DINASTI INTERNATIONAL JOURNAL OF ECONOMICS, FINANCE AND ACCOUNTING (DIJEFA)
E-ISSN : 2721-303X
P-ISSN : 2721-3021
https://dinastipub.org/DIJEFA dinasti.info@gmail.com +62 811 7404 455

DOI: https://doi.org/10.38035/dijefa.v5i3
Received: 29 June 2024, **Revised:** 18 July 2024, **Publish:** 03 August 2024

Evaluation of Raw Material Inventory Policies Using Material Requirement Planning (MRP) and Lot Sizing Methods: Case Study of XYZ MSMEs

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Abstract: Micro, Small and Medium Enterprises (MSMEs) have an important role in economic growth in Indonesia. Inventory management is one of the key aspects in the operational sustainability of MSMEs, especially raw materials used in the production process. One of them is XYZ MSMEs which is a producer of meatball pentol and meatball tofu products which uses several types of raw materials in its production process. The problem currently being faced is that there are often shortages and excesses in purchasing raw materials during procurement. This research aims to analyze the cost of raw material inventory at XYZ MSMEs using five different Lot Sizing methods, namely Economic Order Quantity (EOQ), Period Order Quantity (POQ), Silver Meal (SM), Least Unit Cost (LUC), and Part Period Balancing (PPB). This research uses historical data from MSME XYZ to identify differences in raw material inventory costs between the five MRP methods used. The results of this research show that the Silver Meal (SM) method produces the lowest total inventory costs for beef and tapioca starch as raw materials. Meanwhile, the Part Period Balancing (PPB) method produces the lowest total inventory costs for MSG raw materials.

Keywords: Production Planning, MRP, Lot Sizing, Inventory, Inventory Costs.

INTRODUCTION

Micro, Small, and Medium Enterprises (MSMEs) play a crucial role in the economic growth of Indonesia (Halim, 2020). MSMEs significantly contribute to job creation, increased community income, and overall societal welfare (Vinatra, 2023). Therefore, it is vital to enhance the performance of MSMEs in Indonesia. The performance of MSMEs heavily relies on the decisions of their owners in managing their businesses (Atmika et al., 2023). However, owners often face challenges in managing and implementing inventory management. Inventory management should be given special attention as it is a key aspect of MSME operational sustainability, particularly concerning the raw materials used in the production process (Wulandari & Donoriyanto, 2022).

Raw materials are a critical component in the production process, and maintaining adequate raw material inventory is essential to meet consumer demand for the products offered (Wulandari & Donoriyanto, 2022). Raw material inventory needs to be calculated optimally. Excess raw materials can pose various risks, such as increased maintenance costs, storage expenses, and potential degradation or damage to the quality of the materials, which can reduce the company's profitability (Pratama et al., 2022). Conversely, a shortage of raw materials can disrupt the production process, preventing the company from fulfilling consumer demand, which impacts consumer trust and the company's profits (Wardani et al., 2023). This issue of raw material inventory management is experienced by one MSME, XYZ, which is the subject of this research.

MSME XYZ is a micro, small, and medium enterprise that produces food items such as meatball skewers (pentol bakso) and tofu meatballs (tahu bakso). The primary raw materials for meatball skewers and tofu meatballs are beef and additional supporting ingredients like sago flour. These products are sold in branches and retail stores that sell meatball products and meatball stalls. The problem faced by MSME XYZ lies in the inaccurate control of raw material inventory, which disrupts the production process of meatball skewers and tofu meatballs. In planning raw material inventory, there are frequent occurrences of both shortages and excesses in the raw materials needed for daily production. MSME XYZ experienced a loss in April 2023 due to running out of stock during production caused by a surge in demand. During that month, demand increased by 20% compared to regular days due to the holiday season. Therefore, it is necessary to resolve this issue to plan raw material control efficiently and minimize inventory costs.

One method that can be used to address the issue of excessive raw material inventory at MSME XYZ is to implement the Material Requirement Planning (MRP) method combined with Lot Sizing techniques to calculate the total inventory cost of raw materials. MRP is an approach used to plan raw material needs based on demand and production plans (Tangihon Hutapea, 2022). In implementing Lot Sizing, the cost of raw material inventory can be compared using methods such as Economic Order Quantity (EOQ), Period Order Quantity (POQ), Silver Meal (SM), Least Unit Cost (LUC), and Part Period Balancing (PPB) to achieve optimal inventory costs (Mutiara & Maryati, 2023).

One study showed that applying Material Requirement Planning (MRP) to manage inventory at a nasi uduk (traditional Indonesian dish) MSME improved raw material procurement efficiency and significantly reduced costs (Atmika et al., 2023). Another study on a krupuk (cracker) SME found that the Lot for Lot (L4L) method was the best option compared to Economic Order Quantity (EOQ) and Period Order Quantity (POQ) methods for minimizing total inventory costs (Asshadhiq et al., 2021). Research using the Min-Max method, Economic Order Quantity (EOQ), and Period Order Quantity (POQ) in controlling raw material inventory for brownies demonstrated results in reducing the frequency of orders and more efficient use of raw materials (Nurhasanah et al., 2023). Another study applying Material Requirement Planning (MRP) and Lot Sizing techniques showed that the Period Order Quantity (POQ) method could reduce order frequency in planning coffee bean raw material inventory (Arissanto et al., 2022). Research combining Material Requirement Planning (MRP) and Lot Sizing methods found that Economic Order Quantity (EOQ) provided optimal total costs in planning mochi raw material inventory (Mahesa, 2022). Another study using forecasting combined with Material Requirement Planning (MRP) with Lot for Lot (L4L) and Economic Order Quantity (EOQ) techniques showed more efficient raw material stock management for wallet products (Bagas Efendi et al., 2022). Research on moka bread inventory using Least Unit Cost (LUC), Least Total Cost (LTC), and Lot for Lot (L4L) methods showed that the Least Total Cost (LTC) method resulted in efficient inventory costs (Nuril et al., 2020). Additionally, another study using the Economic Order Quantity

