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Improvement of Cassava Bagasse Flour Characteristics To Increase Their Potential Use as Food

Beni Hidayat[1,*], Udin Hasanudin[2], Siti Nurjanah[2], Neti Yuliana[2]
[1)] PhD student of Agriculture Science Study Program, University of Lampung, 1 Soemantri Brojonegoro Street, Bandar Lampung 35145, Indonesia
[1)] Agricultural Technology Department, Politeknik Negeri Lampung, 10 Soekarno-Hatta Street, Bandar Lampung 35144, Indonesia
[2)] Agricultural Product Technology Department, Faculty of Agriculture, University of Lampung, 1 Soemantri Brojonegoro Street, Bandar Lampung 35145, Indonesia

*e-mail: beni_lpg@polinela.ac.id

Abstract. Efforts to increase the potential utilization of cassava bagasse (tapioca industrial by-product) as food can be done by improving its appearance (colour and odour), increasing protein content, and decreasing HCN levels. The aim of this research was to apply the abrasion peeling method and fermentation process using Saccharomyces cerevisiae in powder form to improve the characteristics of the cassava bagasse flour. The study was prepared in a Completely Randomized Block Design with 2 factors. The first factor was peeling method with two levels: washing method and abrasion method; the second factor was fermentation time with four levels, i.e. 1 day, 2 days, 3 days, and 4 days. The results research showed that the treatment of abrasion method and 4-days fermentation was the best treatment which will produce the cassava bagasse flour with protein content as 6.98%, cyanide content as 8.87%, whiteness degree as 52,70%, odour score as 5.95, starch content as 46.69%, dietary fiber as 23.13% and fat content as 0.95%. Compared to the cassava bagasse flour produced by the small-scale tapioca industry, the cassava bagasse flour of this research had a better white degree (52.70 versus 31.50), higher protein content (6.98% versus 0.92%), lower cyanide content (4.67 ppm versus 30.52 ppm), and a better odor score (5.95 versus 4.50). Improved appearance, increased protein content, and decreased cyanide content through improved peeling methods and the application of fermentation processes will increase the potential use of cassava bagasse as food.

Keywords: *cassava bagasse flour, fermentation, peeling method, small-scale tapioca industry*

1. Introduction

Cassava bagasse is a major by-product of tapioca industry available in abundant quantities at very cheap prices. Indonesia cassava production in 2015 amounted to 21.790.956 ton [1]. If it is assumed 90% of cassava is processed into tapioca (19.611.860 ton), and from 1 ton of cassava will be obtained 30% cassava bagasse [2], it will produce 5.883.558 ton of cassava bagasse. Tapioca processing in Indonesia is also done by small-scale tapioca industry.

Cassava bagasse is potential for foodstuffs and sources of dietary fiber because it still contains starch of 43.1% db (dry basis) and dietary fiber of 47.1% db [3]. The potential of cassava bagasse as food in Indonesia has not been maximally utilized and mostly only used for animal feed purposes.

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Cassava bagasse which produced by small-scale tapioca industry has higher starch content than large-scale tapioca industry which is reflected in the low yield of starch caused by the imperfect extraction process. Adiwinata [2], reported that the average tapioca yield of the small-scale tapioca industry (*PD Semangat Jaya)* was only 21.36%, lower than the large-scale tapioca industry that could reach 25-28%.

The low utilization of cassava bagasse as food in Indonesia is due to its low quality which is reflected in low of white degree, low protein content, and high HCN content (more than 10 ppm). FAO/WHO [4], recommends a safe limit of cyanide intake from food ingredients of 10 mg HCN/kg (Codex standard 176-1989).

Efforts to increase the white degrees and reduce the cyanide content of cassava bagasse flour can be done through improving the peeling process of the cassava outer peels. Currently, the peeling process of the cassava outer peels by the small-scale tapioca industry is done by washing method. The peeling process by the washing method causes still a lot of outer peels left behind which causes brown cassava bagasse and has a high cyanide content. According to Ubalua [5], cassava outer peels have high cyanide content that is more than 30 ppm.

Other efforts to increase protein content and decrease cyanide content of cassava bagasse can be done through the application of the fermentation process, as has been done for animal feed [6] [7], and garri products [8] [9] [10].

Garri fermentation process is different from cassava bagasse fermentation process caused by the difference of composition between garri and cassava bagasse. On garri process, starch is a by-product which is separated during pressing process while cassava bagasse is a by-product of tapioca industry. Fermentation process of cassava bagasse using *Saccharomyces cerevisiae* in powder form reported by Kaewwongsa, et al. [6] and Izah et al. [7] is intended to increase protein content and decrease its cyanide content for animal feed purposes. Therefore further research is needed to improve the characteristics of onggok flour as raw material for food products.

