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Effect of Partial Replacement of Wheat Flour with Various Mangrove Fruit Flours and Different Emulsifiers on Physicochemical Properties of Biscuits

Jariyah[1], Endang Yektiningsih[2], Ulya Sarofa[1], and Peter Adeoye Sopade[3]

[1]*Department of Food Technology, Faculty of Engineering, University of Pembangunan Nasional "Veteran" East Java, Indonesia*
[2]*Department of Agribusiness, Faculty of Agriculture, University of Pembangunan Nasional "Veteran" East Java, Indonesia*
[3]*Food Process Engineering Consultants, Abeokuta Cottage, Australia*

Abstract. Biscuit formulation was produced from the partial substitution of wheat flour using mangrove fruit flour (MFF) with the addition of an emulsifier. In this study, Pedada (*Sonneratia caseolaris*) and Lindur (*Bruguiera ghymnorhiza*) were used as two varieties of MFF. Lecithin and sodium stearoyl lactylate (SSL) was used to enhance the physical properties of the biscuits. An experiment was conducted by replacing wheat flour with MFF at different levels (0%, 20%, and 30%). Margarine, sugars, eggs, glucose syrups, and emulsifiers were added after mixing wheat flour with MFF, baking powder, and milk powder uniformly. Dough sheets were formed and baked on a greased tray at 150^{0}C for 10 to 15 min. The biscuits produced were analyzed for spread ratio, breaking strength, and color (L*, a*, and b*), ranging from 4.13–5.07; 54.07–89.77 N; and 34.70–50.90 L*, 15.17–18.80 a*, and 12.00–28.07 b*, respectively. The analysis of chemical composition showed that the carbohydrate ranged from 90.99–93.60%, protein 4.26–7.12%, fat 0.22–0.59%, ash 0.93–1.75%, and moisture 0.88–1.36%, and the energy value spanned over 391.10–395.33 cal/100 g. Sensory evaluation rating, substitution of 20% with MFF, and SSL addition had the highest acceptability compared to other formulations.

Keywords: biscuit, *Bruguiera ghymnorhiza*, physicochemical properties, *Sonneratia caseolaris*

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1. Introduction

Biscuits are a ready-to-eat food and a convenient product that are commercially prepared and consumed by every age group in many countries [1]. Biscuits are categorized as flour-based products, which are generally low in moisture, flat, crispy, and may be sweetened or unsweetened according to the consumer market. They are produced by mixing various ingredients like wheat flour, water, and shortenings to form a dough. The fermented dough should not be allowed in biscuit processing [2]. Biscuits are classified into three broad groups as spongy goods, crackers, and sweet dough based on the method used for their manufacture. They

*Corresponding author at: Department of Food Technology, Faculty of Engineering, University of Pembangunan Nasional "Veteran" East Java, Surabaya 60294, Indonesia

E-mail address: jariyah.tp@upnjatim.ac.id

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can be made from hard dough, hard sweet dough, or short or soft dough. Soft dough biscuits are rich in fat and sugar and include shortcakes, shortbread, and melted-biscuits. Other types of biscuits include cream crackers, soda crackers, savory biscuits, water biscuits, digestive biscuits, and short dough biscuits [3].

All biscuits are nutritious, contributing valuable quantities of iron, calcium, calories, fiber, and some vitamin B to our diets and daily food requirements. However, baked products are relatively expensive for developing countries, since wheat plants do not grow in the tropics. Therefore, one means to reduce the utilization of wheat flour in biscuit production is a composite flour using local varieties. Composite flours have an additional advantage of improving the nutrient values of biscuits and other baked products [4]. Biscuits can be enriched with carrot extracts to increase β-carotene for health benefits [5]. Mangrove fruit flour (MFF) is rich in dietary fiber and bioactive compounds can potentially contribute to the development of functional food products [6], [7], [8]. Therefore, MFF can be mixed with wheat flour as a composite flour to make biscuits. However, the optimal formulation of composite flours using MFF to produce biscuits has not been systematically determined.