(EOQ) method for snack foods found that it could save inventory costs (Suryani et al., 2022). Research using the Silver Meal Heuristic method for tofu raw materials resulted in lower total inventory costs (Yetrina et al., 2023). Another study using Material Requirement Planning (MRP), Lot for Lot (L4L), Economic Order Quantity (EOQ), and Period Order Quantity (POQ) methods for Balado seasoning raw materials minimized inventory costs (Purnamadewi et al., 2023).

In this research, MRP and Lot Sizing methods are employed to solve the issues. Combining these two methods can plan raw material control more efficiently and timely. MRP can help identify detailed raw material needs, while Lot Sizing can optimize raw material inventory by significantly reducing inventory costs. Thus, this research aims to achieve efficient raw material inventory planning and significantly reduce inventory costs at MSME XYZ.

METHODS

The research method in this study is in the form of a flowchart that explains the stages of research carried out from beginning to end. Quantitative methods are used in this study because the data in the study are in the form of numbers. In this study using MRP analysis to obtain raw materials for each product. ABC analysis is carried out to prioritize which raw materials have a high total cost. The EOQ, POQ, SM, LUC, and PPB methods are used to get the lowest total inventory costs at XYZ UMKM.

Data collection techniques contain the data and tools needed in this study. The following are the data and tools used:

1. Data used
   a) Product demand data at XYZ UMKM
   b) Bill of Material (BOM) data of products
   c) Raw material lead time data
   d) Inventory cost data
   e) Raw material price data
2. Tools used
   a) Microsoft Word
   b) Microsoft Excel
   c) Microsoft Powerpoint
   d) Draw.io

After collecting the data and tools needed in this research, data processing will be carried out. Below is an explanation of the stages of data processing conducted by the researcher:

1. Forecasting
   At this stage, forecasting is performed based on historical demand data to estimate future product demand. The goal is to reduce uncertainty for the upcoming year. Demand is forecasted using the Moving Average (MA) and Exponential Smoothing (ES) methods. The forecasting method with the smallest error value will be selected for this study.
2. Verification
   In this stage, the forecasting results obtained in the previous step are verified. The purpose is to check the accuracy of the chosen forecast before proceeding to the next stage.
3. ABC Analysis
   This stage involves conducting an ABC analysis on each raw material used. This step classifies inventory into three categories: A, B, and C, represented in a Pareto

diagram. For each raw material, calculations are performed to determine their values by multiplying the usage amount by the price per unit.

4. Master Production Schedule
   In this stage, the Master Production Schedule (MPS) is calculated. The MPS includes forecast, available, MPS, and on-hand inventory. The Master Production Schedule is calculated by dividing the forecasted demand by the company's production periods. This calculation aims to establish an accurate production schedule for the company.
5. Material Requirement Planning
   This stage involves calculations using the Material Requirement Planning (MRP) method. This process details the required products and raw material components for specific periods. The MRP calculation includes production and purchase scheduling for raw material components used by the company. It also provides information on finished product demand, component structure, lead times for production or ordering, and current inventory levels within the company. The MRP calculation can also be used to improve cost-effectiveness in production and raw material component purchases. MRP consists of gross requirement, scheduled receipt, on-hand inventory, net requirement, planned order schedule, and planned order release.
6. Lot Sizing Techniques
   At this stage, calculations using Lot Sizing techniques are performed. These calculations aim to determine the optimal total inventory cost. The Lot Sizing techniques used in this research include Economic Order Quantity (EOQ), Period Order Quantity (POQ), Silver Meal (SM), Least Unit Cost (LUC), and Part Period Balancing (PPB). These methods are used to determine the optimal holding and ordering costs for each model. The holding and ordering costs are then summed to obtain the total inventory cost for each model.
7. Comparison of Total Inventory Costs
   In this stage, a comparison of the total inventory costs for each model is performed. This comparison aims to identify the model with the minimum total inventory cost.

RESULTS AND DISCUSSION

Data processing is done by processing the data that has been collected. Data processing contains demand forecasting, ABC analysis, Master Production Schedule, Material Requirement Planning, and Lot Sizing techniques.

Demand Forecasting

The demand forecasting stage will discuss how many products will be produced by UMKM XYZ for the next year. Forecasting is carried out on meatball pentol and tofu meatball products based on sales data for the period July 2021 to December 2023. The following are the stages of processing demand forecasting data:

Demand data for meatballs and tofu meatballs is the data needed in performing forecasting calculations. The following is product demand data for meatballs and tofu meatballs for the period July 2021 to December 2023.

