Improving Organoleptic and Physicochemical Properties of Breadfruit Flour through Tannin Reduction

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Abstract. Breadfruit is classified as a climacteric fruit with a fast respiration process, and in fresh form it has a short shelf life. Breadfruit is a fruit with high carbohydrate content; therefore, it is suitable for processing into flour as well as increasing shelf life, usability, and economic value. The problem is, there are compounds that cause a bitter taste in breadfruit flour. This study aims to develop processing technology to reduce bitter compounds and characterize breadfruit flour. Processing of breadfruit flour selected from the ten methods developed, consisting of peeling the breadfruit, washing, and cutting, blanching (10 minutes) followed by slicing, soaking (in 0.03% sodium bisulfite, 1 hour), pressing, drying the breadfruit chips, and milling. The best method is applied to produce breadfruit flour from various regions (Bone, Seribu Islands, Yogyakarta, Cilacap and South Tangerang). The results showed that the best process could reduce tannins and cyanide up to 84% and 93%, respectively. The characteristics of breadfruit flour from various regions are different. The flour yield ranges from 17-24% of the fruit weight. Breadfruit flour has a carbohydrate content of 92-94% (db), dietary fiber 6.8-8.1%, amylose 17.7-26.1%, tannins 0.11-0.24%, HCN 0.41-1.89 ppm and digestibility of starch in vitro 72.3-87.2%.

1 Introduction

Breadfruit production in Indonesia has steadily increased from 89 231 tons (2010) to 108 374 tons (2016) and 172 373 tons (2021), with production centers in the provinces of West Java, Central Java, East Java, Yogyakarta, East Kalimantan, East Nusa Tenggara, South Sumatera, South Sulawesi, Lampung and Jambi [1]. Breadfruit is a good source of calories for the diet. Breadfruit is rich in carbohydrates and also contains fiber, vitamin C, potassium, protein, and phytochemicals such as flavonoids [2,3].

Breadfruit is a climacteric fruit. The climacteric peak is reached in a short time due to the rapid respiration process. Moreover, compared to some other climacteric fruits, the respiration rate of breadfruit is much higher. This fruit is generally consumed ripe, however, due to its fast respiration pattern, within a few days the breadfruit becomes soft and is no longer suitable for consumption. A higher storage temperature (27.8°C) causes

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this fruit to become soft in a shorter time compared to a lower storage temperature (12.5ºC). However, the ripening process at this lower storage temperature will run abnormally and the quality of the fruit will decrease. During the cold storage period (below 12.5^0C), chilling injury will occur to the fruit. In addition, physical damage (browning, softness) and a bitter taste cause a decrease in quality so that the price becomes cheaper [4]. Until now there is no preservation of fresh breadfruit. Therefore, it is necessary to do alternative processing of fresh breadfruit to increase its economic value. One of the efforts to anticipate the abundance of breadfruit during the peak harvest and extend its shelf life is by processing the breadfruit into intermediate products in the form of flour [5].

The problem with using breadfruit flour is that it has a slightly bitter taste, thus reducing consumer preferences. Several studies have found that in breadfruit seeds and flour, there are compounds that can cause a bitter taste, namely tannins and cyanide acid [6]. The tannin content is also a problem in the development of sorghum flour [7]. Besides causing a bitter taste, tannins have anti-nutritional properties because they can inhibit the digestion of proteins and carbohydrates. On the other hand, tannins are polyphenols with antioxidant properties which are necessary for human health.

Breadfruit seeds contain tannins of 184 mg/kg and 26.4 mg/kg of cyanide. Although it has not been studied specifically, it is possible that the compound that causes the bitter and anti-nutritional taste is also present in the breadfruit flesh. Therefore, it is necessary to investigate how to reduce the bitter taste to increase the palatability of breadfruit-based products. This study aims to develop processing technology to reduce bitter compounds and characterize the quality of breadfruit flour.

2 Materials and methods

2.1 Materials

The main material used is breadfruit from Cilacap-Central Java, Yogyakarta, South Tangerang-Banten, the Seribu Islands, and Bone-South Sulawesi. The fruit is picked at the commercial maturity level, directly from the tree using a tool, namely a special rope so that it does not fall to the ground. Other materials are sodium bisulfite and chemicals for quality analysis of breadfruit flour.

The equipment used for breadfruit flour processing includes shredders, pressers, dryers, steaming pots/pans, knives, and soaking basins. In addition, laboratory equipment is used for flour quality analysis and organoleptic test equipment.

