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"Entrepreneurship on Global Economics Development in the Era of Society 5.0"

Comparison of Raw Material Inventory Control Using EOQ, EPQ, and Kanban for Production Cost Efficiency**Lannia Nur Wahyu Mu'alifah¹, Marhaendra Kusuma¹, Beby Hilda Agustin¹**¹Universitas Islam Kediri

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***Email:** lannianurwahyu57@gmail.com**ABSTRACT**

This study aims to (1) analyze the raw material inventory control of shallots using the EOQ, EPQ, and Kanban methods at CV. Sahabat of fried shallot producers in Kediri Regency, (2) analyze the application of the EOQ, EPQ, and Kanban methods in making production costs efficient at CV. Sahabat. The results of this study indicate that the amount of raw material used for shallots using the EPQ method is more economical than the EOQ and Kanban methods. Production cost efficiency obtained by the EPQ method is also more efficient than by the EOQ and Kanban methods. The novelty of this study is to compare three methods of controlling raw material inventory to make production costs efficient which are applied to fried shallot producers.

Keywords: Inventory Control, Economic Order Quantity, Economic Production Quantity, Kanban, Production Cost Efficiency.

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INTRODUCTION

Every company, both manufacturing and trading companies, is generally required to pay attention to inventories so that they can maintain the continuity of their business activities. Inventory is one of the things that directly influences the smoothness of a production process. Inventory in manufacturing companies generally includes several types, namely raw material or raw material inventory, semi-finished goods inventory, and finished goods inventory. Companies must be able to manage inventory of raw materials properly so that they can have optimal inventory for the smooth running of the company's production process and lower costs incurred by the company. Inventories of raw materials or raw materials are used to meet needs in the production process, while finished goods inventories are used to meet needs in the market.

Companies can control raw material inventories using the Economic Order Quantity (EOQ) method. The EOQ method can be used to plan how often to order raw materials in a certain period and how many orders of inventory are more economical. Economic Order Quantity (EOQ) is the total quantity of goods that can be obtained at a minimum cost or is often said to be the optimal number of purchases (Riyanto, 2013).

The Economic Production Quantity (EPQ) method is the number of product quantities that must be produced or ordered in a single lot size to minimize the total cost which includes setup costs and inventory holding costs. EPQ is the development of an inventory model taking into account the existence of a uniform or uniform production rate or rate of arrival of goods which usually occurs in a manufacturing system where the output of one work station will be input to another work station (Prastya, et al., 2019).

Whereas in the Kanban method, companies can implement a supplier Kanban system or use a Kanban card, which contains the information needed by the company in ordering materials or raw materials as needed (Apriyani and Ahmad, 2017). Where is the communication system or order card used to place orders for raw materials in accordance with the desired quantity needed, the quantity in accordance with the inventory capacity to produce a product.

Production cost efficiency is the reduction of costs used for raw materials, labor and factory overhead in the production process, with the aim of producing the desired profit. A product that is produced economically will be able to compete and be able to generate profits, so a tool is needed to create production cost efficiency. In order to know whether or not the efficiency of a production can be done by calculating the difference between the budget and its realization. Production costs can be said to be efficient if they can produce production that has quantity and quality standards compared to the appropriate price, so that the costs incurred will not contain elements of waste. With this in mind there is a need for an evaluation in the suppression of production costs so as to create an efficiency in production costs which of course has an impact on company profits.

Inventory control and production cost efficiency are two things that are mutually influential and important in the company. The accuracy of raw materials in accordance with the number of needs of the production process, available on time and of high quality will support the production process to run well. The use of appropriate and controlled raw materials as needed keeps costs incurred from being wasteful, thereby saving production costs and becoming more efficient. With the existence of raw material inventory control and a smooth production process, the company can meet the demands of consumers properly.

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Efficient production costs can also make the company obtain increased profits, so that the goals within the company can be achieved as desired.

CV. Sahabat is a company engaged in the field of food production which is located at Jl. Raden Ajeng Kartini No. 29, Cangkring Hamlet, Pelem Village, Pare District, Kediri Regency, East Java. This company produces fried shallots. The company wants to develop its business to the fullest, but in controlling raw materials this company has not implemented optimal management of raw material control. Fluctuating shallot prices cause companies to sometimes purchase large quantities of raw materials in an effort to avoid price increases, so companies have to spend more funds to purchase these raw materials. Shallot raw materials that are stored in the warehouse for too long can experience shrinkage and even rot, which can reduce their quality. Without optimal raw material inventory control, it can result in excess or shortage of raw materials, which can disrupt the smooth production process and also waste costs in procuring raw materials, which results in inefficient production costs. Therefore good raw material inventory control is very important for the company so that the profits obtained by the company are maximized.