Table 1. Demand Data for Meatball Pentol and Tofu Meatballs

Period	Demand	
	Meatball Pentol	Tofu Meatballs
July 2021	7760 Pack	552 Pack
August 2021	8349 Pack	675 Pack
September 2021	7705 Pack	761 Pack
October 2021	7654 Pack	652 Pack
November 2021	7742 Pack	730 Pack
December 2021	8205 Pack	641 Pack
January 2022	7432 Pack	814 Pack
February 2022	7328 Pack	588 Pack
March 2022	8011 Pack	701 Pack
April 2022	9249 Pack	823 Pack
May 2022	8527 Pack	587 Pack
June 2022	7456 Pack	620 Pack
July 2022	8029 Pack	701 Pack
Agustus 2022	7456 Pack	690 Pack
September 2022	7660 Pack	806 Pack
October 2022	7341 Pack	705 Pack
November 2022	7712 Pack	560 Pack
December 2022	8260 Pack	652 Pack
January 2023	7314 Pack	732 Pack
February 2023	7959 Pack	693 Pack
March 2023	7740 Pack	732 Pack
April 2023	9377 Pack	811 Pack
May 2023	7861 Pack	794 Pack
June 2023	8236 Pack	606 Pack
July 2023	7956 Pack	768 Pack
August 2023	7651 Pack	780 Pack
September 2023	7784 Pack	655 Pack
October 2023	7435 Pack	557 Pack
November 2023	7623 Pack	669 Pack
December 2023	8264 Pack	746 Pack

Meatball Pentol Demand Forecasting

In this study, meatball pentol demand forecasting uses the Moving Average (MA) and Exponential Smoothing (ES) methods. The forecasting method that has the smallest MAPE value will be selected in this study. The smallest MAPE data can be seen in the table below.

Table 2. Error of Meatball Pentol Forecasting Results

Forecasting Methods	MAPE	Forecasting Methods	MAPE
MA2	5,65%	MA12	4,34%
MA3	5,79%	MA13	4,54%
MA4	5,66%	MA14	4,26%
MA5	5,98%	MA15	4,37%
MA6	6,08%	MA16	4,20%
MA7	5,88%	ES (α = 0,1)	4,81%
MA8	5,49%	ES (α = 0,2)	5,07%
MA9	5,43%	ES (α = 0,3)	5,24%
MA10	4,81%	ES (α = 0,4)	5,35%
MA11	4,65%	ES (α = 0,5)	5,41%

Description:

: The smallest error with the MAPE method for forecasting demand one year ahead.

Table 2 shows that the smallest forecasting error is the Moving Average 16 (MA16) method. Therefore, the MA16 method is used to forecast meatball pentol demand data for the next one year period, namely January to December 2024, which can be seen in the table below.

Table 3. 2024 Meatball Pentol Forecasting Results

Period	Demand
January 2024	7836,00 Pack
February 2024	7855,06 Pack
March 2024	7854,94 Pack
April 2024	7928,19 Pack
May 2024	7955,00 Pack
June 2024	8011,75 Pack
July 2024	8008,31 Pack
August 2024	7908,44 Pack
September 2024	7862,00 Pack
October 2024	7860,69 Pack
November 2024	7835,31 Pack
December 2024	7885,81 Pack

Based on the results of meatball pentol forecasting, it can be calculated that the raw material requirements in 2024 are shown in table 4.

Table 4. Total Demand for Meatball Pentol 2024

Raw Material Name	Demand	Total Raw Material Requirements
Beef	94.806 Pack	61.623,90 Kg
Tapioca Starch	94.806 Pack	34.130,16 Kg
Salt	94.806 Pack	1.516,90 Kg
MSG	94.806 Pack	3.081,20 Kg
Pepper	94.806 Pack	474,03 Kg
Garlic	94.806 Pack	2.512,36 Kg
Ice Water	94.806 Pack	15.168,96 Kg

Tofu Meatball Demand Forecasting

In this study, forecasting the demand for tofu meatballs uses the Moving Average (MA) and Exponential Smoothing (ES) methods. The forecasting method that has the smallest MAPE value will be selected in this study. The smallest MAPE data can be seen in the table below.

Table 5. Error of Meatball Tofu Forecasting Results

Forecasting Methods	MAPE	Forecasting Methods	MAPE
MA2	13,70%	MA12	9,47%
MA3	11,81%	MA13	9,91%
MA4	11,23%	MA14	10,79%
MA5	11,21%	MA15	10,45%
MA6	11,20%	MA16	10,51%
MA7	10,52%	ES (α = 0,1)	12,18%
MA8	10,57%	ES (α = 0,2)	11,53%
MA9	10,96%	ES (α = 0,3)	11,62%
MA10	10,24%	ES (α = 0,4)	12,02%
MA11	9,55%	ES (α = 0,5)	12,18%

Description:

: The smallest error with the MAPE method for forecasting demand for the next year.

Table 5 shows that the smallest forecasting error is the Moving Average 12 (MA12) method. Therefore, the MA12 method is used to forecast the demand data for tofu meatballs in the next one year period, namely January to December 2024, which can be seen in the table below.

Table 6. Forecasting Results of Tofu Meatballs 2024

Period	Demand
January 2024	680,42 Pack
February 2024	689,17 Pack
March 2024	691,75 Pack
April 2024	690,75 Pack
May 2024	708,00 Pack
June 2024	706,83 Pack
July 2024	712,42 Pack
August 2024	719,92 Pack
September 2024	707,33 Pack
October 2024	695,00 Pack
November 2024	704,08 Pack
December 2024	711,92 Pack

Based on the results of meatball pentol forecasting, it can be calculated that the raw material requirements in 2024 are shown in table 7.

Table 7. Total Demand for Meatball Pentol 2024

Raw Material Name	Demand	Total Raw Material Requirement
Beef	8.422 Pack	1.054,43 Kg
Tapioca Starch	8.422 Pack	2355,63 Kg
Salt	8.422 Pack	42,11 Kg
MSG	8.422 Pack	85,90 Kg
Pepper	8.422 Pack	13,48 Kg
Garlic	8.422 Pack	69,90 Kg
Ice Water	8.422 Pack	421,94 Kg
Tofu	8.422 Pack	168.440 Pcs

Bill of Materials (BOM)

The Bill of Materials will discuss the list of raw materials needed in the production process of meatballs and tofu meatballs. The following is the level, component name, quantity, and unit for meatball pentol and tofu meatball products which can be seen in tables 12 and 13.