2.2 Methods

2.2.1 Reduction of compounds that cause the bitter taste

In this experiment, one type of breadfruit from Cilacap was used. Breadfruit at the commercial maturity level is picked using a tool in the form of a special rope to prevent it from falling to the ground. The fruit was divided into ten groups according to the treatment combination applied, 10 fruit each.

The ten treatments referred to in this experiment included a combination of flour processing stages. Each stage is expected to reduce compounds that cause a bitter taste and improve the quality of breadfruit flour. In general, the stages of the process of making breadfruit flour are peeling the skin (done before or after the blanching process), reducing the size (shredding), blanching, pressing, drying, and milling. The combination of process stages is presented in Table 1.

The flour produced from the ten treatments was analyzed for its physical properties, proximate chemical composition, and the components causing the bitter taste (tannins and cyanide acid). Furthermore, the organoleptic test of breadfruit flour was carried out using the hedonic-scoring method. The results of flour analysis and organoleptic tests were compared with raw materials. The best method was chosen based on the highest percentage of bitter taste reduction (lowest tannin content), with the expected target being the reduction of the compound up to 80%, and the level of acceptability of the panelists.

2.2.2 Experimental design

The experimental design used to determine breadfruit flour processing was a completely randomized design with ten combinations of flour processing stages. Each flour processing method is shown in Table 1. Treatment was repeated 3 times. Each treatment used a sample of 10 breadfruits. Data analysis was processed using the SPSS 13.0 statistical program to obtain an analysis of variance (ANOVA). If there is a significant difference in the treatment factors with a 95% confidence interval, it has to be continued with Duncan's different test.

Table 1. Recapitulation of the process stages in the production of breadfruit flour

Process stages	Production flour method									
	I	II	III	IV	V	VI	VII	VIII	IX	X
1. Peeling, cutting 3-4 cm wedges	√	√	√	√	√	√	√	-	-	-
2. Without peeling, blanching for 10 minutes	-	-	-	-	-	-	-	√	√	√
3. Washing	√	√	√	√	√	√	√	√	√	√
4. Peeling	-	-	-	-	-	-	-	√	√	√
5. Blanching for 10 minutes	-	-	-	-	√	√	√	-	-	-
6. Size reduction / shredding	√	√	√	√	√	√	√	√	√	√
7. Soaking in tap water	-	-	√	-	-	√	-	-	√	-
8. Soaking in 0.03% Na-bisulfite solution, for 1 hour	-	-	-	√	-	-	√	-	-	√
9. Pressing	-	√	√	√	-	√	√	-	√	√
10. Drying at 50-60^{o}C, 20 hours (m.c. ≤12%)	√	√	√	√	√	√	√	√	√	√
11. Milling up to 100 mesh size	√	√	√	√	√	√	√	√	√	√

Description: √ = Done; - = Not done

2.2.3 Breadfruit flour quality characterization

The best breadfruit flour processing method from Table 1 was then applied to breadfruit flour processing from Yogyakarta, Ciputat, Seribu Islands, and Bone. Breadfruit flour from these various regions was then characterized for its physical properties: bulk density, solid density, water solubility, swelling properties of breadfruit flour, proximate composition [8], amylose, tannin, cyanide content [8], and functional properties including *in vitro* starch digestibility and dietary fiber content, as well as organoleptic tests [9].

3 Results and Discussion

3.1 Reduction of compounds that cause bitterness

Breadfruit contains tannins and cyanide acid which are components that cause a bitter taste, although the amount is relatively small in fresh fruit. However, if the material is dried, as in the processing of chips and breadfruit flour, the bitter taste will be concentrated, and it will have an impact on reducing the palatability of processed products. There are various ways

to reduce the content of anti-nutritional compounds in breadfruit, namely through dehulling, soaking, boiling, toasting, and fermenting [3].

Table 1 shows the treatment of the ten combinations of process stages to reduce the bitter taste in breadfruit flour. The breadfruit used at this stage is the Cilacap breadfruit, which in fresh form contains 0.69% tannin (db). As control is breadfruit flour produced by producers from Cilacap Regency. The results of the analysis showed that the tannin content of breadfruit flour ranged from 0.108% (db) in method VII to 0.25% (db) in method II. Methods I and II did not show significant differences with the control flour (tannin content 0.25% db) (Figure 1).

