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Analysis of Procurement and Supply Chain Control of Sugarcane in a Sugar Mill

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ABSTRACT

Sugarcane raw material stocks in sugar factories need to be maintained at an optimal level to avoid either shortage or excess situations that ensuring smooth production. This study aims to analyze the procurement mechanism and inventory control of sugarcane raw materials, analyze the trend of sugarcane raw material procurement, and to analyze the inventory control of sugarcane raw materials. Research was conducted at PT PG Candi Baru Sidoarjo. Data was analyzed using descriptive analysis, trend analysis, and Economic Order Quantity (EOQ) analysis. Results of this study showed the procurement mechanism and inventory control of sugarcane raw materials by PT PG Candi Baru. The trend of sugarcane raw materials had decreased every period caused by several factors. The number of economical sugarcane orders in the last year 2023 was 1,491,545,174 tons. The amount of safety stock that must be owned by PT PG Candi Baru Sidoarjo was 234,044.8 tons. The number of reorder (Reorder Point) was 505,761 tons. The optimal total cost of sugarcane raw material inventory was IDR 20,885,934,920.14, while the company policy was IDR 20,998,060,000. It can be concluded that the EOQ method obtained more efficient results with a financial difference value of IDR 112,125,079.86.

1. INTRODUCTION

Every company needs raw materials as a key element to carry out its production process. According to Andari (2016), companies that produce goods for profit require an efficient raw material management, because raw materials are an important component in the production process. According to Sujarweni (2015), raw materials are the main element that makes up the entire final product. Good raw material management ensures the availability and smooth supply of raw materials needed for the production process.

Industrial activities involve various processes that aim to convert raw materials into final products that are ready for consumption or use by consumers. In production activities, companies need raw materials as the main component to produce the final product. Raw materials are elements used in the manufacture of finished goods (Sulaiman & Nanda, 2015). The continuity of the production process is highly dependent on the availability of raw materials, so it is important to ensure that raw materials are always available to support the course of production without obstacles (Evitha & Ma'ruf, 2019). According to Siahaya (2013), procurement is a structured and rational process to obtain the necessary goods and services, by complying with applicable norms and ethics and following established procedures for the procurement of goods and services. The procurement process includes a planning, acquisition, and management of goods or products to meet the needs of a particular organization or entity. This activity includes purchasing, logistics involving transportation, receiving goods, and storage in warehouses before further use (Wibowati, 2017).

Sugar factory or PG (Pabrik Gula) is one of the important manufacturing industry in Indonesia. Manufacturing companies must be able to manage inventory effectively because it has a direct impact on the continuity of the production process (Okananti *et al*., 2019). According to the Director of Food, Seafood and Fisheries Industry of the Ministry of Industry, several PGs owned by State Company or BUMN (Badan Usaha Milik Negara) have ceased operations and are permanently closed due to various factors, one of which is the limited sugarcane land available, resulting in insufficient supply of the main raw material. Although Indonesia has many sugar factories, their performance is less than optimal due to the lack of raw material supply. According to data from the Directorate General of Agro Industry of the Ministry of Industry, there are 62 sugar factories in Indonesia, consisting of 43 state companies and 19 private sugar factories. Data from the Ministry of Agriculture also shows that in 2021, white crystal sugar production for household needs reached 2.35 million tons, a slight increase compared to the previous year. In 2020, white crystal sugar production only reached 2.13 million tons (Kemenperin, 2015). This shows that in the last three years, the performance of sugarcane fields and sugar factories in Indonesia has improved, although the increase is small. According to Hermawan & Rasbin (2012), public demand for sugar is expected to continue to grow in line with population growth, increasing income levels, and the development of the industrial sector that requires sugar as a raw material. The sugar industry faces various challenges, such as declining sugar production despite increasing consumer demand, high sugar selling prices, and less than optimal operational efficiency in sugar factories.

To improve overall efficiency, companies must purchase and use raw materials carefully and appropriately. This aims to avoid wasting raw materials that can cause unnecessary costs (Hasnawati, 2017). The application of Economic Order Quantity (EOQ) in sugar factory aims to ensure that the company's raw material inventory is managed efficiently, in accordance with company policy, to minimize problems related to inventory (Fadlallh, 2015). The economic order quantity method is used to assist management in making the right decisions, so that the procurement of materials is not excessive and can avoid shortages, with the appropriate amount optimally (Yuliana *et al.*, 2016). Therefore, this study aims to determine the procurement and supply control of sugarcane raw materials at PT. PG Candi Baru Sidoarjo by applying the Economic Order Quantity (EOQ) method. The expected benefits of this research are to provide information and recommendations that are useful for optimizing the procurement and control process of raw materials (sugar cane), so as to reduce operational costs, avoid shortages or excess inventory, and improve the efficiency of the production process.

2. RESEARCH METHODS

The research was conducted for 4 months starting from February 2024 to May 2024 at PT PG Candi Baru Sidoarjo, East Java. The location was determined purposively with the consideration that PG Candi still exists with a milling capacity of 2,750 TCD (ton cane per day).

