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## Using Linear Programming to Use Resources to Make Cakes

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### ABSTRACT

*In this article, we selected cakes of different flavors (ie chocolate, pineapple, butterscotch) using LPP algorithms and analyzed raw materials in (0.5 kg, 1 kg, 2 kg, 3 kg) cakes. The bakery uses a linear program to allocate raw materials to chocolate cakes and the results of the analysis show that 0.5 kg, 1 kg and 2 kg cakes purposefully contributed to profits. As a result, to maximize revenues, these cakes must be produced and sold.*

#### Keywords:

bakery,  
linear programming,  
chocolates,  
analysis

### 1. INTRODUCTION

LP (Linear programming) is a part of mathematics that governs the allocation of limited resources based on a given criterion of optimality useful for several competing activities. In statistics, LP may be a specialized technique employed in investigations aimed to optimize linear functions subject to linear equality and inequality constraints. LP determines how to achieve the finest results in a given mathematical model, such as maximum profit or minimum cost, and lists the requirements in the form of a linear equation. A wide range of applications, including agriculture, manufacturing, transportation, economics, health systems, behavior and social sciences, and the military, use linear programming techniques. Although many corporate organizations see linear programming as a "new science" or a recent discovery in mathematical history, maximizing profit in any commercial organization, such as a production or manufacturing corporation, is nothing new (Neira-2003, Happe-2004).

In modern cultures, it is a mathematical technique. LP (Linear Programming) is considered one of the most significant logical breakthroughs of the mid-twentieth

century. It is now a standard tool that has saved thousands or even millions of dollars for small, medium and large-sized businesses in various manufactured countries of the world. Reports from various discoveries have shown that a lot of production companies, especially those operating in Nigeria, aren't negotiating or aren't yet fully conscious of the appliance of linear optimization. Most manufacturers are faced with the matter of the way to utilize the available resources to maximize profits. This is often because the choice that applied mathematics uses isn't fully implemented. Most manufacturers' decisions have supported the investment utilized in the assembly and profit process. This process reduces the accuracy of forecasts for long periods, such as erratic prices and lack of material or available resources. The decision-making case to support the use of limited resources may have been a major factor that brought the tool of applied mathematics models which is now one of the most important powerful tools that each decision maker (managers) must implement before making effective decisions.

Linear programming is a type of mathematical programming that is used to address optimization issues in which the objectives and constraints are all stated as linear function. Georg Dantzig created it in 1947 to identify the best solution to the army's supply shortages during World War II. It is unquestionably a potent decision-making tool in management science and operations research. Linear programming can also be used for verification and checking methods to determine the accuracy and dependability of decisions made only based on the experience of the manager and without the use of mathematical models. It

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can be used to allocate scarce resources such as material, machine, manpower, and time.

In this context, we will review the prevailing literature. Miller argued in 2007 that applied mathematics may be a generalization of algebra from organizing aircraft routes to transporting oil from refineries to cities to locate affordable food that meets daily demands. Miller argued that the rationale for the good utility of applied mathematics is the ease with which constraints are often integrated into applied mathematics models. In 2012 Amaken and Ezema argue that the problems faced by universal industries are the result of a lack of production inputs resulting in low capacity utilization and resulting in a smaller production. He used linear programming to optimize earnings in the Golden Plastics sector, to determine and achieve the industry's ideal product mix. According to Balogun et al. (2012), the problem in the manufacturing sector is management. Many groups are faced with decisions about how to use limited resources such as personnel, raw materials, and capital. In his drawings titled "Using Linear Programming for Optimal Production" at The Coca-Cola Company, he was able to follow linear programming to help him achieve the most appropriate manufacturing strategies for the Coca-Cola Company. When designing a linear programming version for the manufacturing process, he recognized subsequent selection variables as Coke, Fanta, Schweppes, Fanta Tonic, Crest Soda, etc., some of which identified nine selection variables and constraints within the drink has gone concentration, sugar content, water content and carbon (iv) oxide. The following methods are solved using a simplex algorithm, after data evaluation, they came to the belief that the enterprise switched to the easiest production of the nine products that contributed the most to maximize their income. Veliulukan (2010) noted that compound integer applied mathematics serves an important function during a complete manufacturing plan (i.e. a macro manufacturing plan) that addresses the difficulty of determining what percentage of personnel to the corporate and the producer. should keep. For the quantity and composition of the products to be produced. Weeley argues that the selected variable for programming an integer must be an integer capable of satisfying each target characteristic and constraint.

