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Application of Multi-Item EOQ Method in Raw Material Inventory Control at Jofie Bakery and Cake Shop Medan

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Abstract. Inventory of raw material is one of the factors in the production process. Whereas lack of material would result in a slowing down of production, excess of raw materials would result in increased storage and other costs. The purpose of this study was to identify and analyze the control of the supply of raw materials applied by jofie bakery & cake shop. The kind of research used was quantitative research. The data source in this study USES secondary data sources directly from the company. The result of study showed that the use of EOQ methods on companies was resulted in cheaper cost when compared with the methods used by the company, and there was a difference in cost-saving expenses at 3.5% on average.

Keyword: EOQ, Inventory Control, Raw Material

Abstrak. *Persediaan bahan baku merupakan salah satu faktor dalam proses produksi. Kekurangan bahan baku akan berakibat pada terhambatnya proses produksi, sebaliknya kelebihan bahan baku akan berakibat pada meningkatnya biaya penyimpanan dan biaya lainnya. Tujuan dari penelitian ini untuk mengetahui dan menganalisis pengendalian persediaan bahan baku yang diterapkan oleh Jofie Bakery & Cake Shop. Jenis penelitian yang digunakan adalah penelitian kuantitatif. Sumber data dalam penelitian ini menggunakan sumber data sekunder yang diperoleh langsung dari perusahaan. Hasil penelitian menunjukkan penerapan metode EOQ pada perusahaan menghasilkan biaya yang lebih murah jika dibandingkan dengan metode yang selama ini diterapkan oleh perusahaan, maka terdapat adanya selisih penghematan pengeluaran total biaya untuk bahan baku rata-rata 3,5%.*

Kata Kunci: *EOQ, Pengendalian Persediaan, Bahan Baku*

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1. Introduction

Inventory can be interpreted as items stored for use or sale in the future period. Inventory consist of raw materials, half-finished supply and finished stock. Inventory control needs attention because it related directly to company costs that must be borne by the company. Inventory can be defined as items that are stored for use or sale in future periods or periods. Inventory is a model that is commonly used to solve problems related to the efforts to control raw materials and finished materials in a company's activities. The inventory issues are a common problem in the distribution of goods.

A research about coffee raw material at PT Fortuna Inti Alam and suggest the company to applied EOQ method in controlling their raw material inventory so the company can minimize their inventory cost [1].

Research that aim to determine the proper inventory for Dunkin Donuts Manado. The method used in the research was quantitative descriptive with EOQ equation, safety stock, and reorder point. The result showed that inventory control of raw materials that Dunkin Donuts applied was not optimal. The company did not have running out of inventory on fulfilling consumer demand, but the company still did not able to minimize their inventory cost [2].

The problem about inventory that often occurs is the availability of raw materials that are lacking so that customer demand is not met. Basically all companies set up plans and controlling the materials to minimize the cost of maximizing profits at a certain time. In planning and controlling the raw materials, the main problem is to provide the most appropriate inventory of materials to prevent production activities and funding planted within the company.

Jofie bakery is a business-preparation effort that produced a wide variety of bread. The amount of similar business that still grow right now does not make Jofie Bakery lose and still exists until now. Jofie bakery produced a variety of flavors at an economic price. The main raw materials used in this process are flour, sugar, softener, developers, butter, and other auxiliary ingredients.

Excess inventories will result in damage risk, loss of quality materials, large amounts of funds to be invested, reduced investment costs, and other story-related expenses will increase. While the shortage of supplies will disrupts the production process and cannot meet the demands of the consumer well.

Therefore, a method is required to optimize company supply of raw materials. The method is used in this study is the EOQ method. EOQ methods assume economic demands with constant reservations and lack of inventories. Additionally, the application of the EOQ method would enable

companies to reduce storage costs, space savings for storage, and problems resulting from stockpiling supplies, thereby reducing the possible risks of storage supplies.

