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Development and nutritional evaluation of iron rich instant muffin mix as a complementary food for children

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Abstract

The goal of this study was to design and analyse the nutritional properties of the iron rich instant muffin Mix (IRIMM) for kids. The IRIMM is a dry mixture of food ingredients used in the preparation of ready-to-serve muffins. The IRIMM was made by supplementing refined wheat flour with pearl millet, finger millet and grain amaranth flour at different proportions. Sugar, refined oil, baking soda, baking powder, skimmed milk powder and ripe papaya powder were kept constant. Refined oil was used in each recipe during the preparation of muffins for serving. The muffins were made and then tested by a team of judges. Out of six the best recipes from each combination, *i.e.*, base recipe (control), refined wheat flour supplemented with flours of finger millet, pearl millet and amaranth grain (T_0, T_1 T_2 and T_3) were chosen and dry mixes were prepared and packed in glass jars and laminated aluminium pouches (ALP) for quality evaluation of different nutritional characteristics. The results show higher significance (p = 0.05) in treatment T_3 (IRIMM supplemented with amaranth grain flour) for ash (5.75 ± 0.13 %), fat (4.63 ± 1.19 %), protein (25.25 ± 1.47 %), β-carotene (2.86 ± 0.15 mg/100 g) and iron content (11.35 ± 1.22 mg/100 g) as compared to other treatments. Based on the statistical analysis, significant differences were observed in all sensory parameters of IRIMM for serving. The highest overall acceptability scores were awarded to treatment T_0 (8.78), followed by T_3 (8.65), T_2 (8.55) and T_1 (8.50). The results showed that the products (IRIMM) are highly nutritious and thus, could be used as a complementary food to alleviate iron deficiency in children below five years in developing countries.

1. Introduction

Malnutrition is a broad term that can be referred to as deviations from adequate and optimal nutritional status. In general, it is categorized as under-nutrition and over nutrition (Chuwa *et al*., 2020). Acute malnutrition results in wasting or low weight for height, but chronic malnutrition results in stunting or low height for age, underweight or low weight for age, mineral and vitamin deficiencies or excesses. Obesity and diet-related non-communicable diseases (NCDs) such as diabetes, heart disease, cancer, and strokes are all symptoms of poor nutrition (WHO, 2019). Malnutrition is caused by insufficient food intake during the supplemental feeding period after six months of exclusive breast feeding (Kumssa *et al*., 2015; Muthayya *et al*. 2013). The impact of early nutrition on a child's growth, development, and survival is significant (Michaelsen, 2015; Skau *et al*., 2014). Malnutrition can impact people of all ages, from infancy to old age, from all walks of life, rich and poor and both sexes; as a result, no country in the world can afford to ignore it. Around the world, 149.2 million children under the age of five are stunted, 45.4 million are wasting, and 38.9 million are obese. All regions, with the exception of Africa, are seeing a decrease in the number of stunted children. Protein energy malnutrition (PEM), zinc deficiency (ZD), vitamin a deficiency (VAD), iron deficiency anemia (IDA), and iodine deficiency disorders (IDD) afflicted over two billion people, with 190 million preschool-age children suffering from IDA (Bailey *et al*., 2015). Among all forms of malnutrition, PEM is the largest cause of death. In developing countries, particularly in southern Asia and Sub-Saharan Africa, malnutrition remains a serious public health concern. According to the World Food Programme and a United Nations agency, iron deficiency (ID) is a disorder that occurs when the body does not produce enough red blood cells. It causes weakness, difficulty controlling body temperature, and a weakened immune system, making you more prone to infections (Chuwa *et al*., 2020). Essential proteins, amino acids, vitamins (A, B6, B12, C, D, E, and folic acid), fatty acids, minerals (iron, selenium, zinc, and copper), and phytochemicals are all potential immune-system boosters (Thakur *et al*., 2019; Hamid *et al*., 2021; Bhatt *et al*., 2021). Malnourished, anaemic, and iron-deficient neonates and children were discovered to be sedentary, sluggish, emotionally dull, and less interested in exploring their surroundings (Corapci *et al*., 2006; Lozoff *et al*., 2010). Youngsters who are anaemic are less active and have a poorer mood than children who are not anaemic (Chang *et al*., 2011; Lozoff *et al*., 2007). Nuts, whole grains, fruits, and vegetables, which are high in iron, can assist to treat or prevent anaemia (Yip and Ramakrishnan, 2002). The pseudocereal amaranth grain (*Amaranthus cruentus*) is a nutritious, fast-growing, high-yielding, stress-resistant crop with the potential to help alleviate poverty and malnutrition.

