Glycemic Index of Biscuit Non-Wheat from Mangrove Fruits Flour with Arrowroot and Canna Flours

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ABSTRACT
Unhealthy eating patterns such as consumption of fast food, high fat, low fiber, and not followed by sufficient physical activities can cause health problems. One problem related to high glucose intake is diabetes mellitus, a type of degenerative disease. The food glycemic index is a food level according to its effect on blood glucose levels. The choice of food types that have a low glycemic index will increase insulin sensitivity; hence it is able to control blood glucose levels properly. This study aims to determine the physicochemical characteristics and organoleptic properties of biscuit most favored by consumers from various formulations of mangrove fruits flour (pedada and lindur flour) and tubers (arrowroot flour and canna flour) and to analyze the glycemic index in vivo on human. This study used a one-factor simple randomized design with ten levels of treatment, namely the proportion of mangrove fruit flour (pedada and lindur flour) and tubers (arrowroot and canna flour) of 0:100, 10:90 and 20:80, respectively. The best treatment results obtained on biscuits in pedada flour: arrowroot flour proportion of 20:80 which obtained 3.39% of water content, 3.66% of ash, 4.63% of protein, 6.61% of fat, 81.72 % of carbohydrate by difference, 64.40% of starch, 2.01% of soluble dietary fiber and 11.81% of insoluble dietary fiber. The overall sensory evaluation showed rather like with score 4.70 of taste , 4.85 of color, 4.25 of aroma and crispness. While the value of glycemic index 47.84 and 11.68 of glycemic load.

Keywords: *biscuits, mangrove fruit, arrowroot, canna, glycemic index*

I. INTRODUCTION

Unhealthy eating patterns such as consumption of fast food, high fat, low fiber, and not followed by sufficient physical activities can cause health problems, one of them is diabetes mellitus (DM). It is categorized as a degenerative disease, it is caused by high glucose intake and has been reported to continually increase throughout the year, so there is an emergence of a solution to overcome this problem.

One effort that can be done is by extracting local food sources, for instance the utilization of mangroves such as pedada and lindur or tubers. Pedada (*Sonneratia caseolaris*) which is green, has a sour taste and a distinctive aroma, it is rich in minerals and dietary fiber that can be utilized as a food source [1-2].

Besides pedada, lindur fruit is also suitable to be explored as a new local food source because it contains very high carbohydrates which is equal to 85.10 g / 100 g of material, water content of 54.35%, ash content of 1.01%, fat content of 1.43%, and protein content of 1.83% [3]. The high carbohydrate content makes lindur fruit suitable to be processed into flour [4].

Arrowroot tubers found in Indonesia have advantages such as can be used as a substitute for staple rice and medicine. The glycemic index possessed by arrowroot tubers is also relatively low (14) as compared to other tubers, such as gembili (90), kimpul (95) and sweet potatoes (179). This certainly can provide benefits for diabetics people [5].

Canna bulbs also have nutritional content that has the potential to be used as an alternative food source for rice because every 100 grams consists of 95.00 kcal calories, 1.0 g protein, 0.11 g fat, 22.60 g carbohydrates, 21.00 g calcium, 70.00 g phosphorus, 1.90 mg iron, vitamin B1 0.10 mg, vitamin C 10.00 mg, water 75.00 g [6]. Other substances in it are phosphorus, calcium, iron, vitamin B1, glucose, alkaloids, and sap. This tuber contains fiber and iron which is higher than in potatoes and has a glycemic index of 20.80[7].

The glycemic index (IG) is a food level according to its effect on blood sugar levels (an immediate effect), which is divided into 3 levels namely high IG (> 70), moderate (70-56) and low (<55) [8]. Foods with high glycemic index levels can raise blood sugar levels quickly and trigger large amounts of insulin production [9]. This will cause an increase in hunger after eating and accumulation of fat in adipose tissue [10]. The glycemic index is useful in determining the number and type of food sources of carbohydrates in an effort to control blood sugar levels.

The potential of pedada and lindur and arrowroot tubers and canna with their nutrient content need to be developed to overcome problems that arise due to irregular eating patterns, one of which is to make it as flour in making biscuits. For this reason, research is required on the proper flour formulation with low levels of the glycemic index so that it is expected to be a solution that can reduce the number of people with diabetes mellitus.

II. METHODS

A. Material Procurement

The pedada and lindur fruit obtained from Sidoarjo Mangrove farmer's East Java, Indonesia. Tubers (arrowroot and canna) were purchased from the Kediri Market, East Java, Indonesia. The equipment and chemicals were obtained from the Departement of Food Technology UPN "Veteran" East Java and Department of Agricultural Product Technology Laboratory of Brawijaya University. The chemicals and reagents used were of analytical grade.

