International Journal on Advanced Science Engineering Information Technology

Vol.14 (2024) No. 3
ISSN: 2088-5334

Characteristics of Wet Noodles from Mixed Flour (Wheat and MOCAF) and Butterfly Pea Flower Powder

Herlina [a,*], Tiara Ayu Nashiroh [a], Niken Widya Palupi [a], Yuli Wibowo [b], Lituhayu Supartiningrum [b], Thabed Tholib Baladraf [b]

[a] *Department of Agriculture Product Technology, Faculty of Agriculture Technology, University of Jember, Jember, Indonesia*
[b] *Department of Agro-industrial, Faculty of Agriculture Technology, University of Jember, Jember, Indonesia*
*Corresponding author: *lina.ftp@unej.ac.id*

Abstract—**Modified cassava flour (MOCAF) is a potential ingredient that can be applied to various products, especially when combined with wheat flour. However, previous research has shown that the combination of MOCAF and wheat flour produces low-quality noodle products. Adding polyphenol compounds from butterfly pea flowers will improve wet noodles' functional and nutritional properties. This study aimed to determine the effect of adding butterfly pea flower powder on the wheat flour and MOCAF mixture and its characteristics in wet noodles with varying percentages of butterfly pea flower powder. The method used in this research is a laboratory experiment. In this study, adding butterfly pea powder was 1%, 2%, 3%, 4%, and 5%. Modified cassava flour characteristics studied included thermal, rheological, and functional properties. The results showed that the percentage of butterfly pea flower powder affected the rheological and thermal properties of the flour mixture. The addition of 5% butterfly pea flower powder was the best treatment, with a cooking shrinkage value of 1.97%, water absorption of 20.79%, chewiness of 9.81%, total polyphenols of 0.26 mg/g, antioxidant activity of 26.15%, level of preference for color 5.23, level of choice for aroma 4.97, level of choice for texture 3.97, level of choice for taste 4.8, and level of preference for overall 4.8. The use of butterfly pea flower powder in wheat flour and its application in wet noodles has been proven to improve functional properties and health benefits for consumers.**

Keywords—**Butterfly pea powder; wheat flour; modified cassava flour; quality; wet noodles.**

Manuscript received 23 Oct. 2023; revised 10 Jan. 2024; accepted 31 May 2024. Date of publication 30 Jun. 2024.

I. INTRODUCTION

The demand for wheat and wheat-based processed products in Indonesia is steadily increasing. According to the Central Bureau of Statistics [1], the average wheat consumption per capita increased from 0.047 kg in 2020 to 0.055 kg in 2021. This trend underscores the importance of maintaining food security and meeting the growing demand for wheat flour. Production of one ton of wheat flour requires seven million tons of wheat imports. Reliance on imported food can result in food instability if the government fails to secure it, further necessitating foreign currency. This risk arises from both internal factors, such as a decline in foreign currency reserves, and external factors, such as limited availability in the global market [2]. Noodle companies account for the most significant share of flour consumption, at 55 percent, followed by bread producers at 22 percent and biscuit manufacturers at 18 percent. Most grain imports originate from Australia, Canada, the United States, Russia, Ukraine, Kazakhstan, India, Pakistan, Brazil, and Argentina [3].

Indonesia possesses significant potential for diversifying food production by utilizing alternative carbohydrate sources, thereby enhancing food security. Utilizing local carbohydrate-rich food items is contingent upon their capacity to improve public health within our food security framework. Corn, cassava, and sweet potatoes emerge as pivotal sources of carbohydrates in this context. These commodities hold promising prospects for substituting rice and can be processed into flour as a substitute for imported wheat flour [2]–[4]. Cassava can be processed into modified cassava flour (MOCAF), a fermented product with promising potential as a component in flour blends [5].

MOCAF's unique properties, resulting from the fermentation process, enhance its functional qualities. Despite its potential as a partial substitute for wheat flour, MOCAF can only partially replace wheat flour due to its high amylopectin content, which can impart a sticky texture to the final product [6]. Nevertheless, MOCAF can be effectively used in composite flours, combining multiple types of flour to make bakery products and pastries [5], [7]. Composite MOCAF flour can also be employed in producing wet noodles, as demonstrated in previous research conducted by [8]–[11], resulting in products that meet consumers' nutritional and textural expectations. Integrating MOCAF with wheat flour makes it possible to produce wet noodles with desirable qualities while reducing reliance on imported wheat and promoting locally sourced ingredients. Given the rising demand for wheat products and the potential benefits of using MOCAF, exploring innovative formulations that enhance wet noodles' functional and nutritional value is essential.

To address the growing preference for healthier choices, this study incorporates butterfly pea flower powder as a natural ingredient in the production of wet noodles. Butterfly pea flower powder is selected for its advantageous antioxidant properties, specifically anthocyanins, which are polyphenol derivative compounds commonly used as a natural blue dye [12]–[15]. The polyphenol content in the ethanol extract of butterfly pea flower is 102.37 mg GAE/280nm and 28.8 mg GAE/750nm [16]. The addition of butterfly pea flower powder can provide an attractive color to wet noodles and increase the content of polyphenols (tannins), which interact with gluten while reducing starch digestion and the inflammatory effects of gluten [17].

Previous research by [18] revealed that polyphenols from tea can improve dough stability and noodle elasticity by increasing water absorption, positively impacting noodle texture. Similarly, research by [19] showed that polyphenols from oranges can enhance noodle texture. Another study by [20] polyphenols from tomato skin powder can increase pasta elasticity and improve texture. However, the incorporation of butterfly pea flower powder into a mixture of wheat flour and MOCAF for making wet noodles has yet to be reported. Therefore, it is necessary to research the effect of adding butterfly pea flower powder to the wheat flour and MOCAF mixture and to analyze its characteristics in wet noodles with varying percentages of butterfly pea flower powder.

