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Substitution of Corn Flour and Additional Palm Sugar to Cookies Characteristics

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Abstract

Cookies are biscuits with a crunchy texture made from low protein flour. Corn flour was chosen as a substitute because it only contains <1% gluten. The main problem faced by corn commodities lies in the low sugar content as energy sources, so palm sugar was added to produce cookies with better nutritional value , where the constituent sugar is simpler than granulated sugar. This study aims to determine the effect of corn flour substitution and the addition of palm sugar on the physicochemical and organoleptic characteristics of cookies. This study used a Completely Randomized Design (CRD) with two factors and two replications The first factor was corn flour substitution (0%, 15%, 30%, and 45%) and the second factor was the addition of palm sugar (15%, 20%, and 25%). Physicochemical parameters objectively observed include water content, ash content, protein content, fat content, carbohydrate content, crude fiber content, and color. While organoleptic parameters subjectively observed include color, aroma, texture, taste, and overall acceptance. The study results showed that the substitution of 30% corn flour with the addition of 20% palm sugar produced the highest preferred cookies (ordinary-like) with 6.39% water content, 2.45% ash content, 10.19% protein content, 29.90% fat content, 51.08% carbohydrate content, and 0.09% crude fiber content.

Keywords: Cookies, Corn Flour, Palm Sugar, Substitution

1. Introduction

Cookies are a type of biscuit made from soft dough and have a crunchy texture. Cookies do not require ingredients with high gluten content, so they can take advantage of corn flour which only contains <1% gluten. Substitution of wheat flour with corn flour is based on several reasons, which is as a supply of food products for gluten intolerant sufferers, and as food diversification to help reduce dependence on wheat flour as an imported commodity with corn as raw material because corn production in Indonesia in 2020 is estimated to reach 21.53 million tons [1].

The main problem of corn commodities is that the sugar content as an energy source is still low. Based on that, one way that can be done to increase the sugar content is by adding palm sugar in the manufacture of cookies. Palm sugar contains micronutrients, antioxidants, low glycemic index (GI), fiber and other content that are good for health. The sugars consist of glucose and fructose, almost the same as sweeteners like honey and fructose corn syrup. Conducted a research on the glycemic index of palm sugar, finding that the glycemic index of palm sugar is 35 [2]. Meanwhile, the glycemic index of granulated sugar is 64, which is close to a high glycemic index (>70). Foods with a low GI will raise blood glucose levels slowly, whereas foods with a high GI raise blood glucose levels quickly [3]. Therefore, palm sugar was chosen as a sugar substitute for granulated sugar in the manufacture of cookies.

This research aims to determine the effect of corn flour substitution and the addition of palm sugar on the physicochemical and organoleptic characteristics of cookies. This research hypothesized

that the substitution of 30% corn flour and the addition of 20% palm sugar could produce good cookies accepted by consumers.

2. Material and Methods

Research Time and Place

This research was conducted from January to February 2022 at the Laboratory of Basic Science and Food Processing of the Faculty of Agriculture, Warmadewa University.

Materials

The materials used in this research were distilled water, Lowry reagent, NaOH, H_2SO_4, Folin-Ciocalteu reagent, wheat flour, corn flour, margarine, palm sugar, eggs, and vanilla essence. The tools used in this study were scales, porcelain dishes, tongs, desiccator, muffle, oven, Soxhlet, UV-Vis spectrophotometer, color reader, digital scale, bowl, mixer, spoon, spatula, tray oven, and parchment paper.

Research Methods

The design used in this research was a completely randomized design (CRD) with a factorial pattern consisting of two factors. The first factor is the substitution of corn flour which consists of four levels (0%, 15%, 30%, and 45%). The second factor is the addition of palm sugar which consists of three levels (15%, 20%, and 25%). Each treatment was repeated 2 times to obtain 24 treatment combinations. The stages of making cookies in this research were as follows:

a. Preparation of Tools and Materials

b. Dough Making and Mixing

Making the dough begins with the process of mixing and stirring the ingredients. Mix the margarine and sugar first on high speed and add the eggs. Mix until the dough is just enough to form a cream and add vanilla essence. In the final stage, add the flour and corn flour slowly and stir until evenly mixed.

c. Cookies Printing

Cookies are printed using the molded cookie method, in which the dough is molded by hand, rounded, and then flattened.

d. Oven

Cookies that have been printed are then baked at 180^{o}C for 25 minutes.