B. Preparation of the Flour Sampels

Table 1. The proportion of mangrove fruits flour and tubers flour in making biscuits

Flour		Code Formulations	Ratio (%)	
Pedada /Lindur	: Arrowroot	A	0	100
Pedada /Lindur	: Canna	B	0	100
Pedada	: Arrowroot	C1	10	90
		C2	20	80
Pedada	: Canna	D1	10	90
		D2	20	80
Lindur	: Arrowroot	E1	10	90
		E2	20	80
Lindur	: Canna	F1	10	90
		F2	20	80

The pedada and lindur flour were processed according to procedure by Jariyah et al [2]. The tubers flour were processed through stages of washing, cutting, drying at 50-60^{0}C for 15 h, milling, and 80 mesh sifting. The proportion of mangrove fruits flour with tubers flour showed in Table 1.

C. Preparation of Biscuits

Biscuits were produced from the ten formulations using the method described by Jariyah et al [11]. The sugar, salt, glucose syrup, sodium stearoyl lactylate, skimmed milk powder and baking powder were mixed thoroughly. Then margarine and egg were added and mixed properly to make the dough and then the dough was rolled to a uniform sheet of thickness. The sheet was cut according to the shape and sie of biscuits and baked in the oven, and then cooled for 30 minutes, stored in a plastic container before analysis.

D. Physicochemical Analysis

The physicochemical analysis of the biscuits samples was determined using the method that was described by AOAC [12].

E. Sensory Evaluation

Sensory evaluation of the biscuits used twenty (20), panelists. The appraisal attributes include taste, colour, aroma and crispness.

F. Glycemic Index (GI) and Glycemic Load (GL)

Determination of the glycemic index and glycemic load of biscuit products uses pure glucose as standard food. Determination of the glycemic index using 22 respondents. Respondents involved were having characteristics of nutritional status (BMI 17.19-28.53 kg/m2) and the fasting blood glucose range of 79-100 mg/dl, and age 20-23 years. Measurement of blood glucose levels was done after the respondents fasted from 22:00 to 08:00 in the morning. Then respondents were asked to consume test food (pure glucose and biscuit samples) containing 50 grams of available carbohydrate. Blood samples were taken every 30 minutes within 2 hours. Respondents' blood glucose data were then spread on the X axis as time (minutes) and Y axis as blood glucose levels (mg / dL), then the glycemic index of food was calculated with these two values.

III. RESULTS AND DISCUSSION

A. Chemical Analysis of Flours

The results of chemical analysis were carried out on the raw materials we used, namely mangrove fruits flour (pedada and lindur flour) and tubers flour (arrowroot flour and canna flour) showed in Table 2.

Table 2. Chemical Analysis of Flours

Composition	P (%)	L (%)	Ar (%)	Cn (%)
Yield	7.00	31.34	9.67	8.23
Water	9.39	11.41	11.12	7.25
Ash	4.05	2.44	3.35	4.92
Protein	0.28	2.39	0.22	0.37
Fat	4.19	5.29	2.28	3.26
Carbohydrate	82.09	78.47	83.03	84.20
Starch	-	23.02	75.48	76.72
Amilose	-	16.16	24.60	18.67
Amilopectin	-	6.68	50.88	58.05
Soluble Dietary Fiber	17.74	10.85	0.94	0.89
Insoluble Dietary Fiber	48.82	44.35	6.37	5.46

[a]Notes : P = Pedada Flour, L = Lindur Flour, Ar = Arrowroot Flour, Cn = Canna Flour

B. Chemical of Biscuit Products

The chemical of biscuits product formulated from mangrove fruits and tubers flour showed in Table 3. The water content of biscuits had an average value from 3.16 to 3.44%. Biscuit formulation E2 showed higher water content than the other biscuits. The lower proportion of tubers flour or the higher the proportion of mangrove fruits flour, the water content of the biscuits increases. This was because the water content found in mangrove fruits flour was higher than the water content in tubers. Another factor

that could affect the water content obtained was starch. Starch has a hydroxyl group which can bind to water and can increase the water content in food [13].
The ash content of biscuits had an average value of 3.36 to 3.70%. Biscuit formulation D2 higher ash content than the other biscuits. The higher the proportion of mangrove fruits flour added, the higher the ash content of the biscuits. This was due to the high ash content of the initial raw material in the mangrove fruit flour that affected the final product yielded. The ash content comes from mineral elements and the chemical composition that is not evaporated during the ignition process and the ash content indicates the amount of minerals contained in the material [14].