To avoid an extensive discussion, the researchers limit the discussion to controlling the supply of shallot raw materials using the Economic Order Quantity (EOQ), Economic Production Quantity (EPQ), and Kanban methods for production cost efficiency in CV. Sahabat Pare in 2021. The purpose of this research is to analyze how to control the supply of shallot raw materials using the Economic Order Quantity, Economic Production Quantity, and Kanban methods at CV. Sahabat, and to analyze how to apply the Economic Order Quantity, Economic Production Quantity, and Kanban methods to streamline production costs at CV. Sahabat.

Based on research conducted by Tipaka, et al., (2017) it was found that based on calculations obtained using the EOQ method and the EPQ method can reduce inventory costs compared to company policy. Where the EPQ method minimizes costs compared to the EOQ method. Research conducted by Apriyani and Ahmad (2017), shows that if the EOQ method is applied in a company, it can save raw materials for AA-437 products. While the comparison of the Kanban method and the company's method shows that TIC using the company's method is better applied than the Kanban method. The results of research from Swary (2021) show that using the (EOQ) method costs the quantity of purchased raw materials purchased more economically. So that if inventory costs decrease, the inventory costs incurred by the company will be minimal and the profit earned by the company will increase.

Inventory control is the most important part in a company, one of the activities of a sequence of activities that are closely linked to each other in the entire production operation of the company in accordance with what has been planned beforehand in terms of time, quantity, quality and cost (Assauri, 2016). According to Handoko (2012), inventory control is a very important managerial function because the physical inventory of many companies involves the largest rupiah investment in current assets. Raw material control within the company is expected to increase the cost efficiency of raw material inventory, because this greatly affects the company's production costs. Raw material control can support the activities concerned within the company. The linkage of all the implementation of existing activities within the company will support the creation of good raw material control.

The types of inventory in the company vary depending on the type of business of the company concerned. However, in general it can be said that for trading companies, the type

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of inventory consists of only one, namely merchandise inventory, while for manufacturing companies (companies that manage raw materials into finished goods) (Anwar, 2019). The purpose of inventory control within the company is to obtain the right quality and quantity of materials or goods available at the time needed with minimum costs for the benefit or interests of the company (Haming and Nurnajamuddin, 2012). According to Hansen and Mowen (2013), inventory costs are as follows: 1) ordering costs, 2) preparation or setup costs, and 3) storage costs.

According to Mulyadi (2015), raw materials are materials that form an integral part of the finished product. Raw materials processed in manufacturing companies can be obtained from local purchases, imports, or self-processing. There are two kinds of raw materials that affect the production process. The raw material groups are direct raw materials and indirect raw materials (Ristono, 2013). The size of the raw material inventory is influenced by three factors, namely: 1) The volume or amount needed, namely to maintain the continuity of the production process, the greater the amount of raw material needed, the greater the level of raw material inventory. The planned production volume is determined by sales, the higher the planned production volume requires more raw materials which results in high levels of raw material inventories. 2) The continuity of production does not stop, it requires a high level of raw material inventory or vice versa. 3) The nature of raw or auxiliary materials, whether they are easily damaged (durable good) or durable (undurable good). The goods needed are classified as not durable for long storage, do not need to be stored in large quantities (Ristono, 2013).

The EOQ method is a tool used to determine the volume and frequency of orders required to meet a certain level of demand while minimizing the cost per order (Zaini and Andriana, 2022). EOQ is one of the oldest and most well-known inventory control techniques, this inventory control method answers 2 (two) important questions, when to order and how much to order (Heizer and Render, 2015). The concept in EOQ has several similarities including the frequency of orders (F_n) or the number of orders made by companies in a period.

