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# DESINGING OF MILLET BASED CONVENIENT BREAKFAST MIX USING LINEAR PROGRAMMING APPROACH

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Abstract – India is a leading producer of small millet and it have health promoting effects equal or even in higher amount than fruits and vegetables and have a protective effect against degenerative diseases. One of the convenient breakfasts mix prepared from little millet and the product formulation could be done using a computer-based modelling approach to reduce the errors and biases that can occur when using a consultation process alone. Formulations were designed using linear programming (LP) model to minimise the total cost of finished product. The breakfast mix was developed using little millet rice, dried coconut and sugar with varying quantities of ingredients. Cost and nutritive value of LP formulated mix was calculated and sensory evaluation also was done. The low cost mix (Rs. 42/kg) obtained using linear programming is little millet (51.0 %), dried coconut (32.8 %) and sugar (16.2 %). The formulated mix provides 5.05-6.53 g of protein, 140 mg of calcium and 5.96-7.72 mg of iron. Sensory evaluation results revealed that all the formulated mix scored acceptability range. Linear programming is useful software tool to develop the therapeutic and supplementary foods to minimize the cost of a product.

**Keywords:** Breakfast mix, linear programming, millets, nutritive value

## I. Introduction

India is a leading producer of small millet viz., foxtail millet, little millet, kodo millet, proso millet and finger millet [1]. The world total production of millet grains was 7.62 lakhs metric tonnes and the top producer was India with an annual production of 3.34 lakhs tonnes (43.85%) [2].

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In Indian agriculture, among the total millet growing areas of 23 million ha, small millets alone accounts for about 3.5 million ha. The cultivation of kodo millet, little millet and foxtail millet is more in Madhya Pradesh, Chattisgarh, Orissa, Tamil Nadu, Jharkhand, Karnataka, Andhra Pradesh and Maharashtra. Whole grains like millets have health promoting effects equal or even in higher amount than fruits and vegetables and have a protective effect against insulin resistance, heart disease, diabetes, ischemic stroke, obesity, breast cancer, childhood asthma and premature death. Because of these benefits millets, millets can be used in functional foods and as nutraceuticals. Hence, they are also called as 'nutri cereals' [3]. Thus, millets are strategic in terms of their food, nutritional and livelihood security and their role in local agro-ecosystems [4]. Among the millets, Little millet (Panicum sumatrense) have high nutritional, medicinal value, high dietary fibre content, easy digestibility and other uses. It has medicinal values in the management of diabetes and lowering lipids especially cholesterol.

The little millet rich in starch makes it a great source of energy, excellent source of protein and fibre and also rich in minerals like phosphorus, iron and zinc. Little millet contains total carbohydrate 47.85 g, protein 6.26 g, fat 2.03 g per 100 g. The phytochemical analysis showed that flavanoids 0.18 g and phenolics 0.32 g per 100 g [5]

Linear programming (LP) analysis is an operational research approach that is used to model complex multi factorial problems, including diet-related problems. Product formulation could be done more effectively using a computer-based modelling approach to reduce the errors and biases that can occur when using a consultation process alone. Thus, for any food product development, many factors affect its preference and acceptability. Some factors are intrinsic to the product, such as physical, textural, sensory and other factors are extrinsic, such as social and cultural factors. Marketing studies regarding the determinants of food consumption have consistently shown that consumer choices are largely determined by taste [6].

Linear programming has been used to develop therapeutic and supplementary foods for developing countries to minimize the cost of a product that meets a given nutritional standard or to maximize nutritional value of a product given a cost constraint [7].

Thus, keeping in view the commercial potential of underutilized millet crops, the present study has been planned to optimize the process parameters to develop millet base breakfast food mix using linear programming.

## II. MATERIALS AND METHODS

### A. Sample preparation

The raw materials viz., little millet, coconut and sugar were procured from local market. Little millet was cleaned to remove all foreign matter, broken and immature grains and soaked in water for 8h at room temperature (30±2°C) then subjected to parboiling for 30 min. The parboiled millets was dried for 10 min at 40°C in order to remove the surface moisture then these mass was roasted in the grain roaster till 5% of the grain are popped. The roasted millet grains are cooled in shade to attain the temperature of normal atmospheric condition

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and dehulled using millet mill. Fresh coconut was shredded and dried for 6h at 60oC till it reaches a moisture content of 4-6% (wb). As illustrated in flowchart (Fig. 1), food mixes were prepared using processed little millet, dried coconut and powdered sugar. The parboiled little millet was soaked in hot water for 20 min then dried coconut and powdered sugar were added with small quantity of cardamom as flavouring agent for sensory evaluation studies.

