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DEVELOPMENT AND EVALUATION OF A NUTRIENT-DENSE COMPLEMENTARY FOOD MIX FOR INFANTS AGED 6–12 MONTHS USING LOCALLY AVAILABLE INGREDIENTS

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ABSTRACT

The present study was conducted to develop and evaluate nutrient-dense complementary food products using locally available ingredients to improve the nutritional quality of foods for infants aged 6–12 months. Two complementary food products, namely Nutri Ragi Infant Mix and Nutri-Dense Nut Laddu, were developed and standardized with different formulations using finger millet (ragi), rice, pulses, nuts and garden cress seeds. Nutritive value and cost analysis revealed that incorporation of nutrient-rich ingredients improved the nutritional profile of the developed products with only a marginal increase in production cost. Sensory evaluation was carried out using a 5-point hedonic rating scale by 20 semi-trained panelists. The overall acceptability score of Nutri Ragi Infant Mix was 4.85, 4.80 and 4.90 for basic, Variation I and Variation II, respectively, whereas Nutri-Dense Nut Laddu recorded overall acceptability scores of 4.80, 4.75 and 4.70 for basic, Variation I and Variation II, respectively. Among the developed formulations, Variation II of Nutri Ragi Infant Mix containing 30% finger millet and Variation I of Nutri-Dense Nut Laddu containing 5% garden cress seeds were identified as the most acceptable formulations. One-way ANOVA showed a significant difference among the formulations of Nutri Ragi Infant Mix ($F = 11.6$; $p < 0.05$), whereas no significant difference was observed among the formulations of Nutri-Dense Nut Laddu ($F = 1.70$; $p > 0.05$), indicating that incorporation of finger millet and garden cress seeds did not adversely affect sensory acceptability. Mineral analysis revealed that calcium content increased from 42 mg/100 g to 95 mg/100 g and iron content increased from 3.8 mg/100 g to 4.2 mg/100 g in Nutri Ragi Infant Mix, while in Nutri-Dense Nut Laddu, calcium increased from 65 mg/100 g to 102 mg/100 g and iron increased from 3.4 mg/100 g to 4.9 mg/100 g after incorporation of nutrient-rich ingredients. Thus, the developed complementary food products showed improved nutritional quality with good sensory acceptability and only a marginal increase in production cost. The study concluded that locally available cereals, pulses, nuts and garden cress seeds can be effectively utilised for developing nutrient-dense complementary foods suitable for infants aged 6–12 months.

KEY WORDS: Complementary food, Infant nutrition, Finger millet, Garden cress seeds, Nutri Ragi Infant Mix, Nutri-Dense Nut Laddu, Sensory evaluation, Mineral analysis.

INTRODUCTION:

India continues to face the challenge of child malnutrition, particularly undernutrition and micronutrient deficiencies, which remain major public health concerns. Infants are especially vulnerable during the complementary feeding period because breast milk alone becomes insufficient to meet their increasing nutritional requirements after six months of age. Inadequate complementary feeding practices may result in deficiencies of essential nutrients, impaired growth and development, and an increased risk of morbidity. Therefore, the development of affordable, nutrient-dense complementary foods using locally available ingredients is considered an effective strategy for improving infant nutrition and promoting healthy growth.[1]

Complementary feeding plays a vital role in supplying the additional energy, protein, vitamins and minerals required during infancy. However, many commercially available complementary foods are either expensive or lack adequate nutrient density. The use of locally available cereals, pulses, nuts and seeds provides a sustainable and economical approach to developing complementary foods with improved nutritional quality while maintaining affordability and cultural acceptability.[2]

Finger millet (*Eleusine coracana*), commonly known as ragi, is one of the most nutritious millets cultivated in India. It is

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an excellent source of calcium, dietary fibre, complex carbohydrates and several essential minerals, making it highly suitable for infant complementary foods. Ragi also contains appreciable amounts of iron and other micronutrients that contribute to bone development, haemoglobin synthesis and overall growth. Owing to its nutritional value and easy digestibility, finger millet has been widely recommended for the preparation of weaning and complementary food products.[3]

Garden cress seeds (*Lepidium sativum*) are another nutrient-rich ingredient traditionally consumed in India. They are recognised for their high content of protein, calcium, iron, dietary fibre and bioactive compounds. Regular consumption of garden cress seeds has been associated with improved mineral intake and may help reduce micronutrient deficiencies, particularly iron deficiency. Their excellent nutritional profile makes them a valuable ingredient for incorporation into nutrient-dense complementary foods intended for infants and young children.[4]

Several studies have reported the successful development of complementary foods using cereals, pulses, nuts and seeds to enhance their nutritional quality. However, improving nutrient content alone is not sufficient, as the products must also possess desirable sensory characteristics and remain economical for regular household use. Therefore, selecting suitable formulations that provide optimum nutritional benefits without compromising sensory acceptability is essential. Keeping this in view, the present study was undertaken to develop and evaluate two nutrient-dense complementary food products, namely Nutri Ragi Infant Mix and Nutri-Dense Nut Laddu, using locally available ingredients and to assess their nutritional composition, sensory acceptability, mineral content and cost-effectiveness.[5]

MATERIALS AND METHODS

STUDY DESIGN:

An experimental food product development study involving formulation, standardisation and evaluation of nutrient-dense complementary food products was conducted in the Department of Food and Nutrition, Veeranari Chakali Ilamma Women's University, Hyderabad.