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Consumption of amaranth grain is considered to offer nutritional and health benefits. Apart from amaranth grain, finger millet has the highest calcium content of any food grain (Ihekoronye *et al.*, 1985), as well as being a good source of potassium, zinc, phosphorus, and iron (Ramachandra *et al.*, 1977). It contains a significant amount of vitamin B-complex vitamins, including as thiamine and riboflavin, in addition to minerals. On the other hand, it contains the amino acid methionine, which is deficient in the diets of hundreds of millions of poor people who eat cassava, plantain, polished rice, and maize meal (Barbeau and Hilu, 1993). Pearl millet is a staple cereal that is grown in locations where malnutrition is a major issue. When compared to other cereals, it has a high nutritional content, which implies it has a lot of potentials to aid in food and nutrition security (Shweta, 2015). The antioxidant vitamins C, A, and E, as well as other minerals, are abundant in papaya. Chuwa and Kamal (2022) reported that ripe papaya fruit is the richest source of minerals (magnesium and potassium), vitamins B (folic acid and pantothenic acid), and fibre. Bioactive chemicals found in fruits and their by-products have immense promise for maintaining or improving human health, and there is considerable interest in producing new products with beneficial pharmacological effects (Hamid *et al.*, 2020). These crops were used to create an iron rich instant muffin mix for children under the age of five because of their nutritional benefits. The purpose of this research was to determine the nutritional components IRIMM possesses. The recipes for these commodities can be used by Governments and Non-Governmental Organisations to fight malnutrition, especially iron deficiency in children under the age of five in low-income countries.

2. Materials and Methods

A local food market, Solan, provided refined wheat flour, finger millet, pearl millet, amaranth grain, and ripe papaya fruits, as well as refined oil, skimmed milk powder, baking soda, and baking powder. All of the chemicals and reagents used in this investigation were analytical grade and came from Loba Chemie, International Scientific and Surgicals, in Solan (HP). The same supplier also supplied PET jars and aluminium laminated pouches (ALP). For all treatments and analyses, three replicates were employed, and the findings were calculated on a dry weight basis. The current research was conducted in the Department of Food Science and Technology for product development and nutritional quality assessment, while the iron content of the product was investigated in the Environmental Science Department, Dr. YS Parmar University of Horticulture and Forestry, Nauni-Solani-H.P, 173230, India.

2.1 Preparation of food material

2.1.1 Preparation of cereal and pseudocereal flours

Saleh *et al.* (2013) described a procedure for producing finger millet (*Eleusine coracana*) flour. Clean grains of known weight were cleaned and steeped in warm water (1:3) overnight (12 h). For the preparation of pearl millet flour, Eyzaguirre *et al.* (2006) standardized a technique. The known amount of clean grains was cleaned and steeped in warm water (1 : 2) overnight (12 h). Tanimola *et al.* (2016) recommended that the amaranth grain flour be produced in this way. The grains were steeped in warm water (1:3) for 12 h. The grains of each crop after that were dried in separate batches in a mechanical dehydrator for 3 h at 60 ± 2°C. or until constant moisture content was achieved. To obtain fine and consistent flours, the dry grains were ground and passed through a 36 mm mesh screen in a mixer cum grinder (Havells, Model MX-1155). The flours were put in PET jars, carefully sealed, labelled, and stored at room temperature for future use. The processing procedures for making cereal and fauxcereal flours are shown in Figure 1.

