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Cassava flour production by small scale processors, its quality and economic feasibility

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Abstract

Cassava flour is promising to be used as a food ingredient substitute for wheat and rice flour-based food products. It can be also processed at a rural household level to ensure the income of farmers. This study was aimed at identifying the physical and chemical characteristics of cassava roots and the flour produced as well as the economic feasibility of its production at a small scale. The results showed that cassava flour prepared from Sembung, an Indonesian local variety had fairly good quality parameters according to the national quality standards for moisture, starch, and hydrogen cyanide (HCN) contents, while the physical characteristics were sub-optimal. The yield recovery of cassava flour processing was 20.16% or equivalent to 9.67 ton per year assuming the annual production capacity was 48.00 tons of fresh cassava. A home-scale industry of cassava flour can give a net profit of IDR 49,565,888 or about 3,440 USD per year with the revenue cost ratio of 1.52, net profit margin of 34.15%, return of investment of 51.81% and payback period of 1.02 year. Adjusting the harvest time with crop maturity as well as following proper processing methods would improve the flour yield recovery, quality and economic returns.

Keywords: cassava flour; quality; economic feasibility; home-scale production.

Practical Application: This paper highlights the quality and economic feasibility of small-scale cassava flour production.

1 Introduction

Cultivation of cassava (*Manihot esculenta* Crantz) is becoming a global economic and industrial trend due to its flexible nature to grow under a wide range of soil and climatic conditions (Mtunguja et al., 2019) and allows its use in a number of industries (Li et al., 2017). Cassava also has a competitive price compared to many other food crop commodities and its economic value can be enhanced through processing and development of value added products (Alene et al., 2018). Cassava can be processed into a variety of food products (food additives and fillers, sweeteners, wheat flour substitute for making bread, biscuits, noodles and confectioneries), non-food products (alcohol, organic acids, wood layers, pharmaceuticals, paper, textiles, adhesives), feed, and biofuel. Traditionally cassava is consumed after boiling or cooking and many new or modified food products are also available, which may vary from country to country and among communities in a country (Arief et al., 2018; Mtunguja et al., 2019; Omolara et al., 2017; Otunba-Payne, 2020). Enabling the rural households in such activities by product development at household level is beneficial in terms of providing investment and employment opportunities, particularly for women empowerment (Mtunguja et al., 2019; Omolara et al., 2017; Otunba-Payne, 2020).

In Indonesia, cassava is widely grown throughout the country and plays an important role as the third major source of carbohydrate after rice and maize. As a local food source, cassava has a great potential to be developed as an alternative to partly replace rice as a staple food (Arief et al., 2018). The planting area of cassava in Indonesia is about 1.4 million ha with total annual production of 24.56 million ton (Unteawati & Mutaqin, 2018). Lampung, Central Java and East Java are the major cassava producing areas in Indonesia (Pardian et al., 2021).

Cassava has been processed into starch, flour, modified cassava flour (mocaf), traditional dried cassava (*gaplek*), chips, as well as non-food products, such as an adhesive on charcoal briquettes, animal feed, paper, and textile (Waisundara, 2018). In terms of its utilization in human food, cassava is predominantly consumed as traditional food preparations, which are frequently assumed to be less attractive and have lower societal image compared to food products processed from wheat or rice flours. Therefore, processing cassava into flour has a great potential as it can partly or totally replace the use of wheat flour in food industry as well as in traditional food products (Aristizábal et al., 2017). Cassava is better suitable to replace wheat flour compared to other root and tuber flours due to its high starch content, low production cost, and unique functional properties (Ayetigbo et al., 2018; Chisenga et al., 2019a). The most promising areas of using cassava flour in food products are cookies, breakfast cereals, pastries or pies, cakes, breads, biscuits, noodles, muffins, and doughnuts (Aristizábal et al., 2017).

Cassava flour is made by slicing the peeled roots, followed by drying, pounding/milling, and sieving to separate the fiber from the flour (Aldana & Quintero, 2013; Lebot, 2019).