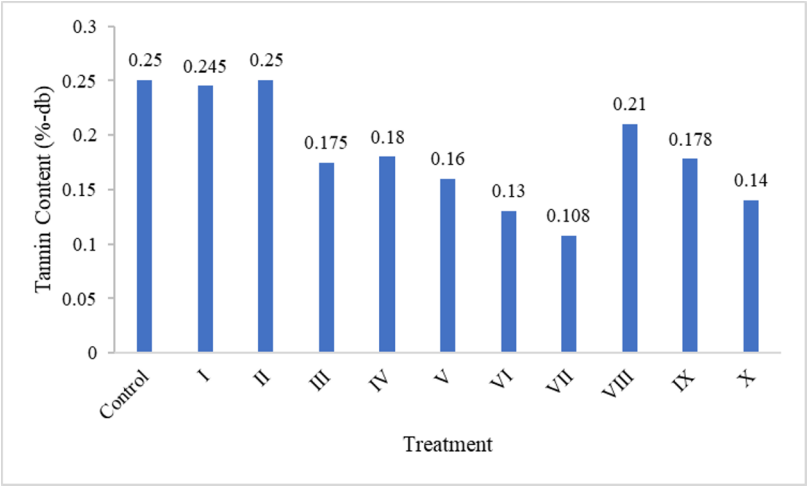

Fig. 1. Tannin content (% db) breadfruit flour of ten treatments

The best method based on tannin content is method VII. The stages of this method are that commercially ripe breadfruit is immediately peeled, washed, and cut into wedges then branched in the boiler for ten minutes. The next step is peeling, soaking in 0.03% sodium bisulfite solution for one hour, then removing the soaking water, adding water for washing, then pressing and drying the chips to a maximum moisture content of 12%. The tannin content of fresh Cilacap breadfruit is 0.69%(db) and after being processed into flour (by method VII) the tannin content drops to 0.108%(db), meaning that this best process can reduce tannins up to 84%. Breadfruit flour processed from method VII was analyzed for HCN content, the result was 0.43 mg/kg. Meanwhile, the HCN in fresh breadfruit is 6.42 mg/kg, so this method can reduce HCN up to 93%.

3.2 Organoleptic Test

To determine the level of reduction of tannins to the level preferred by consumers, an organoleptic test was conducted. Organoleptic tests in the development of low-tannin instant sorghum porridge have been studied and the results show that the addition of tapioca can increase consumer preference [10]. Breadfruit flour is processed into basic porridge (without the addition of other ingredients) so that the bitter taste caused by the compounds contained in breadfruit flour can be felt by the panelists. The results of the organoleptic test showed that treatment VII was the panelist's favorite breadfruit flour product (Table 2). The taste value of breadfruit flour in treatment VII was 4.0 or the highest among the other treatments. This means the lowest bitter taste. This result is in line with the data on the tannin content in breadfruit flour treatment VII which is the lowest among the other

treatments. Meanwhile, the aroma value of breadfruit flour in treatment VII was the smallest, meaning that the aroma of breadfruit was the weakest or the least flavorful.

Table 2. Organoleptic properties of breadfruit flour.

Method of making breadfruit flour	Taste	Aroma
I	3.75	2.75
II	2.05	3.05
III	3.30	2.45
IV	3.55	2.45
V	3.75	2.20
VI	3.75	2.75
VII	**4.00**	**1.90**
VIII	3.40	3.05
IX	2.70	3.15
X	3.85	2.40
Control	2.00	3.00

Score: Taste: 1 = very bitter, 5 = not bitter. Aroma : 1=not strong, 5=very strong

3.3 Breadfruit Flour Characterization

3.3.1 Physical Properties

Yield flour. A dry chip is an intermediate product in breadfruit flour processing. Dry chips with a maximum moisture content of 12% can be stored for more than six months when packed airtight. The results showed that the yield of chips calculated based on the weight of fresh fruit ranged from 18.88% (Bone breadfruit) to 24.67% (Seribu Islands breadfruit), whereas if it was calculated for fruit flesh the yield obtained was 23.47-27.58%. When the dried chips is ground into flour, the yield will be slightly reduced, namely 16.69-22.17% to the weight of fresh fruit or 20.71-27.23% to the weight of the flesh (Table 3). The yield of breadfruit flour depends on the ripening of the fruit and its variety. On average, young breadfruit has a lower flour yield compared to fruit that has optimal maturity.