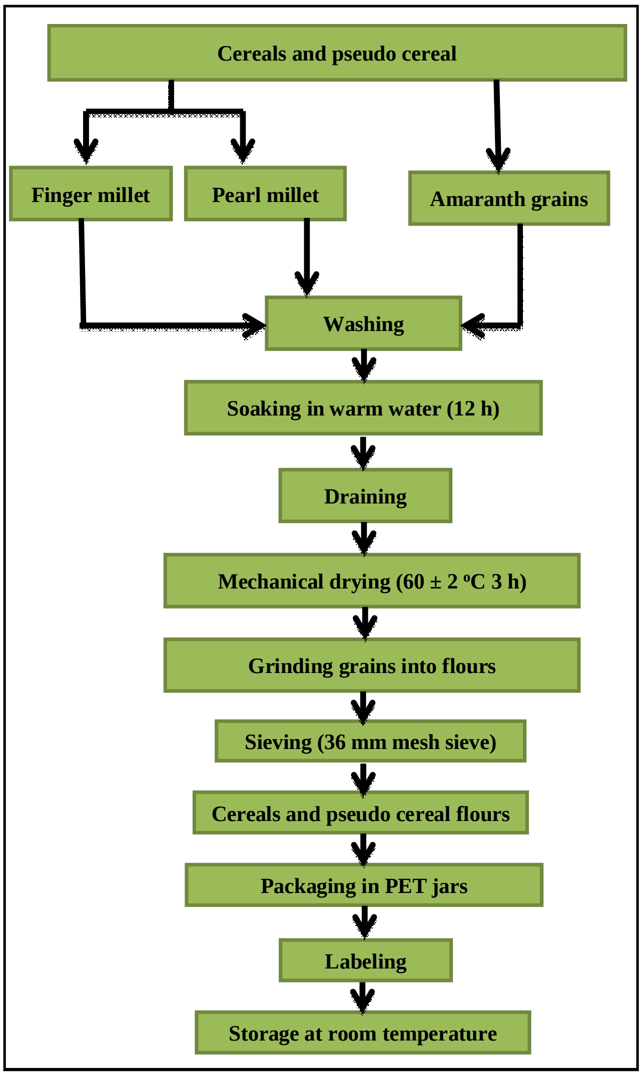

Figure 1: Unit operations for preparation of cereals and pseudo cereal flours

2.1.2 The papaya fruits were washed before being cut in half to make papaya powder

After the fluffy portion/brains/fibrous strains were removed, the halves were cut into strips and seeds were removed. The strips were peeled and chopped into uniform-sized pieces. After steam blanching for 2 min, the pieces were dipped in a 0.1 per cent potassium metabisulfite (KMS) solution for 20 min (Attri *et al.*, 2018). The treated slices were spread out on trays and dried in a mechanical dehydrator at 55 2°C for 18 h or until they reached a consistent moisture content. To make a fine and consistent powder, the dry slices were ground in a mixer cum grinder (Havells, Model MX-1155) and passed through a 36 grit screen. The papaya powder was sealed snugly in a PET jar, labelled, and stored at room temperature until needed. Figure 2 depicts the unit activities that were used to make papaya powder.

Ripe papaya fruit

↓

Washing

↓

Cutting and removal of seeds and fluffy portion

↓

Peeling and cutting into uniform pieces

↓

Steam blanching (2 min)

↓

Dipping in 0.1 per cent KMS solution (20 min)

↓

Mechanical drying (55 ± 2 °C for 18 h)

↓

Grinding of pieces into powder

↓

Sieving (36 mm mesh sieve)

↓

Papaya powder

↓

Packaging in PET jars

↓

Labeling

↓

Storage under ambient condition

Figure 2: **Unit operations for preparation of papaya powder.**

2.1.3 Standardization of the iron rich instant muffin mix recipe

2.1.3.1 Standardization of iron rich instant muffin mix using refined wheat flour

Refined wheat flour was used as the main ingredient in the basic recipe. While the amounts of sugar powder, skimmed milk powder, baking powder, and baking soda were same, the amount of papaya powder changed (Table 1). The amount of refined oil was also kept constant at the time of preparation of muffins for serving. Several preliminary trials were carried out to standardize the recipe. A total of six recipes (Table 1) were taken to select the base recipe to be used in further experiments. The refined wheat flour was roasted for 2-3 min in a non-stick pan till light brown colour. The flour was allowed to cool down under ambient condition and mixed with the rest of the ingredients. The different recipes were prepared by adding water and refined oil to the mixture with constant stirring. The smooth batter was spooned into oiled muffin tins and baked till golden brown. The panelists were given baked muffins to taste and rate. Based on the highest sensory scores, a panel of judges identified the best recipe and designated it as T_0 for further investigation.

Table 1: Description standardization of the iron rich instant muffin mix recipe using refined wheat flour

Ingredients	Treatments					
	Recipe I (T_0)	Recipe II (T_1)	Recipe III (T_2)	Recipe IV (T_3)	Recipe V (T_4)	Recipe VI (T_5)
Refined wheat flour (g)	95	90	85	80	75	70
Papaya powder (g)	5	10	15	20	25	30
Baking powder (g)	10	10	10	10	10	10
Baking soda (g)	0.75	0.75	0.75	0.75	0.75	0.75
Sugar powder (g)	60	60	60	60	60	60
Skimmed milk powder (g)	45	45	45	45	45	45
Refined oil (ml)	20	20	20	20	20	20

2.1.3.1.1 Standardization of amount of water, baking time and temperature for preparation of iron rich instant muffin mix for serving

The different combinations of water, baking time and temperature as detailed in Table 2 for preparation of 100 g instant muffin mix selected under Section 2.1.3.1 for serving were used. The mix of different combinations was prepared by adding the prescribed amount of water and oil with constant stirring to get a batter of smooth consistency. The batter was placed into oiled muffin cups and baked till light brown in the oven for the given time and temperature. A group of judges assessed the muffins using their senses. The best combination was chosen and utilized in subsequent experiments to make muffins.

Table 2: Standardization of amount of water, baking time and temperature for preparation of iron rich instant muffin mix for serving

Quantity of mix (g)	Amount of water (ml)	Baking time (min)	Baking temperature (°C)
100	30	30	100
100	40	40	130
100	50	50	150
100	60	60	180

2.1.3.1.2 Standardization of iron rich instant muffin mix supplemented with finger millet flour

The standard recipe under Section 2.1.3.1 was used for the preparation of muffin mix for serving by replacing wheat flour with finger millet flour at different proportions (Table 3) and keeping other ingredients constant. A panel of judges tasted the prepared muffins and gave them a rating.

2.1.3.1.3 Standardization of iron rich instant muffin mix supplemented with pearl millet flour

To conduct this experiment, the refined wheat flour of the standard recipe selected under Section 2.1.3.1 was replaced with pearl millet flour in varied ratios (Table 4). A panel of judges assessed the prepared muffins for sensory qualities.

2.1.3.1.4 Standardization of iron rich instant muffin mix supplemented with amaranth grain flour

The refined wheat flour of the base recipe (Section 2.1.3.1) was supplemented with amaranth grain flour at different levels (Table 5). The muffin mix for serving different combinations was prepared and judged by a group of judges on their sensory judgement.

