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Application of Linear Programming Technique on Bread Production Optimization in Rufus Giwa Polytechnic Bakery, Ondo State, Nigeria

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Abstract: The paper examined the optimization of bread production in Rufus Giwa Polytechnic Bakery, Owo, Ondo State, Nigeria, using linear programming technique. Three types of bread produced by the bakery were considered in the research and which are medium bread (X_1), large bread (X_2) and extra-large bread (X_3) respectively. Data were collected for four (4) weeks based on temperature per unit of production of the breads using a pocket infrared thermometer so as to know if there will be any deviation in the mode of operation but everything proved to be the same since the process follows a repetitive process of production. The data was analyzed using LINGO software version 15. The findings revealed that optimal solution was attained at X_3=1.175 and Z_{max}=47572.28. It is therefore recommended that the institution bakery should stop producing medium and large bread and produce 235pieces of extra-large bread only from 1.175unit (i.e. 1bag of flour) per day for them to make a maximum profit of #47572.28($239.19) per day or the unit profit on the medium bread and large bread must increase to #39474.87($198.48) and #37450.52($188.30) before it becomes economical to produce.

Keywords: Linear Programming Technique, Bread Production, Optimization, Bakery, Ondo State

1. Introduction

It is observed by people in the society that the strength of an institution in terms of its finances generated lies in the internally generated fund they derived from their established firms or businesses. These institutional owned businesses can be a bakery production, pure water factory, poultry house, garri making factory, etc. These businesses run concurrently during academic sessions and when the schools are not in session except when workers are on vacation.

However, the Nigerian government has seen it compulsory for every institution to be able to generate an internally generated fund through establishing a business enterprise to complement the effort of the government because no business runs without profit maximization as a goal. This is why optimization has to be factored into established firms or businesses owned by the institution so as to avoid wasted investment. Therefore, this work is promising its quota in boosting institutional owned businesses through optimization.

Limitation or restriction is seen as a common problem in any business anywhere in the world. The lack of preventive measures to handle these restrictions can cause liquidation. An individual might be wandering what are these limitations and how the restriction does brings about liquidation. This work seeks to encourage institutional owned businesses by helping them to maximize their profit in the face of constraints so as to avoid losses.

2. Related Study

In Pakistan, Izaz, Norkhairul and Imran [1] estimated an optimal production levels for the different products manufactured at ICI, a multinational company. They used revised simplex method to maximize the profit generated in 2010 subject to cost resource constraints. They considered the production of polyester, soda ash, paints and chemicals in their study. Their findings revealed that the production of the soda ash is most productive contributing more to the objective function. Their findings also revealed that the company can earn significantly profit by operating on the proposed production forecasts.

Using linear programming tools and MATLAB algorithm, Junaid and Mukhtar [2] developed an optimal cutting plan. They employed the use of two software tools to solve mathematical program for optimization of sheet metal cutting plan. It is concluded in their findings that the approaches developed in their work can successfully be applied for obtaining optimal cutting plans and solving constrained cutting stock problems by keeping the trim loss at a minimum level.

In Nigeria, Adebiyi, Amole and Soile [3] focused on linear optimization for achieving product-mix optimization in terms of the product identification and the right quantity in paint production for better profit and optimum firm performance. Their result showed that only two out of the five products they considered in their computational experiment are profitable.

Ibitoye, Atoyebi, Genevieve and Kadiri [4] empirically examined the impact of linear programming in entrepreneur decision making process as an optimization technique for maximizing profit with the available resources. Their work drew examples from a fast food firm that encountered some challenges in the production of meat pie, chicken pie and doughnut due to an increment in the price of raw materials. Their results showed that there should be discontinuity in the production of chicken pie and doughnut and that they should concentrate with production of meat pie.

Vakilifard, Esmalifalak and Behzadpoor [5] showed that the product-mix problem can be used efficiently not only to determine the optimal operational points but also to provide information on how those optimal points could be further increased through changing the constraints of the optimization problem. Their results showed that this information could be used to enhance production by informing expansion plans in which management identifies and take advantage of the capacity of under-utilized constraints and use them to expand the capacity of over-utilized or limiting constraints.

Rajeiyan, Nejati, Hajati, Safari and Alizadeh [6] used linear programming in solving the transportation problem of Services Company. Their result showed that the linear programming can be used in the daily tasks of product management and marketing for production, labour and schedule, assessment, allocation, market research, media choice, media mix, financial stocks and production and composition.

In Nigeria bottling company, Balogun, Jolayemi, Akingbade and Muazu [7] used linear programming technique to derive the maximum profit from production of soft drink for Ilorin plant. Linear programming of the operations of the company was formulated and optimum results derived using software that employed simplex method. Their results showed that two particular items should be produced even when the company should satisfy demands of the other-not-so profitable items in the surrounding of the plants.

Veselovska [8] presented a linear programming model developed in order to achieve flexibility of production processes in operations management and also to minimize costs throughout the whole production process. Their proposed linear programming model of production process is quite general in its nature which makes it possible to apply it on any production process.

