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PRODUCTION AND QUALITY TESTING OF BROWNIES MADE WITH WHITE SWEET POTATO FLOUR

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ABSTRACT

Brownies are generally made with wheat flour, so innovation using local raw materials is needed to expand food diversification. White sweet potato flour has potential for use as it is naturally gluten-free, has a sweet and savoury flavour profile, and can be incorporated into bakery products. This study aims to describe the production process of brownies made with white sweet potato flour, assess their sensory quality, and analyse the level of acceptance among panellists. This study employs a quantitative descriptive approach using a product experimentation method. The hedonic test involved 25 untrained panellists and 5 trained panellists, using a five-point scale for the attributes of colour, aroma, texture and flavour. The data were analysed using mean scores and frequency distributions. The production process comprised ingredient preparation, mixing, steaming, cooling, cutting and serving. Untrained panellists gave an average score of 4.44 for colour, 4.56 for aroma, 4.48 for texture and 4.64 for flavour. Trained panellists gave scores of 4.80 for colour, 4.00 for aroma, 4.00 for texture and 4.40 for flavour. All attributes fell within the 'like' to 'very like' categories. The findings indicate that white sweet potato flour can be used as the main ingredient in steamed brownies with high sensory acceptance. This product has the potential to be developed as a culinary innovation based on local food in Samarinda, although testing of nutritional composition, shelf life and formula optimisation is still required.

Keywords: Brownies; white sweet potato flour; local food; hedonic test; sensory quality

INTRODUCTION

Brownies are a popular baked good due to their distinctive chocolate flavour and their dense, soft and moist texture (Mailisa et al., 2024). This product is generally made from wheat flour, the raw material for which comes from imported wheat. This situation highlights the need to utilise local food ingredients as an

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alternative to wheat flour to support national food diversification and security (Hoo et al., 2024; Sambac, Karmin, et al., 2025)

One local ingredient with potential for further development is the sweet potato *(Ipomoea batatas L.).* Sweet potatoes are easy to cultivate, have high yields, and can be processed into flour to make them more shelf-stable and easier to use in bakery products. Sweet potato flour can absorb water and retain moisture, making it suitable for producing products with a soft and moist texture(Sambac, Enny Karmin, et al., 2025). These characteristics are influenced by the variety and processing methods (Dereje et al., 2020). Purple sweet potatoes also contain anthocyanins, which act as natural pigments and possess antioxidant activity (Li et al., 2019), whilst yellow or orange sweet potatoes are rich in beta-carotene, a provitamin A. Naturally, sweet potato flour is gluten-free, making it a potential ingredient for gluten-free brownies. However, the absence of gluten can affect the product's rise, structure and firmness. (Gavi & Martati, 2018) demonstrated that reducing the amount of wheat flour can decrease the rise and result in denser brownies. Therefore, an appropriate formulation is required to ensure that sweet potato flour brownies retain a soft, dense and moist texture.

Previous research has shown that sweet potato flour can be used in bakery products. (Tuhumury et al., 2018) Found that substituting purple sweet potato flour affected the chemical and sensory characteristics of biscuits. (Selvakumaran et al., 2019) reported that steamed brownies made with 100 per cent purple sweet potato flour produced a soft and porous texture, as well as a distinctive flavour that was rated highly by the panellists. Setyadjid and Setiyaningrum (2022) also found that the ratio of purple sweet potato flour to mocaf determines the moisture content as well as consumer acceptance of the brownies' colour, aroma, flavour and texture. Furthermore, (Dereje et al., 2020) confirmed that the ratio of sweet potato flour to other ingredients influences the chemical and sensory characteristics of brownies. These findings are consistent with the international research by (Halim Ahmad & Wulandari, 2026; Selvakumaran et al., 2019), which showed that the use of orange sweet potatoes can improve the physicochemical properties whilst maintaining the sensory acceptability of brownies.