Table 3: Standardization instant muffin mix supplemented with finger millet flour

Ingredients	Treatments					
	Recipe I (T_0)	Recipe II (T_1)	Recipe III (T_2)	Recipe IV (T_3)	Recipe V (T_4)	Recipe VI (T_5)
Refined wheat flour (g)	85	75	65	55	45	35
Finger millet flour (g)	0	10	20	30	40	50
Papaya powder (g)	15	15	15	15	15	15
Baking powder (g)	10	10	10	10	10	10
Baking soda (g)	0.75	0.75	0.75	0.75	0.75	0.75
Sugar powder (g)	60	60	60	60	60	60
Skimmed milk powder (g)	45	45	45	45	45	45
Refined oil (ml)	20	20	20	20	20	20

Table 4: Standardization instant muffin mix supplemented with pearl millet flour

Ingredients	Treatments					
	Recipe I (T_0)	Recipe II (T_1)	Recipe III (T_2)	Recipe IV (T_3)	Recipe V (T_4)	Recipe VI (T_5)
Refined wheat flour (g)	85	75	65	55	45	35
Pearl millet flour (g)	0	10	20	30	40	50
Papaya powder (g)	15	15	15	15	15	15
Baking powder (g)	10	10	10	10	10	10
Baking soda (g)	0.75	0.75	0.75	0.75	0.75	0.75
Sugar powder (g)	60	60	60	60	60	60
Skimmed milk powder (g)	45	45	45	45	45	45
Refined oil (ml)	20	20	20	20	20	20

Table 5: Standardization of instant muffin mix supplemented with amaranth seed flour

Ingredients	Treatments					
	Recipe I (T_0)	Recipe II (T_1)	Recipe III (T_2)	Recipe IV (T_3)	Recipe V (T_4)	Recipe VI (T_5)
Refined wheat flour (g)	85	75	65	55	45	35
Amaranth grain flour (g)	0	10	20	30	40	50
Papaya powder (g)	15	15	15	15	15	15
Baking powder (g)	10	10	10	10	10	10
Baking soda (g)	0.75	0.75	0.75	0.75	0.75	0.75
Sugar powder (g)	60	60	60	60	60	60
Skimmed milk powder (g)	45	45	45	45	45	45
Refined oil (ml)	20	20	20	20	20	20

2.2 Chemical analysis

The moisture content (%), ash (%), protein (%) and minerals (iron mg/100 g) were determined as per the method suggested by AOAC (2012). Crude fibre (%) was analyzed as per (AOAC, 2010), while crude fat (%) was determined using (AOAC, 2009) method. Ranganna (2009) procedure was employed in scrutinizing β-carotene (mg/100 g), total carbohydrates (%), whereas total energy (Kcal/100 g) was calculated by the differential method as per AOAC (2006) method.

2.3 Sensory evaluation

Serving instant muffin mix was made by adding 50 ml of water and 20 ml of refined oil to 100 g of instant muffin mix and stirring constantly until the batter consistency was reached. The homogenous batter was placed into oiled muffin cups and baked for 50 min at 150°C Celsius. Panelists were asked to score the muffins on a 9-point Hedonic scale for colour, texture/body, flavour, and overall acceptability (1=strongly dislike, 5=neither like nor dislike, 9=like greatly), according to Meilgaard *et al.* (1999) and Thakur *et al.* (2021).

2.4 Data analysis

Complete randomized design (CRD) was used to examine chemical characteristics, while randomized block design (RBD) was used to examine sensory evaluation, as described by Cochran and Cox (1967) and Mahony (1985, respectively. The statistical significance was determined at $p<0.05$, and Tukey's honest significant difference (HSD) was employed to separate the means for comparison.

3. Results

3.1 Standardization of recipe for preparation of iron rich muffin mix using refined wheat flour

The recipe for iron rich instant muffins was standardized by comparing the results of several treatment combinations (Table 1). The sensory evaluation of the produced muffins was conducted by a panel of judges, and the findings are shown in Table 6. The highest sensory scores for colour was recorded in T_2 (8.55), followed by T_3 (8.43), T_0 (8.40), T_1 (8.11), T_5 (7.72) and T_4 (7.36). In texture, highest sensory scores were recorded in T_2 (8.87), followed by T_0 (8.42), T_1 (8.40), T_3 (8.20), T_4 (7.37) and T_5 (7.26). For taste, highest sensory scores recorded in T_2 (8.67), followed by T_3 (8.16), T_1 (7.90), T_4 (7.62), T_5 (7.45) and T_0 (7.40). Overall acceptability, highest sensory scores recorded in T_2 (8.78), followed by T_3 (8.45), T_1 (8.22), T_0 (8.09), T_4 (7.74) and T_5 (7.37). Statistical analysis recorded significant differences in sensory scores of all the parameters. For the preparation of muffins, the amount of water, baking time and the temperature was standardized by comparing different combinations (Table 2). The best combination was found to be 50 mL water, baked for 50 min baking time at 150°C for a mix of 100 g mix. This combination was used for preparation of muffin mix for serving in base recipe, muffin mix supplemented with finger, pearl and amaranth grain flours.