Using farm activities, Felix, Judith, Jonathan and Munashe [9] developed a linear program that reflects choices of selection that is feasible given a set of fixed farm constraints and maximizing income while achieving other goals such as food security. Their result obtained using linear programming is compared with the traditional methods. Their results obtained using the linear programming model shows that they are more superior.

In Nigeria, Anieting, Ezugwu and Ologun [10] applied linear programming technique to determine optimum production of Usmer Water Company, Uyo. They employed TORA software in the analysis of the data using M-method. Their results showed that the values of the decision variables, x_1, x_2, x_3, x_4 and x_5 are 95, 0, 5.9, 10 and 17 respectively.

In Niger Mills Company Plc, Calabar, Iheagwara, Opara, Esemokumo and Lebechi [11] used the application of linear programming to determine the quantity of Golden Penny flour (50kg bags), Golden Penny semovita (10kg bags) and Wheat offals (50kg bags) that the mill should produce in a day in order to maximize profit, given the constraints posed in the production process. Their solution obtained revealed that 576 (50kg) bags of flour, non presently for semovita and wheat offals should be produced daily, in order for the company to achieve a maximum daily profit of #161, 280.00.

3. Methodology

The source of data for this research study was collected from Rufus Giwa Polytechnic Bakery, in Ondo State, Nigeria. The data collected was based on the types of bread been produced by the institution bakery which are medium bread, large bread and extra-large bread respectively. The production process adopts a repetitive approach irrespective of the workmanship involved. The process of observation was carried out for four weeks each in the month of August and September so as to know if there will be any deviation in the mode of operation but everything proved to be the same since the process follows a repetitive mechanism of production. The data collected was based on temperature per unit production of the types of bread. It is confirmed that the capacity of the oven is two hundred and thirty five (235). The oven ambient temperature (i.e. the internal air temperature) was measured to be 450°C using a pocket infrared thermometer, even when the fire was removed completely after heating for three (3) hours. At this temperature (450°C), it is not safe to put the bread in the oven because it will get the bread burnt so we allow the temperature to fall between 160°C and 200°C from the oven floor. This temperature was maintained by gradual firing of the oven to bake the bread. The readings collected were based on the temperature per unit production of the type of breads produced in the institution bakery as shown in Table 1.

Table 1. *Temperature per unit of production of bread per day.*

	Temperature per unit (°C) of production of bread			
Day(s)	**Medium**	**Large**	**Extra-large**	**Capacity**
1	190	183	185	235
2	191	184	170	235
3	185	200	187	235
4	200	192	180	235
5	195	185	200	235
Profit (#)	22562.44	4700.51	40487.05	
Profit ($)[1US dollar=#198.89]	113.44	23.63	203.57	

4. Data Analysis

A linear programming model for the maximization of objective function type can be stated mathematically as follows:

$$\text{Maximize } Z = C_1X_1 + C_2X_2 + C_3X_3 + \cdots + C_nX_n \quad (1)$$

Subject to:

$$a_{11}X_1 + a_{12}X_2 + \cdots + a_{1n}X_n \le b_1 \quad (2)$$

$$a_{21}X_1 + a_{22}X_2 + \cdots + a_{2n}X_n \le b_2 \quad (3)$$

$$\vdots\ \vdots\ \vdots\ \vdots$$

$$a_{m1}X_1 + a_{m2}X_2 + \cdots + a_{mn}X_n \le b_m \quad (4)$$

And

$$X_1 \ge 0; X_1 \ge 0; \ldots, X_n \ge 0 \quad (5)$$

Where:

i. $X_1, X_2, \ldots, X_n$ are decision variable to be maximize. They represent the various type of bread production i.e. $\mathrm{X_1} = \mathrm{medium}; \mathrm{X_2} = \mathrm{large}; \mathrm{X_3} = \mathrm{extra-large}$.

ii. $C_1, C_2, \ldots, C_n$ are the unit profit of the different type of bread production.

iii. a_{ij} are the input-output coefficients or the temperature i required to produce a unit of an activity j. For example, it take 190°C at the first day for medium production; the a_{ij} in this case is 190°C as shown on Table 1.

iv. $b_1, b_2, \ldots, b_m$ are the capacity the oven can contained which is uniform all through for the types of bread produced. The capacity of the oven is 235.

v. Z is the objective function to be maximized. The maximization of Z is carried out so that the m constraints are satisfied.

The linear programming for maximization is:

$$\text{Maximize } (Z) = 22562.44X_1 + 4700.51X_2 + 40487.05X_3 \quad (6)$$

Subject to:

$$190X_1 + 183X_2 + 185X_3 \le 235 \quad (7)$$

$$191X_1 + 184X_2 + 170X_3 \le 235 \quad (8)$$

$$185X_1 + 200X_2 + 187X_3 \le 235 \quad (9)$$

$$200X_1 + 192X_2 + 180X_3 \le 235 \quad (10)$$

$$195X_1 + 185X_2 + 200X_3 \le 235 \quad (11)$$

$$X_1, X_2, X_3 \ge 0 \quad (12)$$

$$\underbrace{min}_{X_1,X_2,X_3} \; -22562.44X_1 - 4700.51X_2 - 40487.05X_3 \quad (13)$$

