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Characterization of Ganyong (*Canna discolor*) and Cowpea (*Vigna unguiculata*) Flour Affected by Heat Moisture Treatment

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ABSTRACT

Cookies are food products that are often a consumption. High glycemic index (GI) cookies consumption causes increased diabetes mellitus (DM) cases. In addition, high GI cookies can improve obesity. DM and obesity lead to other complications and degenerative diseases. The low GI value cookies need to produce for diabetes mellitus prevention. This research contribution is a preliminary study to produce raw material flour for low GI cookies. Heat moisture treatment (HMT) was applied to modify the Canna flour. Canna flour increased the moisture content to 34.39% wet base (WB.), then dried at 92°C for 20.6 h. HMT process increased the resistance starch, soluble and insoluble fiber. Treated Ganyong flour has 2.16 % dry base (DB.) soluble fiber, 30.19 % DB., and 28.03% DB. The result showed that HMT increased total dietary and soluble fiber. Those parameters are essential to low GI cookies for diabetes mellitus prevention. HMT also increased the whiteness index of Ganyong flour.

6
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1. INTRODUCTION

Diabetes Mellitus (DM) is a metabolic disorder disease characterized by abnormally high blood glucose levels (hyperglycemia), which is > 200 mg/dL (Association, 2010). High GI cookies can be found almost in every market. The majority of them were produced from high GI values, such as wheat flour (GI = 85) and sucrose (IG = 65) (Atkinson et al., 2008). An increase in high GI snack consumption cause DM risk. Switch consuming high GI foods with lower ones is an effort to prevent DM. Low GI foods can be created as bakery products such as cookies. It can be produced from low GI ingredients such as tubers, legumes, or whole wheat flour.

Snack production from Indonesian tubers and legumes can minimize wheat utilization as an imported product. Although none of the tubers and legume flour can replace the wheat protein in snack production, they can be used as substituent ingredients (Suismono, 2008). In addition, Canna tubers contain higher dietary fiber than others (Richana & Sunarti, 2004). Foods that are high in dietary fiber generally have a low GI because dietary fiber can inhibit gastric emptying and glucose absorption (Eliasson, 2017). But, Canna tubers do have not too low GI values.

Canna tubers flour can be modified before utilization as a substitute for wheat flour. Canna tubers modification can be modified to increase their resistant starch content. Resistant starch (RS) has the same effect on glucose metabolism as dietary fiber. RS can also inhibit gastric emptying and lower blood glucose levels after eating (Gropper & Smith, 2013). The level of resistant starch in canna flour could be increased optimally using Heat Moisture Treatment (HMT) at a water content of 34.39% and a temperature of 92 for 20.6 hours (Wangrimen, 2019).

Nevertheless, the protein content of Canna flour is low, about 2.34-3.48% dry base (Wangrimen, 2019). Protein and amino acids stimulate insulin secretion (Keane & Newsholme, 2014). Insulin is a hormone produced by pancreatic cells to lower blood glucose levels (Tortora & Derrickson, 2016). Several types of those amino acids are alanine (Ala), arginine (Arg), phenylalanine (Phe), isoleucine (Ile), leucine (Leu), and lysine (Lys) can stimulate insulin secretion (Kanetro & Setyowati, 2013). Using high protein commodities can help to improve the protein content of Canna flour product-based.

Legumes have a high protein content and are easy to obtain. They are also cheaper than animal protein and prevent the risk of animal protein allergy (Astawan, 2009). Cowpea is the legume with the highest protein content in Indonesia after peanuts and soybeans, which is 27.27 %w.b. (Dewi et al., 2015). In addition, according to (Kanetro & Setyowati, 2013), cowpeas are high in insulin secretion-stimulating amino acids compared to other legumes. Cowpea also has increased productivity, reaching 1.5–2 tons/ha (Sayekti et al., 2012). Besides being high in protein, cowpea has a low glycemic index value (Marsono et al., 2002), making it suitable when combined with canna flour in low GI cookie production.

The production of low GI cookies based on HMT-modified canna flour and cowpea flour has never been done before. Therefore, this study contributes to evaluate the characteristics of canna and cowpea flour as a preliminary study before low GI cookies production from HMT-modified canna flour.