The company's ability to create inventory conditions that are always safe or full of security in the hope that it will not experience a shortage of inventory is called safety stock (Fahmi, 2014). Companies need safety stock, the following conditions are needed: 1) The time to order materials (lead time or procurement time) is uncertain, often changes due to the influence of various things or factors, 2) The amount of material used for production always fluctuates and cannot be predicted precisely, 3) Circumstances where the time of ordering is uncertain and the use of materials for the production process also fluctuates greatly. While ROP is a point or limit of the amount of inventory that exists at a time when an order must be held again (Heizer and Render, 2015). With the ROP, the company can know when to place an order again so that the company does not run out of materials.

The EPQ is a development carried out on the EOQ model, the development is carried out by eliminating assumptions regarding unlimited order fulfillment levels, instead there is a limited order fulfillment rate (Eunike et al., 2021). The EPQ method or optimal production level is an inventory control method used to determine a certain amount of production produced by minimizing the total inventory cost which consists of production set-up costs and storage costs (Eunike et al., 2021). In applying the EPQ method calculations focus on optimal production levels so that safety stock calculations do not apply to this method. However, this method also determines the maximum inventory.

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The Kanban system is a way of controlling material in the manufacturing process as a sign of the movement of goods or materials in the production process (Prabowo, 2020). The Kanban system is an information system that harmoniously controls the production system in each production process by using a card (kanban) to signal the need for materials (Elpisah et al., 2022). This method controls the production system in each production process by using a card (kanban) to signal the need for material. The Kanban method requires timeliness and an optimal amount of inventory to avoid stockouts and stockpiling (Apriyani and Ahmad, 2017). This method is very different from the EOQ and EPQ methods.

Production cost efficiency is a comparative relationship between production cost (input) budget and production cost realization (Anthony and Vijay, 2012). To assess the efficiency of production costs, it will directly include three components of production costs, namely raw material cost efficiency, labor efficiency and factory overhead efficiency. To find out whether or not the efficiency of production is done by calculating the difference between the budget and its realization. Production cost efficiency is the company's ability to control or make the best use of costs. Which is used in production activities in producing a product so that there is no waste in using costs. To facilitate decision making on the level of production cost efficiency by companies, it can be done by making efforts to make production cost efficiency assessment criteria (Mahsun, 2013).

To make it easier to make decisions on the level of production cost efficiency by companies, it can be done by making efforts to make production cost efficiency assessment criteria. In assessing the level of production cost efficiency, it can be seen by looking at the following criteria table:

Table 1. Efficiency Assessment Criteria

Criteria	Efficiency
Efficient	Less than 100%
Balanced Efficiency	Equal to 100%
Not Efficient	More than 100%

Source: Mahsun (2013)

If the comparison results obtained are smaller, the production costs are more efficient, this shows that the company has performed well in efficiency, and vice versa. Based on the description above, the framework that can be described in this study is as follows:

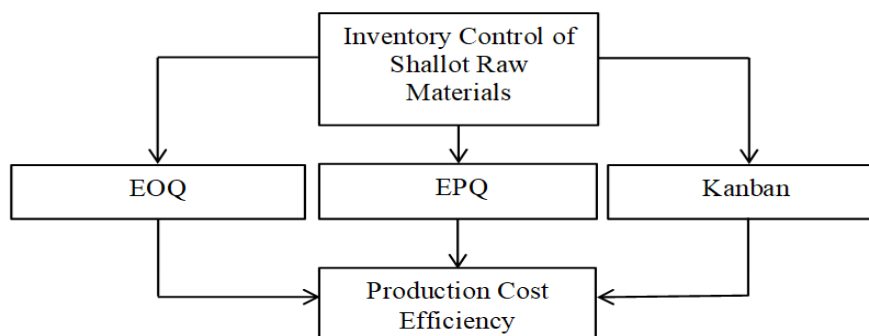


Figure 1. Framework of Think

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Based on the framework above, it can be explained that CV. Sahabat is a manufacturing company engaged in food production, namely the producer of fried shallots. In carrying out a production process, raw material inventory control is needed to make a product in carrying out production process activities. So that the raw materials used do not occur shortages or excesses which can later hinder the production process.

Control is a supervisory process carried out by the company's management in which it observes all the activities of the company's organization whether it goes according to the plans set by the company or not. Raw material inventory control has an important position in the company because raw material inventory has a very large influence on the smooth production. The methods used in raw material inventory control for production cost efficiency are Economic Order Quantity (EOQ), Economic Production Quantity (EPQ), and Kanban. With these methods companies can minimize costs incurred during the production process, so as to save funds spent by companies to make finished products. The smaller the production costs incurred, the more efficient the production costs, so that the company can adjust the production costs incurred by the company in an effort to achieve production cost efficiency so as to increase company profits.

