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Linear Programming Utilization and Optimization of Raw Materials in Bread Baking Industry in Nigeria

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***Abstract**: The work aimed at deciding how limited raw materials of a sample bakery in Nigeria would be allocated to obtain optimum raw material usage and maximize profit. The work was anchored on the Diffusion of Innovation Theory. The data for the research project was collected from Bread Mall, Port Harcourt, Nigeria. The data consisted of the total amount of raw materials (soybean oil, wheat gluten, sugar, yeast, flour, salt, and butter) available for the daily production of three different sizes of bread (small loaf, big loaf, and family size) and profit contribution per each unit size of bread produced. After the formulated model and figures were fixed, the data analysis was carried out with Microsoft Excel Solver. The best result from the model indicated that only one size of bread should be produced, which a big loaf is. The production quantity should be 71, as it will make a maximum profit of N5, 000.00. The study concludes that linear programming is a veritable tool manufacturing company can use to optimize their available raw materials. Amongst other things, the study recommended that the management of bakeries should learn to implement linear programming techniques to optimize their raw materials.*

Keyword: Linear Programming, Linear Programming Utilization, Raw Materials, Optimization of Raw Materials.

BACKGROUND OF STUDY

In many ways, raw material optimization is crucial. It is a major determinant of a product's price and quality. Roughly speaking, the properties of raw materials in the present production method determine around half of the quality of a product. Using proper raw materials is critical for producing high quality at a minimal cost. Operationally, optimization of raw materials refers to the efficient use of raw materials to get the best value for every raw material invested in producing goods. Optimization of the raw material balance provides the best choice for maximising economic gain. In a bread-baking industry, for instance, optimization of raw materials makes the best use of available inventory, taking into account the perishing ability of the products and considering that bread has a different yield when used in different recipes or sold as such. It helps to manage both product portfolio and raw material balance - directly impacting profitability.

It might be challenging to determine the optimal use of raw materials when multi-year purchase agreements are a reality and client demand is constantly changing on the other hand. This brought about diverse raw materials optimization techniques in the manufacturing industry. In manufacturing industries, several optimization techniques are available to minimize or optimize the cost of production, such as Inventory Control Tools, Value Stream Mapping, Lean Manufacturing, Cost of Quality, and many more frameworks. It can be possible through raw materials, wedges, inventory, transportation, investment, resources, minimizing waste, minimizing overproduction, and maintenance. Nevertheless, raw materials and wedges cover more than 65% of production costs, which various techniques can minimize. However, the use of Linear Programming in the optimization of raw materials in the bread-baking industry is not very common, especially in this part of the world (Nigeria).

Mathematically, linear programming is a method of optimizing operations with some constraints (Larry, 2019). In linear programming, the primary goal is to maximise or reduce the numerical value. Linear programming represents a mathematical modeling technique in which a linear function is maximized or minimized when subjected to various constraints (Jude, 2017). In commercial planning, industrial engineering, and to a lesser extent in the social and physical sciences, this method has aided in directing quantitative judgments. Finding the most significant or least significant value of the linear expression (also known as the objective function) under a set of constraints stated as inequalities is the essence of solving a linear programming issue.

Linear programming is a mathematical programming technique that provides the most efficient use of limited resources to achieve a particular goal and the most appropriate choice or distribution among various alternatives (Ekmekci & Tekin, 2017). In this sense, the term “linear” means that all functions in the model are linear, while “programming” means choosing a mode of action or plan. Applications of the method of linear programming were first seriously attempted in the late 1930s by the Soviet mathematician

Leonid Kantorovich and by the American economist Wassily Leontief in the areas of manufacturing schedules and economics. However, their work was ignored for decades (Jude, 2017). Nevertheless, the development of linear programming has been ranked among the most important scientific advances of the mid-20th century (Akpan & Iwok, 2016). It is now a common instrument that has helped most firms of average size in diverse developed nations save hundreds or millions of dollars. The most important contribution of the linear programming models to the decision problems is that the activities adopt the system approach in terms of integrating the relations with the other elements (Özgüven, 2012; Büyükkeklik, 2015). The linear programming model has three essential components: decision variables, the objective (goal), and constraints (Taha, 2017). The basic formulation steps of the linear programming models are i. Problem Identification ii. Model Development iii. Model Solution iv. Evaluation of Model Solution Results v. Solution Implementation (Büyükkeklik, 2015).

