www.ijarp.com ISSN 2456-9992 Page: 01-11

International Journal Advanced Research Publications

Review Article

Volume: 02
Issue: 06

INFLUENCE OF DIFFERENT LOCAL FLOUR SUBSTITUTIONS ON THE PHYSICOCHEMICAL AND PHYSICAL PROPERTIES OF SWEET BREAD

Lutfi Purwitasari, Swastika Dewi, Zahra Nafizha Amani, *Hega Bintang Pratama Putra

Department of Food Technology, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Semarang, Indonesia.

Article Received: 22 April 2026, Article Revised: 12 May 2026, Published on: 01 June 2026

***Corresponding Author: Hega Bintang Pratama Putra**

Department of Food Technology, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Semarang, Indonesia.

DOI: https://doi-doi.org/101555/ijarp.9341

ABSTRACT

Sweet bread is a bakery product made primarily from wheat flour and is widely popular among consumers. The high consumption of sweet bread increases Indonesia's dependence on wheat imports, which may pose risks to national food security and economic stability. Indonesia, as a tropical country, has abundant local food resources that can be utilized as alternative flour sources. This study aimed to evaluate the effect of substituting wheat flour with several local flours, namely banana flour, purple sweet potato flour, red rice flour, and pumpkin flour, in sweet bread products. The study used a completely randomized design (CRD) with five treatments: 100% high-protein wheat flour as control (P1), 50% banana flour, 50% purple sweet potato flour, 50% red rice flour, and 50% pumpkin flour substitutions. The observed parameters included bread expansion, moisture content, L*a*b** color values, and physical appearance, specifically crust formation on the bread surface. The results showed that all substituted local flours affected the physicochemical properties of sweet bread but did not affect the physical appearance, particularly crust formation, of the sweet bread.

KEYWORDS: sweet bread, local flour, wheat flour substitution, physicochemical properties, bread expansion

INTRODUCTION

Bakery products are among the most widely consumed foods in Indonesia. Based on the 2022 Food Consumption Statistics, the consumption of white bread reached 18.4 kg/capita/year, while the consumption of sweet bread and other types of bread reached 54.4 kg/capita/year. Sweet bread is produced through the fermentation of wheat flour into a sweet dough containing 10% sugar or more (Ridhani et al., 2021). Wheat flour is derived from wheat grains, which cannot yet be produced domestically on a large scale in Indonesia, making imports necessary (Rozi et al., 2023). Dependence on wheat imports is considered a risk to food security and price stability (Amalia, 2025). This condition has encouraged food diversification through the utilization of local ingredients as substitutes for wheat flour.

Banana (Musa acuminata) is a tropical fruit widely found in Indonesia and contains carbohydrates, fiber, vitamins, and minerals that fulfill the requirements as a food commodity (Dewi et al., 2023). Purple sweet potato has the potential to be used as a wheat flour substitute due to its high starch content and its ability to enhance nutritional value through fiber and antioxidant compounds (Utami and Mafaza, 2023) Red rice is a type of rice containing natural pigments that function as antioxidants (Syafutri et al., 2020). Based on its nutritional composition, red rice flour contains higher levels of protein, carbohydrates, phosphorus, vitamins, moisture, and fiber compared to wheat flour (Oktaviani, 2025). Pumpkin is a food ingredient rich in dietary fiber, especially pectin, and also contains bioactive compounds, β-carotene, vitamin A, tocopherols, various vitamins, and minerals that can be utilized as flour (Millati and Wahdah, 2020).

The use of local flours as substitutes for wheat flour in bread products has been widely investigated and is known to influence the physical and physicochemical characteristics of sweet bread. The substitution of local flours may lead to changes in loaf expansion, color, moisture content, and physical appearance of the product. Banana flour, purple sweet potato flour, red rice flour, and pumpkin flour possess different characteristics, resulting in varying effects on sweet bread quality. The utilization of various local flours may also contribute to national food security and promote food diversification through the optimization of Indonesia's natural resources (Putra et al., 2024). Therefore, this study aimed to evaluate the effect of different local flour substitutions on the physicochemical and physical characteristics of sweet bread.