2. MATERIALS AND METHODS

2.1. Materials

The materials used in this study were 8-month-old canna tubers which were obtained from Langkaplancar District (Pangandaran Regency), and cowpeas obtained from Grogol Market (West Jakarta).

2.2. Research Methods

2.2.1. Canna flour production

HMT-modified canna flour was prepared using the (Wangrimen, 2019) method to obtain the optimum levels of resistant starch. The production of canna flour begins with washing the canna tubers under running water to remove dirt and debris on the surface of the tubers, such as dust and soil. Next, peel the tubers to remove the skin. Next, Canna tubers that have been peeled off are rewashed to remove the still attached dirt. Then, skinless canna tubers are thinly sliced using a grater to facilitate drying.

The first canna slices were dried by drying in the sun for 3 h, then followed by

a temperature of 60°C for 6 hours using an oven. The resulting dried tubers were then crushed using a blender and sieved using a 35 mesh sieve. Next, the flour modification process using the HMT method was carried out at a flour moisture content of 34.39%. The mass of water that needs to be added to the flour can be determined by Equation 1. The flour added with water was then heated at a temperature of 92 for 20.6 h.

$$(i \times a) + x = f \times (a + x) \quad (1)$$

Where *i* is the initial moisture content of the flour (%), *a* is the weight of the flour (g), *x* is the weight of the water added (g), and *f* is the target moisture content of the flour (%).

2.2.2. Cowpea flour production

The cowpea flour production was carried out using (Devi et al., 2015) method with slight modifications. At first, the cowpeas were sorted and washed with tap water. Then, the beans were soaked in water for 3 h. Then, they were drained using a sieve and germinated for 24 h at room temperature (25°C). The sprouted beans were then dried at 60°C for 5.5 h. The dried beans were ground using a blender and then sieved using an 80 mesh sieve.

2.2.3. Whiteness degree of flour

The degree of whiteness of flour was obtained from the values of *L*, *a**, and *b**, which were known through color testing using CIE Lab Color Space with the help of Adobe Photoshop CS6 software. The degree of whiteness is based on a 0–100 scale, where a value of 100 is described as the highest brightness. The white degree value is obtained using (2):

$$\text{Whiteness Index} = 100 - [(100 - L^*)^2 + (a^*)^2 + (b^*)^2]^{1/2} \quad (2)$$

2.2.4. Moisture Content

Determination of moisture content followed (Fitriani et al., 2021). The sample was dried in an oven at a temperature of 100–105°C until it reached a constant weight. The moisture content can be calculated through (3):

$$\text{Moisture content (\%)} = (W1 - W2)/W1 \times 100\% \quad (3)$$

where *W1* is the weight of the sample before drying and *W2* is the weight of the sample after drying.

2.2.5. Ash content

Determination of ash content (Fitriani et al., 2021) begins with weighing 3–5 g of sample and placed in a porcelain dish whose weight is known. Next, the sample was ashed in an electric furnace until completely ashed using a temperature of 550°C. Finally, samples were cooled in a desiccator and weighed until a constant weight was obtained (≤ 0.0005 g). Then, the ash content in the sample was calculated using (4).

$$\text{Ash content (\%)} = \frac{\text{final weight of the sample (g)} - \text{the porcelain dish weight (g)}}{\text{the weight of sample before ashing (g)}} \times 100\% \quad (4)$$

2.2.6. Protein content

Protein content was determined using the micro Kjeldahl method (Fitriani et al., 2021). The principle of the Kjeldahl process is that nitrogen-containing

compounds in the material are reacted with concentrated H₂SO₄ to form ammonium sulphate salts. Then NaOH was added to neutralize the acidic condition, distilled with boric acid to bind free ammonia, and titrated with HCl solution to determine the amount of N in the sample. The protein content in the sample was calculated using (5).

$$\text{Protein content (\%)} = \frac{(V_1 - V_2) \times N \text{ HCl} \times 0.014 \times c.f.}{w} \times 100\% \quad (5)$$

where V₁ is the HCl volume needed in the sample titration process (mL), V₂ is the HCl volume required for the blank titration process (mL), w is the sample weight (g), c.f. is the conversion factor for nitrogen to protein content.

