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RESEARCH PAPER

Optimization of production plan and profit maximization of value added products of tapioca – Linear programming model

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ABSTRACT

Tapioca crop is suitable for manufacturing the starch. The major value addition products are starch, sago, wafers, animal feed, glucose, gum etc. Linear programming for profit maximization was used in this study. The results could be observed from the study that more amount was spent for electricity, building and machineries, packing materials and fuels. To obtain an optimum production and also to maximize the net returns from the ten different product grades of the starch, sago and wafers, a linear programming model was used. Among the various value added products by utilizing 100 kg of starch, Starch – edible, Sago - super fine and Wafers – white were the value added products suggested. The optimum level of these three products would maximize the profit to level of Rs.360.25 when 100 kg of starch was put into value addition. The optimization of these activities with the limiting resource endowment would thus, indicate that possibilities still existed to further improve the profitability of the units by utilizing that already manufactured starch into more value added products especially starch edible, sago super fine and wafer white. Major problems faced by processors were shortage of electricity, non-availability of good quality tubers, scarcity of labour and non-availability of storage facility for tubers.

KEY WORDS : Starch, Sago, Wafers, Production, Linear programming, Constraints for processors

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Though the processing and production centers for different value added products of tapioca namely, starch, sago, alcohol, animal feed and wafers are concentrated in South India. Tamil Nadu State stands first in respect of processing of tapioca into starch and sago. In India, Sago was produced first in Salem in 1943-44.

Starch is the most important value added product produced from tapioca. Starch is mainly used in the textile industry, in making adhesives, in pharmaceuticals, in paper industry, in confectionery industry etc. 90 per cent of the cassava starch produced in India is from Tamil Nadu. Starch market in Tamil Nadu is semi-organized. 50 per cent of starch is marketed through a well-organized co-operative marketing system under the name SAGOSERVE (The Salem Starch and Sago Manufacturers Service Industrial Co-operative Society Ltd.) and the remaining quantity is marketed directly or through commission agents by the processors to the wholesalers. Traders and primary wholesalers participate in the secret auction for purchasing the starch. These are available starch in three grades like Textile grade, Edible grade and Glucose grade.

Sago is an important value added product from tapioca. They are Payasam, Khichdi, Upma, Bonda are different items prepared by using sago. Sago is used mostly as baby food in West Bengal. In the remaining parts of the country, it is consumed mainly in preparing payasam and wafers. Sago is available in four grades such as Super fine. Milk, Super and Best.

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Majority of sago production units are located in Tamil Nadu. About 60-70 per cent of sago produced in India are from Tamil Nadu. 60 per cent of sago produced in Tamil Nadu were marketed through SAGOSERVE and the remaining were done through direct sales. Majority of sago millers are members of the SAGOSERVE society. Traders and primary wholesalers participate in the secret auction for purchasing the sago.

Wafers are another important value added products from tapioca starch, 100 wafer making cottage industries are functioning at Namagiripet taluk of Namakkal district in Tamil Nadu. These wafers are marketed through WAFERSERVE (The Namagiripet Tapioca By-products Industrial Cooperative Service Society Ltd.). Demand for wafers are more in northern states like Delhi, Gujarat and Uttar Pradesh. Involvement of brokers are limited in this trade. Wafers are availed in three forms like wafers colour, wafers white and wafers chilly.

Objectives:

–To analyze the economic production of starch, sago and wafers in Tamil Nadu.

–To analyze the optimal production plan and profit maximization in value addition of tapioca product.

–To identify the challenges faced by processors and suitable measures to fill the gap in tapioca processing.

Dogains and Sarimveis (2007) reported that the linear programming model is taken into account of all the standard constraints encountered in production scheduling (material balances, inventory limitations, machinery capacity, labour shits and manpower restrictions). The model is applied to optimal production scheduling in a single yogurt production line for major dairy industry. Hassan *et al*. (2001) noted that the linear programming model is highly effective at the level of solving the blending problem. This research has shown that the developed linear programming model for the blending problem has yielded better overall Naphtha productivity for the case of the oil refinery. Koch and Sebastian (2008) reported that in wood processing industry, the cutting process in which wood log is cut down in order to provide the items required by the customers in the desired qualities, size and quantities. In order to reduce the cost of cutting process, a decision support tool was developed which incorporated a linear programming model. Pullan (1997) revealed that linear programming problem served as useful model for various dynamic network problems where storage is permitted at the nodes. He demonstrated this by modeling some hypothetical problems of water distribution, transportation and telecommunications. Sudha *et al*. (2008) indicated that a management strategy with deficit irrigation by supplying less water in non-critical growth period and maximum water during stress sensitive periods were the best viable solution for better performance in Bharathapuzha river basin of Kerala. A linear programming (lp) model, was used to ensure that the reservoir did not spill before reaching its capacity. Zhu and Yao (2011) reported that linear programming (lp) model was formulated as a mixed integer linear programming for determining the locations of warehouses, the size of harvesting team, the type and amounts of biomass harvested/ purchased, stored and processed in each month, the transportation of biomass in the system and analyzed the relationship of the supply capacity of biomass feedstock's to the output and cost of biofuel.