2. Theoritical Review

2.1 Inventory

The inventory is an essential component of a company's production and distribution. Inventories are used as reserves or safety deposits for products that require an indefinite supply of time. Hence, the inventories are uncertain. With inventories, production and distribution operations continue unhindered.

Inventory is a technique related to the determination of the amount of material inventory that must be held to ensure smoothness in production operations, as well as establishing the procurement schedule and the number of orders of goods that should be made by the company [3].

2.2 Inventory Control

Inventory control is an activity to get maximum profit, as well as continuity and smoothness in running a business. Whether a service company, a trade, or a manufacturing company always needs inventory.

2.3 Normality Lilliefors Test

In inventory control, the formulation of statistical science is used to determine distribution patterns, where the distribution pattern can be calculated by testing the normality of observational data. The normality test with the Lilliefors test is performed if the data is a single data or a single frequency data, not group frequency distribution data. One of the requirements of this normality test is that many $n < 30$. This test is done with using Liliefors normality test. For hypothesis testing, procedures that must be done include [4]:

Hyphotesis:

H_0 : Normal distributed sample

H_1 : The sample is not normally distributed.

For hypothesis testing, procedures that must be done include:

a. Data value X1; X2; X3;.....; Xn is used as the default number Z1; Z2; Z3;....; Zn with using formulas (with $\bar{X}$ and S which are averages and standard deviations, respectively).
   Calculating the average of observation samples used formula:

$$\bar{X} = \frac{\sum_{i=1}^{n} X_i}{n} \quad (1)$$

Calculating the standard deviation of the sample used formula:

$$S = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1}} \quad (2)$$

So, to calculate the value Z is used formula:

$$Z_i = \frac{X_i - \bar{X}}{S} \quad (3)$$

Information:

$\bar{X}$ = Average

S = Standard deviation

Z_i = Standard Number

i = 1, 2, 3, … , n

b. For each standard number and using the standard normal distribution list, then calculate the probability:

$$F(Z_i) = P(Z \leq Z_i) \quad (4)$$

c. Calculating the proportion of $Z_1, Z_2, Z_3, \ldots, Z_n \leq Z_i$, if this proportion is expressed by S (Z_i), then:

$$S(Z_i) = \frac{Amount\ of\ Z_1, Z_2, Z_3, \ldots, Z_n \leq Z_i}{n} \quad (5)$$

d. Calculate the difference | F (Zi) – S (Zi)| And set the absolute price.

e. Find the greatest value among the absolute values of the difference $|F(Z_i) - S(Z_i)|$ and make it become L_{hitung} or L_0.

$$L_{hitung} = \max\{|F(Z_i) - S(Z_i)|\} \quad (6)$$

f. The decision-making criteria is comparing L_{hitung} and L_{tabel}. If :

$L_{hitung} \leq L_{tabel}$: then H_0 accepted and the sample is normally distributed.

$L_{hitung} > L_{tabel}$: then H_0 rejected dan the sample is not normally distributed.

with L_{tabel} is the critical value of lilliefors normality test with a real level of α and the number of samples n .

2.4 Economic Order Quantity Method (EOQ)

The Economic Order Quantity method is one of the models of control that aims to determine the number of orders of goods or materials that are most economical according to the needs of the company. This model can increase the efficiency of inventory costs. So that the company can minimize the cost of production without reducing the target or profit to be achieved. EOQ methods are also known as the number of reservations that can minimize total supply costs [5].