Fagoyinbo and Ajibode (2010) noted that a character for business enterprise or efficient achievement and failure through enterprise depends in large part on the ability to make suitable choices. He claims that an observer cannot make a decision solely based on personal experience, speculation, or instinct since the repercussions of poor decisions are extremely costly, therefore making a decision necessitates competence in the applicability of a quantitative approach to the one who enjoys. He defined linear programming as one of the most important quantitative processes for choice and consequently applied it within the powerful use of assets for education personnel, the choice variable for the version of junior personnel and senior personnel and education. There are limits. Since this system is in-career education.

According to Majeke (2013) industrial farmers are constantly faced with the trouble of locating a mix of companies, so that one can provide them the best returns through the pleasant

use of agricultural limited assets (constraints), they have developed exceptionally Diagnosed agriculture sector software. , Gave. In linear programming, especially in the optimization of having an agricultural property to obtain a certain profit (profit). They designed a linear programming version that maximized farmers' profits within a rural area, with the variant's selection variables providing hectares of corn saved for their circle of relative consumption, hectares allocated for soybean manufacturing, and hectares for tobacco manufacturing. To do with the version selection variable for recognition allotted as hectares(5 selection variables) as well as six constraints have been identified. The ensuing version changed to solve the use of PC software (MS Excel).

According to Waheed et al (2012) applied mathematics fashion is routinely used in operations studies and management technology to deal with particular problems related to the use of scarce resources. Application of LP in profit maximization in product-mix company selection of best equipment. To promote their medicated cleaning soap product which includes 1 tablet by %, three tablets by %, 12 tablets by % and one hundred and twenty tablets by %, which may be a problem for some barriers can. With the data analysis package turned into received, the final result of the assessment confirmed that the employer could achieve the ideal month-to-month income level of approximately N271, 296 if he frequently used unit income (concentrating one tablet) of his medicated soap products keeping in mind. Ignoring the different forms of income packages.

The agency manufactures 3 types of cleaning soap, 5 gm white cleaning soap, 10 gm white cleaning soap and 10 gm colored cleaning soap. Evaluating the facts, it appears miles away that the agency spends the color cleaning soap and makes more profit. Colored soap compared to white soap. Therefore the agency is advised to provide colored cleaning soaps (five grams and 10 grams) less white cleaning soaps than colored cleaning soaps to get good returns. Mariam et al (2013) noted that linear programming holds an important place in enhancing management. Stefanos and Dimitrios (2010), sees linear programming as a terrifyingly innovative improvement that has given mankind the ability to country fashionable desires and "best" bites their desires in the face of sensible trouble. given for. He argues that easy linear programming begins with the goal attribute as income maximization for one or more products (activities). Taha (2003) argues that the concept of differential calculus is critical for optimization of the goal characteristic subject to interrupt non-stop operations. For Taha, the Langrangean technique is the maximum suitable technique to solve. The optimization trouble with equality constrains non-stop functions, if the restrictions are non-stop and non-linear. So the suitable technique for the gadget of non-lean programming is the Karush-Kuhn-Tucker technique.

Linear programming is a branch of mathematical programming that focuses on solving optimization problems with goals and constraints that may be stated as a linear function.

It was changed to Advanced in 1947 through Georg Dantzig to find better answers to the problems of military components during World War II. It is an effective tool in

controlling the technical know-how and operation study to select the below certainty.

## MODEL OF LINEAR PROGRAMMING

The conventional linear programming version, with  $n$  selection variables and  $m$  constraints, is written as follows:

$$\begin{aligned} \text{MAXIMUM AND MINIMUM } Z &= a_1k_1 + a_2k_2 + a_3k_3 + \dots + a_nk_n \\ c_{11}k_1 + c_{12}k_2 + c_{13}k_3 + \dots + c_{1n}k_n &(\leq, =, \geq) b_1 \\ c_{21}k_1 + c_{22}k_2 + c_{23}k_3 + \dots + c_{2n}k_n &(\leq, =, \geq) b_2 \\ &\dots\dots\dots \\ c_{m1}k_1 + c_{m2}k_2 + c_{m3}k_3 + \dots + c_{mn}k_n &(\leq, =, \geq) b_m \end{aligned}$$