The level of consumer acceptance can be assessed using organoleptic testing by human senses [9]. Hedonic testing is often used to determine acceptability by measuring the degree of acceptance of a new or improved food product [10]. This method is commonly used to evaluate the development of new products [11] because foodstuff testing is reviewed not only for the chemical properties but also the flavor, aroma, and texture [12]. All four of these factors influence the consumer acceptance of food products [13]. To the best of our knowledge, the formulation of biscuits from a composite flour of MFF and wheat flour has not been reported previously. Therefore, the aim of this study was to formulate a composite flour of MFF (Pedada and Lindur) and wheat flour with the addition of different emulsifiers (lecithin and sodium stearoyl lactylate [SSL]).

2. Materials and Methods

2.1. Material and Chemical Reagents

MFF was obtained from two types of mangrove fruits of the species of Pedada (*Sonneratia caseolaris*) and Lindur (*Bruguiera ghymnorizha*) following the procedures of Jariyah et al [14]. Wheat flour, lecithin, SSL, sugar, baking soda, margarine, skim milk, and glucose syrup were obtained from a local store in Surabaya, Indonesia.

2.2. Formulation of Blends

Preliminary (unpublished) studies showed that MFF higher than 30% produced unacceptable biscuits. For the present study, wheat: MFF ratios of 80:20 and 70:30 were investigated for the two MFF (PFF and LFF), each with lecithin and SSL, yielding a total of ten samples by three times replications. Formulation of biscuit showed in Table 1. All the blends were mixed thoroughly [15].

Table 1. Biscuit formulation from wheat flour and MFF mixture

Formulation	WF : PFF (%)						WF : LFF (%)					
	100:0		80:20		70:30		100:0		80:20		70:30	
	L	SSL	L	SSL	L	SSL	L	SSL	L	SSL	L	SSL
B1	0.5	-	-	-	-	-	-	-	-	-	-	-
B2	-	-	-	-	-	-	-	0.5	-	-	-	-
B3	-	-	0.5	-	-	-	-	-	-	-	-	-
B4	-	-	-	-	0.5	-	-	-	-	-	-	-
B5	-	-	-	-	-	-	-	-	0.5	-	-	-
B6	-	-	-	-	-	-	-	-	-	-	0.5	-
B7	-	-	-	0.5	-	-	-	-	-	-	-	-
B8	-	-	-	-	-	0.5	-	-	-	-	-	-
B9	-	-	-	-	-	-	-	-	-	0.5	-	-
B10	-	-	-	-	-	-	-	-	-	-	-	0.5

* Note: WF : Wheat Flour
PFF : Pedada Fruit Flour
LFF : Lindur Fruit Flour
Lc : Lecithin
SSL : Sodium Stearoyl Lactylate

2.3. Baking Biscuits

The various blends formulated from the mixture of wheat flour and MFF were mixed separately with the same quantity of other ingredients (sugar, baking powder, water, baking fat, and salt). The fat was creamed with sugar until the desired batter texture was obtained, reducing fat particles that homogeneous and smoothen the dough texture. The batter was kneaded on a rolling table to reach the desired thickness. The batter was then cut into a round shape with a biscuit cutter and baked at 150^0C for 10 min (Tri-Star, Indonesia), cooled, and packaged.

2.4. Proximate Composition Determination

The biscuit samples were packaged and analyzed for moisture, total ash, crude fiber, fat, crude protein, and carbohydrates (by difference) using standard methods [16]. The energy value was calculated using water factors by multiplying the portions of protein, fat, and carbohydrates by their physiological fuel value of 4.0, 9.0, and 4.0 kCal/g, respectively.

2.5. Physical Analysis of The Biscuits

The weight and diameter of the baked biscuits were determined [17]. The spread ratio was determined using the method of Gomez et al. [18]. Three rows of five well-formed biscuits were made and the height was measured. The same number was also arranged horizontally edge to edge and the sum diameter was measured. The spread ratio was calculated as diameter/height. The breaking strength of the biscuits was determined using the method of Okaka and Isieh [19] to measure the crispness. A biscuit of a known thickness (0.4 cm) was placed between two parallel wooden bars (3.0 cm apart). Weight was added onto the biscuit until the biscuit snapped. The least weight that caused the biscuit to break was regarded as the breaking strength. L*, a*, and b* color parameters were obtained using CR-400 Chroma Meter-Konica Minolta Sensing.