II. Materials and Method

A. Materials

The materials used for the preparation of samples were butterfly pea flower powder obtained from Kusuka Ubiku in Bantul with the trademark Moringa Pangan Aman, high-protein wheat flour, MOCAF obtained from Rumah MOCAF Banjarnegara, eggs, salt, oil, water, and CMC. All chemicals and reagents used in this study were analytical grade.

B. Method

The research was conducted in two distinct stages: the first involved preparing mixed flour, while the second focused on producing wet noodles.

1) Mixed Flour Preparation: The flour mixture was made by mixing high-protein wheat flour and MOCAF in a ratio of 1:1 100 grams. Furthermore, butterfly pea flower powder was added in various percentages (1%, 2%, 3%, 4%, and 5%) and stirred until homogeneously.

2) Wet Noodles Making: Wet noodles were made using 100 grams of a combination of wheat flour, MOCAF, and butterfly pea flower powder with various percentage variations. The flour that had been homogenized was then added with CMC 1 gram, egg 20 grams, salt 2 grams, and water 45 ml and kneaded until smooth into dough. The finished dough was then formed into sheets and molded using a roll press. In the last step, the noodle dough is boiled for 3 minutes in water at 90℃, drained and then coated with cooking oil. The process of wet noodles making is illustrated in the flow diagram below.

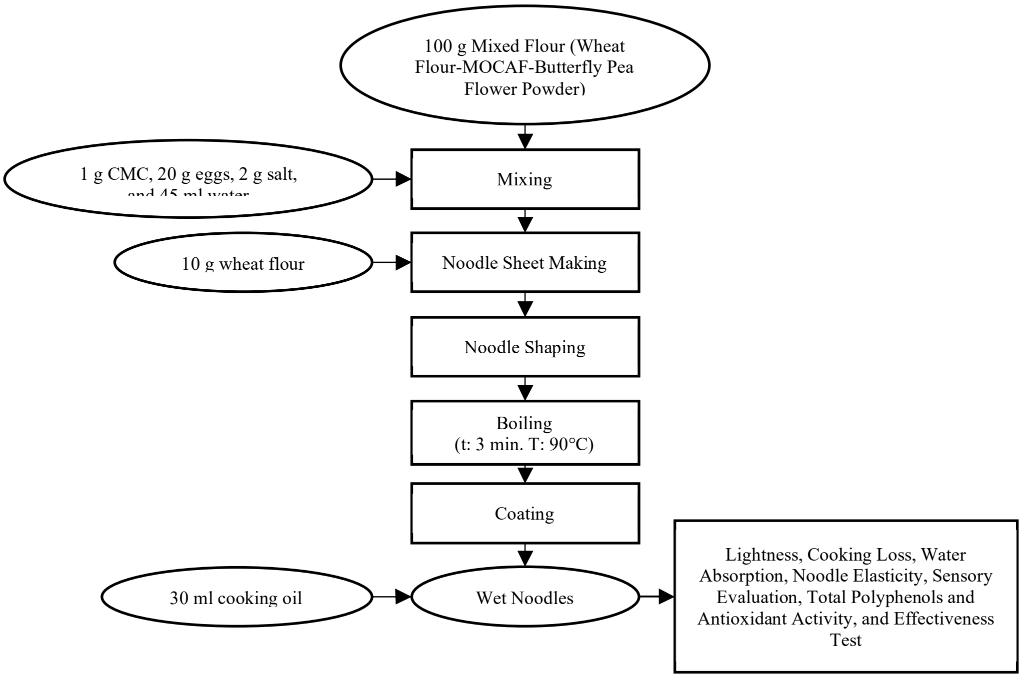

Fig. 1 Wet Noodle Making Process

C. Observation Parameters of Mixed Flour

In this study, the following observation parameters were evaluated to determine the quality of mixed flour:

1) Viscosity Analysis: The viscosity of the wheat flour and MOCAF combination with adding butterfly pea flower powder at various percentage variations was analyzed using a Rapid Visco Analyzer (Techmaster 20-8000 cP, 160 rpm). Samples weighed as much as 3 g, and 25 ml of water was added. Then, the sample was heated and homogenized using a spatula, and the RVA test was carried out.

2) Thermal Properties: The thermodynamic properties of the mixed flour samples were measured using Differential Scanning Calorimetry (Thermo Plus Evo). In the test, the DSC was calibrated with an indium standard. Samples of 2-4 mg were placed in an aluminum DSC pan, and water (1:3) was added. The pan was covered and equilibrated for 24 hours at room temperature. The sample pan and empty pan were heated at 30-135°C until the results were obtained.

3) WHC and OHC: Water Holding Capacity (WHC) and Oil Holding Capacity (OHC) measurements were carried out by adapting the method of Jakobson et al. [21]. Both are calculated with the following formula:

$$\text{WHC/OHC (\%)} = \frac{(\text{weight of sediment} - \text{weight of sample})}{\text{weight of sample}} \times 100 \quad (1)$$

D. Observation Parameters of Wet Noodles

The quality of wet noodles was assessed using the following observation parameters:

1) Lightness (L):* The physical properties of color were tested using a color reader (Minolta CR-10). The L* value indicates brightness using a value range of 0 (black) to 100 (white).

