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Inventory Management in a Selected Bakery for Productivity Enhancement in South-Western Nigeria Using MRP Approach

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ABSTRACT

Effective inventory management is vital for the sustainability and productivity of bakeries, especially in developing countries like Nigeria, where the majority are operated by small and medium-sized enterprises. However, many bakeries face significant challenges in managing their raw material inventories, leading to operational inefficiencies, increased costs, and potential business failure. This study was focused on investigating the application of a modified material requirement planning to enhance the productivity of bakeries in Nigeria. Data were collected from a selected bakery that currently practice a just-in-time inventory management strategy. A quantitative research method was developed, integrating activity-based costing classification through Pareto analysis, the economic order quantity model, and a master production schedule to effectively manage the inventory of the bakeries. Results from the inventory classification showed that flour and sugar are the essential raw materials for the selected bakery, highlighting the need to prioritize these items in the inventory planning process. The findings of the study presented significant financial savings for the bakery. The quantities of raw material to be ordered were reduced, with flour reducing from 200 tons to 102 tons. The total cost of inventory in the bakery was reduced from N7,526,080 per week to N6,937,211, presenting a saving of 7.8% per week. This significantly contributes to the long-term viability and competitiveness of bakeries in the labour market. This study is not only recommended to bakeries within Nigeria but also serves as a valuable guide for similar enterprises seeking to streamline their inventory processes and boost their productivity.

Keywords: Inventory management, Bakeries, Material requirement planning, Pareto Analysis, Quantitative research method

INTRODUCTION

The baking industry is a significant segment of the food manufacturing sector, transforming raw ingredients like flour, sugar, and yeast into a wide range of baked goods, including bread, pastries, cakes, and biscuits. Bakeries in Nigeria primarily focus on bread production, which is considered a fast-moving consumer good. The 2016 KPMG report showed that Nigeria's bread sub-sector is growing faster, with 72 per cent of the $621 million industry dominated by small and medium-scale bakers (Anudu, 2017). Despite their importance, many bakeries in Nigeria have struggled to survive beyond five years, largely due to ineffective inventory management (Woodruff, 2019). Inventory management is a critical component in the operations of bakeries, where the perishable nature of raw materials and finished products necessitates meticulous control over inventory levels. Research has even proven that the absence of a robust inventory management system is a major factor contributing to the high levels of material wastage and low productivity in the bakery industry (Onwumere *et al*., 2012). The research by Otuya and Akporien (2017) highlights that despite the high demand for bakery products, which provides an economic advantage, many bakeries still struggle to achieve profitability due to ineffective inventory management. Due

to poor inventory management practices, bakeries end up with the problem of either overstocking or under-stocking (Kabera & Mukanyangezi, 2024). Overstocking leads to unnecessary capital being tied up in inventory, increased storage costs, and potential material wastage due to spoilage or expiration (Mweshi, 2022). Under-stocking, on the other hand, can result in production delays, unmet customer demand, and reduced sales. In the long term, these inefficiencies can erode the financial stability of bakeries, leading to business failure, job losses, and a worsening unemployment situation (Nwanya, 2015; Oluchi & Nome, 2017).

To tackle these problems that do constantly arise from poor inventory management, various inventory management systems have been developed to optimize the flow of goods and resources. One of the early approaches is the economic order quantity model (EOQ), which helps determine the optimal order quantity to minimize total inventory costs (Kehinde Busola *et al*., 2020). This method has been effectively applied to reduce the total cost of inventory items in manufacturing, as demonstrated by Susanto (2018), where the implementation of EOQ model resulted in more economically fit inventory and reduced storage costs. Just-in-time (JIT) inventory management is another approach used in manufacturing, it aims to minimize inventory holding by synchronizing the production schedule with customer demand. For instance, Egbunike and Imade (2017), using a survey design and regression analysis, found that implementing JIT in small-scale firms in Ogun State, Nigeria, significantly reduced inventory costs and enhanced profitability by aligning production schedules closely with real-time demand.