However, previous research has predominantly used sweet potato flour as a partial substitute or in combination with other flours. Studies that use sweet potato flour as the main ingredient in gluten-free brownies whilst also assessing their organoleptic quality, physicochemical characteristics and moisture retention capacity remain limited. Yet these three aspects are crucial to ensuring the product is of good quality and acceptable to consumers. The novelty of this study lies in the development of gluten-free brownies with sweet potato flour as the main ingredient, integrating organoleptic quality, physicochemical characteristics, and moisture retention capacity. Sweet potato flour is not only used as a substitute for wheat flour but also to shape the sensory profile through the product's natural sweetness, distinctive aroma, and natural colour. This research aims to produce a sweet potato flour-based brownie formulation that is soft, moist, does not dry out easily, and is accepted by consumers as a form of innovation and utilisation of local Indonesian foodstuffs.

LITERATURE REVIEW

Brownies as a Bakery Product

Brownies are a chocolate-based baked good that can be prepared by baking or steaming. They are characterised by their dark brown colour, strong chocolate flavour, and a dense, soft and relatively moist texture. Ingredients commonly used in the production of brownies include wheat flour, sugar, eggs, fat, chocolate and raising agents. Unlike cakes, which prioritise volume and a porous structure, brownies have a denser structure, allowing for the use of non-wheat flours in their formulation (Aji et al., 2026; Permata, 2024).

Based on the method of preparation, brownies can be categorised into baked brownies and steamed brownies. Baked brownies generally have a drier surface, a stronger baked aroma, and a relatively denser texture. In contrast, steamed brownies tend to be softer and moister, as the steaming process reduces water loss during preparation. These differences in method can affect the moisture content, texture, aroma and characteristics of the final product. Brownies have been extensively developed by partially or entirely replacing wheat flour with various local food flours. (Rahmah et al., 2024) demonstrated that the use of non-wheat flours can alter the texture, rising ability, chemical composition and characteristics of brownies. (Rizki Amalia Nurfitriani, 2023) also found that the ratio of purple sweet potato flour to mocaf determines the moisture content as well as the colour, aroma, flavour and texture characteristics of steamed brownies. Such developments form part of food diversification whilst also representing an effort to enhance the added value of local food ingredients.

Sweet Potato Flour as a Food Ingredient

Sweet potato flour is a product obtained through the processes of cleaning, slicing, drying and grinding sweet potato tubers *(Ipomoea batatas L.).* Processing sweet potatoes into flour can extend their shelf life, reduce storage volume and make them easier to use in various food products. Sweet potato flour can be used as a structuring agent, thickener, natural colouring agent, and as a partial or complete substitute for wheat flour. Sweet potato flour possesses functional characteristics such as the ability to absorb and bind water, swell, form a paste, and undergo gelatinisation.

These characteristics are influenced by the sweet potato variety, the condition of the raw material, particle size, temperature, and the drying method. Its relatively high-water absorption capacity has the potential to help maintain the moisture content of bakery products. However, its use in high quantities can also result in a denser texture if the composition of water, fat and binding agents is not adjusted accordingly (Dereje et al., 2020). As well as being a source of carbohydrates, sweet potato flour also contains dietary fibre, vitamins, minerals and bioactive components. Its composition varies depending on the variety and processing method. Purple sweet potatoes contain anthocyanins, which act as natural pigments and possess antioxidant activity (Aji et al., 2026). Yellow or orange sweet potatoes contain beta-carotene as a provitamin A, whilst white sweet potatoes have a relatively neutral colour, making them easier to blend with the brown colour in brownie products.

Naturally, sweet potato flour is gluten-free and therefore has the potential to be used in the development of gluten-free products. However, the absence of gluten can result in a denser, less elastic product structure with a lower rise. Consequently, the formulation of sweet potato flour brownies must strike a balance between the flour, water, eggs, fat and binding agents to achieve the desired structure and moisture content. A 'gluten-free' claim on the final product also requires that all additives used are gluten-free and that the production process is free from cross-contamination. Consequently, the use of sweet potato flour does not automatically make brownies gluten-free if other ingredients containing gluten are used or if they are processed using contaminated equipment.

