Inventory Management for the Reduction of Material Shortage Problem for Pasteurized Sugarcane Juice: The Case of a Beverage Company

Roongrat Pisuchpen
Faculty of Engineering, Industrial Engineering, Kasetsart University, Bangkok, Thailand
Email: fengros@ku.ac.th

Papatsaraporn Rienthong
Faculty of Engineering, Engineering Management Program, Kasetsart University, Bangkok, Thailand
Email: pumhup@hotmail.com

***Abstract*—This research is intended to study the techniques of forecasting seasonal customers' needs of sugar cane juice by using time series analysis. The results of the forecast are the quantities of overall sales of the 12 months from January 2016 to December 2016, calculated to seek for seasonal sugarcane juice and related trends by concerning the limits of manufacturing capacity, costs, and related services to save costs and generate profits. The calculation for the incurring expenditures from the process of ordering raw materials and improper inventory management is done by using Linear Programming. The study seeks the lowest total cost of 5,707,362 THB. When comparing the new results with the old system, 428,381.20 THB/year will be saved in terms of freezing storage .**

***Index Terms*—forecasting, inventory management, linear programming**

I. Introduction

Nowadays, the economy is in a recession and unstable stage due to external factors, which inhibit small, medium and large industries from developing and improving the quality of their products and services. However, if the industries are only thinking of quality competition, they will not be able to maintain their current business. Therefore, it is essential they consider other factors altogether such as product price, and punctual and quick shipping of their goods. Additionally, they need to manufacture products that meet customer's needs and expectations while managing costs in order to maximize profits. They also need to increase sales, reduce costs and improve product quality and punctual delivery of products due to the fact that it is difficult to increase sales under the current economic recession.

The Beverage Company is the one processing seasonal agricultural products. Oversupply or undersupply of raw materials can affect the profits. As a result, inventory management is necessary to produce the amount of goods necessary to be able to supply the market throughout the year while incurring the lowest storage cost.

Currently, the company is aiming for inventory storage of 1,000 CC. pasteurized sugar cane juice because of the sales and its physical characteristics of long storage period. Generally, pasteurized sugar cane juice can be kept for 20 days under the temperature of 4 °C or for 1 year under -18 °C. Nevertheless, the cost for the storage has increased every year to meet the demand of the goods. The management of frozen goods is not yet optimized, resulting in high cost of purchasing raw materials during the period from July to October. To solve the inventory problem, the forecast is a tool that can help improve the management of raw materials. Linear Program is applied to determine an adequate stock of processed goods in order to fulfill sales throughout the year under the constraint of a daily product.

The Purposes of the research are as follows:

1. To forecast customer demand by using the time series analysis for the optimized sales of pasteurized sugar cane juice.
2. To calculate the inventory storage to meet customers' demand to yield the lowest cost of production.
3. To find the most proper procedures to order raw materials and proper management of inventory storage by using Linear Program under constraints the seasonal demand.

II. Literature Review

Donselaar *et al.* [1] show the difference between quick and slow perishable goods in order to understand some important parameters. The difference between those goods is product lifetime; easily perishable goods have shorter lifetime. Easily perishable goods have 30 day lifetime, which depends on sales, and logistics of the goods in different terms such as average weekly sales, the coefficient of deviation of weekly sale, the frequency of

Manuscript received March 28, 2017; revised June 24, 2017.

doi: 10.18178/ijlbpr.6.1.1-6

shipping, product lifetime, the average size of package as a consumer unit, the minimum storage of products, the agricultural forecast, the relation among other activities that can't be anticipated such as drought, famine or flood. In the past, the shipping process relied on 2 factors: first, farmers needed to develop agriculture for a short term because it would be slower in a long biological term for production. Second, as for the planting cycle, the production was evaluated monthly or annually in terms of quantity and quality in a year which fluctuates accordingly to seasons [2].

The process to forecast sales and production to increase the possibility of forecasts for other beverage industries should be both long and short in terms of the source of information and responsibility to the forecast as shown in figure1.

