Glycemic Index Biscuits Formulation of Pedada Flour 
(Sonneratia caseolaris) with Tubers Starch

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Abstract. The glycemic index of food is the level of food according to its effect on blood glucose levels. Foods with low glycemic index have been shown to improve glucose and fat levels in people with diabetes mellitus and improve insulin resistance. Pedada Fruits (Sonneratia caseolaris) is the one of mangrove fruits has a high fiber content, so it can be used as a raw material in biscuits production. The aim of this research to evaluate the glycemic index on the formula biscuit from the pedada flour and starch from white sweet potato, arrowroot, taro, potato and cassava mixed. This research used completely randomized design in factorial patern with one factor and five levels on formulation biscuit of pedada flour with tubers starch (20% : 80%). The biscuits product were measured of the proximate, crude fiber, glycemic index and glycemic load on wistar rats. The best treatment was 20% of pedada flour with 80% of taro starch which produced biscuit with 76.24% of yield, 2.58% of protein , 15.55% of fat, 2.72% of crude fiber, 48.83 of glycemic index and 7.39 of glycemic load.

1. Introduction
Degenerative diseases in Indonesia are increasing, such as diabetes mellitus [1]. Increased degenerative diseases, among others, due to changes in behavior, lifestyle, eating patterns and activities that are not balanced. Riskesdas [2] reported that the prevalence of more malnutrition was obtained at 13.5% and the obesity of 15.4%, the prevalence of diabetes mellitus detected with symptoms is 2.1% of the population age more than 15 years and it is estimated that by 2030 in Indonesia reaches 21.3 million people.

One of the ways of prevention of diabetes mellitus and obesity is by choosing the right food consumption such as functional food. The functional food suitable for application in people with diabetes mellitus and obesity is that has a low glycemic index (IG) [3]. The IG of food is the level of food according to its effect on blood glucose [4]. Regina [5] reported that the foods with low glycemic index have been shown to improve glucose and fat levels in diabetes mellitus patients and improve insulin resistance. In addition, foods with low glycemic index also help control appetite, slow the emergence of hunger so it can help the control weight. The affecting factors of the glycemic index food are: the processing, gelatinization of starch and particle size, the ratio of amylose and amylpectin, the sugar content and osmotic power, the dietary fiber, fat and protein content, and anti-nutrients of food[4]. The measurement of glycemic index (IG) of food was done by giving test food with amount equivalent to 50 grams of carbohydrate to all research subjects [6]. Based on several research results show that the glycemic index can be analysed by in vivo test on rats[7]
Pedada fruit (*Sonneratia caseolaris*) is one of the mangrove fruit from tropical beaches which have high dietary fiber e.i. an insoluble dietary fiber of 53.90% and soluble dietary fiber of 9.80% [8], so it can be used substitution on biscuit product. Biscuits is one of the food products that can be consumed by all age groups from children to adults. The average consumption of biscuits in big cities and rural areas in Indonesia is 0.40 kg / capita per year [9]. Indonesian has rich natural resources of starch, especially at local food crops tubers, as arrowroot, taro, potato, white sweet potato and cassava. Starch can be used as food substitute for flour in food processing such as processing pastries, cakes and bread[10]. The function of this research to evaluate glycemic index of biscuit formulation from pedada flour with five starch of tubers.

2. Material and Methods

Pedada fruit was obtained from farmers mangrove in Wonorejo village Surabaya. The tubers consist of arrowroot, taro, potato, sweet potato starch were obtained from Yogyakarta home industry, cassava starch with brand "Rose Brand" margarine, shortening, baking powder, salt, skim milk were obtained from local market Surabaya. The wistar rats 2-3 months age and 140 to 160 g of weight, GOD-PAP reagents and pure glucose were obtained from Biochemical laboratory Brawijaya University.

2.1. Formulation of biscuit

There were five treatment in formulation biscuit with 20% of pedada flour dan 80% of tubers starch, such as:

A : Pedada flour : sweet potato starch
B : Pedada flour : arrowroot starch
C : Pedada flour : taro starch
D : Pedada flour : potato starch
C : Pedada flour : cassava starch

The proximate analysed in biscuit product and the glycemic index test in wistar rats, glycemic load. The glycemic index were calculated using incremental area method under the blood glucose response curve (IAUC). The area under the curve is calculated by the formula:

\[
L = \frac{\Delta30}{2} + \frac{\Delta50}{2} + \frac{\Delta90}{2} + \frac{\Delta120}{2}
\]

\[
= \frac{\Delta30}{2} + \frac{(\Delta30 - \Delta50)}{2} + \frac{\Delta50}{2} + \frac{(\Delta60 - \Delta50)}{2} + \frac{\Delta90}{2} + \frac{(\Delta90 - \Delta120)}{2}
\]