2.1. Data Type and Source

Primary data was obtained directly from the authorities at PT PG Candi Baru. Research activities were carried out with primary data taken directly from the plant, accounting, and farming facilities sections. Secondary data were obtained from literature studies, books, scientific journals, annual reports of sugar cane of PG Candi Baru company, annual reports of PG Candi Baru partnership pattern, financial reports related to raw material costs of PG Candi Baru, and other electronic information sources relevant to the research objectives.

2.2. Data Collection Methods

Data was collected through several methods, including reading the company reports, interview with relevant persons, and literature studies. The company reports included an analysis of financial statements, consisting costs for mill preparation, sugarcane raw material storage, and total production of the company. The research also analyzed the partnership patterns that included information such as a list of sugarcane plantations, sugarcane plantation area, and sugarcane production. Data on harvest and hauling sugarcane was also considered, including the volume of sugarcane harvested and the amount milled. In addition, data was also collected from interviews involved staff from the crop section to explore the procurement of sugarcane raw materials in the company, the process of procuring sugarcane raw

materials, and the obstacles faced. In addition, the finance department provided information regarding the costs associated with the procurement of sugarcane raw materials, storage costs, and the total cost of sugar production. Staff from Farm Facilities (Bina Sarana Tani) Section explained the partnership pattern applied by the company and the purchase price of sugarcane each year. Lastly, the data was also collected through literature studies from journals, the internet, books, and previous research relevant to the procurement and control of sugarcane raw material inventory.

2.3. Data Analysis Method

2.3.1. Descriptive Method

In this research, the researcher describes descriptively the mechanism of procurement and inventory control of sugarcane raw materials at PT PG Candi Baru. Researchers explained how sugarcane raw materials were obtained starting from the sugarcane planting season to the harvest-haul season and enter the factory to be processed.

2.3.2. Trend Analysis

Trend analysis is a technique used to evaluate historical data to identify the pattern or direction of movement of a particular variable over time. This method helps in understanding how the procurement of sugarcane raw materials at PT PG Candi Baru changes over time and allows for future predictions or planning based on patterns that have been identified through the formula equation:

$$a = \frac{\sum Y}{n}, \quad b = \frac{\sum XY}{\sum X^2}$$
$$Y = a + bX \tag{1}$$

where Y is trend value for milled period, X is time period code, a is constant, b is slope of trend line, and n is number of data pairs. Calculation of the percentage value of sugarcane trend analysis using the following formula:

$$\text{Trend} = \frac{X_n}{X_{n-1}} \times 100\% \tag{2}$$

where X_n is analysis year (following year), and X_{n-1} is base year (starting year).

2.3.3. Economic Order Quantity (EOQ)

Economic Order Quantity (EOQ) is used to analyze the inventory control of sugarcane raw materials at PT PG Candi Baru. This method plays a role in supporting companies to make the right decisions so that the procurement of raw materials is carried out in the optimal amount, thus avoiding excess or shortage of inventory (Yuliana *et al*., 2016). Through good inventory planning, companies are able to meet customer demand quickly and accurately, and avoid excess stock which can lead to inefficient use of funds (Darmawan *et al*., 2015). The EOQ model estimates the optimal amount of inventory by considering the ordering costs and storage costs incurred (Ahmad & Sholeh, 2018). In preparing supplies as raw materials in a company, there are various types of costs that must be incurred (Langke *et al*., 2018). Several costs are considered for determining the amount of purchase using the EOQ method, namely Ordering Cost, Storage Cost, Economic Order Quantity (EOQ), Safety Stock, Reorder Point (ROP), and Total Inventory Cost. These costs were calculated according to the following equations:

$$\text{Order Cost} = \frac{Q}{Fr} \times S \tag{3}$$

with Fr is frequency of ordering raw materials in one period, Q is quantity of sugarcane raw materials per order (tons), and S is cost of ordering sugarcane raw materials per ton (IDR).

$$\text{Storage Cost} = H = \frac{Total\ saving\ cost}{D} \tag{4}$$

where D is annual quantity of sugarcane raw material (ton).

$$\text{Economic Order Quantity} = EOQ = \sqrt{\frac{2DS}{H}} \tag{5}$$

$$\text{Safety stock} = (Maximum\ inventory - Average\ inventory) \times Lead\ Time \quad (6)$$

where maximum inventory and average inventory of sugarcane raw materials is for 1 period, and *Lead Time* is waiting time for ordering sugarcane raw materials in 1 period (day).

$$\text{ROP} = d \times L + SS \quad (7)$$

where d is demand for sugarcane raw materials per order (ton), L is waiting time for ordering sugarcane raw materials (days), and SS is safety stock of sugarcane raw materials (ton)

$$\text{Total Inventory Cost} = TC = \frac{Q}{Fr}\,\text{S} + \frac{Q}{2}\,\text{H} \quad (8)$$

3. RESULTS AND DISCUSSION

According to Handoko (2015), inventory is a general term that refers to everything or resources stored by an organization in anticipation of meeting demand. Inventory is a number of goods stored for future use or sale (Albasit, 2019). Milling realization is the amount of sugarcane that is actually milled or processed in a sugar factory within a certain period of time (Kusuma, 2019). PT PG Candi Baru Sidoarjo conducts a milling period for approximately 150 days from May to November with a total sugarcane area of approximately 5,000 ha and a milling capacity of approximately 2,750 TCD.

