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Technical and Financial Feasability Analysis of Mangrove (*Bruguiera gymnorrhiza*) Starch Production in West Seram District, Maluku Province

Melkhianus

Doctoral Program of Fisheries and Marine Sciences, Brawijaya University

H. Pentury

Fisheries Processing Department, Fisheries Academy, Biak

Happy Nursyam

Processing Department, Faculty of Fisheries and Marine Science, Brawijaya University

Nuddin Harahap

Fisheries and Marine Socio-Economics Department

Faculty of Fisheries and Marine Science, Brawijaya University

Soemarno

Soil Science Department, Faculty of Agriculture, Brawijaya University

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Abstract

The hypocotyls of *Bruguiera gymnorrhiza* have a high carbohydrate content, but have not been widely used as a staple food. An alternative use for *Bruguiera gymnorrhiza* hypocotyls is for the manufacture of starch. In addition to seeking new sources of starch for modern food industry. The research method used a completely randomized factorial design with three replicates and 2 treatment factors: $NaHSO_3$ concentrations of 0.10%. 0.20%. 0.25% and 0.40% and temperatures of 40°C, 50°C and 60°C. Data analysis was carried out using SPSS version 16.0. The best treatment was determined using the De Garmo method. The results show that the best results were obtained from the treatment with a heating time of 5 minutes at 60 ° C with 0.40 % NaHSO3 concentration, producing 21.35 % amylose content, 64.30 % starch content, a viscosity of 40.33 %, 89.99 % solubility and 0.16 % monosaccharide content. a required investment of IRD. 88,550,000. The Net Present Value (NPV) analysis returned a figure of 90,011,325. The Internal Rate of Return (IRR) analysis gave a value of 46.81 %. The Payback Period (PP) analysis shows that the initial investment could be recouped within a period of 4 years and 3 months. The B/C ratio was 1.1. Based on the investment criteria analysis, it would be viable to establish this industry in West Seram District.

Keywords: *Bruguiera gymnorrhiza*, Extraction, Starch, Feasibility analysis

1. Introduction

The use of *Bruguiera gymnorrhiza* hypocotyls in food processing has so far been limited to the use of flour produced naturally with no modern processing. An appropriate processing method is required to increase the economic value of *Bruguiera gymnorrhiza* hypocotyls (Wanma, 2007). *Bruguiera gymnorrhiza* hypocotyls have a high carbohydrate content (Fortuna, 2005; Sadana, 2007; Purnobasuky, 2012) and a fairly high starch content (Pentury, 2010). Starch is the most important nutrient in everyday diet, and the ever-growing need for starch in the modern global food industry has driven efforts to identify new sources of polysaccharide starch (Ancona *et al*, 2001). The highest starch content is found in green and unripe fruits, and can be as high as 70% of dry weight. Based on the above facts, *Bruguiera gymnorrhiza* hypocotyls could become an alternative source of starch, alongside grains (maize, wheat and rice).

Bruguiera gymnorrhiza hypocotyls can be readily found in almost all areas of Indonesia. However their use has been limited to ecological functions. Of course *Bruguiera gymnorrhiza* hypocotyls do not keep for long, and need to be converted into a versatile product with long shelf life and high nutritional content. In this context, there is a need to develop *Bruguiera gymnorrhiza* hypocotyl starch production methods and to study the nutritional value and functionality of this product as well as the amylose content, solubility, monosaccharide content and viscosity to provide guidelines for its use in food products. In addition, the *Bruguiera gymnorrhiza* starch produced should increase the shelf-life of this starch source and prevent decay.

The expected benefits from this research include the determination of the correct concentration and processing heat in order to optimize the quality of the *Bruguiera gymnorrhiza* hypocotyl starch produced, and the development of opportunities to use hypocotyl starch from *Bruguiera gymnorrhiza* as a raw ingredient in the food industry. The goal of this research was to evaluate the technical and financial viability of *Bruguiera gymnorrhiza* hypocotyl starch production.

2. Research and Method

This research was undertaken in the Fisheries Processing Laboratory of the Faculty of Fisheries and Marine Science of Brawijaya University in Malang, Indonesia. The methods used were both descriptive and experimental.