Note :

L = the area under the curve
T = time interval of blood taking (30 min)
\(\Delta30\) = The blood difference of glucose level 30 min after fasting
\(\Delta60\) = The blood difference of glucose level 60 min after fasting
\(\Delta90\) = The blood difference of glucose levels 90 min after fasting
\(\Delta120\) = The blood difference of glucose level 120 min after fasting

3. Result and Discussion

3.1 Proximate of biscuits

The yield of biscuits decrease, allegedly at the time of roasting due to the evaporation process of the water present in the dough. Table 1 shows that the biscuit formulation of C has the highest yield of 76.24% compared with others formulation, because the constituent components of it has moisture content 3.13%, protein 2.58%, fat 15.55%, and high crude fiber 2.72%. The moisture of biscuit shows that the formulation C (Table 1) has the highest moisture of 3.13% compared with the other formulation, because the components of the crude fiber raw material in taro starch was higher (0.17%)
than the other tuber starch so it have the ability to absorb water higher. Taro contains amylose that absorbs water so that it affects the moisture content of a material. According Rahmawati [11] reported that the taro starch contains 14-20% amylose and 56-60% amylopectin, it was related to water absorption. The water absorption of the pine products is determined by the amylose content. The higher the amylose content, the higher the water absorption capacity of the product [12].

Table 1. Proximate analysis of biscuit formulation of pedada fruit flour and tubers starch

| Formulation | Yieled (%) | Moisture (%) | Ash (%) | Protein (%) | Fat (%) | Carbohydrate by difference (%) |
|-------------|------------|--------------|---------|-------------|---------|--------------------------------|
| A           | 75.29±0.58c | 3.09±0.006c  | 3.013±0.002d | 2.43±0.04d  | 15.25±0.01b | 76.22±0.04d |
| B           | 75.48±0.33b | 3.11±0.009b  | 3.104±0.001b | 2.52±0.004b  | 15.052±0.07c | 76.21±0.06c |
| C           | 76.24±0.33a | 3.13±0.011a  | 3.074±0.004c | 2.58±0.01a  | 15.55±0.07a  | 75.67±0.07c |
| D           | 74.33±0.33d | 3.05±0.011d  | 3.001±0.03e | 2.43±0.004c  | 14.88±0.03d  | 76.64±0.01b |
| E           | 72.99±0.58e | 3.01±0.009e  | 3.172±0.01a | 2.37±0.01e  | 14.39±0.13c  | 77.06±0.11a |

The ash in formulation E has the highest compared with the other formulation because the components of raw material content of ash cassava starch is higher than the other tubers. So it can add the value of ash content on the resulting biscuits. In addition, ash content on the flour of pedada fruit is 6.56% high enough to increase the value of ash content of biscuits produced. The more mineral content in the raw materials, the more ash content contained in the material [13]. The ash content at all treatments was higher when compared with ash content according to SNI that is maximum 2%. High levels of ash in biscuits is also caused by the use of materials such as salt and baking powder that contribute minerals. The highest protein in formulation C (2.58%) compared with other formulation, because the components of protein content of raw materials on taro starch (0.37%) than other tubers starch, so it can increase protein biscuit product. Futhermore, protein in pedada fruit flour (6.30%) can increase the value of protein in biscuits. All biscuits in the five treatments are not eligible when compared with the SNI that the minimum protein (9.0%). Based on preliminary research on raw materials, the five starch tubers protein content had not more than 1.0%. The protein contribution in biscuit products that were pedada fruit flour, skim milk as the basic ingredients. Friska [14] stated that low protein can be increased by the addition of skim milk as a source of protein in the product. The fat shows that the formulation C has the highest fat content of 15.55% compared with other formulation because the components of fat in taro starch was higher (0.83%) than other tuber so it can increase the value of fat content in biscuits. While on the formulation E, has the lowest fat (14.39%) caused by the constituent components on cassava starch has the lowest fat (0.10%). Levels of biscuit fat in the five treatments have the minimum requirement of SNI 9.5%. In biscuit products, percent of fat also comes from margarine and shortening added to the dough. Levels of fat in the food ingredients play a role in improving the texture and flavor of food. The product was calculated carbohydrate by the difference. The carbohydrate by difference was reduction of 100% with moisture, ash, fat, and protein content. Carbohydrate levels are strongly influenced by levels of other nutrients. Table 1 shows that the formulation E has the highest carbohydrate (77.06%) compared with other formulation, because in raw material have moisture content 3.01%, protein 2.37%, and fat 14.39%.

