



Utilization of Indigenous Food Processing Methods for the Development of Cereal and Legume Based Complementary Food

Pallavi Singh¹ , Ahmed Hamad² , Aditya Kumar Singh Pundir³ , Sangita Gupta⁴

¹Associate Professor, Faculty of Public Health, Poornima University, Jaipur, Rajasthan, India

²Assistant Professor, Department of Food Hygiene and Control, Faculty of Veterinary Medicine, Benha University, Al-Qalyubia Governorate, Egypt

³Professor, Department of Artificial Intelligence and Data Science, Poornima Institute of Engineering and Technology, Jaipur, Rajasthan

⁴Professor, Faculty of Science and Humanities, Poornima University, Jaipur, Rajasthan, India

Email- pallavi.singh@poornima.edu.in

Abstract. For promoting healthy developments and establishment of child's eating habits, timely introduction of complementary food, which include any liquid or solid preparation of food, not similar with breast milk or any formula feeds, is very crucial. There are different types of cereals and legumes, which are locally available and their nutritional profile is best suited for the preparation of affordable and nutritious complementary food when properly combined and processed. Keeping above point into consideration, wheat flour, carrot flour, potato flour, sesame seeds flour and soya bean flour were combined into four different combinations for the development of 4 treatment of complementary food. Organoleptic evaluation and nutritional analysis were done for the four different treatments of the complementary food and the total cost of formulated complementary products were calculated on the basis of current prevailing market price of utilized raw materials. The organoleptic scores of the developed products described that treatment **CF₃ scored highest** followed by **CF₄ CF₂** and **CF₁**. The total cost of the developed complementary food was around Rs 8.2 – 10. The results show that the developed weaning foods contained, per 100 g of product, **energy** (436-495 kcal), **fat** (4.84-5.22 g), **protein** (23.77-25.58 g), **carbohydrates** (115.71-152.24 g), **dietary fibre** (4.63-4.53 g), **calcium** (146.74-153.42 mg), and **iron** (9.63-11.67 mg). This product was formulated to help meet the nutritional requirements of children in rural areas, offering a more nutritious and affordable supplementary food option for low-income families.

Keywords: Complementary Food, Indigenous Food Processing Methods, Malting, Weaning food

1 Introduction-

For the first six months of life, exclusive breastfeeding is very crucial, but as the infant grows, only mother milk cannot meet their rising nutritional demands. At this stage, introducing appropriate complementary foods alongside continued breastfeeding becomes essential to support healthy growth and development [1]. For promoting healthy developments and establishment of child's eating habits, timely introduction of complementary food, any liquid or solid food preparation not similar with breast milk or any formula feeds, is very crucial. This inclusion is very important to meet daily nutritional need of the infant as well as to mark a significant impact on the future eating pattern and behavioral growth of the infant [2] [3].

The major nutritional requirement of the complementary food for the infant is energy density, quality of available protein and digestibility. In India, different types of traditional complementary foods are prepared with cereals but they are often heavy on stomach and lacks essential nutrients. Addition of legumes in these cereal preparation can enhance the overall energy content as well as improves the availability of high quality protein. Legumes are high in lysine naturally but deficient in sulfur-containing amino acids, while cereals have the opposite profile. When combined in the right proportions, they provide complementary amino acids, greatly enhancing the overall protein quality of the diet [4]. But with the fact that legumes are associated with poor digestibility, less mineral bioavailability high anti-nutritional factors, the utilization in the complementary food is restricted. For enhancing the nutritional quality of complementary food prepared with cereals and legumes, indigenous food processing methods like soaking, dehydration, germination and malting have been found to improve overall protein and starch digestibility and at the same time it reduced antinutritional factors like phytates and tannins [5] [6].

