RECENT DEVELOPMENTS IN CASSAVA STARCH AND DERIVED PRODUCTS USED IN FOOD PROCESSING IN INDONESIA

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ABSTRACT

Annual cassava starch production in Indonesia during the past ten years was about 0.35 million tonnes. Cassava starch is presently utilized mainly for food processing, such as in the canning industry as well as for production of glucose, fructose, sorbitol, monosodium glutamate (MSG), ethanol, noodles, cakes and many traditional foods. Demand for canned food is presently 40% higher than supply. It means that the canned food industries should increase production to meet the demand. Therefore, production of starch, which is the raw material of these industries, has to be increased as well. Developing a small-scale starch industry, which could increase farmers' income, will be discussed. Enzymatic and hydrolization methods are used by the food processing industry. Most of the factories are located in Java island. The capacity of small-scale and large-scale factories are approximately 200 and 1000 tonnes/month, respectively. The prospect of developing a food processing industry using cassava starch as well as other starch-derived products, and its ability to increase farmers' income, will be discussed.

INTRODUCTION

Annual cassava starch production in Indonesia during the past ten years was about 0.35 million tonnes. Cassava starch is presently utilized mainly for food processing, such as in the canning industry as well as for production of glucose, fructose, sorbitol, monosodium glutamate (MSG), ethanol, noodles, cakes and many traditional processed foods. Demand for cassava starch for food and non-food industries were 0.342 and 0.725 million tonnes, respectively (CIC, 1998). Therefore, starch production should be increased to meet the demand.

Presently, demand for canned food is 40% higher than supply. The country is presently importing 5,989 tonnes of cassava starch, 66,733 glucose, 310 of fructose, 2,458 of other inverted sugars and 11.72 tonnes of other convectionary sugars (CBS, 2002). This indicates that both food and non-food industries should increase production to meet the demand. Production of starch, which is the raw material in these industries has to be increased as well.

Medium-size cassava starch factories, with a capacity to process more than 200 tonnes of fresh cassava roots/day, have been developed at various production centers, but were not able to stabilize or increase the fresh root price paid to farmers. Factors that keep the price of the fresh roots low are: 1. roots are bulky and highly perishable; 2. poor road infrastructure and long distance to the factory; and 3. weak marketing system. Development of a village-scale production capacity of both cassava starch and derived products will be a way to reduce transportation costs, while the perishability can be minimized by transporting roots to starch factories in the village soon after harvest. Small-scale starch factories will minimize the transportation cost of bulky roots and stimulate farmers to arrange planting and harvesting time according to the factory's demand. If these small-scale starch factories

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are able to reduce production costs, their products will become more competitive in emerging markets. Derived products of cassava starch in these emerging markets include glucose, glucose syrup, fructose, fructose syrup, sorbitol and MSG.

Other derived products made from cassava starch with good prospects in emerging markets are gum xanthan, bio-degradable plastics and bio-surfactants. Establishment of these industries will depend on the price of cassava starch and on the starch characteristics. Current research on cassava starch-derived products will be discussed in this paper.

DEVELOPMENT OF SMALL-SCALE CASSAVA STARCH FACTORIES

Table 1 shows that most small-scale cassava starch factories are located on Java island, especially in West Java province. Most cassava production on Java island is for direct human consumption as fresh roots (after boiling or roasting) or as dried roots pounded or milled into a flour (Wargiono *et al.*, 2002). Small-scale cassava starch factories in Java use traditional processing methods. This starch is of medium to low quality and is characterized by a high fiber content. This starch is subsequently collected by medium-scale starch factories to be reprocessed into a product of high quality and high fiber. This starch is used as raw material for food industries of high-fiber content products. Small-scale cassava starch factories outside of Java do not use this traditional processing method, and the starch produced is of low quality and has low fiber content. Medium-scale cassava starch factories at production centers are able to process fresh roots at full capacity, while large-scale cassava starch factories in Java find it difficult to produce starch at full capacity. Medium-to large-scale cassava starch factories located outside of Java pay farmers only a low and highly unstable price for cassava roots indicating that there is little cooperation between factories and farmers. This condition in turn affects the level of cassava production, as cassava production is not supported by government policies. Establishment of small-scale cassava starch factories at the village level will allow for a higher price of roots at the farmers' level due to:

- These cassava starch factories are located close to the farmers' fields, so transportation costs are relatively low and the roots can arrive at the factories soon after harvest.
- The members of the farmers group can better plan the time of cassava planting and harvest according to the demand for roots at the factory.