2) Cooking Loss: Determination of cooking water loss was carried out using a method based on Adebayo et al. [22]. The test was conducted by cooking a noodle sample for 4 minutes and transferring the cooking water into a beaker. The beaker was dried in an oven to a constant weight. Then the noodle cooking water was evaporated to dryness in the oven at 105°C. The cooking loss calculation formula is presented as follows:

$$\text{Cooking loss (\%)} = \left(\frac{weight\ of\ residue}{weight\ of\ sample}\right) \times 100 \quad (2)$$

3) Water Absorption: Water absorption testing was conducted using a modified method from Li et al. [23]. Water absorption was calculated from the weight before (Wa) and after cooking (Wb). The formula used is as follows:

$$\text{Water Absorption (\%)} = \frac{(Wb - Wa)}{Wa} \times 100\% \quad (3)$$

4) Elasticity of Noodle: The elasticity of wet noodle samples was measured using a Tensile Tester (EZ Test Shimadzu). The calculation of the elasticity value was carried out using the following formula:

$$\text{Elasticity (\%)} = \frac{(final\ length - initial\ length)}{initial\ length} \times 100\% \quad (4)$$

5) Total Polyphenols and Antioxidant Activity: Total polyphenol testing was performed using the Folin-Ciocalteu method modified from Xu et al. [24]. To test for total polyphenols, 1 g of flour sample was extracted using 25 ml of distilled water, and 5 g of wet noodle sample was extracted using 250 ml of distilled water with constant stirring for 45 minutes. The sample extract was then taken as much as 1 ml mixed with 0.5 ml of Folin-Ciocalteu reagent and allowed to stand for 5 minutes. Next, 1 ml of $Na2CO3$ solution was added, and the absorbance was measured using a wavelength of 765 nm. Antioxidant activity testing was performed using the DPPH method modified by Park et al. [25]. The sample extract was added to 2 ml of DPPH methanol solution. The absorbance was measured at a wavelength of 517 nm.

6) Sensory Evaluation: Sensory testing was conducted using the hedonic test method to measure the level of liking for the product, including taste, color, aroma, texture (chewiness), and overall, on a scale of 1-7. The higher the number given, the better the product. Sensory testing in this study used 30 untrained panelists from the University of Jember.

7) Effectiveness Test: The effectiveness test is conducted by determining the weighted value for each parameter with a range of 0-1 depending on the level of importance of each parameter. The effectiveness value (NE) is calculated to obtain the outcome value (NH). The formula used is as follows:

$$\text{NE} = \frac{(treatment\ value - lowest\ treatment\ value)}{(highest\ value - lowest\ value)} \quad (5)$$

$$\text{NH} = \text{NE} \times \text{Normal Value (NN)}$$

8) Statistical Analysis: The data obtained was analyzed by Analysis of Variance (ANOVA), and if there was a significant difference, it was tested by Duncan's Multiple Range Test (DMRT) with a 95% confidence level. Especially for organoleptic data obtained was tested using the Chi-Square with a 95% confidence level.

III. Result and Discussion

A. Viscosity Analysis

The results of viscosity analysis using a Rapid Visco Analyzer (RVA) showed that adding butterfly pea flower powder affected the viscosity of the flour combination. In general, paste properties are related to the swelling and rupture of starch granules [26]. Adding butterfly pea flower powder decreased the PV and BD values of the flour combination. PV indicates the water absorption capacity and the texture of the product, whereas BD suggests the stability of the paste during heating [27]. The decrease in PV and BD occurred because of competition for water molecule absorption between wheat flour gluten, MOCAF starch, and butterfly pea flower powder hydroxyl groups, causing limited swelling of starch granules and inhibiting gelatinization [28].

Other results also showed that adding butterfly pea flower powder polyphenols decreased TV, FC, SB and increased PT and pasting temperature. This indicates that the flour combination takes a long time to reach peak viscosity. This agrees with the research of Han et al. [18], who stated that polyphenols decrease the viscosity of the paste upon cooling because polyphenol solid crystals disrupt starch chain interactions, resulting in a decrease in the formation of amylose bond zones. Based on this, polyphenols play a role in inhibiting short-term retrogradation. The results of viscosity testing are shown in Table 1.

B. Thermal Properties

The results of testing the thermal properties of the flour combination showed that the higher the percentage of added butterfly pea flower powder, the values of T0, Te, Tp, and ΔH were almost the same in all treatments. However, the control flour sample's temperature value without adding butterfly pea flower powder was slightly lower. This is because butterfly pea flower petals contain many hydrophilic and hydrophobic components, so their addition can increase hydrogen bonds and hydrophobic interactions [29]. In addition, according to the research results of Liu et al. [30], the interaction between starch, gluten, and polyphenols can inhibit the development of the starch structure so that it does not form a perfect low-order crystal structure. The thermal properties test results are presented in Table 1.

TABLE I
ANALYSIS OF VISCOSITY AND THERMAL PROPERTIES OF WHEAT-MOCAF COMBINATION FLOUR WITH BUTTERFLY PEA FLOWER POWDER

Sample	Viscosity analysist							Thermal			
	PV (cP)	TV (cP)	BD (cP)	FV (cP)	SB (cP)	PT (minutes)	PT (°C)	T_0 (°C)	Tp (°C)	Te (°C)	ΔH (J/g)
A0	2951	1857	1094	2787	930	5.47	71.75	65.4	68.7	73.3	-2.146
A1 (1%)	2939	2051	888	3021	970	5.93	73.55	66.1	69.0	73.3	-1.700
A2 (2%)	2822	1959	863	2882	923	6.00	73.45	66.1	69.4	73.8	-1.650
A3 (3%)	2814	1841	973	2698	857	5.80	73.40	66.3	70.0	74.9	-2.097
A4 (4%)	2630	1772	858	2680	908	5.93	72.60	66.3	70.2	75.1	-2.510
A5 (5%)	2672	1800	872	2664	864	5.80	72.65	66.2	69.9	74.8	-2.051

