Proceedings of the International Conference on Agricultural Strategy for Sustainability (ICASS)
October 22–23, 2025 – Pekanbaru, Indonesia
Volume 2, Number 1 (2026): 23-78

Physicochemical and Sensory Properties of Cilembu Sweet Potato Flour (*Ipomoea batatas* L) Dumpling

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Abstract. To increase the use of local raw materials, such as the already popular Cilembu sweet potato, can be substituted in making dumplings to replace some of the wheat flour. This study aims to make dumpling with various concentrations of Cilembu sweet potato flour substitution (0, 10, 20, 30, and 40%) and determine the characteristics of the chemical properties (content of: water, ash, protein, fat, and carbohydrates), physical (expandability), and sensory (flavour, colour, texture, overall preference) of the dumplings produced, determine the dumplings substituted with Cilembu sweet potato flour chosen by the panellists and the maximum amount of Cilembu sweet potato flour substitution that consumers still prefer. The research design was a single-factor Completely Randomized Design (CRD). The data obtained were analyzed using Analysis of Variance (ANOVA). If significant differences were found between treatments, they were further examined using Duncan's Multiple Range Test (DMRT) at the 1% level. The increasing substitution treatment of Cilembu sweet potato flour in making dumplings (0, 10, 20, 30, and 40%), increased the chemical properties of dumpling: water content (from 1.78 - 3.50%), ash content (from 1.5-1.99), and carbohydrate content (from 50.92-55.76), did not affect the protein content, but decreased: fat content (from 39.46 - 33.02), dumpling expansion power (from 107.80-86.60), and had an effect on reducing the sensory properties of dumpling: taste (4.15-2.25), colour (4.40-1.35), texture (4.10-3.30), and overall preference (4.05-3.60). The dumpling substitution of Cilembu sweet potato flour that the panelists most preferred was the substitution of Cilembu sweet potato flour at 10% (score 4.00). Dumplings substituted with Cilembu sweet potato flour up to 30% were still acceptable and liked by the panelists.

Keywords: *Cilembu sweet potato; dumpling; flour substitution; physicochemical properties; sensory properties; expansion power*

1. Introduction

Sweet potatoes are a carbohydrate source grown in Indonesia. Currently, there are approximately 1,000 varieties of sweet potatoes, one of which is the Cilembu sweet potato, a popular variety. This sweet potato is named after its origin, Cilembu Village, Tanjungsari District, Sumedang Regency, West Java [1]. Cilembu sweet potatoes are quite widely available, but their economic value is still limited to being sold raw or baked; they taste sweet with a honey

sensation in them [2]. One way to increase the economic value of Cilembu sweet potatoes is to process them into flour. Flour offers many benefits, namely, to increase shelf life and the ability to process it into various foods [3,4,5]. Sweet potato flour can act as an ingredient in processed foods such as flakes, crackers, bread, pastries (cookies and biscuits), donuts, and sauces [7.8], and is safe for use by people with gluten intolerance [9]. In addition, Cilembu sweet potato flour can be used as a substitute for wheat flour in wheat-based food products, one of which is dumplings. Dumplings are a food product from China. In China, dumplings are known as wonton. Wontons are made from flour, eggs, water, salt, and kansui, and are molded to a thickness of 0.5-1 mm and a width of 8-10 cm on each side, creating a rectangular shape. Wontons are typically filled with a mixture of vegetables and meat, but they can also be kept rectangular. In general, wonton can be served fried or boiled. In Indonesia, wonton is known as dumpling skin, or some people call it dumpling [10]. Dumplings can be served in several ways, namely fried, boiled, and others. Dumplings can be eaten with chicken noodles, meatballs, or even cuanki. Nowadays, dumplings are served fried with the dumpling only, without any filling [11]. Fried dumplings in Indonesia are a favorite to be eaten as a side dish [12].

Wheat flour is the main ingredient in making dumplings [12]. However, in its development, many innovations have been made using local flour as a substitute to reduce dependence on the use of wheat flour because it is an imported ingredient. Some people add or replace some of the wheat flour with tapioca so that the texture becomes chewy [11]. Ref. [10], carried out innovations in making dumplings, namely 100% wheat dumplings as a control, dumplings substituted with sago flour, dumplings substituted with tapioca, and dumplings substituted with glutinous rice flour. Each flour was substituted at 15, 30, and 45%, respectively. The results showed that the dumpling with the best characteristics was made from high-protein flour (16%) with a 30% tapioca substitution. Research on making dumpling skins using purple sweet potato substitution has been conducted by Ref. [13], [14]. However, research on making dumplings using Cilembu sweet potato has not been conducted.