Table 6: Sensory scores of standardized recipe for preparation of iron rich instant muffin mix using refined wheat flour

Treatment (s)	Colour	Texture	Taste	Overall acceptability
T_0	8.40 ± 0.13^b	8.42 ± 0.10^b	7.40 ± 0.22^e	8.09 ± 0.08^d
T_1	8.11 ± 0.06^c	8.40 ± 0.23^b	7.90 ± 0.15^c	8.22 ± 0.17^c
T_2	8.55 ± 0.18^a	8.87 ± 0.31^a	8.67 ± 0.08^a	8. 78 ± 0.23^a
T_3	8.43 ± 0.11^b	8.20 ± 0.16^c	8.16 ± 0.14^b	8.45 ± 0.21^b
T_4	7.36 ± 0.22^e	7.37 ± 0.15^d	7.62 ± 0.19^d	7.74 ± 0.04^e
T_5	7.72 ± 0.16^d	7.26 ± 0.31^e	7.45 ± 0.03^e	7.37 ± 0.11^f
$CD_{0.05}$	0.41	0.46	0.19	0.13

T_0 (95% refined wheat flour +5% papaya powder); T_1 (90% refined wheat flour +10% papaya powder); T_2 (85% refined wheat flour +15% papaya powder); T_3 (80% refined wheat flour +20% papaya powder); T_4 (75% refined wheat flour +25% papaya powder); T_5 (70% refined wheat flour +30% papaya powder).

The values with the same lower case letter on superscript in the same column are non-significant at the 0.05 per cent level of significance.

Table 7: Sensory scores of iron rich instant muffin mix supplemented with finger millet flour

Treatment (s)	Colour	Texture	Taste	Overall acceptability
T_0	7.43 ± 0.21^d	7.43 ± 0.18^d	7.43 ± 0.04^d	7.43 ± 0.10^d
T_1	7.54 ± 0.13^c	7.56 ± 0.11^c	7.59 ± 0.14^c	7.61 ± 0.17^c
T_2	7.90 ± 0.06^b	7.93 ± 0.16^b	7.95 ± 0.33^b	7.98 ± 0.22^b
T_3	8.43 ± 0.08^a	8.45 ± 0.13^a	8.48 ± 0.07^a	8.50 ± 0.03^a
T_4	7.05 ± 0.05^f	7.08 ± 0.22^f	7.10 ± 0.16^f	7.13 ± 0.15^f
T_5	7.18 ± 0.25^e	7.20 ± 0.52^e	7.23 ± 0.34^e	7.25 ± 0.12^e
$CD_{0.05}$	0.79	0.79	0.78	0.78

T_0 (85% refined wheat flour + 15% papaya powder); T_1 (75% refined wheat flour + 10%finger millet flour + 15% papaya powder); T_2 (65% refined wheat flour + 20% finger milletflour + 15% papaya powder); T_3 (55% refined wheat flour + 30% finger millet flour + 15% papaya powder); T_4 (45% refined wheat flour + 40% finger millet flour + 15% papaya powder); T_5 (35% refined wheat flour + 50%finger millet flour + 15% papaya powder).

The values with the same lower case letter on superscript in the same column are non-significant at the 0.05 per cent level of significance.

3.2 Standardization of iron rich muffin mix supplemented with finger millet flour

In this article, the recipe for making instant muffin mix using finger millet flour has been described (Table 3). The sensory evaluation of the prepared muffins was conducted by a panel of judges, and the findings are shown in Table 7. The highest sensory scores for colour was recorded in T_3 (8.43), followed by T_2 (7.90), T_1 (7.54), T_0 (7.43), T_5 (7.18) and T_4 (7.05). In texture, highest sensory scores recorded in T_3 (8.45), followed by T_2 (7.93), T_1 (7.56), T_0 (7.43), T_5 (7.20) and T_4 (7.08). For taste, highest sensory scores recorded in T_3 (8.48), followed by T_2 (7.95), T_1 (7.59), T_0 (7.43), T_5 (7.23) and T_4 (7.10). Overall acceptability, highest sensory scores recorded in T_3 (8.50), followed by T_2 (7.98), T_1 (7.61), T_0 (7.43), T_5 (7.25) and T_4 (7.13). Statistical analysis recorded significant differences in sensory scores of all the parameters.

3.3 Standardization of iron rich muffin mix supplemented with pearl millet flour

The recipe for the preparation of instant muffin mix supplemented with pearl millet flour (Table 4). The made muffins were tasted by a team of judges, and the findings are shown in Table 8. The highest sensory scores for colour was recorded in T_3 (8.45), followed by T_4 (7.50), T_0 (7.43), T_2 (7.05), T_1 (6.95) and T_5 (6.85). In texture, highest sensory scores recorded in T_3 (8.50), followed by T_4 (7.55), T_0 (7.43), T_2 (7.10), T_1 (7.00) and T_5 (6.90). For taste, highest sensory scores recorded in T_3 (8.53), followed by T_4 (7.58), T_0 (7.43), T_2 (7.13), T_1 (7.03) and T_5 (6.93). Overall acceptability, highest sensory scores recorded in T_3 (8.55), followed by T_4 (7.58), T_0 (7.43), T_2 (7.15), T_1 (7.05) and T_5 (6.95). Statistical analysis recorded significant differences in sensory scores of all the parameters.