Table 3. Product results of chip and breadfruit flour

The type of breadfruit	The yield of chip		The yield of flour	
	The whole fruit (%)	The flesh of fruit (%)	The whole fruit (%)	The flesh of fruit (%)
Yogyakarta	21.66^{bc}	27.58^{bc}	21.39^{abc}	27.23^{c}
Ciputat	22.99^{c}	27.18^{bc}	22.17^{cd}	26.20^{bc}
Bone	18.88^{a}	23.47^{a}	16.69^{a}	20.71^{a}
Seribu Island	21.41^{b}	26.61^{b}	20.30^{bc}	25.23^{bc}
Cilacap	$20,25^{ab}$	26.17^{b}	18.42^{ab}	23.81^{ab}

Description: Numbers in the same column followed by the same letter show no significant difference at the 5% level on Duncan's different test.

Bulk density and solid density. The physical property of flour that can provide an overview of material requirements for packaging, storage space, and transportation is bulk density. Foodstuffs that have a low bulk density require a larger space when compared to materials that have a large bulk density. The bulk density is expressed by the ratio between the weight of the material and the volume of the material itself (g/ml). Bulk density is influenced by the type of material, moisture content, shape, and size of the material. Materials that have a smaller bulk density mean the product is more porous. The bulk density of breadfruit flour varies from 0.34 g/ml to 0.45 g/ml (Figure 2). The test results

show that the sequence of solid density values corresponds to the bulk density value. The solid density of breadfruit flour ranges from 0.50 g/ml to 0.62 g/ml (Figure 3).

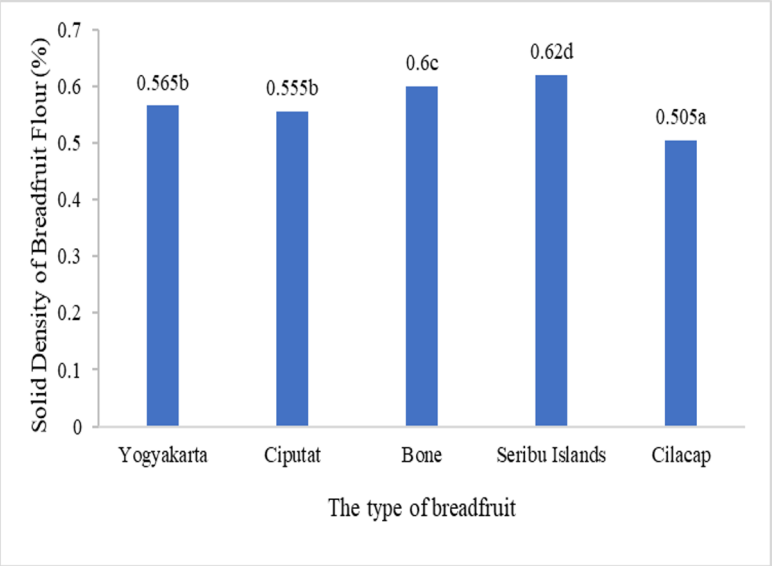

Fig. 2. Bulk density of breadfruit flour

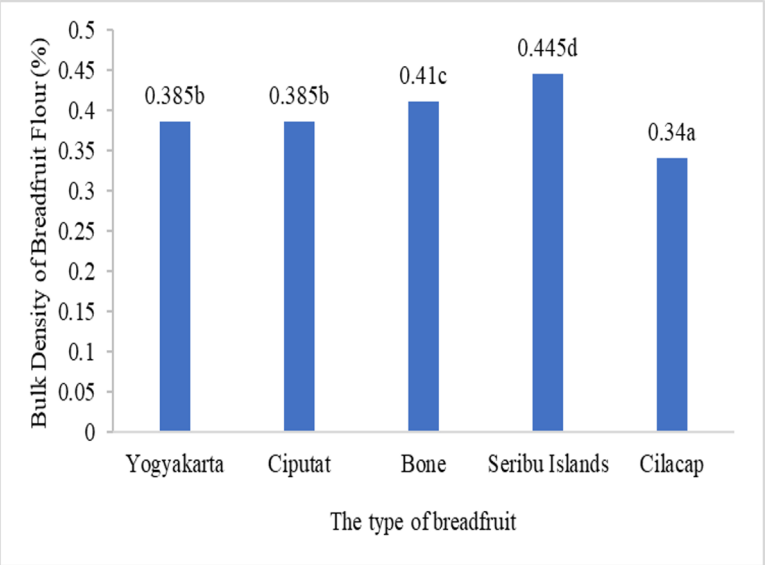

Fig. 3. Solid density of breadfruit flour

3.3.2 Chemical properties

Proximate composition. Breadfruit flour produced in this study had a low moisture content (4-7%) and ash content ranging from 1.55 to 2.19% and was significantly different between varieties. Low water content indicates a low level of damage [3]. The protein content of breadfruit flour ranges from 2.96 to 4.16% (db). Cilacap breadfruit flour showed the lowest protein content, while Bone breadfruit flour had the highest. High protein content will