Table 3. Chemical analysis of biscuits product

FR	**Water (%)**	**Ash (%)**	**Protein (%)**	**Fat (%)**	**CHO *By Difference* (%)**	**Starch (%)**
A	3.21	3.36	4.22	6.26	82.95	69.68
B	3.16	3.44	5.11	7.36	80.85	58.56
C1	3.26	3.58	4.44	6.45	82.27	66.79
C2	3.39	3.66	4.63	6.61	81.72	64.40
D1	3.23	3.61	5.37	7.54	80.26	55.63
D2	3.35	3.70	5.48	7.70	79.77	53.54
E1	3.33	3.47	4.65	6.60	81.96	67.55
E2	3.44	3.51	4.77	6.88	81.40	65.54
F1	3.30	3.57	5.59	7.67	79.88	56.74
F2	3.42	3.63	5.73	7.80	79.43	55.42

Note : FR = Formulation; CHO = carbohydrate

Biscuit formulation F2 showed higher protein content than the other biscuits. The high level of protein in biscuits was due to higher levels of protein content in the raw materials of lindur flour as compared to other flour, consequently it could add value to the protein content of the biscuits, while the low protein content was caused by the roasting process. This roasting process produces heat which can cause denaturation of proteins. Widyastuti et al [15] stated that the high temperatures can increase kinetic energy and cause molecular constituents to move or vibrate very quickly so that it breaks the bonds of these molecules and damages the protein.

Biscuit formulation F2 showed the highest fat content as compared to the other formulations. The increase of fat content in each proportion used occurred along with the decreasing proportion of tubers flour and the increasing proportion of mangrove fruit flour. However, the biggest effect of fat content came from margarine used which was as much as 50% of the weight of the material. Widyastuti [15], reported that additional ingredients such as margarine are thought to contribute to certain degree of fat to biscuits as well as added fat content in raw materials, so that the resulting fat content is also higher, besides high fat comes from the initial raw material in each flour used.

The carbohydrate by difference showed that the addition of lindur fruits flour to the proportion of tubers flour had a lower carbohydrate by difference level as compared to the addition of pedada fruits flour. This could be seen from the average value of biscuits in the formulation C2 at 81.72% higher than biscuits with the formulation E2 at 81.40%. The high carbohydrate content in the biscuits was influenced by the components of the initial raw carbohydrate in the pedada flour, which is 82.09% higher than the carbohydrate content of the lindur flour at 78.47%. Sugito and Haryati [16], stated that the carbohydrate levels are influenced by the levels of components of other nutrients. The higher the level of components of other nutrients, the lower the carbohydrate levels, and vice versa. Components that affect the level of carbohydrate are determined by the method of difference, which is a reduction of 100% with water, ash, protein and fat content.

The starch analysis of biscuit showed that the higher the proportion of mangrove fruits flour used in the formulation, rendered the lower level of the biscuit starch. This was because the starch content of each flour varied. The results of the analysis of raw materials showed the starch content of the lindur fruit flour was 23.02%, arrowroot flour was 75.48%, and canna flour was 76.72%.

C. Sensory Evaluation of Biscuits

The sensory properties of biscuit products tested in this study included color, taste, texture and aroma. The color analysis showed that the panelists liked the the biscuit product, the formulation A and did not like the color of the biscuit product formulation F2. Biscuit product from arrowroot flour formulation A yellowish white, this yellowish white is more likely to be interpreted as brownish yellow by panelists. Biscuit product formulation F2 rendered a thick brown color. The resulting color was thought to originate from the color of canna flour and lindur fruit flour which is browner than the other flour. The more the mixture of canna flour and pedada fruit flour on the biscuit, the darker (brown) the biscuits that the panelists did not like. Hence, the number of canna flour mixtures in biscuit caused a further decrease of the level of preference from the panelists to the color of the canna biscuits produced. This is consistent with the research conducted by Riskiani [17] which states that the addition of canna flour affects the color of the biscuits produced. The color of the biscuits becomes rather dark (reddish brown) when compared to controls that are more brass color.

The taste analysis showed that the panelists liked the taste of the biscuit formulation A and did not like the taste of biscuit product formulation F2. Biscuit formulation A, was preferred by panelists because it has the highest composition of arrowroot flour, so it had a savory taste as compared to other formulation. Whereas biscuit formulation F2 had a slightly bitter taste as compared to other formulations. The bitter taste originated from the tannins found in lindur fruit flour, the more addition of lindur fruit flour, the bitter the biscuit taste and disliked by the panelists. Phenol compounds and tannins in canna tubers can cause a bitter or bitter taste on the tongue because they react with mucous proteins in the mouth during the process of masticating biscuits [17-18]. The texture and consistency of a material will affect the taste caused by the material [19].

The aroma analysis showed that the panelists liked the aroma of biscuit product in the formulation A and did not like the aroma of biscuit product formulation F2. In biscuit with arrowroot flour formulation in the proportion of 100% had a distinctive aroma as compared to other formulations. This was caused by the addition of margarine, sugar and eggs which could affect the aroma of the biscuits. The biscuit product formulation F2 had a slightly unpleasant aroma. The use of canna flour on the production of canna biscuits affected the aroma produced. This was supported by Budiarsih [20], the amount of canna flour added into biscuit would make the unpleasant aroma which disliked by panelists. Every human being always gives different responses to the same stimuli. Differences in sensations that occur can be caused by differences in the level of sensitivity of the sensory organs or because of a lack of knowledge of certain aroma.

