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Research Article

Characteristics of Pie Crusts Made from Modified Cassava Flour (MOCAF) and Red Bean Flour

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Abstract: The development of bakery products has increased the demand for wheat flour alternatives, especially for individuals with dietary restrictions. This study aims to investigate the characteristics of pie crusts made from MOCAF (modified cassava flour) and red bean flour at various ratios. The experimental method used was a completely randomized design (CRD) with four treatments: MK1 (90% MOCAF, 10% red bean flour), MK2 (85% MOCAF, 15% red bean flour), MK3 (80% MOCAF, 20% red bean flour), and MK4 (75% MOCAF, 25% red bean flour). The parameters evaluated included moisture content, ash content, protein content, fat content, and sensory testing (color, aroma, taste, and crumb texture) using descriptive and hedonic tests. The results of the study showed that increasing the proportion of red bean flour significantly affected the sensory characteristics and nutritional content of pie crusts. MK4, with a ratio of 75% MOCAF and 25% red bean flour, achieved the highest hedonic scores for color (3.63), taste (3.50), aroma (3.86), and crumbly texture (4.18), which were most preferred by the panelists. Proximate analysis revealed that MK4 had a moisture content of 4.21%, ash content of 1.88%, protein content of 9.94%, and fat content of 26.09%. In conclusion, the addition of red bean flour to the pie crust formulation with MOCAF improves sensory quality and nutritional value, making it a suitable alternative for healthier bread products.

Keywords: characteristics of pie crust, mocaf, red bean flour

1. INTRODUCTION

The bakery industry is currently experiencing rapid growth with the emergence of numerous bakery products featuring a variety of flavors, shapes, and colors that attract consumers' attention. One type of bakery product experiencing significant growth is the pastry category. Pastry is a general term for various types of cakes made from dough with a high fat content, such as butter or margarine and water, processed using special techniques to produce a layered texture after baking [1]. Some processed products that can be categorized as pastries include flaky pastry, puff pastry, croissant, choux pastry, phyllo pastry, dan shortcrust pastry [2].

Shortcrust pastry is a type of pastry made by mixing fat into flour to form a coarse crumb texture, which is then shaped into dough by adding water gradually[2]. One type of shortcrust pastry is pie crust. Pie crust is a layer of pastry dough that holds a sweet (such as fruit, cream, or custard) or savory (such as meat, vegetables, or cheese) filling, which is then baked until the crust is crisp and the filling is cooked [3]. The main ingredients commonly used in making pie crust include flour, margarine, sugar, and milk [4].

Wheat contains gluten, a complex protein consisting of two main components, gliadin and glutenin [5]. Gluten cannot be consumed by individuals with *autism spectrum syndrome* (ASD) and individuals with *celiac* disease.

In individuals with celiac disease, gluten consumption triggers an immune response that damages cells in the digestive tract, particularly the small intestine, causing inflammation and damage to the intestine [6]. Diversification efforts are important so that food products are not entirely dependent on wheat. One of the ingredients widely used to replace wheat is Modified Cassava Flour

(MOCAF). Modified Cassava Flour is cassava flour produced by modifying cassava cells through fermentation[7]. Modifications to MOCAF aim to improve the quality and functionality of the flour, such as improving texture, increasing nutritional value, and extending the shelf life of the products produced. The characteristics of MOCAF products are identical to wheat flour, so they have the potential to replace wheat flour. The use of MOCAF in the food industry continues to increase, replacing 10% of wheat flour consumption in Indonesia [8].

MOCAF has been used in various food products, including steamed sponge cake by Khotimah [9] with the best treatment ratio of wheat flour and MOCAF of 70:30. [10] MOCAF is also used to make pie crusts with the added innovation of edamame flour. The addition of edamame flour aims to supplement the nutritional content of MOCAF. The nutritional content of MOCAF includes 350 kcal of energy, 85 g of carbohydrates, 0.6 g of fat, 60 mg of calcium, 64 mg of phosphorus, and 0.6 mg of iron, but its protein content is low at around 1.2 g per 100 g of raw material. Several studies have attempted to supplement the protein deficiency in MOCAF by substituting other flours, including soybean flour and mung bean flour. Research's results of [11] shows that soy flour can increase the protein content of MOCAF-based biscuits by up to 12%, but produces a hard texture. The use of mung bean flour by [12] produces cookies that are too fragile and crumble easily. According to [13] A texture that is too hard and crumbly is not desirable in pie crust products.

