Inventory control of raw material on sweet bread production

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Abstract. The purpose of this study was to analyze and evaluate the management of raw material procurement on sweet bread production in Company X. Raw materials are the main factors that support the smooth and effective of the production process. The availability of raw materials must be in accordance with the quality, quantity, timeliness and minimum costs. Therefore, companies need to maintain the level of raw material inventory to avoid the problem of procurement of raw materials, which can affect the company's profit. To plan raw material requirements, the method used is Material Requirement Planning (MRP) with the Economic Order Quantity (EOQ) technique. From the results of raw material requirements calculation, it can be seen that ordering all raw materials is done once a month. Raw materials are ordered in period 0 (the period before the production process), with the number of orders for wheat flour of 28,900 kg, yeast of 1,000 kg, salt of 2,625 kg, sugar of 8,050 kg, powdered milk of 2,125 kg, gluten fat of 2,256 kg, butter of 2,520 kg, bread improver of 220 kg, calcium propionate of 250 kg, water of 3,300 L, ice cubes of 11,830 kg and packaging materials of 455,000 packs. The cost of raw materials inventory in one month reaches IDR 61,707,525.48 or 13.06% of the total sales of sweet bread per month.

1. Introduction
Sweet bread is one of the bakery products that is popular with the public since it can be used as an alternative food substitute for rice [1]. Sweet bread contains carbohydrates, proteins, vitamins and minerals that are very beneficial for the body [2]. The average level of sweet bread consumption in a year reaches 25,584.5 ounces/capita/year [3]. Company X is one of the industries engaged in the processing of sweet bread.

In the production process, it cannot be separated from the need for raw materials. In its implementation, Company X encounters several problems such as the procurement of raw materials that are not structured properly, less-scheduled time for procurement, and the less-calculated quantity determination of ordered raw materials. This causes the Company X to have the experience of keeping more stock of raw materials than it should in the warehouse. Therefore the storage of raw materials in the warehouse exceeds the maximum stack limit and causes the storage cost to increase as well. In addition, Company X has also experienced a shortage of raw materials. At the time, the production process was hampered and consumer demand for sweet bread products could not be met on demand.

Recognizing the importance of raw materials supply to match the quality, quantity, timeliness and minimum costs, it is necessary to apply the management of raw material procurement. The task of
procurement management is to provide the goods needed in production activities and schedule the procurement of raw materials, so that it can increase the profits of a company [4]. The importance of raw materials supply makes the company must really pay attention to the relationship between inventory items so that the determination of raw material needs can be done accurately and efficiently [5].

Material Requirement Planning (MRP) is a method that can be used to plan raw material needs. The MRP method is used to plan inventory that depends on the demand by scheduling the right amount of all needed material [4]. The MRP method is highly useful in minimizing the inventory investment, facilitating the arrangement of the requirement schedule of each component, and as the means of control in production and inventory [6]. The purpose of this study is to plan the needs of raw materials for producing the sweet bread using the MRP method so that a minimal cost can be obtained.

2. Materials and Methods
The raw materials used in producing the sweet bread include wheat flour, yeast, salt, sugar, milk powder, gluten fat, butter, bread improver, calcium propionate, water, ice cubes, and plastic packaging materials. The method used in the research of raw material requirement planning is the calculation of MRP using the Economic Order Quantity (EOQ) technique.

The steps in MRP calculation are as follows:
1. The demand forecasting in order to minimize the effect of uncertain demands [7] and calculation of the safety stock (ss) to anticipate the sudden increase in product demand [8]. In Company X, the demand forecasting is done by the sales estimator based on the data a month earlier. The calculation of ss [9] = (highest demand – average demand) x lead time
2. Determination of the Master Planning Schedule (MPS). MPS shows the number of products that needed to be produced in a certain period [10]. The MPS of the sweet bread product is obtained by adding up the demand forecast and ss.
3. Creation of Bill of Material (BOM). BOM is the structural tree that represents the component and the hierarchy linkage [11].
4. Gross and net requirement calculation. The gross requirement is the projected requirement for the raw materials or the final product at the end of a determined period [12]. The net requirement is the total amount of needs by considering the current and processed stock [5] that obtained from the gross requirements reduced by the on-hand raw materials.
5. Determination of the lot size and also the order time while considering the lead time of each raw material. Lot size (LS) is the optimal amount of items to be ordered. In the lot size calculation, it is needed to consider the time and setup cost to increase the production system performance [13]. The lot size technique used is:

\[ EOQ = \sqrt{\frac{2DS}{H}} \]  

Where:
D = the demand forecasting per time period, S = order cost, H = storage cost per unit
EOQ = the purchase amount of economical raw material

Determination of the time for ordering the raw materials in Company X is done by taking the lead time (LT) of each raw material into account.