Therefore, it is necessary to innovate in making dumplings using Cilembu sweet potato as a substitute at various concentrations. The expected impact is to increase the economic value of this type of sweet potato, as well as to diversify local food based on the Cilembu sweet potato. This study aims to determine the effect of Cilembu sweet potato flour substitution on the chemical, physical, and sensory properties of dumplings, determine the best dumplings preferred by panelists, and determine the percentage of Cilembu sweet potato flour substitution that is still acceptable to panelists.

2. Research Methods

The process of material preparation, making Cilembu sweet potato flour, and production of dumplings, chemical analysis in the form of proximate analysis, physical properties in the form of swelling power, and sensory tests were carried out in the Production Unit Laboratory, Integrated Laboratory, Food Engineering Laboratory, and Organoleptic Test Laboratory, Department of Agricultural Product Technology, Widya Dharma University, Klaten, from mid-January to the end of April 2025.

2.1 Cilembu Sweet Potato Flour Production

Cilembu sweet potato flour production is carried out at the Production Unit Laboratory of the Department of Agricultural Product Technology, Faculty of Technology and Computer, Widya Dharma University, Klaten, Central Java.

Cilembu sweet potatoes, as a material for making flour are purchased at Dukuh Sunkrungan Market, Ketandan Village, North Klaten District, Klaten Regency, Central Java. Chemicals for flour sample analysis include H_2SO_4 solution, H_2O_2, K_2SO_4, H_3BO_3, Na-thiosulfate solution, 0.2 N HCl solution, 40% NaOH solution, CaSO4, BCG-MR indicator, distilled water, benzene, and methyl red indicator. The tools used are cabinet dryer, 80 mesh sieve, digital

balance, weighing bottle, drying oven, desiccator, porcelain cup, bunsen, ashing furnace, tongs, fat flask (Soxhlet), Kjeldahl micro equipment: destruction flask, distillation flask, and Erlenmeyer, crucible, glass beaker, test tube, dropper pipette, Erlenmeyer, Petridis, and filter paper. High-quality Cilembu sweet potatoes are selected by first sorting out undamaged and unrotten sweet potatoes during the harvesting process. Next, they are washed to ensure clean Cilembu sweet potatoes, free from any dirt or soil still attached to them. The clean Cilembu sweet potatoes are then peeled. The peeled sweet potatoes are then sliced or shredded to a thickness of 0.1–0.3 mm.

The next stage is drying the sweet potatoes using a cabinet dryer (temperature 60ºC, 6 hours). The dried sweet potatoes are then ground until smooth. The final stage is sifting the sweet potato flour using an 80-mesh sieve to obtain fine Cilembu sweet potato flour. The sweet potato flour is stored in an airtight jar and given silica gel, so that it lasts when used. The Cilembu sweet potato flour is subjected to chemical analysis (proximate test), including water content, using the thermogravimetric method [15], Ash content using the ashing method [15], protein content using the Micro-Kjeldahl method [15], fat content using the Soxhlet method [15], and carbohydrate content using by-different. The process of making Cilembu sweet potato flour is shown in Figure 1.