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If cassava flour is prepared from bitter cassava, soaking the root chips in water for a few days for detoxification of the cyanogen is performed prior to drying. Pressing the fresh chips is also another method to reduce the cyanogen as it is dissolved in the liquid. The physical and chemical characteristics of cassava flour as well as its functional properties from different cultivars have been reported by some studies (Iwe et al., 2017; Lagnika et al., 2019; Lu et al., 2020; Hasmadi et al., 2020). This shows that cultivar and growing conditions may affect the physical and chemical characteristics of the flour and subsequent quality of the products (Putri & Perdinan, 2018).

Processing of cassava flour is relatively simple and does not require complicated technology and equipment, hence it can be conducted at rural household level. Business opportunities of cassava flour processing into various food products can also be initiated by small vendors or processors, particularly in the cassava producing areas. However, the quality of the flour produced is to be ensured for acceptance by food industry as ingredient and the product can compete with other similar products in the market. Therefore, the present study was aimed at evaluating the physicochemical characteristics of cassava flour and the economic feasibility of its production by small scale processors.

Cassava roots as the ingredient in this study were obtained from southern part of Malang Regency, the second major cassava producing area in East Java Province with the contribution of about 13% and the productivity of 25.9 t/ha (Badan Pusat Statistik Provinsi Jawa Timur, 2019). This area belongs to marginal dry land, which predominantly consists of limestone hills (Sholichin & Prayogo, 2019), suggesting low fertility of the soil condition. Sugar cane, maize and cassava are the primary crops cultivated in this area (Tambunan et al., 2014). Cassava is normally sold as fresh roots (unpeeled and peeled) or processed into *gaplek* (slice-dried roots), therefore introduction of flour processing would be prospective to diversify the uses of cassava, particularly for food products, give added value to the products and ultimately generate the farmers' household income (Iwe et al., 2017).

2 Materials and methods

2.1 Raw materials

The raw materials were fresh cassava roots of Sembung (local variety), which was planted in the rainy season (January) in Kalipare, a southern area of Malang Regency, East Java, Indonesia and harvested at 12 months of maturity. Sembung variety is widely grown by farmers (57.90%) in this area (Saleh et al., 2016; Wijayanti, 2019).

Flour preparation

The flour preparation method was according to (Lagnika et al., 2019) with some modifications. Fresh and good quality roots were selected from the harvested cassava, then peeled, washed and soaked in water for about 15 min to reduce the cyanogen. The roots were then sliced to 2-3 mm thickness using a manual slicer, pressed using a manual hydraulic press to reduce the moisture and release the cyanogen into the liquid. Both the settled starch after removing the liquid and the pressed cassava slices were sun-dried for 4-6 h followed by oven-drying at 55 °C for 24 h. The final steps were milling the dried cassava slices into flour using a flour machine and sieving to obtain an 80 mesh powder.

2.2 Laboratory analysis

Primary data included the physical and chemical characteristics of fresh cassava root and flour were analyzed in the Iletri's Laboratory of Food Chemistry and Technology in Malang, East Java, Indonesia. An economic feasibility analysis of cassava flour production (cassava flour mass balance, production cost, revenue, and benefit) was conducted by direct observation and data collection during flour processing operations. The laboratory analysis for chemical composition of fresh cassava root and flour included the moisture and ash contents using the gravimetry method (Elnovriza et al., 2019), fat content using the direct extraction method/Soxhlet (Elnovriza et al., 2019), protein content following the micro-Kjeldhal method (Mæhre et al., 2018), dry matter content (Misganaw & Bayou, 2020), starch and amylose contents (Ginting & Noerwijati, 2008), HCN content using the argentometry method (Gervason et al., 2017), and titratable acidity (Matela et al., 2019). The physical properties of the fresh root and flour included the Hunter color (L*, a*, and b*) of a cross section of the middle of the root (1 cm-thick) using a color reader (Minolta CR-200b) (Ginting et al., 2015), and the flour whiteness using a Kett Whiteness Tester with $BaSO_4$ as a standard (100%) (Seveline et al., 2020). All the analyses were performed in triplicate.