Using Sweet Potato Flour in Brownies

Several studies have shown that sweet potato flour has potential for use in various bakery products. (Rizki Amalia Nurfitriani, 2023) found that substituting purple sweet potato flour affected the chemical and sensory characteristics of biscuits. The results indicate that increasing the proportion of sweet potato flour can lead to changes in the chemical composition, colour, aroma, flavour and texture of the product.

(Pratiwi, 2020) reported that steamed brownies made with 100% purple sweet potato flour produced a soft, porous texture and had the characteristic sweet flavour of sweet potato. These findings demonstrate that sweet potato flour can be used as the main ingredient in brownies without needing to be combined with wheat flour. However, this study was limited to an assessment of texture and flavour and therefore did not provide a comprehensive picture of the product's physical and chemical characteristics. (Rahmah et al., 2024) Investigated steamed brownies using a combination of purple sweet potato flour and mocaf flour. The results showed that variations in the ratio of the two flours were linked to moisture content and product characteristics. A formulation comprising 30 per cent purple sweet potato flour and 70 per cent mocaf flour produced relatively better flavour, aroma and texture, whilst a formulation with a higher proportion of sweet potato flour had a lower moisture content.

(Rizki Amalia Nurfitriani, 2023) demonstrated that the ratio of white sweet potato flour to mung bean flour influences the chemical and sensory characteristics of brownies. White sweet potato flour serves as a source of carbohydrates, whilst mung bean flour increases the product's protein content. The study indicates that interactions between ingredients must be considered, as changes in flour composition can result in different brownie characteristics. The findings of this national study are consistent with international research by (Dereje et al., 2020). The addition of orange sweet potato purée has been reported to improve the physicochemical characteristics of brownies and increase fibre content without compromising the product's key characteristics. However, that study used sweet potato in the form of purée and still combined it with wheat flour. Consequently, the results do not yet fully address the use of sweet potato flour as the main ingredient for gluten-free brownies.

The Quality of Sweet Potato Flour Brownies

Food product quality refers to the overall characteristics that determine a product's safety, quality compliance and acceptability. The quality of brownies made from sweet potato flour can be assessed based on their physical, chemical and microbiological properties. Physical properties include volume, expansion, texture, firmness, colour and surface appearance. Chemical properties include moisture content, ash, protein, fat, carbohydrates, fibre and bioactive components. Meanwhile, microbiological quality encompasses total plate count, the number of moulds and yeasts, and the presence of pathogenic microorganisms.

Moisture content is one of the key parameters as it relates to the softness, moistness and shelf life of brownies. Brownies with a high moisture content are generally softer and moister but are more susceptible to microbiological spoilage. (Mailisa et al., 2024) demonstrated that varying the ratio of purple sweet potato flour to mocaf results in different moisture contents. This indicates that the proportion of flour needs to be controlled to achieve a balance between the softness and shelf life of the product. The texture of brownies is influenced by the flour composition, moisture content, fibre, protein and fat content, as well as the processing method. Sweet potato flour has water-binding properties that can help retain the product's moisture. However, its fibre content and the absence of gluten can result in a denser texture if sweet potato flour is used in high quantities (Dereje et al., 2020).

The rising ability of brownies is related to the batter's capacity to form and maintain its structure during the baking process. Replacing wheat flour with sweet potato flour can reduce the batter's ability to retain gas because a gluten network does not form. (Marlina & Refialy, 2025) demonstrated that the proportion of non-wheat flour is associated with a reduction in rising ability and an increase in the density of brownies. Although brownies do not require the same level of rising as sponge cakes, a structure that is too dense and hard can reduce product quality. The colour of brownies is influenced by chocolate, the Maillard reaction, the variety of sweet potato, and the processing method. Purple sweet potato flour can produce a darker or purplish colour due to its anthocyanin content, whilst yellow or orange sweet potato flour produces a brownish colour. White sweet potato flour has a relatively neutral colour and therefore does not significantly alter the brown colour that is the main characteristic of brownies (Pratiwi, 2020).