Texture analysis of biscuits showed that the panelists liked the texture of biscuit formulation A and did not like the texture of the biscuit formulation F2. Biscuit formulation with arrowroot flour in the proportion of 100 had a crisp texture, not too brittle or sturdy as compared to other formulations. The biscuit product formulation F2 was not liked by the panelists. This was because the texture of the biscuits was very hard and not crispy. This hard texture was related to the difference in the composition of amylopectin. Mamat and Hill [21], states that the ratio between amylose and amylopectin affects the texture of the biscuits. Amylopectin in food will produce the ability of adhesives which will cause the biscuit structure to be stronger, while the high amylose content in the material can increase the crispness of biscuits produced because amylose in the material forms hydrogen bonds with more water, so that when roasting water will evaporate and leave empty space in the material and make the biscuits crisper. The level of crispness of a food is one of the physical properties of food, this is related to the taste when the cookies chewed [22].

D. Glycemic Index (GI)

The results of GI biscuit analysis using mangrove fruit flour and tubers flour were shown in Table 4.

Table 4. Classification GI of biscuit

Code Formulations	GI	Classification
A	53.60	Low
B	56.89	Moderate
C1	49.79	Low
C2	47.84	Low
D1	53.47	Low
D2	51.92	Low
E1	52.41	Low
E2	50.85	Low
F1	54.14	Low
F2	53.34	Low

Table 4, the lowest GI value was found in the formulation C2 as much as 47.84 and the highest GI value in the formulation B which was equal to 56.89. This could be caused by differences in deitary fiber content of the material. Dietary fiber in food cannot be digested by human digestive enzymes. In the small intestine, soluble dietary fiber forms a thick solution that inhibits the digestion and absorption of carbohydrates and fats, and tends to slow the absorption of glucose and reduce blood plasma cholesterol levels. Whereas the insoluble dietary fiber is immediately degraded by bacteria so that it does not affect the stool weight and does not cause a laxative effect [23].

In addition, all types of formulation had low GI values except for canna flour biscuits with moderate GI values. GI values can be influenced by the levels of amylose and amylopectin in the ingredients. The higher amylose content causes digestion to be slower because amylose is a glucose polymer that has a straight and unbranched chain structure. This unbranched structure makes amylose bound stronger so that it is difficult to gelatinize and consequently difficult to digest [24]. Based on these characteristics, foods containing high amylose has a higher hypoglycemic activity as compared to foods containing high amylopectin.

E. Glycemic Load (GL)

The results of GL biscuit analysis using mangrove fruit flour and tubers flour were shown in Table 5.

Table 5. Classification GL of biscuit

Code Formulations	GL	Classification
A	14.16	Moderate
B	13.35	Moderate
C1	12.61	Moderate
C2	11.68	Moderate
D1	12.08	Moderate
D2	11.33	Moderate
E1	13.37	Moderate
E2	12.66	Moderate
F1	12.37	Moderate
F2	11.92	Moderate

Based on the Table 5, biscuit formulation D2 had the lowest glycemic load than the other biscuits, this due to carbohydrate content of the sample. Gropper et al. [25], states that the value of glycemic load was equivalent to the balance of food consumption. As much the amount of food reserves getting lower, the glycemic load value would become higher. All biscuit products had moderate value of glycemic index in range of 10-19, while high value was more than 20 and low value was less than 10. Based on that, it was necessary having choose the type of cabohydrate, kind of intake form, and the amount of carbohydrate or food consumed. Zang et al. [26] state that foods which has low glycemic index and glycemic load value would increase blood glucose levels quickly and trigger slow rise in blood glucose levels and provide a lower peak blood glucose response so it prevents the hyperglycemia. Mangrove fruit flour biscuits increase blood glucose response less than the other biscuits. The increasing amount of mangrove fruit flour on biscuits could lower glycemic load. This shows that it was better to consume biscuits with adding mangrove flour but should be balanced by reducing the serving portion (<25 g).

IV. CONCLUSION

The best biscuits formulation were obtained the formulation C2 (pedada flour: arrowroot tuber flour with a proportion of 20:80) which showed a water content 3.39%, ash content 3.66%, protein content 4.63 %, fat content of 6.61%, carbohydrate content by difference 81.72%, starch content 64.40%, total sugar 64.40%, and 2.01% of soluble dietary fiber, 11.81 % of insoluble dietary fiber. Sensory test all attribute showed rather like with score 4.70 of taste 4.85 of color, 4.25 of aroma and crispness. The the glycemic index value of 47.84%, and glycemic load of 11.68%.

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