One food ingredient that has the potential to increase protein content in MOCAF-based products without causing a hard or crumbly texture in pie crusts is red bean flour. According to [14] In 100 g of red bean flour, there is 17% protein content. Based on the results of Fitriyani's research [15] The use of 90% MOCAF resulted in flakes with characteristics identical to those made from wheat flour. A ratio of 10% red bean flour successfully increased the protein content of dried noodles to 7.62% [16], [17] shows that substituting 25% of the flour with red bean flour is the best treatment for rolled sponge cake products. Based on the above description, a study was conducted entitled Characteristics of Pai Crust from Modified Cassava Flour (MOCAF) and Red Bean Flour.

2. MATERIALS AND METHODS

This study was conducted at the Agricultural Product Processing Laboratory and the Agricultural Product Analysis Laboratory, Faculty of Agriculture, Universitas Riau, Pekanbaru, from November to February 2025. The raw materials used included red beans, margarine, eggs, powdered sugar, and MOCAF, which were obtained from various stores in Pekanbaru and online. The tools used for making the pie crust included scales, mixing bowls, an oven, baking pans, and pie molds, while the tools for analysis included analytical scales, an oven, a desiccator, a furnace, and organoleptic testing equipment.

This research method used an experimental design with a completely randomized design (CRD) consisting of four treatments of MOCAF ratio and red bean flour:

MK1 = Ratio of MOCAF and red bean flour (90:10)
MK2 = Ratio of MOCAF and red bean flour (85:15)
MK3 = Ratio of MOCAF and red bean flour (80:20)
MK4 = Ratio of MOCAF and red bean flour (75:25)

The research began with the processing of red bean flour, which included sorting, washing, steaming, soaking, drying, and grinding into flour. The preparation of the pie crust begins by mixing MOCAF and red bean flour, adding margarine, sugar, and egg yolk, then the dough is shaped, pierced with a fork, and baked at 140°C for 15 minutes. Observations were made by measuring the water, ash, protein, and fat content. The water content was calculated by drying the sample and measuring the difference in weight, the ash content was calculated by burning the sample and measuring the remaining ash, the protein content was calculated using the Kjeldahl method, and the fat content was extracted using n-hexane solvent in a Soxhlet apparatus. Sensory evaluation was conducted using descriptive and hedonic tests (scale 1-5) to assess the color, aroma, taste, and texture of the pie crust. The data obtained were analyzed statistically using ANOVA, and Duncan's test was used to compare different treatments with analysis using *IBM SPSS Statistics 29*.

3. RESULTS AND DISCUSSION

3.1. Proximate Analysis

Table 1. Average value of proximate analysis of pie crust

Treatments	Moisture Content±SD (%)	Ash Content±SD (%)	Protein Content±SD (%)	Fat Content±SD (%)
MK1 (90:10)	3.36a ± 0.42	1.19a ± 0.13	5.71a ± 0.14	22.29a ± 0.04
MK2 (85:15)	3.60b ± 0.14	1.33b ± 0.04	6.31b ± 0.11	23.69b ± 0.16
MK3 (80:20)	3.87c ± 0.20	1.57c ± 0.06	7.06c ± 0.17	24.87c ± 0.20
MK4 (75:25)	4.21d ± 0.11	1.88d ± 0.00	9.94d ± 0.14	26.09d ± 0.22

Notes: The data is the result of the average value of four repetitions ± Standard of deviation. $p<0.05$

The moisture content of pie crust ranged from 3.36% to 4.21% and increased with increasing red bean flour ratio, because red bean flour has a higher moisture content (10.20%) than MOCAF (8.57%). The moisture content of pie crust is related to its protein content, because water can bind to protein through hydrogen bonds. In addition, heating can break open protein molecules, causing water to become trapped inside them [18]. This study is in line with [19] which shows that the more red bean flour in macaroni, the higher its water content. Similar results were also found in the study by [20] about *crackers*, which show higher moisture content at higher red bean flour. The pie crust in this study with treatments MK1 to MK4 produced moisture content that met Quality requirements for cookies according to SNI 2973:2018, namely a maximum of 5%.