B. Linear programming formulation

A linear programming model was developed to formulate a low cost convenient mix considering protein, calcium, iron and energy requirement profile (According to Recommended Dietary Allowance, ICMR 2010). Formulation was designed with varying quantities of ingredients as shown in Table 1. Three types of constraints were set upon as variables: 1) minimum and maximum quantity of ingredients to be included; 2) energy supply, protein, iron and calcium of each ingredient; and 3) material balance.

The objective function established was:

Min Z = Ci Xi……(1)

where, Z - cost per kilogram of formulation; Ci - cost of ingredient; and Xi -proportion in which ingredient are used in the formulation. According to Table 1, food formulation was developed by using linear programming software [8]

Following assumptions were made (1) serving size: 100 g, (2) linear programming was performed for 100 g sample and (3) 1/6th of RDA for sedentary workers was carried. The low cost mix product (Rs. 42/kg) obtained using linear programming is little millet (51.0%), dried coconut (32.8%) and sugar (16.2%). Considering market price of 2014, the Table 1 was formulated. The product prepared using mixes were sensory evaluated on the various parameters like colour, appearance, flavour, texture, taste and overall acceptability by using five point hedonic scale [9]

## III. RESULT AND DISCUSSION

According to ICMR-RDA 2000, a sedentary worker requires 2425 kcal of energy, 60 g protein, 600 mg calcium and 28 mg iron per day. Table 1 showed the cost and amount of nutrients present in the three selected variables (little millet, dried coconut and sugar).

The different linear programming formulations with objective function and constraint equations are provided in Table 2. The basic assumptions for these formulations were made varying the amount of millet and dried coconut. With the laboratory trails and the amount of millet was kept in the range of 36-56 % and dried coconut was kept as less than or equal to 36 %. The developed product is rich in energy and iron content. However, the energy value does not show any trend. Based on the set of assumptions, best combinations of all ingredients through linear programming formulation are given on Table 3. On comparison, product cost does not show many variations. For the formulation with the decreased percentage of millet showed an increase in percentage of sugar. It could be attributed because that sugar has higher level of energy and vice versa for the decreased percentage of millet composition. Also, the increase of millet in the product formulation showed an increase in iron and protein content 5.96 to 7.75 mg and 5.05 to 6.90 g,

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respectively. The sensory evaluation result (Table 4) revealed that all the samples scored maximum acceptability. Among the product sample A & B have the highest scores compare to other samples.

## IV. CONCLUSION

The millet based breakfast instant mix formulations can be made using linear programing considering the ICMR-Recommended Dietary Allowance values to prepare different target groups (pregnant women, elder and children) foods having maximum acceptability range.

**TABLE 1** COST AND NUTRIENTS PRESENT IN THE SELECTED VARIABLES (PER 100g)

| Variable | Ingredients | Cost* (Rs/kg) | Protein (%) | Calcium (mg) | Energy (Kcal) | Iron (mg) |
|---|---|---|---|---|---|---|
| $X_1$ | Little millet | 40 | 7.7 | 17 | 341 | 9.3 |
| $X_2$ | Dried coconut | 50 | 6.8 | 400 | 662 | 7.8 |
| $X_3$ | sugar powder | 36 | 0 | 0 | 400 | 0 |