The aim of this research was to apply the abrasion peeling method and fermentation process using *Saccharomyces cerevisiae* in powder form to improve the characteristics of the cassava bagasse flour.

2. Materials and Methods

2.1 Materials

The raw materials used were cassava var. kasetsart obtained from Farmers in Jati Agung District, Lampung Selatan Regency, Lampung Province; and *Saccharomyces cerevisiae* in powder form, "Fermipan" brand production of S.I.L. France, obtained from a shop in Bandar Lampung. Non-fermented cassava bagasse is obtained from small-scale tapioca industry, PD Semangat Jaya, Pesawaran Regency, Lampung Province. The chemicals used were Starch (GR, Merck), maltose (Sigma M5885), Dinitrosalicylic acid (DNS, Sigma D-0550), glucose (Sigma G8270), termamyl enzyme (α-amylase, Sigma A-4862), pepsin enzyme (Sigma P-7000), amyloglucosidase enzyme (Sigma A-9913), pancreatin enzyme (Sigma P-1750) obtained from PT Elo Karsa, Jakarta. Chemical composition of cassava var. kasetsart were presented in Table 1.

2.2 Methods

Preparation of fresh cassava bagasse. Preparation of fresh cassava bagasse has been done with two peeling methods, i.e. washing and abrasion. In the washing method, the outer peels of cassava was peeled by means of drained water and peeling occurs due to friction between cassava. In abrasion method, other than due to friction between cassava, peeling also occurs due to friction with the brush. After peeled, then cassava was grated, added water 20 times the weight of cassava, pressed until the liquid that comes out was coloured clear, the cassava bagasse obtained then separated. Next, the cassava bagasse was soaked for 2 hours to dissolve the remaining cyanide, and press back to separate the water.

Process of cassava bagasse fermentation. Cassava bagasse was added 2% of *Saccharomyces cerevisiae* in powder form and stirred evenly, then put in a plastic jar container with a hollow cover. Fermentation was carried out at room temperature for 0, 1, 2, 3, 4, and 5 days.

Analysis of cassava bagasse flour. The cassava bagasse flour analysis was done for fermented cassava bagasse flour and also non-fermented cassava bagasse flour that produced by small-scale tapioca industry. The cassava bagasse flour analysis was performed in the form of odour measurement by sensory analysis based on Hedonic method [11] using 10 trained panellists; white degree testing using whitenestester tife Kett C-100-3; analysis of protein, starch, fatty content according to method of AOAC [12]; analysis of dietary fiber content by the enzymatic method based on Asp et al. [13], and the determination of the cyanide content by the silver nitrate titration method [14].

Data analysis. The analysis was carried out in three replicates for all determinations. The data were analysed by two-way analysis of variance (ANOVA) and and continued with the least significant different (LSD) test. The results are reported as mean ± SD on dry basis (db). The significance of the differences was defined as P<0.05. Data of odor score for each replication was the average value of the 10 panelists.

Table 1. Chemical composition of cassava (mean ± SD) var. Kasetsart

No	Component	Wet basis (wb)	Dry basis (db)
1	Carbohydrate (%)	36.01 ± 1.25	87.01 ± 3.01
	Starch (%)	28.96 ± 2.71	69.97 ± 4.51
	Crude fiber (%)	3.35 ± 0.59	8.10 ± 1.41
	Dietary fiber (%)	6.84 ± 0.80	16.53 ± 1.92
2	Water (%)	58.61 ± 1.19	141.59 ± 2.89
3	Ash (%)	0.56 ± 0.29	1.35 ± 0.71
4	Fat (%)	0.19 ± 0.07	0.46 ± 0.16
5	Protein (%)	1.28 ± 0.07	3.08 ± 0.16
6	Cyanide (ppm)	27.56 ± 1.35	66.59 ± 3.25

3. Results and Discussion

3.1 Characteristics of odor and white degree of fermented cassava bagasse flour

Characteristics of odor and white degree of cassava bagasse flour on various treatment of peeling methods and fermentation time, presented on Table 2.