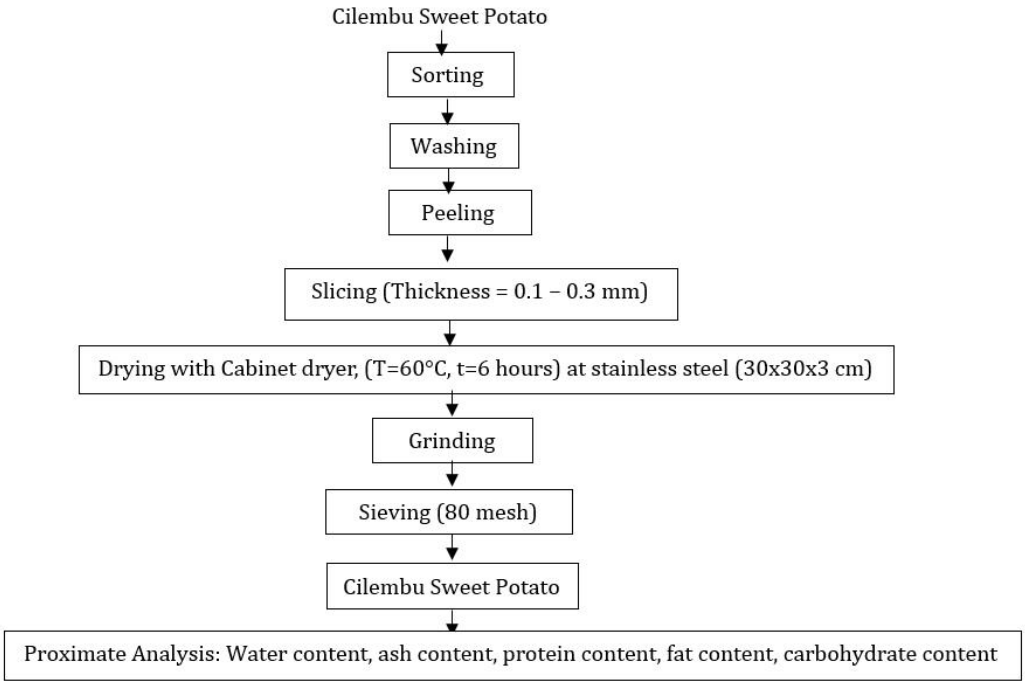

Figure 1. Procedure for producing Cilembu sweet potato flour

2.2 Production of Cilembu Sweet Potato Dumplings

The ingredients used include low-protein wheat flour, margarine, eggs, garlic, salt and flavoring, cooking oil, Sunco brand, purchased at a cake and bread ingredients shop on Rajawali street No. 55, South Bareng, Bareng, Central Klaten District, clean water, and Cilembu sweet potato flour that has been produced using the above procedure.

The ingredients for producing dumplings include low-protein wheat flour, Cilembu sweet potato flour, butter, water, eggs, garlic, salt, and flavoring. All ingredients are mixed by hand until evenly distributed and smooth. The dough is then rolled out using a rolling pin to a uniform thickness of 0.5–1 mm. The flattened dough is formed into a square shape measuring 8 × 8 cm. The square-shaped dumplings are sprinkled with flour to prevent them from sticking to each other. The final step is to fry the dumplings in hot cooking oil at a temperature of 100°C for 35-40 seconds or until cooked. The formulation of ingredients for making dumplings is

presented in Table 1, and the process of producing Cilembu sweet potato dumplings is shown in Figure 2.Each treatment was subjected to chemical property analysis (i.e., proximate analysis including water, ash, protein, fat, and carbohydrate content, using the method as described in the Cilembu flour test analysis), physical properties (in the form of expansion power, Putra et al method [16]), and sensory testing (consisting of flavour, colour, texture, and preference testing, Hedonic Scale Scoring method [17].

Table 1. Formulation of ingredients for production of dumplings substituting Cilembu sweet potato flour for wheat flour

	Amount of ingredients				
Ingredients	Cl_0	Cl_{10}	Cl_{20}	Cl_{30}	Cl_{40}
Cilembu sweet potato flour (grams)	0	20	40	60	80
Wheat flour (grams)	200	180	160	140	120
Margarine (grams)	10	10	10	10	10
Water (ml)	25	25	25	25	25
Eggs (grams)	25	25	25	25	25
Garlic (grams)	10	10	10	10	10
Salt (grams)	2	2	2	2	2
Flavoring (grams)	3	3	3	3	3

