ORIGINAL ARTICLE

Development of Weaning Food Premixes for Infants Based on Ragi, Green Gram and Rice

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ABSTRACT Weaning food is an instant product with high biological value. In the present investigation Weaning food is made from soaked rice and germinated & roasted green gram and Finger millet flours in the ratio of 25:37.5:37.5 and jaggery added as per sweetness. Product assessed for their nutritional quality and storage stability. The analysis undertaken in this study was infant food proximate composition protein, fat, fiber, carbohydrate and energy value is 16.05, 1.42, 3.0, 65.20 and 337.78 respectively, mineral concentration Ca, Fe, K, Mg, P, Na, is 207, 9.36, 990, 126.28, 293 and 38.5 is mg/100 g. The various sensory attributes of the product were evaluated on the 9-point hedonic scale. Sensory Evaluation is done by the hedonic scale under the fifteen expert panel judges. Which is color, flavor, taste, aroma, texture (mouth feel), sweetness, overall acceptability is 9, 8, 9, 8, 7, 8, and 9 respectively. Weaning food is a consumable product due to that microbial analysis also done and calculates standard plate count which is in negligible. The shelf-life of weaning food premix is up-to 6 months at normal room temperature. Hence, weaning food made from Ragi flour, green gram flour and rice flour can be considered as a good and cheap source of protein, fat, fiber, calcium and iron for young children, pregnant women and lactating mothers.

Keywords: Finger millet, Rice, Green gram, Germination, Weaning food

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INTRODUCTION

Functional foods are becoming more and more popular worldwide in view of their inherent health benefits. Today's consumers are more health-conscious and very picky their eating habits. Consumers are looking for food that can not only supplement nutrition balanced nutrition can also increase their health and well-being. Weaning is the most important and critical stage of children's growth and development. Therefore, it is necessary to attach great importance to developing weaning food. The commercial weaning food manufacturers have focused much on supplementing the balanced nutrition to various age groups of children but less emphasis has been given on health and well-being of children. In this direction, it is necessary to develop functional weaning foods to meet the needs of weaned children. Weaning is the stage in which a baby changes from a diet composed entirely of breast milk to a diet similar to that of a community adult. It is a process of introducing semi-solid food into the infant diet. The American Academy of Pediatrics and the World Health Organization recommended waiting until 6 months to introduce baby food[1]. Breast milk is the best food for newborns and the most suitable food. Although most Indian babies are breastfed during the first 6 to 8 months of life, not everyone has a healthy mother who can provide adequate nutrition, which in turn increases the demand for weaning food[2].

Weaning food is specially formulated for the transition from breastfeeding or bottle feeding to normal intake of solid foods for infants between 3 and 9 months of age[3]. The semi-solid food given to the child at this stage is usually defined as weaning food it is prepared by processing ingredients to improve digestibility and nutritional quality. It is classified as a ready-to-eat food. Weaning food supplements with high protein content, high digestibility

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and high energy density must be prepared from readily available low-cost raw materials. This weaning food can be used to meet the needs of growing children, thereby reducing malnutrition in developing countries[4]. Roasting, soaking, fermentation and sprouting these techniques enhance the bioavailability of micronutrients by decreasing the antinutritional factors and improving overall digestibility and absorption of nutrients also reduce the high bulk of complementary food with reducing the viscosity[5].

Rice provides 60% of food intake in Southeast Asia and approximately 35% of food intake in East and South Asia. India has the largest area of rice (45 million hectares), accounting for nearly a quarter of Asia's production, second only to China in world rice is the central part of people's life and culture[6]. In India, Rice production and productivity showed a steady increase. Rice is a excellent source of carbohydrates, low in sodium and fat, does not contain cholesterol, and allergens. It is now widely used in baby food. Rice flour is almost pure starch and the main ingredient of infant formula powder[7]. India is the leading producer of small millets; Annual planting area under them is around 14 million hectares and the annual output remains at around 17.22 million tons. (ICAR, 2020) Finger millet (ragi) is rich in protein, minerals and vitamins. Finger millet (ragi) provides the highest levels of calcium, and antioxidants[8]. Green gram has been cultivated in India since prehistoric times and native crops of India[9]. India is the world's highest producer and consumer of pulses. Green gram is the third most important legume crop in India, nearly 8% of the country's total legume area. In India, mung bean covers an area of 43.26 million hectares and produces 21.65 million tons. Beans are the main source of dietary protein in our vegetarian diet Because of its cheap source of protein; it is called "the poor man's meat"[10]. Mung bean is more common in warmer regions of Southeast Asia, Central Africa, China and the United States Green gram seeds are preferred for feeding babies as it is known for its easy digestibility, low flatulence potential[11].