6. MRP calculation.
7. Calculation of raw material inventory costs.

3. Results and Discussion
3.1. Demand forecasting and calculation of SS
The result of demand forecast can be seen in Table 1. The demand forecasting of sweet bread product on each period is quite stable. The highest demand forecasting occurs in the third period, for about
22,637 packs because there is a promotion so the production of sweet bread increased. The promotion of the sweet bread is made with a system buy 1 get 1 free. This is done to attract consumer interest against the bakery products of Company X.

The sweet bread has a different lead time depends on the distribution location. The furthest distribution location needs a two-day lead time. The calculation result of sweet bread safety stock: 

\[(22,637 - 20,279) \times 2 = 4,717 \text{ packs}\] 
So, Company X must provide for each period of 4,717 packs. SS by the amount of 4,717 packs is an inventory that can be reserved as a security for the continuity of the production process from the risk of stock out in each period. SS is the amount that must be added in each production period which will be the basis for determining the Master Planning Schedule (Table 1).

### 3.2. Master planning schedule (MPS)

The MPS of sweet bread in Company X can be seen in Table 1.

| Period (week) | Demand forecasting + SS | Number of demands (pack) |
|---------------|-------------------------|--------------------------|
| 1             | 18,319 + 4,717          | 23,036                   |
| 2             | 19,866 + 4,717          | 24,583                   |
| 3             | 22,637 + 4,717          | 27,354                   |
| 4             | 20,293 + 4,717          | 25,010                   |

Based on data from MPS, it can be seen if the product that must be produced in accordance with consumer orders and forecast demand on week 1 is 23,036 packs which can be produced in 128 batches. On week 2, the demand was 24,583 packs which could be produced in 137 production batches. On week 3, to produce 27,354 packs, 152 production batches were needed, and 139 batches were produced for the last week to produce 25,010 sweet bread packs.

### 3.3 Bill of material (BOM)

Bill of Material in the sweet bread production can be seen in Figure 1.

**Figure 1.** BOM in the sweet bread production.

The amount that is shown in the BOM (Figure 1) is the quantity necessary to assemble one of the items on a higher level. BOM in the production of sweet bread (level 0) is based on the number of raw materials needed for the first batch of sweet bread production consisting of 6 buns (level 1). 180 packs of sweet bread can be produced in a batch. So, the raw materials needed to produce 180 packs of sweet
bread are 20 kg of wheat flour, 0.89 kg of yeast, 0.8 kg of salt, 4 kg of sugar, 1 kg of milk powder, 0.6 kg of gluten fat, 1.4 kg of butter, 0.06 kg of bread improver, 0.06 kg of calcium propionate, 4 L of water and 6 kg of ice cubes. The packaging materials needed for producing 180 packs of sweet bread are 180 packs. This amount should be considered by Company X in order to produce the appropriate products that have been targeted. If the amount of raw materials provided less than a BOM, then Company X will not be able to produce sweet bread on demand due to a shortage of raw materials. But if the raw material is more than a BOM, then it will appear additional costs for storage, so that production costs will increase.

3.4 Calculation of gross and net requirements
The amount of gross and net requirements of each raw material used to produce the sweet bread in Company X can be seen in Table 2. Based on Table 2, it is known that in the 1st period (P1), to produce 23,036 packs of sweet bread, the raw materials are required as shown in the table on gross requirements row and P1 column. To produce 24,583 sweet bread packs, raw materials are needed as shown in column P2, and to produce 27,354 sweet bread packs, raw materials are needed as shown in column P3. While in column P4 there are not a number of raw materials because based on MRP calculations, the needs in P4 can be fulfilled with the remaining raw materials produced in the previous period. In Company X, there is a stock of raw materials owned by the company at the beginning of the production process period (on hand inventory). The number of on hand for each raw material can be seen in the On H and column. So the net requirement of each raw material at P1 that must be provided by Company X is a number of gross requirements which are reduced by on hand inventory. While the net requirements on P2, P3, P4 is not available because the remaining raw materials from P1 can still be used for the production needs of the P2, P3 and P4 periods. Full information can be seen in MRP explanation.