Research Parameters

Research parameters include analysis of water content (Gravimetry), fat content (Gravimetry), protein content (Spectrophotometry), ash content (Gravimetry), carbohydrate content (by difference), crude fiber (Gravimetry), and the color of the color reader method [4]. The a value obtained from the color intensity is then used to determine the Browning Index (BI) [5]. Subjective observations were carried out by organoleptic assessment. It included a preference test using 15 untrained panelists.

Data Analysis

Observations were made objectively and subjectively. The data obtained were then analyzed for variance. If there was a significantly different effect or a very significant difference between the substitution of corn flour and the addition of palm sugar, the data were further tested with the 5% smallest real difference test for objective data and Duncan's test for subjective data.

3. Results and Discussion

3.2.1 Objective Variable

Water Content

As shown in Table 3, the higher the substitution of corn flour, the lower the water content of cookies. This is due to the low gluten content in the dough. The lower the gluten content, the easier the release of water molecules occurring during baking. The ability of gluten to bind water is very strong, so the lower the addition of gluten, the lower the water content [6]. In addition, corn flour has a low water holding capacity due to the water-soluble fiber components in corn flour, especially -glucan. The lower the -glucan content in flour, the lower the water holding capacity [7]. Meanwhile, the higher the percentage of adding palm sugar, the higher the water content of cookies. This is because palm sugar has a higher water content (10.3%) than granulated sugar (8.3%). In addition, the high water content in cookies is also because of the constituent component of palm sugar is fructose. This is supported by Andragogi [8], that the addition of high fructose sugar can increase the water content of food, because fructose has a high water holding capacity.

Table 3
Effect of Corn Flour Substitution and Palm Sugar Addition on Water Content of Cookies

Corn Flour Substitution	Palm Sugar Addition			Average	
	15%	20%	25%		
0%	7.41	8.07	8.62	8.03	b
15%	6.37	6.81	7.37	6.85	a
30%	6.37	6.39	7.09	6.62	a
45%	6.04	6.44	7.07	6.51	a
Average	6.55a	6.93a	7.53b		

Descriptions: The same letter next to the average value in the same row and column shows no significant effect (P>0.05).

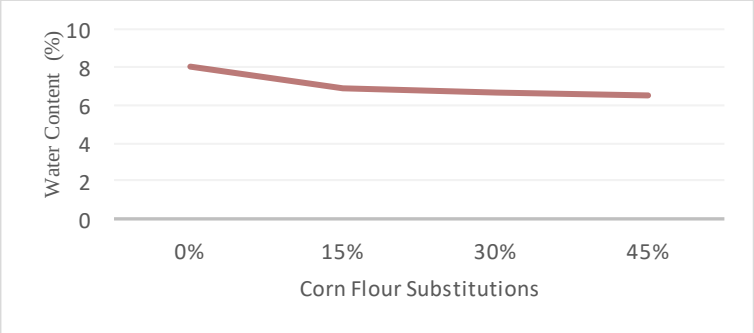

Figure 1
The Effect of Corn Flour Substitution on the Water Content of Cookies

Ash Content

Ash is an inorganic residue from the combustion process or the oxidation of organic food components. Inorganic materials in a material vary greatly and in different amount [9]. As shown in Table 4, even though not significant, the ash content in cookies tends to increase after the substitution of corn flour and the addition of palm sugar. This is because corn flour has an ash content of 1.79% which is greater than wheat flour which only has an ash content of 0.25% [10]. Similarly, with the

higher addition of palm sugar, the ash content also increases. This is because palm sugar has an ash content of 8% [11]. The high ash content of palm sugar is strongly influenced by the mineral content contained in the raw material, namely sap and the ingredients added in the manufacture of palm sugar [8]. Stated that the ash content of nixtamalized corn biscuits is 2.38% [12], biscuits with raw materials of black rice bran and corn flour have 1.69% ash content [13].