3.2. Fiber content

Figure 1, shows that the formulation C has the highest crude fiber (2.72%), while at the maximum SNI of 0.5%. The crude fiber of taro starch 0.18% higher than other tubers starch, while crude fiber in pedada fruit 12.99%) so that it contribution crude fiber on biscuits.
3.3 Glycemic Index

The blood glucose response of the subjects to the provision of pure glucose and five biscuit treatment show in Figure 2. In glycemic index analysis on biscuit using wistar rats 2-3 month age, furthermore were adapted for one week by feeding and drinking ad libitum. The general average carbohydrate content in biscuit was 76.3%, if test food was given to human that equal to 65.5 gram. Based on the research conducted, the biscuit products given to the test animals in the Glycemic Index test contain 0.15 grams of carbohydrate from the product formulation [7;15], so as to obtain 0.15 grams of carbohydrates equivalent to 0.2 grams of the biscuit product. Based on the results of the analysis that has been done with the calculation of the area under the test food curve (five biscuit formulation) and reference food (pure glucose) showed that the glycemic index value on the five biscuit treatments has a low-moderate. The mean value of the glycemic index on the treatment of starchy fruit flour formulations with five tubers starch can be seen in Table 2.

Table 2. The glycemic index of biscuit

| Formulation | Glycemic Index | Classification |
|-------------|----------------|----------------|
| A           | 60.09          | Medium         |
| B           | 50.34          | Low            |
| C           | 48.83          | Low            |
| D           | 52.00          | Low            |
| E           | 63.42          | Medium         |

IG classification: low (<55); Medium (55–70); High (> 70)

Table 2, shows that the glycemic index of biscuits ranged from 48.83 to 63.42. Formulation C the lowest glycemic index (48.83). Foods with high fat content tend to slow the rate of gastric emptying, so the digestive rate of food in the small intestine is also slow. Meanwhile, high levels of protein suspected to stimulate insulin secretion [16], so that glucose in the blood is not excessive and controlled. Based on the result of fat content analysis, fat content of biscuit fruits formulation C has the highest fat (15.55%) was compared with other formulation. Fat in the food consumed will provide a sense of satiety, because fat will leave the stomach slowly. This will slow down the emptying time of the stomach, thus slowing the onset of hunger. However, fatty foods should be consumed wisely. Total fat consumption should not exceed 30% of total energy and total saturated fat consumption does not exceed 10% of total energy [17]. In the analysis of protein content that has been done, protein content of biscuit formulation C has the highest protein, thus affecting the value of Glycemic Index biscuit generated compared with other biscuit formulations. According to Mendosa [18], the addition of protein to carbohydrates can slow down the peanut process or peak of the glucose response. Foods with high fat and protein content tend to have lower IG compared to similar low fat and protein foods [16;19]. The crude fiber thickens the density or thickness of the food mixture in the digestive tract. This slows the passage of food in the digestive tract and inhibits enzyme movement [4]. Thus the digestive process becomes slow and eventually the blood sugar response becomes lower. Based on the analysis of crude fiber content that has been done, biscuit with the formulation C showed the highest crude fiber content 2.72%, so tends to have low glycemic index compared with other formulation biscuits.
3.4. Glycemic Load (GL)

Figure 3 shows that the formulation C has the lowest glycemic load 7.39 compared with other biscuit. According Kindo [20], the categories of glycemic load more than 20 were high categorized, 10-19 medium categories and less than 10 indicate low GL. Based on the calculations on the treatment formulations, the glycemic load generated in the lower classification. Glycemic load aims to assess the impact of carbohydrate consumption by taking into account IG food [4]. Glycemic loads provide more complete information on the effects of actual food consumption on elevated blood sugar levels.

![Figure 3. The glycemic load of biscuits](image)

4. Conclusion

There were a real effect on the treatment of pedada flour biscuit formulations with five tubers starch to yield, moisture, ash, protein, fat content, carbohydrate by difference and crude fiber. The best treatment biscuit was obtained on formulation C which characteristic 76.24% of yield, 2.58% of protein, 15.55% of fat, 2.72% of crude fiber, 48.33 of glycemic index and 7.39 of glycemic load.

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