Table 8: Sensory scores of iron rich instant muffin mix supplemented with pearl millet flour

Treatment (s)	Colour	Texture	Taste	Overall acceptability
T_0	7.43 ± 0.11^b	7.43 ± 0.08^c	7.43 ± 0.32^c	7.43 ± 0.24^c
T_1	6.95 ± 0.13^d	7.00 ± 0.12^d	7.03 ± 0.15^e	7.05 ± 0.21^e
T_2	7.05 ± 0.15^c	7.10 ± 0.18^d	7.13 ± 0.09^d	7.15 ± 0.32^d
T_3	8.45 ± 0.09^a	8.50 ± 0.26^a	8.53 ± 0.16^a	8.55 ± 0.29^a
T_4	7.50 ± 0.17^b	7.55 ± 0.23^b	7.58 ± 0.14^b	7.58 ± 0.14^b
T_5	6.85 ± 0.21^d	6.90 ± 0.06^e	6.93 ± 0.13^f	6.95 ± 0.04^f
$CD_{0.05}$	0.94	0.94	0.99	1.04

T_0 (85% refined wheat flour + 15% papaya powder); T_1 (75% refined wheat flour + 10% pearl millet flour + 15% papaya powder); T_2 (65% refined wheat flour + 20% pearl millet flour +15% papaya powder); T_3 (55% refined wheat flour + 30% pearl millet flour + 15% papaya powder); T_4 (45% refined wheat flour + 40%pearl millet flour + 15% papaya powder); T_5 (35% refined wheat flour +50%pearl millet flour+15% papaya powder).

The values with the same lower case letter on superscript in the same column are non-significant at the 0.05 per cent level of significance.

Table 9: Sensory scores of iron rich instant muffin mix supplemented with amaranth grain flour

Treatment (s)	Colour	Texture	Taste	Overall acceptability
T_0	7.43 ± 0.11^c	7.43 ± 0.08^c	7.43 ± 0.07^c	7.43 ± 0.19^b
T_1	6.60 ± 0.13^f	6.63 ± 0.16^f	7.10 ± 0.12^e	7.25 ± 0.16^c
T_2	6.93 ± 0.09^e	6.95 ± 0.10^e	7.13 ± 0.17^e	7.23 ± 0.05^c
T_3	7.70 ± 0.21^b	7.73 ± 0.14^b	7.50 ± 0.06^b	7.45 ± 0.24^b
T_4	8.25 ± 0.18^a	8.28 ± 0.24^a	8.50 ± 0.26^a	8.65 ± 0.18^a
T_5	7.15 ± 0.23^d	7.23 ± 0.22^d	7.33 ± 0.27^d	7.28 ± 0.13^c
$CD_{0.05}$	1.02	1.02	0.87	0.79

T_0 (85% refined wheat flour + 15% papaya powder); T_1 (75% refined wheat flour + 10%amaranth grain flour + 15% papaya powder); T_2 (65% refined wheat flour + 20% amaranth grain flour + 15% papaya powder); T_3 (55% refined wheat flour + 30% amaranth grain flour + 15% papaya powder); T_4 (45% refined wheat flour + 40% amaranth grain flour + 15% papaya powder); T_5 (35% refined wheat flour +50%amaranth grain flour + 15% papaya powder).

The values with the same lower case letter on superscript in the same column are non-significant at the 0.05 per cent level of significance.

Table 10: Chemical characteristics of iron rich instant muffin mix

Parameters	Treatments			
	T_0	T_1	T_2	T_3
Moisture (%)	3.08 ± 0.04^a	3.07 ± 0.06^a	3.09 ± 0.05^a	3.11 ± 0.01^a
Crude protein	20.71 ± 0.16^c	23.42 ± 2.40^b	23.30 ± 0.99^b	25.25 ± 1.47^a
Crude fat (%)	2.38 ± 0.07^d	3.85 ± 0.53^b	2.61 ± 0.08^c	4.63 ± 1.19^a
Crude fibre (%)	0.19 ± 0.72^c	3.28 ± 1.18^b	3.94 ± 0.82^a	3.28 ± 0.84^b
Total carbohydrates (%)	68.75 ± 4.37^a	64.21 ± 3.90^b	65.46 ± 3.86^b	61.26 ± 3.99^c
β-carotene (mg/100 g)	2.04 ± 0.08^c	1.89 ± 0.10^d	2.46 ± 0.12^b	2.86 ± 0.15^a
Iron (mg/100 g)	4.92 ± 014^d	7.68 ± 0.83^c	9.31 ± 0.07^b	11.35 ± 0.09^a
Ash (%)	5.08 ± 0.03^d	5.45 ± 0.63^c	5.54 ± 0.29^b	5.75 ± 0.13^a
Total energy (Kcal/100 g)	378.50 ± 4.30^a	372.05 ± 6.47^c	362.77 ± 8.82^d	374.59 ± 5.93^b

T_0 (85% refined wheat flour + 15% papaya powder); T_1 (75% refined wheat flour + 10%amaranth grain flour + 15% papaya powder); T_2 (65% refined wheat flour + 20% amaranth grain flour + 15% papaya powder); T_3 (55% refined wheat flour + 30% amaranth grain flour + 15% papaya powder); T_4 (45% refined wheat flour + 40% amaranth grain flour + 15% papaya powder); T_5 (35% refined wheat flour + 50%amaranth grain flour + 15% papaya powder).