A collection of mathematical programming techniques known as linear programming is focused with or useful in allocating restricted or scarce resources to numerous competing activities based on an established optimality criterion (Akpan & Iwok, 2016). It was created during the Second World War as a result of the need to address logistical issues in the armed forces. In operations research, linear programming (LP) is a special method for optimising linear functions under linear equality and inequality constraints. In a given mathematical model with a given set of constraints expressed as a linear equation, linear programming identifies the optimum path to take to obtain the desired result, such as maximum profit or least cost. The linear programming technique is used in various applications, including agriculture, industry, transportation, economics, health system, behavioral and social science, and the military. Although many business organizations see linear programming as a "new science" or recent development in mathematical history, there is nothing new about profit maximization in any business organization (i.e., in a production company or manufacturing company). Therefore, it remains a mathematical technique used in today's modern societies.

STATEMENT OF PROBLEM

From the researcher's experience and report of various surveys, it has been made known that many production companies (such as bread baking companies), particularly the ones operating in Nigeria, are not conversant or yet to know the application of Linear Programming in the optimization of raw materials fully. Because linear programming, which offers a proper mathematical approach to decision-making, has not been completely utilised, many production organisations occasionally struggle with how to use the available resources to maximise profit. Currently, the majority of production managers in Nigeria's bread-baking businesses base their decisions on the overall input required throughout the manufacturing process. The rate at which production companies (especially feed mill producing companies) liquidate in Nigeria is alarming, which can be traced to wastage of production resources, high level of idleness on the production floor, and the inability of the production companies to maximize the meaningful profit that will enable these companies to meet up with the expectations of its stakeholders (Solaja et al., 2019). This is so because most of these companies use traditional techniques in production planning; only a few are aware of the application of this technique in production planning. This approach of making decisions is always biassed since it makes it more difficult to predict future events like price fluctuations and shortages of raw materials or resources. Making decisions based on limited resources is a major problem factor that brought the application of the linear programming model, which is now one of the most powerful tools all decision-makers (managers) must apply to achieve effective decision-making.

The lack of good literature on the relationship between linear programming utilization and optimization of raw materials in the bread-baking industry in Nigeria is another issue that has triggered this research work. To authenticate this, For instance, Akpan and Iwok (2016) investigated the application of linear programming to optimize raw materials in a bakery. They found that a small loaf, followed by a big loaf, contributes objectively to the profit. Ekmekci and Tekin (2017) examined production planning in industrial enterprises and optimization practice in an industrial enterprise via linear programming, and it was revealed that the profit (optimal value of the objective function) had 4.579.066,50 TL. In addition, profit from production under regular work hours, with overtime and the holding cost, have been 4.479.550,00 TL, 107.745,00 TL, and 8.228,50 TL, respectively. Isaac (2015) investigated production scheduling optimization using a linear programming model in copper production companies in Ghana. It was found that the impact of varying operational constraints on the linear programming model was examined to verify the effects of changes on the outcomes of the model. Finally, Oladejo et al. (2019) examined the optimization principle and its application in optimizing Landmark University bakery production using linear programming. The study revealed that Family loaf and Chocolate bread contributed objectively to the profit. Previous empirical studies have shown that studies have been done on the use of linear programming in the optimization of raw materials and production planning generally in Nigeria and outside of Nigeria, but much has not been done in bakery industries in Nigeria. The last was done in 2016. Based on the reality and knowledge gaps pointed out above, the researcher considers it necessary to embark on this research.

AIM AND OBJECTIVES OF STUDY

This study aimed to decide how limited raw materials of a sample bakery in Nigeria would be allocated to obtain optimum raw material usage and maximize profit. The main objectives of this study are:

1. To construct a mathematical model which provides optimal raw material used for production output under a typical operational environment.