To summarize**,** wine production [2] needs study and application of forecast of long and short term. According to the study of subjective and scientific methods, they both are involved with the forecast of the productivity of grapes in order to be more precise. Nevertheless, quantitative study should be conducted by using other additional factors. This study also displays the whole picture and constraints of qualitative study.

Ahumada and Villalobos [3] introduced a model for planning on a short term decision for the fresh food industry. The development of this application offers high incomes to farmers. The production and the extension of the harvesting season from the plan clearly shows a significant saving on the fresh food management, higher wages and more product shipping for farmers.

Inventory can be categorized into 4 groups: raw materials and pieces of them that are ordered, inventory from the production process, finished products and inventory of raw materials that are tools for maintenance [4].

III. EXPERIMENTS

According to the whole purposes of this research, it is for improving the standards and the methods of proper control of inventory to reduce oversupply and undersupply of pasteurized sugarcane juice.

A. *Collection of Quantitative Data*

The sales of 1,000cc Pasteurized sugarcane juice had been collected from January 2011 to December 2015 and arranged onto Microsoft Excel

B. *To Forecast the Main Raw Material and the Demand of Customer for Planning the Productivity is a 1 Year Term*

The methods of forecast are (1) Simple Moving Average (2) Simple Exponential Smoothing (3) Double Exponential Smoothing (4) Holt-Winters Smoothing and Decomposition Method. Each method is conducted with Minitab Program. The forecast can be analyzed to find an optimized method by checking Mean Absolute Deviation, (MAD), Mean Absolute Percentage Error (MAPE) and Mean Squared Deviation (MSD)

The outcome from comparing each forecast methods of fresh sugarcane juice and 1,000cc Pasteurized sugarcane juice is shown in Table I and Table II.

TABLE I. COMPARISON OF EACH FORECAST METHOD OF USING FRESH SUGARCANE AS A RAW MATERIAL

(Method)	values used for	(Mean Absolute Deviation: MAD)	(Mean Square Deviation: MSD)	(Mean Absolute Percentage Error: MAPE)
(Single Moving Average)	2 months	10958	216624820	24
	3 months	11519	219643192	24
	6 months	12648	247066829	28
	12 months	12558	253052803	29
(Single Exponential Smoothing)	(Alpha) = 0.448180	10880	196407969	24
(Double Exponential Smoothing)	(Alpha) = 0.851223	10979	225135254	25
	(Gamma) = 0.018680			
(Classical Decomposition Method) - Additive Decomposition	with trend	8628	145562068	21
(Classical Decomposition Method) - Multiplicative Decomposition	with trend	8724	148746022	21
(Winters Method) - Additive	(Alpha) = 0.1	10359	172384761	26
	(Gamma) = 0.1			
	(Delta) = 0.1			
(Winters Method) - Multiplicative	(Alpha) = 0.1	9135	141449803	22

TABLE II. COMPARISON OF EACH METHOD OF FORECASTING THE SALES VOLUME OF 1,000CC PASTEURIZED SUGARCANE JUICE

(Method)	values used for forecast	(Mean Absolute Deviation: MAD)	(Mean Square Deviation: MSD)	(Mean Absolute Percentage Error: MAPE)
(Single Moving Average)	2 months	5917	59055346	12
	3 months	6957	72031642	14
	6 months	7941	92054070	16
	12 months	7479	87647332	16
(Single Exponential Smoothing)	(Alpha) = 0.904804	5349	49345113	11
(Double Exponential Smoothing)	(Alpha) = 1.19051	5982	56094971	13
	(Gamma) = 0.01000			
(Classical Decomposition Method) - Additive Decomposition	with trend	4398	30686652	9
(Classical Decomposition Method) - Multiplicative Decomposition	with trend	4409	31072021	9
(Winters Method) - Additive	(Alpha) = 0.1	5015	39165043	11
	(Gamma) = 0.1			
	(Delta) = 0.1			
(Winters Method) - Multiplicative	(Alpha) = 0.1	4658	34534751	10

The analysis to select the forecast method is considered from the case study and the result from comparing the precision of MAD together with MAPE and MSE of raw materials and the sales volume. The method used for forecast is Classical Decomposition Method - Additive Decomposition because MAD, MAPE and MSE yield the lowest values when compared to other methods. The forecast of ordering a raw material and customers' demand from January 2016 to December 2016 are shown in Figure 1 and Figure 2 respectively.