The ash content of the pie crust ranged from 1.19% to 1.88%, with the highest ash content in treatment MK4 (1.88%) and the lowest in MK1 (1.19%). The increase in ash content occurred in line with the increase in red bean flour ratio, which was caused by the higher ash content of red bean flour (4.32%) compared to MOCAF (1.61%). Ash content reflects the mineral content in food ingredients, where red bean flour has more minerals, such as calcium (502 mg), phosphorus (429 mg), and potassium (1265.5 mg), compared to MOCAF, which contains calcium (60 mg), phosphorus (64 mg), and potassium (403 mg). This study is consistent with research of [21] which shows an increase in ash content in muffins as the amount of red bean flour increases, and research of [22] about *waffles* that showed ash content between 1.22% and 2.61% in red bean flour ratio. The pie crust in this study met the maximum ash content standard of 2% in accordance with SNI 2973:2018.

The protein content of pai crust ranged from 5.71% to 9.94%, with the highest protein content in the MK4 treatment (9.94%) and the lowest in MK1 (5.71%). This increase in protein content was in line with the increase in the ratio of red bean flour, which has a higher protein content (31.4%) than MOCAF (2.78%). The protein content in pie crust is also influenced by the egg yolks used in the dough, which contain 16.3 g of protein per 100 g. The protein content of red beans, which is the second highest after soybeans, also contributes, with amino acid content such as leucine (76.61 mg/gram), lysine (72 mg/gram), methionine (10.56 mg/gram), and tryptophan (10.08 mg/gram) [23]. Research's result of [24] also showed an increase in protein content in cookies as the ratio of red bean flour increased. The pie crust in this study met the minimum protein content standard of 5% in accordance with SNI 01-2973:2018.

Fat is a heterogeneous component, and fat analysis is generally performed by extracting the material using solvents such as diethyl ether or other solvents [25]. The fat content of the pie crust ranged from 22.29% to 26.09%, with the highest content in the MK4 treatment (26.09%) and the lowest in MK1 (22.29%). This increase in fat content was due to the higher fat content in red bean flour (3.07%) compared to MOCAF (0.98%). This study is in line with [26] which shows that the more red bean flour, the higher the fat content in the cookies, with the highest fat content reaching 26.77%. In addition, fat content is also influenced by additives such as margarine and egg yolks, which contribute significantly to fat content, as margarine contains about 80% fat [27].

3.2. Sensory Analysis

Table 2. Average value of sensory analysis of pie crust

Treatments	Color±SD (%)	Aroma±SD (%)	Taste±SD (%)	Crumb±SD (%)
MK1 (90:10)	3.06a ± 0.86	3.49a ± 0.88	3.16a ± 0.86	3.18a ± 0.83
MK2 (85:15)	3.48b ± 0.87	3.59a ± 0.74	3.43b ± 0.77	3.49b ± 0.72
MK3 (80:20)	3.55b ± 0.89	3.74ab ± 0.83	3.48b ± 0.72	3.73b ± 0.76
MK4 (75:25)	3.63b ± 0.83	3.86b ± 0.74	3.50b ± 0.82	4.18c ± 0.75

Notes: The data is the result of the average value of four repetitions ± Standard of deviation. $p<0.05$

The crust color scores ranged from 2.23 to 3.00, with the highest score in the MK4 treatment (3.00). The higher the MOCAF ratio used, the more yellow the crust color tended to be, while the more red bean flour used, the darker the color. This is caused by differences in the color of the raw materials, where MOCAF is white and red bean flour is reddish brown. The brown color of the pie crust increases with the addition of red bean flour, because the anthocyanin pigment in red bean flour is sensitive to high temperatures and can fade [28]. The brown color is also influenced by the Maillard reaction, which is a reaction between sugar and protein that produces melanoidins, substances that give a yellowish-brown color [29]. The baking process causes this reaction, which changes the color of the pie crust to brown [30]. The color of the pie crust can be seen in Figure 1.