Businesses face the problem of prioritizing inventories based on their value. the ABC/Pareto analysis has been widely adopted as a strategic approach to assert control of this problem. This method, rooted in Pareto's 80/20 rule, asserts that a small percentage of inventory items (typically around 20%) account for a large portion of the total inventory value (about 80%) (Ravinder & Misra, 2014). ABC analysis categorizes inventory into three classes—A, B, and C—based on their importance, enabling businesses to focus more resources on managing high-value items (Category A) while using less stringent controls for lower-value items (Categories B and C) (Kehinde Busola *et al*., 2020). Although ABC analysis provides a useful framework for categorizing inventory, it has been criticized for relying too heavily on cost as the main criterion. Cost by itself might not be sufficient to convey the complexity of inventory management, particularly in dynamic environments (Dhoka & Choudary, 2013). Ravinder and Misra (2014) suggested that multi-criteria analysis, which incorporates additional factors beyond cost, can provide a more robust inventory management system.

In addition to these management systems, material requirement planning emerged as a powerful tool for managing production processes. MRP is a computer-based system that helps manufacturers determine the quantity and timing of raw material orders to ensure efficient production (Aremu & Adeyemi, 2011), MRP systems have evolved over the decades to meet the needs of various industries, including bakeries. These systems address key questions: "When to order/deliver?" and "How much to order?" to manage inventory effectively (Bhadiyadra, 2018). In line with the MRP approach, Bolarinwa and Fajebe (2021) applied an operation research-based technique which applied goal programming to design an inventory management system for a bakery. Though the study proved beneficial it appears to be complex to implement in a manual setting. Various detailed research have been carried out across different firms to establish the relationship between effective inventory management practice and productivity (Martínez & García, 2006; Lazaridis & Tryfonidis, 2006; Mohamad *et al.,* 2016; Helen *et al*., 2017; Bolarinwa & Fajebe, 2021). However, there is limited focus on inventory management in bakeries, particularly in Nigeria. Therefore, this research is aimed at developing a system to manage inventory and enhance productivity in bread production industries. The objectives of this study are as follows:

- Classification of inventory in bakeries using the ABC model.
- Utilize the EOQ model to manage inventory in the selected bakeries.
- Determine reorder points for essential raw materials using the master production schedule.

The scope of this study is limited to the bread production company in Ibadan city, Southwest Nigeria.

METHODOLOGY

This section details the methodology employed to develop an inventory management system aimed at enhancing the productivity of bakeries in Nigeria.

Research Design

The study employs a quantitative research design, utilizing a case study approach to systematically assess inventory management practices in the selected bakery. This design enables a thorough examination of the challenges and opportunities in inventory management, with a specific focus on the application of MRP in a manual, non-automated setting.

Case Study Overview

The case study was conducted in small-to-medium-sized bakeries located in Ibadan city, Southwest Nigeria. The bakery produces two types of bread—White Bread and Sliced Bread—and currently operate using a just-in-time production system. The case study approach allowed for a thorough investigation into the specific challenges and opportunities the bakery faces in managing its inventory.

Data Collection

The data was collected using both primary and archival sources. Interviews with factory managers, and bakers were conducted to understand the existing inventory management practices. Factory tours were undertaken to verify data and gather additional insights. Archival records and operational documents from the bakery provided information on inventory levels, ordering patterns, and costs associated with inventory management.

Sampling Technique

The bakery was selected due to the production processes, reliance on manual inventory management practices, and the availability of data. The sampling was done to ensure that the findings could be generalized to other bakeries of similar size and operational structure within the region.

Inventory Management System

The methodology is structured around a modified MRP process, integrating ABC Classification and EOQ modelling. The following steps outline the research process:

Pareto Principle: ABC Classification

Inventory classification is achieved by comparing the percentage composition and percentage usage value of the items. The percentage composition indicates the proportion of each inventory item used in the product, while the percentage usage value represents the cost associated with these inventory items. The three classes are graded as follows.

- A: high percentage value but low percentage composition
- B: moderate low percentage value and composition
- C: very low percentage value and high percentage composition

Equation (1) calculates the total cost associated with each inventory item by multiplying the weekly quantity used by its unit price, allowing for an accurate assessment of inventory cost and usage.

$$Usage\ value = Quantity\ per\ week\ \times\ unit\ price \quad (1)$$

Economic Order Quantity Model

This study follows the basic assumptions of the EOQ model. Addition assumptions are as follows:

- The carrying cost of each raw material is taken as 10% of the unit cost
- Ordering cost is 25% of the total weekly cost of the raw material.
- A year is equivalent to 52 weeks

$$Q^* = \sqrt{\frac{2DK}{H}} \quad (2)$$

$$TC = PC + H + K \quad (3)$$

Where, Q* = Quantity to order,
D = Annual demand
K = Ordering cost
H = Carrying cost
PC = Purchase Cost

Modified Material Requirement Planning Process

Step **1: Determine Gross Requirement:** The total quantity of products ordered over a period (one week in this study) was determined based on forecasted sales quantities from each bakery.