2.5 Carrying Cost

Carrying costs (H) are usually expressed on basic per unit for some time periods (though sometimes expressed in the average percentage of supplies). Traditionally, carrying costs are linked to annual basis (per year). So the amount of inventory available is between two extreme points. Logical deduction is that the amount of inventory available is the average level of inventory, defined as follows:

$$\text{Average of Inventory} = \frac{Q}{2} \tag{7}$$

The relationship for this average inventory is maintained regardless of the order size, Q, or frequency of bookings (time period, t), so it can be determined the total annual carrying cost by multiplying the average amount in inventory by the annual carrying cost (H), then the total carrying cost per year (TH):

$$\begin{aligned} TH &= \text{Average inventory} * \text{Carrying cost} \\ &= \frac{Q^*}{2} . H \end{aligned} \tag{8}$$

Where:

TH = Total of carrying cost
Q^* = Quantity of economic order
H = Carrying cost

2.6 Ordering Cost / Set Up Cost

Ordering cost is stated in basis per order, the value represents only the cost per order and not the total of ordering cost. Ordering the item does not exceed the existing demand because the demand is known with certainty, the the frequency of order per year (F) is defined as follows:

$$F = \frac{D}{Q^*} \tag{9}$$

Where:

F = Order frequency per year
D = The quantity of needs per year
Q^* = The quantity of economic order

2.7 Safety Stock

Safety stock is an inventory that is reserved as a safety of the company's production process. Simply, safety stock is a prevention against stockouts (depleted inventory in the warehouse) [6]. The calculation of safety supplies is as follows:

$$Safety\ Stock = \sigma\ .\ Z \tag{10}$$

Where:

Safety stock = Safety stock

σ = Standard deviation

Z = Safety factors used by the company

2.8 Reorder Point

A reorder point (ROP) is a point or limit to the amount of inventory available at a time at which the order must be held back. The calculation of ROP is as follows:

$$ROP = Safety\ Stock + (Lead\ Time\ .\ d) \tag{11}$$

Where:

ROP = Reorder Point ;

Lead Time = Waiting time;

d = Average use of raw materials per day

2.9 Total Inventory Cost

Total Inventory Cost TIC can be defined as the total amount of costs associated with inventory, but in the context of the EOQ method, TIC is the sum between the total cost of ordering and the total cost of storage. TIC values can be obtained with the following equation [7]. The total inventory cost (TIC) calculated by summing the total order cost (*TS*) and total carrying cost (*TH*), are:

$$TIC = \text{Order Cost} + \text{Carrying Cost}$$

$$TIC = \frac{D}{Q}.S + \frac{Q}{2}.H \tag{12}$$

2.10 Calculating Q (Inventory) Optimal

The first derivative of the equation will be searched $TIC = \frac{D.S}{Q} + \frac{Q.H}{2}$, and since what will be found Q* (optimal Q value), then the equation $TIC = \frac{D.S}{Q} + \frac{Q.H}{2}$, and it will be lowered against Q.

$$TIC = \frac{D}{Q}.S + \frac{Q}{2}.H$$

$$TIC = \frac{D\,S}{Q} + \frac{Q\,H}{2}$$

$$\frac{d(TIC)}{d(Q)} = \frac{-DS}{Q^2} + \frac{H}{2}$$

The requirement to obtain a mininum point is the first derivative of TIC that is equal to zero can be written as follows:

$$\frac{d(TIC)}{d(Q)} = 0$$

So:

$$\frac{-D\,.\,S}{Q^2} + \frac{H}{2} = 0$$

$$Q^2 = \frac{2.D.S}{H}$$

$$\frac{H}{2} = \frac{DS}{Q^2}$$

$$Q^2 = \sqrt{\frac{2\mathrm{DS}}{\mathrm{H}}}$$

$$\mathrm{Q} = \sqrt{\frac{2\mathrm{DS}}{\mathrm{H}}},$$

Since Q is the optimal value, it is symbolized to Q*. It can be written into:

$$Q^* = \sqrt{\frac{2\,.\,D\,.\,S}{H}} \quad (13)$$

Where:

Q^* = Optimal number of bookings

D = Amount of use of raw materials

S = Booking fee for each order (rupiah/order)

H = Storage costs (units/rupiah/year)

