Storage Control Uses EPQ Method to Supply Continuous Demand and Discrete Demand at Tofu Warno Business

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Abstract

The Tofu Warno is one of the oldest businesses in this area that only produces single item product, white tofu. This business has two types of demand, that is continuous demand and discrete demand. Continuous demand must be sent daily to the market in a constant quantity and increasing on Tuesdays and Wednesdays. While discrete demand consists of two types, that is discrete demand that must be supply every Saturday for meatball tofu sellers and discrete demand that must be supply every three days for fried tofu sellers. An increase in demand that occurs on a certain day causes a shortage of supply so that the Business cannot supply both types of demand simultaneously. To solve The Tofu Warno Business's problem, it is important to make improvements in the production system with determine optimal production for continuous and discrete demand in The Tofu Warno with Economic Production Quantity (EPQ) method. The results of data processing is the optimal production for the Tofu Warno is 13 times delivery in a month with a total cost of one cycle of IDR32,519,422.

Keywords
Economic Production Quantity, Continuous Demand, Discrete Demand and Storage.

1. Introduction
One that affects inventory control is the type of demand. Companies generally have two types of demand, namely continuous demand, and discrete demand, it means that companies have requests that must be fulfilled continuously and requests that are fulfilled only at a specific time (Fibrianie et al. 2018). Two types of demand cause the company to have good production management to fulfill customer requests.

The Tofu Warno is one of the businesses that have two types of demand. This tofu business is one of the oldest tofu factories in Kuok which has been operating since 2008 on Jalan Prof. M. Yamin Kuok, Kampar Regency, Riau. Its products are sold to several places in various quantities and times. Continuous demand must be fulfilled daily with constant requests and increases on Tuesdays and Wednesdays because they are market days. In comparison, discrete demand consists of two types: discrete demand that must be fulfilled every Saturday for meatball tofu sellers and

discrete demand that must be fulfilled every three days for fried tofu sellers. Production and demand data of tofu for the past month can be seen in Table 1 below.

Table 1. Production and demand data **of** tofu in May 2022

Date / Time	Production Quantity	Continuous Demand	Discrete Demand	Over	Shortage
Sunday / 1	7200	7200	0	0	0
Monday / 2	0	0	0	0	0
Tuesday / 3	0	0	0	0	0
Wednesday / 4	7200	5760	0	1440	0
Thursday / 5	7200	5760	1080	1800	0
Friday / 6	7200	5760	0	3240	0
Saturday / 7	7200	5760	4800	0	-120
Sunday / 8	7200	5760	1080	360	0
Monday / 9	7200	5760	0	1800	0
Tuesday /10	7200	7200	0	1800	0
Wednesday /11	7200	7200	1080	720	0
Thursday /12	7200	5760	0	2160	0
Friday /13	7200	5760	0	3600	0
Saturday /14	7200	5760	5880	0	-840
Sunday /15	7200	5760	0	1440	0
Monday /16	7200	5760	0	2880	0
Tuesday /17	7200	7200	1080	1800	0
Wednesday /18	7200	7200	0	1800	0
Thursday /19	7200	5760	0	3240	0
Friday /20	7200	5760	1080	3600	0
Saturday /21	7200	5760	4800	240	0
Sunday /22	7200	5760	0	1680	0
Monday /23	7200	5760	1080	2040	0
Tuesday /24	7200	7200	0	2040	0
Wednesday /25	7200	7200	0	2040	0
Thursday /26	7200	5760	1080	2400	0
Friday /27	7200	5760	0	3840	0
Saturday /28	7200	5760	4800	480	0
Sunday /29	7200	5760	1080	840	0
Monday /30	7200	5760	0	2280	0
Tuesday /31	7200	7200	0	2280	0

An increase in tofu demand that occurs on certain days causes tofu factories to have a shortage of supplies so they cannot meet both types of demand. As a result, tofu business owners often cannot sell their products to the market as

much as usual because they run out of stock when meeting the large demand from tofu and meatball sellers, in other words, tofu business owners cannot fulfill continuous demand while meeting discrete demand.

Another production problem found at the Tofu Warno is a discrepancy in production time. The time needed to produce one tofu molds (120 pcs) is five minutes. This tofu business produces 60 tofu molds (7,200 pcs) per day which should only take 300 minutes (5 hours). Production time in the field often exceeds the production time that should be. This is due to the pause between production which is used by workers to rest. The production process, which should have been completed faster, ended up being one to two hours late, which ended up consuming all of the working hours. The amount of production that should be able to meet all demands simultaneously becomes constrained because of undisciplined workers. The Tofu Warno has lost the opportunity to sell its products because it cannot meet all demand.