Step **2: Calculate Net Requirement:** The net requirement was calculated by adjusting the gross requirement with the available inventory using the formula:

$$NR = GR - I \quad (4)$$

where NR = net requirement,
GR = gross requirement,
I = available inventory.

Step **3: Explode Bill-of-Materials (BOM):** The BOM for both products was developed and exploded to determine the required raw materials. Given the single-level nature of the production process, the explosion was limited to one level.

Step **5: Screen for ABC Items:** Inventory items were screened and classified into ABC categories to establish control levels.

Step **6: Determine optimal quantity to order:** Using the EOQ model determine the amount to order for each inventory in the bill of material. All assumptions of the EOQ model hold in this study.

Step **7: Schedule Planned Orders:** Using the MPS and requirement plan, planned orders were scheduled to ensure the timely availability of materials.

RESULTS AND DISCUSSION

Table 1 presents the gross requirement of products per week for the bakery. The gross requirement represents the total quantity of each product that the bakery need to produce weekly. It's important to note that the net requirement, which represents the actual amount needed to fulfil the production demand after accounting for available inventory and other factors, equals the Gross Requirement in this case. This is because shrinkage and other losses are considered negligible, meaning that all the gross requirement is expected to be produced without significant loss during production.

Table 1. Gross requirement of product per week in tons

	Weight (ton)
White Bread	23.5
Slice Bread	23.8

The bill of material was collected separately for both products (white bread and sliced bread). Table 2 lists the various ingredients needed weekly to produce bread at the bakery.

Table 2. Joint Bill Material required for bread production

S/N	Inventory	Weekly Quantity (tons)
1	Flour	20.00
2	Sugar	2.80
3	Salt	0.42
4	Butter	0.44
5	Yeast	0.14
6	EDC	0.14
7	Preservative	0.26
8	Water	2.20
9	Firewood	2.12
10	Milk	0.04
11	Glucose	0.04
12	Flavour	0.02
13	Egg	0.04

Table 3 presents the inventory analysis for the bakery, outlining the weekly quantities, unit prices, and usage values of various ingredients. Flour represents the highest usage value at 76.77%, showing its importance in production. Sugar comes next with a usage value of 13.82%, indicating it is also significant. Other items like salt, butter, and yeast contribute smaller percentages to the total usage value. The total cost of these materials for the week is ₦7,526,080.

Table 3. Usage value of inventory

S/N	Inventory	Weekly Quantity (tons)	Unit Price (N/Kg)	Usage Value	Total Usage (%)
1	Flour	20.00	270	5,400,000	76.77
2	Sugar	2.80	450	1,260,000	13.82
3	Salt	0.42	82	34,400	0.74
4	Butter	0.44	650	286,000	1.78
5	Yeast	0.14	1200	280,000	4.44
6	EDC	0.14	1600	64000	0.39
7	Preservative	0.26	1100	2200	0.50
8	Water	2.20	1	2,200	0.50
9	Firewood	2.12	12	25,440	0.22
10	Milk	0.04	1500	30,000	0.27
11	Glucose	0.04	1000	40,000	0.33
12	Flavour	0.02	1100	22,000	0.19
13	Egg	0.04	1500	60,000	0.50
Total				**N7,526,080**	**100%**

The most important inventory in the production of bread was found to be flour and sugar, according to the Pareto analysis results shown in Table 4 and Figure 2. These materials are essential for maintaining continuous production, making it crucial for bakeries to

prioritize their inventory planning. In Table 4 the inventory is represented by their serial number.