METHOD

The scope of this research discusses controlling the supply of shallot raw materials using the Economic Order Quantity, Economic Production Quantity, and Kanban for production cost efficiency at CV. Sahabat during 2021. This research is a quantitative study, which is based on efforts to test existing theories, which include variables that can be assessed with numbers to determine whether the generalization of the theory is wrong or right. The reason for choosing the research location in CV. Sahabat, because this company has not implemented a specific method of managing raw material supplies, the availability of supporting data as research material, and the company's management is very open in providing explanations and data needed in this research, so that the data collection process becomes fast and smooth.

The source of data used in this study is primary data, namely data collected directly from the first party. The data collected is a report on raw material data, and production data, and production budget data for 2021. This data is collected by conducting interviews and documentation. The interview was conducted directly with the Head of Company Administration.

The method used in this study is descriptive quantitative, namely data analysis whose testing is in the form of numbers and calculations based on existing facts, by collecting, processing, and analyzing data. The analysis technique or data analysis steps carried out by the researcher are as follows:

1. Perform calculations using the EOQ method:

1) Determine the most economical ordering quantity of raw materials, with the formula:

$$EOQ = \frac{\sqrt{2DS}}{H}$$

Information:

D = annual demand (unit)

S = cost per order

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H = holding Cost

- 2) Calculating the amount of safety stock, with the formula:

$$\text{Safety Stock} = (\text{Maximum usage} - \text{Average usage}) \times \text{Lead time}$$

- 3) Calculating the reorder point, with the formula:

$$\text{ROP} = d \times l + \text{SS}$$

Information:

ROP = reorder Point

d = demand rate

l = lead time

SS = safety Stock

2. Perform calculations using the EPQ method:

- 1) Calculating the optimal amount of production, with the formula:

$$\text{EPQ} = \sqrt{\frac{2 \times D \times S}{H \times (1 - \frac{d}{p})}}$$

Information:

D = annual demand (unit)

S = set-up cost

H = holding cost

d = demand rate

p = production rate

- 2) Calculating the maximum inventory, with the formula:

$$I_{\max} = \text{EPQ} \left(1 - \frac{d}{p}\right)$$

Information:

I_{max} = maximum inventory

EPQ = economic production quantity

d = demand rate

p = production rate

3. Perform calculations using the Kanban method:

- 1) Calculating the number of kanban cards needed, with the formula:

$$N = \frac{d \times (c + Wp + \alpha)}{K}$$

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Information:

N = total kanban

d = demand rate

c = order cycle

W_p = order time

K = pallet capacity

α = safety coefficient

2) Calculating the order quantity:

$$\sum \text{Order Quantity} = N \times K$$

Information:

N = total kanban

K = pallet capacity

4. Calculating production cost efficiency by company, EOQ, EPQ, and Kanban methods use the following formula:

$$\text{Production Cost Efficiency} = \frac{\text{Realization of Production Cost in 2021}}{\text{Production Cost Budget in 2021}} \times 100\%$$

5. Comparing the efficiency of production costs by company using the EOQ, EPQ, and Kanban methods.

RESULT AND DISCUSSION

Calculation of the EOQ Method

Calculation of the number of purchases of economical shallots raw materials, to determine the amount of purchases that are economical use the following calculations:

$$EOQ = \frac{\sqrt{2DS}}{H}$$

$$EOQ = \frac{\sqrt{2 \times 153.211 \times 14.375}}{120,97}$$

$$EOQ = 6.034,27 \text{ Kg.}$$

Rounded up to 6.034 Kg.

The frequency of ordering raw materials is as follows:

$$F = \frac{D}{Q}$$

$$F = \frac{153.211}{6.034}$$

$$F = 25,39 \text{ times.}$$

Rounded up to 25 times.

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It is known that CV. Sahabat so far have not provided reserve red onion supplies or safety stock to anticipate a shortage of shallot raw materials, to determine safety stock using the following calculation:

Safety Stock = (Maximum usage – Average usage) × Lead time

Safety Stock = (14.909 – 12.768) × 1

Safety Stock = 2.141 Kg

Then to determine the reorder point or ROP use the following calculation:

ROP = d × l + SS

ROP = 425,58 × 1 + 2.141

ROP = 2.546,58 Kg.