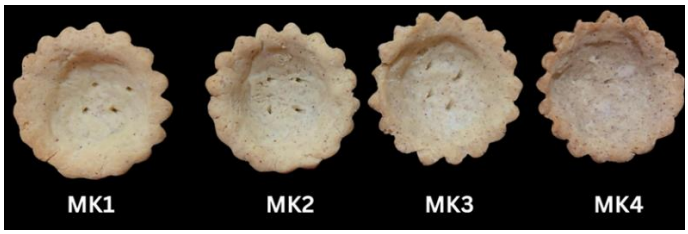

Figure 1. The color of pie crust

The hedonic assessment scores for the color of the pie ranged from 3.06 to 3.63, with the highest score in treatment MK4 (3.63), indicating the highest level of liking. Treatment MK1 received the lowest score (3.06), indicating a less preferred color. The more red bean flour used, the higher the panelists' preference for the color of the pie crust, in line with the results of the study of [31] Regarding *flakes*, preference for color increased with the addition of red bean flour.

Aroma scores of the pie crust ranged from 2.43 to 3.40, with the highest score in treatment MK4 (3.40) and the lowest in MK1 (2.43). The low score in MK1 indicates that the dominant aroma is cassava, while in MK4, which has a higher proportion of red bean flour, the aroma is more preferred by the panelists, indicating the contribution of red bean flour to the improvement in aroma. The less MOCAF used and the more red bean flour used, the higher the panelists' preference for the aroma of the pie crust. These results are consistent with research[32] which shows that increased use of red bean flour in products such as Nutrimat bars produces a distinctive red bean flour aroma that is preferred by panelists. The average hedonic aroma score of the pie crust ranged from 3.49 to 3.86, with the highest score in treatment MK4 (3.86) and the lowest in MK1 (3.49). The more red bean flour used, the more the panelists liked the aroma of the pie crust. These results are consistent with research [18], which shows that the aroma of products with more red bean flour was preferred by the panelists, while the aroma of products with more sweet potato flour tended to be less preferred.

Taste is a perception received through the sense of taste and becomes a parameter in determining the panelists' level of preference for the product [33]. The crust taste scores ranged from 2.10 to 3.43, with the highest score in treatment MK4 (3.43), indicating a dominant red bean flavor. Treatment MK1 had the lowest score (2.10), indicating a dominant cassava flavor. The more red bean flour used, the stronger the red bean flavor in the pie crust, according to research of [34] which shows an increase in red bean flavor as the red bean flour ratio increases. The hedonic rating scores ranged from 3.16 to 3.50, with the highest score in MK4 (3.50), indicating the highest level of panelist

preference. MK1 received the lowest score (3.16), which was lower than the other treatments. These results are consistent with research of [35] which shows an increase in panelists' preference for the taste of the product as the amount of red bean flour increases.

The crumb texture of pie crust ranged from 2.43 to 4.07, with the highest score in treatment MK1 (4.07), indicating fragile pie crust, and the lowest in MK4 (2.43), indicating non-fragile pie crust. This decrease in brittleness is due to the amylose content in red bean flour, which is higher than that in MOCAF. Amylose, which easily absorbs water, causes the texture of the pie crust to become harder after baking, in line with the research of [36] which shows that the more red bean flour, the harder the texture of the pie crust. The average hedonic fragility assessment score ranged from 3.18 to 4.18, with the highest score in the MK4 treatment (4.18), indicating the highest preference for the fragility of the pie crust. The MK1 treatment obtained the lowest score (3.18). These results indicate that the more red bean flour used, the more the panelists liked the crispness of the pie crust. This increase in preference is consistent with previous research by [30] which shows that adding red bean flour makes the texture denser and harder, so that the pie crust does not crumble easily.

4. CONCLUSION

Based on the research results, the selected pie crust treatment was MK_4 with 75% MOCAF and 25% red bean flour. The ratio of MOCAF and red bean flour used in the production of pie crusts affects moisture content, ash content, protein content, sensory color, taste, aroma, and hedonic and descriptive brittleness. Pie crusts from treatment MK4 had a moisture content of 4.21%, ash content of 1.88%, and protein content of 9.94%, with hedonic characteristics of the pie crust being light brown in color (somewhat liked), with a cassava and red bean flour aroma (somewhat liked), a cassava and red bean flour taste (somewhat liked), a non-crumbly texture (liked), and overall panelist evaluation indicating that the pie crust was favorable.

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