2. To link the proposed modeling solution to a case study at a bakery company

3. To interpret the outcomes of the applied model in a case study after applying the Management Scientist Version 5.0 to the model.

THEORETICAL FRAMEWORK

Rogers' (1962) Diffusion of Innovation Theory is the theoretical framework on which this work is anchored. This theory postulates that individuals and social systems will adopt new technologies and innovative ideas at different points and that the point innovation is accepted into a system determines subsequent outcomes.

Assumptions of the Theory

i) There will always be differences in how quickly and to what extent people within a particular social system accept new concepts, methods, and technologies.

ii) Individuals and arms of institutions that adopt innovations early will naturally outperform late adopters and the laggards (Odu, 2017).

This theory implies that as bakery companies across Nigeria work towards optimizing their raw materials by adopting linear programming, there will be inconsistency on how and when these companies will accept to adopt this effective technique. Some, for the sake of being too money-conscious or the belief of "stick to what you know," may not want to follow the trend and adopt this technique on time. The theory predicts from the second assumption that bakery companies who accept early enough to adopt and utilize this tool will outperform those who will accept later.

The justification of the Diffusion of Innovation Theory as the theoretical base of this study is based on the fact that the theory explains and predicts how early adoption of linear programming will have a more significant positive effect on raw material optimization than late adoption.

CONCEPT OF LINEAR PROGRAMMING UTILIZATION

In business and industry, linear programming is used for scheduling, transportation, and production planning (Solaja et al., 2019). For example, airlines use linear programs to schedule their flights, considering scheduling aircraft and staff. To optimise shipping time or cost, delivery services employ linear programming to schedule and route shipments. Retailers utilise linear programming to plan how to place orders with suppliers for goods and schedule deliveries to their stores. Manufacturing businesses schedule and plan their production using linear programming. Financial firms utilise linear programming to plan payments when transferring money between institutions or to decide the mix of financial products they offer. Finally, healthcare institutions use linear programming to ensure that the proper supplies are available when needed.

Many major companies employ analysts who are capable of carrying out the necessary studies, including those involving linear programming and other mathematical methodologies. Businesses that need to implement these tactics into their planning and scheduling procedures benefit from the assistance of consulting organisations that specialise in such techniques. The usage of methods like linear programming as a component of mathematical business models may be described using a variety of words in the business world. For example, optimization, operations research, business analytics, data science, industrial engineering, and management science describe mathematical modeling techniques, including linear programming and related meetings.

A subset of mathematical programming known as linear programming is used to tackle optimization problems when the objectives and any associated constraints may be stated as a linear function. (Solaja et al., 2019). George Dantzig developed it in 1947 to find optimal solutions to supply problems to the Force during World War II. It is a powerful tool for decision-making under certainty in management science and operations research. In order to ensure the accuracy and dependability of judgments made entirely based on the manager's knowledge without the assistance of a mathematical model, linear programming may also be utilised for verification and checking methods (Amole et al., 2016). Finally, it helps allocate scarce resources like materials, machines, man, and time. According to (Salaja et al., 2019), the advantages of linear programming include the following:

i. Complex Problem: The technique can solve the complex problem we encounter in real life.
ii. Simplicity: With the use of a straightforward and easy approach known as simplex, a linear programming model may be solved.

iii. Multipurpose: This method may be used to address a variety of issues in daily life.
iv. Quality Decision: Linear Programming helps decision-makers make quality decisions. With the help of this technique, decision-makers are more objective in their decision.
v. Maximization of Resources: This technique helps maximize resources that are limited in nature. Managers can deploy this technique in the allocation of limited resources.
vi. Multiple Constraint: This technique is more suitable for solving problems with multiple constraints