Table 4
Effect of Corn Flour Substitution and Palm Sugar Addition on Ash Content of *Cookies*

Corn Flour Substitution	Palm Sugar Addition			Average	
	15%	20%	25%		
0%	1.93	2.08	2.50	2.17	a
15%	1.80	2.28	2.48	2.19	a
30%	1.93	2.45	2.53	2.30	a
45%	2.03	2.33	2.53	2.29	a
Average	1.92a	2.28b	2.51b		

Descriptions: The same letter next to the average value in the same row and column shows no significant effect (P>0.05).

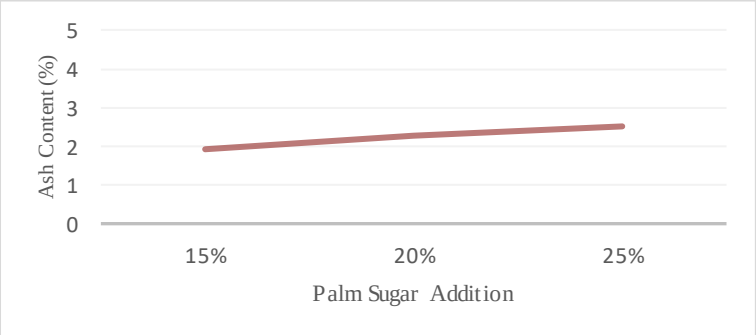

Figure 2
The Effect of Palm Sugar Addition to the Ash Content of Cookies

Protein Content

Based on the results shown in Table 5, there was an increase in protein content along with an increase in the percentage of corn flour and palm sugar combinations. The increase in protein content was due to corn flour and palm sugar combinations having higher protein content (9.69% and 1.5%, respectively) than low protein flour (8%) [10]. This is in line with research, that the protein content on cookies with the addition of corn flour is higher than cookies without it, which are 11.23% and 9.79%, respectively [13]. It can be seen that protein can be denatured by high temperature heating of food ingredients, especially foods that have high protein content [14].

Table 5
Effect of Corn Flour Substitution and Palm Sugar Addition on Protein Content of *Cookies*

Corn Flour Substitution	Palm Sugar Addition			Average	
	15%	20%	25%		
0%	8.94	9.20	9.41	9.18	a
15%	9.59	9.90	10.07	9.85	ab
30%	10.13	10.19	10.28	10.20	b
45%	11.04	11.43	11.59	11.35	c
Average	9.92a	10.18a	10.34a		

Descriptions: The same letter next to the average value in the same row and column shows no significant effect (P>0.05).

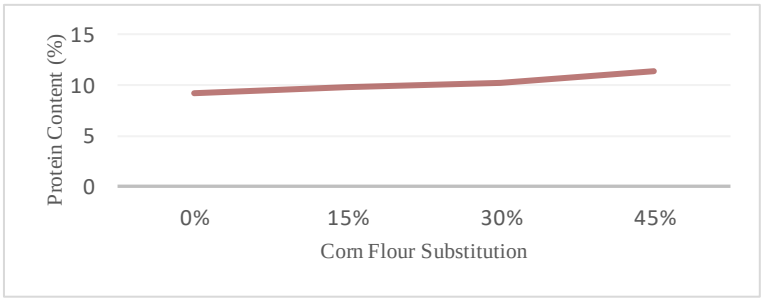

Figure 3
The Effect of Corn Flour Substitution on the Protein Content of Cookies

Fat Content

The fat content in cookies increased after the substitution of corn flour and the addition of palm sugar. This is because the fat content in corn flour and palm sugar is higher than the fat content in wheat flour. The fat content in wheat flour is 1.3% [15], while in corn flour is 9.38% and palm sugar is 1.70% [11]. There is a tendency for the fat cookies decrease, because the nature of the fat that is not heat resistant causes the fat to melt and even evaporate into other components such as flavor [16]. Palm sugar consists of two monosaccharide sugars, namely glucose and fructose [17]. As shown in Table 6, the fat content of the control cookies was lower than that of the treatment cookies. This is because sucrose sugar in the control cookies is in the form of disaccharides, while palm sugar is in the form of monosaccharides which will bind more fat, thus making the fat content of the treatment cookies higher [18].