Table 1. Realization of milling at PT. PG Candi Baru during the period of 2019-2023

No.	Description	Unit	Realization				
			2019	2020	2021	2022	2023
1.	Sugarcane Quantity	ton					
	TS (self-owned)	ton	53,883.60	55,648	47,764.2	41,683.70	44,693.8
	TRK (partnership community)	ton	264,624.4	253,964.1	255,892.2	255,403.3	252,880.5
	TRM (independent community)	ton	140,741.9	472,900	103,768.6	105,000	110,000
	Total	ton	459,249.9	332,261.3	407,425	402,087	407,574.3
2.	Sugarcane Productivity	ton/ha					
	TS (self-owned)	ton/ha	96.6	83.5	76.1	88.9	76.5
	TRK (partnership community)	ton/ha	61.8	77.3	75	77.1	69.1
	TRM (independent community)	ton/ha	82.5	87.3	83.1	78.9	76.2
	Total	ton/ha	80.3	82.7	78.67	81.6	73.9
3.	Yield	%	7.95	6.68	7.00	6.45	7.49
4.	Sugar Production	ton	30,000.3	22,200	24,071.1	27,084.0	30,871.4

PG Candi Baru in the last 5 years from 2019 to 2023 experienced fluctuations in the sugar produced. Based on the data in Table 1, the highest increase in sugar production was in 2023 30,871.4 tons with the amount of sugarcane 412,011.2 tons and the lowest was in 2020 of 22,200 tons with the amount of sugarcane 332,261.3 tons. This means that PG Candi Baru does not always have a constant increase each year for the supply of raw materials and the production of sugar produced. With good monitoring, companies can improve control over the production process, optimize efficiency, and achieve optimal results in accordance with the set production targets and quality standards (Akindipe, 2014). Management control system is a process that aims to ensure that resources are obtained and utilized efficiently and effectively in order to achieve organizational goals (Wrihatnolo & Dwidjowijoto, 2006).

3.1. Procurement Mechanism and Inventory Control of Sugarcane

The supply of raw materials at PT. PG Candi Baru Sidoarjo is carried out in accordance with the capacity and schedule of milling days. Inventory is material or goods that are stored with the intention of meeting certain needs or goals (Unsulangi *et al*., 2019). According to Assauri (2018), raw material inventory is a physical material used in the production process, which can be obtained from natural sources or purchased from suppliers or manufacturers of raw materials for use by manufacturing companies. To meet the needs of sugarcane raw materials, PT. PG Candi Baru Sidoarjo cooperates with sugarcane farmers from various regions such as Sidoarjo, Pasuruan, Gresik, Mojokerto, Malang, Lumajang, and other regions. In order for the milling capacity to be fulfilled, PT. PG Candi Baru conducts

estimates and calculations to determine sugarcane production through production estimation and preliminary analysis. This helps determine the right harvesting time, prepare labor, work transportation, and costs that must be incurred. To ensure the need for raw materials in accordance with the target milling capacity, PT. PG Candi Baru Sidoarjo conducts the following stages (Figure 1).

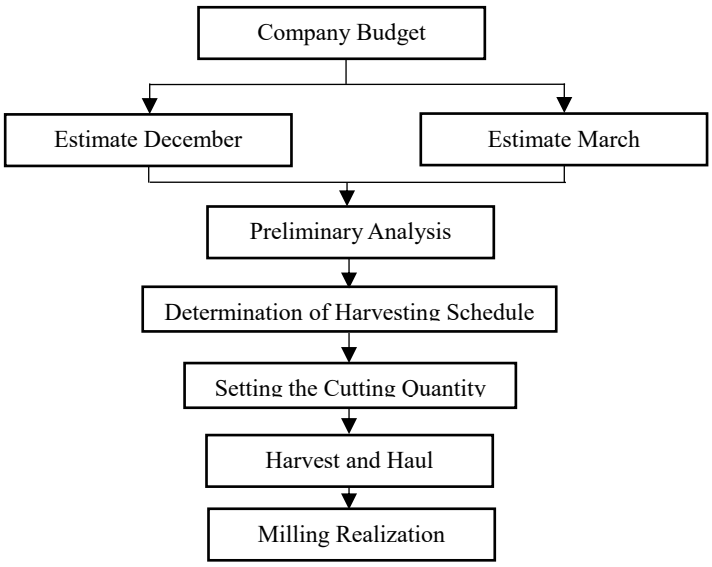


Figure 1. Flow of sugarcane procurement and inventory control mechanism of PT. PG Candi Baru Sidoarjo

1. Determining the Company Budget

The company budget is a definite number that must be determined in advance in a company. The targeted company budget is determined based on the company budget for the last three years. The company budget must increase every year to ensure that the company's revenue also increases. Given that labor costs continue to increase every year, the company budget must also be increased. If the company budget does not increase, the company will suffer losses. To achieve the company's budget target, PT. PG Candi Baru divides the composition of the amount of sugarcane based on the farmers' sugarcane category. Details of the sugarcane composition are presented in Table 2.