PV = *peak viscosity*; TV = *trough viscosity*; BD = *breakdown*; FV = *final viscosity*; SB = *setback*; PT = *peak time*; Pasting Temp = *pasting temperature; T_0 = onset temperature; Tp = peak temperature; Te = end temperature; ΔH = enthalpy of gelatinization*

C. WHC and OHC

Water Holding Capacity (WHC) is the ability of a chemical component to bind or hold water because it has a polar, hydrophilic part [31]. A high WHC value produces food products with good texture and quality [21]. Previous research by Georgiana et al. stated that there were 13 hydrophilic components identified in butterfly pea flower petals with the highest concentrations, including *ternatin* and *delfinidin* derivatives [32]. Based on the test results, the sample with the addition of 5% butterfly pea flower powder had the highest value, 88.6%, and the sample without the addition of butterfly pea flower powder had the lowest value, 78.5%. The detailed WHC test results are presented in Table 2.

TABLE II
WATER HOLDING CAPACITY (WHC) AND OIL HOLDING CAPACITY (OHC) WHEAT-MOCAF COMBINATION FLOUR WITH BUTTERFLY PEA FLOWER POWDER

Sample	**WHC (%)**	**OHC (%)**
A0	78.5 ± 0.80^{a}	93.2 ± 0.83^{a}
A1	79.7 ± 1.13^{a}	95.7 ± 1.35^{ab}
A2	81.8 ± 2.89^{ab}	96.6 ± 1.31^{bc}
A3	85.4 ± 0.76^{bc}	97.3 ± 1.71^{bc}
A4	86.4 ± 3.16^{c}	98.9 ± 0.80^{c}
A5	88.6 ± 1.26^{c}	99.7 ± 1.83^{c}

Oil holding capacity (OHC) is a functional property of flour caused by the presence of food components, such as proteins that have non-polar parts [31]. A high OHC value has the potential to be applied to food formulations because it can improve food flavor [21]. This is due to the lipophilic components contained in it in the form of seven fatty acid compounds, four phytosterol compounds, and two *tocol* compounds. Among these compounds, stigmasterol and β-sitosterol have the highest concentration [32]Based on the test results, the highest value is the sample with 5% butterfly pea flower powder, at 99.7%, and the lowest value is the sample without adding butterfly pea flower powder, at 93.2%. The detailed OHC test results are presented in Table 2.

D. Total Polyphenols and Antioxidant Activity Mixed Flour

The total polyphenol value of the combined flour with the addition of 5% butterfly pea flower powder produced the highest total polyphenol value of 1.55 mg/g. In contrast, the combined flour obtained the lowest value without adding butterfly pea flower powder, which was 0.43 mg/g. According to the literature, butterfly pea flower powder contains anthocyanins, polyphenol-derived compounds. Several anthocyanins with special structures have been found in butterfly pea flowers, such as *ternatin* D1, which is delphinidin-3-O-(6-O-malonyl-β-D-glucopyranosyl)-3',5'-di-O-(-6-O-(E-4-)-O-(6-OEρ-*coumaroil-β-D-glucopyranose*)-*ρ-coumaroil*).-β-D-glucopyranoside and *deacilternatin*, which is delphinidin-3,30',5'-tri-O-β-D-glucopyranoside [33]. The detailed total polyphenol test results are presented in Table 3.

TABLE III
TOTAL POLYPHENOLS AND ANTIOXIDANT ACTIVITY WHEAT-MOCAF COMBINATION FLOUR WITH BUTTERFLY PEA FLOWER POWDER

Sample	**Antioxidant activity (%)**	**Total polyphenols (mg/g)**
A0	16.33 ± 0.16^{a}	0.43 ± 0.02^{a}
A1	23.23 ± 0.29^{b}	0.88 ± 0.03^{b}
A2	26.50 ± 0.44^{c}	1.06 ± 0.00^{c}
A3	30.55 ± 1.42^{d}	1.19 ± 0.01^{d}
A4	31.49 ± 0.73^{de}	1.35 ± 0.05^{e}
A5	32.49 ± 1.09^{e}	1.55 ± 0.05^{f}

The highest antioxidant activity value of flour was the combined flour sample with 5% butterfly pea flower powder at 32.49%. The lowest was the combined flour sample without adding butterfly pea flower powder at 16.33%. In the combined flour sample, antioxidant activity increased with adding butterfly pea flower powder due to its bioactive content. The anthocyanin content in butterfly pea flowers has been widely used over the years as a potential antioxidant [34]. This is consistent with the increase in total polyphenol value and antioxidant activity. Table 3 presents the detailed results of the antioxidant activity values.

E. Lightness of Wet Noodle

In measuring the wet noodles' lightness level (L*), adding butterfly pea flower powder reduced the L* value. The higher the L* value, the darker the brightness of the resulting product. The measurement results showed that the wet noodle sample with combined flour without adding butterfly pea flower powder produced the highest value of 71.09 ± 3.28. The wet noodle sample with combined flour and adding 5% butterfly pea flower powder produced the lowest value of 43.70 ± 0.49. This is thought to be due to the nature of wheat flour and MOCAF flour, which are very bright white [35]. On the other hand, butterfly pea flower powder contains anthocyanin polyphenols, which give the wet noodles a blue [36]. In addition, the cooking process oxidizes polyphenols so that the whiteness of the noodles decreases [37]. The results of the brightness level measurement (L*) are presented in Table 4.