The above model can also be expressed in a compact form as follows. Optimize (max or min)

$$Z = \sum_{j=1}^n c_j k_j \text{ (objective function)}$$

Subject to the linear constraints

$$\sum_{j=1}^n c_{ij} k_j (\leq, =, \geq) b_i \text{ where } i = 1, 2, 3, \dots, m$$

$$k_j \geq 0, \text{ where } j = 1, 2, \dots, n$$

$$(\leq, =, \geq) \text{ where } i = 1, 2, 3, \dots, m$$

$$k_j \geq 0, \text{ where } j = 1, 2, \dots, n$$

Where  $a_1, a_2, \dots, a_n$  symbolize the according to unit profit (or cost) of selection variables  $k_1, k_2, \dots, k_n$  to the cost of the goal function. And  $c_{11}, c_{12}, \dots, c_{2n}, \dots, c_{m1}, c_{m2}, \dots, c_{mn}$  represent the amount of resource consumed per unit of the decision variables. The  $b_i$  represents the total availability of the  $i^{\text{th}}$  resource.  $Z$  represents the measure of performance which can be either profit, or cost or reverence etc.

## Standard form of a LP Model

The LP model may be expressed in its standard form as follows:

$$\begin{aligned} \text{MAXIMUM AND MINIMUM } Z &= a_1k_1 + a_2k_2 + a_3k_3 + \dots + a_nk_n + 0.s_1 + 0.s_2 + 0.s_3 + \dots + 0.s_m \\ c_{11}k_1 + c_{12}k_2 + c_{13}k_3 + \dots + c_{1n}k_n + s_1 &= b_1 \\ c_{21}k_1 + c_{22}k_2 + c_{23}k_3 + \dots + c_{2n}k_n + s_2 &= b_2 \\ c_{m1}k_1 + c_{m2}k_2 + c_{m3}k_3 + \dots + c_{mn}k_n + s_m &= b_m \end{aligned}$$

$$k_1, k_2, k_3, \dots, k_n \text{ non negative}$$

$$s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_8, s_9, s_{10}, s_{11}, \dots \text{ are positive}$$

this form can be written as

$$\text{Max} = \sum_{j=1}^n c_{ij} k_j + \sum_{i=1}^m s_i c_j$$

Subject to the linear constraints

$$\sum_{j=1}^n c_{ij} k_j + s_j = b_i \text{ } i=1, 2, 3, \dots, m$$

## Analysis of Data Presentation

The data for this study was collected from Pooja's Home Made Cake, Bhopal. The facts include common quantities of raw ingredients (flour, sugar, yogurt, baking powder, vinegar, chocolate essence, vegetable oil, cocoa powder, milk, whipping cream, and chocolate bars) used to manufacture 4

extraordinary shapes of cakes every day are taken. (0.5 kg, 1 kg, 2 kg and 3 kg) and income contribution per unit length of cake produced. Fact evaluation completed with Lingo software. The material content of each raw fabric per unit manufactured from the cake produced is proven below.

## FLOUR

42kg total flour available

150gm of flour is required for each half kilogram of cake.

Each kilogram of cake takes 250gm of flour.

Each 2 kg cake takes 400g of flour.

Each 3 kg cake takes 600g of flour.

## SUGAR

28kg total sugar available

Each half kilogram of cake takes 120gm of sugar.

1 kilogram of cake needs 220gm of sugar.

250gm of sugar is required for each unit of 2 kg of cake.

350gm of sugar is required for each unit of 3 kg of cake.

## CURD

Curd available in total = 27kg

100gm of curd is required for each half kilogram of cake.

Each kilogram of cake takes 200gm of curd.

250gm of curd is required for each unit of 2 kg of cake.

350gm of curd is required for each unit of 3 kg of cake.

## BAKING POWDER:

1.5kg total quantity of Baking Powder available

6gm Baking Powder is required for each half kilogram of cake.

10gm Baking Powder is required for each kilogram of cake.

13gm Baking Powder is required for every 2 kg of cake.

Each 3 kg cake takes 15gm Baking Powder.

## VINEGAR

5kg total quantity of Vinegar available

6gm Vinegar is required for each half kilogram of cake.

1 kilogram of cake needs 12 grams of Vinegar.

18gm Vinegar is required for each unit of 2 kg cake.

Each 3 kg of cake demands 24gm of Vinegar.