Table 6
Effect of Corn Flour Substitution and Palm Sugar Addition on Fat Content of *Cookies*

Corn Flour Substitution	Palm Sugar Addition			Average	
	15%	20%	25%		
0%	24.33	25.25	24.67	24.75	a
15%	25.01	22.49	24.39	23.96	a
30%	32.80	29.90	31.35	31.35	b
45%	32.83	31.96	34.98	33.26	c
Average	28.74b	27.40a	28.85b		

Descriptions: The same letter next to the average value in the same row and column shows no significant effect (P>0.05).

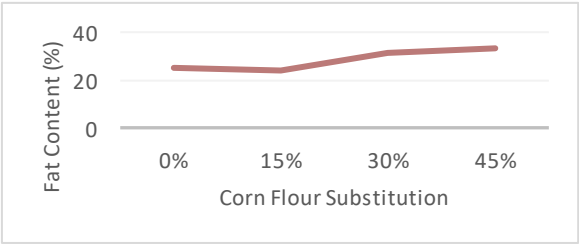

Figure 4
The Effect of Corn Flour Substitution on Cookies Fat Content

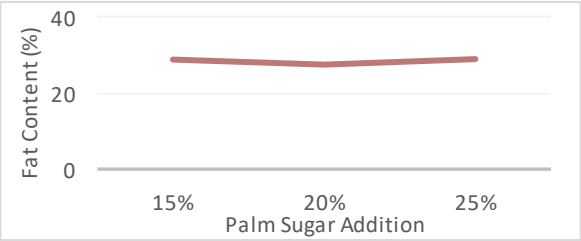

Figure 5
The Effect of Palm Sugar Addition on Cookies Fat Content

Table 7
Effect of Corn Flour Substitution and Palm Sugar Addition on Carbohydrate Content of *Cookies*

Corn Flour Substitution	Palm Sugar Addition		
	15%	20%	25%
0%	57.39b b	55.41ab c	54.81a c
15%	57.23ab b	58.53b d	55.69a c
30%	48.78a a	51.08b b	48.75a b
45%	48.07b a	47.85b a	43.84a a
LSD (0.05)	2.00		

Descriptions:
1. The same letter on the same line next to the mean shows no significant effect (P>0.05).
2. Different letters in the same column below the average indicate a significant effect (P<0.05) to very significant (P<0.01).

The higher the substitution of corn flour and the addition of palm sugar, the carbohydrate content tends to decrease, as shown in Table 7. The carbohydrate content is influenced by the increase of water, ash, fat, and protein content, which are calculated by difference [19]. The lower the other nutritional components content, the higher the carbohydrate content [20]. In addition, the low carbohydrate content in cookies is also influenced by the carbohydrate content found in wheat flour, where wheat flour has a higher carbohydrate content than corn flour. The carbohydrate content of wheat flour is 82.35% [10], while corn flour is 70.86%.

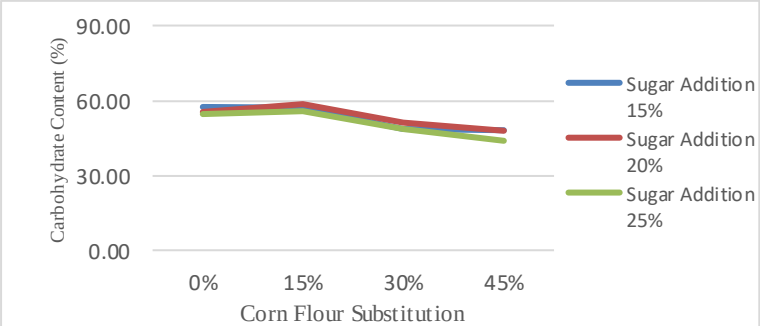

Figure 6
Interaction of Carbohydrate Levels in Corn Flour Substitution Cookies and Palm Sugar Addition

Crude Fiber Content

Based on the results of the analysis as shown in Table 8, there was an increase in crude fiber content as the percentage of corn flour increased. This is caused by the crude fiber content in corn flour is more than in wheat flour. This result is in accordance with the raw material analysis, corn flour contains 2% crude fiber, while the crude fiber in wheat flour is 1.18% [21]. Meanwhile, with the addition of palm sugar, the crude fiber content in cookies tends to increase but not significantly, because palm sugar does not contain crude fiber. The results of the crude fiber analysis are also in line with the research, the crude fiber content of cookies with corn flour substitution, which is 2.23% and 0.98% without corn flour substitution [22].