2.6. Sensory Evaluation

The sensory evaluation used hedonic scale scoring, with 25 male and female panelists selected from the Food Technology Department of UPN "Veteran" East Java, Indonesia. The panelists were asked to evaluate the biscuit product, including the color, flavor, aroma, texture, and overall acceptance, on a scale of 1–5. The score of 5 is "really like," whereas the score of 1 is "really dislike" [20]. Samples were given a different code, placed randomly, and presented at the same time, and it was ensured that the panelists did not know the sample code [12]. The panelists were given a cup of water to rinse their mouth after each stage of the sensory evaluation [21].

2.7. Proximate Composition Determination

Analysis data were obtained from triplicate experiments, and the results were subjected to analysis of variance (ANOVA). Mean values were compared at $p < 0.05$ level of significance using least significant difference (LSD). The statistical package Minitab version 17 was used for analyzing the data.

3. Results and Discussion

3.1. Physical Properties of the Biscuits

The effects of different levels of PFF, LFF, lecithin, and SSL on the physical parameters are presented in Table 2. It can be observed that there was no significant difference ($p > 0.05$) in the spread ratio. However, the other physical properties were significantly different ($p < 0.05$) in breaking strength and color parameters (L*, a*, and b*). The spread ratio varied from 4.13±0.37 to 5.07±0.42. The formula of composite flour by partial placement of wheat flour with 30% PFF with the addition of SSL was the lowest based on the spread ratio, while the control biscuits with lecithin exhibited the highest spread ratio (5.07±0.42). Nominally, increasing the amount of PFF with lecithin increased the spread ratio, whereas the SSL emulsifier decreased the ratio, possibly because the emulsifier bound the dietary fiber components of the MFF. Sindhuja et al. [15] reported that increasing the spread ratio and decreasing the breaking strength indicate a crispier biscuit texture. Emulsifiers improve the spread ratios of biscuits by forming complexes with amylose, delay starch gelatinization, and lower dough viscosity [22]. Kohajdova et al. [23] add that fiber can decrease specific volumes due to gluten–fiber interactions.

There were no apparent visual differences using PFF and LFF, as seen in Figure 1 and 2. The biscuit brightness scores (L*) ranged from 34.70±0.78 to 50.90±1.40. However, darker biscuits were produced with SSL.

Table 2. Physical Properties of Biscuit Produce from Wheat- MFF Mixtures, With Addition Emulsifier (Lecithin and SSL)

Formulation	Spread ratio	Breaking strength (N)	Colour		
			L*	a*	b*
B1	5.07±0.42^{a}	64.50±15.62^{ab}	50.90±1.40^{a}	18.80±1.00^{a}	26.40±0.89^{a}
B2	4.45±0.50^{a}	58.23±14.83^{ab}	50.30±3.00^{a}	17.07±0.67^{ab}	28.07±2.28^{a}
B3	4.23±0.30^{a}	63.20±15.37^{ab}	37.77±1.10^{cd}	15.93±0.21^{bc}	13.87±0.21^{c}
B4	4.43±0.47^{a}	89.77±_7.38^{a}	34.70±0.78^{d}	15.23±0.55^{bc}	12.00±0.44^{c}
B5	4.40±0.11^{a}	61.47±10.96^{ab}	37.60±1.00^{cd}	15.87±0.64^{bc}	13.40±0.78^{c}
B6	4.50±0.02^{a}	75.20±11.27^{ab}	41.73±0.65^{b}	16.93±0.49^{abc}	17.97±0.51^{b}
B7	4.32±0.18^{a}	56.57± 0.20^{ab}	37.67±0.64^{cd}	17.03±1.27^{abc}	13.37±0.78^{c}
B8	4.13±0.37^{a}	74.03±19.10^{ab}	36.67±0.65^{d}	15.17±0.93^{c}	12.63±0.51^{c}
B9	4.61±0.31^{a}	54.07±6.19^{b}	37.70±0.27^{cd}	16.23±0.35^{bc}	13.73±0.67^{c}
B10	4.41±0.28^{a}	64.73±2.55^{ab}	41.20±1.32^{b}	16.50±0.50^{bc}	17.03±0.97^{b}