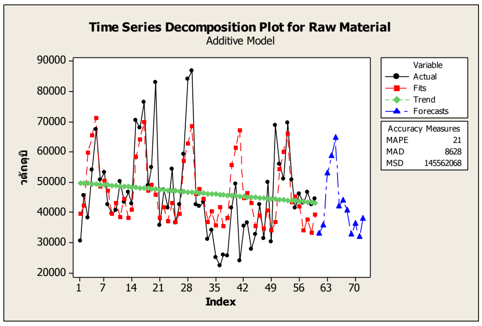

Figure 1. The forecast of using raw materials during January 2016 - December 2016.

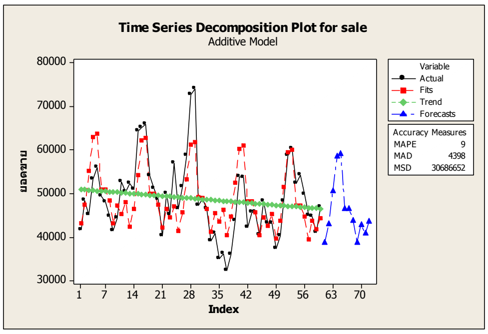

Figure 2. The forecast of the sales volume of 1,000cc Pasteurized sugarcane juice during January 2016 - December 2016.

IV. CONSIDERATION OF RELATED FACTORS

The related factors and limitation for Pasteurized sugarcane production are considered to control the inventory of the raw materials used for productions in order to minimize the cost. Moreover, the policy of controlling the inventory of finished products is implemented with the model.

To begin the process of producing 1,000cc Pasteurized sugarcane juice, Packs of 10 kilograms of fresh sugarcane juice stored under 15 ℃ are required to be unpacked. Then, the juice is first filtered at 80 meter/inches' square, and is later sent to resting buckets and is chilled to 10 °C. Next, it's moved to the second filter at 80 meter/inches square and the production process is paused for Pasteurization at 80-85 ° C for 20 seconds. Then, its temperature is dropped to 0-8 ° C in the resting buckets before being packaged with 2 automatic packaging machines. Finally, it is stored in the freezer at 0-4 °C, and eventually is shipped to customers.

The factory used in this case study has 1 Pasteurizing machine for producing the juice. To produce 1,000 cc Pasteurized sugarcane juice, fresh sugarcane juice is only used for Pasteurization and being packaged to be shipped to customers as shown below.

- Productivity (kilogram /month) = Productivity of a machine x running hours x Yield. Productivity of 1000cc Pasteurized sugarcane = 1 x 8 x 2 6 x 0.95 = 197,600 kilogram /month
- Cost of production per unit = 2.331 THB/kg.
- Cost of storage under 0 °C = 1.8 THB/kg.
- Cost of storage under -18 °C 1 month first = 2.6 THB/kg.
- Cost of storage under -18 °C over 1 month = 1.6 THB/kg.
- Capacity for a storage room under 0 °C = 12,000 kg.

- Beginning inventory Quantity Dec15 = 3,094 kg.
- Raw material cost per unit (Nov-Jun) = 7 THB/kg.
- Raw material cost per unit (Jul-Oct) = 8 THB/kg.
- Demand for raw materials = The sales forecast for 2016
- The ability to find raw materials = The Forecasts Raw material 2016
- Form of storage; first come first served (FIFO)

