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AN EMPIRICAL STUDY OF LINEAR PROGRAMMING FOR OPTIMAL USE OF RAW MATERIALS IN BAKERY: A STUDY OF ALHERI BREAD DANJA, KATSINA STATE

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ABSTRACT

This paper studied the optimization of bread production in Alheri Bread Danja, Katsina State, Nigeria, using Simplex algorithm of linear programming. The method was used to allocate raw materials to competing variables (large bread, medium bread and small bread) in bakery for the purpose of profit maximization. The analysis was carried out and the result showed that 0 unit of small bread, 0 unit of medium bread and 64.5506 units of large bread should be produced respectively in order to make a profit of ₦4518.5393. From the analysis, it was observed that only large bread contributes objectively to the profit. Hence, more of large bread is needed to be produced and sold so as to maximize the profit.

Key words: Linear programming model, decision variables, optimal result, Simplex method

1. INTRODUCTION

Companies in the world have faced problems on optimization of production inputs. A company's endurance in a competitive market closely depends on its ability to produce the highest quality products at the lowest possible cost (Kumar, 2010).

Linear programming is the branch of applied mathematics that deals with particular class of business related problems for optimization. It is therefore the best method for determining an optimal solution among alternatives in order to meet a specified objective function limited by various constraints and restrictions (Shaheen and Ahmad, 2015). It contains a linear objective function which is to be optimized (maximize or minimize) subject to a certain number of constraints. The constraints

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are also linear inequalities or linear equation in the variables used in objective function. An application of linear programming technique in business is to maximize the total profit, to minimize the total cost, to arrange the best times to start and finish project etc. In real life situation, linear programming (LP) is very important part in different areas of industry. A large of companies are using LP to solve kinds of particular problems. Business organizations frequently look with choices identifying with the utilization of limited resources. These resources may incorporate people, materials and money. The LPP then becomes a problem of allocating scarce resources to products in a manner such that profits are at a maximum and/or costs are at a minimum. However, managers in companies create gaps in adopting the method to allocate scarce resources among operations and providing quantitative analysis for each production period due to lack of awareness (Yahya, 2004).

The aim of every business organization is to make profit as that will guarantees its continuous existence and productivity. In this modern day, manufacturing industries at all levels are faced with the challenges of producing goods of right quality, quantity and at right time and more especially at minimum cost and maximum profit for their survival and growth. Thus, this demands an increase in productive efficiency of the industry **(**Oladejo, Abolarinwa, Salawu Lukman & Bukari, 2019).

Ezeliora and Obiafudo (2015) studied the optimal production cost of raw materials to its production output using LP solver to solve and to optimize its monthly production output. Based on their result, the monthly optimal production output was 0.00000001225. The company has to budget at least the optimal result to achieve their monthly cost of production. The result helps the company to eliminate excess waste that incurs in their cost of production.

The sole objective of every organization or firm is to make profit as that will sustain its survival and productivity. In this modern day, manufacturing industries at all levels are faced with the challenges of producing goods of right quality, quantity and at right time and more especially at minimum cost and maximum profit for their survival and growth. Similarly, many industries are faced with scarcities of production inputs resulting in low capacity utilization and outputs. The decision of which commodity should be produced and in what quantity and by which process is most effective in attaining the goals of the organization, by combining the limited resources at the disposal of the management and is the main task before production manager. Nevertheless, with all these obstacles the business would still need to operate profitably. Essentially, decision makers and planners should be aware of the importance of the LP model on profit maximization. But most manufacturing companies like Alheri Bread Danja, Katsina State are yet to explore the importance

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of the LP model in their production decision-making instead they use traditional accounting methods such as cost-volume-profit analysis, as well as budgeting and budgetary control, in trying to provide a lasting solution to the challenge of optimal decision making. But, others simply use trial-and-error method or intuition which usually results in ineffective and inefficient allocation of resources, instability and reduction in the profitability profile of these industries.