MATERIALS AND METHODS

Raw Materials Procurement

Finger Millet (*Eleusine coracana)*, Green Gram (Vigna radiata) variety Phule M-2 collected from Reginol research station VNMKV center Parbhani, Maharashtra. Ragi kernels have a fragile endosperm and a complete seed coat. Due to these characteristics, grains cannot be polished like rice or other grains. Grains need to be crushed all the time to make flour directly from the flour mill[12]. Ragi ML-365 variety were used, to make flour at Food Engineering Laboratory, Maharashtra Institute of Technology Aurangabad. Rice (Oryza sativa) variety Kali mooch purchased from D mart Aurangabad. Collected raw material where sorted and graded for remove foreign impurities after washing further processing to prepare their flours where done as per Flow Diagram 1.

Production of Composite Malted Flour

The cleaned Rice, Green gram and Finger millet were malted separately following the method described by with slight modification[13,14]. The Rice, Green gram and Finger millet were soaked in potable water at ambient temperature for 2 hr, 12 hr, and 12 hr at the end of the soaking period, the moisture content of the grains had increased to 40- 45%. The hydrated grains were placed in bags prepared from muslin cloth. The bags containing kernels were immersed in tap water contained in plastic buckets and then placed for germination at 30ÚC and 98% relative humidity to begin the steeping phase. The Green gram grains and Ragi were allowed to germinate for 24 hr. and 48 hr. respectively depending on the nature of the grains. During the germination process, the surface of the kernels was sprayed with tap water. Following germination, the tray with the kernels were then transferred to Sun drying The sprouted grains were dried until a moisture content of 12-15% was reached. Then the sprouted grains were roasted in separately on roasting pan at 70 to 80 ^{0}C and the malted grain flours were blended to formulate complementary energy rich foods Sieving is carried out in 70 mesh number. (Table.1). Then the blend was milled in hammer mill (SVS, Portable Multipurpose flour mill) and were mixed thoroughly in ribbon blender into smooth homogenous powder and then stored in airtight containers at room temperature (25 - 30°C) until used. Ready-to-eat weaning mix of each formulated complementary foods was made by mixing flour in cold water 10g of blend flour dissolved in 220 ml distilled water and 30 gm of jaggery added for sweetness cooked at 95 ^{0}C for 15 min. to form thick porridge, after which samples were taken for analyses.

Functional Properties of Weaning Food

Bulk density, Water Absorption Capacity (WAC) of the sample and Water Solubility Index were determined by previously described methods with slight modifications in sample preparation method[15-17].

Nutritional Composition

Samples obtained from different blends of supplemented malt weaning blends were analyzed for moisture, ash, carbohydrate, protein, crude fat and crude fiber, minerals[18]. The inductively coupled plasma mass spectrometer (ICP-MS) method was used to determine the selected mineral content of the malt weaning mix[19]. Energy value (calorific value) is quantified using an indirect calculation method[4].