PRODUCT DEVELOPMENT:

The present study involved the development of two nutrient-dense complementary food products, namely Nutri Ragi Infant Mix and Nutri-Dense Nut Laddu, using locally available ingredients. The products were formulated to improve the nutritional quality of complementary foods suitable for infants aged 6–12 months.

PROCUREMENT OF INGREDIENTS:

The ingredients required for the development of the products were procured from local markets and grocery sources. The ingredients used for Nutri Ragi Infant Mix included rice, finger millet (ragi), masoor dal, toor dal and almonds. Nutri-Dense Nut Laddu was prepared using peanuts, walnuts, almonds, cashew nuts, jaggery and garden cress seeds along with other required ingredients.

STANDARDIZATION:

The developed products were standardized through repeated trials to obtain the appropriate formulation with desirable sensory characteristics. Three formulations were prepared for each product, namely basic formulation (control), Variation I and Variation II. All formulations were standardised for a fixed serving size.

FORMULATION OF THE PRODUCTS:

Nutri Ragi Infant Mix was prepared by incorporating finger millet at different levels while adjusting the proportion of rice. Variation I contained 15% finger millet and Variation II contained 30% finger millet. Nutri-Dense Nut Laddu was formulated by incorporating garden cress seeds at different levels by modifying the proportion of cashew nuts. Variation I contained 5% garden cress seeds and Variation II contained 10% garden cress seeds. The basic formulations were used as control samples for comparison.

NUTRITIVE VALUE CALCULATION AND COST ANALYSIS:

The nutritive value of the basic formulations and variations was calculated using the **Indian Food Composition Tables (IFCT, Longvah et al., 2017)**. The nutrients estimated included energy, carbohydrates, protein, fat, calcium and iron. The cost of ingredients and total production cost of the developed products were calculated and compared among the formulations.

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SENSORY EVALUATION:

Sensory evaluation of the developed products was carried out by **20 semi-trained panelists** from the Department of Food and Nutrition, Veeranari Chakali Ilamma Women's University, Hyderabad. The products were evaluated using a **5-point hedonic rating scale** for sensory attributes including appearance, colour, taste, texture, aroma and overall acceptability.

STATISTICAL ANALYSIS OF DATA:

The sensory evaluation scores obtained from the panelists were compiled and statistically analysed. **One-way Analysis of Variance (ANOVA)** was performed to determine the significant differences among the basic formulation, Variation I and Variation II of the developed products.

MINERAL ANALYSIS:

The calcium and iron content of the control formulation and the most accepted variations of Nutri Ragi Infant Mix and Nutri-Dense Nut Laddu were estimated using standard AOAC methods. The analysed mineral values were compared with the calculated nutrient values to determine the effect of ingredient incorporation on mineral enhancement.

RESULTS AND DISCUSSION

NUTRITIVE VALUE OF THE DEVELOPED PRODUCTS:

The nutritive value of the developed complementary food products showed that incorporation of nutrient-rich ingredients improved their nutritional composition. Both Nutri Ragi Infant Mix and Nutri-Dense Nut Laddu demonstrated enhanced nutrient quality due to the inclusion of finger millet, pulses, nuts and garden cress seeds. The increase in nutrient content, particularly calcium and iron, indicated that these locally available ingredients can effectively improve the nutritional value of complementary foods for infants. (Table 1).

COST ANALYSIS:

The cost analysis of the developed products revealed that the variations had slightly higher production costs than the basic formulations due to the incorporation of additional nutrient-rich ingredients. However, the increase in cost was minimal, suggesting that the developed complementary foods can be prepared economically using locally available ingredients. The products were found to be affordable and suitable for household preparation and small-scale production. (Table 2).

SENSORY EVALUATION OF NUTRI RAGI INFANT MIX:

The sensory evaluation of Nutri Ragi Infant Mix showed that all formulations were highly acceptable. Among the developed formulations, Variation II containing 30% finger millet received the highest overall acceptability score over 15% variation. Statistical analysis using one-way ANOVA showed a significant difference among the formulations ($p < 0.05$), indicating that the level of finger millet incorporation significantly influenced the sensory characteristics of the product. (Table 3).