2.1 Experimental Data Collection

Bruguiera gymnorrhiza hypocotyls were peeled, cleaned and cut into pieces <0.5 cm the soaked for 48 hours to reduce the tannin content before extraction. A completely randomized factorial design was used with three replicates and 2 treatment factors: the heating temperature with values of 40°C (S1), 50°C(S2) and 60°C(S3); and the concentration of the $NaHSO_3$ solution with values of 0.10 % (KA), 0.20 % (KB), 0.25 (KC), 0.40 % (KD). All treatments were applied for 5 minutes.

2.2 Data Analysis

The experimental data were analysed using SPSS version 16.0 software. A Duncan test was then applied to evaluate the differences between means for the various treatments. The parameters tested were starch content, amylose content, solubility, monosaccharide content and viscosity. The best treatment was selected using a weighted effectiveness index (De Garmo *et al*., 1984). The results were used as the basis for a technical and financial analysis of small-scale industrial starch production.

3. Results and Discussion

3.1. Characterisation of Bruguiera gymnorrhiza starch

The calculations show that the best combination of the various research parameters was obtained from the treatment using an 0.25% $NaHSO_3$ solution concentration combined with a heating temperature of 60°C (S_3KC). This most effective treatment produced an amylose content of 19.58%, a starch content of 65.61%, a viscosity value of 733.66 cP, a monosaccharide content of 3.07% and a solubility of 91.99%; yield was 15.74% and degree of whiteness was 46.62%, with an overall result of (Nh) 0.681.

The results showed that initially increasing the concentration of natrium bisulphite increased the amylose and starch contents, however the starch content reached an optimum at a concentration of 0.25% and was reduced at 0.40%. This is similar to Efendi., (2011) who stated that the concentration of sodium bisulphite increased the Yield, fat and free fatty acids. The reduction in the percentage of starch was also caused by an increase in the concentration of sodium bisulphite. The more sodium bisulphite is used, the greater the amount of starch which is oxidised and dissolved in the oxidising solution.

3.2. Analysis of Marketing Aspects

The potential market for *Bruguiera gymnorrhiza* starch in Indonesia would be similar to that of starch from cereal flour and similar products. Based on data from the Ministry for Industry, national consumption of flour is continuously increasing. By the first semester of 2013, consumption had reached 2.6 million metric tons, an increase of 1.08 percent compared to the same period in 2012. Domestic flour production had a 90% market share in supplying raw materials to the national food industry, the remainder being imported. National flour production in 2010 was 3.6 million metric tons, rising to 4 million tons in 2011 and 4.6 million tons in 2012. The average monthly demand was around 400,000-450,000 metric tons/month. These data show that there is an opportunity for *Bruguiera gymnorrhiza* hypocotyl starch to compete in the domestic market.

Table 1. Indonesian Imports of Various Starches

Starch type	Starch Import Volume (Metric Tons/Year)		
	2009	2010	2011
Wheat starch	1,198	3,010	1,241
Maize (corn) starch	79,730	253336	96,757
Potato starch	14,071	14,296	8,873
Cassava starch	166,813	294,832	435,419
Sago starch	3,401	0	500
Other starches	25	7,366	10,156
Inulin	2,569	4,022	3,744

Source: Kemenperin, 2011

3.2.1. Raw Materials Analysis

The mangrove forests in Maluku Province cover 165,775 ha (Bapedalda Provinsi Maluku, 2004). More specifically, data from a LandSat 7 ETM+ image in 2005 showed that mangrove forests in West Seram District cover 3,823.30 ha, with 553.84 ha in Kotania Bay, and *Bruguiera gymnorrhiza* is the most dominant species. An estimate of the production area was made through dividing the total mangrove area by the number of species present (17) resulting in a conservative figure of 32.6 ha. As the mangrove distribution is uneven and parts of the coast are difficult to access, 60% of this area was taken and rounded to the nearest integer to produce a production area estimate of 20 ha.