Figure 1: Flow Diagram

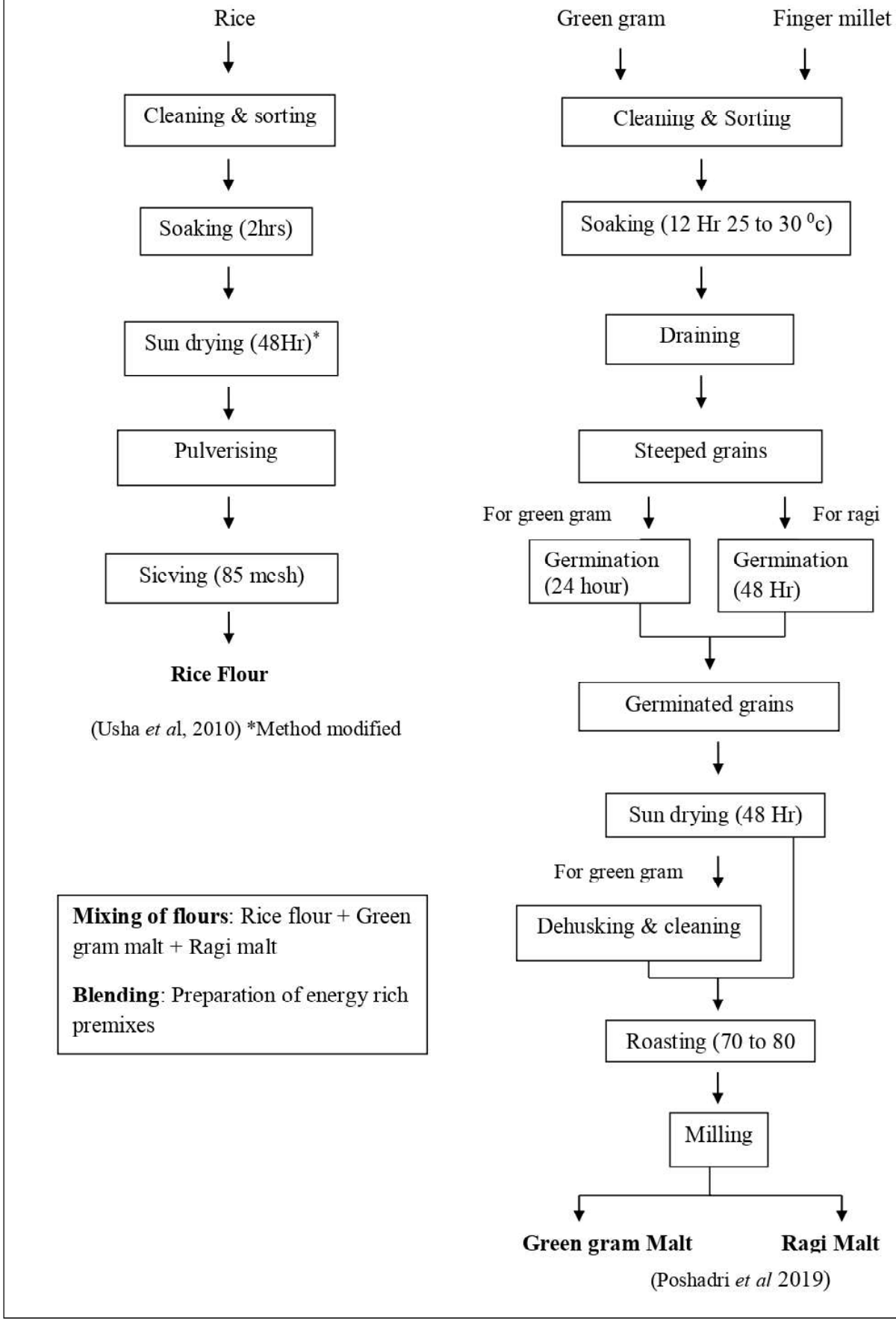


Table 1: Formulations Trials Developed for Preparation of Weaning Food Premixes

S. No.	Raw Material ↓ Formula →	I	II	III	IV	V	VI	VII	VIII
1	Rice	70	30	30	50	25	33.33	25	25
2	Green gram	15	35	30	25	30	33.33	40	37.5
3	Finger millet	15	35	40	25	45	33.33	35	37.5
Total (%)		100	100	100	100	100	100	100	100

Microbial Quality Analysis

Standard Plate Count

Microbial analysis was done to determine total plate count (TPC) of the samples on the nutrient agar media for bacterial count by the previously recommended method[20]. The total plate count of sample was determined by use of nutrient agar medium. Suspended 5.88 g in 250 ml distilled water and heated until to dissolve the medium completely sterilized by autoclaving at 15 psi pressure (121 °C) for 15 minutes. The three serial dilutions, i.e., 10^1, 10^2 and 10^3, were poured in Petri plate

Yeast and Mold Count

Microbial analysis was done to determine total yeast and mold count of the samples on the potato dextrose agar media for yeast and mold count by the previously recommended method[20]. The Yeast and mold count of products were determined by using potato dextrose agar (PDA) and the pour plate technique was used for the isolation. The media was sterilized and poured into plates. The dilutions of sample were made up to 10-5 and then the 0.1 ml of aliquot was used for streaking. Plates were incubated at 30 °C for 48-72 hrs, and results noted in cfu/ml. The yeast and mold count of product was examined on production day.