Extent literatures have revealed that studies on linear programming problem is important in today's industrial operations. It is established that even though there are a lot of studies conducted on the subject matter within and outside the country. For example, Akpan, and Iwok (2016), Gera (2017) and Oladejo, Abolarinwa, Salawu and Lukman (2019) focused on the Application of Linear Programming for Optimal Use of Raw Materials because Research in the area of allocating resources for bread types and in katsina not done.

The main objectives of this study are to highlight the benefits of using linear programming techniques for the industry and also to formulate an LP model which provides optimal allocation of resources in Alheri Bread Danja Katsina.

2. LITERATURE REVIEW

There are many researches done in Linear Programming. However, the few studies selected are reviewed below. Agarana, Anake and Adeleke (2014) applied linear programming to model unsecured loans and bad debt risk control in banks. The analysis is carried out using simplex method and specifically useful for banks whose corporate policy include giving out some percentage of some category of loans without collateral. The peculiar situation is modelled as a linear programming problem. The dual of the minimization linear programming problem is formulated and the resulting maximization linear programming problem is solved using simplex method. A sensitivity analysis is carried out by altering the percentages of the unsecured loans. It is shown that a reduction in the percentage of unsecured loan improves the banks objectives marginally especially when the loan is of a longer term. Also for the bank to be seen as a small and medium scale business friendly bank, the price it has to pay is minimal improvement in her returns from her loan portfolio. It was assumed that the beneficiaries of this unsecured loans are responsible enough to pay back their loans as at when due.

Olayinka, Olusegun, Kellikume & Kayode (2015) examined the impact of Linear Programming in entrepreneur decision making process as an optimization technique for maximizing profit with the available resources. They cited example from Kingston

Joe Nigeria Limited a fast food firm who encountered some challenges in the production of meat pie, chicken pie and do not due to an increment in the price of raw materials. The paper used linear programming technique to analyze the problem encountered by this firm and therefore provide and optimum solution with recommendation that it should discontinue the production the production of children pre and do not and concentrate with production of meat pie.

Akpan, and Iwok (2016) conducted a study on the Application of Linear Programming for Optimal Use of Raw Materials in Bakery. They used the concept of Simplex algorithm; an aspect of linear programing to allocate raw materials to competing variables (big loaf, giant loaf and small loaf) in bakery for the purpose of profit maximization. The analysis was carried out and the result showed that 962 units of small loaf, 38 units of big loaf and 0 unit of giant loaf should be produced respectively in order to make a profit of N20385. From the analysis, it was observed that small loaf, followed by big loaf contribute objectively to the profit. Hence, more of small loafs and big loafs are needed to be produced and sold in order to maximize the profit.

Gera (2017) examined the optimization Problem of Product Mix and Linear Programming Applications: Case Study in the Apparel Industry. The optimization problem of product mix is essential to the success of the industry for meeting customer needs. A quantitative decision-making tool called linear programming can be used for the optimization problem of product mix. The monthly held resources, product volume, and amount of resources used to produce each unit of product and profit per unit for each product have been collected from the company. The data gathered was used to estimate the parameters of the linear programming model. The model was solved using LINGO 16.0 software. The findings of the study show that the profit of the company can be improved by 59.84%, that is, the total profit of Birr 465,456 per month can be increased to Birr 777,877.3 per month by applying linear programming models if customer orders have to be satisfied. The profit of the company can be improved by 7.22% if the linear programming formulation does not need to consider customer orders.

Jyothi, Prakasa and Sivasundari (2019) applied linear programming model for production planning in an engineering industry. They develop a mathematical model for determining the best possible required capacity, workforce and lot-size. They presented a production planning problem from a case study organization where single piece flow based cellular manufacturing is being operated. Selected product is “Alternator” used in automobiles, which is one of many products being manufactured in that industry. This final solution was validated by comparing with the observed

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values of the industry for 12 months. This validated model is useful for the industry to derive suitable production plans.