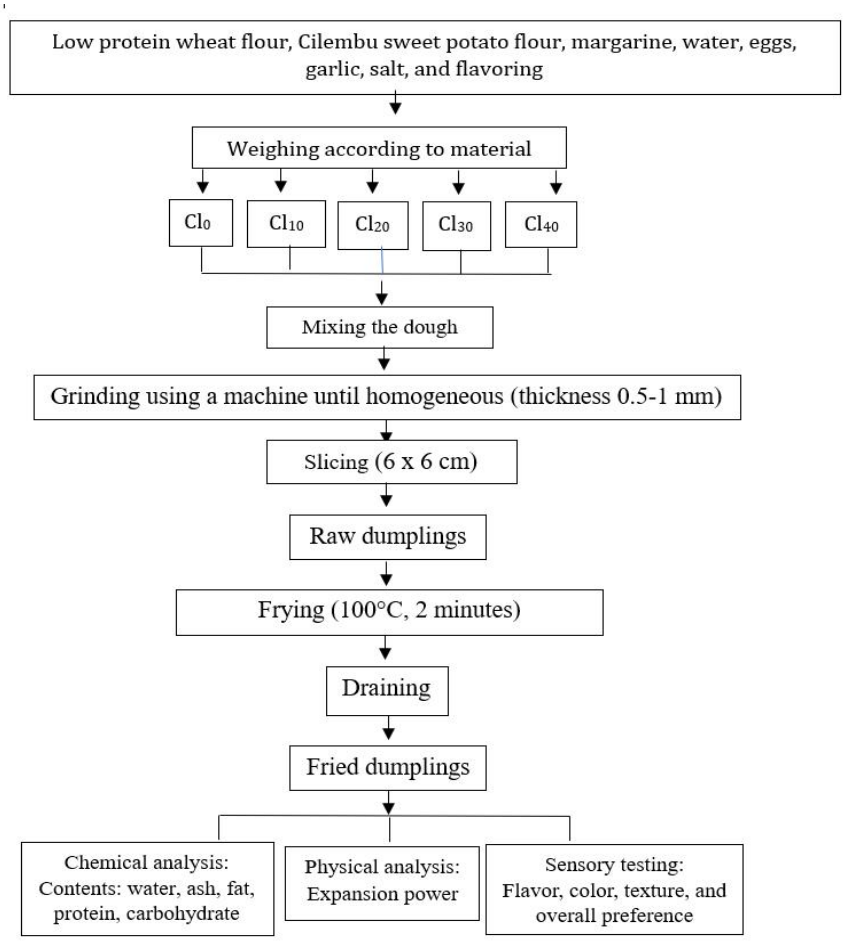

Figure 2. Procedure for producing Cilembu sweet potato pumplings

This study used a single-factor Completely Randomized Design with 5 treatments: Cl0 as control, Cll0 (10% substitution of Cilembu sweet potato flour), Cl20 (20% substitution of Cilembu sweet potato flour), Cl30 (30% substitution of Cilembu sweet potato flour, and Cl40 (40% substitution of Cilembu sweet potato flour). Each treatment was repeated three times, resulting in a total of 15 experimental units. The data obtained were tabulated, and then data analysis was carried out with analysis of variance (ANOVA) using the System Analysis Statistic (SAS) version 9.4 program. If there were differences, the Duncan Multiple Test (DMRT) was continued at a significance level of 1% [18]. The research data are displayed as the mean ± SD (standard deviation).

3. Results and Discussion

3.1 Chemical Analysis Results (proximate analysis) of Cilembu Sweet Potato Flour

The results of the chemical analysis of Cilembu sweet potato flour are presented in Table 2.

Table 2. Results of chemical analysis (proximate analysis) of Cilembu sweet potato flour.

Sample	component				
	Water content (%)	Ash content (%)	Protein content (%)	Fat content (%)	Carbohydrate content (%)
Cilembu sweet potato flour	7.72	2.02	3.98	1.48	84.84

Research by Ref. [19], on the Effect of Partial Substitution of Rice Flour with Cilembu Sweet Potato Flour (Ipomea batatas (L. Lam Cv. Cilembu) on the Characteristics of Steamed Apem Cake, the results of proximate analysis of Cilembu sweet potato flour were: water content 7.73%; ash content 2.24%; protein content 4.21%; fat content 1.00%; carbohydrate content 84.82%, and crude fibre content of 6.24%. When compared with the results of proximate analysis in this study, it can be seen that the protein content of Cilembu sweet potato in this study was lower (3.98%) compared to the research by Ref. [19] which was 4.21%, while the fat content in this study was higher (1.48%), while the research by Suriani et al was 1.00%. This is due to the difference in the origin of the Cilembu sweet potato raw materials used in this study. Different growing environments for Cilembu sweet potatoes can produce different tuber compositions [20].

The amylose content of Cilembu sweet potato flour is 11.60%, and the amylopectin content is 63.68% [21]. Based on the amylose to amylopectin ratio, the amylose content in starchy foods is classified into 4, namely high (>25%), medium (20-25%), low (10-20%), very low (2-9%), and waxy (1-2%) [22,23]. Based on this, Cilembu sweet potato has a relatively low amylose content. The starch content of wheat flour is 75.28%, while the sucrose content of fresh Cilembu sweet potato is 8.49%, and increases when the storage period increases from 2, 4, and 6 weeks, respectively, by 10.9%, 11.4%, and 12.6% [21]. This confirms that the longer it is stored, the sweeter the Cilembu sweet potato will taste.