Total yeast and mold Count (cfu/g) = No. of colonies × Dilution factor

Coli Form

The coliform and basically *E. coli* are the indicator microbes of water contamination by faces and therefore it was mandatory to examine the contamination. The Coliform gives red pink colonies on MacConkeys agar so it was used for examination. Using the pour plate technique, appropriately 0.1 ml aliquots was taken in duplicate plates and tempered MacConkeys agar was added. The agar was allowed to solidify and then overlay of about 5 ml of MacConkeys agar was added. Allow agar to solidify. Plates were inverted and incubated at 35 °C for 24 hours. Red colonies surrounded by a zone of precipitate and report as "presumptive coli forms cfu/g".

Total coliform count (cfu/g) = No. of colonies × Dilution factor

Sensory Evaluation

Sensory evaluation of the ready-to-eat weaning mix for each supplementary formula was carried out on sensory attributes like color, flavor, taste, aroma, texture/mouth feel, sweetness and overall acceptability By 15 judges (including 5 nursing mothers and other PhD in Food Science and Master in Food Processing Technology[21]. with some modifications. The acceptability of the sensory assessment was carried out at Aurangabad. Cerelac (wearing on foods sold in the market to provide better nutrition for children between 12 to 14 months), samples of energy-rich complementary weaning foods (A, B, and C) were used for evaluation. The samples are coded using T1, T2, and T3 and are provided in a balanced presentation order. Provide team members with a glass of water and spicy wafers, and instruct them to rinse and swallow water between samples. They were given written instructions and asked them to use a nine-point hedonic scale based on color, flavor, taste, aroma, texture/mouth feel, sweetness, and overall acceptability (1 = very dislike to 9 = very much[21]. Apply the range method of statistical analysis to test the significance of preference.

Statistical Analysis

Statistical analysis of all the reported values were done in terms means ± standard deviation (SD). Microsoft Excel tool was used to perform the statistical analysis.

RESULTS AND DISCUSSION

Functional Properties of Weaning Food

Table 2 shows the results of the functional properties of the weaning food. The results clearly indicated that there were significant differences between weaning foods in terms of functional properties.

Nutritional Composition of Weaning Food

Table 3 shows the results of the Nutritional composition of

Table 2: Functional Properties of Weaning Food

S. No.	Water Solubility Index (%)	Water Absorption Capacity (ml H_2O/g)	Bulk Density (g/ml)
I	0.901±0.01	5±0.05	2.8±0.05
II	0.862±0.01	6±0.1	6.6±0.1
III	0.833±0.01	6±0.1	4.9±0.05
IV	0.908±0.01	5.2±0.1	3.7±0.05
V	0.885±0.01	5±0.05	4.5±0.05
VI	0.886±0.01	5±0.05	5.1±0.05
VII	0.877±0.01	4±0.05	5.8±0.1
VIII	0.886±0.01	6±0.1	5.6±0.1

Note: All data are the Mean ± S.D of Three replicates.

Table 3: Nutrient Composition of Energy Rich Supplementary Weaning Foods for 100 g*

	Cerelac	I	II	III	IV	V	VI	VII	VIII
Protein (g)	15	11.63	15.55	14.47	13.62	13.72	15.22	16.59	16.05
Fat (g)	9	1.91	1.47	1.47	1.69	1.42	1.51	1.42	1.42
Fiber (g)	2	1.84	2.92	3.08	2.36	2.92	2.78	3.02	3
Carbohydrate (g)	68.5	70.11	65.74	65.74	67.93	66.69	66.09	64.69	65.2
Energy Value (Kcal/100 gm)	415	345	338	335	342	334.42	339	338	338.5
Calcium (mg)	400	90.36	193	209	142	230	184	199	207
Iron (mg)	7.5	7.98	9.2	8.77	6.81	9.94	9.32	9.15	9.36
Potassium (mg)	440	297	546	513	394	529	538	594	990
Magnesium (mg)	45	100	120	118	96.8	122	116.3	127.75	126.28
Phosphorus (mg)	300	204	282	278	244	287	279	295	293
Sodium (mg)	120	24.2	25.8	24.9	25.1	25.8	22	26	38.5

Note: Values presented as the average of three repeated determinations and expressed on a dry weight basis. "Cerelac" is the wearing on foods sold in the market to provide better nutrition for children between 12 to 14 months. *All the values are average of Three determinations.

the weaning food. The results clearly indicated that there were significant differences between weaning foods in terms of nutrition and minerals.

