

DIETARY FIBER AND ANTIOXIDANT ACTIVITY OF GLUTEN-FREE COOKIES WITH COFFEE CHERRY FLOUR ADDITION

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ABSTRACT: Coffee husk and coffee pulp are by-product of coffee fruit and bean processing, can be considered as potential functional ingredients for food production as coffee cherry flour (CCF). The CCF contains a lot of carbohydrates, proteins, caffeine, tannins, and polyphenols. In this study, CCF was combined with modified arrowroot starch (MAS) and modified cassava flour (MOCAF) into cookies and improvement on the physical, chemical, and nutraceutical properties of the cookies were studied. The cookies consisted of 20 % of MOCAF and 80 % mixed of modified arrowroot starch and CCF in five levels (80 %: 0 %; 75 %: 5 %; 70 %: 10 %; 65 %: 15 %; 60 %: 20 %) and objective physical, chemical, and nutraceutical properties of the cookies were assessed. The results showed that the total dietary fiber content was enhanced from 11.69 % to 19.48 % with a high proportion of 20 % CCF. The cookies added with CCF displayed enhanced antioxidant activity. Acceptable cookies were obtained by adding 5 % CCF. Thus, the results implied that cookies with CCF addition obtained dietary fiber enriched cookies with improved antioxidant activity.

Index terms: Functional ingredients, improved nutrition, modified cassava flour, modified arrowroot starch, waste to food, zero waste.

1 INTRODUCTION

Coffee is one of the most popular drinks in the world. Coffee plants include two plant species, namely *Coffea arabica* L. and *Coffea canephora* Pierre ex A. Froehner, which are commonly known as Arabica coffee and Robusta coffee (ALVES et al., 2011). The process of processing coffee fruit into seeds will produce waste, which are coffee pulp in wet processing and coffee husk in dry processing (BLINOVÁ, et al., 2017; BONDESSON, 2015; JANISSEN, HUYNH, 2017). According to Farah and Santos (2015), coffee fruit has four layers that become waste, namely the skin (epicarp or exocarp), mesocarp, endocarp, and the silverskin. All layers together in one fraction called coffee husks, while the so-called coffee pulp is without silverskin (ESQUIVEL, JIMÉNEZ, 2012; PADMAPRIYA, THARIAN, THIRUNALASUNDARI, 2013; BONDESSON, 2015). Dry process of coffee production yields 12 % coffee husk (MURTHY, NAIDU, 2012), while the wet process produces coffee pulp as much as 40 % to 50 % of the weight of fresh coffee fruit (DIAS et al., 2015; ESQUIVEL, JIMÉNEZ, 2012).

The previous study reported that coffee husk and coffee pulp had been used as non-food ingredients, such as for compost, bio absorbents, bioethanol production or caffeine extraction (GURRAM et al., 2016; MURTHY, NAIDU, 2012; SETYOBUDI, et al., 2018). Whereas coffee husk

and coffee pulp have great potential as a functional food ingredient (SETYOBUDI et al., 2019) due to its components contained such as of proteins (8 % to 11 %), lipids (0.5 % to 3 %), minerals (3 % to 7 %), carbohydrates (58 % to 85 %), reducing sugars (14 %), caffeine (~1 %), and tannin (~5 %) and 0.2 mg g⁻¹ to 1.9 mg g⁻¹ of 5-O-caffeoylquinic acid compound, the main phenolic compound found in Arabica and Robusta coffee (FRANCA, OLIVEIRA, 2009; MULLEN et al., 2013). Some of the studies that have been conducted to utilize coffee husk as a dietary fiber ingredient (BENITEZ et al., 2019), a food supplement (ESQUIVEL, JIMÉNEZ, 2012; BLINOVÁ, L. et al., 2017); an antioxidant and anti-bacterial (MURTHY et al., 2012; DUANGJAI et al., 2016). Although there are relatively many studies on cookie recipes (CF GLOBAL HOLDINGS, 2019), research on coffee cherry flour (CCF) as a functional food has never been found