1.1 Objectives

The research objectives are to determine optimal production for continuous and discrete demand, and provide production scheduling proposals to manage the work process so that it is completed on time in The Tofu Warno Business.

2. Literature Review

Inventory control is an activity to control the number of raw materials and finished goods inventory so that companies can avoid disruptions to the production process and determine optimal sales and purchases. Inventory control is an activity that is sequentially closely related during the production process by what has been planned in advance both in time, amount, quantity and cost. The purpose of inventory control is to keep operational costs as low as possible so that the company's performance and profits remain optimal (Nasution and Ningrum 2020).

Maesprillanti et al. (2020) explain that Economic Production Quantity (EPQ) is a certain amount produced by minimizing the total cost of inventory. The EPQ method can be achieved if the set-up costs and carrying costs incurred are minimum, meaning that the total inventory cost (TIC) provided will be minimum at an optimal production level. The classical EPQ method was developed to consider two types of demands, namely continuous and discrete. Oktavia conducted research in 2016 to determine the size of production lots and the number of simultaneous shipments with continuous demand and discrete demand.

Continuous demand or constant demand is a type of request with the condition that the product will be delivered continuously at any time in a unit of time. In comparison, discrete demand is demand that is fulfilled within a specific time interval. The character of discrete demand is that it can occur at any time so it is different every time. The frequency of discrete demand delivery occurs n times in each cycle. Companies with a discrete demand type will have high product holding costs because some of their products are stored in storage for longer. This type of inventory will affect the amount of inventory that must be prepared and the cost of storing the product (Fibrianie et al. 2018).

The basic assumptions used in the EPQ model with two types of demand are as follows (Fibrianie et al. 2018):

a. Discrete demand delivery time interval is fixed.
b. Component costs remain the same throughout the production cycle.
c. Product prices are fixed prices and there are no purchase discounts.
d. There is no damage or decrease in machine performance during production activities.
e. There is no backorder and rework conditions.
f. Production capacity is fixed.
g. There are no defective products produced.
h. There is no safety stock.
i. There is no product consumption during the production process. The demand in this cycle is fulfilled from the previous cycle's production results.
j. Only produce a single item product.

The notations used in the EPQ model with two types of demand are as follows (Fibrianie et al. 2018):

T : length of cycle time (time)
cp : production cost (Rp/unit)
cs : machine set-up fee (Rp)
cf : fixed shipping cost (Rp)

cd : variable shipping cost (Rp/unit)
h : storage cost (Rp/time unit)
h_1 : product storage costs carried by costomers (Rp/time unit)
D : total demand (unit/time)
D_D : discrete demand (unit/time)
D_C : continuous demand (unit/time)
P : production capacity (unit/time)
n : frequency of delivery of discrete demand in one cycle (integer number)
TC : total cost of each cycle (Rp)
E[TCU(T)]: average cost of one production period (Rp)

Optimal cycle time length

$$T = \sqrt{\frac{2(c_s + nc_f)}{\frac{hD^2}{P} + hD + \frac{D_D(h_1 - h)}{n}}} \quad \dots (1)$$

Total cost of each cycle

$$TC = c_pTD + c_s + (nc_f + c_dTD) + \left(\frac{hT^2DD_C}{2P} + \frac{hT^2D_C}{2}\right) + \left(\frac{hT^2DD_D}{2P} + \frac{(n-1)T^2D_D}{2n}\right) + \frac{h_1T^2D_D}{2n} \quad \dots (2)$$

The average cost of one period

$$E[TCU(T)] = c_pD + \frac{c_s}{T} + n\frac{c_f}{T} + c_dD + \frac{hTD}{2P}(D_C + D_D) + \frac{hT}{2}(D_C + D_D) + \frac{TD_D}{2n}(h_1 - h) \quad \dots (3)$$

The Gantt chart is named after its inventor, Henry Gantt, who was discovered in the 1800s. Gantt chart is a planning diagram for scheduling activities with more than one process and different process sequences. Gantt charts are used for simple scheduling or projects that do not have complex activities that are highly dependent on one another (Widyastuti et al. 2019). Dipohusodo (1996) explain in his book the benefits of the Gantt chart are describe a timetable showing the process or stages of each primary activity, project planning communication tools to related parties in order to maximize the use of resources, monitor the progress that can be achieved compared to activities carried out without scheduling, and can be used for scheduling repetitive operations.