Table 11. Bill of Materials for Meatball Pentol

Bill of Materials				
Products:	**Meatball Pentol**			
Level	**Component Name**	***Quantity***	**Satuan**	***Made/Buy***
0	Meatball Pentol	1	Pack	*Made*
1	Beef	0,6500	Kg	*Buy*
1	Tapioca Starch	0,3600	Kg	*Buy*
1	Salt	0,0160	Kg	*Buy*
1	MSG	0,0325	Kg	*Buy*
1	Pepper	0,0050	Kg	*Buy*
1	Garlic	0,0265	Kg	*Buy*
1	Ice Water	0,1600	Kg	*Buy*

Table 12. Bill of Materials for Tofu Meatballs

Bill of Materials				
Products:	**Tofu Meatballs**			
Level	**Component Name**	***Quantity***	**Satuan**	***Made/Buy***
0	Tofu Meatballs	1	Pack	*Made*
1	Beef	0,1252	Kg	*Buy*
1	Tapioca Starch	0,2797	Kg	*Buy*
1	Salt	0,0050	Kg	*Buy*
1	MSG	0,0102	Kg	*Buy*
1	Pepper	0,0016	Kg	*Buy*
1	Garlic	0,0083	Kg	*Buy*
1	Ice Water	0,0501	Kg	*Buy*
1	Tofu	20	Pcs	*Buy*

ABC Analysis

At the ABC analysis stage will discuss the determination of the most important types of raw materials in the inventory system. ABC analysis classifies goods based on a value ranking from the highest value to the lowest value which is divided into three groups, namely group A, group B, and group C. Based on tables 4 and 7, the total raw material requirements can be calculated, which are shown in the table below.

Table 13. Total Raw Material Requirements 2024

Raw Material Name	Total Raw Material Requirement
Beef	62.678,33 Kg
Tapioca Starch	36.485,79 Kg
Salt	1.559,01 Kg
MSG	3.167,10 Kg
Pepper	487,51 Kg
Garlic	2.582,26 Kg
Ice Water	15.590,90 Kg
Tofu	168.440 Pcs

Based on the total raw material requirements in 2024, the classification of raw materials can be calculated, which is shown in the following table.

Table 14. ABC Analysis of Raw Material Requirements

Nama Bahan Baku	Jumlah Kebutuhan (D)	Harga per kg atau per pcs (C)	D x C	D x C Kumulatif	%	Kumulatif %	Kelompok
Daging Sapi	62.678,33	Rp 66.500	Rp 4.168.109.328	Rp 4.168.109.328	83,19%	83,19%	A
Pati Tapioka	36.485,79	Rp 12.400	Rp 452.423.838	Rp 4.620.533.076	9,03%	92,22%	B
MSG	3167,10	Rp 46.000	Rp 145.686.572	Rp 4.766.219.648	2,91%	95,13%	B
Bawang Putih	2.582,26	Rp 29.000	Rp 74.885.586	Rp 4.841.105.235	1,49%	96,63%	C
Air Es	15.590,90	Rp 4.000	Rp 62.363.609	Rp 4.903.468.843	1,24%	97,87%	C
Tahu	168.440	Rp 350	Rp 58.954.000	Rp 4.962.422.843	1,18%	99,05%	C
Merica	487,51	Rp 82.000	Rp 39.975.426	Rp 5.002.398.270	0,80%	99,84%	C
Garam	1.559,01	Rp 5.000	Rp 7.795.030	Rp 5.010.193.300	0,16%	100%	C
Total	**290.990,90**		**Rp 5.010.193.300**		**100%**		

Table 9 shows the results of the ABC Analysis calculation of raw material requirements. Based on the above calculations, the inventory included in group A is beef. Group B is tapioca starch and msg. Group C is garlic, ice water, tofu, pepper, and salt.

Master Production Schedule

At the Master Production Schedule stage will discuss production planning which serves to determine the number and production schedule of the final products, namely meatballs and tofu meatballs. The master production schedule (MPS) is compiled based on the results of data processing at the demand forecasting stage for the next year or in 2024. In this study, all MPS calculations, MRP, and Lot Sizing techniques are calculated in periods of days. The provisions are one year there are 12 months, one month there are 24 days. So that in one year there are 288 days, but the calculation data in this study is summarized in a 12-month period. In this study, the production process of meatball pentol and tofu meatballs has a leadtime of 0. MPS for meatball pentol and tofu meatball products can be seen in tables 10 and 11.

Table 15. MPS of Meatball Pentol

Period	Demand (Pack)	MPS (Pack)
January 2024	7836,00	8188
February 2024	7855,06	7832
March 2024	7854,94	7832
April 2024	7928,19	7832
May 2024	7955,00	7832
June 2024	8011,75	8188
July 2024	8008,31	7832
August 2024	7908,44	7832
September 2024	7862,00	8188
October 2024	7860,69	7832
November 2024	7835,31	7832
December 2024	7885,81	7832

Table 16. MPS Tofu Meatballs

Periode	Permintaan (Pack)	MPS (Pack)
Januari 2024	680,42	714
Februari 2024	689,17	680
Maret 2024	691,75	680
April 2024	690,75	680
Mei 2024	708,00	714
Juni 2024	706,83	714
Juli 2024	712,42	714
Agustus 2024	719,92	714
September 2024	707,33	714
Oktober 2024	695,00	714
November 2024	704,08	680
Desember 2024	711,92	714

Material Requirement Planning

At the Material Requirement Planning (MRP) stage will discuss production planning and ordering raw materials. In planning the needs of these raw materials there is a delivery lead time, so that the determination of when and how much raw material is ordered on raw

materials needs to be done. In this study, all calculations of MPS, MRP, and Lot Sizing techniques are calculated in periods of days. The provisions are one year there are 12 months, one month there are 24 days. So that in one year there are 288 days, but the calculation data in this study is summarized in a 12-month period. The following are MRP calculations on meatball pentol products, tofu meatballs, beef raw materials, tapioca starch, and msg shown in tables 12, 13, 14, 15, and 16.