Oladejo, Abolarinwa, Salawu and Lukman (2019) studied applications of optimization principle in optimizing profits of a production industry using linear programming to examine the production cost and determine its optimal profit. This paper makes use of secondary data collected from the records of the Landmark University Bakery on five types of bread produced in the firm which include Family loaf, sliced family bread, Chocolate loaf, medium size bread, small size bread. The solution obtained revealed that Landmark bakery unit should concentrate much more in production of 14,000 loaves of Family loaf and 10,571 loaves of Chocolate bread while others type should be less produced since their value is turning to zero in order to achieve a maximum monthly profit of N1,860,000. From the analysis, it was observed that Family loaf and the Chocolate bread contributed objectively to the profit. Hence, more of Family loaf and Chocolate bread are needed to be produced and sold in order to maximize the profit.

3. METHODOLOGY

The method of data collection used in this paper is secondary data obtained from Alheri Bread Danja in 2021 and NCSS statistical software was used to analyze the data. Data was collected that has to do with the number of raw materials utilized in the production of large, medium and small bread. A linear programming model using simplex algorithms was also adopted in the process of data analysis.

4. LINEAR PROGRAMMING MODEL

The general linear programming model with n decision variables and m constraints can be stated in the following form.

Optimize (max or min) $Z = c_1x_1 + c_2x_2 + \cdots + c_nx_n$

$s.t.$

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$$a_{11}x_1 + a_{12}x_2 + \cdots\cdots\cdots + a_{1n}x_n (\leq, =, \geq) b_1$$

$$a_{12}x_1 + a_{22}x_2 + \cdots\cdots\cdots + a_{2n}x_n (\leq, =, \geq) b_2$$

$$\vdots \qquad \vdots \qquad \vdots$$

$$\vdots \qquad \vdots \qquad \vdots$$

$$a_{m1}x_1 + a_{m2}x_2 + \cdots\cdots\cdots + a_{mn}x_n (\leq, =, \geq) b_m$$

The above model can also be expressed in a compact form as follows.

Optimize (max or min) $Z = \sum_{j=1}^{n} c_j x_i \ldots \ldots \ldots (objective\ function)$

Subject to the linear constrains

$\sum_{j=1}^{n} a_{ij} x_j (\leq, =, \geq)\, b_i, i = 1,2, \ldots \ldots m\ and\ x_j \geq 0, j = 1,2, \ldots \ldots n$

Where $c_1, c_2, \ldots \ldots c_n$ represent per unit profit (or cost) of decision variables $x_1, x_2, \ldots \ldots x_n$ to the value of the objective function and $a_{11}, a_{12}, \ldots \ldots, a_{2n} \ldots \ldots a_{m1}, a_{m2} \ldots \ldots, a_{mn}$ represent the amount of resource consumed per unit of the decision variables. The b_i represents the total availability of the i_{th} resource, Z represents the measure of performance which can be either profit, or cost etc.

Standard form of a Linear Programming Model The use of the simplex method to solve a linear programming problem requires that the problem be converted into its standard form. The standard form of a linear programming problem has the following properties.

i. All the constraints should be expressed as equations by adding slack or surplus variables.

ii. The right-hand side of each constraint should be made of non-negative (if not). This is done by multiplying both sides of the resulting constraints by -1.

iii. The objective function should be of a maximization type.

For n decision variables and m constraints, the standard form of the linear programming model can be formulated as follows.

Optimize (max or min) $Z = c_1x_1 + c_2x_2 + \cdots + c_nx_n + 0s_1 + 0s_1 + \cdots \ldots \ldots + 0s_m$