Table 8
Effect of Corn Flour Substitution and Palm Sugar Addition on Crude Fiber Content of *Cookies*

Corn Flour Substitution	Palm Sugar Addition			Average	
	15%	20%	25%		
0%	0.04	0.05	0.05	0.05	a
15%	0.07	0.07	0.05	0.07	ab
30%	0.09	0.09	0.09	0.09	b
45%	0.14	0.12	0.16	0.14	c
Average	0.08a	0.08a	0.09a		

Descriptions: The same letter next to the average value in the same row and column shows no significant effect (P>0.05).

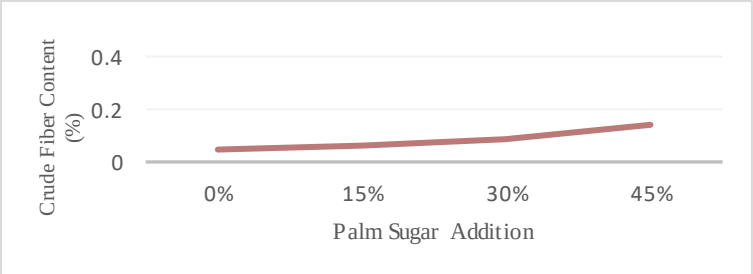

Figure 7
The Effect of Corn Flour Substitution on Cookies Crude Fiber Content

Colour

Lightness (L* values)

The higher percentage of the addition of palm sugar, the brightness value (L*) on the cookies tend to decrease (small), so that the cookies are darker in color. This darkening color is due to the original dark color of palm sugar. This is in line with research, making cream cheese cake using palm sugar, the more palm sugar used, the color of cream cheese cake becomes darker, which had a brightness value (L*) of 78.40 with the addition of 5% palm sugar and a brightness value (L*) of 68.3 with the addition of 30% palm sugar [23].

As the percentage of corn flour substitution increases, the brightness value (L*) tends to increase so that the color of cookies looks brighter. This is due to the yellow color produced by corn flour. This is in accordance with Utami's statement, food made through processing or heating can change color according to the food used [24].

Red Colour Intensity (a* value)

The higher percentage of the addition of palm sugar to the cookies, the more positive the a* value (the color is getting redder). This is due to the red color that appears because the raw material for palm sugar is red. There is a tendency that the higher the substitution of corn flour, the a* value becomes lower (away from the reddish level). This is due to the yellow color of corn flour which appears due to the presence of -carotene in corn. Color will affect the level of consumer acceptance of a food product, related to whether or not the color produced from the food product is attractive. The yellow color that comes from corn flour can increase consumer acceptance of the color of cookies [25].

Blue Colour Intensity (b* value)

The more substitution of corn flour in cookies, the more positive the b* value (the color is getting yellower). This is because of the yellow color that comes from corn. Corn flour is yellow

because of the content of -carotene with different brightness levels [26]. Meanwhile, the more addition of palm sugar, the b* value in cookies tended to decrease (away from the yellowish level). This is due to the red color produced by palm sugar. A strong red color in palm sugar will override the yellow color in corn flour, so the color of cookies becomes darker.

Table 9
Effect of Corn Flour Substitution and Palm Sugar Addition on Colour of *Cookies*

Corn Flour Substitution : Palm Sugar Addition	Lightness (L*)	Red Colour Intensity (a*)	Blue Colour Intensity (b*)
0% : 15%	45.02 ab	8.22 a	30.44 a
0% : 20%	41.47 a	9.48 a	29.15 a
0% : 25%	42.19 ab	9.69 ab	30.17 a
15% : 15%	44.52 ab	8.16 a	31.97 ab
15% : 20%	45.70 b	8.32 a	32.26 ab
15% : 25%	40.23 a	9.18 ab	30.85 ab
30% : 15%	48.66 b	7.45 a	34.57 ac
30% : 20%	43.60 ab	9.16 a	33.07 ac
30% : 25%	46.44 ab	9.74 ab	34.13 ac
45% : 15%	45.35 a	8.21 a	35.41 ac
45% : 20%	46.56 ac	8.38 a	35.64 ac
45% : 25%	44.14 abc	10.08 ab	34.17 ac

3.2.2 Subjective Variables

Colour

The color of palm sugar is reddish brown so that the resulting cookies practically turn from yellow to brown, so it is clear that the more palm sugar is added, the darker the cookies color will be. In the product results, cookies are dark in color. The more use of corn flour, the brighter the color of the cookies. This is because the material corn flour that has been treated with water immersion can prevent the enzymatic browning process from occurring because it avoids contact with oxygen [27].