Note: *In each column, values with different letters are significantly ($p \leq 0.05$) different

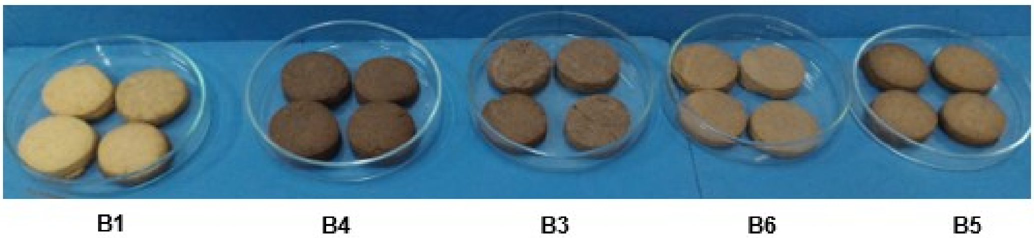

Figure 1. Biscuit Produce from WF and MFF Mixture with Addition of Lecithin

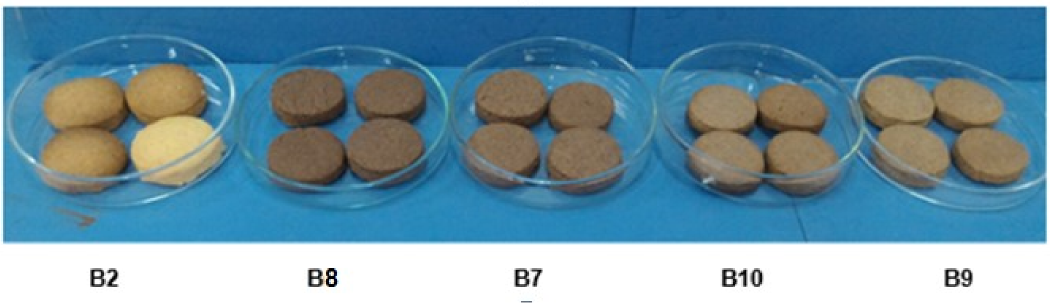

Figure 2. Biscuit Produced from MFF with Addition of SSL

3.2. Chemical Properties of the Biscuits

The chemical properties of the biscuits are presented in Table 3. The moisture content of the biscuits has an average of 1.10%. Partial substitution using MFF has no significant difference ($p < 0.05$) in moisture content and calculated energy parameters. However, the treatments affected the other measured chemical properties.

Table 3. Chemical properties of biscuit produce from wheat- MFF mixtures, with addition emulsifier (lecithin and SSL)

Formulation	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate *by Different* (%)	Calory (Cal/100gr)
B1	1.29±0.22[a]	1.75±0.09 [b]	0.42±0.06[cd]	5.09±0.28[ef]	92.33±0.68[abc]	391.10±0.52[bc]
B2	1.20±0.22 [a]	1.43±0.07 [a]	0.33±0.04[abc]	4.71±0.41[def]	91.46±0.28[bc]	389.95±0.79[c]
B3	1.07±0.14[a]	1.26±0.07[bc]	0.39±0.07[bcd]	5.21±0.42[cdef]	92.07±0.59[bc]	392.66±1.11[abc]
B4	1.01±0.47[a]	1.40±0.07[b]	0.22±0.06[d]	6.24±0.42[abc]	91.13±0.80[cd]	391.44±1.84[bc]
B5	0.91±0.13[a]	0.99±0.17[cd]	0.24±0.04[cd]	4.26±0.41[f]	93.60±0.45[a]	393.60±0.49[ab]
B6	0.86±0.09[a]	1.21±0.06 [bc]	0.30±0.07[cd]	5.69±0.38 [bcde]	91.93±0.34[bc]	393.21±0.52[ab]
B7	1.36 ±0.06[a]	1.11±0.12[cd]	0.56±0.08[bc]	5.82±0.31[bcd]	91.15±0.41[cd]	392.91±1.10[ab]
B8	1.21±0.14[a]	1.26±0.06[bc]	0.36±0.06[cd]	7.12±0.32[a]	90.04±0.30[c]	391.94±0.59[bc]
B9	1.09±0.17[a]	0.93±0.13[cd]	0.38±0.05[cd]	4.85±0.19[def]	92.75±0.29[ab]	393.79±0.19[ab]
B10	0.88±0.07[a]	1.03±0.05[d]	0.59±0.08[a]	6.51±0.39[ab]	90.99±0.38 [cd]	395.33±0.86[a]