Subject to the linear constraints

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$$a_{11}x_1 + a_{12}x_2 + \cdots\cdots\cdots + a_{1n}x_n + s_1 = b_1$$

$$a_{12}x_1 + a_{22}x_2 + \cdots\cdots\cdots + a_{2n}x_n + s_2 =$$

$$\vdots \qquad\qquad \vdots \qquad\qquad \vdots$$

$$\vdots \qquad\qquad \vdots \qquad\qquad \vdots$$

$$a_{m1}x_1 + a_{m2}x_2 + \cdots\cdots\cdots + a_{mn}x_n + s_m = b_m$$

$$x_1, x_2, \cdots\cdots x_n, s_1, s_2, \cdots\cdots s_m \geq 0$$

This can be stated in a more compact form as
$Z = \sum_{j=1}^{n} c_j x_i + \sum_{j=1}^{m} 0s_i$
Subject to the linear constraints
$\sum_{j=1}^{n} a_{ij}x_j s_i = b_i, i = 1,2, \ldots\ldots m$ and
$x_j s_i \geq 0\ (for\ all\ i\ and\ j)$

Assumptions

i. It is assumed that the raw materials required for production of bread are limited (scarce)
ii. It is assumed that an effective allocation of raw materials to the variables (small, medium and large bread) will aid optimal production and at the same time maximizing the profit of then bakery.
iii. It is assumed that the qualities of raw materials used in bread production are standard (not inferior).

Table 4.1: Alheri Bread production constraint

R/MATERIALS	QTY: SMALL	QTY: MEDIUM	QTY: LARGE	AVAILABLE RESOURCES
Flour	148g	386g	690g	45000g
Sugar	21g	58g	89g	5745g
Butter	3g	9g	17g	1134g
Yeast	0.3g	1.2g	2g	140g
Water	105ml	329ml	499ml	35600ml
Selling price	N60	N250	N300	
Cost	N52	N207	N230	
Profit	**N8**	**N43**	**N70**	

See detailed explanation of table 1 in Appendix 1.

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Let X, X_2 and X_3 represent the number of Units of small, medium and large bread respectively

Max Z = $8x_1 + 43x_2 + 70x3$

Subject to $148x_1 + 386x_2 + 690x_3 < 45000$

$21x_1 + 58x_2 + 89x_3 < 5745$

$3x_1 + 9x_2 + 17x_3 < 1134$

$0.3x1 + 1.2x2 + 2x3 < 140$

$105x_1 + 329x_2 + 499x_3 < 35600$

x1, x2, 3, > 0

Convert inequality to equality sign and add slack variables appearing in each equation to coefficient of zero.

Max Z = 8x1 + 43x2 + 70x3 + 0s1 + 0s2 + 0s3

Subject to 148x1 + 386x2 + 690x3 + 0s1 + 0s2 0z3 = 45000

21x1 + 48x2 + 89x3 + 0s1 + 0s2 + 0s3 = 5745

3x1 + 9x2 + 17x2 + 0s1 + 0s2 + 0s3 = 1134

0.3x + 1.2x2 +2x3 + 0s1 + 0s2 + 0s3 = 140

105x1 + 329x2 + 499x3 + 0s1 + 0s2 + 0s3 = 35600

x1, x2, x3 > 0

The optimal solution from NCSS software for the above linear programming problem is obtained as follows:

Table 4.2 Output of the formulated LP problem

Variable	Optimal Value	Original Cost	Reduced Cost	Status
C1	0.0000	6.0000	-12.9286	Non basis
C2	0.0000	53.0000	0.0000	Basis
C3	64.5506	69.0000	-14.2857	Non basis
Obj. Fn	4518.5393			

$X_1 = 0, X_2 = 0\ X_3 = 64.5506\ Z = 4518.5393$

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The result shows that 0 unit of small bread, 0 units of medium bread and 64.5506 unit of large should be produced respectively in order to make an optimum profit of N4518.5393. This therefore indicates that the large bread contributes objectively to the profit. Hence, more of it is needed to be produced and sold in order to maximize the profit.