Treatment of peeling method and fermentation time significantly (p <0.05) to white degree of fermented cassava bagasse flour. Treatment of peeling method by abrasion method in 4 days fermentation will produce fermented cassava bagasse flour with best white degree (52.70%). The higher value of white degree of fermented cassava bagasse flour in abrasion method than washing method is related to the perfection of separation of the outer peels of cassava with brownish color In the abrasion method, the outer peels will be completely separated so that the cassava bagasse flour will be whiter. In the abrasion method, the outer peels will be completely separated so that the cassava bagasse flour will be whiter. The 4-day fermentation treatment will produce fermented cassava bagasse flour with a whiter color than 5 days fermentation time that associated with the growth of contaminant microbes. Hidayat et al. [15] reported that during the process of drying cassava slices often grow *Aspergillus flavus* with blackish mycelium.

The odor characteristic of fermented cassava bagasse flour was significantly affected (p <0.05) by fermentation time but not affected (p> 0.05) by peeling method. The fermentation time treatment up to 5 days will result the fermented cassava bagasse flour with low odor score (3.35 and 3.90). The apparent decrease (p <0.05) of odor score in the 5-day fermentation was associated with the production of metabolites during the fermentation process. This showed that the fermentation process with semi-solid system has a negative effect on odor score of fermented cassava bagasse flour. The opposite phenomena was reported by Olaoye et al. [10] on the sub-merged fermentation of garri using lactic acid bacteria which indicates the length of the fermentation process has a positive effect on the sensory attribute. This difference was due to different methods of fermentation. In sub-merged fermentation using lactic acid bacteria, flavour is produced, in contrast to semi-solid fermentation, the flavour formed was the off-flavor which is the product of microorganism metabolite.

Table 2. Characteristics of odour and white degree of fermented cassava bagasse flour (mean ± SD), % dry basis

Treatment	White degrees (%)	Odour*
Washing method, fermentation time 0 day	31.30 ± 0.91 f	6.10 ± 0.02 ab
Washing method, fermentation time 1 day	38.10 ± 1.63 de	6.40 ± 0.05 ab
Washing method, fermentation time 2 days	36.50 ± 0.84 de	6.30 ± 0.16 ab
Washing method, fermentation time 3 days	37.30 ± 3.88 de	5.80 ± 0.33 ab
Washing method, fermentation time 4 days	33.20 ± 1.03 f	5.90 ± 0.08 ab
Washing method, fermentation time 5 days	31.60 ± 1.11 f	3.35 ± 0.18 c
Abrasion method, fermentation time 0 day	58.70 ± 0.21 a	6.15 ± 0.08 ab
Abrasion method, fermentation time 1 day	56.40 ± 1.11 b	6.50 ± 0.10 a
Abrasion method, fermentation time 2 days	55.60 ± 0.07 b	6.25 ± 0.05 ab
Abrasion method, fermentation time 3 days	55.30 ± 0.07 b	6.00 ± 0.26 ab
Abrasion method, fermentation time 4 days	52.70 ± 0.19 c	5.95 ± 0.14 ab
Abrasion method, fermentation time 5 days	39.40 ± 1.47 d	3.90 ± 0.06 c

Hedonic scale : 9 (like extremely), 8 (like very much), 7 (like moderately), 6 (like slightly), 5 (neither like nor dislike), 4 (dislike slightly), 3 (dislike moderately), 2 (dislike very much), 1 (dislike extremely)

Values with the same letters are not significantly different (P > 0.05)

3.2 Chemical Composition of Fermented Cassava Bagasse Flour

Protein Content

The fermentation time treatments had significant effect ($p < 0.05$) on the protein content of fermented cassava bagasse flour but the peeling method treatment had no significant effect ($p > 0.05$), as presented in Table 3. The higher the protein content with the longer the fermentation time was related to the higher number of biomass of saccharomyces cerevisiae cells that formed. The increase in protein content during cassava bagasse fermentation is in line with the results of a study conducted by Olaoye et al. [10], Adepoju et al [16], Owuamanam [17], [18] during the fermentation process of the garri. Although a 5-day fermentation time on the abrasion method will produce the cassava bagasse flour with the highest protein content but this treatment has a low odour score. A low odour score on the 5-day fermentation length associated with the generation of metabolites during fermentation.

Based on protein content (Table 3) and odour score (Table 2) hence optimal treatment was abrasion method and 4 day fementation time which will produce fermented cassava bagasse flour with protein content 6,98% and odour score 5,95.