Table 2. Sugarcane composition share at PT. PG Candi Baru Sidoarjo during 2019-2023

Sugarcane Source	Unit	2019	2020	2021	2022	2023
TS (self-owned)	ton	47,644.3	46,457.7	35,959.7	39,978.4	46,218.4
TRK (partnership community)	ton	219,891.7	213,938.5	200,007.2	242,575.4	210,038.0
TRM (independent community)	ton	109,940.8	71,865.1	107,914.7	137,296.3	155,754.8
Total	ton/ha	377,476.8	332,261.3	348,881.6	419,850.1	412,011.2

2. Sugarcane Estimate

The amount of sugarcane was estimated twice, at December and March. December is the end of the milling season for PT. PG Candi Baru Sidoarjo. December estimation is carried out to achieve the Company's Budget target. The objectives of this estimation include estimating the land area for sugarcane planting, sugarcane population through estimated production, and determining the amount of sugarcane available. The parties involved include SKW (Sinder Kebun Wilayah), head of farmer group, PLPG (Sugar Factory Field Officer), plantation foreman, and PTA (Harvest-Haul Officer). From the results include the composition and amount of sugarcane that will be obtained to achieve the company's budget target. The estimate, however, can not be used as a definite reference.

The March estimation is based on the amount of standing sugarcane plant. The purpose of this estimation is to get a figure that is close to reality (with a 5% correction factor). This estimation estimates the amount of sugarcane raw materials that will enter PT. PG Candi Baru Sidoarjo to fulfill the daily milling capacity. March estimation becomes the basic reference in running the production process, and the results are used to determine the milling pattern, milling capacity, milling days, and milling time. Based on the March estimation that has been carried out by PT PG Candi Baru Sidoarjo, the 2023 milling capacity is set at 2,750 TCD with a planned 170 days of milling. The actors involved in the March estimation include the head of the farmer group, SKW, PLPG, plantation foreman, and PTA. The March taxation has an exact calculation because it is based on the existing sugarcane condition.

3. Estimation Methods

The assessment was conducted by three field officers. The first officer recorded and calculated the measurement results from outside the field. The second officer counted normal sugarcane stalks by setting a sample plot of sugarcane every approximately 15 meters using a hand counter. To measure the height of sugarcane stalks, a meter was used, the diameter of the stalks was measured with a caliper, and the weight of the stalks per meter was measured using a scale. There are two methods used in the estimation, namely the diagonal method and the zig-zag method. If the sugarcane varieties grown are homogeneous, the diagonal method is used. If the sugarcane varieties are heterogeneous, the zig-zag method is used. If the degree of heterogeneity is very high, the starting point is determined by throwing wood or stones freely towards the field, then the zig-zag method is applied. A third person measures the height of the sugarcane from the growing point, usually 20 cm from the top. Objects measured in the taxation include the number of stems, stem height, stem diameter, and stem weight per meter.

In each observed plot, sugarcane samples were taken to weigh the weight of the stalk per meter. This activity should ideally be carried out 10 times on different sample plots in the same field, with the aim of obtaining a representative weight of sugarcane stalks from the field. Each of the 10 samples of sugarcane stalks is weighed, then the results are averaged. Basically, the workings of the estimate December and the estimate March are the same, the difference between the two is the time of implementation. Estimate December is carried out in December based on sugarcane buds, while estimate March is carried out in March based on standing sugarcane.

4. Preliminary Analysis

Preliminary analysis is conducted to conduct a maturity analysis or often referred to as mill analysis. This analysis involves observing the sugarcane by taking samples that include the diameter, length, height, and maturity of the sugarcane. The maturity analysis serves to determine the appropriate maturity of a harvesting plot. The results of this analysis are expected to represent the conditions of the plantation concerned and produce reliable figures. The process of sugarcane maturity runs from the lower internode to the upper internode and the degree of maturity depends on the age of the sugarcane. Young cane maturity is characterized by lower internode sugar content greater than the upper internode, ripe cane maturity is characterized by lower internode sugar content equal to the upper internode, and overripe cane maturity is characterized by lower internode sugar content less than or equal to the upper internode.

5. Determination of Harvesting Schedule

The determination of the harvesting schedule is first done by SKW (Sinder Kebun Wilayah). From SKW, this schedule will be reviewed by BST (Bina Sarana Tani) based on the planting period, maturity factor, and garden evaluation. If declared feasible, SKW will submit the schedule to SKK (Sinder Kepala Kebun), which is then submitted to Kasie Tebang Angkut and must be approved by the Head of Plantation. After being approved by the Head of Plantation, the BST will prepare a schedule of plantations that are ready to be cut down and provide the schedule to the Head of Logging for the implementation of logging. PG is also obliged to inform the farmer group that the harvesting schedule must be carried out in accordance with the plan agreed upon in the meeting.