Table 17. MRP Calculation for Meatball Pentol

Periode	0	1	2	3	4	5	6	7	8	9	10	11	12
GR		8188	7832	7832	7832	7832	8188	7832	7832	8188	7832	7832	7832
SR													
OH	0	0	0	0	0	0	0	0	0	0	0	0	0
NR		8188	7832	7832	7832	7832	8188	7832	7832	8188	7832	7832	7832
Porec		8188	7832	7832	7832	7832	8188	7832	7832	8188	7832	7832	7832
Porel		8188	7832	7832	7832	7832	8188	7832	7832	8188	7832	7832	7832

Description:
GR (Gross Requirement)
SR (Scheduled Receipt)
OH (On Hand Inventory)
NR (Net Requirement)
Porec (Planned Order Receipts)
Porel (Planned Order Release)

Table 17 above shows the gross requirement for meatball pentol products for 12 periods. Period 1 requires 8188 packs of meatballs, because there is no production leadtime, the company can produce meatballs in the same period as the gross requirement. The number of packages of meatballs will be used as the basis for calculating beef raw materials.

Table 18. MRP Calculation of Tofu Meatballs

Periode	0	1	2	3	4	5	6	7	8	9	10	11	12
GR		714	680	680	680	714	714	714	714	714	714	680	714
SR													
OH	0	0	0	0	0	0	0	0	0	0	0	0	0
NR		714	680	680	680	714	714	714	714	714	714	680	714
Porec		714	680	680	680	714	714	714	714	714	714	680	714
Porel		714	680	680	680	714	714	714	714	714	714	680	714

Table 18 above shows the Gross Requirement of meatball tofu products for 12 periods. Period 1 requires 714 packs of tofu meatballs, because there is no production leadtime, the company can produce tofu meatballs in the same period as the gross requirement. The number of tofu meatballs will be used as the basis for calculating beef raw materials.

Table 19. Beef MRP Calculation

Periode	0	1	2	3	4	5	6	7	8	9	10	11	12
GR		198,96	190,29	190,29	190,29	190,45	198,96	190,45	190,45	198,96	190,45	190,29	190,45
SR													
OH	0,00	0,04	0,75	0,46	0,17	0,72	0,77	0,32	0,87	0,91	0,46	0,17	0,72
NR	0,00	198,96	190,25	189,54	189,83	190,28	198,23	189,68	190,13	198,09	189,54	189,83	190,28
Porec		199	191	190	190	191	199	190	191	199	190	190	191
Porel	199	191	190	190	191	199	190	191	199	190	190	191	0

Table 19 above shows the results of the Gross Requirement of beef raw materials from periods 1 to 12. Period 1 requires 198.96 boxes of beef gross requirements, so that in period 0 199 boxes of beef are ordered because there is a lead time of 2 days and the order is rounded up to meet the production needs for that period. Because the MRP period above is in months and the leadtime is in days, 2 days are rounded up to 1 month. One box of beef has a net weight of 27.2 kg, so the gross beef requirement in period 1 is equivalent to 5,411.59 kg. The gross beef requirement is the aggregate requirement to meet the production needs of 8188 packs of meatballs and 714 packs of tofu meatballs.

Table 20. MRP Calculation of Tapioca Starch

Periode	0	1	2	3	4	5	6	7	8	9	10	11	12
GR		125,90	120,39	120,39	120,39	120,77	125,90	120,77	120,77	125,90	120,77	120,39	120,77
SR													
OH	0,00	0,10	0,72	0,33	0,94	0,17	0,27	0,51	0,74	0,84	0,07	0,68	0,91
NR	0,00	125,90	120,28	119,67	120,06	119,83	125,73	120,49	120,26	125,16	119,93	120,32	120,09
Porec		126	121	120	121	120	126	121	121	126	120	121	121
Porel	126	121	120	121	120	126	121	121	126	120	121	121	0

Table 20 above shows the results of the Gross Requirement of tapioca starch raw materials from periods 1 to 12. Period 1 requires 125.9 sacks of tapioca starch gross requirements, so that in period 0, 126 sacks of tapioca starch are ordered because there is a lead time of 2 days and the order is rounded up to meet the production needs for that period. Because the MRP period above is in the form of months and leadtime is in the form of days, 2 days are rounded up to 1 month. One sack of tapioca starch has a net weight of 25 kg, so the gross need for tapioca starch in period 1 is equivalent to 3,147.39 kg. The gross need for tapioca starch is the aggregate need to meet the production needs of 8188 packs of meatballs and 714 packs of tofu meatballs.