3. Methods

The research methodology contains the stages carried out in the research.

3.1 Primary Phase

The primary phase is carried out by survey or direct observation of the research location. Then collect theoretical references related to the problem under study to be used as a basis for problem-solving. After that, formulate the problem in research and determine the problem objectives, assumptions, and problem boundaries.

3.2 Data Collection

The required data consists of primary data and secondary data.

a. Primary data
   Primary data is the results of interviews and determines production capacity. Interviews were conducted by directly meeting the employees at the Tofu Warno to ask for some information about the data needed. Meanwhile, production capacity is the optimal amount of production the company can achieve according to the available resources, which is influenced by data on raw materials, workers' salaries, working hours, and production time.
b. Secondary data
   Secondary data was obtained from data records owned by the Tofu Warno. Secondary data needed is the company profile, data on the total of continuous and discrete demands, production cost data, machine set-up cost data, storage cost data, shipping cost data, and delivery frequency.

3.3 Data Processing

a. Optimal cycle time
   The optimal cycle time is calculated to determine the length of the production cycle to fulfill the total demands at a lower cost. The optimal cycle time length can minimize the possibility of stock out. The optimal cycle time is calculated using formula 1.
b. The total cost of one cycle
   The total cost of one cycle is calculated to determine the total costs incurred in one cycle according to the optimal cycle time length. The total cost of one cycle is calculated using formula 2.
c. The average cost of one period
   The average cost of one period is the result of dividing the total cost of one cycle by the cycle time length. The results of calculating the average cost of the new period will be compared with the average cost of the old period to be analyzed and provide conclusions from the research results. The average cost of one period is calculated using formula 3.
d. Gantt Chart
   Gantt Chart is used to describe the optimal production schedule according to the results of the EPQ calculation. The steps for making a Gantt chart are making a time scale to guide the time the production takes place on the table and sorting the main production activities from start to finish. Then determine the length of time required for each activity. Lastly, mark each activity according to the length of time required.

4. Data Collection

Data collection was carried out by interviews with one of the employees at the Tofu Warno to get the required primary and secondary data. The object of this research is the Tofu Warno Business. Initially, this tofu business only produced small quantities to be sold to a nearby market. As time passed, this tofu business continued to grow until now, it sells its products in two different markets every day and can sell its production to fried tofu sellers and meatball tofu sellers. This Business currently has four workers who work every day from 11.00 – 18.00 WIB.

4.1 Discrete and Continuous Demand Data

The Tofu Warno produces 60 molds (7200 pcs) of tofu in one day. Discrete and continuous demand data (in mold units) for the past year can be seen in Table 2 below.

Table 2. Discrete and Continuous Demand Data

No	Month	Continuous Demand	Discrete Demand
1	June	1560	250
2	July	1464	290
3	August	1596	250
4	September	1548	250
5	October	1584	290
6	November	1548	250
7	December	1596	259
8	January	1584	290
9	February	1440	241
10	March	1608	263
11	April	1536	330
12	May	1488	241
Total		18552	3204
Average		1546	267

4.2 Production Cost

Production costs are the total costs used in the production process consisting of raw material costs, employee costs, and overhead costs. The costs spent on a one-day production process at the Tofu Warno can be seen in Table 3 below.

Table 3. Production Cost Data

Cost Type	Quantity Used	Price	Amount
Raw Material Cost			
Soybeans	150 kg	IDR580,000/sacks	IDR1.740.000
Vinegar	85 ml	IDR5,000,000/jerrycan (35 L)	IDR12.200
Employee Cost			
Salary	4 person	IDR150,000/person	IDR600.000
Overhead Cost			
Electricity Cost	-	-	IDR10.000
Total Cost in One Day			IDR2,362,200
Total Production in One Day			60 molds
Production Cost			IDR39,370/molds

4.3 Machine Set-Up Cost

The Tofu Warno uses three machines: a water machine, a grinding machine for grinding soybeans, and a boiler for cooking the mashed soybeans. The only machine that has a set-up cost is the boiler. It takes 2 hours to boil water in the boiler so that the steam produced can be used during production. The process of boiling the water still uses firewood. The firewood used in one day is as much as half a pick-up truck for IDR 100,000.

