://doi.org/10.14710/metana.v16i1.30461

Mahmudah, K., & Nopiyanti, V. (2019). Penetapan kadar asam lemak bebas pada minyak goreng kemasan dan minyak goreng curah dengan perlakuan berdasarkan lama waktu pemanasan. *CERATA Jurnal Ilmu Farmasi,* 10(1), 1-4. https://doi.org/10.61902/cerata.v10i1.67

Makmur, S. A. (2018). Penambahan tepung sagu dan tepung terigu pada pembuatan roti manis. *Gorontalo Agriculture Technology Journal*, 1(1), 1-9. https://doi.org/ 10.32662/gatj.v1i1.161

Panjaitan, T. W., Rosida, D. A., & Widodo, R. (2017). Aspek mutu dan tingkat kesukaan konsumen terhadap produk mie basah dengan substitusi tepung porang. *Jurnal Teknik Industri HEURISTIC*, 14(1), 1-16.

Prayitno, S. A., Tjiptaningdyah, R., & Hartati, F. K. (2018). Sifat kimia dan organoleptik brownies kukus dari proporsi tepung mocaf dan terigu. *Jurnal Teknologi dan Industri Pertanian Indonesia*, *10*(1), 21-27. https://doi.org/10.17969/jtipi.v10i1.10162

Pontolulli, D. F., Assa, J. R., & Mamuaja, C. F. (2017). Karakteristik sifat fisik dan sensoris mie basah berbahan baku tepung Sukun (*Arthocarpus altilis fosberg*) dan tepung ubi jalar ungu (*Ipomea batatas* l). *Cocos,* 1(8), 1-12. https://doi.org/ 10.35791/cocos.v1i8.17831

Rachmawati, W. & Ramdanawati, L. (2020). Pengembangan klorofil dari daun singkong sebagai pewarna makanan alami. *Pharmacoscript,* 3(1), 87-97.

Rahmawati, S.H., Untari, D. S., Herdiana, N. H., & Inke, L.A. (2021). Pengaruh penambahan tepung porang pada proses pembuatan mi ikan patin sebagai gelling agent. *Fisheries of Wallacea Journal,* 2(2), 70-78. https://doi.org/10.55113/fwj. v2i2.791

Sari, H. P., Agustia, F. C., Subardjo, Y. P., & Ramadhan, G. R. (2018). Biskuit mocaf–garut tinggi zat besi meningkatkan kadar Fe darah dan kadar hemoglobin pada tikus Sprague Dawley. *Jurnal Gizi Indonesia (The Indonesian Journal of Nutrition),* 7(1), 49-53. https://10.14710/jgi.7.1.49-53

Sihmawati, R. R., Rosida, D. A., & Panjaitan, T. W. S. (2019). Evaluasi mutu mie basah dengan substitusi tepung porang dan karagenan sebagai pengenyal alami. *Jurnal Teknik Industri Heuristic,* 16(1), 45-55.

Simão, A. A., Santos, M. A. I., Fraguas, R. M., Braga, M. A., Marques, T. R., Duarte, M. H., Santos, C. M., Freire, J. M., & Corrêa, A. D. (2013). Antioxidants and chlorophyll in cassava leaves at three plant ages. *African journal of agricultural research*, 8(28), 3724-3730

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

Subeki, S., Asih, I. P., Setyani, S., & Nurainy, F. (2018). Kajian formulasi daun singkong (*Manihot esculenta*) dan rumput laut (*Eucheuma cottonii*) terhadap sifat sensor dan kimia nori. *Prosiding Seminar Nasional Pengembangan Teknologi Pertanian*.

Syarif, M., Rivai, H., & Fahmi, F. (2007). Pemeriksaan kadar oksalat dalam daun singkong (*Manihot utilissima Pohl*) dengan metoda spektrofotometri kinetik. *J. Sains dan Teknologi Farmasi*, 12(1), 50-52.

Trisnawati, M. I., & Nisa, F. C. (2015). Pengaruh penambahan konsentrat protein daun kelor dan karagenan terhadap kualitas mie kering tersubstitusi mocaf. *Jurnal Pangan dan Agroindustri*, 3(1), 237-247.

Tristantini, D., Ismawati, A., Pradana, B. T., & Jonathan, J. G. (2016). Pengujian aktivitas antioksidan menggunakan metode DPPH pada daun tanjung (*Mimusops elengi* L). *Prosiding Seminar Nasional Teknik Kimia*, 1-7.

Tsumbu, C. N., Deby-Dupont, G., Tits, M., Angenot, L., Franck, T., Serteyn, D., & Mouithys-Mickalad, A. (2011). Antioxidant and antiradical activities of Manihot esculenta Crantz (*Euphorbiaceae*) leaves and other selected tropical green vegetables investigated on lipoperoxidation and phorbol-12-myristate-13-acetate (PMA) activated monocytes. *Nutrients*, *3*(9), 818-838. https://doi.org/10.3390/nu3090818

Tuhumury, H. C., Ega, L., & Sulfiyah, P. (2020). Karakteristik fisik mie basah dengan variasi tepung terigu, tepung mocaf, dan tepung ikan tuna. *The Journal of Fisheries Development, 4*(1), 43-50

Umri, A. W., & Wikanastri, H. (2017). Kadar protein, tensile strength, dan sifat organoleptik mie basah dengan substitusi tepung mocaf. *Jurnal Pangan dan Gizi,* 7(1), 38-47. https://doi.org/10.26714/jpg.7.1.2017.38-47

Widjanarko, S. B., Sutrisno, A., & Faridah, A. (2011). Efek hidrogen peroksida terhadap sifat fisiko-kimia tepung porang (*Amorphophallus oncophyllus*) dengan metode maserasi dan ultrasonik. *Jurnal Teknologi Pertanian, 12*(3), 143-152.

Widjanarko, S. B., Faridah, A., & Sutrisno, A. (2014). Optimization of ultrasound-assisted extraction of konjac flour from Amorphophallus muelleri Blume. *Gums and stabilizers for the food industry*, 17, 109-122.

Witoyo, J. E., Ni'maturohmah, E., Argo, B. D., Yuwono, S. S., & Widjanarko, S. B. (2020). Polishing effect on the physicochemical properties of porang flour using centrifugal grinder. IOP Conference Series: Earth and Environmental Science. *IOP Publishing*, 475(1), 012026.

Wulandari, Z., and Arief, I. I. (2022). Tepung Telur Ayam: nilai gizi, sifat fungsional dan manfaat*. Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan,* 10(2), 62-68.

Wulantika, W., &Supriyanto, M. F. (2022). Karakteristik mi tinggi antioksidan dari daun kelor (*Moringa oleifera* L.) dan daun beluntas (*Pluchea indica* L.). *Jurnal Rekayasa dan Manajemen Agroindustri*, 10(2), 194-201. *et*

Yuliyandjaja, J. P., Widayat, W., Hadiyanto, H., Suzery, M. & Budianto, I. A. (2020). Diversifikasi tepung mocaf menjadi produk mie sehat di PT. Tepung Mocaf Solusindo*. Indonesia Journal of Halal,* 2(2), 40-45.