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Optimization production model and financial feasibility analysis on planning of integrated lontar sugar industry in Rote Ndao, East Nusa Tenggara, Indonesia

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Abstract. *Fahrizal, Jasman, Nggadung Y, Kartiwan. 2020. Optimization production model and financial feasibility analysis on planning of integrated lontar sugar industry in Rote Ndao, East Nusa Tenggara, Indonesia. Trop Drylands 21: 25-30.* In general, lontar (*Borassus flabellifer*) sugar consists of molded sugar and crystal sugar produced from lontar sap. Both types of sugar can be produced together in one business unit, but in fact, most home industries produce them partially. This research aimed to obtain an optimization of production model and financial feasibility of integrated lontar sugar industry. The linear programming optimization method was used to determine the optimal amount of molded and crystal lontar sugar production with the objective function of profit maximization. The model was validated on lontar sugar home industry in Rote Ndao District, East Nusa Tenggara Province, Indonesia. Scenario of price change and interest rates were used to measure the level of sensitivity of financial feasibility. The results showed that a maximum profit of IDR 186,741 was obtained by producing 47.25 kgs of molded sugar and 57.93 kgs of crystal sugar every day. The financial feasibility analysis of IRR, NPV, and BC indicators showed that the project was still feasible when the sugar price fall down by 10%, the price of lontar sap increased by 20%, and interest rates rose to the level of 24%.

Keywords: Financial feasibility, lontar sugar industry, optimization production model

INTRODUCTION

The main objective of industrial activity or business is to obtain the maximum profit by maximizing revenue and minimizing cost (Budiasa et al. 2012; Priyanto 2008; Sukanteri et al. 2013; and Soedjana 2007). The maximum profit can be achieved through product diversification in one integrated business unit. Diversification can be performed in the form of diversifying the types of products produced (horizontal integration) or further processing to produce other products (vertical integration).

In the production process, the final product can be obtained from a number of inputs of raw materials. Jonnson (2008) divides the production process into various groups, including the final product that can be produced from the same source of raw materials. For example, molded sugar and crystal sugar can be produced from the same source of raw material, i.e. lontar sap (*Borassus flabellifer* L.). Molded sugar is brown sugar that is produced from the process of evaporation of lontar sap and then molded in a certain shape using any tools made of lontar leaf while the crystal sugar is produced in the form of small granules like flour. Besides the shapes, the main difference between the two products is production/ processing time, economic value, shelf life, and taste.

Lontar sugar is an agro-industrial product that is produced through the activity of processing the lontar sap through mechanical and chemical processes. Stages of processing carried out depends on the type of sugar produced. The initial stage in the production of both molded sugar and crystal sugar is collecting the sap and then filtering it. This process aims to separate the impurities for example twigs, leaves, and insects from the sap. Further, the evaporation process is carried out by cooking the sap on the stove using firewood until it thickens. After stirring, thick sap is immediately put into a circular mold, and is called molded sugar or *gula lempeng*.

The steps of making crystal sugar are longer than those of molded sugar. When the sap has been thickened, it is then cooled while stirred so that the crystallization occurs. Next, scouring is done to avoid clumping which may reduce the size of the crystal granules. Sieving, a mechanical size separation process (Toledo 2007), is done to produce the desired size of crystal granules. Crystal sugar produced at this stage still has high water content, so it needs to be dried. Drying process may be done naturally in the sun or using an oven. The moisture of crystal sugar is very influential on shelf life. In the drying process, clumping may occur, so it needs to be sieved again. At this stage, crystal sugar produced is separated into two, the first are those pass the sieve that matches the desired size, and the second are those not pass the sieve.

The production of lontar sugar at the level of home industry is carried out partially; meaning that the making of molded sugar and crystal sugar is performed separately. The facts show that business units managed in this way are susceptible to risk of failure, inefficient use of resources, and ultimately reduce the benefits obtained.

Integrated business system is one of the strategies to maximize revenue. Integrated system in lontar sugar production is defined as an effort to produce molded sugar and crystal sugar in one business unit, home industry for example. Limited resources factor is an important reason for the need for an integrated business system. A number of studies have shown that an integrated business system can maximize revenue (Budiasa et al. 2012; Priyanto 2008; Sukanteri et al. 2013; and Gradiz et al. 2007) and minimize risk (Soedjana 2007), also provided added value (Kusumastuti et al. 2015).