The economic feasibility analysis methods used in this study included descriptive qualitative and quantitative analysis. Qualitative descriptive analysis was used to explain the results relating to the technical and processing of the cassava flour, particularly its mass balance. Quantitative analysis was used to explain the cost and return of cassava flour production as well as its feasibility. The components of economic feasibility analysis for cassava flour production included mass balance analysis to determine the amount of incoming materials compared to materials coming out of the cassava flour processing (Mustafa, 2015), revenue (Sriyadi et al., 2021), production cost (C) (Ojiako et al., 2018), net income (I) or profit (Ojiako et al., 2018), revenue cost ratio to determine the profitability or the efficiency of flour production (Elisabeth & Prasetiaswati, 2018; Gustina et al., 2020), net profit margin (NPM) to measure the ratio of net income to sales (Pangestu et al., 2015), return of investment (ROI) (Walyupin et al., 2018); and payback period (PP) which indicates the period of time during the investment to get an overall return (Stelling et al., 2018).

3 Results and discussion

3.1 Physical and chemical characteristics of cassava fresh roots

The moisture content of the fresh root was relatively high (Table 1) that may relate to the harvesting time that occurred in the rainy season (Januari) (Chisenga et al., 2019b). Cassava harvested in the wet/rainy season normally has a higher moisture content than that harvested in the dry season (Ginting & Noerwijati, 2008; Teye et al., 2011). Adira 4 variety was noted to

Table 1. Physicochemical characteristics of cassava fresh root.

Characteristics	Content[a]
Moisture (%)	70.14 ± 0.75
Dry matter (%)	28.86 ± 0.16
Ash (% fw)	1.03 ± 0.01
Fat (% fw)	0.17 ± 0.03
Protein (% fw)	0.70 ± 0.07
HCN (ppm fw)	34.56 ± 0.38
Hunter color	
L*	87.8 ± 0.71
a*	5.3 ± 0.10
b*	35.0 ± 1.35

[a]Values are means ± standard deviation of triplicate analysis. fw = fresh weight; L* = lightness level that ranges from 0 (dark/black) to 100 (bright/white); a* = green (-100) up to red (+100); b* = blue (-100) up to yellow (+100).

contain 58.95% of moisture when harvested in the dry season, however it increased by 9.5% in the rainy season (Ginting & Noerwijati, 2008). The moisture content is reported to have negative correlations with dry matter and starch contents (Ginting et al., 2011).

The dry matter content was 28.86% (Table 1), which was within the normal value of fresh cassava roots that ranges from 17-47%. The majority of cassava roots has dry matter content around 20-40% and considered to be high if the value is more than 30% (Teye et al., 2011). Relatively low dry matter content obtained in this study was related to a high moisture of the roots (Table 1). Greater values of dry matter in 11 cassava genotypes grown in Ghana (31.45-40.74%) were reported (Misganaw & Bayou, 2020), while lower values were recorded in five Cameroon varieties harvested in the rainy season *c.a.* 22.23-26.31% (Laya et al., 2018). The dry matter content is highly influenced by the cultivar, maturity, crop season, location and efficiency of the canopy in trapping sunlight (Teye et al., 2011) and negatively correlated with the rainfall growing conditions of cassava crop (Ojiambo et al., 2017). This parameter has become an important trait for cassava breeders (Rabbi et al., 2017) as well as farmers and industries since it relates to the economic value of cassava product (Teye et al., 2011), particularly for flour and starch industries. About 70-82% of the dry matter is starch (Chisenga, 2019), thus it can be used to predict or estimate the flour or starch yield recovery. Moreover, higher dry matter content may give better cooking qualities and extend the storage time (Eleazu & Eleazu, 2012).

The ash content is related to the mineral content stored in the root per unit weight. Table 1 shows that the ash content of Sembung variety was 1.03%. This value was slightly higher than those of three cassava varieties studied by (Peprah et al., 2020), *c.a.* 0.89-1.02% as well as by (Laya et al., 2018) in five cassava varieties (1.01-1.13%). In addition to cultivar, the ash content is also affected by the environmental conditions and soil fertility.