Subject to:

$$\begin{bmatrix} 190 & 183 & 185 \\ 191 & 184 & 170 \\ 185 & 200 & 187 \\ 200 & 192 & 180 \\ 195 & 185 & 200 \\ -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} \le \begin{bmatrix} 235 \\ 235 \\ 235 \\ 235 \\ 235 \\ 0 \\ 0 \\ 0 \end{bmatrix} \quad (14)$$

LINGO software is used in analyzing the formulated equations and the result is display as shown below:

Global optimal solution found.
Objective value: 47572.28
Infeasibilities: 0.000000
Total solver iterations: 1
Elapsed runtime seconds: 0.08
Model Class: LP
Total variables: 3
Nonlinear variables: 0
Integer variables: 0
Total constraints: 6
Nonlinear constraints: 0
Total nonzeros: 18
Nonlinear nonzeros: 0
Variable Value Reduced Cost
X1 0.000000 16912.43
X2 0.000000 32750.01
X3 1.175000 0.000000
Row Slack or Surplus Dual Price
1 47572.28 1.000000
2 17.62500 0.000000
3 35.25000 0.000000
4 15.27500 0.000000
5 23.50000 0.000000
6 0.000000 202.4353
Ranges in which the basis is unchanged:
Objective Coefficient Ranges:
Current Allowable Allowable
Variable Coefficient Increase Decrease
X1 22562.44 16912.43 INFINITY

X2 4700.510 32750.01 INFINITY
X3 40487.05 INFINITY 17346.09
Righthand Side Ranges:
Current Allowable Allowable
Row RHS Increase Decrease
2 235.0000 INFINITY 17.62500
3 235.0000 INFINITY 35.25000
4 235.0000 INFINITY 15.27500
5 235.0000 INFINITY 23.50000
6 235.0000 16.33690 235.0000

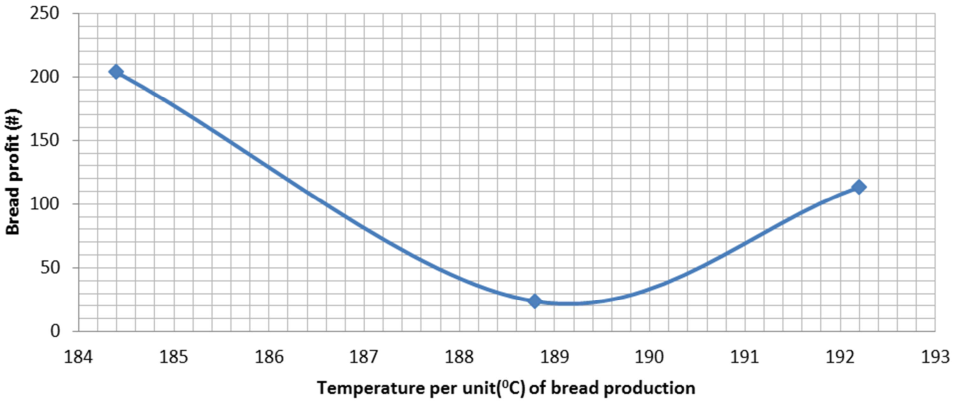

Figure 1. *Graph of bread profit against temperature per unit of bread production.*

5. Conclusions

This research work has been able to analyze the current activity of bread production using linear programming technique. From the sensitivity analysis and optimality tests carried out using LINGO software, it is observed that optimal solution has been attained at $X_3 = 1.175$ and $Z_{max} = 47572.28$ while X_1andX_2 did not have any significant influence on the optimal solution. It is worthy of note that X_1, X_2andX_3 are the decisions variables which represent medium bread, large bread and extra-large bread respectively. Also, the slack variables, $S_1$and S_2 (at row 5 & 6) where not taking into consideration in the final result as they have no economic value.

From the findings, for the institution bakery to make a maximum profit of #47572.28, they should produce 235pieces of extra-large bread only from 1.175unit (i.e. 1bag of flour) and stop the production of medium and large bread as they do not contribute to the maximum profit the institution bakery makes in the face of the constraints they operate upon. This conclusion holds for the current activity in the institution bakery. Medium bread and large bread is not economical to produce. Their opportunity cost measures negative impact of producing them to the maximum profit. However, the unit profit on the medium bread and large bread must increase to 39474.87 and 37450.52 (present value plus opportunity cost) before it becomes economical to produce.

From the graph in Figure 1, it is also revealed that the extra-large bread shows a significant profit of approximately $203.6 based on the mean value of 184.4 for temperature per unit of extra-large bread production as against medium and large bread that shows a profit of $113.4 and $23.6 based on the mean value of 192.2 and 188.8 for temperature per unit of medium and large bread production respectively.

Based on the analysis made and the conclusion drawn, the institution bakery is advice to stop producing medium and large bread and produce 235pieces of extra-large bread only from 1.175unit (i.e. 1bag of flour) per days for them to make a maximum profit of #47572.28 per day.

This method of profit maximization should be adopted by institution bakeries in their business in order to escape liquidation and frustration.

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