6. Setting the Number of Harvesting

Determination of the allocation of harvesting and the person in charge of the process of harvesting and transporting is carried out by PG. The implementation of slashing and hauling can be done by the farmers themselves or by PG. The difference lies in the responsibility, if the PG carries out, then the PG is responsible for the sugarcane that is cut down

and transported. However, if the harvesting is done by the farmers themselves, PG is not directly involved in the implementation of harvesting and transporting. Farmers are required to meet the quality standards set by PG in the process of cutting and transporting. Nevertheless, PG can provide loan assistance related to slashing and transporting, such as sugarcane transport vehicles, harvesting labor, and harvesting tools. The amount of sugarcane cut is adjusted to the mill's daily milling capacity and the harvesting schedule set by the PG. This aims to ensure that the supply of sugarcane entering the PG is in accordance with the daily needs of the factory, so that there is no shortage of raw materials.

7. Harvest and Haul

Harvest and haul at PT PG Candi Baru Sidoarjo is carried out every day during the milling season in accordance with the capacity and milling schedule. The harvesting plan is highly dependent on the results of production estimation, such as December estimation and March estimation. Slash and haul is coordinated by 1 Slash and Haul Officer (PTA) who oversees several foremen, where each foreman is responsible for 35 loggers.

8. Milling Realization

Milling realization is the implementation of the results of the company's budget determination, December estimation, March estimation, preliminary analysis and slash and carry. In order for the supply of sugarcane entering the PG to be in accordance with the milling capacity and in accordance with the milling day, the PG regulates the amount of sugarcane entering each day in accordance with the milling capacity, namely by making a harvesting plan schedule. If a plantation is ready to be cut down, the PG makes a PG harvesting order. After obtaining a harvesting order, the sugarcanes are cut down according to PG's needs either by the farmers themselves or by PG, so that the amount of sugarcane input is different for each plantation.

3.2. Trends in Sugarcane Raw Material Procurement at PT. PG Candi Baru Sidoarjo

According to Faradiba (2020), a trend is defined as a tendency to move up or down in the long term based on the average change that occurs over time. This activity requires a large data set and monitoring over a long period of time, so that the analysis can reveal the fluctuations that occur and the factors that influence these changes (Ibrahim, 2003). In this study the data used is sugarcane realization data from 2019 to 2023, including sugarcane stock and milling day realization (Table 3).

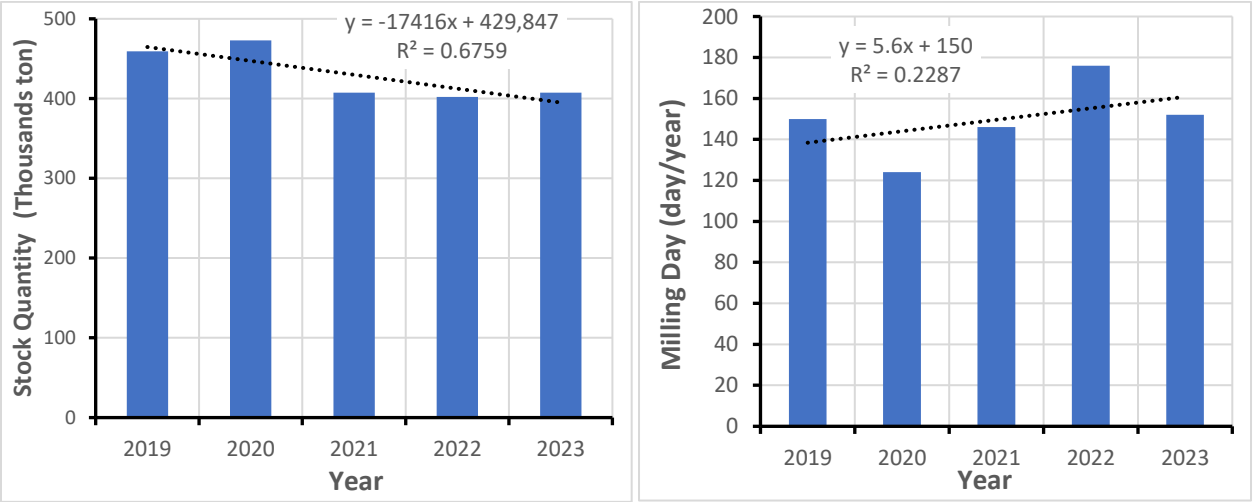
Table 3. Sugarcane trend analysis for sugarcane stock and milling day at PT. PG Candi Baru Sidoarjo

Year	Sugarcane Stock (ton)				Milling Day (day/year)			
	Total (Y)	X	XY	X^2	Total (Y)	X	XY	X^2
2019	459,249.9	-2	-918,500	4	150	-2	-300	4
2020	472,900.0	-1	-472,900	1	124	-1	-124	1
2021	407,425.0	0	0	0	146	0	0	0
2022	402,087.0	1	402,087	1	176	1	176	1
2023	407,574.3	2	815,148.6	4	152	2	304	4
Total	2,149,236.2	0	-174,164	10	748	0	56	10