METHODOLOGY

The processors (50) were randomly selected from the list of processors operated in districts. In order to study the value addition and preference of various by products from tapioca, 10 industrial consumers were also selected randomly from the list obtained from Wafers Serve. The primary data were collected from the sample respondents during the month of January, 2012.

Analytical framework:

Optimal production plan and profit maximization:

In order to arrive at an optimum production plan that would maximize the net return by processing, a given quantity of starch (the basic raw material used for further processing into different value added products), a linear programming model of the following form was proposed in this study:

Maximize

$$\text{Max } Z = \sum_{j=1}^{n} C_j X_j$$

Subject to,

$$\sum_{j=1}^{n} a_j X_j \leq b_i$$

(j=1,2... ... .n)

(i=1,2... ... .n)

$$X_j \geq 0$$

where,

Z= Aggregate profit from all the ten activities

a_{ij} – Amount of i^{th} input required to produce one unit of j^{th} activity (input co-efficient)

c_j – Profits from j^{th} activity (Rs./qtl)

X – Level of activity j (products grade).

In this study, ten activities *viz.*, starch textile grade, starch edible grade, starch glucose grade, sago super fine grade, sago milk grade, sago super grade, sago best grade, wafers colour grade and wafers white grade, wafers chilly grade were considered:

b – Constraints

b_1 = Labour (man days)

b_2 = Water (litre)

b_3 = Raw materials required (kg)
b_4 = Electricity (hours)
b_5 = working capital requirement (Rs.).

Garret's ranking technique:

Garett (1965) suggested a scoring technique procedure for converting the ranks in to scores when the number of items ranked from respondent to respondent. The ranks assigned by the respondents were converted into per cent position by using the formula:

$$\text{Percentage position} = \frac{100\,(R_{ij} - 0.5)}{N_j}$$

where,

R_{ij} = Rank given for i^{th} factor by j^{th} individual
N_j = Number of factors ranked by j^{th} individual.

ANALYSIS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Production of starch and sago from raw tuber:

The details of cost incurred in processing of raw tubers into starch and sago are presented in Table 1. In order to obtain 90 kg of starch, 346 kg of raw tubers have to be processed. If the raw tubers were processed to obtain 90 kg of sago, 409 kg of raw tubers were to be processed. Based on this conversion factor, the cost of production of starch and sago with the cost of raw material (tubers) was estimated.

It could be seen from Table 1, an amount of Rs.63.35 was incurred as fixed cost and Rs.1847.45 as variable cost to process raw tuber into 90 kg of starch. Thus, the total cost of production was worked out to be Rs.1910.80 to process 346 kg of raw tuber to obtain 90 kg of starch. The average sale price of starch was Rs.21.63/kg thus, yielding a gross income of Rs.1947.20 and leaving a net profit of Rs.36.40 for 90 kg of starch.

With regard to manufacturing of sago, an amount of Rs.66.30 was incurred as fixed cost and Rs.2221.90 as variable cost to process raw tuber into 90 kg of sago. The total cost of production was worked out to be Rs.2288.20 to process 409 kg of raw tuber to obtain 90 kg of sago. The average sale price of sago was Rs.27.44/kg thus, yielding a gross income of Rs.2469.67 and leaving a net profit of Rs.181.47 for 90 kg of sago.

Production of wafers from wet starch:

Starch is the basic product to manufacture wafers. In this study, wet starch was used as the basic raw material to make wafers. Thus, the cost of production of wafers using wet starch are presented in Table 2.

It could be seen from Table 2, that an amount of Rs.64.06 was incurred as fixed cost and Rs.2123.44 as variable

Table 1 : Cost of production of starch and sago (Rs.90/ kg)

Sr. No.	Particulars	Starch		Sago	
		Amount	Per cent	Amount	Per cent
I	**Fixed cost**				
1.	Building and machines	57.60	3.01	59.50	2.60
2.	License fees	0.25	0.01	0.30	0.01
3.	Insurance and taxes	5.50	0.29	6.50	0.28
	Total fixed cost	63.35	3.31	66.30	2.90
II	**Variable cost**				
4.	Salaries to staff	30.50	1.60	30.50	1.33
5.	Labour	25.75	1.35	32.75	1.43
6.	Electricity	36.75	1.92	82.25	3.59
7.	Repairs and maintenance	15.00	0.79	20.30	0.89
8.	Fuels and oils	33.60	1.76	47.75	2.09
9.	Gunny bags	10.00	0.52	10.00	0.44
10.	Other expenses	35.05	1.83	35.15	1.54
11.	Raw material cost (raw tuber)	1660.80	86.92	1963.20	85.80
Total variable cost		1847.45	96.68	96.68	97.10
Total cost of processing (I+II)		1910.80	100.00	2288.20	100.00
Sale price		1947.20		2469.67	
Net profit		36.40		181.47	