Table 1. Number and scale of cassava starch factories in Indonesia by region in 1998.

	Number of factories		
Region	Small	Medium	Large
Java	211	80	0
Sumatra	13	19	70
Kalimantan	0	4	4
Sulawesi	0	0	11
Maluku and Irian Jaya	0	2	1

Source: *PT. CIC, 1998.*

Once organized, the farmers' group can adopt appropriate varieties and improved agronomic practices that will increase cassava yields and production.

As more than 50% of cassava starch is currently produced on Sumatra island, especially in Lampung province, the government of Lampung province is supporting a program for the development of small-scale starch factories (ITTARA). A case study was conducted in these sub-districts where ITTARA has been implemented. It indicates that small factories can not easily produce high-quality starch. It means that the price of starch will still be low and these small-scale cassava starch factories will not be able to compete with the big starch factories. The main reason for the low quality of starch is the sun-drying process used by small-scale starch factories. Factors affecting low price are starch quality and marketing system. The low quality of starch and poor linkages with the marketing system are the reasons why small-scale starch producers have no bargaining power and have a low profit margin. Improving the drying process and organizing the marketing system by ITTARA member associations or corporations (KOPATARA) might be a way to increase starch quality and thus the bargaining power of small-scale starch factories. The advantage of developing KOPATARA is to establish a floor price for fresh cassava roots among the members of ITTARA for the small-scale production of either wet or dry starch (**Table 2**).

Table 2. Processing costs and the break-even point for production of wet and dry cassava starch in small-scale factories in Lampung province of Indonesia in 2001.

	(Rp/kg)					
Price of peeled fresh root	160	170	180	190	200	210
Processing cost of wet cassava starch	10.23	10.23	10.23	10.23	10.23	10.23
Total production cost of wet cassava starch	170.23	180.23	190.23	200.23	210.23	220.23
Processing efficiency of wet starch (%)	35	35	35	35	35	35
Break-even point (BEP) for wet starch	486.37	514.94	543.51	572.08	600.66	629.23
Cassava starch drying cost	30	30	30	30	30	30
Total processing cost of dry starch	200.23	210.23	220.23	230.23	240.23	250.23
Processing efficiency of dry starch (%)	20	20	20	20	20	20
Break-even point (BEP) for dry starch	1001.12	1051.12	1101.12	1151.12	1201.12	1251.12

Processing efficiency percentage = kg of product per 1 kg of raw material x100%
Source: *Feasibility study of small-scale cassava starch factory development program (ITTARA).*

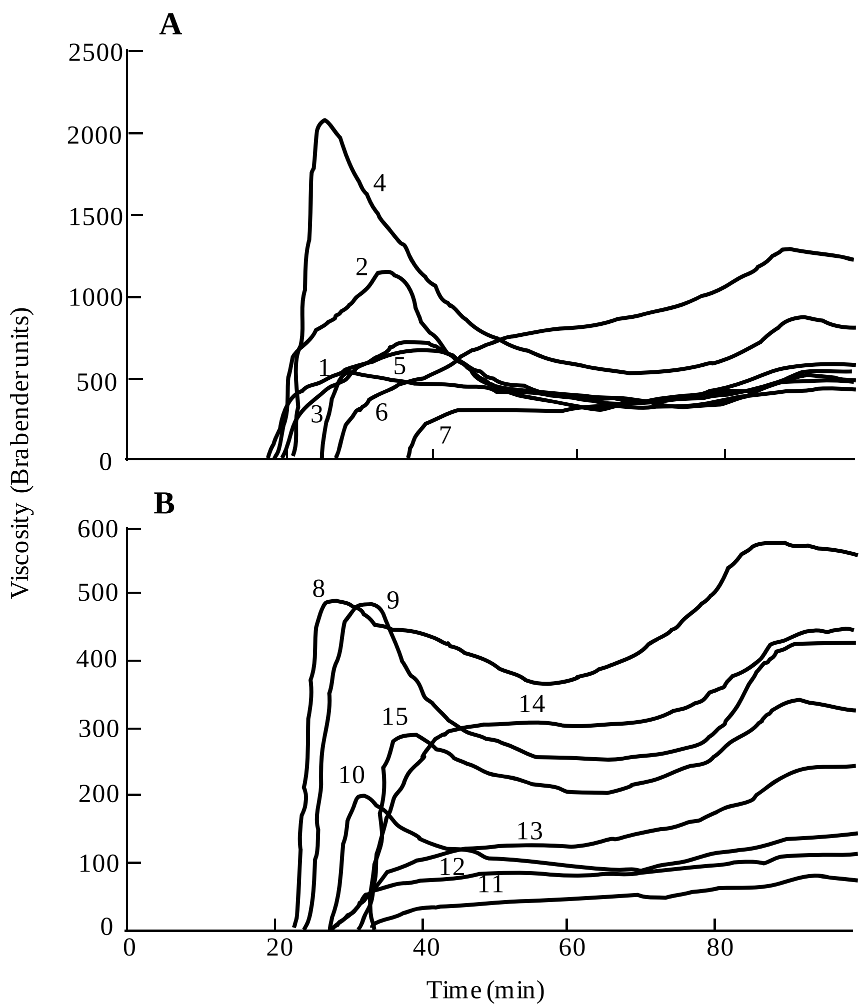
Reasons for the low price of fresh roots at the farmers' level when large-scale cassava starch factories process the roots are:

- High transportation cost due to long distance from the farmers cassava field to the starch factories, and the bulkiness of roots.
- Bad road infrastructure, allowing trucks to transport fresh roots only during the dry season. As such, most farmers harvest cassava at the same time during the dry season.
- Fresh roots are highly perishable, so the price of fresh roots decreases when it takes more than three days for the roots to reach the starch factories.
- The bargaining power of the farmer is low due to the lack of alternative markets to sell the roots.

The high production cost and the problems of poor infrastructure and root perishability can be reduced by the development of small-scale cassava starch factories at production centers run by farmers' groups. The ability to produce low-cost starch will in turn support the development of industries producing starch-derived products.

CASSAVA STARCH AND DERIVED PRODUCTS USED IN FOOD PROCESSING

Cassava starch can be used as raw material for many kinds of industries, both food and non-food, due to its intrinsic characteristics (**Figure 1**). Among the various starches cassava starch is generally the cheapest. It means that developing a cassava starch industry may be a way to establish several starch-derived industries as well. These industries may include noodles, cakes, fermentation products, glucose, fructose, and sorbitol. Demand for cassava starch for these industries is presented in **Table 3.**



1. Yam; 2. Oca; 3. Ulluco; 4. Potato; 5. Sweet potato; 6. Queensland arrowroot; 7. Arracacha; 8. Arowroot; 9. Cassava; 10. Swamp palm; 11. Giant taro; 12. Yam bean; 13. Cocoyam; 14. Plantain; 15. Taro

Figure 1. Visco-amylograms of non-cereal starches.
Source: *Dufour et al., 2000.*

Table 3. Annual starch demand for various starch-based industries in Indonesia.

Industries	Demand: Amount ('000 t)	Demand: %
Food industries		
Syrup sugars[1)]	151	14
Instant noodles	45	4
Cakes	70	6
Biscuits	28	3
Others	48	5
Total	**342**	**32**
Non-food industries		
Paper	63	6
Textile	6	1
Sorbitol	43	4
Others	612	57
Total	**724**	**68**

[1)]glucose, fructose

Source*: *PT CIC. 1998

1. **Instant noodle industry**

Consumption of instant noodles in Indonesia increases at a rate of 12.38% per year. PT Indofood Sukses Makmur is the biggest instant noodle company in the country, followed by PT Asia Inti Selera, PT Nissinmas, PT. ABC President Food Enterprises, PT Mie Barokah, and followed by another 25 smaller instant noodle companies (Capricorns, 1998). These companies produce about 9.2 million packs/year of instant noodle. The cassava starch demand of these industries is about 0.045 million tonnes corresponding to about 0.20 million tonnes of fresh roots. In order to obtain a monthly supply of starch for the noodle industries they should cooperate with ITTARA by provinding external credit for the purchase of fertilizers and for land preparation costs.