a. Raw Material Specifications

The main raw material used to produce *Bruguiera gymnorrhiza* starch is the hypocotyls of the *Bruguiera gymnorrhiza* growing in the production region. The hypocotyls are harvested when still immature or unripe and green in colour, because such unripe hypocotyls contain more starch than mature ripe hypocotyls in which much of the starch has been converted to sugar. Ripe hypocotyls are dark and puIRDlish in colour. Starch was extracted from the hypocotyls using the optimised process, so that the flour produced had the most favourable composition, containing 19.58% amylose, 65.61% starch, 3.07% monosaccharide with 733.66 cP viscosity 91.99% solubility, 15.74% yield and 46.62% whiteness.

b. Raw Material Availability

The distance between naturally occurring *Bruguiera gymnorrhiza* was around 5x5 metres, giving a density of around 400 trees/ha. Each tree can produce around 200 hypocotyls per harvest; as there are around 25 fruit per 1 kg, each tree can produce around 8 kg and 1 hectare of mangrove forest *(Bruguiera gymnorrhiza*) can produce around 3,200 kg. With a processing yield of around 15.74%, and around 3,200 kg of fruit produced per ha, around 500 kg/ha of starch could be produced, giving a production volume of 10,000 kg of starch per harvesting season from an area of 20 ha. This production capacity could potentially be increased as not all of the mangrove forest is considers to be a production area.

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3.2.2. Planning Production Capacity

Based on a raw material availability of 500 kg of *Bruguiera gymnorrhiza* starch per harvest and considering the market demand of 400,000-450,000 metric tons/month, as well as the still relatively large need for imports, and the extent and productivity of hypocotyl-producing *Bruguiera gymnorrhiza* stands in West Seram District, production capacity was set at 100 kg/day. This means that with an area of 20 ha, around 400 trees per hectare and around 200 hypocotyls per harvest per tree weighing in at an average of 25 hypocotyls/kg, each tree should produce on average around 8 kg of hypocotyls.

3.2.3. Production Technology and Process

Small-scale industrial production of *Bruguiera gymnorrhiza* starch requires simple and relatively inexpensive equipment. The *Bruguiera gymnorrhiza* starch production process is shown in Figure 1.

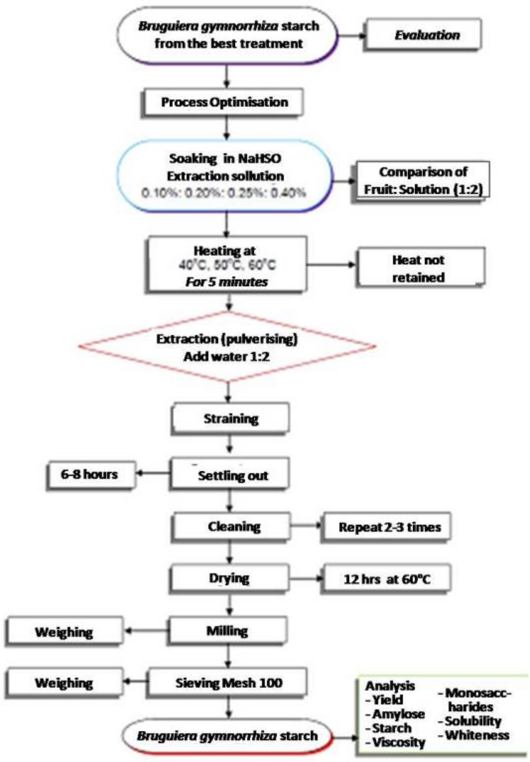

Figure 3.3. *Bruguiera gymnorrhiza* starch production process

3.3. Financial Analysis

3.3.1. Investment

Investment costs comprise fixed assets and include the costs of renting premises, purchasing machinery and equipment, a number of fixed assets, initial activities or pre-investment costs, contingency funds, and the provision of various other support facilities. In this study we calculated the total investment costs for setting up a *Bruguiera gymnorrhiza* starch factory with a production capacity of 100 kg per day to be IRD. 88,550,000.

Table 2. Investment Costs for Setting up a *Bruguiera gymnorrhiza* starch factory

No	Cost Component	Outlay (IRD.)
1	Pre-investment	4,000,000
2	Hire of Premises	12,000,000
3	Machinery & Equipment	46,000,000
4	Support Facilities	20,750,000
5	10% Contingency Fund	5,800,000
	Total	**88,550,000**

3.3.2. Production Costs

Production costs are outgoings made by the company in order to obtain raw materials and pay for production factors in order to produce a product. The production cost components are: raw materials, packaging materials, supporting facilities, wages and labour costs, administrative and marketing/sales costs. Te total costs incurred in producing *Bruguiera gymnorrhiza* starch are shown in Table 3.2. The total annual production costs for the *Bruguiera gymnorrhiza* starch product was calculated as IRD. 127,072,600.