From Figure 2a, it can be seen that the results of the trend analysis of sugarcane raw material inventory at PT. PG Candi Baru Sidoarjo from 2019 to 2023 show a downward trend every year. This can be seen from the trend (Eq. 9).

$$Y = 429{,}847.24 + (-17{,}416.4)\ X \quad (9)$$

Trend analysis that shows a decline in the procurement of sugarcane raw materials is caused by various factors. The first factor is a decrease in plant productivity, such as adverse weather conditions, climate change, extreme weather can reduce sugarcane yields and pest attacks that are not handled properly can damage sugarcane plants and reduce yields. The second factor is a reduction in the area of planting, such as changes in land use that were previously used to grow sugarcane are converted for other activities such as infrastructure development or planting other more profitable crops. The third factor is market demand, such as a decrease in demand for granulated sugar in the market which causes a reduction in sugarcane production and changes in consumer preferences for sugar substitute products.



(a) (b)

Figure 2. (a) Sugarcane stock trend, and (b) Milling day at PT. PG Candi Baru Sidoarjo 2019-2023

From Figure 2b, it can be seen that the results of the trend analysis of milling days at PT. PG Candi Baru Sidoarjo from 2019 to 2023 show an upward trend. This can be seen with the following trend analysis equation:

$$Y = 150 + (5.6)\,X \tag{10}$$

The relationship between decreasing raw material inventory and increasing milling days in each period can be described as follows:

1. Increased raw material consumption: As milling days increase, it means that the factory is performing more production operations. This causes the consumption of sugarcane raw materials to increase as more sugarcane is required to keep sugar production going.
2. Procurement is not fast enough: The process of procuring raw materials cannot keep up with the rate of consumption during the increased milling days. This is due to various factors such as delays in delivery, logistical issues, and other constraints in the supply chain.
3. Influence of Season and weather conditions: Seasonal and weather factors can affect sugarcane production. During certain seasons, such as the rainy season, sugarcane production may be reduced or transportation of sugarcane from the fields to the mill becomes more difficult, further reducing the available supply of raw materials.
4. Ineffective inventory control: Sub-optimal inventory control can lead to an imbalance between raw material requirements and available inventory. Poor inventory management can result in stock-outs even though milling days continue.
5. Inaccurate production planning: Production planning that does not accurately consider the increase in milling days and raw material requirements can cause raw material inventories to decrease. If the projected raw material requirements are not correct, the mill may run out of stock before the end of the milling period.

An increase in milling days along with a decrease in cane inventory can have various impacts on sugar mill performance such as suboptimal production capacity, decreased operational efficiency, increased production costs, decreased product quality, tighter inventory management, decreased labor productivity, risk of losing customers and impact on finances.

3.3. Raw Material Inventory Control with the EOQ Method

According to Griffin (2016), control is the process of regulating activities within the organization so that targeted performance elements remain within acceptable limits. According to Siregar *et al*. (2013), inventory control is a function that regulates and directs the implementation of plans through arrangements in the form of procedures, such as manuals,

standards, criteria, or procedures, to enable optimization and implementation of programs by related elements and units. Sugarcane raw material inventory control is a management process that aims to ensure that the amount of sugarcane required for sugar production is always available in the right amount and at the right time.

Based on the data obtained in Table 4, the supply of sugarcane raw materials at PT. PG Candi Baru Sidoarjo in the last 5 years from 2019 to 2023 has fluctuated. Within 5 years the material inventory decreased by 11.25% or average of 2.25%. Based on this data, the highest increase in sugarcane inventory in 2020 was 472,900 tons and the lowest was in 2022 of 402,087 tons. The average amount of sugarcane inventory in the last 5 years is 434,747.68 tons. This means that PG Candi Baru did not always have a constant increase each year for the supply of sugarcane raw materials.

Based on the data obtained in Table 5 regarding data on the cost of storing sugar cane raw materials from 2019 to 2023, the average value of electricity costs is IDR 3,958,905,400, the average warehouse maintenance cost is IDR 123,258,304, and the average warehouse depreciation cost is IDR 237,042,000.

Table 4. Sugarcane raw material inventory at PT. PG Candi Baru Sidoarjo for the Period 2019-2023

Category	Material Inventory Realization (ton)				
	2019	2020	2021	2022	2023
TS (self-owned)	53,883.6	55,648.0	47,764.2	41,683.7	44,693.8
TRK (partnership community)	264,624.4	253,964.1	255,892.2	255,403.3	252,880.5
TRM (independent community)	140,741.9	163,287.9	103,768.6	105,000.0	110,000.0
Total	459,249.9	472,900.0	407,425.0	402,087.0	407,574.3
5 Year Average			434,747.68		

Table 5. Sugarcane storage cost data at PT. PG Candi Baru Sidoarjo for the period 2019-2023

Cost Type	2019 (IDR 000)	2020 (IDR 000)	2021 (IDR 000)	2022 (IDR 000)	2023 (IDR 000)	Average (IDR 000)
Electricity	4,960,574	3,515.559	5,064,495	3,418,779	2,835,120	3,958,905
Warehouse Maintenance	124,541	153,172	102,441	115,342	120,795	123,258
Warehouse Depreciation	260,830	333,927	286,180	216,869	87,404	237,042
Total Cost of Storage	5,345.945	4,002,658	5,453,116	3,750,990	3,043,319	4,319,206