3.2 Analysis Results of Cilembu Sweet Potato Dumpling

Analysis of Cilembu sweet potato dumplings included proximate analysis, which consisted of water content, ash content, protein content, fat content, and carbohydrate content; physical analysis, especially expansion power; and sensory testing, encompassing flavor, colour, texture, and overall preference.

The results of the proximate analysis of Cilembu sweet potato substitute dumplings are shown in Table 3. The higher the substitution of Cilembu sweet potato flour (from 0% to 40%), the higher the water content of the dumplings. This can be caused by the crude fiber content of

Table 3. Results of proximate analysis of dumplings substituted with Cilembu sweet potato flour

Sample	Water content (%)	Ash content (%)	Protein content (%)	Fat content (%)	Carbohydrate content (%)
Cl_0	1.78±0.18^{c}	1.5±0.03^{c}	6.36±0.03^{ns}	39.46±0.90^{a}	50.92±0.67^{c}
Cl_{10}	2.44± 0.19^{b}	1.54±0.01^{c}	6.32±0.01^{ns}	36.87±0.33^{b}	52.85±0.45^{b}
Cl_{20}	2.72±0.34^{b}	1.8±0.04b^{a}	6.2±0.07^{ns}	34.44±0.97^{c}	54.86±0.57^{a}
Cl_{30}	3.41±0.08^{a}	1.94±0.03^{a}	5.97±0.71^{ns}	33.34±0.26^{cd}	54.88±0.50^{a}
Cl_{40}	3.50±0.10^{a}	1.99±0.07^{a}	5.77±0.02^{ns}	33.02±0.88^{d}	55.76±0.19^{a}

The mean followed by the same letter in the same column indicates that there is no significant difference between the treatments at the 1% significance level. NS=non-significant.

Cilembu sweet potato of 6.24% [19], while the fibre content of sweet potato flour is 3.20 to 3.46% [24]. Fibre is a large molecule in the form of a polymer, with a complex structure and containing many hydroxyl groups. This hydroxyl group is polar with a folded matrix structure that forms hydrogen bonds, and has a large water-binding capacity [25]. The increase in water content can also be caused by the ratio of amylose and amylopectin. The amylose content of Cilembu sweet potato is relatively low at 11.60%, while the amylopectin content is 63.68%. Amylopectin is a starch molecule that has many branched chains and a few straight chains. Therefore, amylopectin molecules are amorphous, so they easily absorb water [26]. This high amylopectin content causes the increase in sweet potato flour to increase the water content of dumplings. Based on SNI 01-2713-1999 for fish crackers products, the water content for fish crackers is a maximum of 11%, so the water content of dumplings in this study still meets SNI standards [27].

Ash content indicates the presence of minerals (inorganic compounds) found in food ingredients and processed foods, so that ash content represents the total presence of minerals in food ingredients [28]. The substitution of Cilembu flour has a very significant effect, namely, the greater the number of substitutions, the increase in the ash content of dumplings. The ash content originates from the ingredients used in making dumplings, as listed in Table 1, which presents the formulation of ingredients for dumplings using Cilembu sweet potato flour substitutes. Sweet potatoes generally contain several minerals. The main mineral contained in sweet potatoes is potassium, at 0.76-1.22%. Other minerals found in sweet potatoes are magnesium 0.04 - 0.15%, sodium 0.06 - 0.18%, phosphorus 0.07- 0.19%, calcium 0.09 - 0.29%, zinc 18.85 - 33.75 mg/kg, iron (Fe) 20.65 - 45.35 mg/kg, copper 3.60 - 8.50 mg/kg, and manganese 8.80 - 16.55 mg/kg [4,29], while the ash content in wheat flour ranges from 0.44 - 0.67% (w/w). The addition of salt in making dumplings further increases the ash content of the resulting dumplings.