Cookies, one type of pastry, is very popular for Indonesian people. Commonly, raw material as carbohydrate source used in cookies production is wheat. Recently, efforts to utilize Indonesian local carbohydrate sources need to be developed. In 2018, the total import of wheat had reached 12 × 10⁶ t and placed Indonesia as the largest wheat importer in the world (MCDONALD, 2018). Many studies have been carried out on cookies using local carbohydrate which,

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including cookies from modified arrowroot starch - MAS (HARTATIK, DAMAT, 2017), gluten-free cookies (CHAUHAN et al., 2015; GIUBERTI et al., 2017), tapioca and rice flour (MONTES et al., 2015). Modification of arrowroot starch by gelatinization-retrogradation is known to increase resistant starch levels (DAMAT et al., 2017b). The purpose of this study was arranged to evaluate the influence of coffee cherries flour (CCF) which is found to be rich in dietary fiber and antioxidant activity, on the physical, chemical, and sensory characteristics of gluten-free cookies made from modified arrowroot starch (MAS) and modified cassava flour (MOCAF).

2 MATERIAL AND METHODS

Materials

Arrowroot starch was obtained from farmers in Batu, East Java, Indonesia, coffee cherries flour was obtained from farmers in Dampit, Regency, Malang, East Java, Indonesia, MOCAF [modified cassava flour (cassava = *Manihot esculenta* Crantz)], was purchased from a farmer in Blitar, East Java, Indonesia. Arrowroot starch (arrowroot = *Maranta arundinacea* L.) was further modified by gelatinization retrogradation (FARIDAH, et al., 2013). Other ingredients are milk powder, egg yolk, fat, and sugar which were purchased from minimarket in Malang City, East Java, Indonesia.

Chemicals

Aquades, anti-foam, petroleum benzene, catalyst (Na_2SO_4 and HgO), H_2SO_4 , NaOH , boric acid, ethanol, 2,2-Diphenyl-1-picrylhydrazyl (DPPH), HCl was purchased or obtained from CV Makmur Sejati in Malang City, East Java, Indonesia. All other chemicals and solvent were of analytical grade.

Chemicals analysis of coffee cherries flour and modified arrowroot starch

CCF and MAS were analyzed for moisture, ash, protein, fat, and carbohydrate by different according to Puwastien et al., (2011), while carbohydrate by different according to Puwastien et al., (2011). Nitrogen content was estimated by the micro-Kjeldahl method and was converted to protein by using the factor 6.25. Analysis of total dietary fiber, antioxidant activity, and color intensity were not tested in MAS. Total dietary fiber was evaluated according to Puwastien et al., (2011). The level of total dietary fiber was calculated by following the Formula (1):

Total dietary fibre = weight (residue) – weight (ash + protein)

The antioxidant activity in CCF was determined by free radical scavenging activity according to the method described by Shekhar and Anju (2014). DPPH (1,1-diphenyl-2-picrylhydrazyl) the solution was prepared by mixing 2 mg DPPH, and 10 mL ethanol then shook and stored in the refrigerator. Cookies sample was prepared by mixing 1 g cookies and 9 mL ethanol, then centrifuged for 10 min at 4 000 rpm (1 rpm = 1/60 Hz). The filtrate was added with 1 mL of DPPH solution and allowed to stand for 10 min to turn yellow. The absorbance of the resulting solution was measured at 517 nm using a spectrophotometer. Antioxidant activity was calculated by following the Formula (2):

Antioxidant activity (%) = $(A_b - A_s) / (A_b) \times 100 \%$

where A_b is the absorbance at 517 nm of the blank control and A_s is the absorbance of the sample. The color intensity of CCF, L (brightness), a (redness), b (yellowness) were determined using Moharra and Youssef Methode (2014).

Baking of cookies

Baking of cookies was initiated by mixing of 20 g tapioca flour, 50 g sugar, 10 g egg yolk, 10 g milk powder, and 75 fat. After 10 min, MAS and CCF in different levels (80 % : 0 %; 75 % : 5 %; 70 % : 10 %; 65 % : 15 %; 60 % : 20 %) and 20 % MOCAF were added, then cookies were formed into round shape. After baking over 150 °C for 30 min (BOSHRA, et al., 2014), cookies were cooled to room temperature and were stored until further analysis.