2.11 Total of Company Inventory Cost

TIC_{per} = Biaya Penyimpanan + Biaya Pemesanan

$$TIC_{per} = \frac{D}{Q}.S + \frac{Q}{2}.H \quad (14)$$

3. Research Methodology

The analytical steps in this study are as follows:

a. Collect literature study from of journals, books and previous research journals related to the EOQ method and the object of study.
b. Observation
c. Problem identification to determine the variable that needs and related to the method.
d. Collecting the data

That data used in this study is primary data of analysis result and interview. The data collected is as follows:

1. Type of raw materials in Jofie Bakery,
2. The quantity of each inventory of raw materials at 2019,
3. Ordering cost of raw material per unit;
4. Carrying cost of raw material per unit.

e. Data processing
   1. To test the normality data using liliefors test.
   2. Determine the optimal order quantity for each.
   3. To fulfill the frequency of order for each variable or materials.
   4. Find the safety stock.
   5. Calculate the reorder point (ROP).
   6. Determinate the origin of raw material inventory cost.
   7. Calculate the total of inventory cost.

f. Discuss the result

   After the result has found, so it will make a discussion of the result that found.

g. Make the conclusion and suggestion

4. Results & Discussions

4.1 Research Design

The data obtained is from direct observation of the company, record keeping, and company archives that match the data needed in solving. The problem is as follows:

a. The types of raw materials Jofie Bakery & Cake Shop are flour, butter, sugar, softener, and developer.
b. The each month inventory's quantity of all raw material in the period January 2019 to December 2019.
c. Raw material ordering cost for the period January 2019 to December 2019.
d. Carrying cost of raw materials for the period January 2019 to December 2019.

Table 1. Table of Raw Material Invetorie at Jofie Bakery & Cake Shop 2019

Month	Quantity of Stocks				
	Flour (kg)	Butter (kg)	Sugar (kg)	Softener (kg)	Developer (kg)
January	1.883	1.155	1.875	83	15
February	1.950	1.245	2.100	98	20
March	1.875	1.140	1.800	975	15
April	1.890	1.170	1.800	98	18
May	1.725	855	1.500	38	12
June	2.250	1.650	2.175	120	23

July	2.025	1.290	1.950	105	18
August	2.100	1.350	1.950	105	18
September	1.650	825	1.500	30	14
October	1.815	1.050	1.770	87	18
November	1.875	1.185	1.800	90	15
December	2.775	2.205	2.400	180	27
Total	23.813	15.120	22.620	1.109	216

Table 2. Table of Raw Material's Using at Jofie Bakery & Cake Shop 2019

Month	Quantity of Using				
	Flour (kg)	Butter (kg)	Sugar (kg)	Softener (kg)	Developer (kg)
January	1.770	1.086	1.763	78	14
February	1.794	1.145	1.932	90	18
March	1.669	1.015	1.602	67	13
85April	1.758	1.088	1.674	91	17
May	1.604	795	1.395	35	11
June	2.025	1.485	1.958	108	21
July	2.823	1.161	1.755	95	16
August	1.890	1.215	1.755	95	19
September	1.568	784	1.425	29	13
October	1.636	945	1.593	78	16
November	1.706	1.078	1.638	82	14
December	2.636	2.095	2.280	171	26
Total	21.879	13.892	20.770	1.019	198
Average	1.823	1.158	1.731	85	17

Table 3. Raw Material Ordering Cost at Jofie Bakery & Cake Shop 2019

Type of Cost	Cost/Fee (Rp)
Administration Cost	950.000
Transportation Cost	13.000.000
Telephone and Communication Cost	1.200.000
Total	15.150.000

The cost of booking is constant, where the amount does not depend on the amount of value or the amount of materials ordered so that every inventory item at Jofie Bakery & Cake Shop requires the same booking cost. The frequency of bookings is 36 times made each year.