Rounded up to 2.547 Kg.

Calculation of the EPQ method

To calculate the optimal amount of fried shallot production is as follows:

$$EPQ = \sqrt{\frac{2 \times D \times S}{H \times \left(1 - \frac{d}{p}\right)}}$$

$$EPQ = \sqrt{\frac{2 \times 58.609 \times 250.000}{305,96 \times \left(1 - \frac{163}{170}\right)}}$$

EPQ = 1.384,04 Kg.

Rounded up to 1.384 Kg.

The production frequency is as follows:

$$F = \frac{D}{Q}$$

$$F = \frac{58.128}{1.384}$$

F = 42,34 times.

Rounded up to 42 times.

Next perform the calculation of the maximum inventory, to find out the maximum inventory is as follows:

$$I_{\max} = EPQ \left(1 - \frac{d}{p}\right)$$

$$I_{\max} = 1.384 \left(1 - \frac{163}{170}\right)$$

$I_{\max}$ = 69,2 Kg.

Rounded up to 69 Kg.

Calculation of the Kanban Method

In calculating the number of supplier kanban cards, the first is by determining the daily need for raw materials by using the following formula:

$$d = \frac{\sum \text{monthly requirement}}{\sum \text{working days}}$$

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Table 2. Daily Raw Material of Shallot Requirements of in 2021

Months	Total of working days	Daily Raw Material Requirements (Kg)
January	25	558
February	24	495
March	27	329
April	25	395
May	24	577
June	25	551
July	26	417
August	24	456
September	26	563
October	25	594
November	26	573
December	26	570
Total	303	6.078
Avarage	-	507

Source: Processed by Researchers, 2022

It is known that the pallet capacity in the company is 1,500 kg. To calculate the frequency of delivery of shallot raw materials as follows:

$$fp = \frac{\sum fb}{K} = \frac{153.211}{1.500} = 102 \text{ times/year}$$

The number of days used for 1 order of shallot raw materials can be calculated as follows:

$$\sum 1 \text{ day order} = \frac{\sum \text{working days}}{fp \text{ one period}} = \frac{303}{102} = 2,970$$

To find out the delivery time is as follows:

$$\text{With 1 day} = 8 \text{ hours work} = 8 \times 60' = 480'$$

$$\text{Travel time from supplier location to company location} = 2 \text{ hours} = 2 \times 60' = 120'$$

$$Wk = \frac{\text{Supplier time to location}}{\text{Total of hours worked in 1 day}} = \frac{120'}{480'} = 0,25$$

After knowing the order time and delivery time, the order cycle is obtained as follows:

$$c = \frac{|A|}{1} = \frac{|2,970-0,25|}{1} = 3 \text{ days}$$

To determine the cycle time, it takes the loading time of goods to the pallet (C), which is 30 minutes, then divided by the total working time, which is 480 minutes. So that the time to order raw materials for shallots is obtained as follows:

$$Wp = c \times C = 3 \times \frac{30'}{480'} = 0,1875 \text{ days}$$

The company has determined a safety coefficient of 10%. After all of the above is known, so that calculations can be carried out to determine the number of Kanban cards as follows:

$$N = \frac{d \times (c + Wp + \alpha)}{K}$$

$$N = \frac{507 \times (3 + 0,1875 + 0,1)}{1.500}$$

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$N = 1,111$ card.

Rounded up to 1 card.

The order quantity is the total order quantity of shallot raw materials which can be calculated as follows:

$$\sum \text{Order Quantity} = N \times K = 1 \times 1.500 \text{ Kg} = 1.500 \text{ Kg.}$$

So, based on the calculation above, it can be seen that the quantity of raw material orders that the company can make is 1 card with a quantity of 1.500 kg.