Table 21. MRP MSG Calculation

Periode	0	1	2	3	4	5	6	7	8	9	10	11	12
GR		13,67	13,07	13,07	13,07	13,09	13,67	13,09	13,09	13,67	13,09	13,07	13,09
SR													
OH	0,00	0,33	0,26	0,18	0,11	0,02	0,35	0,26	0,17	0,50	0,41	0,33	0,24
NR	0,00	13,67	12,74	12,82	12,89	12,98	13,65	12,74	12,83	13,50	12,59	12,67	12,76
Porec		14	13	13	13	13	14	13	13	14	13	13	13
Porel	14	13	13	13	13	14	13	13	14	13	13	13	0

Table 21. above shows the results of the gross requirement for msg raw materials from periods 1 to 12. Period 1 requires 13.67 boxes of msg gross requirements, so that in period 0 an order of 14 boxes of msg is placed because there is a lead time of 2 days and the order is rounded up to meet the production needs for that period. Because the MRP period above is in the form of months and leadtime is in the form of days, 2 days are rounded up to 1 month. One box of msg has a net weight of 20 kg, so the gross msg requirement in period 1 is equivalent to 273.39 kg. The gross msg requirement is the aggregate requirement to meet the production needs of 8188 packs of meatballs and 714 packs of tofu meatballs.

Lot Sizing Technique

The Lot Sizing technique will discuss the calculation of the optimal lot in planning raw material orders. The raw materials studied are raw materials included in group A and group B, namely beef, tapioca starch, and msg. In this study, all calculations of MPS, MRP, and Lot Sizing techniques are calculated in a period of days. The provisions are one year there are 12 months, one month there are 24 days. So that in one year there are 288 days, but

the calculation data in this study is summarized in a 12-month period. The following is a breakdown of the costs involved in ordering each raw material.

Table 22. Details of Raw Material Inventory Costs

Bahan Baku	Kebutuhan	Biaya Simpan (Rp)	Biaya Pesan (Rp)
Daging Sapi	2311 *box*	154,35	112322
Pati Tapioka	1464 karung	71,17	62322
MSG	159 *box*	50,14	62322

Table 22 shows the number of requirements for each raw material in one year, the cost of storing per day of each raw material, and the cost of ordering per message of each raw material.

Economic Order Quantity

Economic Order Quantity (EOQ) is an approach that uses the concept of minimizing storage costs and ordering costs. The EOQ method is a method that has inventory in the warehouse, so the company must bear storage costs. However, the use of this EOQ method can make the company to minimize shipping costs because the number of orders placed uses an average [10]. The following is an EOQ calculation on beef raw materials.

$$EOQ = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2 \times 2.310{,}28 \times 112.322}{44.451{,}71}} = 109\ box$$

The calculation of ordering beef raw materials using the EOQ method is shown in Table 23.

Table 23. Calculation of MRP Beef EOQ Method

DS	Periode (bulan)												
	0	1	2	3	4	5	6	7	8	9	10	11	12
GR		199	190	190	190	190	199	190	190	199	190	190	190
SR													
OH	0	1324	1334	1336	1211	1361	1385	1290	1329	1311	1311	1312	1311
NR		12	9	5	10	2	5	11	7	0	11	8	4
Porec		218	218	218	218	109	218	218	218	109	218	218	218
Porel	218	218	218	218	109	218	218	218	109	218	218	218	0

Table 23 above shows the calculation of beef MRP using the EOQ method for 12 months. Based on this data, it can be seen that to meet the needs of beef in the first period requires 218 boxes of beef. The following is the cost of beef raw material inventory with the EOQ method.

Table 24. Beef Inventory Costs EOQ Method

EOQ *Cost*	
Ordering Frequency	22
Total Inventory	2398
Inventory Cost	Rp 2.440.981,31
Order Cost	Rp 2.471.084,00
Total Cost	Rp 4.912.065,31

Period Order Quantity

Period Order Quantity (POQ) is an approach that uses the concept of economic ordering quantities to be used in periods that have diverse demand properties. This method is based on the EOQ method to determine the optimal number of orders that need to be placed during the ordering period interval in one period. The following is an EOQ calculation on beef raw materials.

$$POQ = \frac{EOQ}{R} = \frac{109}{8{,}02} = 14 \text{ periode}$$

The calculation of ordering beef raw materials using the POQ method is shown in Table 25.

Table 25. Calculation of MRP Beef POQ Method

DS	Periode (bulan)												
	0	1	2	3	4	5	6	7	8	9	10	11	12
GR		199	190	190	190	190	199	190	190	199	190	190	190
SR		0	0	0	0	0	0	0	0	0	0	0	0
OH	0	1351	1303	1247	1399	1499	1356	1203	1527	1451	1393	1454	1161
NR		17	15	12	5	9	7	3	4	2	0	0	0
Porec		226	226	226	113	226	226	113	226	226	226	104	182
Porel	226	226	226	113	226	226	113	226	226	226	104	182	0

Table 25 above shows the calculation of beef MRP using the POQ method for 12 months. Based on this data, it can be seen that to meet the needs of beef in the first period requires 226 boxes of beef. The following is the cost of beef raw material inventory using the POQ method.

Table 26. Cost of Beef Inventory POQ Method

POQ *Cost*	
Frekuensi Pemesanan	21
Total Persediaan	2321
Biaya Simpan	Rp 2.523.865,23
Biaya Pesan	Rp 2.358.762,00
Total Cost	Rp 4.882.627,23

Silver Meal

The Silver-Meal heuristic (SM) introduced by Silver and Meal in 1973 is a method that focuses on calculating the total inventory cost for each period [34]. The principle used in this approach is to minimize the total relevant cost per unit of time during replenishment. The heuristic is used as a basis for determining the average cost per period by adding the number of orders according to the number of periods. Orders are planned when the average cost per period increases for the first time [35]. The following is the calculation of SM on beef raw materials.