Evaluation of cookies

Physical characteristic

The determination of hardness expressed as using a Hitachi Texture Analyzer with a 75 mm cylinder probe.

Color measurement of cookies

The color intensity of cookies was determined according to the methods described in Section 2.3.

Sensory evaluation of cookies

The sensory evaluation of cookies was held to define the acceptability of the product.

Cookies samples were served to 20 panelists who were given some query in a form to rate each sensory attribute. Cookies were tested for aroma, texture, preference, and taste on a 5- point hedonic scale.

Analysis of cookies

Chemical analysis

Cookies were analyzed for moisture, ash, protein, and fat and carbohydrate by different according to the method described in Section 2.3.

Total dietary fiber

The principle of this method is sequential digestion using the enzymes alpha-amylase, protease and amyloglucosidase. Before the testing process is carried out, the sample must be removed from fat and protein and then dried. To precipitate the soluble dietary fiber, ethanol is added to the sample. Total dietary fiber (TDF) is the residue left after washing insoluble residues and precipitates with alcohol and acetone, dried, weighed and corrected for protein and ash content. The dry sample was used for the analysis of total dietary fiber according to the method described in Section 2.3.

Measurement of antioxidant activity by free radical scavenging activity

Cookies of 2 g was measured for antioxidant activity according to the method described in Section 2.3.

Statistical analysis

This research was conducted in Randomized Block Design (RBD) with one factor, the proportion of MAS and CCF in five levels and performed in three replicates. Duncan's new multiple range tests was used to determine the difference of means, and $P \leq 0.05$ was considered to be statistically significant (SMITH, 2018).

3 RESULTS AND DISCUSSION

Chemical analysis and color intensity of MAS and CCF

The proximate composition of MAS, CCF dan MOCAF are displayed in Table 1. Among three ingredients, the highest of total dietary fiber content (TDF) was 27.66 % in CCF, which is higher than TDF in wheat bran, oat bran, and mango peel powder that reported to be 6.6 %, 15 %, and 19 % respectively, (AJILA et al., 2008).

Therefore, the enrichment of cookies with coffee cherries flour would increase the nutritional quality of the product. The coffee cherries flour showed that antioxidant activity was found to be 36.9 %. According to Duangjai et al. (2016) said that coffee pulp contains cinnamic hydroxyl acids (chlorogenic, caffeic, and ferulic acid). This compound donates hydrogen atoms to molecules that are oxidized.

The color intensity of CCF exhibited that the brightness is less than 50, whereas the brightness of MAS was not assessed, however, according to Damat, et al. (2017b) reported that the MAS tend to be brownish. L value is a measure of the light-dark (brightness) fraction of product surface color which ranged from 0 to 100, the bigger the brightness score, the brighter of color, and vice versa. Thus, CCF would contribute to the dark color of the product.

Physical characteristic of cookies

Effect of CCF on the hardness of cookies prepared using five proportions (80 % : 0 %; 75 % : 5 %; 70 % : 10 %; 65 % : 15 %; 60 % : 20 %) of CCF and MAS was tested. The addition of CCF can increase the hardness of cookies, although no significant difference. The hardness of these cookies is harder than the others. (HARTATIK, DAMAT, 2017), reported that her cookies had found to be 37.66 N. The increase in hardness of cookies may be due to relatively lower moisture in cookies detected (Table 3).

Moreover, Ateş & Elmacı (2019) stated that coffee cherries flour could increase the level of hardness in cakes. The starch retrogradation process (amylopectin), which results in increased crystallization or molecular regularity of starch polymers (amylopectin) is the leading cause of increased hardness of cookies. In addition, the trapping of some of the water in starch crystals during the retrogradation process causes the distribution of water in cookies to shift from gluten to starch (amylopectin) thereby reducing water availability as a plasticizer on the gluten matrix. This causes the texture of cookies to be dry and brittle (DAMAT et al., 2017a). The hardness is also influenced by the level of fiber content in the product (Table 5). The higher the fiber content in food products the higher the value of hardness (BOSHRA et al., 2015).