The nutrient composition of formulated weaning food has been presented in Table 3. I, II, III, IV, V formula does not provide required amount of protein as per recommended dietary allowances for weaning food so this formulas are rejected. Cerelac flour contains 15.0% protein, 9.0% Fat, fiber 2.0, and carbohydrate 68.5%, and the total calorific value of the product was 415Kcal/100g product. The value of various minerals, *viz*. Calcium, iron, potassium, magnesium, phosphorus, and sodium are 400, 7.50, 440, 45, 300, and 120 mg/100 g product, respectively. However, weaning food made from Rice, Green gram and Finger millet varieties in formulation contain 15.22%, 16.59% and 16.05% protein, 1.51%, 1.42%, and 1.42% fat, 2.78%, 3.02% and 3.0% crude fiber, 66.09%, 64.69% and 65.20% carbohydrates, respectively. The total calorific values of formulated weaning food were found 339, 338 and 338.5 Kcal/100 g of premix respectively. finger millet not only improves the taste, but also enriches protein, calcium and fiber, B vitamins, *in vitro* protein digestibility and reduces the level of anti-nutrients in the grain[22]. The minerals values of formulated weaning food were calcium 184 mg, 199 mg and 207 mg, Iron 9.32 mg, 9.15 mg and 9.36 mg, potassium 538 mg, 594 mg and 990 mg, magnesium 116.3 mg, 127.75 mg and 126.28 mg, phosphorus

279.12 mg, 295 mg and 293 mg, sodium 22 mg, 26 mg and 38.5 mg/100 g, respectively. Therefore, it was found that formulated weaning food is rich in minerals and is significantly superior to Cerelac. Feeding infants with modified malt foods made from locally available food crops formulated for children in the state in this study may promote their growth and development[23].

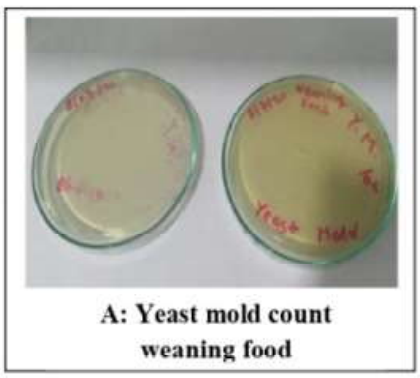
Microbial Quality Analysis

Microbial contents of the formulated raw flour and Weaning food products were analyzed. In order to check the safety of the products as can be contaminated with yeast, mold & total coli form. Result showed that microbial count of raw material and product however very less microbial colonies were observed on nutrient agar. The standard plate count of weaning food premix was carried out at the stage of storage. The premix stored in LDPE bag showed the count of 8 × 102, 10 × 102 and 12 × 102 for 1, 60 and 120 days respectively. While product showed 4 × 102. Microbial count of weaning food products lower than formulated raw flour. This low count was might be due to temperature used for roasting, low water activity and hygienic practices followed during processing. According to data from the Food Safety Center of the Ministry of Food and 45 Environmental Hygiene, prevention of food adulteration act (India) Weaning Food Standards, bacterial count (not exceeding) 40,000 cfu/g

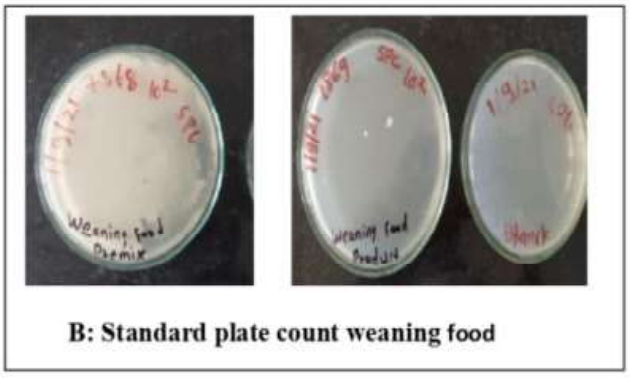
Table 4: Total Yeast, Mold and Total *Coli* Form Content of Formulated Weaning Food Premix and Product

S. No.	Sample		Total Plate Count (cfu/g)	Yeast and Mold (cfu/g)	Coli Form (cfu/g)
1	Weaning food premix	Fresh sample	10×10^2	Absent	1×10^2
		After 60 days	10×10^2	Absent	1×10^2
		After 120 days	10×10^2	Absent	1×10^2
2	Weaning food product		4×10^2	Absent	Absent