The fresh root contained low amount of fat that was around 0.17% (Table 1). This value was below the range noted by (Peprah et al., 2020) *c.a.* 0.41-0.88%, but slightly higher than that investigated by (Morgan & Choct, 2016) *c.a.* 0.1%. The protein content was 0.70% as given in Table 1. Fresh cassava normally has protein content of about 0.4-1.5% (Bayata, 2019). The similar fat and protein contents were also noted in Malang 4, an Indonesian improved cassava variety *c.a.* 0.13% and 0.56%, respectively (Ariani et al., 2017).

The total cyanogen content of the fresh roots was 34.56 ppm (Table 1). A cassava cultivar is considered bitter type if the HCN content is more than 50 ppm (Ojiambo et al., 2017). In fact, Sembung variety has bitter taste and normally belongs to bitter cassava. However, in this study lower value was seen in this variety that may be due to harvesting time which coincided with the rainy season. The total cyanogen in cassava roots increased when grown in low rainfall or drought stress condition (Cardoso et al., 2005; Ndubuisi & Chidiebere, 2018). This suggests that the cultivar, harvesting time and environmental conditions influence HCN content in fresh cassava roots (Frediansyah, 2017). A higher HCN content is reported for Malang 4 variety (116.37 ppm) (Ariani et al., 2017). It is essential to reduce the HCN content for bitter cultivars through processing in order to make the food products safe for consumption. High HCN content (> 100 ppm) is obviously toxic for humans (Ndam et al., 2019), while the concentration of less than 50 ppm is considered innocuous (Falade & Akingbala, 2010).

In general, the colors of cassava root flesh are white and yellow (Devy et al., 2018) and this is dictated by the genetic factor of the cassava crop (Njoku & Mbah, 2020). The cassava root with yellow color generally contain higher β-carotene with a total carotenoid value of 1.2-14.2 μg/100 g, which is particularly important in combating vitamin A malnutrition (Devy et al., 2018). The root of Sembung variety had white flesh color with a high lightness (L*) value (87.8) and low values of redness (a*) and yellowness (b*) as presented in Table 1. The white-fleshed cassava is preferred for flour preparation than the yellow-flesh as it does not contain any pigment of carotenoid (Ayetigbo et al., 2018), resulting in a white color of the flour. This is essential as the whiteness level is established as one of the national standard quality requirements for cassava flour (Pertiwi, 2017).

3.2 Physicochemical characteristics of cassava flour

The moisture content of cassava flour processed from Sembung variety has met the national standard quality for cassava flour which is 12% maximum (Table 2). Flour with moisture content < 12% is safe for storage and gives longer shelf-life (Sujitha et al., 2018). The ash content was higher than the value established by the national standard quality, however it was yet lower than the maximum value listed in the Codex Standard as presented in Table 2. The ash content in this study was also within the range values of cassava flours reported by some studies that ranged from 1.25-2.43% (Aldana & Quintero, 2013; Lu et al., 2020; Hasmadi et al., 2020). The ash content will affect the color of final products. The higher the ash content, the darker the color of the product.

The starch content has met the national standard quality requirement for cassava flour which is minimum 75%. Previous studies showed the starch contents of cassava flour varied from 65.5 to 81.2% (Aldana & Quintero, 2013); 76,4% (Lu et al., 2020);

Table 2. Physicochemical characteristics of flour.

Characteristics of flour	Content[a]	National Standard Quality 01.2997-1996 (Dewan Standardisasi Nasional, 1996)	Codex Standard 176-1989 (Food and Agricultural Organization, 1995)
Moisture (%)	7.10 ± 0.58	Maximum 12.0	Maximum 13.0
Ash (% fw)	2.28 ± 0.03	Maximum 1.5	Maximum 3.0
Starch (% fw)	87.24 ± 3.64	Minimum 75	-
HCN (ppm fw)	11.61 ± 1.03	Maximum 40	Maximum 10
Titratable acidity (mL 0.1 N NaOH/100 g fw)	4.30 ± 0.12	Maximum 3.00	-
Whiteness level (Ba_2SO_4) (%)	81.3 ± 0.50	Min 85.0	-

[a]Values are means ± standard deviation of triplicate analysis.

and 72.5-76.2% (Lagnika et al., 2019). The high starch content of cassava flour contributes to crispy texture of the end products (Chukwu & Abdullahi, 2015).