4.4 Holding Cost

Holding costs consist of holding costs paid by the tofu business and holding costs paid by customers. The total holding costs paid by each other can be seen in Tables 4 and 5 below.

Table 4. Holding Cost Paid by The Tofu Business

No	Cost Type	Amount
1	Electricity Cost	IDR100
2	Depreciation Cost	IDR700
Total		IDR800

Table 5. Holding Cost Paid by Customer

No	Cost Type	Amount
1	Electricity Cost	IDR100
2	Depreciation Cost	IDR1,300
Total		IDR1,400

4.5 Delivery Cost

Delivery costs consist of fixed delivery costs and variable delivery costs. Fixed elivery costs are salaries for employees who deliver products IDR 15,000/deliver. Meanwhile, variable delivery costs are the gasoline needed to deliver IDR 223/mold products.

4.6 Delivery Frequency Data

The frequency of continuous and discrete demand delivery can be seen in Table 6 below.

Table 6. Delivery Frequency Data

No	Month	Continuous Demand	Discrete Demand
1	June	30	10
2	July	29	10
3	August	31	10
4	September	30	10
5	October	31	10
6	November	30	10
7	December	31	11
8	January	31	10
9	February	28	9
10	March	31	11
11	April	30	10
12	May	29	9
Total		361	120
Average		30	10

5. Results and Discussion

a. Optimal Cycle Time

$$T = \sqrt{\frac{2(c_s + nc_f)}{\frac{hD^2}{P} + hD + \frac{D_D(h_1 - h)}{n}}}$$

$$T = \sqrt{\frac{2(100{,}000 + 10 \text{ x } 15{,}000)}{\frac{800 \text{ x } 1{,}813^2}{2{,}520} + 800 \text{ x } 1{,}813 + \frac{267\ (1{,}400 - 800)}{10}}}$$

$$T = \sqrt{0{,}2}$$

$$T = 0.4$$

The optimal shipping cycle time is 0.4 month, or the equivalent of 13 times a month.

b. Total Cost of One Cycle

$$TC = c_pTD + c_s + (nc_f + c_dTD) + \left(\frac{hT^2DD_C}{2P} + \frac{hT^2D_C}{2}\right) + \left(\frac{hT^2DD_D}{2P} + \frac{(n-1)T^2D_D}{2n}\right) + \frac{h_1T^2D_D}{2n}$$

$$TC = (39{,}370 \text{ x } 0.4 \text{ x } 1{,}813) + (100{,}00) + (10 \text{ x } 15{,}000 + 223 \text{ x } 0.4 \text{ x } 1{,}813) + \left(\frac{800 \text{ x } 0.4^2 \text{ x } 1{,}813 \text{ x } 1{,}546}{2 \text{ x } 2{,}520} + \frac{800 \text{ x } 0.4^2 \text{ x } 1{,}546}{2}\right) + \left(\frac{800 \text{ x } 0.4^2 \text{ x } 1{,}813 \text{ x } 267}{2 \text{ x } 2{,}520} + \frac{(10-1)0.4^2 \text{ x } 267}{2 \text{ x } 10}\right) + \left(\frac{1{,}400 \text{ x } 0.4^2 267}{2 \text{ x } 10}\right)$$

$$TC = 31{,}858{,}096 + 100{,}000 + 330{,}450 + 211{,}821 + 15{,}330 + 3{,}723$$

$$TC = \text{IDR}32{,}519{,}422$$

The total cost required to carry out one production cycle according to the optimal cycle time is IDR32,519,422.

c. Average Cost of One Period

$$E[TCU(T)] = c_pD + \frac{c_s}{T} + n\frac{c_f}{T} + c_dD + \frac{hTD}{2P}(D_C + D_D) + \frac{hT}{2}(D_C + D_D) + \frac{TD_D}{2n}(h_1 - h)$$

$$E[TCU(T)] = (39{,}370 \times 1{,}813) + \frac{100{,}000}{0.4} + 10\frac{15{,}000}{0.4} + (223 \times 1{,}813) + \frac{800 \times 0.4 \times 1{,}813}{2 \times 2{,}520}(1{,}546 + 267) + \frac{800 \times 0.4}{2}(1{,}546 + 267) + \frac{0.4 \times 1{,}546}{2 \times 10}(1{,}400 - 800)$$