V. Finding the Result by Using Linear Program

Related variables:

i	= month
D_i	= sales volume/sales volume prediction (kilogram)
X_{1i}	= productivity (kilogram)
I_{0i}	= volume of beginning inventory (kilogram)
I_i	= volume of end inventory (kilogram)
SS_i	= volume of spare inventory (kilogram)
Y_{1i}	= volume of storage under 0-4 °C
Y_{2i}	= volume of freezing storage (kilogram)
C_{1i}	= cost of production per unit (baht/kilogram)
P_{1i}	= cost of raw material per unit (baht/kilogram)
E_{1i}	= expenditure per unit (baht/kilogram)
C_{2i}	= cost of storage under 0-4 °C (baht/kilogram)
C_{3i}	= cost of freezing storage under -18 °C (baht/kilogram)
C_{3ai}	= cost of freezing storage, first month (baht/kilogram)
C_{3bi}	= cost of freezing storage, the next month (baht/kilogram)
TC_1	= Total cost of production
TC_2	= Total cost of storage under 0-4 °C
TC_3	= Total cost of freezing storage under -18 °C
Z	= Total cost (baht/kilogram)
C	= productivity (kilogram)
R_i	= forecast of raw materials (kilogram)
S	= area for the factory (kilogram)

The program covers the related factors and constraints to find the optimized volume of inventory to minimize the cost, as follows; Formulate a mathematic model shows the target of the optimum volume of production and storage for the lowest total cost or closest to the actual plausible volume.

Min Z= the total cost of production + the total cost of storage.

= [(the cost of product per unit + the expenditure of production per unit) x productivity] + [the cost of storage per unit (4 ℃) x end product] + [the cost of storage per unit (-18 ℃) x the volume of frozen products]

$$\text{Min } Z = TC_{1i} + TC_{2i} + TC_{3i} \quad (1)$$

$$= C_{1i}X_{1i} + C_{2i}Y_{1i} + C_{3i}Y_{2i} \quad (2)$$

$$= [(P_{1i} + E_{1i}) \text{ x } X_{1i}] + [(C_{2i} \text{ x } Y_{1i})] + [(C_{3i} \text{ x } Y_{2i})] \quad (3)$$

with -safety stock (SS_i) = Y_{1i}

-inventory (end product) $I_i = Y_{1i} + Y_{2i}$

-the cost of freezing storage C_{3i} can be subdivided into C_{3ai} and C_{3bi}

If $Y_{2i} = 0$, it means there is no freezing storage. $I_i = Y_{1i}$ (or SS_i) = $I_{0i} + X_{1i} - D_i$ yields

If $Y_{2i} \neq 0$, it means there is freezing storage which can be subdivided into 2 cases as follow:

1. $Y_{2i} > Y_{2(i\text{-}1)}$ indicates that there is an increasing freezing storage from the previous month yielding this equation:

Min Z= $[(P_{1i} + E_{1i}) \text{ x } X_{1i}] + [(C_{2i} \text{ x } Y_{1i})] + [(C_{3ai} \text{ x } (Y_{2i} – Y_{2(i\text{-}1)})] + [(C_{3bi} \text{ x } (Y_{2(i\text{-}1)})]$

2. $Y_{2i} \leq Y_{2(i\text{-}1)}$ indicates that there is the freezing storage of the previous month was used yielding an equation as

Min Z = $[(P_{1i} + E_{1i}) \text{ x } X_{1i}] + [(C_{2i} \text{ x } Y_{1i})] + [(C_{3bi} \text{ x } (Y_{2i})]$

** $I_i > Y_{1i}$ (or SS_i) so, $I_i - Y_{1i} = Y_{2i}$

- Safety Stock (SS_i or Y_i) >= average sales volume daily x3

-Safety Stock (SS_i or Y_i) <= the size of freezing room for inventory storage of 12,000 kilogram

-freezing inventory (I_{fi}) >= 0

Limitation in equation

-productivity of fresh sugarcane juice (X_i) >= 0

-productivity of fresh sugarcane juice (X_i) <= productivity of 197,600 kilogram per month

During July to October period, the raw materials give less fresh sugarcane than other period. The limitation is the undersupply problem leads to insufficient sales volume. The constraints of searching for the raw materials are:

-productivity of fresh sugarcane juice (X_i) during July to October <= capability of searching for the raw materials (forecast of the raw materials*(2/3))

Constraints on inventory

-Beginning inventory (I_{0i}) >= 0

-End inventory(I_i) >= 0

VI. Research and Procedures

This research is intended to find the optimized volume of production and inventory storage to meet customers' demand with the goal of reaching the lowest cost. Calculate the inventory management is done by using Linear Programming with the results shown in Table III. As for the condition and constraints, the calculation for the optimized use of the raw materials and optimized story to meet customers' needs is that input raw materials is equal to productivity without inventory storage because the product is easily perishable, which can be stocked as spare inventory at least 3 days.