## CHOCOLATE ESSENCE:

Chocolate Essence total availability = 0.9kg

Each half kilogram of cake takes 3gm of Chocolate Essence.

1 kilogram of cake necessitates 6gm of Chocolate Essence.

9gm of Chocolate Essence is required for each unit of 2 kg of cake.

12gm of Chocolate Essence is required for each unit of 3 kg of cake.

## VEGETABLE OIL

Vegetable oil is offered in a total quantity of 22kg.

Vegetable oil (70gm) is required for each half kilogram of cake.

130g of vegetable oil is required for each unit of 1 kg of cake.

220g of vegetable oil is required for each unit of 2 kg of cake.

Each unit 3 kg of cake requires 350gm of Vegetable oil

### COCO POWDER

The total amount of Coco Powder on hand is 9.5kg.

35gm Coco Powder is required for each half kilogram of cake.

75gm Coco Powder is required for each unit of 1 kg of cake.

100g Coco Powder is required for each 2 kg cake unit.

Coco Powder (130gm) is required for each unit of 3 kg of cake.

### MILK

The total amount of milk on hand is 41 kg.

Each half kilogram of cake takes 175 gram of milk.

Milk is required for each unit of 1 kg of cake, which is 265gm.

A total of 440gm of milk is required for each unit of 2 kg of cake.

500g of milk is required for each unit of 3 kg of cake.

### WHIPPING CREAM

The total amount of Whipping Cream on hand is 117 kg.

300g of whipping cream is required for each half kilogram of cake.

600g of whipping cream is required for each unit of 1 kilogram of cake.

1200g of whipping cream is required for each unit of 2 kg of cake.

For each 3 kg of cake, 1800g of whipping cream is required.

### CHOCOLATE BAR

The total weight of chocolate bars provided is 58 kg.

Each half kilogram of cake takes 150 gram of chocolate.

A total of 300gm of chocolate is required for each unit of 1 kilogram of cake.

A total of 600g of chocolate is required for each unit of 2 kg of cake.

A total of 900gm of chocolate is required for each unit of 3 kg of cake.

Profit contribution different types of cakes produced

Profit of  $\frac{1}{2}$  kg of cake = Rs85

Profit of 1kg of cake =Rs150

Profit of 2 kg of cake = Rs225

Profit of 3 kg of cake= Rs300

### Data in a tabular form:

| RAW MATERIAL      | Material of different types of cake |       |       |       | Total Material Available |
|-------------------|-------------------------------------|-------|-------|-------|--------------------------|
|                   | 1/2kg                               | 1kg   | 2kg   | 3kg   |                          |
| Purpose Flour     | 150gm                               | 250gm | 400gm | 600gm | 42kg                     |
| Sugar powder      | 120gm                               | 200gm | 250gm | 350gm | 28kg                     |
| Curd              | 100gm                               | 200gm | 250gm | 350gm | 27kg                     |
| Baking powder     | 6gm                                 | 10gm  | 13gm  | 15gm  | 1.5kg                    |
| Vinegar           | 6gm                                 | 12gm  | 18gm  | 24gm  | 5kg                      |
| Chocolate essence | 3gm                                 | 6gm   | 9gm   | 12gm  | 0.900kg                  |

|                |       |        |        |        |       |
|----------------|-------|--------|--------|--------|-------|
| Vegetable oil  | 70gm  | 132gm  | 220gm  | 350gm  | 22kg  |
| Coco powder    | 35gm  | 75gm   | 100gm  | 130gm  | 9.5kg |
| Milk           | 175gm | 265gm  | 440gm  | 600gm  | 41kg  |
| Whipping Cream | 300gm | 600gm  | 1200gm | 1800gm | 117kg |
| Chocolate bar  | 150gm | 300gm  | 600gm  | 900gm  | 58kg  |
| Profit         | Rs 85 | Rs 150 | Rs 225 | Rs 300 |       |