Materials

The flours used in this study were high-protein wheat flour (Bogasari Cakra Kembar), purple sweet potato flour (Hasil Bumiku), banana flour (Hasil Bumiku), red rice flour (Hasil

Bumiku), granulated sugar (Rose Brand), instant yeast (Fermipan), chicken eggs, liquid milk (Ultra Milk), margarine (Blue Band), and salt (Cap Kapal). The instruments used for analysis included a color reader (Chromameter Konica Minolta CR-20), ruler, analytical balance (Fujitsu), and moisture oven (Memmert).

This study was an experimental research using a Completely Randomized Design (CRD). The experiment involved the substitution of high-protein wheat flour with banana flour, purple sweet potato flour, red rice flour, and pumpkin flour. Treatment P0 served as the control, while 50% substitution of high-protein wheat flour with local flours consisted of: (P1) banana flour, (P2) purple sweet potato flour, (P3) red rice flour, and (P4) pumpkin flour. Each treatment was conducted in triplicate. The observed parameters included moisture content, bread expansion, L*a*b* color values, and physical appearance.

Methods

The sweet bread was prepared by mixing a total of 225 g flour according to the treatment with 45 g granulated sugar, 7 g instant yeast, 40 g egg, 120 mL cold liquid milk, 50 g margarine, and 1.5 g salt. The dough was mixed using a mixer for 10 minutes until smooth and elastic. The dough then divided into several portions (dividing), rounded (rounding), and proofed for 30–35 minutes at 40–45°C. After proofing, the dough was degassed and weighed to 20 g, then rounded again and measured for height and diameter using a ruler as the initial expansion data before fermentation. The dough was proofed again for 25–30 minutes at 40–45°C. Before baking, the dough height and diameter were remeasured as the expansion data after fermentation. The dough was baked for 15 minutes at 170–180°C, and egg yolk was applied to the surface at the 7th minute of baking. After baking, the sweet bread height and diameter were measured again using a ruler.

Moisture content was determined using the gravimetric method based on AOAC (2012). Bread expansion was analyzed according to the method of Pusuma et al., (2018) by comparing the increase in sweet bread volume to the initial dough volume. Color analysis was conducted following Pratama (2019) with modifications by taking color measurements from three different points. The obtained data were tabulated and statistically analyzed. Significant differences among treatment means were analyzed using one-way ANOVA followed by Duncan's test at a significance level of $p<0.05$. Statistical analysis was performed using Microsoft Excel and SPSS software version 26.

RESULTS AND DISCUSSION

Dough Expansion

Bread expansion refers to the ability of bread to undergo changes in size before baking (proofing) and after the baking process. Several studies by Arifin et al., (2023), Darmawansyah and Ninsix (2016), and Gozali et al., (2021) reported that the substitution of wheat flour with other ingredients can affect the expansion of sweet bread. Bread expansion is closely related to the ability of the dough to form and retain gas produced during the fermentation process (Saepudin et al., 2017). The results presented in Figure 1 showed that the control treatment (P0) had the highest fermentation expansion, while treatment P3, which substituted wheat flour with red rice flour, exhibited the lowest fermentation expansion.