increase its binding power [11]. Protein is a macro-nutrient component needed by the body, where food containing high protein tends to reduce the glycemic response. This is due to the metabolism of protein in the body taking longer than carbohydrates. Therefore, protein tends to decrease the glycemic response [12].

Table 4. Proximate chemical composition of breadfruit flour

The type of breadfruit	Moisture (%)	Ash (%db)	Fat (%db)	Protein (%db)	Carbohydrate (%db)
Yogyakarta	4.07^{a}	1.98^{c}	1.97^{bc}	3.06^{ab}	93.26^{b}
Ciputat	4.17^{a}	1.55^{a}	2.08^{c}	2.97^{ab}	93.42^{b}
Bone	4.38^{a}	1.94^{bc}	1.85^{bc}	4.16^{c}	92.06^{b}
Seribu Island	6.01^{b}	2.19^{c}	1.47^{ab}	2.96^{ab}	93.38^{b}
Cilacap	7.33^{c}	1.70^{ab}	1.30^{a}	3.47^{bc}	85.33^{a}

Description: Numbers in the same column, followed by the same letter indicate that there is no significant difference at the 5% level on Duncan's different test.

Breadfruit flour has a higher fat content (>1%) than rice flour (<1%). **Table 4** shows the fat content of breadfruit flour ranging from 1.30 to 2.08%. Fat metabolism in the body takes a longer route, so it takes longer than carbohydrates and proteins. Therefore, fat tends to decrease the glycemic response [12-14]. The main component in breadfruit flour is carbohydrates, which is more than 92% (db), and starch makes up the largest composition of the carbohydrates. The results of statistical tests for carbohydrate content showed that there were significant differences between the varieties tested. The carbohydrate content in breadfruit flour ranges from 92.06 (Bone breadfruit flour) to 93.42% db (Ciputat breadfruit flour). The carbohydrate content of breadfruit flour as a result of research ranged from 82.86 to 91.51%.

Amylose. The main parameter affecting the cooking quality and taste quality of flour-based products is amylose. As an illustration, rice flour that has high amylose when processed will produce a food product with a relatively hard texture, whereas a low amylose content in food commodities will produce a product with a soft texture [15]. Each characteristic can be used to produce food products that match the desired texture.

Table 5. Amylose, dietary fiber and in vitro digestibility of breadfruit flour

The type of breadfruit	Amylose (%db)	Dietary fiber (%db)	Starch digestibility (%)
Yogyakarta	22.98^{b}	6.86^{a}	74.9^{b}
Ciputat	24.05^{b}	6.91^{a}	72.34^{a}
Bone	17.67^{a}	7.76^{b}	87.19^{f}
Seribu Island	22.06^{b}	8.11^{b}	84.55^{e}
Cilacap	21.95^{b}	6.85^{a}	82.16^{f}

Description: Numbers in the same column, followed by the same letter indicate that there is no significant difference at the 5% level on Duncan's different test.

The amylose content of breadfruit flour in this study ranged from 17.67 to 26.08% (db) and was significantly different between varieties ($p<0.05$) (Table 5). Bone breadfruit flour has a softer texture compared to other varieties. The amylose content of this study was higher than that of [16], who reported that breadfruit flour has amylose content ranging from 11.8 to 20.70%. The dietary fiber of breadfruit flour in this experiment is significantly different between varieties, that ranged from 6.85-8.11%. As reported by [17,18], fiber content has many benefits for the body by inhibiting the emptying of the digestive tract so that you don't get hungry quickly, preventing obesity, diabetes, and other degenerative diseases. Even though the dietary fiber in breadfruit seems to be slowly fermented like other fruit from the same family (jackfruit) due to its densely-packed cell walls structure, it

gives a similar benefit to the body by controlling blood glucose levels, attenuating cholesterol absorption, and other advantages as their typical fermentation rates which can give variation in the gut microbial fermentation properties [19, 20] .