$$E[TCU(T)] = 71{,}377{,}810 + 224{,}049 + 336{,}073 + 404{,}299 + 232{,}868 + 323{,}678 + 3{,}575$$

$$E[TCU(T)] = \text{IDR}72{,}902{,}355$$

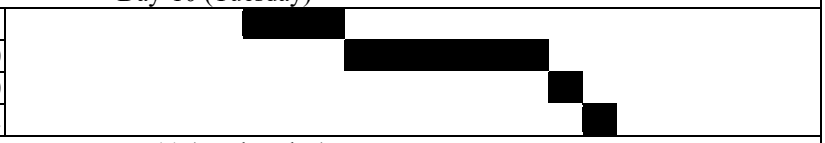
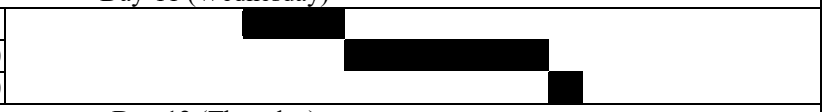
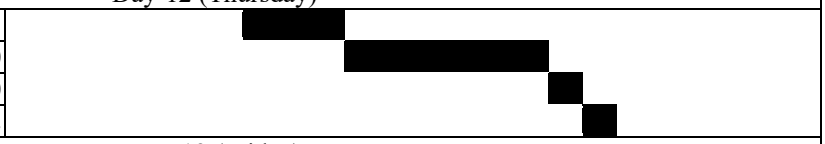
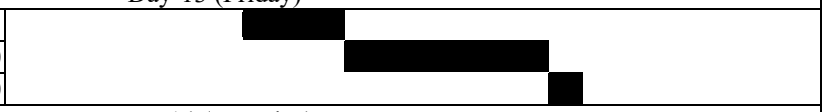
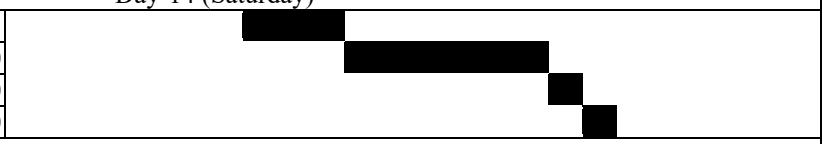
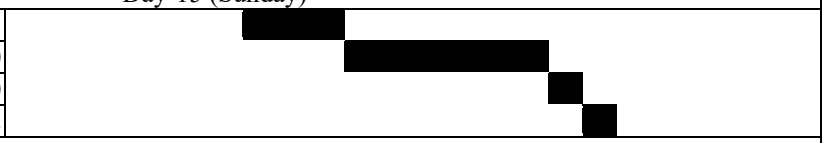
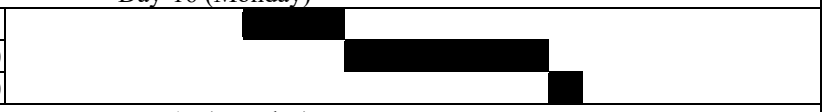
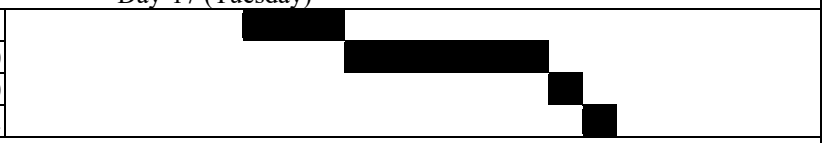
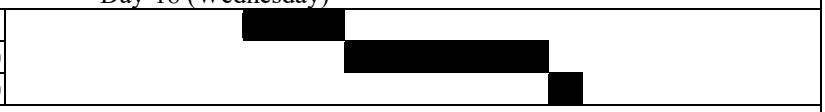
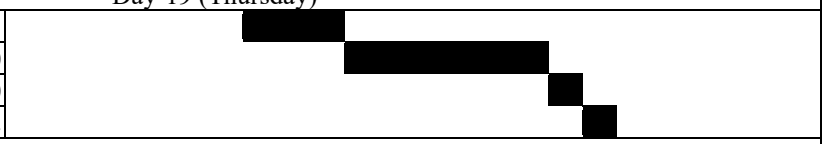
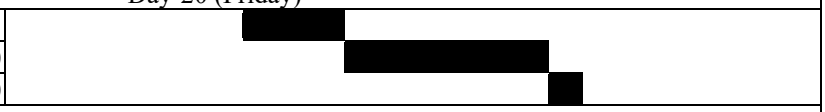
The average cost for producing one period according to the optimal cycle time is IDR72,902,355.