Note: *In each column, values with different letters are significantly ($p<0.05$) different

Quality requirements according to SNI 01-2873-1992 stipulate that biscuits must have a maximum moisture content of 5.0%, maximum ash content of 1.6%, protein content of at least 9.0%, the minimum fat content of 9.5%, and carbohydrate content of at least 70.0%. The biscuit product remain acceptable to consumers although in terms of the protein and fat contents, the biscuits were below the specifications, while the higher carbohydrate content causes the need to evaluate possible contributions of the biscuits to glycaemic response and implications for diabetes.

3.3. Sensory Properties of the Biscuits

Sensory assessment is necessary to evaluate the acceptability of the biscuits. Table 4 displays the summary of sensory evaluation based on the color, flavor, aroma, texture, and overall acceptance of the biscuits. The scores showed that the color, flavor, aroma, texture, and overall acceptance of the biscuits substituted with MFF and with the addition of an emulsifier were in the range of "rather like" to "really like." The average preference of biscuit colors B3 to B10 was lower than B1 and B2, and MFF brown color addition made biscuit appearance less attractive for panelist. According to Jariyah et al., [6] the MFF color made from PFF flour has an °Hue of 71.43±0.17 that describes the color of PFF as a mixture of yellow and red or a reddish yellow [14]. This is caused by a browning reaction during PFF processing, as Pedada fruit contains 24 components, including eight steroids, nine terpenoids, three flavonoids, and four carboxyl benzene derivatives [24]. The formation of a brown color was triggered by an oxidative reaction catalyzed by phenol oxidase and polyphenol oxidase enzyme.

Biscuit formulas B3 and B4 had a taste (1.32-1.60), aroma (1.89-2.17), texture (2.49-2.60), and overall acceptance (1.91-1.99) that were rather liked by panelists due to acidic taste and an aroma from the PFF. Thus, the panelists did not like it. The textural hedonic analysis was not preferable based on panelist assessment because the addition of lecithin could not form a porous matrix. However, biscuit formulas B7 and B8 with the addition of SSL had a favorable texture according to panelists, because its cripness. This showed that SSL could reduce the level of texture hardness, even though the PFF dietary fiber was higher than in LFF.

Table 4. Sensory evaluation score of biscuit from wheat flour and mangrove fruit flour mixture with addition of emulsifier (Lecithin or SSL)

Formu-lation	Mean Score Sensory Attributes				
	Colour	Taste	Aroma	Texture	Overall Acceptability
B1	3.72+0.80[a]	3.75+0.74[a]	3.36+0.73[ab]	3.40+0.65[a]	3.83+0.69[a]
B2	3.49+0.69[ab]	3.75+0.67[a]	3.41+0.70[a]	3.37+0.68[a]	3.80+0.72[a]
B3	2.27+0.57[d]	1.60+0.58[d]	2.17+0.65[e]	2.60+0.68[c]	1.99+0.52[c]
B4	2.28+0.71[d]	1.32+0.35[d]	1.89+0.64[e]	2.49+0.66[c]	1.91+0.62[c]
B5	2.77+0.62[cd]	3.00+0.55[bc]	2.87+0.55[bcd]	3.31+0.62[a]	3.12+0.57[b]
B6	2.95+0.57[bc]	3.25+0.65[abc]	2.82+0.51[cd]	3.25+0.56[ab]	3.23+0.54[b]
B7	2.44+0.66[cd]	1.68+0.66[d]	2.27+0.56[e]	2.65+0.75[bc]	2.13+0.58[c]
B8	2.56+0.91[cd]	1.68+0.57[d]	2.13+0.52[e]	2.57+0.68[c]	2.08+0.76[c]
B9	2.96+0.66[bc]	3.40+0.68[ab]	2.99+0.58[abc]	3.43+0.70[a]	3.37+0.48[ab]
B10	2.56+0.80[cd]	2.78+0.68[c]	2.33+0.51[de]	3.04+0.70[abc]	2.84+0.69[b]