The aroma and flavour of the product are also influenced by the variety and proportion of sweet potato flour used. The use of sweet potato flour can impart a natural sweetness and a distinctive aroma that sets this product apart from wheat flour brownies. However, using it in large quantities can result in a strong sweet potato aroma or aftertaste. Therefore, the formulation needs to be adjusted so that the distinctive characteristics of the sweet potato remain apparent without overpowering the chocolate flavour, which is the defining characteristic of brownies(Setianingrum et al., 2025).

METHOD

This study employed a quantitative descriptive approach using an experimental method. The research was conducted from January to May 2026 at the Pastry Kitchen Laboratory of the Department of Tourism, Samarinda State Polytechnic. The experiment involved making steamed brownies using white sweet potato flour as a substitute for wheat flour, based on a predetermined formulation. All ingredients

were weighed according to the formulation and processed using the same procedures, equipment, timing and steaming conditions.

The product evaluation involved 30 panellists selected using purposive sampling, comprising 25 untrained panellists and 5 trained panellists. Untrained panellists were members of the public aged 17 or over, in good health, with no impairment of smell or taste, and with no allergies to the product's ingredients. Trained panellists comprised chefs or professionals in the culinary and pastry sectors with at least two years' work experience and an understanding of bakery product evaluation.

Data were collected through experiments, questionnaires and documentation. The quality of the brownies was assessed based on the attributes of colour, aroma, texture and taste using a five-point hedonic scale, namely 1 = strongly dislike, 2 = dislike, 3 = somewhat like, 4 = like, and 5 = strongly like. The samples were presented in uniform sizes and coded to minimise bias in the assessment (Sugiyono, 2020). The data were analysed descriptively using mean values, frequency distributions and percentages. The results of the assessments by trained and untrained panellists were presented separately in tabular form and then interpreted to describe the quality and level of acceptance of the brownies made from white sweet potato flour.

RESULTS AND DISCUSSION

Brownies Formula Development

The development of steamed brownies made from white sweet potato flour involved two formulation trials. The two formulations differed in the quantities of eggs, vanilla, and mixing time. The results of the initial trial are presented in Table 1.

Table 1. Results of the white sweet potato flour brownie formulation experiment

Characteristics	Formula 1	Formula 2
Vanilla	More	Less
Eggs	Less	More
Beating the eggs	Longer	Shorter
Colour	Dark chocolate	Dark chocolate
Aroma	Chocolate-dominant and not fishy	You can still smell the eggs
Texture	Dense, soft and fudgy	Brittle and prone to breaking
Decision	Final formula	Not used

Source: Research data (2026).

The first formula was chosen as the final formula because it produced brownies that were dark brown in colour, had a chocolatey aroma, were free from any fishy odour, and had a dense, soft and fudgy texture. The second formula was not used because it produced a stronger eggy aroma and a crumbly texture.

Process and Product Characteristics

The process of making brownies consists of the preparation, cooking and serving stages. During the preparation stage, all the ingredients are weighed using

digital scales in accordance with the recipe. Butter, oil and dark chocolate are melted using the bain-marie method. The eggs, sugar and vanilla are then whisked together, before being combined with the melted chocolate and dry ingredients to form a smooth batter.

The batter was steamed for 30–40 minutes until cooked through, then left to cool at room temperature. The brownies were cut into uniform pieces, measuring approximately 4 × 4 × 3 cm, before being served to the panellists. The resulting product had a relatively smooth surface, a dark brown colour, a dominant chocolate aroma, and a dense yet soft texture.



Figure 1. White sweet potato flour brownies
Source: Researcher's documentation (2026).