There are different types of cereals and legumes, which are locally available and their nutritional profile is best suited for the preparation of affordable and nutritious complementary food when properly combined and processed. For households with limited resources in rural and peri-urban areas, where nutritional deficiencies during weaning phase is very common, these low cost preparation of complementary food is essential. This increases the importance of scientifically evaluated compositions for the development of complementary food which is nutritionally sufficient for the infant as well as acceptable in terms of their sensory attributes like color, texture, Flavour and cost. Under the influence of above stated point, this research was planned to formulate a cost-effective and nutritious complementary food by utilizing malted cereals and legumes in a scientifically designed combination. Different treatments of formulated complementary food were evaluated in the study in terms of their sensory acceptability, nutritional composition and cost.

2 Materials and Methods-

The ingredients required for the development of the complementary food like Wheat, soya beans, sesame seeds and Jaggery were procured from the local grocery shops of the Jaipur while potato and carrot were sourced from the vegetable market of Jaipur. The experiments were conducted in the Public health Nutrition Lab, Poornima University, Jaipur in the year 2024.

Preparation Of Potato and Carrot Flour-

First, the fresh potato and carrot were washed, peeled cleaned and cut into the fine slices. Blanching was done for 5 minutes (at boiling temperature with 2% salt solution). A tray dryer (Biogen Scientific C.A.T. No. BGS-123) was used to dry the slices of potato and carrot for 7 hours at 60 ± 2 °C. then the dried slices of potato and carrots were ground into powder using an automatic blender (Tandem Brand, India) and then sieved through a sieve (SETHI Firm, India, Mesh Size of $180 \mu\text{m}$). The fine potato and carrot flour were then secured for the late use via placed it into the Low Density polyethylene (LDPE) bags and sealed with a heat sealer (Golden Engle, India) (Fig.-1)

PREPARATION OF POTATO AND CARROT FLOUR



Fig. 1. - Formulation of Potato and Carrot Flour

Formulation of Malted Wheat and Soyabean Flour

Preparation of Malted Wheat and Soyabean flour was started with selection of unbroken clean grains and then preliminary washing is done with 0.05% aqueous lime solution to prevent fungus. The grains were soaked in double volume of water for 12-48 hrs. at 20 °C, till the moisture content reaches 40%. After that germination process was done in which grains were kept in muslin cloth for germination for 3-5 days and in this duration, water was sprinkled after every 12 hours. After the germination process, preliminary drying was done in Air for 1-2 hrs. and final drying was done under sun to about 10% of Moisture. After that dry roasting was done at 60–85 °C then grains were cooled and grounded into fine flour with the help of automatic blender. The flours were sieved through a sieve (Mesh Size of 180 μ m). The fine potato and carrot flour were then placed into the Low Density polyethylene (LDPE) bags and sealed with a heat sealer and kept for later use. (Fig.-2)



Fig. 2. -Formulation of Malted Wheat and Soyabean Flour

Formulation of Sesame Seed Powder-

The sesame seeds were not subjected to any type of food processing and the sesame seed powder was simply prepared by grinding the clean and good quality sesame seed with the help of automatic grinder and store the powder into the Low Density polyethylene (LDPE) bags and sealed with a heat sealer and kept for later use. (Fig-3).

PREPARATION OF SESAME SEED FLOUR

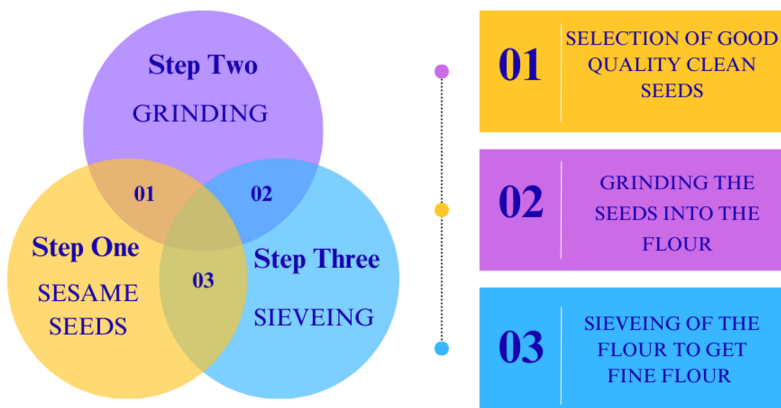


Fig. 3. - Formulation of Sesame Seed Flour

Development of Complementary Food-

The complementary food was developed by preparing four basic variation by combining all the prepared flour and powder in different proportions namely CF1, CF2, CF3, and CF4. The reconstitution of formulated complementary food was done in two forms-one with water and another one with milk and for the sensory acceptability of the developed complementary food, some jaggary as a sweetener was added separately. For increased acceptability during sensory evaluation, one hundred grams of complementary powder was mixed with 45 ml of lukewarm water or milk and 50 grams of jaggary.