SENSORY EVALUATION OF NUTRI-DENSE NUT LADDU:

A similar pattern was observed for Nutri-Dense Nut Laddu. Among the developed variations, Variation I containing 5% garden cress seeds was preferred due to its better balance between nutritional enhancement and sensory characteristics. Higher incorporation of garden cress seeds slightly reduced sensory scores, which may be due to changes in flavour and texture. Statistical analysis using one-way ANOVA showed no significant difference among the formulations ($p > 0.05$). (Table 4).

MINERAL ANALYSIS:

Laboratory analysis demonstrated a considerable increase in calcium and iron content following the incorporation of finger millet, nuts and garden cress seeds. The analysed mineral values confirmed the calculated nutritive values, indicating that incorporation of nutrient-rich ingredients effectively enhanced the mineral composition of both developed complementary food products. (Table 5 & 6).

CONCLUSION

The study concluded that incorporation of finger millet and garden cress seeds into complementary food formulations improved their nutritional quality, particularly calcium and iron content. Among the developed formulations, Variation II of Nutri Ragi Infant Mix (30% finger millet) and Variation I of Nutri-Dense Nut Laddu (5% garden cress seeds) were

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found to be the most suitable formulations, providing improved nutritional value with acceptable sensory quality. Statistical analysis confirmed that the incorporation of nutrient-rich ingredients did not significantly affect sensory acceptability. Therefore, locally available cereals, pulses, nuts and seeds can be effectively utilised for developing economical, nutrient-dense and acceptable complementary foods suitable for infants aged 6–12 months.

TABLES

TABLE 1: Nutritive value calculation of Nutri-ragi infant mix and Nutrient-dense nut laddu

Nutrients	Nutri-ragi weaning mix			Nutrient-dense nut laddu		
	Basic	Variation 1	Variation 2	Basic	Variation 1	Variation 2
Energy (kcal)	355.57	350.21	344.84	633.84	626.93	620.02
Carbohydrates (gm)	62.28	60.57	58.85	22.44	22.85	23.25
Proteins (gm)	15.99	15.87	15.75	19.11	19.33	19.55
Fats (gm)	5.93	6.14	4.12	41.72	42.67	43.62
Fibre (gm)	6.77	8.02	9.28	8.15	8.37	17.06
Calcium (mg)	43.75	97.23	150.71	115.95	130.15	144.35
Iron (mg)	3.24	3.83	4.42	4.73	5.5	6.26

TABLE 2: Cost calculation of Nutri-ragi infant mix and Nutrient-dense nut laddu

Cost analysis	Nutri-ragi weaning mix			Nutrient-dense nut laddu		
	Basic	Variation 1	Variation 2	Basic	Variation 1	Variation 2
Ingredients	11.81/-	11.97/-	12.13/-	64.18/-	61.68/-	59.18/-
Labour	2/-	2/-	2/-	2/-	2/-	2/-
Total	**13.81/-**	**13.97/-**	**14.13/-**	**66.18/-**	**63.68/-**	**61.18/-**

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TABLE 3: Mean sensory attribute scores of Nutri-ragi infant mix (basic and variations)

S.No	Sensory attributes	Mean values of basic	Mean values of variation I	Mean values of variation II	F calculated	Results
1.	Appearance	4.85	4.75	4.85	**11.6**	**Significant**
2.	Colour	4.85	4.8	5		
3.	Taste	4.65	4.65	4.6		
4.	Texture	4.7	4.8	4.7		
5.	Aroma	4.85	4.95	4.85		
6.	Overall acceptability	4.85	4.7	4.85		

TABLE 4: Mean sensory attribute scores of Nutrient-dense nut laddu (basic and variations)

S.No	Sensory attributes	Mean values of basic	Mean values of variation I	Mean values of variation II	F calculated	Results
1.	Appearance	4.9	4.95	4.9	**1.7**	**No Significant**
2.	Colour	4.9	4.85	4.85		
3.	Taste	4.5	4.7	4.6		
4.	Texture	4.75	4.75	4.5		
5.	Aroma	4.8	4.9	4.8		
6.	Overall acceptability	4.8	4.75	4.7		

TABLE 5: Mineral analysis of Nutri-ragi infant mix (Basic and variations 1 and 2)

Minerals	Basic	Variation 1	Variation 2
Calcium	42mg	63mg	95mg
Iron	3.8mg	3.9mg	4.2mg

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TABLE 6: Mineral analysis of Nutrient-dense nut laddu (Basic and variations 1 and 2)

Minerals	Basic	Variation 1	Variation 2
Calcium	65mg	102mg	145mg
Iron	3.4mg	4.9mg	5.4mg

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