Calculation of Production Cost Efficiency

Production costs are the sum of the costs of raw materials, direct labor costs and factory overhead costs. While cost efficiency is production costs that are made so that the results obtained are minimal or low. Production cost efficiency is calculated by comparing the actual production costs with the production cost budget, in order to obtain production cost efficiency as follows:

Table 3. Comparison of Production Cost Efficiency

Descriptions	Company	EOQ	EPQ	Kanban
Production Cost Budget	IDR4.627.373.500	IDR4.627.373.500	IDR4.627.373.500	IDR4.627.373.500
Realization of Production Costs	IDR4.660.557.530	IDR4.581.897.530	IDR4.467.992.530	IDR4.625.757.530
Production Cost Efficiency	100,72%	99,02%	96,56%	99,97%

Source: Processed by researchers, 2022

Based on the table above, it shows that the efficiency of production costs by company is 100.72%, which means it is not efficient. The EOQ method shows a production cost efficiency of 99.02% which means it is efficient. Then the production cost efficiency based on the EPQ method is 96.56%, which indicates that it has been efficient. While the efficiency of production costs based on the Kanban method is 99.97%, which means balanced efficiency.

DISCUSSION

Inventory control of raw materials based on calculations using the EOQ method obtained an economical amount of red onion raw material purchases of 6,034 Kg in one order, with an order frequency of 25 times a year. Then obtained a total safety stock of 2,141 Kg and an ROP of 2,547 kg was obtained, where the company had to reorder raw materials when the raw material inventory level had reached 2,547 Kg. In calculations using the EPQ method, the optimal amount of fried shallot production is 1,384 Kg for one production, so the raw material for shallots required is 3,460 Kg. Then the production frequency is 42 times a year and the maximum inventory of the total production is 69 Kg. While in the calculation using the Kanban method, the number of supplier kanban cards is 1 card with the number of red onion raw material orders of 1,500 kg per kanban card. The frequency of ordering or shipping raw materials for shallots is 102 times in one year.

Production cost efficiency is the company's ability to control or utilize the costs used in production activities as well as possible so that there is no waste in using costs. Production costs are the total of raw material costs, direct labor costs, and factory overhead costs. To find out the efficiency of production costs, namely by comparing the actual production costs

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with the production cost budget. Company CV. Sahabat has never used any method to control the supply of red onion raw materials, so the level of production cost efficiency obtained is 100.72% with a production cost of IDR 4,660,557,530, which means that the production cost is not efficient. However, if the company applies the EOQ method, it obtains a production cost efficiency level of 99.02% with a production cost of IDR 4,581,897,530, which can be said that production costs have been efficient. Then if the company applies the EPQ method, the production cost is IDR 4,467,992,530 and the efficiency level is 96.56%, which indicates that it is efficient. Meanwhile, based on the Kanban method, an efficiency level of 99.97% was obtained with a production cost of IDR 4,625,757,530, so it can be said that efficiency is balanced.

Raw material inventory control using the EPQ method can make production costs efficient. By using the EPQ method, the company can find out what the optimal amount of production is, so that the costs incurred to prepare raw materials also become efficient and affect the production costs that will be incurred will also be efficient.

IMPLICATIONS

Based on the results of data analysis that has been carried out by researchers, it is suggested that companies should use the Economic Production Quantity (EPQ) method to control their raw material supplies by determining the quantity ordered for raw materials to be produced to meet the demand for fried shallots. Because by using the EPQ method, the company can determine the amount of production that must be carried out, so that the purchase of raw materials is in accordance with the needs to be produced. Companies are also advised to use the EPQ method. Because the EPQ method can save more on production costs that must be incurred by the company in the future, production costs incurred can be more efficient so that the profits earned later will also increase. The limitation of this research is that it does not examine other components of production costs, but only examines the components of production costs, raw material costs. For further research, it is hoped that this research can be developed with other production cost components such as direct labor costs and factory overhead costs.

CONCLUSION

Based on the economical ordering of red onion raw materials using the EOQ method, it was obtained 6,034 Kg. Total safety stock is 2,141 Kg, and ROP is 2,546 Kg. Then based on the EPQ method, the optimal production volume is 1,384 kg and the maximum inventory is 69.2 kg. And while based on the Kanban method, a total delivery frequency of 102 times a year is obtained with a quantity of not more than 1,500 Kg. The number of kanban used to place an order is 1 kanban card with 1 delivery 1 time per day. Inventory control of shallot raw materials according to the EOQ, EPQ, and Kanban methods shows that the EPQ method is more efficient than the two methods.

The level of production cost efficiency at CV. Sahabat that is equal to 100.72%, based on the EOQ method obtained a production cost efficiency of 99.02%, while based on the EPQ method obtained a production cost efficiency of 96.56% and based on the Kanban method obtained a production cost efficiency of 99.97%. Production costs using the EPQ method can achieve production cost efficiencies that the company wants to achieve.

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