The limitation is the undersupply problem during July to October that leads to insufficient sales volume. 12,000 kilograms of inventory a day can be stored either by chilling it at 0-4 ° C or freezing at -18 ° C. At 0-4 ° C Pasteurized sugarcane juice lasts 20 days while at -18 °C it lasts 1 year with the same physical characteristics. The lowest total yielded cost is 5,707,362.29 baht.

Furthermore, the new policies are analyzed with Sensitivity Analysis of the total cost as follow.

A. *The Change in Price of Raw Materials in Each Period*

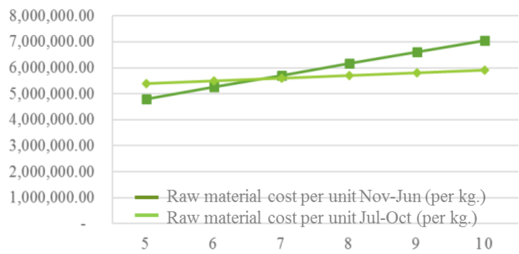

Figure 3. The sensitivity analysis of the total cost to the change in price of raw materials in each period.

Sensitivity Analysis of the total cost which is calculated from the cost of production and storage shows 2 periods of change in cost of raw materials: November-June and July-October. It is found that the total cost increases in both periods; however, the change in cost during November to July has more effect on the total cost as forecast as there is more order of raw materials.

TABLE III. SALES AND STORAGE VOLUME IN 2016

	Unit	Kilogram	Kilogram	Kilogram	Kilogram	Kilogram	Kilogram	Kilogram	Baht	Baht	Baht	Baht
2016		The Forecasts Raw material 2016	The sales forecast for 2016	Beginning Inventory	Production	Ending Inventory	Safety Stock	Freezing Stock (-18 C)	Cost of Production	Cost of inventory (4 C)	Cost of frozen inventory (-18 C)	Total Cost
	Variable	Ri	Di	I0i	Xi	Ii	Y1i (or SS)	Y2i	TC1i	TC2i	TC3i	Z
1st month	Jan	42,855.30	38,689.77	3,094.00	39,464.74	3,868.98	3,868.98	-	368,245.51	6,964.16	-	375,209.67
2nd month	Feb	45,570.30	42,874.94	3,868.98	43,293.45	4,287.49	4,287.49	-	403,971.22	7,717.49	-	411,688.71
3nd month	Mar	53,012.60	50,612.92	4,287.49	51,386.72	5,061.29	5,061.29	-	479,489.48	9,110.33	-	488,599.80
4th month	Apr	58,826.20	58,489.96	5,061.29	59,277.67	5,849.00	5,849.00	-	553,119.92	10,528.19	0.00	563,648.11
5th month	May	64,645.80	59,155.84	5,849.00	59,222.43	5,915.58	5,915.58	-	552,604.51	10,648.05	-	563,252.57
6th month	Jun	41,980.20	46,373.36	5,915.58	113,952.73	73,494.95	12,000.00	61,494.95	1,063,292.90	21,600.00	159,886.87	1,244,779.77
7th month	Jul	43,846.30	46,362.83	73,494.95	29,230.87	56,362.99	4,636.28	51,726.71	301,984.08	8,345.31	82,762.73	393,092.12
8th month	Aug	40,541.10	43,800.93	56,362.99	27,027.40	39,589.46	4,380.09	35,209.37	279,220.07	7,884.17	56,334.99	343,439.23
9th month	Sep	32,787.00	38,596.16	39,589.46	21,858.00	22,851.30	3,859.62	18,991.69	225,815.00	6,947.31	30,386.70	263,149.01
10th month	Oct	36,344.50	42,800.88	22,851.30	24,229.67	4,280.09	4,280.09	-	250,316.69	7,704.16	0.00	258,020.85
11th month	Nov	41,803.80	40,826.05	4,280.09	40,628.56	4,082.60	4,082.60	-	379,105.12	7,348.69	0.00	386,453.80
12th month	Dec	43,834.90	43,481.34	4,082.60	43,746.87	4,348.13	4,348.13	-	408,202.01	7,826.64	-	416,028.65
									5,265,366.50	**112,624.49**	**329,371.29**	**5,707,362.29**