Summary

In this paper linear programming simplex method was applied for optimal use of raw material in Alheri bread Danja local government, Katsina State. The decision variables were the three different sizes of bread (small bread, medium bread and large bread) produced by Alheri Bread. The researcher focused mainly on five raw materials (flour, sugar, butter, yeast and water) used in the production and the amount of raw material required of each variable (bread size). The result shows that 0 unit of small bread, 0 unit of medium bread and 64.5506 units of large bread should be produced respectively so that the profit of the company can be maximized up to ₦4518.5393

5. CONCLUSION AND RECOMMENDATIONS

Based on the result of the analysis, Alheri Bread, more of large bread should be produced in order to attain maximum profit, because they contribute mostly to the profit earned by the company. Based on the conclusion drawn, the following recommendations were made:

i) Alheri Bread should commit more of its resources in producing large bread in order to maximize its profit.

iii) The management of the company should adopt marketing strategy that will persuade customers to patronize their bread especially the large size for the purpose of maximizing profit.

iv) The management of the company should also adopt quantitative approach in decision making like the LPM as it is clear that model based decision is important for its accuracy and objectivity.

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REFERENCES

Agarana, Anake and Adeleke (2014) Application of Linear Programming Model to Unsecured Loans and Bad Debt Risk Control in Banks. International Journal of Management, Information Technology and Engineering (BEST: IJMITE Vol. 2, Issue 7, 93-102

Akpan, N. P.& Iwok, I.A. (2016) Application of Linear Programming for Optimal Use of Raw Materials in Bakery. *International Journal of Mathematics and Statistics Invention (IJMSI), Volume 4 PP-51-57*

Ezeliora and Obiafudo. Optimization of production cost using Linear Programming solver. Journal of Scientific and Engineering (2015). pp. 13-21

Gera (2017) the Optimization Problem of Product Mix and Linear Programming Applications: Case Study in the Apparel Industry, *Open Science Journal,*2(2), pp, 1-11

Jyothi, Prakasa and Sivasundari (2019) Application of Linear Programming Model for Production Planning in an Engineering Industry-A Case Study, *International Journal of Engineering Research & Technology (IJERT)* Vol. 8

Oladejo N. K, Abolarinwa A, Salawu S.O and Lukman A.F (2019) Optimization Principle and Its' Application in Optimizing Landmark University Bakery Production Using Linear Programming, *International Journal of Civil Engineering and Technology (IJCIET)* Volume 10, Issue 02, February 2019, pp. 183-190.

Olayinka, Olusegun, Kellikume & Kayode (2015) Entrepreneur Decision Making Process and Application of Linear Programming Technique, *European Journal of Business, Economics and Accountancy* Vol. 3, No. 5, pp 1-5.

Yahya W. B. (2004). Determination of Optimum Product Mix at Minimum Raw Material Cost, Using Linear programming. Nigeria Journal of Pure and Applied Sciences, 19, 1712– 1721.

Shaheen, S. and Ahmad, T. (2015). Linear Programming Based Optimum Resource Utilization for Manufacturing of Electronic Toys. International Research Journal of Engineering and Technology (IRJET), 2 (1), 261–264

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APPENDIX 1

Data Presentation and Analysis

Flour

Total amount of flour variable=45000g

Each unit of small bread requires 148g of flour

Each unit of medium bread requires 386g of flour

Each unit of large bread requires 690g of flour

Sugar

Total amount of sugar available=5745g

Each unit of small bread requires 21g of sugar

Each unit of medium bread requires 58g of sugar

Each unit of large bread requires 89g of sugar

Butter

Total amount of butter available =1134g

Each unit of small bread requires 3g of butter

Each unit of medium bread requires 9g of butter

Each unit of large bread requires 17g of butter

Yeast

Total amount of yeast available=140g

Each unit of small bread requires 0.3g of yeast

Each unit of medium bread requires 1.2g of yeast

Each unit of large bread requires 2g of yeast

Water

Total amount of yeast available=35600ml

Each unit of small bread requires 105ml of water

Each unit of medium bread requires 329ml of water

Each unit of large bread requires 499ml of water

Profit contribution per unit product (size) of bread produced

Each unit of big loaf = N8

Each unit of giant loaf = N43

Each unit of small loaf = N70

The above data can be summarized in a tabular form.

Total available raw material