When a problem can be represented with a linear objective function and linear inequality constraints, linear programming may be used to allocate limited resources to competing activities in the best way possible (James, 2016). A linear programme consists of a collection of variables, a linear objective function that shows how each variable contributes to the desired result, and a set of linear constraints that specify the upper and lower bounds on the values of the variables. A collection of values for the problem variables that provide the best or smallest value of the objective function and are compatible with all the restrictions is referred to as the "answer" to a linear programme. A real-world problem is translated into a linear programme using the formulation process. A computer programme can be used to solve an issue after it has been expressed as a linear programme. This makes solving a linear programme rather simple. The formulation of the issue and understanding of the answer are the most difficult aspects of using linear programming. The following are very important tips to note about linear programming (James, 2016):

i. Decision Variables: In a linear programme, the variables are a collection of values that must be established in order to solve the issue; the issue is resolved after the optimal values for the variables have been established. The variables are sometimes referred to as choice variables since it must be chosen what value each one should have. The variables often indicate how much of a resource to utilise or what degree of activity to engage in. Defining the problem's variables is one of the most complex and crucial steps in formulating a problem as a linear program. However, sometimes creative variable definition can be used to dramatically reduce the size of the problem or make an otherwise non-linear problem linear.
ii. Objective Function: To maximise or reduce a numerical value will be the goal of a linear programming issue. This value might represent the cost of a project, the projected number of tourist days at a park, the number of endangered species that will be rescued, or the quantity of a certain type of habitat to be maintained. It could also be the expected net present value of a project or a forest property. Linear programming is a general technique, and its applications are limited mainly by our imaginations and ingenuity. The objective function indicates how much each variable contributes to the value to be optimized in the problem.
iii. Constraints: These are mathematical expressions that combine the variables to express limits on the possible solutions. For example, they may express that the number of workers available to operate a particular machine is limited or that only a certain amount of steel is available per day.

Furthermore, it is essential to know that linear programming has diverse uses. Amongst the many uses are the under-listed as derived from the work of (James, 2016):

i. Optimum allocation of jobs between machines for maximum utilization of machines.
ii. Optimum assignments of jobs between workers to have maximum labor productivity.
iii. Optimum staffing in hotels, police stations, and hospitals to maximize efficiency.
iv. Optimal staffing levels for trains and buses to have low operating costs.
v. Optimum facilities in telephone exchange to have minimum breakdowns.
vi. Optimum product mix to maximize profit.
vii. Optimum schedule of orders to minimize the total cost.
viii. Optimum media mix to get maximum advertisement effect.
ix. Optimum schedule of supplies from warehouses to minimize transportation costs.
x. Optimum line balancing to have minimum idling time.
xi. Optimum allocation of capital to obtain maximum return on investment

CONCEPT OF OPTIMIZATION OF RAW MATERIALS

A raw material, also known as a feedstock or, most correctly, unprocessed material, is a material used to produce goods, finished products, energy, or intermediate materials, which are feedstock for future finished products (Yogesh et al., 2017). As feedstock, the term connotes these materials are bottleneck assets and important for producing other products. An example of this is iron ore which gives steel raw material and a feedstock used in the production of screws, nuts and bolts, various machine parts, automobile industries, and equipment for food and pharmaceutical industries.

The term "raw material" denotes materials in minimally processed or unprocessed states; e.g., raw latex, crude oil, cotton, coal, raw biomass, iron ore, air, logs, or seawater, i.e. "any product of agriculture, forestry, fishing and any other mineral that is in its natural form or which has undergone the transformation required to prepare it for international marketing in substantial volumes." So it is imperative to optimize the cost of raw materials by maintaining the quality of raw materials.

Operationally, optimization of raw materials refers to the efficient use of raw materials to get the best value for every raw material invested in producing goods. Optimization of raw materials is vital in various aspects. First, it is one of the most decisive factors for the quality and cost of a product. Raw material optimization gives the optimal decision that maximizes economic profit (Great, 2015). Second, it makes the best use of available inventory, considering the perishing ability of the products and considering that beef has a different yield when used in different recipes or sold. Third, it helps an organization to manage both product portfolio and raw material balance - directly impacting profitability. Roughly speaking, half of the quality of a product is determined by the characteristics of raw materials in the current production technology. Using proper raw materials is critical for producing high quality at a minimal cost. Raw material balance optimization gives the optimal decision that maximizes economic profit. In a bread-baking industry, for instance, optimization of raw materials makes the best use of available inventory, taking into account the perishing ability of the products and considering that bread has a different yield when used in different recipes or sold as such. Finally, it helps to manage both product portfolio and raw material balance - directly impacting profitability.