Table 6. Ordering cost at PT. PG Candi Baru Sidoarjo for the period 2019-2023

Year	Order Quantity (ton)	Order Frequency	Cost (IDR/ton)	Ordering Cost (IDR 000)	Progress (%)
2019	153,083.3	3	450,000	22,962,495	
2020	157.633.0	3	450,000	23,644,950	0.029
2021	135.808.3	3	450,000	20,371,249	-0.138
2022	134,029.0	3	450,000	20,104,350	-0.001
2023	135,858.1	3	450,000	20,378,715	0.01
Average	143,282	3	450,000	21,492,352	

1) Ordering Cost

According to Heizer & Render (2015), ordering costs are costs incurred in the ordering process, which include costs for forms, order processing, purchasing, administrative support, and others. The company orders sugarcane from three plantations (TS, TRK, and TRM), with costs calculated per ton. The calculation result for ordering cost is presented in Table 6. It can be seen that the ordering costs incurred by the company PT PG Candi Baru in 2019-2023 fluctuate every year. The average amount of ordering costs at PT PG Candi Baru is IDR 21,492,352,000. The progress of the ordering costs fluctuated where increasing in 2020 and 2023, but decreasing in 2021 and 2022.

2) Storage Cost

According to Heizer & Render (2015), holding cost is the cost borne by the company for storing or storing inventory in the warehouse for a certain period of time. The amount of storage costs at PT. PG Candi Baru Sidoarjo is calculated

using Equation (4) with the results are presented in Table 7. The storage cost of sugarcane raw materials greatly varies yearly, but tend to decrease. The highest storage costs was 13,384.34 IDR/ton and the lowest was 7,466.91with average of from 2019 to 2023 was IDR 10,056.94 per ton cane.

Table 7. Storage cost at PT. PG Candi Baru Sidoarjo for the period 2019-2023

Year	Total Storage Cost (IDR)	Storage Quantity D (ton)	Storage Cost (IDR/ton)	Progress (%)
2019	5,345,945,000	459,249.90	11,640.60	
2020	4,002,658,000	472,900.00	8,464.07	-0.272
2021	5,453,116.000	407,425.00	13,384.34	0.581
2022	3,750,990,000	402,087.00	9,328,80	-0.303
2023	3,043,319,521	407,574.30	7,466.91	-0.199
Average	4,319,205,704	429,847.24	10,056.94	

3) Economic Order Quantity (EOQ) Analysis

Economic Order Quantity (EOQ) is a method to determine the optimal order quantity to minimize the total costs incurred by the company related to inventory management and purchasing raw materials (Haritsah *et al*., 2019). This method helps companies to determine the most economically efficient order quantity of raw materials. Calculations with the EOQ method are calculated using Equation (5) with the results are showed in Table 8. The calculation of optimal ordering (EOQ) of sugarcane raw materials at PT Candi Baru Sugar Factory Sidoarjo revealed that the optimal amount of sugarcane order was in the range of 1,113,651.07 to 1,625,471.16 tons with average of 1,378,635,15 tons. The EOQ fluctuated, increased slightly during 2020, 2022, and 2023, but decreased in 2021.

Table 8. Economic Order Quantity (EOQ) analysis at PT. PG Candi Baru Sidoarjo for the period 2019-2023

Year	D (ton)	S (IDR 000)	H (IDR)	EOQ (ton)	Progress (%)
2019	459,249.90	22,962,495	11,640.60	1,346,050.09	
2020	472,900.00	23,644,950	8,464.07	1,625,471.16	0.207
2021	407,425.00	20,371,249	13,384.34	1,113,651.07	-0.314
2022	402,087.00	20,104,350	9,328.80	1,316,458.26	0.182
2023	407,574.30	20,378,715	7,466.91	1,491,545.17	0.132
Average				1,378,635.15	

4) Safety Stock

According to Heizer & Render (2015), safety stock is a reserve inventory stored by the company to prevent material shortages. Safety Stock is calculated using Equation (6) with the results are presented in Table 9. The safety stock in 2019 was 223,082.2 tons, in 2020 192,662.2 tons, in 2021 240,167.74 tons, in 2022 242,748.6 tons, and in 2023 it was 234,044.8 tons. The average amount of sugarcane safety stock from 2019 to 2023 is 226,541.108 tons. The development of the safety stock percentage value in 2020 has decreased by 0.316%, in 2021 it has increased by 0.246%, in 2022 it has increased by 0.01%, and in 2023 it has decreased by 0.035%.