The maximum profit in a business can be known by using optimization methods, for example, linear programming optimization. This method is a formal mathematical technique that selects the combination and level of activities of all plausible activities without ignoring the availability of resources and other specified constraints. A number of studies have been using linear programming, for example, Gradiz et al. (2007), in calculating economically integrated production between sugarcane cultivation and livestock. Budiasa et al. (2012); Sukanteri et al. (2013) used a linear programming approach for optimization of integrated farming systems. Abbas and Indriani (2010) used linear programming to optimize the production process of food products.

Mathematically, the problem of linear programming is generally stated as follows (Cohen and Cyert 1976):

Maximize:

$$Z = \sum_{j=1}^{n} c_j x_j \tag{1}$$

Constraints to:

$$\sum_{j=1}^{n} a_{ij} x_j \{\leq = \geq\} b_i ; i = 1, 2, \ldots, \tag{2}$$

$$x_j \geq 0 ; j = 1, 2, \ldots, \tag{3}$$

Where Z in equation (1) is the objective function; x*j* is the activity or decision variable; c*j* is the contribution of activity *j* to the value of the objective function; a*j* is the i-th resource unit used or i-th output unit produced per activity unit of *j*; and *bi* is the level of available resources or minimum requirements for each obstacle. Equations (2) and (3) respectively are a collection of constraints and non-negative conditions that must be met in the optimization process.

Essentially, planning is a process of preparing a set of decisions that are carried out in such a directed and systematic manner that goals can be achieved effectively and efficiently (Fahrizal 2015). In an effort to maximize the economic potential of lontar trees and the revenue of lontar sugar business, it is necessary to set planning of the integrated of molded and crystal lontar sugar home industry, especially in the aspects of production and assessment of financial feasibility of investment, as well as strategies for maximizing benefits.

MATERIALS AND METHODS

Research design

This research refers to problem-solving methods using a system approach. The system approach is an organizational analysis approach using system characteristics as a starting point for analysis. The study was designed to consist of two stages. Stage 1 was the preparation of an optimization model of molded sugar and crystal sugar production. The output data of the optimization model of molded sugar and crystal sugar production were used to perform stage 2, i.e. financial feasibility analysis for the integrated molded and crystal lontar sugar industry.

The flow diagram of developing the sugar production optimization model and financial feasibility is presented in Figure 1.

Data collection

The research was carried out in the lontar sugar home industry, Duadolu Village and Oetutulu Village, Rote Barat Daya District, Rote Ndao District, East Nusa Tenggara Province. Both of these villages are production centers of molded sugar and crystal sugar in Rote Ndao District. Data collection used literature study methods, field observations, interviews, filling out questionnaires and depth interviews with a number of experts who are considered to have knowledge of molded and crystal sugar. The collected data was then analyzed qualitatively and quantitatively.

Data processing and analysis

The stages of compiling the optimization model of integrated molded and crystal sugar production are as follows: developing the objective function, namely revenue maximization, then formulating the constraint function, consisting of constraints of production capacity, number of requests, number of workers, number of fuelwood and integer number constraints. The next step is calculating the amount of molded and crystal sugar production using linear programming method.

The formulation of the optimization model of molded sugar and crystal sugar production is stated as follows:

Maximize:

$$Z = H_{GC} X_1 + H_G \tag{4}$$

Constrains :

$$aX_1 + bX_2 \leq \tag{5}$$

$$cX_1 \leq GC ; dX_2 \leq \tag{6}$$

$$eX_1 \leq GC ; fX_2 \leq \tag{7}$$

$$gX_1 + hX_2 \leq \tag{8}$$

$$X_j \geq 0 ; j = 1,2 \tag{9}$$

Where:

Z = Maximum amount of revenue
HGC = price of molded sugar (IDR kg^{-1})
HGS = price of crystal sugar (IDR kg^{-1})
X1 = molded sugar production (kg day^{-1})
X2 = crystal sugar production (kg day^{-1})
GC = molded sugar could be partially produced (kg)
GS = crystal sugar could be partially produced (kg)

a = yield of molded sugar (%)
b = yield of crystal sugar (%)
NL = amount of lontar sap available (kg)
c = molded sugar demand (%)
d = crystal sugar demand (%)
e = molded sugar workforces
f = crystal sugar workforces
g = firewoods for molded sugar (kg day^{-1})
h = firewoods for crystal sugar (kg day^{-1})
KB = the amount of firewoods available (kg)

Equation (4) is an objective function; equation (5) is a constraint function of production capacity; equation (6) constraint of requests number; equation (7) labor constraints equation (8) firewood constraint; and equation (9) is a constraint of integer numbers or non-negative conditions that must be met in the optimization process.