In manufacturing industries, several optimization techniques are available to minimize or optimize the cost of production, such as Inventory Control Tools, Value Stream Mapping, Lean Manufacturing, Cost of Quality, and many more frameworks. It can be possible through raw materials, wedges, inventory, transportation, investment, resources, minimizing waste, minimizing overproduction, and maintenance. However, raw materials and wedges cover more than 65% of production costs, which various techniques can minimize.

LINEAR PROGRAMMING UTILIZATION AND OPTIMIZATION OF RAW MATERIALS

Using linear programming to optimize the use of available raw materials in a manufacturing company can be a veritable solution to managers' challenging decision-making concerning this issue. Often, manufacturing firms do not know which product to concentrate more on when they have limited resources (raw materials). Ezema and Amaken (2016) argue that the problem of industries worldwide is the shortage of production inputs which results in low capacity utilization and, consequently, low outputs. Also, Balogun et al. (2014) reported that the problem in production sectors is the problem of management, that many companies are faced with decisions relating to the use of limited resources such as workforce, raw materials, and capital. At some points, experience and intuition may not proffer a solution. Therefore, it calls for a scientific approach, of which linear programming is reliable. In line with this, Snezanza and Milorad (2018) recognize linear programming as an important tool in energy management despite the non-linearity property of many energy systems. They argue that the non-linearity property can be converted to a linear form by applying Taylor series expansion so that the optimization method can be applied to determine the best means of generating energy at a minimum cost.

The success and failure that an individual or organization experiences in business planning depend primarily on the ability to make the appropriate decision (Fagoyinbo & Ajibode, 2010). This is to emphasize that managers in organizations such as bakeries need not base their decisions on personal experience or feeling but be practical about it by going the scientific way. Managers need to empirically find solutions to the problem of limited raw materials usage that they are confronted with almost daily by adopting linear programming. This will give a scientific solution to the troubling situation. Stephanos and Dimitrios (2017) see linear programming as a significant revolutionary development that has given humanity the ability to state general goals and to lay out a path of complex decisions to take to "best" achieve its goals when faced with the practical problem of great complexity. They argue that simple linear programming begins with determining the interrelationship of an objective function as the maximization of profit for one or more products (activities). This is to add that problem of decision-making in an organization that involves figures expressed in a linear form can be taken care of with linear programming.

Finally, it is noteworthy that the production planning problem is one of the most critical applications of optimization tools using linear programming. According to Waheed et al. (2012), linear programming models are frequently used in operation research and management sciences to solve specific problems concerning the use of scarce resources. Furthermore, Solhi et al. (2013) reported that linear programming is vital in improving management decisions. It is still regarded as new science but has proven to be capable of solving problems such as production planning, allocation of resources, inventory control, and advertisement. This, therefore, buttresses that linear programming is a dependable instrument for finding solutions to problems of optimization of raw materials in organizations, especially manufacturing firms.

MODEL FORMULATION

In the model below, Ci represents the profit derived from the sales of the products (i = 1,2,3,4), and Xi represents the loaf size to be made (i = 1,2,3,4).

$Z = C_1X_1 + C_2X_2 + C_3X_3 + C_4X_{4.....} C_nX_n$

Subject to

$a_{11}x_1 + a_{12}x_2 + a_{13}x_3 \leq b_1$

$a_{12}x_1 + a_{22}x_2 + a_{23}x_3 \leq b_2$

$a_{13}x_1 + a_{22}x_2 + a_{33}x_3 \leq b_3$

$a_{j1}x_1 + a_{j2}x_2 + a_{j3}x_3 \leq b_j$

Non Negativity = $x_{1,}\ x_{2,}\ x_{3\ldots}\ x_n \geq 0$

The model can be written in this Canonical form

3

$Z = \sum c_jx_j$

j = 1, 2….3

Subject to

3

$\sum a_{ij}x_j \leq b_i$

j = 1, 2….3

j = soybean oil, wheat gluten, sugar, yeast, flour, and butter.

i = quantity of materials to be used

bi = Resources available

Assumptions

i. The raw materials required for bread production are assumed to be limited (scarce).
ii. It is assumed that an effective allocation of raw materials to the variables (small loaf, big loaf, and family size) will aid optimal production and, at the same time, maximize the profit of the bakery.
iii. It is assumed that the qualities of raw materials used in bread production are standard (not inferior).