Table 9. Safety stock of sugarcane for PT. PG Candi Baru Sidoarjo

Year	Max. Inventory (ton)	Average Inventory (ton)	Lead Time (day)	Safety Stock (ton)	Progress (%)
2019	264,624.4	153,083.3	2	223,082.2	
2020	253,964.1	157,633.0	2	192,662.2	-0.316
2021	255,892.2	135,808.3	2	240,167.7	0.246
2022	255,403.3	134,029.0	2	242,748.6	0.01
2023	252,880.5	135,858.1	2	234,044.8	-0.035
Average				226,541.108	

5) Reorder Point (ROP)

According to Heizer & Render (2015), reordering or Reorder Point (ROP) is a method used to determine the time to order new sugarcane raw materials, so that companies can avoid stock shortages during the lead time period (waiting time) of ordering. Reordering is calculated using Equation (7) with the results are presented in Table 10. The Reorder Point in 2019 was 529,248.80 tons, in 2020 507,928.20 tons, in 2021 511,784.4 tons, in 2022 510,806.6 tons, and in 2023 as much as 505,761 tons. The average amount of ROP or reordering sugar cane from 2019 to 2023 is 513,105.80 tons. The development of the percentage value of ROP in 2020 has decreased by 0.04%, in 2021 it has increased by 0.007%, in 2022 it has decreased by 0.001%, and in 2023 it has decreased by 0.009%.

Table 10. Reorder point (ROP) sugarcane at PT. PG Candi Baru Sidoarjo

Year	D (ton)	Lead Time (day)	Safety Stock (ton)	ROP (ton)	Progress (%)
2019	153.083,3	2	223,082.2	529,248.80	
2020	157,633.0	2	192,662.2	507,928.20	-0.04
2021	135,808.3	2	240,167.7	511,784.40	0.007
2022	134,029.0	2	242,748.6	510,806.60	-0.001
2023	135,858.1	2	234,044.8	505,761.00	-0.009
Average				513,105.80	

6) Total Cost Inventory

According to Heizer & Render (2015), the total cost of inventory (TC) is the total cost required by the company to meet the minimum raw material inventory in one year. The calculation of the total cost of inventory is calculated using Equation (8) with the results are revealed in Table 11. The total inventory cost (TC) generated in 2019 amounted to IDR 23,853,486,726.03145, 2020 amounted to IDR 24,312,058,255.954. In 2021 it was IDR 21,280,373,760.9761, in 2022 it was IDR 20,729,515,000, and in 2023 it was IDR 20,885,934,920.1422. The average amount of total inventory costs (TC) from 2019 to 2023 is IDR 22,212,273,733. The development of the percentage value of total inventory costs in 2020 has increased by 0.019%, in 2021 it has decreased by -0.124%, in 2022 it has decreased by -0.25%, and in 2023 it has increased by 0.007%.

Table 11. Total Cost of Sugarcane Inventory with EOQ Method and PG Candi Sidoarjo Policy

Year	Q (ton)	Order Frequency	S (IDR)	H (IDR)	TC (IDR)	Progress (%)	TC Policy PG Candi (IDR)
2019	153,083.3	3	450,000	11,640.60	23,853,486,726		23,999,367,000
2020	157,633.0	3	450,000	8,464.07	24,312,058,256	0.019	24,513,545,000
2021	135,808.3	3	450,000	13,384.34	21,280,373,761	-0.124	21,337,297,000
2022	134,029.0	3	450,000	9,328.80	20,729,515,000	-0.25	20,897,070,000
2023	135,858.1	3	450,000	7,466.91	20,885,934,920	0.007	20,998,060,000
Average					22,212,273,733		22,349,067,800

Based on Table 11, it can be seen that the total inventory cost calculated using the EOQ (Economic Order Quantity) method is more efficient than the total inventory cost incurred by the company. Thus, it can be concluded that the application of the EOQ method in managing sugarcane raw material inventory at PT. PG Candi Baru Sidoarjo will result in more effective cost savings.

4. CONCLUSION

The mechanism of procurement and inventory control of sugarcane raw materials at PT PG Candi Baru Sidoarjo starts from the company cooperating with sugarcane farmers which are divided into 3 categories, namely TS (self-owned), TRM (Independent Community), and TRK (Partnership Community). PG Candi Baru conducts a number of steps, namely determining the Company Budget and milling capacity of 2,750 TCD and 170 days of milling. Then estimates

and calculations for December and March, preliminary analysis, determination of the harvesting schedule, setting the harvesting and hauling which is then carried out the sugarcane milling. The results obtained a decrease in the procurement of sugarcane raw materials by a total 11.25% during the period of 2019-2023 from 459,249.9 ton in 2019 to 407,574.3 in 2023. This mean an annual decrease of average 2.25%. The decrease in the amount of sugarcane raw material is caused by various factors, including decrease in plant productivity, a reduction in planting area, and decrease in demand for sugar in the market. Based on the results of the analysis of inventory control of sugarcane raw materials using the EOQ (Economic Order Quantity) method, the number of orders that are economical in the last year 2023 is 1,491,545.174 tons. The amount of safety stock that the company is 234,044.8 tons with the number of reorders (Reorder Point) is 505,761 tons. The optimal total cost of sugarcane raw material inventory is IDR 20,885,934,920.1442, while the company's policy is IDR 20,998,060,000. It is concluded that the EOQ method obtained more efficient results with a difference value of IDR112,125,079.8578.

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