Data input for optimization model is processed using the application program LINGO 12.0 *Lindo System Inc*. Data analysis was carried out by linear programming. Input data of investment feasibility models were analyzed using indicators of NPV, IRR, and BC ratio eligibility.

RESULTS AND DISCUSSION

Lontar sugar production

Lontar sugar production consists of two main activities, namely tapping and processing the sap (cooking sap into sugar). Marketing sugar is the next activity after production. These three activities are carried out by the home industry producing lontar sugar. Thus the lontar sugar business consisted of on-farm and off-farm activities. Sugar production is driven by the amount of sap collected.

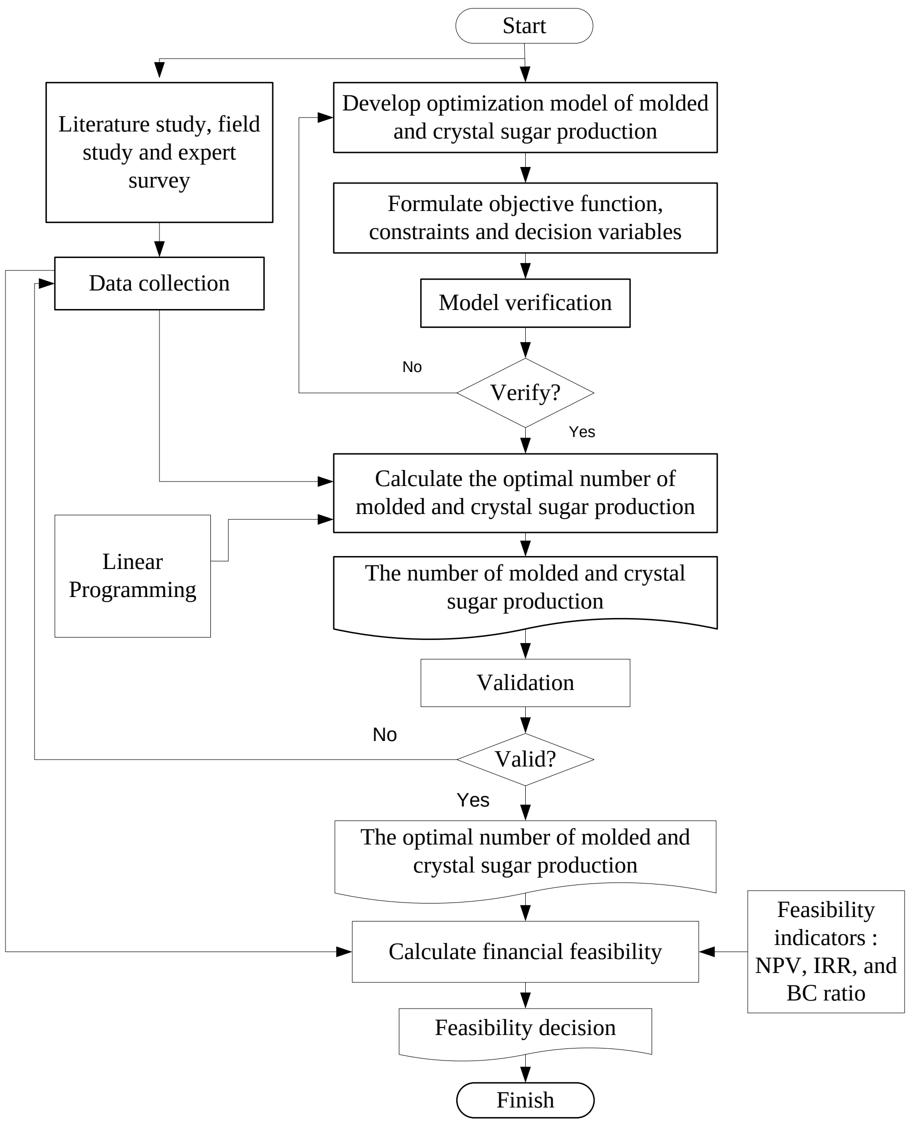

Figure 1. Stages of the research

The amount of sap collected is determined by the number of productive lontar trees, the number of flowers of each lontar tree, and the productivity of the flower. The study showed that the average number of tree ownership was 20, the average number of inflorescence (*mayang*) flowers per tree was 5, and the average productivity of flower was 2.5 liters of sap per day. Thus, the average of sap production was 12.5 liters per day per tree, or 250 liters for 20 trees. The amount of this sap is assumed to be constant during the sugar production season, from April to end of November every year.