The data in the table are the average pooled values (mean ± SD). Values in the same row with the same lower case letter on the superscript are non-significant at the 0.05 per cent level of significance.

3.4 Standardization of iron rich muffin mix supplemented with amaranth grain flour

The recipe for the preparation of instant muffin mix supplemented with amaranth grain flour (Table 5). The prepared muffins were subjected to a panel of judges for sensory evaluation and the results are depicted in Table 9. The highest sensory scores for colour was recorded in T_4 (8.25), followed by T_3 (7.70), T_0 (7.43), T_5 (7.15), T_2 (6.93) and T_1 (6.60). In texture, highest sensory scores recorded in T_4 (8.28), followed by T_3 (7.73), T_0 (7.43), T_5 (7.23), T_2 (6.95) and T_1 (6.63). For taste, highest sensory scores recorded in T_4 (8.50), followed by T_3 (7.50), T_0 (7.43), T_5 (7.33), T_2 (6.13) and T_1 (6.10). Overall acceptability, highest sensory scores recorded in T_4 (8.65), followed by T_3 (7.45), T_0 (7.43), T_5 (7.28), T_2 (7.25) and T_1 (7.23).

Statistical analysis recorded significant differences in sensory scores of all the parameters. The highest overall acceptability score of 8.65 was given to T_4, followed by T_3 (7.45), T_0 (7.43), T_5 (7.28), T_1 (7.25) and T_2 (7.23).

3.5 Chemical characteristics of iron rich instant muffin mix

The data appended in Table 10 shows the chemical characteristics of IRIMM. The moisture content was non-significant among four treatments ranging from 3.07 to 3.11 per cent. The mean crude protein was significantly found to be highest in T_3 (25.25 %) and lowest in T_0 (20.71 %). A significant difference was observed between T_0, T_1 and T_3 with T_3 possessing the highest mean crude fat (4.63 %) and T_0 minimum crude fat content (2.38 %). A significant difference was noticed between all treatments for crude fibre. The highest mean crude fibre content was analyzed in T_2 (3.94 %) and the lowest mean crude fibre was noted in T_0 (0.19 %). The treatments T_0, T_1, T_2 and T_3 had total carbohydrates of 68.75, 64.21, 65.46 and 61.26 per cent. The mean β-carotene values 2.04, 1.89, 2.46 and 2.86 mg/100 g were perceived in T_0, T_1 T_2 and T_2, respectively. A significant difference was obtained in iron values 4.92, 7.68, 9.31 and 11.35 mg/100 g for T_0, T_1 T_2 and T_3, respectively. A significant difference was noted in mean ash content between all treatments. The highest mean ash content was recorded in treatment T_3 (5.75 %) and the minimum was found in treatment T_0 (5.08 %). The total energy of 378.50, 372.05, 362.77 and 374.59 Kcal/100 g was recorded in T_0, T_1 T_2 and T_3, respectively.

4. Discussion

4.1 Sensory scores of standardized recipe for preparation of iron rich instant muffin mix using refined wheat flour

In Table 6, the highest scores for colour, texture, taste and overall acceptability was noted as 8.55, 8.87, 8.67, and 8.78, respectively in muffins of treatment T_2. Based on the highest sensory scores, T_2 was selected and referred to as T_0 (85% wheat flour + 15% papaya powder) for conducting further evaluation.

4.2 Sensory scores of iron rich instant muffin mix supplemented with finger millet flour

Data in Table 7 revealed significantly higher scores for colour (8.43), texture (8.45), taste (8.48) and overall acceptability (8.50) were awarded to treatment T_3. However, the scores for all sensory parameters of different treatments were above the acceptable limits but keeping in view the maximum overall acceptable score, the treatment T_3 (55% wheat flour + 30% finger millet flour + 15% papaya powder) was selected on the basis of sensory scores and referred to as T_1 for further evaluation.

4.3 Sensory scores of iron rich instant muffin mix supplemented with pearl millet flour

The data (Table 8) showed significant differences among all the different treatments. It can be seen that the treatment T_3 got the highest overall acceptability score of 8.55, followed by 7.58 (T_4), 7.43 (T_0), 7.15 (T_2), 7.05 (T_1) and 6.95 (T_5). The muffin of treatment T_3 obtained 8.45, 8.50 and 8.53 scores for colour, texture and taste, respectively. Keeping in view the highest overall acceptability scores, treatment T_3 was selected and referred to as T_2 (55% refined wheat flour + 30% pearl millet flour +15% papaya powder) for further evaluation. The graphical presentation of sensory scores of muffins of different combinations.

4.4 Sensory scores of iron rich instant muffin mix supplemented with amaranth grain flour

Significant differences in scores of various treatments can be seen from the data (Table 9). The highest overall acceptability score of 8.55 was given to T_4, followed by T_3 (7.45), T_0 (7.43), T_5 (7.28), T_1 (7.25) and T_2 (7.23). The scores obtained by treatment T_4 for colour, texture and taste were 8.25, 8.28 and 8.50, respectively. Based on the highest overall acceptability score, treatment T_4 was selected and referred to as T_3 (45% refined wheat flour + 40% amaranth grain flour +15% papaya powder) for conducting further studies.