Table 3. Annual (1 year) Production Cost Components for *Bruguiera gymnorrhiza* Starch

No	Component	Cost (IRD)
1	Raw materials	81,405,000
2	Packaging materials	594,000
3	Supporting facilities	1,809,600
4	Wages and labour	30,720,000
5	Administrative overheads	3,360,000
6	Marketing/Sales costs	3,384,000
7	Maintenance and Repairs	5,800,000

3.3.3. Basic Production Costs

Bruguiera gymnorrhiza starch was packed in 1 kg plastic bags. The annual production capacity of *Bruguiera gymnorrhiza* starch was 270 metric tons. The basic or net production cost (HPP) of each kg of *Bruguiera gymnorrhiza* starch was calculated to be IRD. 4,000. Based on this figure the suggested retail price was IRD 6,500, with a 25% mark-up. This calculation was made because the current market price of starch as a raw material or ingredient varied from IRD. 5,000/kg to IRD. 7,500/kg. Annual production costs were calculated, including all fixed and variable costs for 1 year comprising raw materials, labour and other costs.

3.3.4. Income Analysis

Gross income was calculated by multiplying the product volume by the unit price. At the beginning of a project the production facilities are generally not being pressed to produce maximum output, and production tends to rise gradually so that income will also grow steadily year by year. In this project it was planned to sell the *Bruguiera gymnorrhiza* starch product with a price of IRD. 6,500/kg, which was assumed to remain constant during the project life with a maximum annual production capacity of 27,000 kg. It was therefore estimated that the annual gross company income would be IRD. 175,500,000 if the factory operated at full capacity.

3.3.5. R/C Ratio

Total income from the *Bruguiera gymnorrhiza* starch production plant of IRD. 175,500,000and total costs of IRD. 137,077,600 produce an R/C ratio of 1.28. This figure is greater than so that the *Bruguiera gymnorrhiza* starch production business should be profitable. The R/C ratio of 1.28 means that the capital invested will produce revenue 1.28 times greater than the expenditure incurred.

3.3.6. Profitability

Profit is the result of subtracting all costs incurred by the company from the total revenue. With a total annual revenue of IRD. 175,500,000 and total production costs of IRD. 137,077,600, subtracting total costs from total revenue yields an average annual profit of IRD. 38,422,400.

3.3.7. Rentability

The rentability of a business is the ratio of between operational profit and the capital used to produce this profit, including both internal and outside investment, expressed as a percentage. With a rentability of 49.1 %, the *Bruguiera gymnorrhiza* starch production business could produce an operational profit of 49.1 % for the capital used over a period of one year. Because Rentability is often used to evaluate the efficiency of the use of capital within a company, economic rentability is also often considered to represent the ability of a company to make use of all the capital working within it to make a profit.

3.3.8. *Break Event Point* (BEP)

The Break Event Point (BEP) is the point at which the production volume produces neither profit nor loss. "The result obtained on the basis of sale value was IRD.193,885 kg. per day". And the BEP for the production unit was 30 kg/day. This means that the *Bruguiera gymnorrhiza* starch plant would neither make a profit nor make a loss if a minimum production volume of 30 kg/day could be maintained. This figure indicates the break-even point for sales at which sales of *Bruguiera gymnorrhiza* would yield neither profit nor loss.

3.4. Feasibility Analysis

3.4.1. NPV (*Net Present Value*)

In a Net Present Value analysis, all future cash flow expenditures and receipts are converted to **Present Value** and added up to produce an accumulated value of all cash flow during the life of the investment. This calculation produced an NPV value of 90,011,325 assuming a ten year project life. This figure represents the net benefit which will accrue during the next ten years based on current value. The NPV is greater than zero which means that the project is viable.