*Prices as of January 2016

TABLE 2 DIFFERENT FORMULATIONS THROUGH LINEAR PROGRAMMING

| **FORMULATION** | **MIN Z** | **EQUATION** | |
|---|---|---|---|
| **1** | $4X_1 + 5X_2 + 3.6X_3$ | Energy( kcal) | **$341.0\ X_1 + 662.0\ X_2 + 400\ X_3 \geq 430$** |
| | | Protein (%) | $7.7\ X_1 + 6.8\ X_2 + 0\ X_3 \leq 10$ |
| | | Iron( mg) | **$9.3\ X_1 + 7.8\ X_2 + 0\ X_3 \geq 3$** |
| | | Calcium (mg) | **$17.0\ X_1 + 400\ X_2 + 0\ X_3 \geq 140$** |
| | | **Ingredient (serving size)** | **$1\ X_1 + 1\ X_2 + X_3 = 1$** |
| | | Limitation | **$1\ X_1 + 0\ X_2 + 0\ X_3 = 0.36$** |
| | | | **$0\ X_1 + 1\ X_2 + 0\ X_3 \leq 0.36$** |
| **2** | **$4X_1 + 5X_2 + 3.6X_3$** | Energy( kcal) | $341\ X_1 + 662\ X_2 + 400\ X_3 \geq 430$ |
| | | Protein (%) | $7.7\ X_1 + 6.8\ X_2 + 0\ X_3 \leq 10$ |
| | | Iron( mg) | $9.3\ X_1 + 7.8\ X_2 + 0\ X_3 \geq 3$ |
| | | Calcium (mg) | **$17\ X_1 + 400\ X_2 + 0\ X_3 \geq 140$** |
| | | **Ingredient (serving size)** | **$1\ X_1 + 1\ X_2 + 1\ X_3 = 1$** |
| | | **Limitation** | $1\ X_1 + 0X_2 + 0\ X_3 = 0.41$ |
| | | | $0\ X_1 + 1\ X_2 + 0\ X_3 \leq 0.36$ |
| **3** | **$4X_1 + 5X_2 + 3.6X_3$** | Energy( kcal) | **$341\ X_1 + 662\ X_2 + 400\ X_3 \geq 430$** |
| | | Protein (%) | **$7.7\ X_1 + 6.8\ X_2 + 0\ X_3 \leq 10$** |

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| | | | |
|---|---|---|---|
| | | Iron( mg) | $9.3\ X_1 + 7.8\ X_2 + 0\ X_3 \geq 3$ |
| | | Calcium (mg) | $\mathbf{17\ X_1 + 400\ X_2 + 0\ X_3 \geq 140}$ |
| | | **Ingredient (serving size)** | $\mathbf{1\ X_1 + 1\ X_2 + 1\ X_3 = 1}$ |
| | | **Limitation** | $1\ X_1 + 0\ X_2 + 0\ X = 0.46$ |
| | | | $0\ X_1 + 1X_2 + 0\ X_3 \leq 0.36$ |
| **4** | $\mathbf{4X_1 + 5X_2 + 3.6X_3}$ | Energy( kcal) | $341\ X_1 + 662\ X_2 + 400\ X_3 \geq 430$ |
| | | Protein (%) | $\mathbf{7.7\ X_1 + 6.8\ X_2 + 0\ X_3 \leq 10}$ |
| | | Iron( mg) | $\mathbf{9.3\ X_1 + 7.8\ X_2 + 0\ X_3 \geq 5}$ |
| | | Calcium (mg) | $\mathbf{17\ X_1 + 400\ X_2 + 0\ X_3 \geq 140}$ |
| | | **Ingredient (serving size)** | $\mathbf{1.0\ X_1 + 1.0\ X_2 + 1\ X_3 = 1}$ |
| | | **Limitation** | $\mathbf{1.0\ X_1 + 0\ X_2 + 0\ X_3 = 0.51}$ |
| | | | $\mathbf{0\ X_1 + 1\ X_2 + 0\ X_3 \leq 0.36}$ |
| **5** | $\mathbf{4X_1 + 5X_2 + 3.6X_3}$ | **Energy** | $\mathbf{341\ X_1 + 662\ X_2 + 400\ X_3 \geq 430}$ |
| | | **Protein** | $7.7X_1 + 6.8\ X_2 + 0X_3 \leq 10$ |
| | | **Iron** | $9.3X_1 + 7.8\ X_2 + 0X_3 \geq 3$ |
| | | **Calcium** | $\mathbf{17\ X_1 + 400\ X_2 + 0X_3 \geq 140}$ |
| | | **Ingredient (serving size)** | $1\ X_1 + 1\ X_2 + 1X_3 = 1$ |
| | | **Limitation** | $\mathbf{1\ X_1 + 0\ X_2 + 0X_3 = 0.56}$ |
| | | | $0\ X_1 + 1\ X_2 + 0X_3 \leq 0.36$ |