TABLE 1 - Proximate composition (g/100 g dry sample), total dietary fiber, antioxidant activity, and color intensity of coffee cherries flour, modified arrowroot starch, and modified cassava flour.

| Component | Coffee Cherry Flour | Modified Arrowroot Starch | Modified Cassava Flour ^{a)} |
|--------------------------|---------------------|---------------------------|--------------------------------------|
| Moisture (%) | 10.10 | 11.85 | 8.41 |
| Ash (%) | 3.10 | 0.44 | 1.12 |
| Protein (%) | 5.10 | 0.38 | 5.29 |
| Fat (%) | 1.89 | 1.29 | 2.54 |
| Carbohydrate (%) | 79.71 | 86.03 | 81.16 |
| Antioxidant activity (%) | 36.9 | NA* | NA* |
| Total dietary fiber (%) | 27.66 | NA* | 1.55 |
| Color intensities: | | | |
| a) Brightness level (L) | 40.57 | NA* | NA* |
| b) Redness level (a) | 1.05 | NA* | NA* |
| c) Yellowness level (b) | 6.20 | NA* | NA* |

*NA, not assessed; ^{a)}Soetikno et al., (2017)

Color of cookies

Table 2 indicates that the addition of CCF affected significantly the intensity of the color of cookies in three values -brightness (L), redness (a), and yellowness (b). All three values decreased with the increase in the level of CCF. The color intensity of these cookies is lower than the others. Chauhan et al. (2015), reported that "L," "a," and "b" value of his cookies ranged from 61.7 to 65.2, 6.33 to 7.15, and 21.83 to 25.05, respectively. This phenomenon can be influenced by modified arrowroot starch, which tends to be brownish, so when applied to a product, the color becomes less attractive (DAMAT et al., 2017b). In addition, cookies that are getting darker are also caused by the brightness value of CCF (Table 1), which was 42.6. Ateş & Elmacı (2019) support this phenomenon who mentioned that the addition of coffee cherry flour would reduce the redness and yellowness of the cake.

Chemical characteristic of cookies

Table 3 shows that the addition of CCF influenced significantly all proximate components - moisture, protein, fat, ash, and carbohydrate of cookies. The increase of CCF level decreased moisture and fat. On the other hand, three proximate components enhanced with the increase in the level of CCF. The change of proximate component in cookies may be due to the proximate component contained in raw materials (Table 1).

Based on Table 1, the moisture of CCF is lower than MAS. Thus, the moisture of cookies was decreased when the proportion of MAS also

decrease. Low moisture in cookies might be caused by structural changes in starch granules in arrowroot starch were modified due to the occurrence of the retrogradation gelatinization process. As a result of gelatinization, the starch structure becomes more compact, so the ability to absorb water drops. The results of this study are similar to the results of research carried out by (HARTATIK, DAMAT, 2017) which states that the water content of cookies from modified arrowroot starch by means of heat moisture treatment is lower compared to the moisture content of cookies from natural arrowroot starch.

Fat in cookies is greater compared to fat in raw materials (Table 1) because there is an addition of margarine and egg yolk. In addition, high dietary fiber contained in CCF could contribute to the decrease of fat in cookies. Fiber content will hinder fat extraction, so fat content cannot be perfectly extracted when a fat analysis is carried out (AMBRIZ, et al., 2008). Thus, the fat of cookies was decreased when the proportion of CCF increases.

Both ash and protein of CCF are higher than MAS (Table 1). Thus, the ash and protein of cookies were increased when the proportion of CCF also increased. While carbohydrate levels in cookies are caused by the raw materials used containing high levels of carbohydrates (Table 1). In addition, high dietary fiber contained in CCF could be influenced an increase of carbohydrate in cookies because according to (BOSHRA, et al., 2015). the amount of fiber will affect the carbohydrate level in food.