$$\text{Order Cost} = \frac{Total\ of\ Order\ Cost}{Frequency\ of\ Bookings\ in\ a\ Year}$$

$$= \frac{15.150.000}{12}$$

$$= \text{Rp. } 1.262.500$$

Table 4. Raw Material Storage Cost at Neko Neko Bakery & Cake 2019

Type of Cost	Cost/Fee (Rp)
Rent a Warehouse	50.000.000
Electricity	35.000.000
Total	85.000.000

From : Jofie Bakery & Cake Shop Medan

The total storage cost of the raw material supply at Jofie Bakery & Cake Shop is

$$\text{Storage Cost} = \frac{Total\ of\ Storage\ Cost}{Amount\ of\ All\ Supplies}$$

$$= \frac{85.000.000}{62.878\ kg}$$

= Rp. 1.351,82 per kg in 1 year for each unit

4.2 Liliefors Normality Test for Flour

Hypothesis:

H_0 : Supply of flour raw materials is normally distributed.

H_1 : Supply of flour raw materials is not normally distributed.

Table 5. Liliefors Normality Test Data of Raw Material Supplies (Flour)

No	X_i	Z_i	$F(Z_i)$	$S(Z_i)$	$\lvert F(Z_i) - S(Z_i)\rvert$
1	1.883	-0,34	0,3669	0,5	0,1331
2	1.950	-0,12	0,4522	0,6666	0,2144
3	1.875	-0,37	0,3557	0,4166	0,0609
4	1.890	-0,32	0,3745	0,5833	0,2088
5	1.725	-0,88	0,1894	0,1666	0,0228
6	2.250	0,90	0,8159	0,9166	0,1007
7	2.025	0,14	0,5557	0,75	0,1943
8	2.100	0,39	0,6517	0,8333	0,1816
9	1.650	-1,13	0,1292	0,0833	0,0459
10	1.815	-0,57	0,2843	0,25	0,0343
11	1.875	-0,37	0,3557	0,4166	0,0609
12	2.775	2,67	0,9962	1	0,0038

From Table 5 can found that $L_0 = Max[|F(Z_i) - S(Z_i)|] = 0{,}2144$, $L_0 = L_{\alpha(n)}$ found from Table of Lilliefors Normality test with real levels α = 0.05 and n = 12. $L_{\alpha(n)} = L_{0{,}05(12)} = 0{,}2420$.

So, $L_{hitung} < L_{tabel}$, that means the supply's data of flour raw materials in Jofie Bakery & Cake Shop in the period January - December 2019 followed the pattern of normal distribution inventory.

4.3 Liliefors Normality Test for Butter

Hypothesis:

H_0 : Supply of butter raw materials is normally distributed.

H_1 : Supply of butter raw materials is not normally distributed.

$L_0 = Max[|F(Z_i) - S(Z_i)|] = 0{,}2385$, $L_0 = L_{\alpha(n)}$ found from Table of Lilliefors Normality test with real levels α = 0.05 and n = 12. $L_{\alpha(n)} = L_{0{,}05(12)} = 0{,}2420$.

So, $L_{hitung} < L_{tabel}$, that means the supply's data of butter raw materials in Jofie Bakery & Cake Shop in the period January - December 2019 followed the pattern of normal distribution inventory.

4.4 Liliefors Normality Test for Sugar

Hypothesis:

H_0 : Supply of sugar raw materials is normally distributed.

H_1 : Supply of sugar raw materials is not normally distributed.

$L_0 = Max[|F(Z_i) - S(Z_i)|] = 0{,}1621, L_0 = L_{\alpha(n)}$ found from Table of Lilliefors Normality test with real levels α = 0.05 and n = 12. $L_{\alpha(n)} = L_{0{,}05(12)} = 0{,}2420$.

So, $L_{hitung} < L_{tabel}$, that means the supply's data of sugar raw materials in Jofie Bakery & Cake Shop in the period January - December 2019 followed the pattern of normal distribution inventory.

4.5 Liliefors Normality Test for Softener

Hypothesis:

H_0 : Supply of softener raw materials is normally distributed.