Table 2: Production of wafers from wet starch (Rs. /90 kg)

Sr. No.	Particulars	Amount (Wafers)	Per cent
I	**Fixed cost**		
1.	Building and machines	40.63	1.86
2.	License fees	1.56	0.07
3.	Insurance and taxes	21.87	1.00
	Total fixed cost	64.06	2.93
II	**Variable cost**		
4.	Salaries to staff	43.75	2.00
5.	Labor	100.00	4.57
6.	Electricity	60.94	2.79
7.	Repairs and maintenance	43.75	2.00
8.	Fuels and oils	125.00	5.71
9	Gunny bags	156.25	7.14
10.	Other expenses	31.25	1.43
11.	Raw material cost (wet starch)	1562.50	71.43
Total variable cost		2123.44	97.07
Total cost of processing (I+II)		2187.50	100.00
Sale price		2999.70	
Net profit		812.20	

cost to process wet starch into 90 kg of wafers. The total cost of production was worked out to be Rs.2187.50 to process 156.25 kg of wet starch to obtain 90 kg of wafers. The average sale price of wafers was Rs.33.33/kg thus yielding a gross income of Rs.2999.70 and leaving a net profit of Rs.812.20 for 90 kg of wafers.

Optimal production plan for processing units:

In order to arrive at an optimum production plan that would maximize the net return of the processing units, linear programming technique was applied in this study. The input-output co-efficients and constraints were specified based on the averages obtained from the sample processing units.

Choice of typical processing unit:

To be more realistic, a typical processing unit would be preferred to synthetic situations. Hence, it was necessary to identify a processing unit which could represent the overall sample processing unit. Representativeness is referred here as situations which could by and large match the other units in terms of capacity and other resource endowments. In the present study, average capacity of the unit was considered while selecting the representative processing unit. The model was fitted to the data collected from processing units manufacturing starch and used this starch as only the base raw material for sago and wafers production.

Bringing together all the estimates of parameters of the linear programming models, initial technological matrix was formulated. The technological matrix included the value added activities namely, ten different product grades for starch, sago and wafers that were carried out by the sample processing units. The "TORA" statistical package was employed to fit the linear programming model and used to solve. The results obtained are presented in Table 3.

It could be seen from Table 3 that among the various value added products by utilizing 100 kg of starch, Starch – Edible, Sago - Super fine and Wafers – White were the value added products suggested. The optimum level of these three products would maximize the profit to the level of Rs.360.25 when 100 kg of starch was put into value addition. Among the various constraints, the quantity of starch required to convert into respective grades of starch and also other value added products like sago and wafers, electricity and working capital required were the limiting factors which had the shadow prices.

The optimization of the activities with the limiting resource endowment would thus, indicate that possibilities still existed to further improve the profitability of the units by utilizing the already manufactured starch into more value added products especially starch edible, sago super fine and wafers white.

The appropriateness of the linear programming methods

Table 3 : Optimal choice among different value added products from starch

Sr. No.	Activities	Objective co-efficients	Levels	Objective value contribution
1.	Starch – Textile	220	0.00	0.00
2.	Starch – Edible	270	0.69	186.14
3.	Starch - Glucose	235	0.00	0.00
4.	Sago - Super fine	320	0.07	23.29
5.	Sago – Milk	260	0.00	0.00
6.	Sago – Super	240	0.00	0.00
7.	Sago – Best	235	0.00	0.00
8.	Wafers - Colour	190	0.00	0.00
9.	Wafers - White	220	0.69	150.82
10.	Wafers - Chilly	170	0.00	0.00
	Objective function (maximum)			360.25

Table 4: Problems faced by the processors in tapioca processing

Sr. No.	Reasons	Score	Rank
1.	Electricity power	62.50	I
2.	Non-availability of tubers round the year for processing (seasonal)	61.50	II
3.	Scarcity of labour	39.20	III
4.	Improper infrastructure facility during rainy days	37.45	IV
5.	Non - availability of storage facility for tubers	35.45	V

for resource allocation in the processing units has been demonstrated in this study. This is evident from the results obtained from the profit maximization type of Linear programming model fitted to the data collected from ten different product grades for starch, sago and wafers. The results thus showed that if the processing unit produces 100 kg of starch the optimum level for the firm to receive the maximum possible profit would be Rs.360.25. The constraints like labour, quantity of water required, quantity of starch required, electricity hours and working capital were faced by precessors.

Problems faced by the processors in tapioca processing:

Problems faced by the processors are shown in Table 4. Main problems faced by them were electricity. Non- availability of tubers round the year was the second major constraints. All round the year it is not possible for production of tapioca by farmers because it requires eight months to mature. Tuber availability is reduced during the month from April to July. Scarcity of labour is another constraint faced by the processors particularly during the processing of tapioca tubers. The rainy days is the next constraints faced by the tapioca processors. Because, starch product needs to dry in the drying yard to remove the moisture content present in it. Non - availability of storage facility for tubers was the next constraints faced by the processors.

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