| Table 2. Material requirement planning (MRP) |
|---------------------------------------------|
| **Sweet Bread** LT = 2 days, LS = EOQ | P0 | P1 | P2 | P3 | P4 | Total |
|-----------------|-----|-----|-----|-----|-----|-------|
| Gross requirement | 23,036 | 24,583 | 27,354 | 25,010 |
| Inventory on hand | 20,279 | 20,279 | | | | |
| Net requirement | 2,757 | 24,583 | 27,354 | 25,010 |
| Planned Order Receipt | 2,757 | 24,583 | 27,354 | 25,010 |
| Planned Order Release | 2,757 | 24,583 | 27,354 | 25,010 |
| **Wheat Flour** LT = 7 days, LS = 28,900 | P0 | P1 | P2 | P3 | P4 | Total |
| Gross requirement | 2,731.17 | 3,039.03 | 2,778.61 | 8,548.81 |
| Inventory on hand | 2,253 | 2,253 | 28,421.83 | 25,382.80 | 22,604.19 | 80,914.82 |
| Net requirement | 478.17 | | | | |
| Planned Order Receipt | 28,900 | | | | |
| Planned Order Release | 28,900 | | | | |
| **Yeast** LT = 3 days, LS = 1,000 | P0 | P1 | P2 | P3 | P4 | Total |
| Gross requirement | 54.08 | 60.18 | 55.02 | 169.28 |
| Inventory on hand | 43 | 43 | 988.92 | 928.74 | 873.72 | 2,877.37 |
| Net requirement | 11.08 | | | | |
| Planned Order Receipt | 1,000 | | | | |
| Planned Order Release | 1,000 | | | | |
| **Salt** LT = 7 days, LS = 2,625 | P0 | P1 | P2 | P3 | P4 | Total |
| Gross requirement | 36.87 | 41.03 | 37.52 | 115.42 |
| Inventory on hand | 31 | 31 | 2,619.13 | 2,578.09 | 2,540.58 | 7,799.80 |
| Net requirement | 5.87 | | | | |
| Planned Order Receipt | 2,625 | | | | |
| Planned Order Release | 2,625 | | | | |
| **Sugar** LT = 7 days, LS = 8,050 | P0 | P1 | P2 | P3 | P4 | Total |
| Gross requirement | 545.74 | 607.26 | 555.22 | 1,708 |
| Inventory on hand | 450 | 450 | 7,954.26 | 7,347 | 6,791.78 | 22,993 |
Table 2. Material requirement planning (MRP) (continued)