Sugar yield is calculated from the ratio of the total sugar weight obtained to the total sap weight cooked. The result of calculation showed that the molded sugar yield was 15% with moisture content of 8.6%, while the crystal sugar yield was 13.8% with a moisture content of 2.68%. The water content of the two sugars are still suitable for the required limits of a maximum of 10% for molded sugar) and 3% for crystal sugar (National Standardization Agency of Indonesia 1995). The sugar production capacity then can be calculated or predicted based on the yield and the total sap obtained (Fahrizal 2015).

The activity of making sugar starts at 04 am. It starts with collecting sap from lontar tree, filtering the sap, and then cooking it into sugar on a stove heated using firewood, usually *kosambi* (*Schleichera oleosa*) wood. Firewood was bought as much as 4 cubic meters every 14 days (assuming 1 cubic is equivalent to 1000 kg). The firewood consumption for the production of molded sugar and crystal sugar is not the same. Based on the interview of farmers, the consumption of firewood is approximately 0.7 cubic for molded sugar and 0.8 cubic for crystal sugar per 3 days. This value then was used to estimate the amount of firewood consumption per day.

There are 3 workforces involved in making molded sugar, i.e. 1 tapper and 2 cookers as well as molding and packaging the sugar. Production of crystal sugar needs 4 workforces, i.e., 1 tapper, 2 cookers and at stage of refinement, it requires 1 workforce. On average each home industry has 5 workforces.

Lontar sugar products are sold at traditional markets every Wednesday and Friday. The sale is made after the activity of making lontar sugar is finished. Molded sugar is sold in units of pieces, while crystal sugar is in units of volume. No sales in weight units. When the units are converted, the price of molded sugar is IDR 15,000 per kg, while the crystal one is IDR 20,000 per kg. The sugar offered is not always sold out. The amount sold out fluctuated, depending on the demands. In general, the demand for molded sugar is higher than that of crystal one. Historical data on the exact number of requests is not available, therefore, a judgment approach is used by the home industry namely 90% for molded sugar and 80% for crystal sugar.

Production optimization of molded sugar and crystal sugar

Determination of the optimal amount of molded sugar and crystal sugar production was carried out in an integrated manner using the single objective optimization approach with the objective function of maximizing profits. There are two decision variables used, namely the amount of molded sugar and crystal sugar production. The formulation of constraint functions in the optimization model was developed based on the results of interviews with lontar sugar industry players and supported by direct observations in the field.

Linear programming optimization method was used to determine the optimal amount of molded and crystal sugar production. According to Taha (2003), linear programming is a mathematical method in allocating limited resources to achieve a goal such as maximizing profits and minimizing costs. The results of optimization showed that maximum profit possibly obtained was IDR 186,741,- per day. This value can be achieved by producing 47.25 kg of molded sugar and 57.93 kg of crystal sugar per day.

Analysis of financial feasibility

The financial feasibility analysis was carried out on the planning of the integrated molded sugar and crystal sugar industry of home industry scale in Rote Ndao District, ENT Province. The establishment or exploitation of the lontar sugar industry can be done by Village-Owned Enterprises (BUMDES), Regional-Owned Enterprises (BUMD), or private companies. The management model of the lontar sugar industry is a partnership system, which includes buying sap from farmers or tappers, then processing it into molded sugar and crystal sugar. The estimated investment cost is IDR 350,000,000. This fee is intended for the purchase of land, buildings, machinery and equipment, vehicles, and supporting facilities. Capital is obtained from bank loans as much as 60% of the total capital with a 10-year payback period with an interest rate of 12% per year. The remaining 40% is their own capital. Prices and costs of calculating financial feasibility are those that are applied at the time of calculation. In this analysis, product demand was stable, products were sold out at the end of each year, and throughout the life of the project. The assumptions used in the calculation of the financial feasibility analysis are presented in Table 1.