Table 4. Inventory classification

Classes	Inventory
A-item	1,2
B-item	3,4,5
C-item	6,7,8,9,10,11,12,13

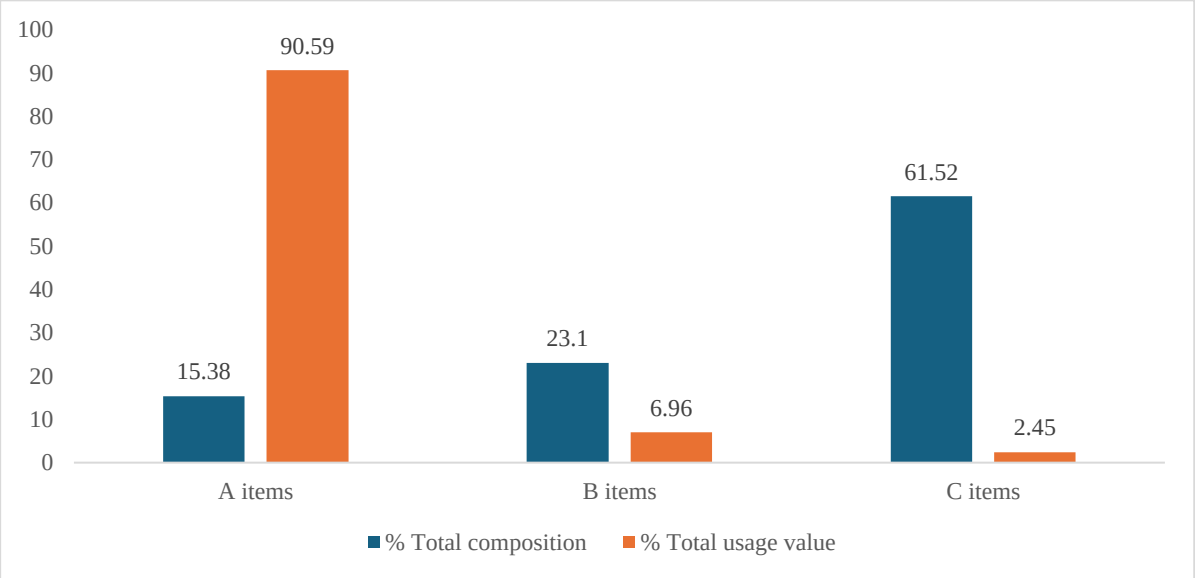

Figure 1: ABC classification of Inventory

The application of the EOQ model resulted in a substantial reduction in the quantities of raw materials ordered. For instance, the quantity of Flour ordered was reduced from the usual order of 200 tons as revealed by the manager of the bakery to 102 tons per order, demonstrating a more efficient use of resources. This reduction led to a significant decrease in total inventory costs from ₦7,526,080 to ₦6,937,211 per week, reflecting a 7.8% savings per week. The lack of adherence to material requirements planning by the bakery is evident from their current ordering practices.

Table 5. Result of application of the EOQ model

S/N	Inventory	Total Cost	EOQ Unit (tons)
1	Flour	27,540,000	102
2	Sugar	5,895,000	13.1
3	Salt	98,400	1.20
4	Butter	715,000	1.10
5	Yeast	1,320,000	1.10
6	EDC	144,000	0.09
7	Preservative	110,000	0.10
8	Water	10,200	10.2
9	Firewood	122,400	10.2
10	Milk	75000	0.05
11	Glucose	10,000	0.01
12	Flavour	11,000	0.01
13	Egg	22,500	0.015
Total		**36,073,500**	

The master production schedule shows the quantity of materials to purchase by week. Using one of the essential materials as an example, Table 6 shows the MPS for flour. The MPS ensures the availability of raw materials, which solves the problems of production delay. This same method can be carried out for all the remaining inventories.

Table 6. MPS for Flour

Period	1	2	3	4	5	6	7	8
Gross requirement	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Schedule receipts			102,000					102,000
On hand (**50,000)**	30,000	10,000	92,000	72,000	52,000	32,000	12,000	
Planned order	102,000							

CONCLUSIONS

In this study, the application of integrating a material requirement planning (MRP) system into the inventory management processes of bakeries in Nigeria has been evaluated. The findings showed that by focusing on essential raw materials like flour and sugar, bakeries can cut down on excess inventory, reduce waste, and realize significant cost savings. The developed inventory system demonstrates a weekly savings of 7.8% in inventory costs and a reduction in inventory order quantities. This indicates that productivity in bakeries can be enhanced by maintaining minimal stock levels while still achieving increased output.

RECOMMENDATIONS

From the findings of this study, it is recommended that

- Bakeries should adopt a systematic management approach to ensure orders are placed at the right time and for the right amount of quantity.
- Bakeries should improve record-keeping to ensure effective inventory management.

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