F. Cooking Loss of Wet Noodle

The cooking loss test results show that the wet noodle sample with adding 5% butterfly pea flower powder produced the highest value of 1.97%. The wet noodle sample without adding butterfly pea flower powder produced the lowest value of 0.75%. This is due to the decrease in gluten content that occurs in wet noodles, which results in the weakening of the gluten network and starch polymers, resulting in the dispersion of the wet noodle solids in cooking water [38]. On the other hand, adding butterfly pea flower powder contributes antioxidant activity that can weaken the gluten network because it can interfere with the formation of disulfide bonds in glutenin. [39]. However, the cooking loss value of wet noodles is also related to the TV and WHC values of the flour combination. The high-water absorption ability of the hydroxyl groups of butterfly pea flower reduces the amount of water available to form intermolecular connections and starch-gluten networks during wet noodle dough preparation. The results of the cooking loss of wet noodles are presented in Table 4.

G. Water Absorption of Wet Noodle

The results of the water absorption test showed that the highest water absorption value was obtained by the wet noodle sample without adding butterfly pea flower powder, which was 26.50%. The lowest value was obtained for the wet noodle sample by adding butterfly pea flower powder, which was 20.79%. The reduction of the gluten fraction in wheat flour with the addition of butterfly pea flower powder resulted in decreased water retention in the noodles [40]In addition, the addition of butterfly pea flower powder had a high WHC value, causing water absorption competition between wheat flour gluten, MOCAF starch, and butterfly pea flower powder hydroxyl groups. This reduced water availability for gelatinization during the wet noodle boiling process resulted in low gelatinization. The results of the water absorption in wet noodles are presented in Table 4.

H. Elasticity of Wet Noodle

Elasticity testing on wet noodles was conducted on cooked wet noodles. The results showed that wet noodles without adding butterfly pea flower powder had the highest elasticity of 26.79%. Wet noodles with 5% butterfly pea flower powder had the lowest elasticity of 9.81%. The elasticity value of wet noodles is related to the PV value of the flour combination used. The decrease in PV value in the combined flour sample with butterfly pea flower powder has low expandability and elasticity because polyphenols interfere with the formation of disulfide bonds in the gluten network [39]. In addition, competition for water absorption between gluten, starch, and hydrophilic components can damage the protein structure [41]. The results of the elasticity of wet noodles are presented in Table 4.

TABLE IV
QUALITY CHARACTERISTICS OF WET NOODLE

Sample	L*	Cooking Loss (%)	Water absorption (%)	Elasticity (%)
A0	71.09±3.28^{e}	0.75±0.03^{a}	26.50±1.11^{d}	26.79±1.02^{e}
A1	56.76±1.06^{d}	1.05±0.05^{b}	24.46±0.88^{c}	23.55±1.03^{d}
A2	49.07±0.51^{c}	1.43±0.05^{c}	23.83±1.12^{bc}	17.78±0.47^{c}
A3	47.11±0.89^{bc}	1.55±0.07^{cd}	22.75±0.65^{abc}	17.62±0.55^{c}
A4	44.04±0.20^{ab}	1.63±0.07^{d}	21.77±0.92^{ab}	11.52±0.50^{b}
A5	43.70±0.49^{a}	1.97±0.08^{e}	20.79±0.76^{a}	9.81±0.15^{a}

I. Total Polyphenols and Antioxidant Activity of Wet Noodles

The highest polyphenol value of wet noodles is the noodle sample with the addition of 4% butterfly pea flower powder, which is 0.30 mg/g, and the lowest value is the noodle sample without the addition of butterfly pea flower powder, which is 0.10 mg/g. This is related to the previous discussion if the cooking loss value of wet noodles increases along with the amount of butterfly pea flower powder addition so that it can be known if the highest addition of butterfly pea flower powder to wet noodle samples causes the loss of wet noodle solids during cooking. Butterfly pea flowers contain anthocyanins which are polyphenol-derived compounds, such as *ternatin* D1 and *deacilternatin* [33]. Anthocyanins are water-soluble because of their polar components [34]. The detailed total polyphenol test results are presented in Table 5.

The highest antioxidant activity value of wet noodles was the noodle sample with adding butterfly pea flower powder at 5%, namely 26.15%, and the lowest value was the noodle sample without adding butterfly pea flower powder at 2.33%. Butterfly pea flowers contain bioactive compounds such as anthocyanins, alkaloids, and tannins with antioxidant activity [42]. Unlike the total polyphenols that decreased in the sample with 5% butterfly pea flower powder, the antioxidant activity of wet noodles did not decrease between butterfly pea flower powder treatments. This is because compounds with antioxidant activity, such as alkaloids and tocopherols, are insoluble in water. Tocopherol was identified in butterfly pea flower petals as a lipophilic component by Shen et al. [31].

The detailed results of the antioxidant activity values are presented in Table 5.

TABLE V
TOTAL POLYPHENOLS AND ANTIOXIDANT ACTIVITY WET NOODLE

Sample	Antioxidant activity (%)	Total polyphenols (mg/g)
A0	2.33±0.10[a]	0.10±0.00[a]
A1	8.50±0.10[b]	0.12±0.03[b]
A2	9.10±0.05[c]	0.15±0.01[c]
A3	14.15±0.20[d]	0.25±0.00[d]
A4	23.55±0.20[d]	0.30±0.02[d]
A5	26.15±1.09[e]	0.27±0.00[e]

J. Sensory Evaluation

Sensory evaluation showed that adding butterfly pea flower powder affected the color and texture of the wet noodles. In the color component, panelists liked the color of wet noodles with the addition of butterfly pea flower powder 5% because it produces a more intense color due to the *ternatin* content in butterfly pea flower powder [42]. The wet noodle treatment with adding 1% butterfly pea flower powder was less preferred because it had a pale blue that needed to be more attractive. For the texture component, panelists preferred the control sample because it was more elastic. This is because the addition of butterfly pea flower powder to the combination of wheat flour and MOCAF can weaken the strength of gluten and disrupt the structure of wet noodles because the polyphenols contained interfere with the formation of disulfide bonds in the gluten network [39], [40]. Based on this, it is suspected that wet noodles with an inelastic texture are less preferred by panelists. On the other hand, the results for aroma, flavor, and overall parameters showed no significant difference. Based on this, panelists cannot distinguish wet noodles from each treatment because they have the same quality. The sensory evaluation chart is presented in Figure 2.