2.2.7. Lipid content

The flour's lipid content was determined using the Soxhlet method (Fitriani et al., 2021). This method extracts lipid with petroleum ether. Then the solvent was evaporated using the gravimetric method so that the weight of the lipid could be known. The lipid content of the sample can be calculated using Equation 6.

$$\text{Lipid content} = \frac{\text{lipid weight (g)}}{\text{sample weight (g)}} \times 100 \quad (6)$$

2.2.8. Total carbohydrate content

The total carbohydrates were estimated using the by-difference method. The total carbohydrates were calculated by reducing 100 portions of the sample with the sum of moisture, ash, lipid, and protein content which can be seen in Equation 7.

$$\begin{aligned} \text{Total Carbohydrate} \\ = 100\% - (\text{moisture} + \text{ash} + \text{lipid} + \text{protein content}) \end{aligned} \quad (7)$$

2.2.9. Amylose content

Determination of amylose content was carried out using the iodine binding method (Chemistry, 1970). The blue color shows the presence of amylose due to the reaction between amylose and iodine compounds. The intensity of the blue color varies depending on the amylose content in the material. First, 100 mg of the sample was put into a test tube and given 1 mL of 95% ethanol and 9 mL of 1 N NaOH. Then the solution was heated in boiling water at 100°C for 10 minutes to form a gel. Next, the test tube was cooled, then the solution was transferred to a 100 mL volumetric flask to be diluted with distilled water.

The 5 mL sample was put into a 100 mL volumetric flask and added 1 mL of 1 N acetic acid and 2 mL of 2% I₂. The mixed solution was then diluted with distilled water, shaken, and rested for 20 min until the solution turned blue. Furthermore, the color intensity of the solution was measured using a spectrophotometer at a wavelength of 625 nm. The amylose content was calculated using a standard curve of amylose. The distilled water added with 2% I₂ was a blank solution.

2.2.10. Total starch content

Starch content was determined by the acid hydrolysis method (Chemistry, 1970). First, the sample was washed with distilled water and then filtered using filter paper to remove water-soluble carbohydrates. The resulting filtrate was discarded, while the residue was removed from the filter paper by washing with water and then

hydrolyzed with 25% HCl for 2.5 h. After hydrolysis, the sample was cooled and neutralized with 1 N NaOH solution, diluted, and filtered with filter paper. The filtrate obtained was then tested for its sugar content by determining reducing sugar content. Finally, the glucose level was multiplied by a conversion factor of 0.9 to get the starch content.

2.2.11. Resistant starch content

Analysis of resistant starch content (Chemistry, 1970) was started by dissolving 0.5 g of sample with 25 mL of 0.1 M phosphate buffer pH 7.0 and 0.1 mL of amylase. Next, the beaker containing the sample was closed to incubate for 15 min at 100°C in a water bath, stirring occasionally. After incubation, the sample was cooled at room temperature, and 20 mL of distilled water and 5 mL of 1 N HCl were added. Then the sample was added with 1 mL of 1% pepsin and heated in a water bath for 30 min.

After the sample was reacted with the pepsin enzyme, 5 mL of 1 N NaOH and 0.1 mL of amylase were added. Then the Erlenmeyer glass containing the sample was closed and incubated again in a shaking water bath for 30 min at 100°C. The sample is then filtered with filter paper whose weight is known. The residue obtained was then dissolved and analyzed for its starch content by the acid hydrolysis method to determine the level of resistant starch.

2.2.12. Dietary fiber

Dietary fiber analysis based on (Chemistry, 1970). As much as 0.5 g of the sample was put in a beaker glass. Then, 50 mL phosphate buffer pH 7.0 and 0.1 mL amylase was added. Next, the glass containing the sample was closed and incubated for 30 min at 100°C in a water bath, stirring occasionally. After incubation, the sample was cooled at room temperature. Next, 20 mL of distilled water and 5 mL of 1 N HCl were added. Then the 1 mL of 1% pepsin was added and heated in a water bath for 30 min.

After the sample was reacted with pepsin, 5 mL of 1 N NaOH and 0.1 mL of amylase were added. Then the Erlenmeyer glass containing the sample was closed and incubated for 30 min at 100°C. Next, filter the sample with a constant filter paper of known weight. The residue obtained was used to determine the content of insoluble fiber, while the filtrate obtained was used to determine the content of soluble fiber. The residue was washed with 2 × 10 mL of ethanol and 2 × 10 mL of acetone. After washing, the residue was dried gravimetrically (with an oven at 105°C to constant mass). The dry residue weight obtained is the weight of insoluble dietary fiber.