Product Composition-

The details of treatments and replications are as follows-

Table 1. Different Treatments of Complementary Food

Formulation Code	PF (%)	SBF (%)	WWF (%)	CF (%)	SSF (%)
CF1	20	25	35	10	10
CF2	20	20	40	10	10
CF3	15	20	45	10	10
CF4	15	15	50	10	10

* PF=Potato Flour, SBF= Soya Bean Flour, WWF= Whole Wheat Flour, CF= Carrot Flour, SSF=Sesame Seed Flour

Nutritional Analysis-

Proximate composition of the samples was assessed following the procedures recommended by the Association of Official Analytical Chemists [7]. Moisture, crude fiber, crude protein was analyzed using standard AOAC protocols. Energy values were calculated using established energy conversion factors, while carbohydrate levels were determined by difference. The fat content was assessed through Soxhlet extraction with the LTSW-4 system. Iron levels were measured using an atomic absorption spectrophotometer (HV-AAS02-2100), and calcium was quantified through titrimetric analysis.

Sensory Analysis-

The sensory evaluation of the complementary food was performed using the Nine-Point Hedonic Scale as outlined by Srilakshmi (2011)[8]. The attributes evaluated included color, appearance, body and texture, taste, flavor, and overall acceptability. A panel of fifteen trained judges assessed the products, with each sensory test conducted three times. Prior to evaluation, the panelists received brief semi-training sessions to familiarize them with the product characteristics and the scoring ranges associated with the nine-point scale as outlined in earlier literature [9] [10].

Statistical Analysis-

Sensory attribute values were reported as mean \pm standard deviation, derived from three replicates. To assess statistical significance, Analysis of Variance (ANOVA) was employed to compare the sensory characteristics across different treatments of complementary food.

Result and Discussion-

Table 2 presents the sensory evaluation outcomes for the formulated weaning foods. The mean scores revealed that the panel generally accepted all formulations. Nonetheless, there were significant differences ($P < 0.05$) in overall acceptability, among the various treatments.

Table 2. The Mean Sensory Scores of Complementary Food prepared with Milk.

Formulations	Taste & Flavour	After Taste	Color	Consistency	Overall Acceptability
CF1	6.3 \pm 0.19	6.6 \pm 0.39	7.1 \pm 0.33	6.6 \pm 0.24	6.9 \pm 0.24
CF2	6.6 \pm 0.39	7.2 \pm 0.12	7.1 \pm 0.33	7.1 \pm 0.24	7.1 \pm 0.24
CF3	7.7 \pm 0.29	7.7 \pm 0.29	7.8 \pm 0.19	7.5 \pm 0.22	7.8 \pm 0.25
CF4	7.1 \pm 0.33	7.5 \pm 0.22	7.4 \pm 0.24	6.4 \pm 0.24	7.4 \pm 0.18
FCAL	5.45	15.13	10.59	4.22	6.06
FTAB	3.83	3.83	3.83	3.83	3.83

Table 2 presents the mean sensory scores of the formulated complementary foods. In terms of taste and flavor, CF3 obtained the top scorer (7.7), followed by CF4 (7.1), CF2 (6.6), and CF1 (6.3). The after-taste scores also showed CF3 as the most preferred (7.7), with CF4 (7.5), CF2 (7.2), and CF1 (6.6) following. For color, treatment CF3 shows the highest sensory score (7.8), followed by CF4 (7.4), CF2 (7.4), and CF1 (7.1). A similar sensory scores were obtained for consistency, where treatment CF3 again shows the highest scores (7.5), with subsequent scores for CF2 (7.1), CF1 (6.6), and CF4 (6.4).