4.5 Chemical characteristics of iron rich instant muffin mix

The muffin mix selected from base recipe (T_0), muffin mix supplemented with finger millet flour (T_1), muffin mix supplemented with pearl millet flour (T_2) and muffin mix supplemented with amaranth grain flour (T_3) were analyzed for different chemical characteristics (Table 10).

The moisture levels determined in this study were lower than the range reported by Asare *et al.* (2004) and also those suggested by Codex Alimentarius (CODEX, 1985). The roasting of refined wheat, pearl millet, finger millet and grain amaranth flour before mixing with other ingredients during the preparation of instant muffin mix may be the reason for the low moisture content in the present study. The lower the moisture content of instant muffin mix, the better the shelf stability and product quality, as chemical and physical deterioration is less likely at such low moisture content (Intipunya and Bhandari, 2010). The substitution of (40 %) amaranth grain flour and (30 %) pearl millet and finger millet flours with refined wheat flour in Instant Muffin Mix contributed to a significant increase in protein content of T_1, T_2 and T_3. Similarly, the addition of 45 per cent skimmed milk powder to the product is another reason for the higher protein content of the final products. According to US Dairy Export Council (2005), skimmed milk powder has protein content ranging from 34 to 37 per cent. The protein analyzed in the present study was higher than that investigated by Banakar (2005); Sharma *et al.* (2020); Rani and Sood (2020) in the muffin mix. Nutritionally, protein content in all treatments T_0, T_1, T_2 and T_3 are above the recommended daily intake (RDI) for protein needed from complementary foods suggested by Garrow *et al.* (1999); WHO (2001); ICMR (2010) for infants and children in the age group of 6 months to 6 years. The fat obtained in this research is higher than the observations of Banakar (2005); Niharika *et al.* (2020); Negi *et al.* (2021), but similar to Sharma *et al.* (2020) in the instant muffin mix. The fat content in the current study (2.38-4.63 %) was significantly greater than the limits indicated for 9-11-month-old infants' daily lipid needs (Dewey and Adu-Afarwuah, 2008).

The findings for crude fibre are higher than those analyzed by Niharika *et al.* (2020) and within the range of the values scrutinized by Sharma *et al.* (2020); Rani and Sood (2020) in the instant muffin mix. The results of the present study for total carbohydrates are higher than the findings of Sharma *et al.* (2020); Negi *et al.* (2021), but almost similar to the data analyzed by Skripko (2021) while lower than the range given by Niharika *et al.* (2020). The low carbohydrate content in the current study may be due to low glycemic index foods (finger and pearl millets, amaranth grains and papaya fruit) used in the formulation of muffin mix (Chuwa *et al.*, 2021). The results for β-carotene are almost near to the value recommended by WHO (2001); and ICMR (2010), for β-carotene intake per day, *i.e.*, 4.20 and 4.80 mg/day for infants and children in the age group of 7-12 months and 1-6 years, respectively. Therefore, infants and children require 200 g of the mix for the preparation of muffins to meet RDI for β-carotene. Supplementing refined wheat flour with pearl millet, finger millet and grain amaranth flours during the development of instant muffin mix boosts the iron contents of the final products. The iron content recorded in the present study for treatments T_1, T_2 and T_3 is above the amount recommended by Garrow (1999); WHO (2001); ICMR (2010), for infants and children in the age group of 7 months to 6 years. Supplementation of refined wheat flour with 30 per cent pearl millet and finger millet and 40 per cent amaranth grain flour raise the ash content of instant muffin mix in treatment T_1, T_2 and T_3 compared to control (T_0). These results are in line with Banakar (2005), Judhao *et al.* (2018), and Sharma (2018), who found a similar tendency in the Muffin Mix. Butte (1999) recommended energy requirements of infants and children in Kcal/kg body weight to be 334 Kcal (5-6 months), 349 Kcal (6-9 months) and 372 Kcal (9-12 months). Therefore, the amount of total energy investigated in this study is above the Butte (1999) recommendations for infants (5-12 months), but lower than the recommendation of WHO for infants in the age group of 6-23 months while above the recommendation of ICMR (2010) for infants (6-12 months).

5. Conclusion

In order to address stunting and wasting in children in developing nations, the development of high-quality supplementary foods (iron rich instant muffin mix) with better nutritional and sensory qualities is critical. The iron levels in all of the Instant Muffin Mixes created in this study were significant (4.92-11.35 mg/100 g), meeting the RDI for iron in supplementary meals. Other nutrients in supplementary meals, such as fibre, fat, protein, ash, and energy, are also within the Codex Alimentarius requirements. On a 9-point Hedonic scale, the overall acceptance scores of all immediate MM for serving ranged from 8.50 to 8.65. It was determined that the iron rich instant muffin mix developed in this study was highly nutritious, and that Government and non-Governmental Organizations (NGOs) could include it in children's diets to provide balanced nutrition and help reduce iron deficiency, which is common in many developing countries.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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