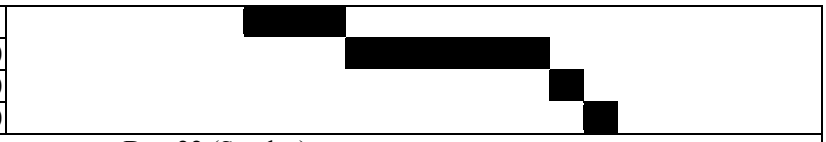
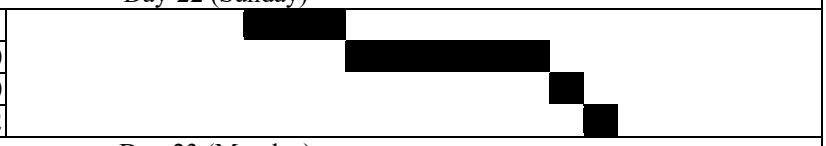
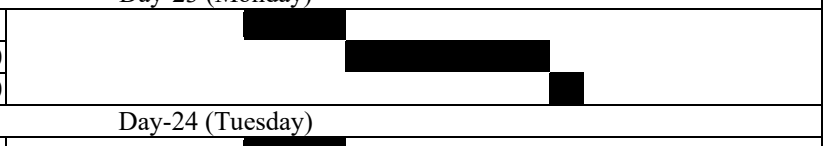
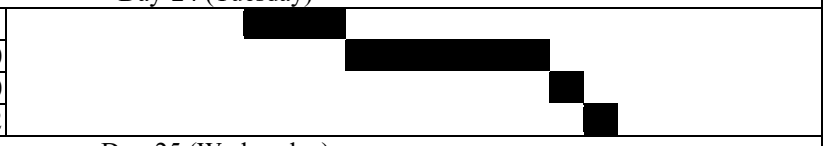
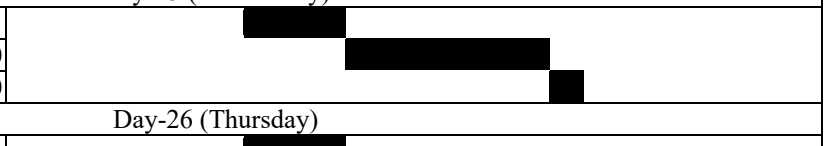
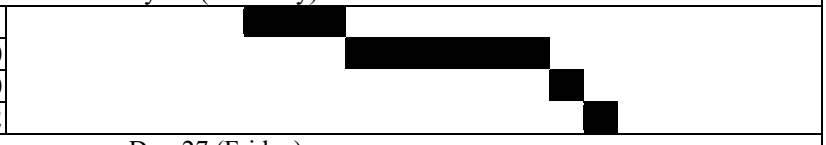
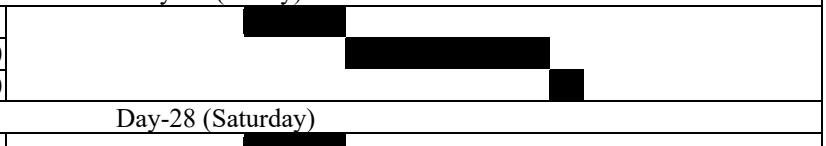
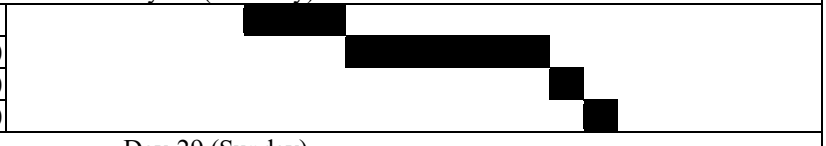
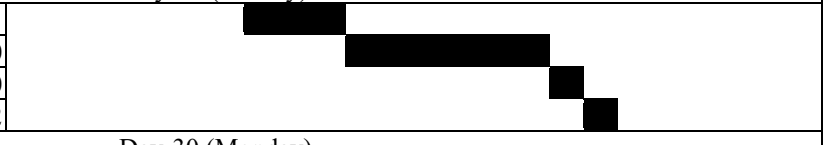
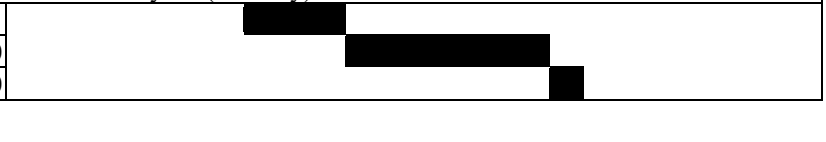
d. Gantt Chart