Overall acceptability scores were highest in the treatment CF3 as the most accepted formulation developed (7.8), accompanied by CF4 (7.4), CF2 (7.1), and CF1 (6.9). The Statistical interpretation of the data shows a significant differences among treatments at the 5 percent level as the calculated F- value was higher than the tabulated F-Value. The statistical calculations clearly show that sensory attributes of the developed complementary food significantly differed across different formulations of the product.

Table 3. - The Mean Sensory Scores of Complementary Food prepared with Water

Formulations	Taste & Flavour	Color	Overall Acceptability	Consistency	After Taste
CF1	6.8±0.25	6.9±0.24	6.9±0.4	7.3±0.37	6.7±0.3
CF2	6.9±0.37	7.1±0.09	7.0±0.31	7.5±0.38	6.9±0.33
CF3	7.4±0.2	7.3±0.19	7.4±0.24	7.3±0.2	6.8±0.2
CF4	7.2±0.31	7.3±0.19	7.4±0.24	7.0±0.2	7.0±0.31
FCAL	7.10	5.07	16.14	3.90	1.87
FTAB	3.83	3.83	3.83	3.83	3.83

Table 3 presents the mean sensory scores of the formulated complementary foods. In terms of Flavour and taste of the developed product, treatment CF3 obtained the highest score (7.4), followed by CF4 (7.2), CF2 (6.9), and CF1 (6.8). For color of the developed complementary food, treatment CF3 obtained the highest scores (7.3), followed by CF4 (7.3), CF2 (7.1), and CF1(6.9). A similar pattern of the sensory scores was observed for consistency, where treatment CF3 scored highest (7.3), with subsequent scores for CF2 (7.5), CF1 (7.3), and CF4 (7.0). The sensory scores for after taste showed that treatment CF3 was the most accepted (6.8), with CF4 (7.0), CF2 (6.9), and CF1 (6.7) following.

The sensory scores for overall acceptability were further highest in treatment CF3 as the most sensory acceptable formulation (7.4), accompanied by CF4 (7.4), CF2 (7.0), and CF1 (6.9). The Statistical interpretation of the data shows a significant differences among treatments at the 5 percent level as the calculated F- value was higher than the tabulated F-Value. The statistical calculations clearly show that sensory attributes of the developed complementary food significantly differed across different formulations of the product.

Table 4. - Nutritional Composition and Average Cost of the Prepared Complementary Food

Formulations	CF ₁	CF ₂	CF ₃	CF ₄
Moisture (g)	13.48	13.38	12.66	12.56
Energy (Kcal)	436.5	453.95	477.65	495.10
Protein (g)	23.77	24.18	25.19	25.58
Fat (g)	4.84	5.02	5.11	5.22
Fibre (g)	4.63	4.87	4.53	4.88
Carbohydrate (g)	115.71	147.89	150.09	152.24
Iron (mg)	9.63	10.22	11.09	11.67
Calcium (mg)	146.74	148.89	151.09	153.42
Average Cost/100 g	10	9.1	8.55	8.2

The results showed that formulation CF₄ had the highest energy value (495.1 kcal), followed in descending order by CF₃ (477.65 kcal), CF₂ (453.95 kcal), and CF₁ (436.5 kcal). Protein content was also greatest in CF₄ (25.58 g), with CF₃ (25.19 g), CF₂ (24.18 g), and CF₁ (23.77 g) showing progressively lower values. Carbohydrate levels increased with higher proportions of malted wheat flour, with CF₄ recording the maximum (152.24 g), followed by CF₃ (150.09 g), CF₂ (147.89 g), and CF₁ (115.71 g). Fat content was also greatest in CF₄ (5.22 g), with CF₃ (5.11 g), CF₂ (5.02 g), and CF₁ (4.84 g) showing progressively lower values. Fibre levels increased with higher proportions of malted wheat flour, with CF₄ recording the maximum (4.88 g), followed by CF₃ (4.53 g), CF₂ (4.87 g), and CF₁ (4.63 g). Mineral content, particularly calcium was similarly highest in CF₄ (153.42 mg) followed by CF₃ (151.09 mg), CF₂ (148.89 mg) and CF₁ (146.74 mg). Similar pattern was seen in the iron content of the developed complementary foods as treatment CF₄ shows the highest value (11.67 mg) followed by CF₃ (11.09 mg), CF₂ (10.22 mg) and CF₁ (9.63 mg). Overall, the findings indicate that incorporating malted cereals and legumes into complementary food formulations enhances their nutritional quality.