TABLE 2 - Effect of coffee cherry flour and modified arrowroot starch on hardness and color of cookies.

| Treatment | Hardness (N) | Color intensity | | |
|---------------------------------------|--------------|----------------------|-------------------|----------------------|
| | | Brightness level (L) | Redness level (a) | Yellowness level (b) |
| P ₀ (MAS:CCF= 80 % : 0 %) | 30.34 a | 48.26 c | 4.36 d | 14.40 d |
| P ₁ (MAS:CCF= 75 % : 5 %) | 34.22 a | 46.54 b | 3.62 c | 11.94 c |
| P ₂ (MAS:CCF= 70 % : 10 %) | 28.99 a | 45.20 b | 2.92 c | 10.66 c |
| P ₃ (MAS:CCF= 65 % : 15 %) | 56.43 a | 43.26 a | 2.02 b | 7.98 b |
| P ₄ (MAS:CCF= 60 % : 20 %) | 34.07 a | 41.48 a | 1.10 a | 6.10 a |

All data are the mean of five replicates. Mean followed by different letters in the same column differs significantly ($P \leq 0.05$).

TABLE 3 - Effect of coffee cherry flour and modified arrowroot starch on proximate composition of cookies

| Treatment | Moisture (%) | Ash (%) | Protein (%) | Fat (%) | Carbohydrate (%) |
|--------------------------------------|--------------|---------|-------------|---------|------------------|
| P ₀ (MAS:CCF= 80 % : 0 %) | 5.04 e | 0.73 a | 1.72 a | 14.80 a | 77.69 a |
| P ₁ (MAS:CCF= 75 % : 5 %) | 4.47 d | 0.84 b | 3.49 b | 13.53 b | 77.66 a |
| P ₂ (MAS:CCF=70 % : 10 %) | 3.94 c | 0.93 c | 4.26 c | 12.24 c | 78.60 b |
| P ₃ (MAS:CCF=65 % : 15 %) | 3.44 b | 1.03 d | 5.14 d | 10.84 d | 79.53 c |
| P ₄ (MAS:CCF=60 % : 20 %) | 2.94 a | 1.18 e | 5.96 e | 9.56 e | 80.34 d |
| Standar of Cookies * | Max 5 | Max 1.6 | Min 5 | Min 9.5 | Min 70 |

All data are the mean of five. Mean followed by different letters in the same column differs significantly ($P \leq 0.05$). * SNI 2973-2011

In the heating process will damage the bonds of fat and fat will be bound by carbonate. This bond is called amyloid (SAJILATA, 2006). Therefore, carbohydrate of cookies was increased along with the increase of CCF proportion.

Based on the quality requirements of cookies referring to SNI 2973-2011 (SNI = *Standar Nasional Indonesia* = Indonesian National Standard), exhibited that all cookies with variants of the proportion of MAS and CCF coincide its requirement.

Sensory evaluation of cookies

Table 4 shows that the flavor of the cookies was relatively weak when CCF added more than 5 % level because coffee husk produces a distinctive aroma of polyphenol compounds. The texture of cookies became less acceptable with an increase in the level of CCF, because the cookies became harder, reflected in hardness values (Table 2). The taste of the cookies was improved on the addition of CCF, but it made unpleasant taste, because the husk coffee will produce a slightly bitter taste may be due to its polyphenol content.

The preference score was decreased with an increase in the level of CCF, influenced by other organoleptic. Considering all sensory attributes, it could be inferred that cookies containing CCF were as acceptable as control cookies up to 5 % level of CCF addition. Therefore, accept cookies for overall sensories was obtained can be prepared using 5 % CCF formulations.

Dietary Fiber Content of Cookies

Cookies added with CCF displayed increased total dietary fiber content (Table 5). The results implied that there is a significant increase in the TDF content in cookies added with CCF. As can be seen from Table 1, the total dietary fiber of TDF is highest than the other. According to Bekalo & Reinhardt (2010), coffee husk contains 24.5 % cellulose, 29.7 % hemicellulose, 25.7 % lignin, and 6.2 % ash. In addition, Modified arrowroot starch has a resistant starch content of 3.07 % to 9.84 %, where arrowroot starch is physically modified and physical hydrolysis has higher food fiber compared to those modified by acid hydrolysis.