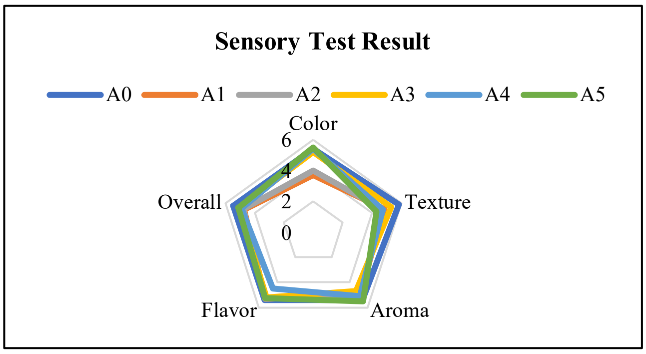

Fig. 2 Sensory evaluation of wet noodle

K. Effectiveness Test

Based on the effectiveness test results, sample A5, which added 5% butterfly pea flower powder, had the highest value of 0.60. Followed by samples A0, A3, A4, A2, and A1. In detail, sample A5 has cooking shrinkage of 1.97%; water absorption of 20.79%; chewiness of 9.81%; total polyphenols of 0.26 mg/g; antioxidant activity of 26.15%; color liking level of 5.23; aroma liking level of 4.97; texture liking level (chewiness) of 3.97; taste liking level of 4.8; and overall liking level of 4.8. The complete effectiveness testing graph is presented in Figure 3.

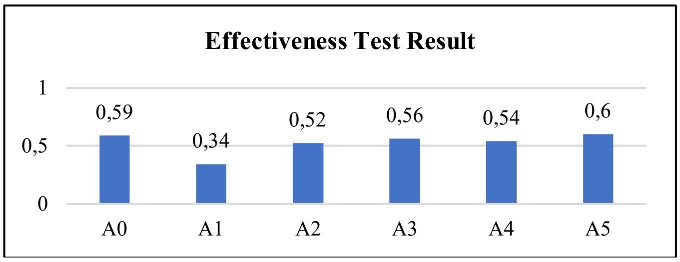

Fig. 3 Effectiveness test result

IV. CONCLUSION

Based on the conducted research, it can be concluded that the addition of butterfly pea flower powder significantly affects the physicochemical properties (water holding capacity and oil holding capacity) and bioactive properties (total polyphenols and antioxidant activity) of the combination of wheat flour and modified cassava flour. Incorporating butterfly pea flower powder into wet noodles made from a blend of wheat flour and modified cassava flour improved cooking loss characteristics and bioactive properties (total polyphenols and antioxidant activity). Conversely, adding butterfly pea flower powder decreased lightness, water-holding capacity, and elasticity. The best treatment, as determined by effectiveness testing, was achieved using the A5 wet noodle sample, comprising a blend of wheat flour and modified cassava flour with 5% butterfly pea flower powder. These findings offer an alternative for enhancing the quality of wheat flour by combining it with MOCAF and incorporating butterfly pea flower powder. Furthermore, applying these findings to wet noodle products is anticipated to serve as a valuable reference and recommendation for businesses and industry stakeholders.

ACKNOWLEDGMENT

The authors thank the Agricultural Product Technology, University of Jember, for their support in completing this research.

REFERENCES

[1] BPS, "Catalog : 1101001," *Stat. Indones. 2020*, vol. 1101001, p. 790, 2022.

[2] F. Rozi *et al.*, "Indonesian market demand patterns for food commodity sources of carbohydrates in facing the global food crisis," *Heliyon*, vol. 9, no. 6, p. e16809, 2023, doi:10.1016/j.heliyon.2023.e16809.

[3] E. Soesilowati, N. Kariada, and O. Paramita, "Improving Non-wheat Flour Quality As a Form of Local Food Conservation," *KnE Soc. Sci.*, vol. 2019, pp. 146–156, 2019, doi: 10.18502/kss.v3i18.4708.

[4] R. A. Zeinab, E.-G. M.M, and E.-S. A. M.Abd, "Substitution of wheat flour by local cereals and pulses flour 'An approach to overcome wheat gap in Egypt' 1. Protein and dry gluten content of flour," *Alexandria J. Agric. Sci.*, vol. 63, no. 4, pp. 215–237, 2018, doi: 10.21608/alexja.2018.26137.

[5] M. G. R. Pandin, C. S. Waloejo, D. Sunyowati, and I. Rizkyah, "The Potential of Mocaf (Modified Cassava Flour) as Disaster Emergency Food," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 995, no. 1, pp. 0–7, 2022, doi: 10.1088/1755-1315/995/1/012006.

[6] N. Diniyah, M. Iguchi, M. Nanto, T. Yoshino, and A. Subagio, "Dynamic Rheological, Thermal, and Structural Properties of Starch from Modified Cassava Flour (MOCAF) with Two Cultivars of Cassava," *J. Teknol. dan Manaj. Agroindustri*, vol. 12, no. 1, pp. 89–101, 2023.