The scheduling of the production process and delivery at Tofu Warno Business according to the result of EPQ method calculation can be seen in Table 7 below.

Table 7. Gantt Chart

Process	Qty	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Day-1 (Sunday)																									
Preparation phase									■	■															
Production process	7200											■	■	■	■	■	■	■							
Continuous demand delivery	5760																		■	■	■	■	■	■	■
Day-2 (Monday)																									
Preparation phase									■	■															
Production process	7200											■	■	■	■	■	■	■							
Continuous demand delivery	5760																		■	■	■	■	■	■	■
Discrete demand delivery	772																								
Day-3 (Tuesday)																									
Preparation phase									■	■															
Production process	7200											■	■	■	■	■	■	■							
Continuous demand delivery	7200																		■	■	■	■	■	■	■
Day-4 (Wednesday)																									
Preparation phase									■	■															
Production process	7200											■	■	■	■	■	■	■							
Continuous demand delivery	7200																		■	■	■	■	■	■	■
Discrete demand delivery	772																								
Day-5 (Thursday)																									
Preparation phase									■	■															
Production process	7200											■	■	■	■	■	■	■							
Continuous demand delivery	5760																		■	■	■	■	■	■	■
Day-6 (Friday)																									
Preparation phase									■	■															
Production process	7200											■	■	■	■	■	■	■							
Continuous demand delivery	5760																		■	■	■	■	■	■	■
Discrete demand delivery	772																								
Day-7 (Saturday)																									
Preparation phase									■	■															
Production process	7200											■	■	■	■	■	■	■							
Continuous demand delivery	5760																		■	■	■	■	■	■	■
Discrete demand delivery	4800																								
Day-8 (Sunday)																									
Preparation phase									■	■															
Production process	7200											■	■	■	■	■	■	■							
Continuous demand delivery	5760																		■	■	■	■	■	■	■
Discrete demand delivery	772																								
Day-9 (Monday)																									
Preparation phase									■	■															

Production process	7200	
Continuous demand delivery	5760	
Day-10 (Tuesday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	7200	
Discrete demand delivery	772	
Day-11 (Wednesday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	7200	
Day-12 (Thursday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	5760	
Discrete demand delivery	772	
Day-13 (Friday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	5760	
Day-14 (Saturday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	5760	
Discrete demand delivery	4800	
Day-15 (Sunday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	5760	
Discrete demand delivery	772	
Day-16 (Monday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	5760	
Day-17 (Tuesday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	7200	
Discrete demand delivery	772	
Day-18 (Wednesday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	7200	
Day-19 (Thursday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	5760	
Discrete demand delivery	772	
Day-20 (Friday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	5760	
Day-21 (Saturday)		

Preparation phase		
Production process	7200	
Continuous demand delivery	5760	
Discrete demand delivery	4800	
Day-22 (Sunday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	5760	
Discrete demand delivery	772	
Day-23 (Monday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	5760	
Day-24 (Tuesday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	7200	
Discrete demand delivery	772	
Day-25 (Wednesday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	7200	
Day-26 (Thursday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	5760	
Discrete demand delivery	772	
Day-27 (Friday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	5760	
Day-28 (Saturday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	5760	
Discrete demand delivery	4800	
Day-29 (Sunday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	5760	
Discrete demand delivery	772	
Day-30 (Monday)		
Preparation phase		
Production process	7200	
Continuous demand delivery	5760	

6. Conclusion

Based on the results of data processing, it has been terminated that the optimal production for the Tofu Warno is 13 times delivery in a month with a total cost of one cycle of IDR32,519,422. The new delivery schedule is every two days with a production process is 6 working hours. This result is the optimal production time so that the Tofu Warno can fulfill all demands without increasing storage costs. Tofu Warno employees must be disciplined in their work so that production can run well.

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