2. **Cake and biscuit industries**

In the cake and biscuit industries cassava starch is mixed with wheat flour, at about 10-20% for cakes and at 30-80% for biscuits. The wheat flour demand is about 4 million tonnes which is totally imported; therefore, mixing wheat flour with cassava starch is a way to reduce the production cost of cakes and biscuits. The demand for cassava starch in these industries is about 90,000 tonnes/year. Demand for these products increases at an annual rate of 14.9% (Capricorns, 1998). This means that the cake and biscuit industries have good future prospects, and demand for cassava starch could be increased as well. Household-scale cake and biscuit industries could be developed in the villages. For that reason, cassava starch should be just as available as wheat flour in local markets.

3. **Fermentation industries**

The fermentation industries, which produce products such as glucose, fructose, and sorbitol, and organic acids like MSG, citric acid and enzymes, can use both fresh and dry cassava roots as the raw material; most of the products are currently imported. Domestic production should be increased to meet the demand.

Demand for cassava starch for production of glucose, fructose and sorbitol is about 0.17 million tonnes and increases annually at a rate of 9.17% (CBS, 2000; Capricorns, 1998). But most of these products are still being imported. The demand for glucose syrup is 40% higher than current production, similar to glucose, fructose, maltose, mannitol and sorbitol. Demand for glucose as raw material for the production of candy, soft drinks, traditional medicines and the biscuit industries tend to increase (CBS, 2000). Domestic production of these products should urgentlty be increased to meet the demand.

Glucose syrup can be produced by hydrolizing starch with either acid or α-amylase enzyme. Cutting the starch chain using acid will produce a mixture of dextrin, maltose and glucose (**Figure 2**).

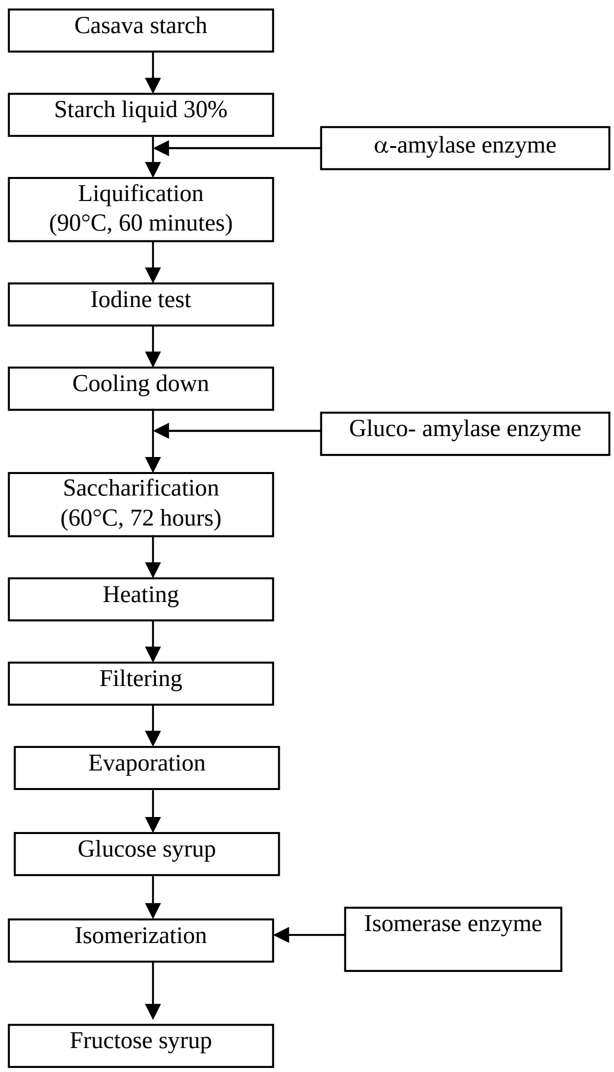


Figure 2. Flow chart for producing glucose and fructose syrups from cassava starch.

Imported gluco-amylase and α-amylase for producing glucose and fructose syrups could well be substituted by other enzymes produced domestically (Richana *et al.*, 1999; Lestari *et al.*, 2000). **Table 4** shows that the amylose content of cassava starch is lower than that of arrowroot, but the productivity of cassava roots is much higher than that of arrowroot. For that reason, cassava starch will probably be the main raw material for the domestic glucose and fructose syrup industries.

Table 4. Amylose content of different types of starches and their effect on the yields of glucose and inverted sugars in the saccharification process.