| Material          | LT   | LS    | P0  | P1  | P2  | P3  | P4  | Total  |
|-------------------|------|-------|-----|-----|-----|-----|-----|--------|
| Milk powder       | 7 days | 2,125 | P0  | 137.66 | 153.18 | 140.06 | 431 |
|                   |      |       | P2  | 1,099.34 | 1,946.15 | 1,806.10 | 6,076 |
|                   |      |       | P3  | 8,050    | 2,125    | 2,125    | 6,076 |
| Gross requirement |      |       | P3  | 8,050    | 2,125    | 2,125    | 6,076 |
| Inventory on hand |      |       | P3  | 112      | 112      | 2,099.34 | 1,946.15 | 1,806.10 | 6,076 |
| Net requirement   |      |       | P3  | 25.66    | 2,125    | 2,125    | 6,076 |
| Planned Order Receipt |      |       | P3  | 2,125    | 2,125    | 2,125    | 6,076 |
| Planned Order Release |      |       | P3  | 2,125    | 2,125    | 2,125    | 6,076 |
| Gluten fat        | 7 days | 2,256 | P0  | 81.12    | 90.27    | 82.53    | 254 |
|                   |      |       | P2  | 2,241.88 | 2,151.61 | 2,069.07 | 6,597 |
|                   |      |       | P3  | 8,050    | 2,125    | 2,125    | 6,076 |
| Gross requirement |      |       | P3  | 112      | 112      | 2,099.34 | 1,946.15 | 1,806.10 | 6,076 |
| Inventory on hand |      |       | P3  | 14.12    | 2,256    | 2,125    | 6,076 |
| Net requirement   |      |       | P3  | 14.12    | 2,256    | 2,125    | 6,076 |
| Planned Order Receipt |      |       | P3  | 2,256    | 2,125    | 2,125    | 6,076 |
| Planned Order Release |      |       | P3  | 2,256    | 2,125    | 2,125    | 6,076 |
| Bread improver     | 3 days | 220  | P0  | 7.37     | 8.21     | 7.50     | 23.08 |
|                   |      |       | P2  | 218.63   | 210.42   | 202.92   | 643.96 |
|                   |      |       | P3  | 2,241.88 | 2,151.61 | 2,069.07 | 6,597 |
| Gross requirement |      |       | P3  | 67       | 67       | 2,241.88 | 2,151.61 | 2,069.07 | 6,597 |
| Inventory on hand |      |       | P3  | 6        | 6        | 218.63   | 210.42   | 202.92   | 643.96 |
| Net requirement   |      |       | P3  | 64       | 64       | 218.63   | 210.42   | 202.92   | 643.96 |
| Planned Order Receipt |      |       | P3  | 220      | 220      | 220      | 660 |
| Planned Order Release |      |       | P3  | 220      | 220      | 220      | 660 |
| Calcium propionate | 3 days | 250  | P0  | 7.37     | 8.21     | 7.50     | 23.08 |
|                   |      |       | P2  | 248.63   | 240.42   | 232.92   | 733.96 |
|                   |      |       | P3  | 2,241.88 | 2,151.61 | 2,069.07 | 6,597 |
| Gross requirement |      |       | P3  | 67       | 67       | 2,241.88 | 2,151.61 | 2,069.07 | 6,597 |
| Inventory on hand |      |       | P3  | 1.37     | 220      | 220      | 660 |
| Net requirement   |      |       | P3  | 1.37     | 220      | 220      | 660 |
| Planned Order Receipt |      |       | P3  | 250      | 250      | 250      | 750 |
| Planned Order Release |      |       | P3  | 250      | 250      | 250      | 750 |
| Water             | 1 day | 24,090 | P0  | 545.74   | 607.26   | 555.22   | 1,708.22 |
|                   |      |       | P2  | 23,994.26 | 23,387   | 22,831.78 | 71,113.03 |
|                   |      |       | P3  | 240.42   | 232.92   | 232.92   | 733.96 |
| Gross requirement |      |       | P3  | 450      | 450      | 450      | 1,350 |
| Inventory on hand |      |       | P3  | 95.74    | 95.74    | 95.74    | 287.22 |
| Net requirement   |      |       | P3  | 95.74    | 95.74    | 95.74    | 287.22 |
| Planned Order Receipt |      |       | P3  | 24,090   | 24,090   | 24,090   | 72,270 |
| Planned Order Release |      |       | P3  | 24,090   | 24,090   | 24,090   | 72,270 |
| Ice cubes         | 1 day | 11,830 | P0  | 818.61   | 910.89   | 832.83   | 2,562.34 |
|                   |      |       | P2  | 11,686.39 | 10,775.50 | 9,942.66 | 33,754.55 |
|                   |      |       | P3  | 23,994.26 | 23,387   | 22,831.78 | 71,113.03 |
| Gross requirement |      |       | P3  | 675      | 675      | 675      | 2,025 |
| Inventory on hand |      |       | P3  | 113.61   | 113.61   | 113.61   | 340.84 |
| Net requirement   |      |       | P3  | 113.61   | 113.61   | 113.61   | 340.84 |
| Planned Order Receipt |      |       | P3  | 11,830   | 11,830   | 11,830   | 35,510 |
| Planned Order Release |      |       | P3  | 11,830   | 11,830   | 11,830   | 35,510 |
| Packaging materials | 7 days | 455,00 | P0  | 24,583   | 27,354   | 25,010   | 76,947 |
|                   |      |       | P2  | 450,696  | 423,342  | 398,332  | 1,312,928 |
| Gross requirement |      |       | P2  | 20,279   | 20,279   | 20,279   | 61,037 |
| Inventory on hand |      |       | P2  | 4304     | 4304     | 4304     | 12,912 |
| Net requirement   |      |       | P2  | 4304     | 4304     | 4304     | 12,912 |
| Planned Order Receipt |      |       | P2  | 455,000  | 455,000  | 455,000  | 1,362,500 |
| Planned Order Release |      |       | P2  | 455,000  | 455,000  | 455,000  | 1,362,500 |

3.5 Determination of lot size and order time
Lot size of the order and lead time of each raw material can be seen in Table 3. Based on Table 3, the amount that listed in the EOQ column is the most optimal number of orders for each raw material, where the calculation of the amount is adjusted by calculating the number of requests with the holding costs and setup costs. While the lead time is adjusted for each raw material, with a range of at least 1
day (because the supplier's location is close to Company X), and the longest is 7 days (the location of the supplier is far from Company X).