Aroma

The aroma of corn flour and palm sugar has been mixed with the aroma of wheat flour, making it tends to produce the aroma of corn and palm sugar that covers the aroma of flour. The high percentage of corn flour and palm sugar affects the distinctive aroma of cookies. In accordance with Muliana's opinion that the more additional raw materials are used, the more the aroma produced will tend to the aroma of the ingredients used [28]. According to Marsigit, the aroma contained in a food ingredient comes from the natural nature of the material and some comes from a variety of mixtures of constituent materials [29].

Texture

Texture is a pressure property that is observed with the mouth when bitten and chewed and then swallowed and palpated with the fingers [30]. The texture of cookies is influenced by the substitution of corn flour and the addition of palm sugar. While the treatment without using corn flour and the addition of high palm sugar resulted in a soft and mushy cookie texture. This is because cookies in this treatment contain high water content. The high water content comes from palm sugar. Meanwhile, the texture of cookies with corn flour substitution produces cookies that are more crispy. This is due to the use of corn flour in the dough, corn flour does not contain gluten so the dough does not form a sticky network with a chewy texture [11].

Flavour

It is suspected that the higher the addition of corn flour and palm sugar in the manufacture of cookies, the more the panelists prefer the taste produced. The distinctive taste of corn arises because of the relatively fast nixtamalization time [31]. This is in accordance with the opinion of Tridjaja, the taste that is formed in cookies, apart from being obtained from the addition of sugar [32].

Overall Acceptance

Based on the results of the analysis, the substitution of corn flour and the addition of palm sugar do not affect the overall acceptance of cookies. All panelists accept and like cookies. The average preference for overall acceptance was influenced by the panelists' assessment of the color, aroma, texture and taste of cookies in each treatment.

Table 8
Average Subjective Value of Corn Flour Substitution Cookies and Palm Sugar Addition

Corn Flour Substitution : Palm Sugar Addition	Colour	Aroma	Texture	Flavour	Overall Acceptance
0% : 15%	4,07a	4,07a	3,40a	4,00a	4,00a
0% : 20%	3,73a	3,93a	3,80a	4,47a	4,33a
0% : 25%	3,67a	3,87a	3,27a	4,27a	4,27a
15% : 15%	4,60a	4,00a	3,93a	3,20a	4,20a
15% : 20%	4,60a	5,27a	4,87a	5,20a	5,13a
15% : 25%	3,47a	4,27a	4,07a	4,60a	4,60a
30% : 15%	4,40a	3,80a	3,60a	4,20a	4,07a
30% : 20%	4,87a	4,93a	5,73a	5,87a	5,73a
30% : 25%	3,80a	4,20a	4,13a	4,07a	4,47a
45% : 15%	4,33a	4,07a	3,93a	3,87a	4,40a
45% : 20%	4,00a	4,27a	3,60a	4,13a	3,80a
45% : 25%	3,73a	3,67a	3,87a	4,40a	3,73a

Descriptions: The average value followed by the same letter in the same row and column showed no significant effect (P>0.05).

4. Conclusion

Cookies with corn flour substitution and the addition of palm sugar have a darker color than cookies with wheat flour with an average value (L*) of 44.49, a value of (a*) 8.84, a value of (b)* 32.65. Good chemical characteristics of cookies are found in the treatment of cookies with 30% corn flour substitution and the addition of 20% palm sugar with 6.39% moisture content, 2.45% ash content, 10.19% protein content, 29.90% fat content, carbohydrate content 51.08%, and crude fiber content 0.09%. Cookies with 30% corn flour substitution treatment and 20% palm sugar addition were cookies with the highest preference value in the organoleptic test, which ranged from 4.87–5.87 (ordinary – like).

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