Drying the soaked cassava chips followed by milling into flour may reduce the HCN content up to 81% (Ndam et al., 2019). In this study, the HCN content of the flour was 11.61 ppm (Table 2), suggesting a reduction of 66% compared to that of the fresh root (Table 1). This value is slightly lower than that of flour made from Malang 4 variety *c.a.* 17.4 ppm (Yulifianti & Ginting, 2011) and much lower than the safe/permissible limit prescribed in the national standard quality for cassava flour (40 ppm) (Rasulu, 2014). However, it was slightly higher than the value issued by Codex standard 176-1989 and national standard quality for modified cassava flour (10 ppm). A range of HCN content (8.62-15.48 ppm) in processed cassava flour was reported from six varieties in Zambia (Chisenga et al., 2019b) Yulifianti & Ginting (2011) investigated slightly higher HCN contents in cassava flour prepared from five cultivars, ranging from 13.7-22.0 ppm. The processing methods, including peeling, washing, soaking, pressing, drying, and milling potentially reduce the HCN and influence the final amount in the flour (Ginting, 2013).

The titratable acidity value of cassava flour produced was slightly higher relative to the national standard quality of cassava flour (Table 2). An increase in acidity could be useful for product preservation, however it can also alter the taste and odor of the final product (Akinyele et al., 2020). Similar value was earlier reported for cassava flour made from Malang 4 variety *c.a.* 4 mL 0.1 N NaOH/100 g (Ariani et al., 2017). Slow or delayed drying of fresh cassava chips, particularly by sun-drying during the rainy season would give high moisture, which is favorable for the spoilage microbial growth and fermentation of the starch to produce organic acids (Obimpeh, 2018).

The whiteness value of cassava flour was 81.3% (Table 2), less than the minimum level (85%) set by the national standard quality. The greyish-white color of cassava flour obtained in this study might be affected by the high ash content of the fresh roots (Table 1). A slightly higher whiteness value was noted for the flour derived from Malang 4 variety *c.a.* 83% (Ariani et al., 2017). However, a lower value of cassava flour whiteness (76.9%) was reported from Lampung (Arief et al., 2012). The quality of the water used during processing and slow drying, particularly during the rainy season may also contribute to the whiteness level of the flour produced.

3.3 Feasibility of cassava flour production

The mass balance analysis of cassava flour processing showed that in one batch of cassava flour production with a capacity of 200 kg of fresh cassava could yield 40.32 kg of cassava flour (20.16%) as presented in Figure 1. A similar yield (19.60-23.11%) was also noted from previous study (Ariani et al., 2017), however it was lower than the value reported by Arief et al. (2012), *c.a.* 25-30%.

Peeling the fresh roots and washing are the initial stages of cassava flour processing (Figure 1). The yield of peeled cassava obtained was 85.40%, suggesting that almost 15% of the cassava roots were wasted, including the peels, dirt/soil, and the unusable base and tip of the roots. The value of this portion was quite high, thus it is essential to determine the particular characteristics of fresh cassava roots needed for flour production, including those cultivars with less peel to flesh ratio. This finding was approximately similar to an earlier study (Luketsi & Rohmah, 2019) who reported that the loss was 12.45% during peeling and washing of the fresh roots.

The next stage is soaking the peeled cassava to prevent browning due to the activity of polyphenolase enzyme and slicing, followed by pressing the cassava slices. During pressing, about 62.69% of the water was removed, resulting in a yield of 31.86% (Figure 1). The purpose of pressing the slices is to speed up the drying process and to reduce the HCN content of cassava (Niyibituronsa et al., 2021).