Starches	Amylose content (%)	Glucose syrup yield (%)		Invested sugar yield (%)	
		A[1)]	B[1)]	A[1)]	B[1)]
Arrowroot	34.80[c]	83.5[ab]	73.08[bc]	86.51[b]	89.45[b]
Cassava	29.86[b]	80.0[ab]	87.98[a]	87.02[a]	87.54[a]
Sago	23.94[a]	62.5[c]	64.09[c]	87.66[a]	87.57[a]

[1)]A = Enzymatic hydrolization method; B = Acid hydrolization method
Source: *Richana et al., 2000.*

The great amount of imported glucose, fructose and sorbitol indicates that production of these products produced by large-scale factories with a capacity of about 1000 tonnes/month is still lower than the demand The establishment of small-scale factories following the ITTARA model, using cassava-starch to increase domestic production of glucose and fructose syrup should be supported. Small-scale glucose syrup factories set up in Central Java seem to be economically sound. The capacity of this factory is 200 tonnes/month; the use of acid in the hydrolization process is most suitable for this small scale. The products of this factory become the raw material of large-scale factories, which further process glucose into fructose syrup and sorbitol. This could be a model for the establishing of small-scale glucose and fructose syrup industries.

RECENT RESEARCH DEVELOPMENTS

The best prospects for developing bioprocesses based on cassava starch are bio-degradable products such as gum xanthan and biosurfactants.

- **Gum xanthan**

Gum xanthan is a hetero-poly-saccharide produced extra-cellularly by *Xanthomonas campestris* bacteria. Gum xanthan is utilized by many factories due to its chemical characteristics and unique rheology. Gum xanthan is used as coagulator, suspender, stabilizer, and emulsifyer for industries of food, textile, ceramic, paper, print ink, medicines fungicides and pesticides (Petit, 1979; Ochao *et al.*, 1992). Demand for gum xanthan is higher than production. About 342 tonnes of this product are imported to meet domestic demand (CBS, 2000).

Cassava starch used as the media for producing *Xanthomonas campestris* bacteria produced 26.5% gum xanthan, while glucose used as the media produced 31.5% (Wiryosasmita, 1993). This result shows the potential for establishing gum xanthan production factories, since production of cassava starch and glucose can be increased according to demand. Since the demand by many factories in the country is relatively high, developing gum xanthan production facilities is urgently needed in the near future.

- **Biosurfactants**

Surfactants or surface-active agents are used for industries of detergents, cosmetics, food additives, insecticides and herbicides (Banat, 1993). As demand for biosurfactants by industries is increasing, therefore, biosurfactants should be produced domestically. Research result shows that cassava starch is a potential culture media for producing biosurfactants (**Table 5**). As the dependance of many factories on biosurfactants increases, the demand for cassava starch used as the raw material also increases. There is therefore a good posibility to establish biosurfactant factories in the country.

Table 5. Effect of various glucose substrates as carbon source on the yield of lipopeptide biosurfactants by *Bacillus* sp. BMN 14.

Glucose substrates	Biomass (g/l)	Biosurfactant extract (g/l)	Surface elasticity (mN/m)
Glucose (Sigma)	2.02	0.85	33.5
Cassava starch 1	1.94	0.78	33.6
Cassava starch 2	1.87	0.68	35.0
Arrowroot root starch 1	1.78	0.73	36.0
Arrowroot root starch 2	1.81	0.58	38.0
Sago starch 1	1.96	0.81	34.6
Sago starch 2	2.08	0.62	38.0

***Source:** Richana et al., 2000*

- **Poly-β-hydroxy butirate**

Poly-β-hydroxy butirate (PHB) is characterized by its structural elasticity; it is easy to be formed and can be formed either as fibers or can be processed into plastic film (Caldwell, 1994). The production process of PHB is based on various micro-organism species. The capability of each micro-organism to produce a high yield of this product is affected by the kind of culture media, such as *Alcaligenus entrophus* on fructose, *Pseudomonas* sp on methanol, *Bacillus* sp, and *Rhizobium* on glucose (Atkinson and Mavituna, 1991; Holmes, 1988).

CONCLUSIONS

As the development of cassava by the year 2020 will be better integrated into emerging markets, through the efficient and enviromentally sound production of a diversified mix of high-quality and competitive products for food, feed and industry, and the model for agricultural development will involve the active participation of farmers, this will lead to a more demand-driven and industrialized agriculture. Therefore, developing industries of cassava starch-derived products is a way to obtain high added-value of cassava.

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