METHODOLOGY

The data for this research project was collected from Bread Mall, Port Harcourt, Nigeria. The data consisted of the total amount of raw materials (soybean oil, wheat gluten, sugar, yeast, flour, salt, and butter) available for the daily production of three different sizes of bread (small loaf, big loaf, and family size) and profit contribution per each unit size of bread produced. The data analysis was carried out with Microsoft Excel Solver. The content of each raw material per each unit product of bread produced is shown below:

Soybean Oil

Total amount (volume) of soybean available = 12.0L

Each unit of small loaf requires 0.21L of soybean oil

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Each unit of big loaf requires 0.0149L of soybean oil

Each unit of family size requires 0.087L of soybean oil

Wheat gluten

The total amount of wheat gluten = 16.0g

Each unit of small loaf requires 0.00012g of wheat gluten

Each unit of big loaf requires 0.000167g of wheat gluten

Each unit of family size requires 0.002g of wheat gluten

Sugar

The total amount of sugar available = 170g

Each unit of small loaf requires 0.15g of sugar

Each unit of big loaf requires 0.17g of sugar

Each unit of family size requires 0.20g of sugar

Yeast

The total amount of yeast available = 30kg

Each unit of small loaf requires 0.022kg of yeast

Each unit of big loaf requires 0.031kg of yeast

Each unit of family size requires 0.039kg of yeast

Flour

The total amount of flour available = 350kg

Each unit of small loaf requires 0.14kg of flour

Each unit of big loaf requires 0.20kg of flour

Each unit of family size requires 0.24kg of flour

Salt

The total amount of salt available = 10g

Each unit of small loaf requires 0.10g of salt

Each unit of big loaf requires 0.14g of salt

Each unit of family size requires 0.21g of salt

Butter

The total amount of butter available = 15g

Each unit of small loaf requires 0.15g of butter

Each unit of big loaf requires 0.20g of butter

Each unit of family size requires 0.30g of butter

Profit contribution per unit product (size) of bread produced

Small loaf (each unit) = N50

Big loaf (each unit) = N70

Family size (each unit) = N95

The above data can be summarized in a tabular form.

Raw Material	**Product**			**Total Available Raw Material**
	Small Loaf	Big Loaf	Family Loaf	
Soybean oil	0.021	0.0149	0.087	12.0
Wheat gluten	0.00012	0.000167	0.002	16.0
Sugar	0.15	0.17	0.20	170
Yeast	0.022	0.031	0.039	30
Flour	0.14	0.20	0.24	350
Salt	0.10	0.14	0.21	10
Butter	0.15	0.20	0.30	15
Profit	N50	N70	N95	

Linear Programming Model of the Company

Let the quantity of small loaf to be produced = x1

Let the quantity of big loaf to be produced = x2

Let the quantity of family loaf to be produced = x3

Let Z denote the profit to be maximized

The linear programming model for the above production data is given by

Maximize $Z = C_1X_1 + C_2X_2 + C_3X_{3.....} C_nX_n$

Maximize $Z = 50X_1 + 70X_2 + 95X_3$

Subject to

$0.021x_1 + 0.0149x_2 + 0.087x_3 \leq 12$

$0.00012x_1 + 0.000167x_2 + 0.002x_3 \leq 16$

$0.15x_1 + 0.17x_2 + 0.20x_3 \leq 170$

$0.022x_1 + 0.031x_2 + 0.039x_3 \leq 30$

$0.14x_1 + 0.20x_2 + 0.24x_3 \leq 350$

$0.10x_1 + 0.14x_2 + 0.21x_3 \leq 10$

$0.15x_1 + 0.20x_2 + 0.30x_3 \leq 15$

$x_{1,}\ x_{2,}\ x_3 \geq 0$

Converting the model into its corresponding standard form, we have:

Maximize $Z = 50X_1 + 70X_2 + 95X_3 + 0_{s1} + 0_{s2} + 0_{s3} + 0_{s4} + 0_{s5} + 0_{s6} + 0_{s7}$

Subject to

$0.021x_1 + 0.0149x_2 + 0.087x_3 + 0_{s1} = 12$

$0.00012x_1 + 0.000167x_2 + 0.002x_3 + 0_{s2} = 16$

$0.15x_1 + 0.17x_2 + 0.20x_3 + 0_{s3} = 170$

$0.022x_1 + 0.031x_2 + 0.039x_3 + 0_{s4} = 30$

$0.14x_1 + 0.20x_2 + 0.24x_3 + 0_{s5} = 350$

$0.10x_1 + 0.14x_2 + 0.21x_3 + 0_{s6} = 10$

$0.0011x_1 + 0.00105x_2 + 0.00017x_3 + 0_{s7} = 15$

$x_1, x_2, x_3, s_1, s_2, s_3, s_4, s_5, s_6, s_7 \geq 0$

The above linear programming model was solved using Microsoft Excel Solver, which gives an optimal solution of:

X1 = 0.0, X2 = 71, X3 = 0.0

Z = 5000.0

RESULTS /DISCUSSION OF FINDINGS

Table1: Target Cell (Max)

Cell	Name	Original Value	Final Value
$E$14	Unit Profit Total Profit	0	5000

Table 2: Adjustable Cells

Cell	Name	Original Value	Final Value
$B$2	Size of Bread to Make X1	0	0
$C$2	Size of Bread to Make X2	0	71.42857143
$D$2	Size of Bread to Make X3	0	0

Table3: Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$E$5	Soybean oil Used	1.064285714	$E$5<=$G$5	Not Binding	10.93571429
$E$6	Wheat gluten Used	0.011928571	$E$6<=$G$6	Not Binding	15.98807143
$E$7	Sugar Used	12.14285714	$E$7<=$G$7	Not Binding	157.8571429
$E$8	Yeast Used	22.14285714	$E$8<=$G$8	Not Binding	7.857142857
$E$9	Flour Used	14.28571429	$E$9<=$G$9	Not Binding	335.7142857
$E$10	Salt Used	10	$E$10<=$G$10	Binding	0

$E$11	Butter Used	14.28571429	$E$11<=$G$11	Not Binding	0.714285714

Fig1: Microsoft Excel Answer Report 1

Based on the data collected, the best result from the model, as shown in the tables above, indicates that only one size of bread should be produced: a big loaf. Therefore, the production quantity should be 71. This will produce a maximum profit of ₦5000.00.

It suggests that the company, in pursuit of raw materials optimization, is required to concentrate on the production of the big loaf and produce 71 units and drop other products, which will enhance the company's raw material optimization and profit potential above the current operating profits.

CONCLUSIONS

The analysis of data carried out in this research work and the results show that Bread Mall Bakery limited should produce all three sizes of bread (small loaf, big loaf, and family size) to ensure it satisfies its customers. Also, more big loaves should be produced to optimize raw materials and attain maximum profit since they contribute to the profit earned by the company. Also, the result of the study shows that with the available resources, the company can optimize its raw material by producing 71 units of the big loaf and dropping the production of other sizes in order to attain a maximum profit of ₦5,000.00 Also, the application of linear programming techniques is a powerful techniques production managers ought to adopt in production planning, as this will improve company's performance by optimizing the limited raw material and enhancing total profit. The study further reveals that it is not enough for production companies to be after raw materials optimization alone but profit maximization; this will benefit the company rather than optimizing raw materials alone. The study, therefore, concludes that linear programming is a veritable tool manufacturing company can use to optimize the use of their available raw materials.

RECOMMENDATIONS

These suggestions are put out in light of the findings:

1. The management of bakeries should learn to implement linear programming techniques to optimize their raw materials.
2. Management of bakeries should not base their decision on experience and intuition but an analytical and scientific approach.
3. Other production/manufacturing companies should adopt linear programming to enable them to utilize their available raw materials judiciously.

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