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TABLE 3. COST, NUTRITIVE VALUE AND INGREDIENTS OF DIFFERENT MIX FORMULATIONS

| Formulation | Cost (Rs/100g) | Nutritive value | | Ingredients (per 100g) |
|---|---|---|---|---|
| A. $4X_1 + 5X_2 + 3.6X_3$ | 4.213 | Energy(kcal) | 466.451 | $X_1$ = 0.360 |
| | | Protein (%) | 5.048 | $X_2$ = 0.334 |
| | | Iron(mg) | 5.959 | $X_3$ = 0.305 |
| | | Calcium (mg) | 140 | |
| B. $4X_1 + 5X_2 + 3.6X_3$ | 4.230 | Energy(kcal) | 462.945 | $X_1$ = 0.410 |
| | | Protein (%) | 5.418 | $X_2$ = 0.333 |
| | | Iron(mg) | 6.407 | $X_3$ = 0.257 |
| | | Calcium (mg) | 140 | |
| C. $4X_1 + 5X_2 + 3.6X_3$ | 4.247 | Energy(kcal) | 459.438 | $X_1$ = 0.460 |
| | | Protein (%) | 5.789 | $X_2$ = 0.330 |
| | | Iron(mg) | 6.855 | $X_3$ = 0.201 |
| | | Calcium (mg) | 140 | |
| D. $4X_1 + 5X_2 + 3.6X_3$ | 4.281 | Energy(kcal) | 452.420 | $X_1$ = 0.560 |
| | | Protein (%) | 6.530 | $X_2$ = 0.326 |

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| | | | | |
|---|---|---|---|---|
| | | Iron( mg) | 7.752 | $X_3$ = 0.113 |
| | | Calcium (mg) | 140 | |
| E. $4X_1 + 5X_2 + 3.6X_3$ | 4.298 | Energy( kcal) | 448.918 | $X_1$ = 0.610 |
| | | Protein % | 6.901 | $X_2$ = 0.324 |
| | | Iron( mg) | 8.201 | $X_3$ = 0.066 |
| | | Calcium ( mg) | 140 | |

TABLE 4 SENSORY SCORES FOR THE PRODUCTS

| **Sensory Attributes** | | **Samples** | | | |
|---|---|---|---|---|---|
| | **A** | **B** | **C** | **D** | **E** |
| Appearance | 3.75 | 3.75 | 3.92 | 3.25 | 3.50 |
| Colour | 4.00 | 3.92 | 3.92 | 3.75 | 3.75 |
| Texture/Consistency | 4.00 | 3.75 | 3.83 | 3.25 | 3.50 |
| Flavour/Aroma | 3.92 | 3.67 | 3.58 | 3.75 | 3.08 |
| Taste | 4.17 | 3.83 | 3.92 | 3.58 | 3.17 |
| Overall Acceptability | 4.17 | 3.40 | 3.92 | 3.42 | 3.25 |

**Score**: 5: Excellent, 4: very good, 3: good, 2: fair, 1: poor

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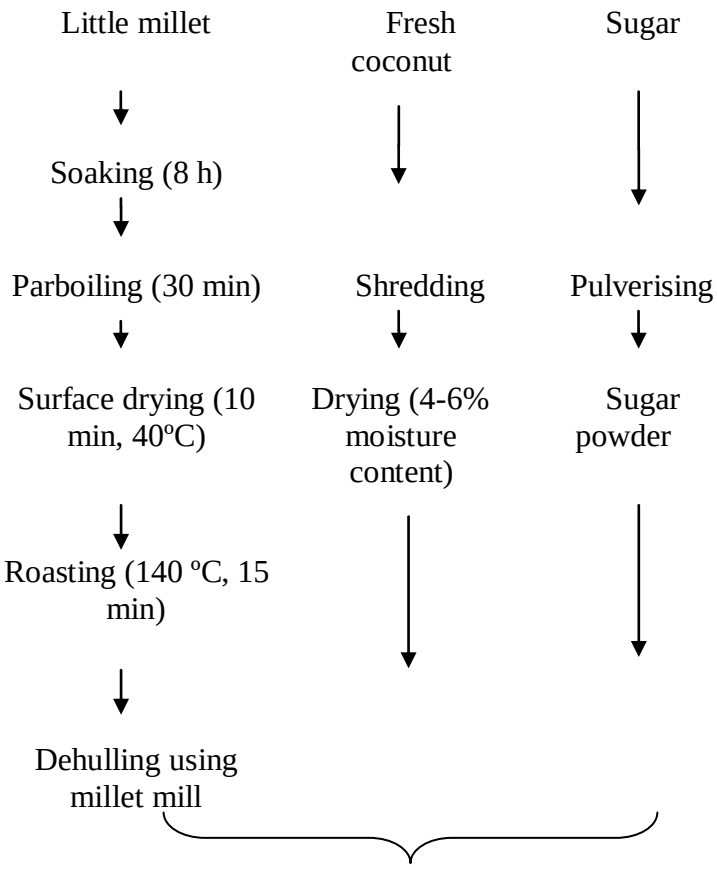
Fig. 1. PREPARATION OF MIXES

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