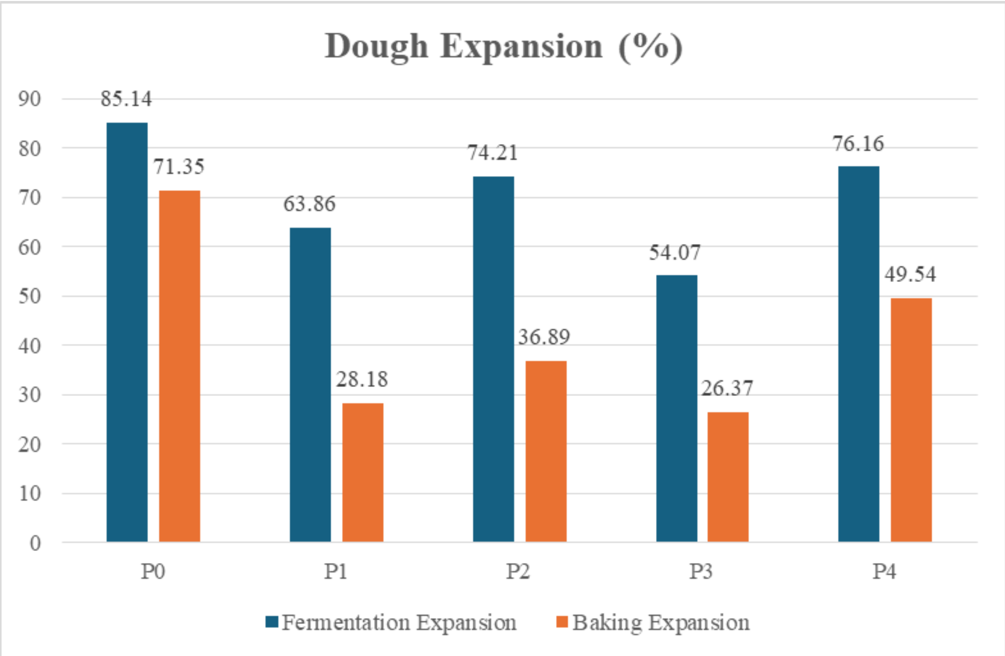

Figure 1. Fermentation Expansion and Oven Expansion of Sweet bread with Different Local Flour Substitutions.

The highest oven expansion was also observed in the control treatment (P0), while the lowest was found in the wheat flour substitution with red rice flour (P3). High fiber content, such as glucomannan, may weaken the gluten network and consequently reduce bread volume during baking (Boudrag et al., 2025). Wheat flour, which was the main ingredient in the control treatment (P0), contains relatively high protein levels ranging from 11.48–14.08% wb (Kusnandar et al., 2022). These proteins consist of glutenin and gliadin fractions that contribute to dough elasticity and plasticity. Weakening of the gluten network reduces the dough's ability to retain gas produced during fermentation (Hidayat and Ulfa, 2024).

The fermentation and oven expansion results presented in Figure 1 showed that P4, the substitution with pumpkin flour, still produced relatively high expansion values due to the presence of pectin, which helps maintain dough structure and retain water (Yulianti and Basri, 2019). In contrast, the use of purple sweet potato flour (P2), banana flour (P1), and red rice flour (P3) resulted in lower fermentation expansion values. This indicates that local flour substitution with lower gluten content and higher fiber levels allows gas to escape more easily, thereby reducing bread expansion (Kiranawati et al., 2021).

Moisture Content

Water is one of the essential components in food products. It may exist as intracellular or external water and functions as a solvent medium in various emulsion-based products such as butter and margarine (Makmur, 2017). Moisture content affects the shelf life of food products because higher moisture levels increase the possibility of microbial growth, resulting in faster food deterioration (Agustia et al., 2021). Figure 2 shows that the average moisture content of sweet bread in all treatments ranged from 17.1% to 28.4%. According to the Indonesian National Standard (SNI 01-3840-1995) for sweet bread quality requirements, the maximum allowable moisture content is 40%. Therefore, the moisture content of sweet bread in this study still met the SNI quality standard.