[7] J. Okoko, A. Alonge, and P. Ngoddy, "High quality-cassava flour (HQCF) composites: Their thermal characteristics in retrospect," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 445, no. 1, 2020,

doi:10.1088/1755-1315/445/1/012043.
[8] F. Violalita, Evawati, S. Syahrul, H. F. Yanti, and K. Fahmy, "Characteristics of Gluten-Free Wet Noodles Substituted with Soy Flour," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 515, no. 1, 2020, doi:10.1088/1755-1315/515/1/012047.
[9] S. B. Wahjuningsih *et al.*, "Formulation, Nutritional and Sensory Evaluation of Mocaf (Modified Cassava Flour) Noodles with Latoh (Caulerpa lentillifera) Addition," *Curr. Res. Nutr. Food Sci.*, vol. 11, no. 3, pp. 1008–1021, 2023, doi: 10.12944/CRNFSJ.11.3.08.
[10] D. A. Prihayati and E. Purwani, "The Effect of Composite Flour Composition (Sorghum, Mocaf, and Wheat) on the Elongation, Tensile Strength, and Acceptance of Noodles," p. 17, 2024, doi:10.3390/engproc2024063017.
[11] A. Hinggiranja, N. M. A. S. Singapurwa, I. G. P. Mangku, I. P. Candra, and A. A. M. Semariyani, "The Characteristics of Wet Noodles from Mocaf Flour and Moringa Flour," *Formosa J. Sci. Technol.*, vol. 2, no. 4, pp. 1091–1104, 2023, doi:10.55927/fjst.v2i4.3647.
[12] W. Triadji Nugroho, M. Kurnianto, M. Wibowo, A. Brilliantina, and B. Hariono, "Chemical and Sensory Characteristics of Dried Noodles with Addition of Telang Flower Extract (Clitoria ternatea L)," *Food Agric. Sci. Polije Proc. Ser.*, vol. 3, no. 1, pp. 96–102, 2020.
[13] Netravati, S. Gomez, B. Pathrose, M. R. N, M. J. P, and B. Kuruvila, "Comparative evaluation of anthocyanin pigment yield and its attributes from Butterfly pea (Clitorea ternatea L.) flowers as prospective food colorant using different extraction methods," *Futur. Foods*, vol. 6, no. August, p. 100199, 2022, doi:10.1016/j.fufo.2022.100199.
[14] E. J. Jeyaraj, Y. Y. Lim, and W. S. Choo, "Extraction methods of butterfly pea (Clitoria ternatea) flower and biological activities of its phytochemicals," *J. Food Sci. Technol.*, vol. 58, no. 6, pp. 2054–2067, 2021, doi: 10.1007/s13197-020-04745-3.
[15] X. Fu, Q. Wu, J. Wang, Y. Chen, G. Zhu, and Z. Zhu, "Spectral Characteristic, Storage Stability and Antioxidant Properties of Anthocyanin Extracts from Flowers of Butterfly Pea (Clitoria ternatea L.)," *Molecules*, vol. 26, no. 22, p. 7000, Nov. 2021, doi:10.3390/molecules26227000.
[16] T. N. M. Tuan Putra, M. K. Zainol, N. S. Mohdisa, and N. Mohdmaidin, "Chemical characterization of ethanolic extract of butterfly pea flower (Clitoria ternatea)," *Food Res.*, vol. 5, no. 4, pp. 127–134, 2021, doi: 10.26656/fr.2017.5(4).744.
[17] A. L. Girard and J. M. Awika, "Effects of edible plant polyphenols on gluten protein functionality and potential applications of polyphenol–gluten interactions," *Compr. Rev. Food Sci. Food Saf.*, vol. 19, no. 4, pp. 2164–2199, 2020, doi: 10.1111/1541-4337.12572.
[18] X. Han *et al.*, "Physicochemical interactions between rice starch and different polyphenols and structural characterization of their complexes," *Lwt*, vol. 125, no. October 2019, p. 109227, 2020, doi:10.1016/j.lwt.2020.109227.
[19] R. A. T. Nilusha, J. M. J. K. Jayasinghe, O. D. A. N. Perera, and P. I. P. Perera, "Development of pasta products with nonconventional ingredients and their effect on selected quality characteristics: A brief overview," *Int. J. Food Sci.*, vol. 2019, 2019, doi:10.1155/2019/6750726.
[20] A. Betrouche *et al.*, "Antioxidant Properties of Gluten-Free Pasta Enriched with Vegetable By-Products," *Molecules*, vol. 27, no. 24, pp. 1–17, 2022, doi: 10.3390/molecules27248993.
[21] K. Jakobson *et al.*, "Techno-Functional and Sensory Characterization of Commercial Plant Protein Powders," *Foods*, vol. 12, no. 14, pp. 1–21, 2023, doi: 10.3390/foods12142805.
[22] W. A. Adebayo, B. S. Ogunsina, and K. A. Taiwo, "AZOJETE-CIGR Section VI Special Issue: Innovation & Technologies for Sustainable Agricultural Production & Sensory, Textural and Cooking Quality of Instant Noodles Produced from Musa SPP-Wheat Composite Flours," *Food Suffic. AZOJETE*, vol. 14, pp. 74–85, 2018.
[23] S. Li, D. Tang, S. Liu, S. Qin, and Y. Chen, "Improvement of noodle quality: The effect of ultrasonic on noodles resting," *J. Cereal Sci.*, vol. 96, no. September, p. 103089, 2020, doi:10.1016/j.jcs.2020.103089.