The results of the analysis of variance of protein content of dumplings substituted with Cilembu sweet potato flour (0-40%) showed no significant difference between treatments. The wheat flour used in this study was low-protein wheat flour, because dumplings are processed products that do not require development like bread. Low-protein wheat flour has a protein content ranging from 8 to 10% [30]. The protein content of Cilembu sweet potato flour is only 3.98%, so the substitution of wheat flour with Cilembu sweet potato flour does not significantly affect the protein content of dumplings. Other researchers also reported that the protein content of sweet potatoes is generally low, ranging from 1.9 - 2.6% [4,31], and 2.4 - 2.9% [4,5]. The higher the amount of Cilembu sweet potato flour substituted, the lower the fat content of the resulting dumplings. The fat content of Cilembu sweet potato flour in this study was relatively low, at 1.48%. Similarly, the fat content of wheat flour is low. The high fat content in dumplings is due primarily to the addition of ingredients such as eggs and the oil used in frying the dumplings. Cilembu sweet potato is classified as a tuber. Sources of carbohydrates in foods

commonly consumed come from tubers, grains, and nuts [32]. The greater the amount of Cilembu sweet potato flour substituted, the higher the carbohydrate content of the dumplings. This is due to the high carbohydrate content of Cilembu sweet potato flour at 84.84%, so the greater the percentage of Cilembu sweet potato flour substituted means that more wheat flour is replaced with Cilembu sweet potato flour, thus increasing the carbohydrate content in the dumplings. The results of the analysis of physical properties in the form of expansion power of Cilembu sweet potato dumplings are presented in Table 4.

Table 4. The expansion power of Cilembu sweet potato dumplings

Sample	Expansion power (%)
Cl_0	107.80 ± 1.00^a
Cl_{10}	9.40 ± 0.87^b
Cl_{20}	92.40 ± 0.43^c
Cl_{30}	$90.20 \pm .,62^d$
Cl_{40}	86.60 ± 0.20^e

The mean followed by the same letter in the same column indicates that there is no significant difference between the treatments at the 1% significance level.

Table 4 shows that the higher the percentage of wheat flour substitution in making dumplings, the lower the expansion power of the dumplings. This can be caused by the inhibition of the gelatinization process due to the decreasing amylopectin molecules in the dumpling's ingredient [33,34]. During frying, the temperature will increase, resulting in water evaporation. Furthermore, the resulting steam pressure pushes the starch gel and forms air cavities; finally, the dumplings expand. Reducing the amount of wheat flour in making dumplings will likely reduce the amylopectin content in the mixed flour used as an ingredient in making dumplings, resulting in a decrease in the amount of wheat flour and an increase in the amount of Cilembu sweet potato flour, which will reduce its expansion power [33].

In addition, the expansion power of dumplings is also influenced by their water content. The higher the substitution of Cilembu sweet potato, the higher the water content in the ingredients, thereby reducing the rising power of the resulting dumplings [14]. Dumplings without substitution have a more gluten matrix than dumplings substituted with Cilembu sweet potato flour. The expansion power of dumplings during the frying process is also greatly influenced by the gluten matrix in wheat flour. During the frying process, the gluten protein from wheat flour will experience denaturation, and the water contained in the gluten turns into water vapor. The presence of water vapor will push the gluten matrix so that the dumplings expand [10,35]. The results of the sensory properties analysis of Cilembu sweet potato flour substitute dumplings, including flavor, colour, texture, and overall preference, are presented in Table 5.

The results of the sensory test of flavor, the increasing substitution of Cilembu sweet potato flour, and the lower flavor value. The flavor value is from the lowest of 2.25 (savory, typical dumpling, slightly sweet). And the highest of 4.15 (typical savory dumpling). The panelists gave the highest score to dumplings without the substitution of Cilembu sweet potato flour. The substitution of Cilembu sweet potato flour will reduce the typical savory flavor of dumplings towards a slightly sweet flavor, while panelists are used to consuming dumplings with a savory flour. Substitution of 10% Cilembu sweet potato flour, panelists did not recognize any change in flavor. The treatment of substitution of Cilembu sweet potato flour 20 and 30% panelists gave very little different scores, so that the dumplings Cl_{20} and Cl_{30} flavor almost the same (savory to slightly savory typical of dumplings).

Table 5. Sensory test scores of Cilembu sweet potato dumplings

Sample	Parameter Sensory			
	Flavor (%)	Colour (%)	Texture (%)	Overall preference (%)
Cl_0	4.150±0.88[a]	4.40±0.88 a	4.10±0.778a	4.05±0.95a
Cl_{10}	4.05±0.95[a]	4,00±0.86 a	4.05±0.887a	4.00±0.86a
Cl_{20}	3.30±1.03[b]	2.95±0.61 b	3.55±0.945ab	3.85±0.88a
Cl_{30}	2.70±1.17[bc]	2.40±0.94 c	3.35±0.93b	3.55±0.88a
Cl_{40}	2.25±1.133[c]	1.35±0.75 d	3,30±0.923b	2.60±1.188b

The mean followed by the same letter in the same column indicates that there is no significant difference between the treatments at the 1% significance level.