The initial capital needed for home-scale cassava flour production is to purchase assets or investment on tools and machineries. In this study, the largest investment cost was for purchasing machineries and ovens, which accounted for 80% of the total investment (Table 3). The production of cassava flour with a capacity of 200 kg of fresh cassava roots took about 3 days. With an effective 20-working day per month, the production capacity was approximately 4.0 tons of fresh cassava roots or 48.00 tons per year. The total cost of cassava flour production covered the fixed and variable costs. The fixed cost included the depreciation cost for tools and machines as well as the maintenance cost, while the variable cost consisted of the purchase cost of raw

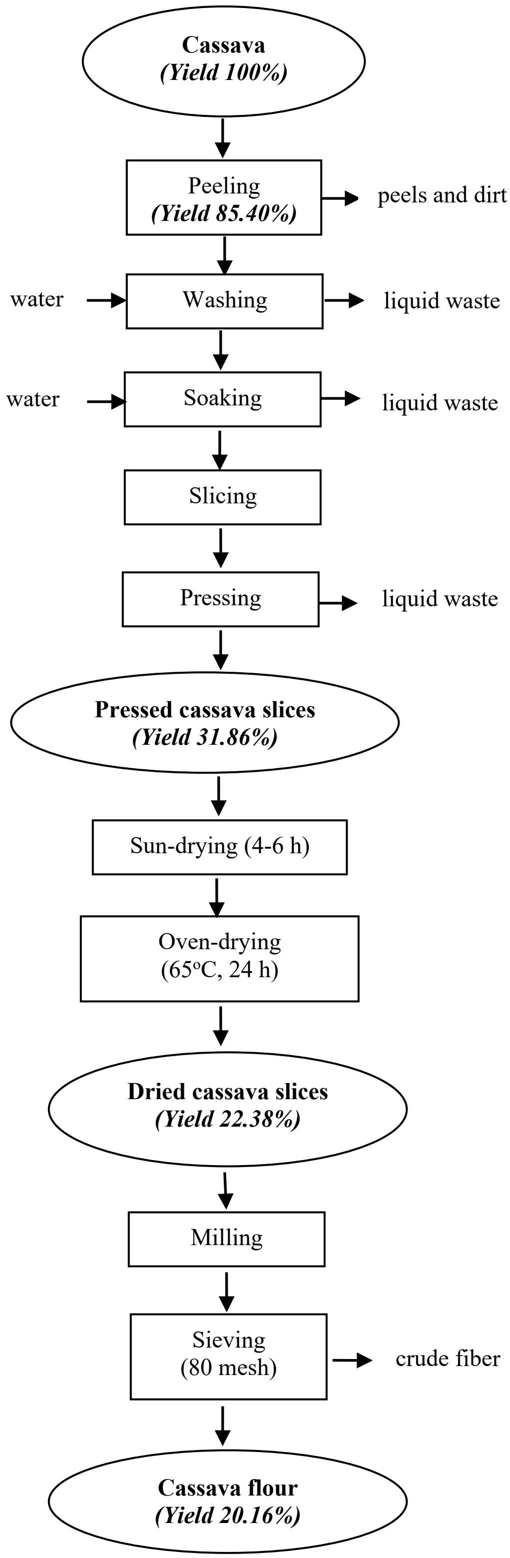

Figure 1. Flow chart and mass balance of cassava flour processing.

Table 3. Components of cassava flour investment capital at home-scale industry.

Type of tools and machineries[a]	Number of units	Unit price (IDR)[b]	Amount (IDR)
Chopper machine	1	7,500,000	7,500,000
Flour machine	1	3,500,000	3,500,000
Pressing tool (manual hydraulic press)	1	2,500,000	2,500,000
Electric cabinet oven (with 5 shelves)	2	13,400,000	26,800,000
Manual big scale	1	2,400,000	2,400,000
Digital small scale	2	150,000	300,000
Plastic sealer	1	300,000	300,000
Glass blender	2	750,000	1,500,000
80-mesh sieve	4	240,000	960,000
Big plastic basin	10	55,000	550,000
Medium plastic basin	10	44,000	440,000
Knife	5	25,000	125,000
Bamboo mat	30	15,000	450,000
Big plastic spoon	5	10,000	50,000
Plastic storage box	10	300,000	3,000,000
Total investment			50,375,000

[a]Data were collected from the machineries and tools used during the flour processing operation; [b]Data were collected from the market during this study performed.