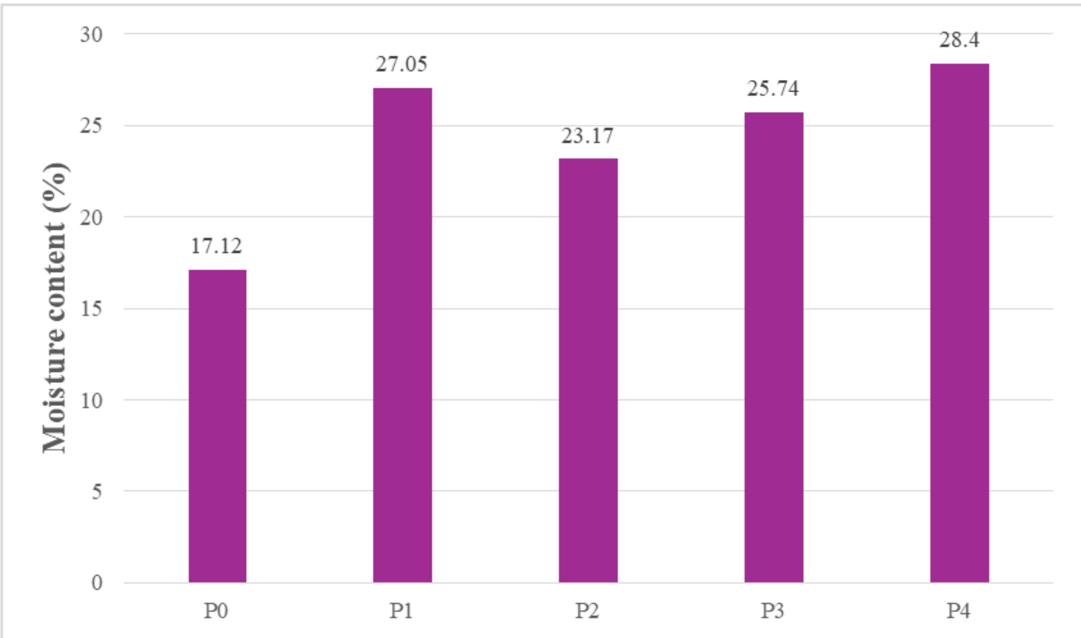

Figure 2.Moisture Content of Sweet bread with Different Local Flour Substitutions.

The control sweet bread made from 100% wheat flour had the lowest moisture content because wheat flour contains gluten as the dominant component compared to fiber, causing more water to be utilized for gluten network formation while some water evaporates easily during baking (China et al., 2022). This result is supported by another study reporting that the addition of sweet potato flour and soybean flour mixtures produced biscuits with higher moisture content compared to the control biscuits (Roger et al., 2022). The use of pumpkin flour as a 50:50 substitution for wheat flour (P4) resulted in the highest increase in sweet bread moisture content among all substitution treatments. Pumpkin flour contains starch and pectin with high water-binding capacity, therefore higher usage levels tend to increase product moisture content (Sari and Kurniawati, 2023).

The moisture content of P1, which used banana flour, was higher than that of purple sweet potato flour (P2) and red rice flour (P3). A study by Ewunetu et al., (2023) showed that banana flour is highly hygroscopic and contains many hydrophilic molecules, resulting in bread products with higher moisture content. Sweet bread substituted with red rice flour (P3) showed slightly higher moisture content than sweet bread with purple sweet potato flour (P2). This finding is in agreement with Oppong et al., (2021), who stated that starch components such as amylose and amylopectin in red rice influence bread moisture content.

L*a*b* Colour

Based on Table 1, the highest L* value was observed in the control treatment, while the lowest L* value was found in sweet bread substituted with 50% wheat flour and purple sweet potato flour (P2). The highest a* value was obtained in the 50% wheat flour and purple sweet potato flour substitution treatment (P2), whereas the lowest a* value was found in the control treatment (P0). The highest b* value was shown by sweet bread substituted with 50% wheat flour and banana flour (P1), while the lowest b* value was observed in the sweet bread substituted with 50% wheat flour and pumpkin flour (P4).

Table 1. L*a*b* Colour of Sweet bread with Different Local Flour Substitutions.

Color attributes	Samples				
	P0	P1	P2	P3	P4
L*	68,06 ± 3,12^{d}	55,76 ± 1,75^{c}	42,47 ± 1,15^{a}	50,88 ± 2,25^{b}	57,81 ± 2,36^{c}
a*	20,98 ± 0,85^{a}	25,53 ± 1,37^{b}	31,05 ± 1,60^{c}	28,93 ± 1,82^{c}	23,78 ± 1,62^{b}
b*	56,36 ± 0,63^{c}	59,94 ± 0,94^{d}	54,45 ± 0,82^{b}	57,48 ± 1,23^{c}	52,51 ± 0,60^{a}

Note: Significant differences ($p<0.05$) are indicated by different superscripts within the same coloumn. P0 = Control treatment; P1 = 50% banana flour substitution; P2 = 50% purple sweet potato flour substitution; P3 = 50% red rice flour substitution; P4 = 50% pumpkin flour substitution.