Panelists will be impressed with the colour of processed food products that do not deviate from the colour they should be, so that the colour of processed food plays a role in determining its quality [36]. The treatment of substitution of Cilembu sweet potato flour for wheat flour in making dumplings has a very real effect. Panellists gave the lowest colour score to dumplings that were substituted with the most Cilembu sweet potato flour (40%) with a value of 1.35, (brown colour criteria), while the highest score of 4.40 (slightly brownish yellow criteria) was in dumplings without Cilembu sweet potato substitution, followed by dumplings with 10% Cilembu sweet potato substitution with a score of 4.00. Colour enhancement can be caused by the colour of the raw materials. Cilembu sweet potato flour is yellowish.

In production dough with wheat flour, the increasing amount of Cilembu sweet potato flour substituted has the impact of increasing the colour of the dumplings, after frying. This is in accordance with the results of previous research that the substitution of purple sweet potato flour for dumpling skin, which is increased by 0.5, 10, and 15%, increasingly increases the colour towards dark, which is influenced by the colour of the sweet potato as one of the ingredients for making dumplings [33]. The increase in colour can also be caused by the intensification of a non-enzymatic browning reaction called caramelization. Caramelization is a reaction caused by heating carbohydrate- or sugar-containing materials [37,38]. In this study, the higher the Cilembu sweet potato flour content, the higher the carbohydrate and sucrose content. Increasing the temperature through the frying process further increases the colour intensity, as stated by Barua and Srivastav [39].

Increasing the percentage of substitution with Cilembu sweet potato flour further decreased the texture scores given by the panelists. Samples C_0 and C_{10} scored 4.10 and 4.05 (crispy), while samples C_{20}, C_{30}, and C_{40} scored 3.55, 3.35, and 3.30 (slightly crispy), respectively. Increasing the percentage of substituted Cilembu sweet potato flour caused a decrease in the crispiness of the dumplings. This could be due to the lower water content of the dumplings in treatments C0 and C10 compared to samples C_{20}, C_{30}, and C_{40}. The increasing percentage of substituted Cilembu sweet potato flour in dumplings production further increased the water content and further decreased the crispiness of the dumplings. Treatment C_0 (wheat flour only) did produce crispy dumplings, but it was slightly brittle. The addition of Cilembu sweet potato reduced the brittleness of the dumplings.

Sensory attribute assessment in the overall preference test includes the overall appearance of liking or disliking the flavor, colour, and texture of the Cilembu sweet potato flour substitution dumplings, showing significantly different analysis of variance results. The liking criteria were obtained in samples C_0, C_{10}, C_{20}, and C_{30} with scores of 4.05, 4.00, 3.85, and 3.55, respectively, while sample C_{40} had a slightly different liking criterion. The lowest flavor score was sample C_{40}, which has a savory, typical dumpling, slightly sweet flavor, brown colour, and a slightly crunchy texture, and the lowest expansion power. From the actual texture, it was not

much different from samples C_{20} and C_{30}, but in terms of flavor and colour, it was very different, and had the lowest expansion power, so it had the lowest overall preference score.

4. Conclusions

From the results and discussion of this study, it was concluded that the treatment of Cilembu sweet potato flour substitution in dumplings production which increased (0, 10, 20, 30, and 40%), increased the chemical properties of dumplings: water content (from 1.78 - 3.50%), ash content (from 1.5-1.99), and carbohydrate content (from 50.92-55.76%), did not impact the protein content, but decreased: fat content (from 39.46 - 33.02), dumplings expansion power (from 107.80-86.60), and effected on reducing the sensory properties of dumplings: flavour (4.15-2.25), colour (4.40-1.35), texture (4.10-3.30), and overall preference (4.05-3.60). The dumplings' substitution of Cilembu sweet potato flour, which the panelists most preferred, was the substitution of Cilembu sweet potato flour as much as 10% (score 4.00). Dumplings made with up to 30% Cilembu sweet potato flour were still acceptable and liked by the panelists.

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Acknowledgement

Research project, Widya Dharma University has supported this research based on the Number: 013/F.02.01/PUSLIT/I/2025