Table 4. Components of cassava flour production cost on a year.

Components of production cost	Number of units	Unit price (IDR)[a]	Amount (IDR)
Fixed cost			
1. Depreciation costs of tools and machineries for flour processing (1 set)[b]	-	3,295,833	3,295,833
2. Maintenance cost for flour processing (1 set)[c]	-	329,583	329,583
Total fixed cost (A)			3,625,416
Variable cost			
1. Cassava (kg)	48,000	1,000	48,000,000
2. Electricity (total per year)	-	14,045,693	14,045,693
3. Water (total per year)	-	800,000	800,000
4. Packaging (@ 1 kg)	9,677	32.55	315,000
5. Labor (person)	3	40,000/day	28,800,000
Total variable costs (B)			91,960,693
Total costs (A + B)			95,586,109

[a]Data were collected during this study performed; [b]Depreciation cost is estimated from the economic life of machineries (10-20 years) and tools (1-5 years) and respective price as listed in Table 3; [c]Maintenance cost is calculated as 10% of depreciation cost.

and supporting materials, such as electricity, water, and plastic bag for packaging and the labor cost (Table 4).

The highest production cost was observed for purchasing the cassava roots as the main raw material, which reached more than 50% of the total production cost (Table 4). The price of cassava at farm level in this present study was IDR 1.000 per kg. This price was relatively high compared to those reported by (Rozi & Pudjiastuti, 2019) in some areas in Java, which tended to persist at IDR 800-900 per kg. This reflects the price fluctuation of cassava following the harvesting time and seasonal availability in the field.

The average production of cassava flour per day was 40.32 kg, equivalent to 9.67 tons of cassava flour in one year. Using the cassava flour selling price used in this study was IDR 15,000 or 1.04 USD per kg, which was below the price of a commercial cassava flour brand produced by Agung Bumi Agro Company in East Java, Indonesia (IDR 18,000 per kg). Based on such price, the annual revenue was calculated to be IDR 145,152,000. If the revenue subtracted by the annual production cost of IDR 95,586,112 (Table 4), the net profit was IDR 49,565,888 (Table 5) or about 3,440 USD. The production of cassava flour would be profitable as revenue cost ratio was 1.52. This suggests that for every IDR 1,000 the production cost incurred, would generate the revenue of IDR 1,520.

The profit of cassava flour production can also be estimated using the net profit margin (NPM), return of investment (ROI), and payback period. The NPM shows the net income of cassava flour production over the sales, while ROI exhibits the net income of cassava flour production over production cost, which includes the depreciation and maintenance costs for tools and machineries that have been invested for the production of cassava flour. The NPM value of 34.15% and ROI value of 51.81% (Table 5) showed that the production of cassava flour at home-scale industry was considerably profitable. The greater the values of NPM and ROI, the greater the capability of the flour industry to generate high profit. The payback period shows the period when the amount of investment can be returned through the profit obtained. Therefore, the payback period estimation becomes an attractive factor for investors. The payback period was estimated to be 1.02 year, meaning that the capital investment for cassava flour production would be able to be returned in about one year.

Table 5. Financial feasibility analysis of annual cassava flour production.

Component	Amount[a]
Flour production per day (kg)	40.32
Flour production per year (kg)[b]	9,677
Flour selling price (IDR/kg)	15,000
Revenue per day (IDR)	604,800
Revenue per year (IDR)[b]	145, 152,000
Production cost per year (IDR)[b]	95,586,112
Initial invesment costs (IDR)[c]	50,375,000
Net income (IDR)	49,565,888
Revenue cost ratio	1.52
Net profit margin (NPM) (%)	34.15
Return of investment (ROI) (%)	51.85
Payback period (year)	1.02

[a]Data were collected during this study performed; [b]Estimated for 240-effective working day per year; [c]Listed in Table 3.