The high L* value in the control treatment (P0) indicated that the bread had a brighter color compared to the local flour substitution treatments. This was because wheat flour undergoes a bleaching process (Pangestuti and Darmawan, 2021). The decrease in L* values in substitution treatments was influenced by the natural pigments present in each local flour, such as anthocyanins in purple sweet potato (Salim et al., 2017), brown pigments in red rice (Anggraini and Dewi, 2017), and carotenoids in pumpkin and banana flours (Yong et al., 2019). The lowest L* value in treatment P2 indicated that anthocyanin pigments from purple sweet potato contributed to a darker color in sweet bread.

The a* value represents the redness level of the product. The high a* value in treatment P2 was influenced by the anthocyanin content in purple sweet potato, which produced a reddish-purple color in the bread (Salim et al., 2017). In contrast, the lowest a* value in the control treatment indicated that wheat flour bread had lower red color intensity because it lacked dominant natural pigments (Pangestuti and Darmawan, 2021). The b* value indicates the yellowness level of the product. Treatment P1 produced the highest b* value, indicating a more yellow color compared to the other treatments. This was attributed to the natural carotenoid pigments in banana flour as well as browning reactions during baking (Sihombing et al., 2024). Meanwhile, the lowest b* value in the pumpkin flour substitution treatment indicated lower yellow intensity due to the dominance of brownish-orange color after baking. In addition to natural pigments, color changes in all treatments were also influenced by Maillard reactions and sugar caramelization during the sweet bread baking process (Ramadhania et al., 2025).

Crust Appearance

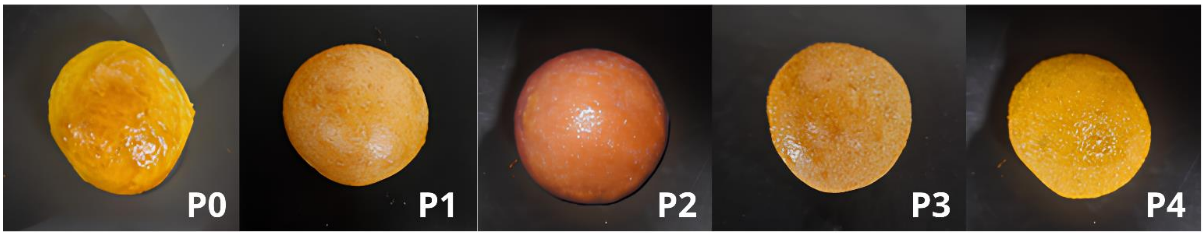

Figure 3. Physical appearance (cracking crust) of Sweet Bread by Different Local Flour Subtitutions

Based on Figure 3, all treatments showed no cracking crust. Cracking crust in bread refers to the formation of cracks or splits on the bread surface during the baking process. The absence of cracking crust in all treatments indicates that the dough formulations were still able to maintain the stability of the bread surface structure during baking. This condition was likely due to the proportion of wheat flour used, which was still sufficient to form a gluten network capable of maintaining dough elasticity and preventing the bread surface from cracking due to gas pressure during the oven spring process (Chikpah et al., 2023). In addition, optimal proofing and baking processes also contributed to more uniform gas distribution within the dough and the formation of a smoother and more uniform crust in all treatments (Ammar et al., 2022).

CONCLUSION

Based on the study conducted, the use of local flours as substitutes for wheat flour affected the physicochemical characteristics and appearance of sweet bread. Sweet bread substituted with banana flour, purple sweet potato flour, red rice flour, and pumpkin flour showed differences in fermentation expansion, oven expansion, moisture content, and L*a*b* color values. However, the crust appearance of sweet bread produced from all treatments showed no differences.

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