TABLE 4 - Effect of coffee cherry flour and modified arrowroot starch on the sensory evaluation of cookies

| Treatment | Flavor (5) | Texture (5) | Taste (5) | Preference (5) |
|--|------------|-------------|-----------|----------------|
| P ₀ (MAS:CCF = 80 % : 0 %) | 3.70 b | 3.73 b | 3.66 b | 3.60 b |
| P ₁ (MAS:CCF = 75 % : 5 %) | 3.43 b | 3.60 b | 3.43 b | 3.56 b |
| P ₂ (MAS:CCF = 70 % : 10 %) | 3.00 a | 2.80 a | 2.86 a | 2.93 a |
| P ₃ (MAS:CCF = 65 % : 15 %) | 2.76 a | 3.50 b | 2.86 a | 2.80 a |
| P ₄ (MAS:CCF = 60 % : 20 %) | 3.03 a | 3.60 b | 2.66 a | 2.80 a |

Mean followed by different letters in the same column differs significantly ($P \leq 0.05$).

TABLE 5 - Effect of coffee cherry flour and modified arrowroot starch on total dietary fiber and antioxidant activity of cookies.

| Treatment | Total Dietary Fiber (%) | Activity of Antioxidant (%) |
|--|-------------------------|-----------------------------|
| P ₀ (MAS:CCF = 80 % : 0 %) | 11.69 a | 32.31 a |
| P ₁ (MAS:CCF = 75 % : 5 %) | 12.61 b | 37.75 b |
| P ₂ (MAS:CCF = 70 % : 10 %) | 14.42 c | 38.77 c |
| P ₃ (MAS:CCF = 65 % : 15 %) | 16.20 d | 39.39 c |
| P ₄ (MAS:CCF = 60 % : 20 %) | 19.48 e | 40.10 d |

All data are the mean of five replicates. Mean followed by different letters in the same column differs significantly ($P \leq 0.05$).

Modified arrowroot starch, both physically and acid-physical hydrolysis contains total dietary fiber about three to four times greater than natural arrowroot starch. Physical modification of arrowroot starch contains total food fiber of 9.07 %, consisting of 0.79 % of soluble fiber and 8.28 % of insoluble fiber. Arrowroot starch hydrolysis-physical modification contained total food fiber of 9.84 %, consisting of 2.86 % of soluble fiber and 6.98 % of insoluble fiber. Increased content of dietary fiber in modified arrowroot starch because of the resistant starch formed due to the modification process of starch is also included in dietary fiber. Increased levels of total dietary fiber in starches undergoing a cycle of heating-copying processes occur because of increased levels of insoluble fiber. Resistant starch is measured as insoluble fiber but has physiological functions such as soluble fiber (FARIDAH et al., 2013).

Antioxidant Activity of Cookies

Table 5 shows that the antioxidant activity of cookies increased significantly with the CCF added. According to Table 1, the antioxidant activity of CCF is highest than the other. Thus, the antioxidant activity of cookies was increased when the proportion of CCF also increased. Duangjai et al. (2016) state that antioxidant activity (DPPH IC₅₀) in coffee pulp ranged from 82 $\mu\text{g mL}^{-1}$ to

153 $\mu\text{g mL}^{-1}$. In addition, Elva et al. (2017) said that coffee pulp contains hydroxycinnamic acids (chlorogenic, caffeic, and ferulic acid). This compound donates hydrogen atoms to molecules that are oxidized.

4 CONCLUSION

The chemical composition of CCF showed that it is a good source of dietary fiber. Cookies enriched with CCF exhibited increase significantly total dietary fiber up to 19.48 % and antioxidant activity up to 40.10 %. Thus, coffee cherry flour, a by-products of coffee fruit and bean processing, can be considered as potential functional ingredients for the cookies production.

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