3.4 Prospective of cassava flour production

Farmers in the study area (Kalipare Sub-district) normally sell cassava as fresh roots (unpeeled and peeled) or *gaplek* (slice-dried roots) as presented in Table 6. During this study, the price of unpeeled fresh roots was around IDR 1,000/kg. The unpeeled cassava roots through the middle men are distributed to starch manufactures in East Java region as well as to cracker, noodle and snack processors (Wijayanti, 2019). Meanwhile, the peeled and overnight-soaked roots are sold to cassava crisps industries in Surabaya, the capital city of East Java province with a selling price of around IDR 1,600-1,700/kg. The added value of selling peeled cassava was calculated about IDR 260-345/kg or about 26-34% compared to the unpeeled roots (Table 6).

Gaplek or slice-dried cassava roots are mostly sold to feed industries and for export purpose. During this study in 2019, the selling price of *gaplek* ranged from IDR 2,500-3,000/kg. This price was not profitable for farmers and no added value was gained (Table 6) as the yield recovery of *gaplek* is about 30-40% of the fresh roots. During the period of 2015-2019, there was a decrease trend in international selling price of imported *gaplek*, thus this global condition likely affected the *gaplek* price at farm level. In 2019, the average price of imported *gaplek* was US$ 198 per ton or approximately IDR 2,800/kg, which decreased by 11.4% than that of 2018. The highest price of *gaplek* occurred in 2014 *c.a.* US $270 per ton (IndexBox, 2020). Therefore, *gaplek* has not been longer processed by farmers in this study area since 2017.

Based on this condition, processing of cassava into other products becoming essential in giving the added value, such as raw (un-fried) cassava cracker and flour. Processing of un-fried cassava crackers, including grating, dough making and moulding, steaming, cooling, slicing, and sun-drying (Arum,

Table 6. Existing fresh and processed cassava products in the study area and the potential development of cassava products run by a home-scale processor.

Type of cassava products	Yield	Price (IDR/kg)	Revenue (IDR/kg)	Cost (IDR/kg)	Revenue cost ratio	Added value (IDR/kg)	Reference
Existing fresh and cassava products:							
Fresh cassava roots (unpeeled)		1,000					Personal communication
Fresh cassava roots (peeled)	± 85%	1,600-1,700	1,360-1,445	1,100	1.24-1.31	260-345	Personal communication
Gaplek (traditional slice-dried roots)	± 30-40%	2,500 (Grade A) 3,000 (Grade B)	1,050-1,200	1,150	0.91-1.04	-100[a]-50	Personal communication
Potential development of cassava products:							
Raw cassava crackers	± 33%	9,500	3,167	2,290	1.38	1,121	Elisabeth & Prasetiaswati, 2018
Cassava flours	20.16%	15,000	3,024	1,991	1.52	1,033	Obtained from this study

[a]No value added is obtained.

2018) normally takes one week (Elisabeth & Prasetiaswati, 2018) with the added value of about IDR 1,121/kg (Table 6) or equivalent to 112%. The added value of cassava flour was slightly lower relative to that of cassava crackers *c.a.* IDR 1,033 per kg or 103%, however the processing step was considerably shorter, thus it can be run within three to four days. Also the equipments needed are simple and gives higher revenue cost ratio (Tabel 6), suggesting the superiority of cassava flour processing. Therefore, introduction of flour processing would be prospective to diversify the uses of cassava, increase the added value and generate the farmers' income.

4 Conclusion

The flour prepared from Sembung, a local cassava variety in Indonesia approximately had good physical and chemical characteristics as it met the national standard quality requirements for moisture, starch, and HCN contents, while the ash and acidity values were slightly higher and slightly lower for the whiteness level. The yield of cassava flour production was about 20.16% or equivalent to 9.67 tons of cassava flour with a capacity of 48.00 tons of fresh cassava roots per year. It is profitable to run the home-scale industry of cassava flour based on the net profit of IDR 49,565,888 or about 3,440 USD per year, revenue cost ratio of 1.52, the net profit margin of 34.15%, the return of investment of 51.81% and the payback period of 1.02 year. This profit can be increased through proper harvesting time and maturity of cassava as well as the processing methods in order to improve the flour yield recovery and quality.

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