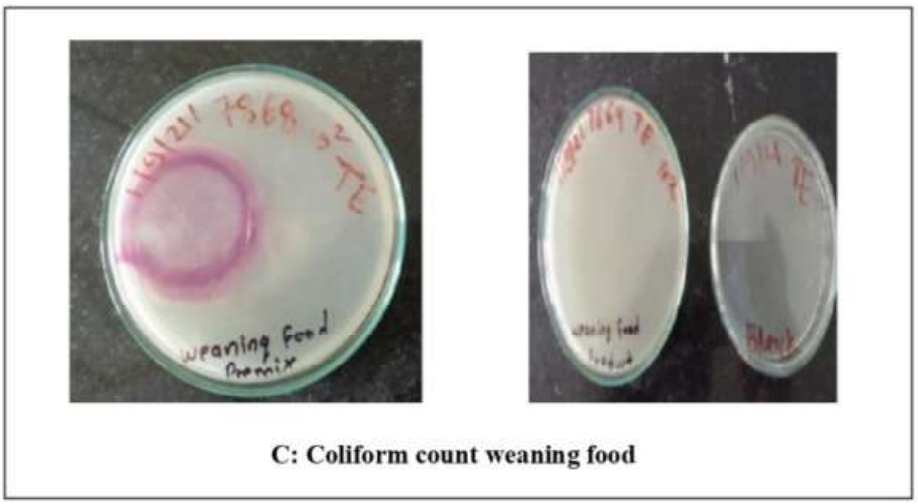
Figure 2: Microbial Analysis of Weaning Food Premix and Product



A: Yeast mold count weaning food



B: Standard plate count weaning food



C: Coliform count weaning food

Figure 3: Final Product

Table 5: Sensory Evaluation of Energy Rich Complementary Weaning Foods**

Samples	Control	VI	VII	VIII
Color	6	7	8	9
Flavor	6	7	7	8
Taste	5	7	7	9
Aroma	6	6	7	8
Texture/mouth feel	5	7	6	7
Sweetness	6	6	6	8
Overall acceptability	6	7	7	9

Note: ** All values in triplicate analysis and expressed as mean

Sensory Evaluation

Compared with the supplementary food Cerelac, the sensory quality of the energy-rich supplemental weaning food sample C was liked very much on the hedonic scale[21] (Table 3). The results showed that compared with the Cerelac as a control the average value of various sensory attributes (i.e., color, flavor and taste) varied in the range of 6 to 9. Formulated weaning food tastes good and the flavor is different to Cerelac. The average score of sensory evaluation showed that all energy-rich weaning supplementary food samples prepared from locally grown foods were within the acceptable range, while the energy-rich weaning supplementary food samples prepared from Rice: Green Gram: Finger millet 25: 37.5: 37.5 has a significantly better color (9), flavor (8), taste (9), aroma (8), texture/mouth feel (7), sweetness (8), and overall acceptability (9).

Cost Economics

Total cost of production for 1 kg of weaning food premix made from rice, green gram and finger millet was calculated in table.6 found to be with an average of Rs. 426 /-. Which was comparatively less than other available weaning food in market so; it showed the techno-economical feasibility of prepared weaning food. Therefore the product can be recommended for commercial exploration. These costs are for laboratory (small) scale preparation of weaning food. These may still be reduced during mechanization of process of mass production.

Table 6: Cost Economics for the Selected Infant Food Premix

S. No.	Raw Material	Rate (Rs.)	Quantity Require (g)	Cost (Rs.)
1	Rice	76/kg	250	19
2	Green gram	120/kg	375	45
3	Finger millet	70/kg	375	26.25
4	Jaggery	85/kg	3000	255
	Total cost of raw material			345.5
A	Processing cost (@ of 20 percent of raw material cost)			69
B	Packaging cost			1.5
C	Miscellaneous charges			10
	Total cost 345.5 + 69 + 1.5 + 10			426

CONCLUSION

This study shows that the energy-rich complementary weaning food sample-VIII (Rice: Green Gram: Finger millet the ratio is 25: 37.5: 37.5) can be used to produce nutritious and high-quality malt weaning food with good Sensory properties. Further research has also shown that families from rural areas can prepare energy-rich weaning mixtures from their produce through a simple malting and milling process. Rice protein complements legume protein, and finger millet supplementary foods may be suitable for nutritional intervention programs. Therefore, based on the above observations, supplementary foods can be easily produced at the household or/and commercial level, and need to be promoted in rural areas through various promotion activities. The cost of formulated energy rich complimentary weaning food was found to be 426 kg.

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