*Note: Means in the same row with different superscripts are significantly different at $p \leq 0.05$

Unlike biscuit formulas, B5 and B6 with lecithin, biscuits that were produced had the flavor and texture that overall preferred by the panelist. Likewise, biscuit formulas B9 and B10 with the addition of SSL were liked by the panelists for their flavor, aroma, texture, and overall acceptance; this was because LFF did not contain vitamin C, which causes a sour taste, and a dietary fiber content lower than PFF. Thus, lecithin or SSL could capture hydrogen bonds and form a porous matrix, causing a crunchy texture. According to Sari et al. [13], the flavor and texture were the main factors that influenced the panelist acceptance of biscuits.

The best biscuit from two types of MFF and the addition of an emulsifier was selected by organoleptic testing, flavor, texture, and overall acceptance, as presented in Figure 3. Figure 3 shows that biscuits substituted with 20% PFF and with the addition of 0.5% SSL (B7) had a higher score than biscuit formulas B3 and B4 in flavor, texture, and overall acceptance. Biscuits substituted with 20% LFF with the addition of 0.5% SSL (B9) had a higher score of flavor, texture, and overall acceptance than biscuit formulas B5 and B6, even these three attributes score approached the biscuit control (B2). MFF addition is similar with germinated fenugreek flour [25], *Moringa oleifera* flour [26], which preferred by panellist.

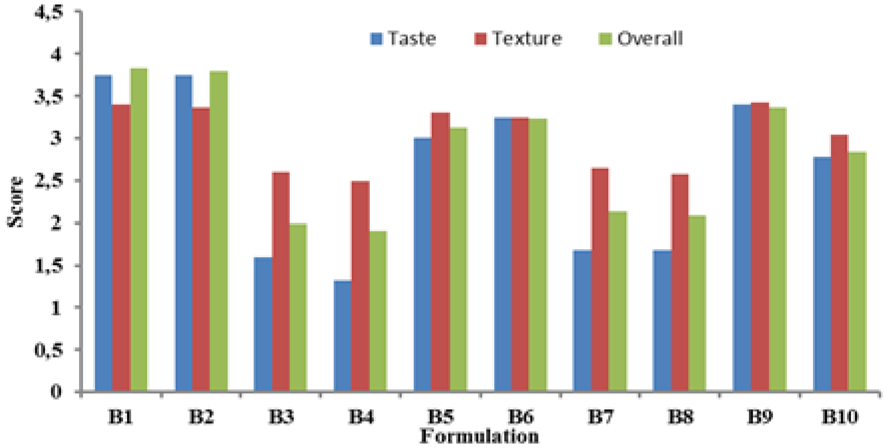

Figure 3. Hedonic score of taste, texture and overall of biscuit MFF

Partially substituting wheat flour with mangrove flour in biscuit production revealed that the substitution did not affect the spread ratio, moisture content, and energy value of the biscuits. However, treatments significantly affected the other physical and chemical properties of the biscuits. The results showed that it is possible to produce wheat–mangrove flour biscuits with either lecithin or SSL as an emulsifier. Other properties (e.g. glycaemic properties) of the composite biscuits will need to be evaluated for futher studies to optimize and choose an acceptable mangrove flour substitution. Notably, biscuits with a substitution of 20% MFF and the addition of 0.5% SSL were favoured by panellists for all sensory attributes. Thus, MFF has the potential to be optimally used in bakery products. Furthermore, MFF can promote the utilization of mangrove fruit for food products.

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