Meanwhile, the filtrate volume was adjusted to 100 mL, and then 400 mL of warm 95% ethanol was added (it had been heated at 60°C). The filtrate was allowed to settle for 1 h. Then the filtrate was filtered with ash-free filter paper. The residue obtained from the filtrate was washed with 2 × 10 mL of ethanol and 2 × 10 mL of acetone and then dried gravimetrically (with an oven at 105°C to a constant mass). The dry residue weight obtained is the weight of soluble dietary fiber. Total dietary fiber content is obtained using (8).

$$\begin{aligned} \text{Total Dietary Fiber (\%)} \\ = \text{Insoluble Dietary Fiber (\%)} + \text{Soluble Dietary Fiber (\%)} \end{aligned} \quad (8)$$

3. RESULT AND DISCUSSION

3.1. Chemical characterization of the flour

Table 1 shows the chemical characterization of the flour such as canna flour,

HMT-modified canna flour, and cowpea flour. It was modified using Heat Moisture Treatment (HMT) to change the starch content into resistant starch to reduce the glycemic index value.

Table 1. Chemical characteristics of HMT-modified canna flour and cowpea flour

Compound	Native canna flour	HMT-modified canna flour	Cowpea flour
Moisture (%WB.)	6.1116	4.8941	12.7663
Ash (%DB.)	4.0162	4.4363	4.0357
Amylose (%DB.)	28.3100	28.8068	15.0695
Starch (%DB.)	73.2573	67.1817	48.6433
Resistance starch (%DB.)	1.9112	7.8878	2.5549
Soluble fiber (%DB.)	1.1044	2.1625	4.8017
Insoluble fiber (%DB.)	20.0563	28.0343	35.3053
Total dietary fiber (%DB.)	21.1607	30.1967	40.1070
Protein (%DB.)	4.3240	4.4572	22.0712
Lipid (%DB.)	0.8001	0.7366	1.7338
Total carbohydrate (%DB.)	84.7481	85.4758	59.3931

Although there is no specific research on the glycemic index of canna flour, the glycemic index value of canna tubers is moderate, which is 65 (Juwita, 2012). The amylopectin content greater than amylose in canna tuber starch can be one of the reasons for the low glycemic index (GI) value. Starch with a higher amylopectin content is easier to digest because the branched structure of amylopectin consists of short glucose chains easily accessible by amylase. At the same time, amylose is more difficult to digest because it has a tighter structure (Horstmann et al., 2017).

The starch content in native canna flour used in this study was 73.2573%DB. with amylose of 28.31%DB. Meanwhile, HMT-modified canna flour in this study showed lower starch content but higher total dietary fiber and resistant starch. They were 67.1817%DB., 30.1967 %DB. and 7.8878 %DB., respectively. The mechanism of the HMT process starts from the disruption of the crystalline structure and the dissociation of the double-stranded structure, followed by a re-association process of a denser crystal structure (retrogradation) to form type 3 resistant starch (Li, 2018). The retrogradation process resulted in the crystal structure. This structure is denser as the forming of amylose chains easily and the stable hydrogen bonds (Provost et al., 2016).

3.2. Colour characterization of the flour

The whiteness of HMT-modified canna and cowpea flour were also tested. The whiteness value of HMT-modified canna flour was 62.30, while cowpea flour was 77.59 (Table 2). This indicates that HMT-modified canna flour has a darker colour than cowpea flour.

Table 2. The degree of whiteness of flour

Flour	L*	a*	b*	Whiteness Index
HMT-modified canna flour	73.00	4.00	26.00	62.30
Cowpea flour	84.67	0.67	16.33	77.59

4. CONCLUSIONS

HMT affect the increase of dietary fiber and resistant starch on the canna flour. Those two compounds are essential for producing low GI cookies in future research. The dietary fiber increases by 42.70%, and the resistance starch increase by 312.71% from the

native canna flour. The cowpea flour was brighter than the HMT-modified canna flour. The cowpea flour can be used to improve the colour of the final product of cookies.

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