Let Quantity of  $\frac{1}{2}$  kg cake to be produce =  $k_1$

Let Quantity of 1 kg cake to be produce =  $k_2$

Let Quantity of 2 kg cake to be produce =  $k_3$

Let Quantity of 3 kg cake to be produce =  $k_4$

### MAXIMIZE:

$$Z = 85k_1 + 150k_2 + 225k_3 + 300k_4$$

$$0.150k_1 + 0.250k_2 + 0.400k_3 + 0.600k_4 \leq 42$$

$$0.120k_1 + 0.200k_2 + 0.250k_3 + 0.350k_4 \leq 28$$

$$0.100k_1 + 0.200k_2 + 0.250k_3 + 0.350k_4 \leq 27$$

$$0.006k_1 + 0.010k_2 + 0.013k_3 + 0.015k_4 \leq 1.5$$

$$0.006k_1 + 0.012k_2 + 0.018k_3 + 0.024k_4 \leq 5$$

$$0.003k_1 + 0.006k_2 + 0.009k_3 + 0.012k_4 \leq 0.9$$

$$0.070k_1 + 0.132k_2 + 0.220k_3 + 0.350k_4 \leq 22$$

$$0.035k_1 + 0.075k_2 + 0.100k_3 + 0.130k_4 \leq 9.5$$

$$0.175k_1 + 0.265k_2 + 0.440k_3 + 0.600k_4 \leq 41$$

$$0.300k_1 + 0.600k_2 + 1.200k_3 + 1.800k_4 \leq 117$$

$$0.150k_1 + 0.300k_2 + 0.600k_3 + 0.900k_4 \leq 58$$

Where

$k_1, k_2, k_3, k_4$  are non negative

Standard form of model

### MAXIMIZE:

$$Z = 85k_1 + 150k_2 + 225k_3 + 300k_4 + 0s_1 + 0s_2 + 0s_3 + 0s_4 + 0s_5 + 0s_6 + 0s_7 + 0s_8 + 0s_9 + 0s_{10} + 0s_{11}$$

$$0.150k_1 + 0.250k_2 + 0.400k_3 + 0.600k_4 + s_1 = 42$$

$$0.120k_1 + 0.200k_2 + 0.250k_3 + 0.350k_4 + s_2 = 28$$

$$0.100k_1 + 0.200k_2 + 0.250k_3 + 0.350k_4 + s_3 = 27$$

$$0.006k_1 + 0.010k_2 + 0.013k_3 + 0.015k_4 + s_4 = 1.5$$

$$0.006k_1 + 0.012k_2 + 0.018k_3 + 0.024k_4 + s_5 = 5$$

$$0.003k_1 + 0.006k_2 + 0.009k_3 + 0.012k_4 + s_6 = 0.9$$

$$0.070k_1 + 0.132k_2 + 0.220k_3 + 0.350k_4 + s_7 = 22$$

$$0.035k_1 + 0.075k_2 + 0.100k_3 + 0.130k_4 + s_8 = 9.5$$

$$0.175k_1 + 0.265k_2 + 0.440k_3 + 0.600k_4 + s_9 = 41$$

$$0.300k_1 + 0.600k_2 + 1.200k_3 + 1.800k_4 + s_{10} = 117$$

$$0.150k_1 + 0.300k_2 + 0.600k_3 + 0.900k_4 + s_{11} = 58$$

Where

$k_1, k_2, k_3, k_4$  are non negative

$s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_8, s_9, s_{10}, s_{11}$  are positive

Solving these all equations BY **LINGO software** and we get

$$k_1 = 112, k_2 = 48, k_3 = 19, k_4 = 0_{\text{non negative.}}$$

Now the maximum profit

$$Z = 85 \times 112 + 150 \times 48 + 225 \times 19$$

$$= 9520 + 7200 + 4275$$

$$\text{Rs.20995}$$



## RESULT AND CONCLUSION

The optimal result obtained from the model based on the data collected suggests that three sizes of cakes should be produced, 1/2 kg and 1 kg and 2 kg. Their production quantity should be 1/2 kg cake is 112 units, 1 kg cake is 48 units, and 2 kg cake is 19 units. This will result in a maximum profit of Rs 20995.

### Summary

The goal of this study is to use applied mathematics for optimum utilization of resources in cake production. A homemade cake become used as our case study. The choice variables in this study are 4 exclusive sizes (half of kg, 1 kg, 2kg and 3kg) of home made cakes. The researcher focused primarily on the raw materials used in the production (flour, sugar, curd, vinegar, milk, vegetable oil, cocoa powder, chocolate bars, baking powder, and whipping cream) for each variable, the number of raw materials required. The result indicates that 112 unit 1/2 kg cakes, 48 unit 1 kg cakes, and 19 unit 2 kg cakes should be created, resulting in a maximum profit of Rs. 20995.

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