H_1 : Supply of softener raw materials is not normally distributed.

$L_0 = Max[|F(Z_i) - S(Z_i)|] = 0{,}2040, L_0 = L_{\alpha(n)}$ found from Table of Lilliefors Normality test with real levels α = 0.05 and n = 12. $L_{\alpha(n)} = L_{0{,}05(12)} = 0{,}2420$.

So, $L_{hitung} < L_{tabel}$, that means the supply's data of softener raw materials in Jofie Bakery & Cake Shop in the period January - December 2019 followed the pattern of normal distribution inventory.

4.6 Liliefors Normality Test for Developer

Hypothesis:

H_0 : Supply of developer raw materials is normally distributed.

H_1 : Supply of developer raw materials is not normally distributed.

$L_0 = Max[|F(Z_i) - S(Z_i)|] = 0{,}1870, L_0 = L_{\alpha(n)}$ found from Table of Lilliefors Normality test with real levels α = 0.05 and n = 12. $L_{\alpha(n)} = L_{0{,}05(12)} = 0{,}2420$.

So, $L_{hitung} < L_{tabel}$, that means the supply's data of developer raw materials in Jofie Bakery & Cake Shop in the period January - December 2019 followed the pattern of normal distribution inventory.

4.7 Determination of Optimal Booking by EOQ Method

Through calculations using the equation formula (12) and (13) then obtained the optimal ordering value for each raw material.

Table 6. Optimal and Frequency of Order for Each Raw Materials

Raw Materials	$\boldsymbol{Q}^*$ (kg)	F(every order)
Flour	6.392,71	3
Butter	5.093,94	3
Sugar	6.228,59	3
Softener	1.379,62	1
Developer	608,14	1

4.8 Determination the Amount of Safety Stock

To determine the number of safety supplies, standard deviation is needed for the use of each raw material in 2019 and also safety factors (Z) used by the company. The company expects the stock out to be only 5%, so the value of the Z safety factor used is 1,65.

So that the order value of each raw material can be seen in table 7.

Table 7. Table Optimal Order of Raw Material According to EOQ 2019

Raw Materials	$\boldsymbol{Q}^*$ (kg)	*Safety Stock* (Kg)	*Reorder Point* (Kg)	Total of Storage Cost (Rp)
Flour	6.392	488	549	9.023.739,78
Butter	5.093	607	646	7.190.438,95
Sugar	6.228	427	484	8.794.912,46
Softener	1.379	63	66	1.947.352,68
Developer	608	7	8	859.464,39
Total				27.815.908,26

The comparison of Total Inventory Cost (TIC) inventory by company with Total Inventory Cost (TIC) based on the EOQ method can be seen in the following table:

Table 8. Comparison of Raw Material Cost at Neko Neko Bakery & Cake with EOQ Method 2019

TICper	*TIC* EOQ	Difference
Rp. 48.296.376,87	Rp. 27.815.908,26	Rp. 20.480.468,61

From the table above, the total cost of raw material supplies according to neko Neko Bakery & Cake company is amounted to Rp. 48.296.376,87. While according to EOQ amounted to Rp. 27.815.908,26. And there is a difference of Rp. 20.480.468,61 from the calculation of raw materials Total Inventory Cost.

5. Conclusion

Based on the results of research and discussion, it can be concluded that the application of the EOQ method to Jofie bakery & Cake Shop results in a cheaper cost when compared to the simple method applied by the company so far, namely not applying the reorder point. This is evidenced by the difference in calculation of Total Inventory Cost (TIC) between the company's method and the EOQ method. Where the total cost of raw material supplies according to Jofie Bakery & Cake Shop amounted to Rp.48,296,376.87 while according to EOQ amounted to Rp.27,815,908.26 and can be made savings of 3,5% of the cost of raw material supplies according to Jofie Bakery & Cake Shop.

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