Table 27. Calculation of Beef Lot Sizing SM Method

Period (days)	Cumulative Demand	Storage Cost	Order Cost	Periodic
1	9	Rp 51,88	Rp 112.322,00	Rp 112.373,88
2	18	Rp 1.544,77	Rp 112.322,00	Rp 56.933,38
3	26	Rp 4.015,61	Rp 112.322,00	Rp 38.779,20
4	35	Rp 8.236,14	Rp 112.322,00	Rp 30.139,54
5	44	Rp 13.897,67	Rp 112.322,00	Rp 25.243,93
6	52	Rp 20.098,28	Rp 112.322,00	Rp 22.070,05
7	61	Rp 28.511,62	Rp 112.322,00	Rp 20.119,09
8	70	Rp 38.365,96	Rp 112.322,00	Rp 18.836,00
9	78	Rp 48.272,18	Rp 112.322,00	Rp 17.843,80
10	87	Rp 60.854,17	Rp 112.322,00	Rp 17.317,62
11	96	Rp 74.877,16	Rp 112.322,00	Rp 17.018,11
12	104	Rp 88.489,00	Rp 112.322,00	Rp 16.734,25
13	104	Rp 88.494,21	Rp 112.322,00	Rp 15.447,40
14	113	Rp 106.633,97	Rp 112.322,00	Rp 15.639,71

Table 27 above shows the calculation of Lot Sizing on beef using the SM method. Based on the above calculations, the optimal ordering lot is obtained with a cumulative demand of 104 boxes in the 13th period. This is characterized by the lowest periodic results and there is no indication of an increase in the periodic value. The following is the calculation of MRP on beef using the SM method.

Table 28. Calculation of MRP Beef SM Method

DS	Period (month)												
	0	1	2	3	4	5	6	7	8	9	10	11	12
GR		199	190	190	190	190	199	190	190	199	190	190	190
SR		0	0	0	0	0	0	0	0	0	0	0	0
OH	0	1050	1149	1149	1131	1165	1182	1085	1117	1201	1199	1198	919
NR		17	17	16	16	15	14	14	7	13	12	12	11
Porec		199	208	208	208	208	208	208	104	208	208	208	139
Porel	199	208	208	208	208	208	208	104	208	208	208	139	0

Table 28. above shows the calculation of beef MRP using the SM method for 12 months. Based on this data, it can be seen that to meet the needs of beef in the first period requires 199 boxes of beef. The following is the cost of beef raw material inventory using the SM method.

Table 29. Beef Inventory Costs SM Method

Silver Meal Cost	
Ordering Frequency	23
Total Inventory	2314
Inventory Cost	Rp 2.090.615,39
Order Cost	Rp 2.583.406,00
Total Cost	Rp 4.674.021,39

Least Unit Cost

Least Unit Cost (LUC) is a method used to determine order quantity and total inventory cost [34]. This method is similar to the Silver Meal heuristic, but the difference is that the Silver Meal heuristic uses the number of periods to calculate the cost per period. Meanwhile,

Least Unit Cost uses the number of units in the order horizon to determine the lowest unit cost [36]. The following is the calculation of LUC on beef raw materials.

Table 30. Calculation of Beef Lot Sizing with the LUC Method

Period (days)	Cumulative Demand	Storage Cost	Order Cost	*Unit Cost*
1	9	Rp 51,88	Rp 112.322,00	Rp 12.485,99
2	18	Rp 1.544,77	Rp 112.322,00	Rp 6.325,93
3	26	Rp 4.015,61	Rp 112.322,00	Rp 4.474,52
4	35	Rp 8.236,14	Rp 112.322,00	Rp 3.444,52
5	44	Rp 13.897,67	Rp 112.322,00	Rp 2.868,63
6	52	Rp 20.098,28	Rp 112.322,00	Rp 2.546,54
7	61	Rp 28.511,62	Rp 112.322,00	Rp 2.308,75
8	70	Rp 38.365,96	Rp 112.322,00	Rp 2.152,69
9	78	Rp 48.272,18	Rp 112.322,00	Rp 2.058,90
10	87	Rp 60.854,17	Rp 112.322,00	Rp 1.990,53
11	96	Rp 74.877,16	Rp 112.322,00	Rp 1.949,99
12	104	Rp 88.489,00	Rp 112.322,00	Rp 1.930,87
13	104	Rp 88.494,21	Rp 112.322,00	Rp 1.930,93

Table 30 shows the calculation of Lot Sizing on beef using the LUC method. Based on the above calculations, the optimal ordering lot is obtained with a cumulative demand of 104 boxes in period 12. This is characterized by the lowest unit cost results and there is no indication of an increase in the unit cost value. The following is the MRP calculation on beef using the LUC method.

Table 31. MRP Calculation for Beef LUC Method

DS	Periode (bulan)												
	0	1	2	3	4	5	6	7	8	9	10	11	12
GR		199	190	190	190	190	199	190	190	199	190	190	190
SR		0	0	0	0	0	0	0	0	0	0	0	0
OH	0	1157	1005	1325	1595	1401	1342	1195	1405	1393	1519	1454	1391
NR		9	14	0	0	3	2	2	0	0	0	0	0
Porec		200	192	200	226	235	131	262	208	96	200	192	182
Porel	200	192	200	226	235	131	262	208	96	200	192	182	0

Table 31 above shows the calculation of beef MRP using the LUC method for 12 months. Based on this data, it can be seen that to meet the needs of beef in the first period requires 200 boxes of beef. The following is the cost of beef raw material inventory using the LUC method.