[24] M. Xu, Y. Wu, G. G. Hou, and X. Du, "Evaluation of different tea extracts on dough, textural, and functional properties of dry Chinese white salted noodle," *Lwt*, vol. 101, no. August 2018, pp. 456–462, 2019, doi: 10.1016/j.lwt.2018.11.066.
[25] G. Park, H. Cho, K. Kim, and M. Kweon, "Quality Characteristics and Antioxidant Activity of Fresh Noodles Formulated with Flour-Bran Blends Varied by Particle Size and Blend Ratio of Purple-Colored Wheat Bran," *Processes*, vol. 10, no. 3, 2022, doi:10.3390/pr10030584.
[26] A. Zhang, "Effect of wheat flour with different quality in the process of making flour products," *Int. J. Metrol. Qual. Eng.*, vol. 11, 2020, doi: 10.1051/ijmqe/2020005.
[27] S. Kraithong and S. Rawdkuen, "Quality attributes and cooking properties of commercial Thai rice noodles," *PeerJ*, vol. 9, 2021, doi:10.7717/peerj.11113.
[28] Y. Zhao, X. Dai, E. Mackon, Y. Ma, and P. Liu, "Impacts of Protein from High-Protein Rice on Gelatinization and Retrogradation Properties in High-and Low-Amylose Reconstituted Rice Flour," *Agronomy*, vol. 12, no. 6, 2022, doi: 10.3390/agronomy12061431.
[29] S. X. Chen *et al.*, "Effect of grape seed power on the structural and physicochemical properties of wheat gluten in noodle preparation system," *Food Chem.*, vol. 355, no. February, p. 129500, 2021, doi:10.1016/j.foodchem.2021.129500.
[30] R. Liu, C. Shi, Y. Song, T. Wu, and M. Zhang, "Impact of oligomeric procyanidins on wheat gluten microstructure and physicochemical properties," *Food Chem.*, vol. 260, pp. 37–43, 2018, doi:10.1016/j.foodchem.2018.03.103.
[31] Y. Shen, S. Hong, G. Singh, K. Koppel, and Y. Li, "Improving functional properties of pea protein through 'green' modifications using enzymes and polysaccharides," *Food Chem.*, vol. 385, no. December 2021, p. 132687, 2022, doi:10.1016/j.foodchem.2022.132687.
[32] G. K. Oguis, E. K. Gilding, M. A. Jackson, and D. J. Craik, "Butterfly pea (Clitoria ternatea), a cyclotide-bearing plant with applications in agriculture and medicine," *Front. Plant Sci.*, vol. 10, no. May, pp. 1–23, 2019, doi: 10.3389/fpls.2019.00645.
[33] N. M. Thuy, V. Q. Minh, T. C. Ben, M. T. T. Nguyen, and H. T. N. Ha, "Identification of Anthocyanin Compounds in Butterfly Pea Flowers (*Clitoria ternatea* L.) by Ultra Performance Liquid," *Molecules*, vol. 26, no. 7, pp. 1–13, 2021.
[34] N. N. Hasanah, E. Mohamad Azman, A. Rozzamri, N. H. Zainal Abedin, and M. R. Ismail-Fitry, "A Systematic Review of Butterfly Pea Flower (Clitoria ternatea L.): Extraction and Application as a Food Freshness pH-Indicator for Polymer-Based Intelligent Packaging," *Polymers (Basel).*, vol. 15, no. 11, 2023, doi:10.3390/polym15112541.
[35] M. Gómez, L. C. Gutkoski, and Á. Bravo-Núñez, "Understanding whole-wheat flour and its effect in breads: A review," *Compr. Rev. Food Sci. Food Saf.*, vol. 19, no. 6, pp. 3241–3265, 2020, doi:10.1111/1541-4337.12625.
[36] G. C. Vidana Gamage, Y. Y. Lim, and W. S. Choo, "Anthocyanins From Clitoria ternatea Flower: Biosynthesis, Extraction, Stability, Antioxidant Activity, and Applications," *Front. Plant Sci.*, vol. 12, no. December, pp. 1–17, 2021, doi: 10.3389/fpls.2021.792303.
[37] J. H. Kim, J. E. Kim, W. H. Kim, K. V. Tan, and S. M. Shim, "Plant based protein products: Characterization and functionality of dried tofu noodles containing lotus root powder," *Food Biosci.*, vol. 43, no. April, p. 101342, 2021, doi: 10.1016/j.fbio.2021.101342.
[38] Gaikwad K K, Pawar G S, and Shingote A B, "Effect of Addition of quinoa Flour on Cooking and Sensorial qualities of Noodles," *Biol. Forum-An Int. J.*, vol. 13, no. 2, p. 660, 2021.
[39] N. Ooms and J. A. Delcour, "How to impact gluten protein network formation during wheat flour dough making," *Curr. Opin. Food Sci.*, vol. 25, pp. 88–97, 2019, doi: 10.1016/j.cofs.2019.04.001.
[40] C. Deng, O. Melnyk, and Y. Luo, "Substitution of wheat flour with modified potato starch affects texture properties of dough and the quality of fresh noodles," *Food Sci. Technol.*, vol. 43, pp. 1–9, 2023, doi: 10.1590/fst.128222.
[41] M. Schopf and K. A. Scherf, "Water absorption capacity determines the functionality of vital gluten related to specific bread volume," *Foods*, vol. 10, no. 2, pp. 0–12, 2021, doi: 10.3390/foods10020228.
[42] S. Gomez, B. Pathrose, M. Joseph, and M. N. Raj, "Comparison of Anthocyanin Pigment Extraction Techniques to Evaluate the Free Radical Scavenging Capacity of Butterfly Pea (Clitoria ternatea L.) Flower," *Biol. Forum-An Int. J.*, vol. 14, no. 3, p. 995, 2022.