3.4.2. Internal Rate of Return (IRR)

The Internal Rate of Return represents the flow of returns on investment which will produce a condition where NPV of incoming cash flow = NPV or outgoing cash flow. A project is feasible to implement if the IRR value is greater than the desired minimum rate of return which is usually based on bank interest rates. The IRR of this project was calculated as 46,81 %. This value indicates that the project would be viable because the IRR is higher than current bank interest rates which are around 19 %.

3.4.3. Net Benefit Cost Ratio (Net B/C)

This criterion compares the benefits from the project with the costs of implementing the project. The calculations produced a Net B/C value of 1.1. This value is greater than 1, meaning that implementing the project would be financially viable.

3.4.4. Payback Period

Calculating the Payback Period is one way to work out the time it would take to repay the initial investment, and is given in years. The payback period for this business venture was calculated as 4 years and 3 months. This period is shorter than the projected project life of 10 years, so that it can be considered worthwhile to pursue the *Bruguiera gymnorrhiza* starch production scheme.

3.4.5. Sensitivity analysis

Sensitivity analyses were applied to two parameters, firstly increases in the cost of raw materials and secondly a fall in retail price. This analysis will show whether or not the business will be sensitive to decisions taken with respect to certain changes. The results of the sensitivity analysis are shown in Table 4.

Table 4. Sensitivity Analysis for increases in raw material costs and reduction in retail price.

Change	Investment Criteria		
	NPV (IRD)	IRR (%)	Net B/C
Raw material costs increase by 5 %	87,051,478	43.83	1.0
Retail price decrease of 5 %	80,357,673	40.80	1.0

Based on the calculations shown above, in normal conditions the production of *Bruguiera gymnorrhiza* starch would be feasible because the business meets investment viability criteria. Should there be an increase of 5 % in raw material costs, *Bruguiera gymnorrhiza* starch production would still be viable even though there would be a reduction in net benefits. Similarly, a reduction in retail price would also reduce benefits. However the Net B/C ratio is at the break even point so that any increase of more than 5% in raw material costs or decrease of more than 5% in retail price would cause the business to run at a loss or fail. In general it can be concluded that the production of *Bruguiera gymnorrhiza* starch would be sensitive to raw material costs and retail prices.

3.5. Socio-economic Impact Analysis

Establishing a new industry in a given area will have direct and indirect impacts on the lives of people nearby and the surrounding environment. In the case of the proposed project to establish a *Bruguiera gymnorrhiza* starch production industry in West Seram District, the main impact felt by surrounding communities would be the opening up of new opportunities for employment. The wages or other remuneration of employees and casual workers in the *Bruguiera gymnorrhiza* starch business would have a direct impact on the economic condition in the surrounding area and would also increase the consumption of the goods and services on offer, thus having an indirect effect on the local economy.

Another effect of establishing starch production from *Bruguiera gymnorrhiza* hypocotyls in West Seram District would be the utilization of the *Bruguiera gymnorrhiza* mangrove stands. These stands which have been unexploited up to now could then used to provide economic benefits. The advent of the *Bruguiera gymnorrhiza* starch industry would mean increasing use of *Bruguiera gymnorrhiza* hypocotyls and would therefore increase community awareness and communities living around the mangrove ecosystem should become more careful not to exploit the mangroves indiscriminately and even begin to care for and maintain their mangroves to ensure a continuous supply of "raw materials for starch production"

The business plan for this industry includes working with local communities to obtain the *Bruguiera gymnorrhiza* hypocotyls as the raw material for starch production, so that the *Bruguiera gymnorrhiza* hypocotyls which had been valueless would provide economic benefits for local people.

4. Conclusion

The technical feasibility analysis shows that West Seram District has potential for the development of a *Bruguiera gymnorrhiza* starch industry because raw materials are abundant there. The market opportunities for *Bruguiera gymnorrhiza* starch are quite good, because a large proportion of starch needs are still provided through imports. West Seram District has more extensive mangrove forests than the other districts in Maluku Province which have mangrove ecosystems, and also has the status of a "*Kawasan Ekonomi Khusus*" (Special Economic Zone) with access to industries which require starch as a raw material.

The financial viability analysis produced an NPV of 90,011,325, a Net B/C of 1.1 and an IRR of 4.81 %. Therefore it can be concluded that it would be financially viable to establish an industrial plant to produce *Bruguiera gymnorrhiza* starch in West Seram District.

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