Table 32. Beef Inventory Costs LUC Method

LUC *Cost*	
Frekuensi Pemesanan	26
Total Persediaan	2324
Biaya Simpan	Rp 2.497.626,38
Biaya Pesan	Rp 2.920.372,00
Total Cost	Rp 5.417.998,38

Part Period Balancing

Part Period Balancing (PPB) is a heuristic method based on the concept of balancing ordering costs with storage costs [37]. This method entails calculating the storage cost as a function of the number of periods covered by the current order. Iteration is complete when the storage cost for an order exceeds the ordering cost. The order quantity that has the total storage cost closest to the ordering cost is considered optimal. The following is the calculation of PPB on beef raw materials.

Table 33. Calculation of Beef Lot Sizing with PPB Method

Period	Cumulative Demand	Store Cost	Order Cost	*Diff*
1	9	Rp 51,88	Rp 112.322,00	Rp 112.373,88
2	18	Rp 1.544,77	Rp 112.322,00	Rp 110.829,12
3	26	Rp 4.015,61	Rp 112.322,00	Rp 108.358,28
4	35	Rp 8.236,14	Rp 112.322,00	Rp 104.137,74
5	44	Rp 13.897,67	Rp 112.322,00	Rp 98.476,21
6	52	Rp 20.098,28	Rp 112.322,00	Rp 92.275,60
7	61	Rp 28.511,62	Rp 112.322,00	Rp 83.862,26
8	70	Rp 38.365,96	Rp 112.322,00	Rp 74.007,92
9	78	Rp 48.272,18	Rp 112.322,00	Rp 64.101,70
10	87	Rp 60.854,17	Rp 112.322,00	Rp 51.519,71
11	96	Rp 74.877,16	Rp 112.322,00	Rp 37.496,72
12	104	Rp 88.489,00	Rp 112.322,00	Rp 23.884,88
13	104	Rp 88.494,21	Rp 112.322,00	Rp 23.879,67
14	113	Rp 106.633,97	Rp 112.322,00	Rp 5.739,92
15	122	Rp 126.214,72	Rp 112.322,00	Rp 13.840,84

Table 34. shows the calculation of Lot Sizing on beef using the PPB method. Based on the above calculations, the optimal ordering lot is obtained with a cumulative demand of 113 boxes in period 14. This is characterized by the lowest diff result and there is no indication of an increase in the diff value. The following is the calculation of MRP on beef using the PPB method.

Table 35. Calculation of MRP Beef PPB Method

DS	Periode (bulan)												
	0	1	2	3	4	5	6	7	8	9	10	11	12
GR		199	190	190	190	190	199	190	190	199	190	190	190
SR		0	0	0	0	0	0	0	0	0	0	0	0
OH	0	1351	1303	1247	1399	1499	1356	1203	1527	1451	1393	1454	1169
NR		17	15	12	5	9	7	3	4	2	0	0	0
Porec		226	226	226	113	226	226	113	226	226	226	104	183
Porel	226	226	226	113	226	226	113	226	226	226	104	183	0

Table 35 above shows the calculation of MRP for beef using the PPB method for 12 months. Based on this data, it can be seen that to meet the needs of beef in the first period requires 226 boxes of beef. The following is the cost of beef raw material inventory using the PPB method.

Table 36. Beef Inventory Costs PPB Method

PPB *Cost*	
Frekuensi Pemesanan	21
Total Persediaan	2321
Biaya Simpan	Rp 2.523.865,23
Biaya Pesan	Rp 2.358.762,00
Total Cost	Rp 4.882.627,23

Comparison of Total Inventory Costs

At this stage, a comparison of total inventory costs with 5 Lot Sizing techniques will be carried out on beef raw materials, tapioca starch, and msg. The five Lot Sizing technique methods are EOQ, POQ, SM, LUC, and PPB. The method that has the lowest Total Cost is the chosen method. The following is a comparison of total inventory costs with Lot Sizing techniques.

Table 37. Comparison of Total Inventory Costs of Lot Sizing Techniques

Methods	Beef	Starch Tapioca	MSG
EOQ	Rp 4.912.065,31	Rp 1.969.041,68	Rp 596.803,78
POQ	Rp 4.881.392,46	Rp 2.026.757,27	Rp 1.492.442,05
SM	Rp 4.674.021,39	Rp 1.942.263,89	Rp 618.166,61
LUC	Rp 5.417.998,38	Rp 2.192.709,93	Rp 10.749.249,98
PPB	Rp 4.882.627,23	Rp 2.018.502,02	Rp 569.780,21
TC Minimum	SM	SM	PPB

Table 31 shows the results of the comparison of total inventory costs on beef raw materials, tapioca starch, and msg with Lot Sizing techniques. In beef raw materials and tapioca starch, the selected method is the Silver Meal method with a total inventory cost of Rp 4,674,021.39 and Rp 1,942,263.89. While in MSG raw materials the selected method is Part Period Balancing with a total inventory cost of Rp 569,780.21.

CONCLUSION

Based on the results and discussion using the MRP method and Lot Sizing technique above, the following conclusions can be drawn:

1. Planning using the Material Requirement Planning (MRP) method for meatball and tofu meatball products of UMKM XYZ based on the forecasting results, it is found that the Moving Average 16 (MA16) forecasting method for meatballs and MA12 for tofu meatballs gets the smallest error value with a value of 4.20% and 9.47% respectively.
2. The Lot Sizing policy in the process of planning raw material requirements by combining the Material Requirement Planning (MRP) method and Lot Sizing techniques found that planning raw material requirements for beef and tapioca starch gets the optimal cost using the Lot Sizing technique Silver Meal (SM) method with a total inventory cost of Rp 4,674,021.39 and Rp 1,942,263.89. As for msg raw materials, the optimal cost is obtained using the Lot Sizing technique of the Part Period Balancing (PPB) method with a total inventory cost of Rp 569,780.21.

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