Table 3. Chemical composition of fermented cassava bagasse flour on various treatment of peeling methods and fermentation time (mean ± SD), % dry basis

Treatment	Protein (%)	Starch (%)	Fat (%)	Dietary fiber (%)	Cyanide (ppm)
Washing method, fermentation time 0 day	1.21 ± 0.20 e	53.35 ± 0.54 a	0.95 ± 0.06 a	22.99 ± 0.37 a	29.87 ± 0.11 a
Washing method, fermentation time 1 day	2.52 ± 0.04 d	51.24 ± 0.95 b	0.86 ± 0.04 ab	19.99 ± 0.07 b	27.21 ± 0.37 b
Washing method, fermentation time 2 days	4.80 ± 0.09 c	49.35 ± 2.16 cd	0.72 ± 0.05 ab	17.99 ± 1.99 c	22.98 ± 0.70 c
Washing method, fermentation time 3 days	6.30 ± 0.23 b	48.78 ± 0.49 d	0.71 ± 0.04 ab	14.02 ± 2.42 de	15.84 ± 0.08 e
Washing method, fermentation time 4 days	7.18 ± 0.27 a	46.76 ± 0.99 e	0.69 ± 0.10 ab	13.23 ± 0.37 e	10.57 ± 0.08 g
Washing method, fermentation time 5 days	7.22 ± 0.03 a	45.54 ± 0.10 ef	0.62 ± 0.01 ab	13.09 ± 0.53 e	10.17 ± 0.31 gh
Abrasion method, fermentation time 0 day	1.20 ± 0.07 e	53.29 ± 1.34 a	0.93 ± 0.13 a	17.69 ± 0.18 c	19.89 ± 0.16 d
Abrasion method, fermentation time 1 day	2.77 ± 0.01 d	52.28 ± 0.07 ab	0.89 ± 0.04 ab	16.77 ± 0.20 c	12.03 ± 0.41 f
Abrasion method, fermentation time 2 days	4.44 ± 1.35 c	50.76 ± 0.94 bc	0.81 ± 0.04 ab	15.26 ± 0.32 d	9.99 ± 0.14 gh
Abrasion method, fermentation time 3 days	6.19 ± 0.16 b	48.68 ± 0.99 d	0.70 ± 0.01 ab	14.27 ± 0.05 de	9.53 ± 0.61 h
Abrasion method, fermentation time 4 days	6.98 ± 0.25 ab	46.69 ± 0.98 e	0.59 ± 0.01 ab	13.49 ± 0.52 e	8.87 ± 0.28 h
Abrasion method, fermentation time 5 days	7.07 ± 0.22 ab	44.53 ± 1.36 f	0.53 ± 0.10 ab	13.31 ± 0.07 e	8.78 ± 0.03 h

Values with the same letters are not significantly different (P > 0.05)

Starch Content

The data in Table 3 revealed that the fermentation time treatment had significant effect (p <0.05) on the starch content of fermented cassava bagasse flour but the peeling treatment had no significant effect (p> 0.05). Decreased starch content was in line with the increase on protein content with the longer of the fermentation process. Treatment of abrasion method and 4 days fermentation time will produce fermented cassava bagasse flour with starch content of 46.69%. The lower starch content with the longer fermentation process associated with its use as nutrition source by *Saccharomyces cerevisiae*. Decreased starch content was in line with the increase in protein content with the longer the fermentation process. This was in accordance with the opinion of Yuliana et al. [19], that in the process of fermentation of high starch products, starch is a major source of nutrients during the fermentation process.

Fat Content

The fermentation time treatment had significant effect (p <0.05) on the fat content of fermented cassava bagasse flour but the peeling treatment had no significant effect (p> 0.05) as shown in Table 3. Fat content decline was in line with the increase in protein content with the longer of the fermentation process. Treatment of abrasion method and 4 days of fermentation will produce fermented cassava bagasse flour with a fat content of 0.59%. The lower fat content with the longer the fermentation process associated with its use as nutrient source by *Saccharomyces cerevisiae*. Decreased fat content was in line with the increase in protein content with the longer the fermentation process. Owuamanam [17] reported that the reduction of fat content during the fermentation process of gari is a metabolic activity of microorganisms involved in the fermentation process.