| Raw Material     | D     | S     | H    | EOQ  | Lead Time (day) |
|------------------|-------|-------|------|------|-----------------|
| Wheat flour      | 8,548.811 | 5,510,000 | 112.8 | 28,900 | 7               |
| Yeast            | 169.283  | 910,000 | 310  | 1,000 | 3               |
| Salt             | 115.421  | 3,010,000 | 103.96 | 2,625 | 7               |
| Sugar            | 1,708.223 | 3,640,000 | 194.24 | 8,050 | 7               |
| Milk powder      | 430.903  | 3,510,000 | 682  | 2,125 | 7               |
| Gluten fat       | 253.925  | 3,510,000 | 352.03 | 2,256 | 7               |
| Butter           | 600.187  | 3,010,000 | 572.72 | 2,520 | 7               |
| Bread improver   | 23.084   | 910,000 | 880  | 220   | 3               |
| Calcium propionate | 23.084   | 910,000 | 680  | 250   | 3               |
| Water            | 1,708.223 | 1,210,000 | 7.27 | 24,090 | 1               |
| Ice cubes        | 2,562.335 | 910,000 | 33.33 | 11,830 | 1               |
| Packaging materials | 76,947   | 3,058,000 | 2.32 | 455,000 | 7               |

3.6 Material requirement planning (MRP)
Based on Table 2, the amount of gross requirements and on hand inventory from each raw material has been known, so that Company X can calculate the amount of net requirements from each raw material. The amount of net requirements that has been known then becomes the basis for calculating the deficiencies number of orders for each raw material in the production of sweet bread on P1 (planned order receipt). Planned order receipts must be adjusted to the lot size of each raw material. Based on data from the planned order receipt, Company X must order this amount, taking into account the lead time of each raw material. Because the lead time of each raw material is between 1 - 7 days, then the order of each raw material must be carried out before the production process P1 (planned order release is carried out in the period 0 or before P1). The rest of the raw material that is not used in P1 then becomes on hand inventory for P2, and so on. Based on the data, P2, P3 and P4 do not require ordering raw materials again because the order based on P1 data is sufficient until the production process P4.

3.7 Cost calculation of raw material inventory
Based on the cost calculation results of the raw material inventory (Table 4), the total cost of raw material control is IDR 61,707,525.48/month or 13.06% of the total sales of sweet bread per month (sweet bread sales revenue of IDR 472,500,000/month).
| Raw Material       | Number of inventory (kg) | Total Holding cost (IDR) | Total Set up cost (IDR) | Total cost (IDR) |
|--------------------|--------------------------|--------------------------|-------------------------|------------------|
| Wheat flour        | 80,914.82                | 9,127,191.279            | 5,510,000               | 14,637,191.28    |
| Yeast              | 2,877.37                 | 891,985.506              | 910,000                 | 1,801,985.506    |
| Salt               | 7,799.80                 | 810,867.156              | 9,030,000               | 3,820,867.156    |
| Sugar              | 22,993                   | 4,466,166.652            | 3,640,000               | 8,106,166.652    |
| Milk powder        | 6,076                    | 4,143,548.834            | 3,510,000               | 7,653,548.834    |
| Gluten fat         | 6,597                    | 2,322,186.63             | 3,510,000               | 5,832,186.63     |
| Butter             | 7,147.96                 | 4,093,778.162            | 3,010,000               | 7,103,778.162    |
| Bread improver     | 643.96                   | 566,684.712              | 910,000                 | 1,476,684.712    |
| Calcium propionate | 733.96                   | 499,092.732              | 910,000                 | 1,409,092.732    |
| Water              | 71,113.03                | 516,991.747              | 1,210,000               | 1,726,991.747    |
| Ice cubes          | 33,754.55                | 1,125,039.115            | 910,000                 | 2,035,039.115    |
| Packaging materials| 1,312,928.00             | 3,045,992.96             | 3,058,000               | 6,103,992.96     |
| **Total inventory costs** |                       |                          |                         | **61,707,525.48** |

4. Conclusion

Based on the MRP method, the raw material ordering schedule that must be carried out by Company X is the order of 2,757 packs of sweet bread in week 1, 24,583 packs in week 2, 27,354 packs in week 3 and 25,010 in week 4. All raw materials have to be ordered in the last week of the previous month. The order for wheat flour is 28,900 kg, 1,000 kg of yeast, 2,625 kg of salt, 8,050 kg of sugar, 2,125 kg of milk powder, 2,256 kg of eggs, 2,520 kg of butter, 220 kg of bread improver, 250 kg of calcium propionate, 3,300 L of water, ice cubes of 11,830 kg, and 455,000 packs of packaging. The total cost that must be spent on controlling the raw materials is IDR 61,707,525.48/month or 13.06% of the total sales of sweet bread per month.

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