Panellists' Assessment Results

The product assessment involved 25 untrained panellists and 5 trained panellists. The trained panellists comprised three culinary professionals from the Midtown Hotel in Samarinda and two staff members from Fanny's Lapis Labu in Samarinda. The attributes assessed included colour, aroma, texture and taste. A summary of the assessment results is presented in Table 2

Table 2: A summary of the assessment results is presented

Attribute	Untrained panellists (n = 25)	Category	Trained panellists (n = 5)	Category
Colour	4,44	Love it	4,80	Love it
Aroma	4,56	Love it	4,00	Like
Texture	4,48	Love it	4,00	Like
Flavour	4,64	Love it	4,40	Love it
Overall average	**4,53**	**Love it**	**4,30**	**Love it**

Source: Research data (2026).

Among the untrained panellists, taste received the highest score of 4.64, followed by aroma at 4.56, texture at 4.48, and colour at 4.44. All attributes fell within the 'very much like' category. Meanwhile, the trained panellists gave the highest score to colour at 4.80, followed by taste at 4.40, and aroma and texture at 4.00 each. Overall, both groups of panellists rated the product as 'very much liked'. The distribution of ratings for each attribute is shown in Table 3.

Table 3. Distribution of panellists' ratings of the brownies

Attributes	Panelist group	Score 5	Score 4	Score 3	Score 2	Score 1
Colour	Untrained	64%	24%	8%	0%	4%
Colour	Trained	80%	20%	0%	0%	0%
Aroma	Untrained	56%	44%	0%	0%	0%
Aroma	Trained	0%	100%	0%	0%	0%
Texture	Untrained	56%	36%	8%	0%	0%
Texture	Trained	0%	100%	0%	0%	0%
Flavour	Untrained	64%	36%	0%	0%	0%
Flavour	Trained	40%	60%	0%	0%	0%

Source: Research data (2026).

Panellists' Responses

Untrained panellists generally stated that the colour, aroma, texture and flavour of the brownies were satisfactory. The flavour of the sweet potato was noted to be noticeable, but not overly dominant compared to the chocolate flavour. Trained panellists also gave positive feedback on the product, particularly regarding its colour and flavour. Some panellists suggested introducing a variety of toppings and further developing the product for marketing, as brownies made with sweet potato flour are still relatively rare in Samarinda.

The first formula was selected as the final formula because it produced brownies with a dark brown colour, a dominant chocolate aroma, and a dense, soft and fudgy texture, whilst the second formula produced a stronger egg aroma and a crumbly texture. These differences are thought to be related to the quantities of eggs and vanilla, as well as the mixing time of the batter. Using more vanilla helps mask the egg aroma, whilst longer mixing produces a more stable batter. The absence of gluten in sweet potato flour means that the formation of the brownie's structure depends more heavily on the balance of eggs, fat, liquid, and the mixing process. This is in line with Dereje et al. (2020), who explain that sweet potato flour's ability to absorb and bind water can help retain the product's moisture, but an unbalanced formulation has the potential to result in a texture that is either too dense or too brittle.

The assessment results showed that all attributes of the brownies were well received by both groups of panellists. Colour received an average score of 4.44 from untrained panellists and 4.80 from trained panellists. The dark brown colour was primarily due to the use of dark chocolate and the heating process, whilst the relatively neutral colour of the white sweet potato flour did not mask the visual characteristics of the brownies. This characteristic is an advantage compared to purple sweet potato flour, which can produce a purple or darker brown colour due to its anthocyanin content (Li et al., 2019). Aroma received an average score of 4.56 from untrained panellists and 4.00 from trained panellists. The combination of chocolate, butter, vanilla and the subtle aroma of sweet potato produced a pleasant aroma without any off-putting eggy odour. These results support Setyadjid and

Setiyaningrum (2022), who stated that the composition of flour and additives plays a role in shaping the aroma of brownies. The lower score from trained panellists merely indicates a tendency in the assessment and cannot be interpreted as a significant difference, as no inferential testing was carried out.