Table 1. Assumptions used in the calculation of the financial feasibility analysis

Description	Value
Investment (IDR)	350,000,000
Operational cost (IDR year^{-1})	362,135,000
Fixed cost (IDR year^{-1})	332,135,000
Variable cost (IDR year^{-1})	30,000,000
Revenue (IDR for 10-years)	5,773,462,500
Interest rate (% pa)	12
Length of investment (years)	10
Number of production days	8 months (± 245 days)
Molded sugar yield (%)	15
Crystal sugar yield (%)	13,8
Price of molded sugar (IDR kg^{-1})	15.000
Price of crystal sugar (IDR kg^{-1})	20.000
Price of lontar sap (IDR liter^{-1})	1.050

Table 2. Results of financial feasibility sensitivity analysis using scenarios

Scenario criteria	NPV	BC ratio	IRR (%)	PBP (years)	Conclusion
The price of molded sugar and crystal sugar fall as much as 10%	244,625,986	1.10	13.60	2.11	Feasible
Increase of interest rate as much as 24%	181,793,784	1.09	12.01	1.63	Feasible
Increase of price of lontar sap as much as 20%	190,925,898	1.06	10.43	2.46	Feasible
Increase of price of lontar sap as much as 30%	-15.005.407	1.00	0.89	-	Not feasible

The results of financial analysis found that at a discount rate of 12% the NPV value was IDR 561,265,811. A positive NPV means that the integrated lontar sugar industry is feasible. IRR value of 28.46% means that the project is feasible because it is greater than the specified bank interest rate which is 12%. BC ratio value was 1.21. This value is greater than 1, meaning that the integrated lontar sugar industry is feasible. The sensitivity analysis was then performed using a scenario by reducing sugar prices by 10%, raising interest rates by 24%, and raising lontar sap prices by up to 30%. The results of the sensitivity analysis are presented in Table 2. The results of the sensitivity analysis of the three components indicated that the business is no longer feasible if the price of lontar sap rises to 30% from the stipulated base price of IDR 1,050 per liter.

Discussion

Production of molded sugar and crystal sugar can be done together because the raw material is the same and the production process is not much different. The stages of crystal sugar production process are more numerous, because, after the evaporation process, it is continued with the process of cooling, crystallization, size reduction, sieving, and drying. Meanwhile, molded sugar was shaped immediately after the evaporation process. Production equipment was also not much different. The making of crystal sugar used more equipment because the production process stages are also more numerous. A number of production equipment can be used together, such as kitchens, filtering, and evaporation equipment. Thus, it can reduce investment costs. The skills to make molded sugar and crystal sugar are almost the same, so that home industry can make them. This is the main reason for these two products can be made together in one business unit.

Production of lontar sugar takes place twice a day, i.e. morning and afternoon. Based on optimization of production model, to get maximum profit, the manufacture of molded sugar and crystal sugar can be done together at one time or partially. The number of productions was 47.25% for molded sugar and 57.93% for crystal sugar respectively. The percentage of production will be obtained by separating thick sap into two parts after evaporation process. One part is for crystal sugar and another for molded sugar. Production of lontar sugar can also be carried out alternately, such as crystal sugar in the morning and molded sugar in the afternoon. The second alternative is more difficult to implement because the amount of sap is relatively the same.

Optimization of sugar production used a linear programming approach. The model was validated in the planning of lontar sugar home scale industry in Rote Ndao District, East Nusa Tenggara Province. Based on the optimization result, maximum profit of IDR 186,741 per day was obtained. This value is highly dependent on the variable productivity of sap, sap price, yield of lontar sugar, price of sugar, availability of firewood, and demand.

The maximum profit value was obtained from the optimization result, becomes a reference for analyzing financial feasibility, using indicators of Net present value (NPV), Internal rate of return (IRR), and Benefit-cost and ratio (BC Ratio). The results of the feasibility analysis found that the integrated lontar sugar industry is feasible to be implemented. In the feasibility analysis, the most influential factor is the price of sap. In this model, the price of sap is determined by the supplier farmer and value is constant. In reality, this value can change. Changes in sap price will have impact on the feasibility of establishing an integrated lontar sugar industry. Therefore, the recommendation of the research is to develop a model for determining the price of lontar sap. Fluctuation of lontar sap price will be inputted in determining the selling price of sugar, as well as an evaluation of the feasibility indicators.

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