Cyanide and tannins. Cyanide acid or HCN is a compound that causes a bitter taste. This compound is often found in tubers, especially cassava. Figure 4 shows that breadfruit flour contains HCN from 0.41 ppm (Yogyakarta breadfruit flour) to 1.89 ppm (Seribu Islands breadfruit flour), although this is much lower than the HCN content in cassava (> 50 ppm). In fresh breadfruit, the HCN level does not taste bitter, but if it is dried, the bitter taste becomes real.

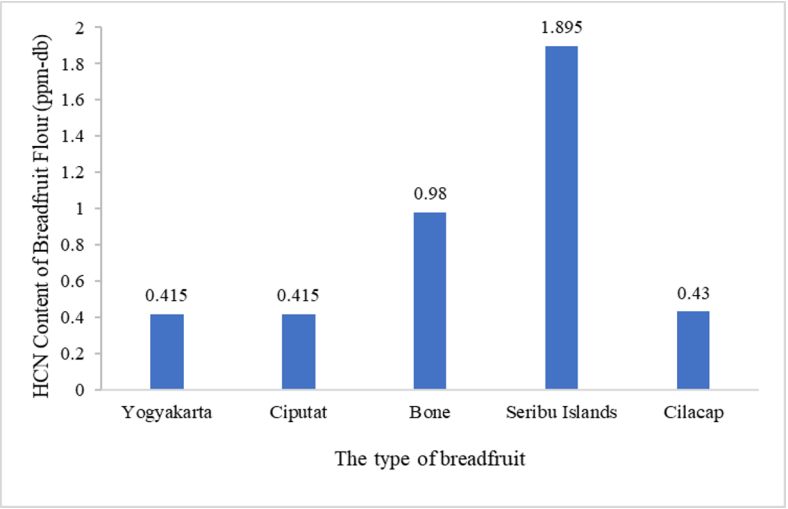

Fig. 4. HCN content of breadfruit flour

Another component that causes a bitter taste in breadfruit is tannins. Figure 5 shows the tannin content of breadfruit ranging from 0.11 to 0.24% (db). Tannin compounds are antinutrients that can form a complex compound with starch or protein which can reduce the digestibility of both components [3, 20].

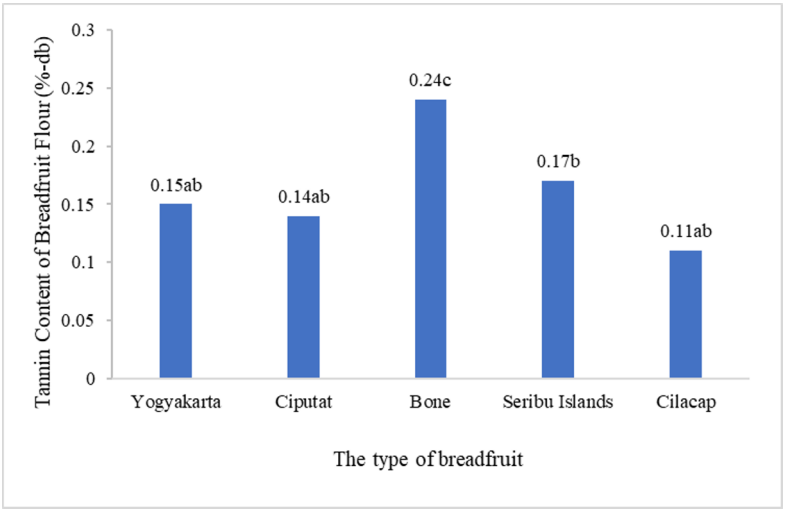

Fig. 5. Tannin content of breadfruit flour

4 Conclusion

The best method for making breadfruit flour is method VII, namely commercially ripe breadfruit, peeled, washed, cut into wedges then blanched (10 minutes), then peeled, soaked (in 0.03% sodium bisulfite 1 hour), pressed and dried the chip to a maximum 12% moisture content. This method can reduce tannins and cyanide acid up to 84 and 93%, respectively. The characteristics of breadfruit flour from various regions vary. The yield to fruit weight was 16.69-22.17% or 20.71-27.23% to fruit flesh. Breadfruit flour has an ash content of 1.55-2.19% (db); carbohydrates 85.33-93.38%(db); digestibility of starch in vitro 72.34-87.19%, dietary fiber 6.86-8.11% and amylose 17.67-24.05%.

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