Dietary Fiber Content

Treatment of peeling method and fermentation time significantly (p <0.05) to dietary fiber content of fermented cassava bagasse flour (Table 3). The lower dietary fiber content with the longer the fermentation process was related to the metabolic activity of Saccharomyces cerevisiae which will elaborate the dietary fiber into a digestible component. Dietary fiber content decline was in line with the increase in protein content with the longer of the fermentation process. Treatment of abrasion method and 4 days of fermentation will produce fermented cassava bagasse flour with dietary fiber content of 13.49%. The opposite phenomena was reported by Olaoye et al. [10] on the sub-merged fermentation of garri using lactic acid bacteria which increases the dietary fiber content during the fermentation process. The difference of the changes pattern in dietary fiber content was due to differences of fermentation method. On the sub-merged fermentation using lactic acid bacteria, bacteria did not use dietary fiber as a source of nutrients. In contrast to semi-solid fermentation using *Saccharomyces cerevisiae*, dietary fiber, especially soluble dietary fiber was also used by microorganisms as a source of nutrition.

Cyanide content

Treatment of peeling method and fermentation time significantly (p <0.05) to cyanide content of fermented cassava bagasse flour (Table 3). The lower the cyanide content by the longer the fermentation process was related to the decomposition of the component by the Saccharomyces cerevisiae as stated by Etsuyankpa et al [20] and Gunawan et al [21]

3.3 Characteristic Differences Between Non-fermented and Fermented Cassava Bagasse Flour

Characteristic differences between non-fermented and fermented cassava bagasse flour, presented on Table 4. The non-fermented cassava bagasse flour used was produced by a small-scale tapioca industry that was peeled off with a washing method. The fermented cassava bagasse flour used was cassava bagasse flour from treatment of abrasion method and 4 days of fermentation.

Table 4. Chemical composition of non-fermented versus fermented cassava bagasse flour (mean ± SD), % dry basis

No	Parameter	Non-fermented cassava bagasse flour	fermented cassava bagasse flour
1	Pati (%)	55.36 ± 0.47	46.69 ± 0.98
2	Dietary fiber (%)	23.13 ± 0.49	13.49 ± 0.52
3	Fat (%)	0.95 ± 0.21	0.59 ± 0.01
4	Protein (%)	0.92 ± 0.04	6.98 ± 0.25
5	White degree (%)	31.50 ± 3.75	52.70 ± 0.19
6	Cyanide (ppm)	30.52 ± 5.61	8.87 ± 0.77
7	Odour score (scale 1-9)	4.50 ± 0.61	5.95 ± 0.14

Compared to non-fermented cassava bagasse flour, fermented cassava bagasse flour was more qualified as foodstuff (Table 4) as reflected in higher protein content (6.98% versus 0.92%), lower cyanide content (8.87 ppm versus 30.52 ppm) , better odor score (5.95 to 4.50), and better white degree (52.7 versus 31.5).

Higher protein content of fermented cassava bagasse flour was strongly associated with increased growth of *Saccharomyces cerevisiae*. The higher the growth of *Saccharomyces cerevisiae* will be the higher the cell biomass that was formed and the higher the protein content of cassava bagasse flour. Increased protein content of cassava bagasse flour during the fermentation process using Saccharomyces cerevisiae also reported by Kaewwongsa et al. [6] and Izah et al. [7].

As growth increases, the metabolic activity of Saccharomyces cerevisiae will produce linamarase enzymes that will decompose cyanides into non-toxic compounds [19] [20]. Cyanide content of fermented cassava bagasse flour of 8.87 ppm qualifies its use as food [4]. The fermentation activity until 4 days of fermentation will also increase the odor score of cassava bagasse flour.

The increased use of cassava bagasse flour as food was also reflected in the increase in white degree. The increase of white degree of cassava bagasse flour was greatly influenced by abrasion method application on cassava peeling process. Cassava bagasse flour which was peeled with abrasion method will contain less brown outer peels so the color of the flour will be more white.

Fermented cassava bagasse flour has a lower starch content than non-fermented cassava flour (Table 4). According to Nurhayati et al. [22], during the fermentation process, the starch will be hydrolyzed into shorter chain polymers, so potentially further modified to resistant starch through the application of autoclaving-cooling cycles [23]. The use of starch as the main source of nutrition during the fermentation process is also reported by Yuliana [19] on the fermentation process of sweet potato flour.

4. Conclusions

Application of abrasion method dan 4 days of fermentation akan menghasilkan tepung onggok dengan karakteristik yang optimal sebagai bahan pangan, yaitu memiliki kandungan protein sebesar 6.98%, kandungan HCN 8.87 ppm, derajat putih sebesar 52.7, skor aroma sebesar 5.95, kandungan pati 46.69%, kandungan serat pangan 23.13%, dan kandungan lemak sebesar 0.95%.

Improved appearance, increased protein content, and decreased HCN content through improved peeling methods and the application of fermentation processes will increase the potential use of cassava bagasse as food.

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