The texture of the brownies received an average score of 4.48 from untrained panellists and 4.00 from trained panellists. The dense, soft and moist texture is thought to be related to the ability of sweet potato flour to bind water. Although gluten-free, the use of the correct amounts of eggs, fat and liquid can result in a structure that is not too hard. These results are consistent with those of Dereje et al. (2020), who stated that the water-binding capacity of sweet potato flour influences the consistency and moisture content of baked goods, and with Sani et al. (2018), who found that sweet potato flour can produce steamed brownies with a soft and porous texture. Flavour was rated as the highest attribute, scoring 4.64 from untrained panellists and 4.40 from trained panellists. The combination of chocolate, sweet, savoury and rich flavours produced the distinctive character of sweet potato without masking the main flavour of the brownies. These findings are consistent with those of Selvakumaran et al. (2019), who demonstrated that the use of sweet potato can produce brownies with good physicochemical characteristics and sensory acceptability.

Overall, untrained panellists gave an average score of 4.53 and trained panellists gave an average score of 4.30, both of which fall within the 'very like' category. These results indicate that white sweet potato flour brownies are acceptable to both the public and culinary professionals. Positive feedback regarding marketing potential and the development of topping variations also suggests the product's initial potential for further development. However, these results cannot yet be generalised as an indication of market potential, as they involved only 30 panellists selected via purposive sampling. The study also did not include testing of moisture content, instrumental texture, nutritional content, microbiological safety and shelf life. Therefore, further testing with a larger number of respondents, as well as physicochemical and microbiological analyses, is required before the product can be developed on a commercial scale.

CONCLUSIONS

This study demonstrates that white sweet potato flour can be used as an alternative ingredient in the production of steamed brownies. The selected formula produced brownies with an attractive dark brown colour, a chocolate aroma blended with the subtle scent of sweet potato, a dense yet soft and moist texture, and a sweet, rich and savoury flavour. The evaluation results indicated that all product attributes were well received. Untrained panellists gave an average score of 4.44 for colour, 4.56 for aroma, 4.48 for texture, and 4.64 for flavour, whilst trained panellists gave an average score of 4.80 for colour, 4.00 for aroma, 4.00 for texture, and 4.40 for flavour. The overall average was 4.53 for untrained panellists and 4.30 for trained panellists, both of which fall within the 'very much liked' category. Thus, white sweet potato flour brownies have good sensory quality and acceptance and could be developed as an innovative bakery product based on local food ingredients. Further research is recommended to test nutritional content, physicochemical properties, microbiological safety, and shelf life, and to compare different

proportions of sweet potato flour to identify an optimal formula. Product development could also be carried out through variations in toppings, improvements to packaging and market testing with a larger number of consumers before the product is commercially launched.

PERNYATAAN

Konflik Kepentingan *(Competing Interests)*

Penulis menyatakan bahwa tidak terdapat konflik kepentingan finansial, pribadi, profesional, maupun hubungan lain yang dapat memengaruhi pelaksanaan penelitian, penulisan, atau publikasi artikel ini.

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Penelitian ini tidak menerima pendanaan khusus dari lembaga pemerintah, swasta, maupun organisasi lainnya. Penelitian dilaksanakan secara mandiri oleh penulis.

Pengungkapan Penggunaan Kecerdasan Buatan Generatif *(Generative AI Disclosure)*

Dalam proses penyusunan manuskrip, penulis menggunakan alat generative *Artificial Intelligence (AI)* secara terbatas untuk membantu penyuntingan bahasa, perbaikan tata bahasa, penerjemahan, dan penyempurnaan struktur kalimat. AI tidak digunakan untuk menghasilkan, memanipulasi, atau menginterpretasikan data penelitian maupun untuk menggantikan proses analisis dan pengambilan keputusan ilmiah dari penulis. Seluruh keluaran yang dihasilkan dengan bantuan AI telah diperiksa dan diverifikasi oleh penulis. Penulis tetap bertanggung jawab sepenuhnya atas keakuratan, orisinalitas, integritas, serta kepatuhan etis seluruh isi manuskrip.

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