B. *The Change in Purchase of Raw Materials during July to October*

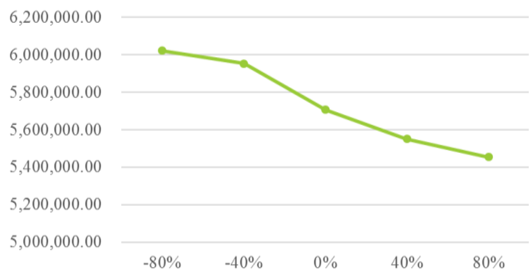

Figure 4. Sensitivity analysis of the total cost to the change in volume of purchase of raw materials during July to October.

Besides, sensitivity analysis of the total cost to the change in volume of purchase of raw materials during July to October shows that if the company can manage to get 40% more of raw materials within the period, it can save 156,330 baht of the cost annually. If 80%, 253,388 baht per year will be saved, which covers the whole monthly sales and decreases the cost of freezing storage.

C. *The Change in Size of a Chilling Room*

Although the size of the room during July to August is the same, it can't lower the cost; if the capacity of storage increases from 12,000 kilograms to 18,000 kilograms, the cost saved is a little, only 4,800 baht.

From Sensitivity Analysis of the total cost to the 3 changes as mentioned above, it is found that the change in the purchase of raw materials during July to August has the biggest impact to the total cost. If the company can manage to purchase more raw materials during that period, it can save more cost up to 100,000 baht without extending or increasing the number of freezing rooms.

VII. CONCLUSIONS

The study demonstrates the quantitative data and the forecast of factors of productions and yields during 12 months of which the problem of managing the volume of inventory of raw materials is too much, and the storage is not compatible with the production and the management of inventory. This case study uses the techniques of forecast, the research of processing and simulated situations to manage the inventory of raw materials to decrease related expenditures and to provide the optimized outcome. The study seeks the lowest total cost of 5,707,362 THB.

REFERENCES

[1] K. V. Donselaar, T. V. Woensel, R. Broekmeulen, and J. Fransoo, "Inventory control of perishables in supermarkets," *International Journal of Production Economics*, vol. 104, no. 2, pp. 462-472, 2006.

[2] S. Steinhagen, J. Darroch, and B. Bailey, "Forecasting in the wine industry: An exploratory study," *International Journal of Wine Marketing*, vol.10, no. 1, pp. 13-24, 1998.

[3] O. Ahumada and J. R. Villalobos, "Operational model for planning the harvest and distribution of perishable agricultural products," *International Journal of Production Economics.* vol. 133, no. 2, pp. 677-687, 2011.

[4] J. Zabawa and B. Mielczarek, "Tools of Monte Carlo simulation in inventory management problems," in *Proc. 21st European Conference on Modelling and Simulation*, European Council for Modeling and Simulation, Czech Republic, 2007, pp. 56-61.

Roongrat Pisuchpen received her Bachelor of Engineering in Industrial Engineering from Kasetsart University (Thailand), Master of Engineering in Industrial and Systems Engineering and PhD in Industrial and Systems Engineering from Asian Institute of Technology (Thailand). Currently, she is an Associate Professor in Industrial Engineering at Engineering Faculty, Kasetsart University in Bangkok. Her main research interests include Petri Net models, simulation modeling and analysis, and applications of operations research.

Papatsaraporn Rienthong received her Bachelor of Industrial Engineering, from the University of Mahidol, Master of Engineering in Engineering Management, from Kasetsart University (Thailand). Her work experience in 2009-2013, she was Logistic planner in planning department at Thai Beverage Logistic Co., Ltd., Bangkok, Thailand. At present, she was Assistant Manager at Numaoyraimaijon Co., Ltd., Ratchaburi, Thailand.