3 Discussion-

The present study utilizes some indigenous food processing methods like dehydration, germination and dry roasting for the development of cereal and legume based complementary food for infants with the fact that these processing methods increase the bio-availability of the nutrients by reducing the anti-nutritional factors as well as increase

the Flavour and palatability of the food products. Similar finding was stated that processing methods such as malting and germination play a key role in bringing about desirable chemical and physical changes in food formulations [11]. Sprouting cereals and legumes is particularly beneficial, as it improves their nutrient profile and contributes to better overall nutritional value. The development of complementary foods using malted cereals and pulses plays a crucial role in meeting the nutritional requirements of infants, particularly after six months of age when breast milk alone is no longer sufficient to support optimal growth and development. As per the guidelines of the World Health Organization, timely introduction of nutrient rich complementary food is very crucial in infant after 6 month of age for preventing growth retardation [12]. In India, the unavailability of nutritional supplements especially for infants and delayed introduction of complementary feedings are the major reason behind high prevalence of infant malnutrition (International Institute for Population Sciences [13]).

To address these nutritional gaps, Fortified supplementary blends proves very beneficial. For Better energy density and nutrient quality, these formulations often consist of mixes of cereals and legumes along with oil, sugar, micronutrients, and, in some cases, animal-source proteins [14]. Another research further explained that combination of cereals and legumes supplemented with micronutrients improves the quality of protein and mineral content, making them suitable for supporting infant growth [15]. Utilization of indigenous food processing methods like malting in the present study correlates with previously done researches indicating that malted cereals and legumes show increased digestibility, higher enzymatic activity, and reduced viscosity, enabling infants to take sufficient nutrients per serving [16].

Combination of malted cereals and legumes already offer a balanced profile of calories, high-quality plant protein and key micronutrients, making them a great foundation for complementary feeding. Improved immunological function and healthy growth is supported with addition of vegetable flours such as potato and carrot, which offers easily digestible carbohydrates, dietary fibre, beta-carotene and other phytonutrients [17] [18] [19]. Addition of sesame seed powder provides an additional layer of nutritional benefit, as sesame seeds are rich in calcium, iron, healthy fats and antioxidant lignans, which improves the energy density and micronutrient adequacy of complementary foods [20].

Overall, the evaluation of sensory acceptability and nutritional composition from this study reveal that the formulated complementary foods are appealing, nutrient-dense, and adequate for infant feeding. The findings of the study illustrated that low cost indigenous food processing methods and value addition can significantly enhance the nutritional composition of prepared complementary food and can be utilized to reduce the prevalence of undernutrition in low resource settings.

4 Conclusion-

The study concluded that utilization of indigenous food processing methods like soaking, dehydration, germination and dry roasting can help in the preparation of cost effective, easily digestible and highly nutritious complementary food for infants. Malted

cereal and pulse combination provides a robust mix of energy and high quality protein, and their nutritional benefit improves further when blended with vegetable flours such as potato and carrot, which contribute fibre, natural sugars and vital vitamins that support healthy growth. Addition of sesame seed powder enhances the overall energy density and offers vital minerals and healthy lipids. Altogether, these ingredients and indigenous food processing methods generate a complementary food that is more appealing, more nutrient rich and ideally adapted to meeting the dietary demands of infants after six months of age.

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Authors' Contributions.

Pallavi Singh: Conceptualization, Methodology, Investigation, Data curation, Resources, Writing - review, and editing.

Ahmed Hamad- Supervision, Validation, Writing - review & editing.

Aditya Kumar Singh Pundir- Supervision, Validation, Writing - review & editing.

Sangeeta Gupta- Supervision & editing.

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