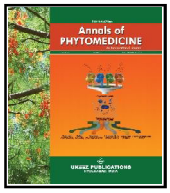
Annals of Phytomedicine 11(2): 602-611, 2022

DOI: http://dx.doi.org/10.54085/ap.2022.11.2.74

Annals of Phytomedicine: An International Journal
http://www.ukaazpublications.com/publications/index.php

Print ISSN : 2278-9839 Online ISSN : 2393-9885



Original Article : Open Access

Formulation, nutritional and sensory evaluation of ready-to-reconstitute instant weaning mix

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Article Info

Article history
Received 13 October 2022
Revised 11 December 2022
Accepted 12 December 2022
Published Online 30 December-2022

Keywords
Banana pulp
Golden maize flour
Rice flour
Sensory evaluation
Whole wheat flour
Mashed potatoes

Abstract

The aim of this study was to evaluate the nutritional and sensory qualities of ready-to-reconstitute instant weaning (gruel) mix formulated from blends of whole wheat flour, mashed potatoes and banana pulp (50:25:25 for blend A), whole wheat flour supplemented with rice flour (10:40:25:25 for blend B), whole wheat flour supplemented with golden maize flour (20:30:23:25 for blend C) and whole wheat flour supplemented with rice and golden maize flour (10:20:20:25:25 for blend D). Sugar and skimmed milk powder were kept constant in each blend. All blends were kept in glass jars and Laminated Aluminium Pouches were analyzed for sensory and nutritional qualities. The results for sensory evaluation showed that blend B had the highest overall acceptability score (8.95), followed by blends C and D (8.80) and last was bend A (8.75). The highest nutritional characteristics exhibited by blend A which had 4.01 ± 0.34% moisture, 12.89 ± 1.25% crude protein, 4.06 ± 0.04% crude fat, 5.85 ± 0.31% crude fibre, 76.35 ± 0.08% total carbohydrate, 1.27 ± 0.02 mg/100 g b-carotene, 4.87 ± 0.08% ash and 361.38 ± 3.99 kcal/100g total energy. Therefore, the study recommended blends A, B, C and D as weaning food to the Government and non-Governmental Organizations to alleviate protein-energy malnutrition among infants in low-income nations.

1. Introduction

Young children need nutrition care to support their growth and development from six months up to five years (Weng *et al*., 2012). The newborn depends on breast or cow's milk for up to six months (Chuwa, 2022). After that, the baby needs different food blends of complementary foods as additional nutrients for proper growth and development. Proper weaning food should be provided along with breast milk for up to 2 years. Weaning food should provide all important components like carbohydrates, proteins, fats, minerals, vitamins, water, fibre (Dewey, 2013). Energy-rich foods are required for infants in the age group of 6-9 months. Any imbalance, deficiency and excess nutrients eventually lead to malnutrition. Malnutrition is a broad term that can be defined as a deviation from proper and optimal nutritional status. Generally, it is classified as malnourished and overnourished (Chuwa *et al*., 2020). Malnutrition manifests itself as weight loss or underweight (acute malnutrition), age-related stunting or short stature (chronic malnutrition), age-related underweight or underweight, and lack or excess of minerals and vitamins. Overnutrition including obesity and diet-related non-communicable diseases (NCDs) such as diabetes, heart disease, some cancers, and stroke are malnourished (WHO, 2019).

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Worldwide, 149.2 million children under the age of 5 are stunted, 45.4 million are underweight, and 38.9 million are overweight. The number of stunted children is decreasing in all regions except Africa. Among all forms of malnutrition, protein-energy malnutrition (PEM) is the direct cause of death. Malnutrition continues to be a major public health problem in developing countries, particularly in South Asia and sub-Saharan Africa. The first 1000 days following conception (conception to 2 years post-partum) are considered a 'window of opportunity to resolve the issue of malnutrition. The combinations of different dietary patterns, food fortification and supplemental food aids have been used in different countries to curtail malnutrition in infants and children (WFP, UNICEF, 2006). The best way to prevent malnutrition is to eat a balanced, nutrient-rich diet. Immunizations and nutritional supplements for children can also reduce the burden of severe and moderate malnutrition. To address childhood malnutrition, the development of low-cost plant-based complementary foods is an effective strategy with the condition that these are affordable for most of the population. The choice of these foods considers the nutritional quality of each crop, availability as a staple and how the combination will be effective to address infant undernutrition in developing countries.

Rice is considered the best of all grains and is the staple food of more than 3 billion people around the world, including in Asia and African countries. It powers more than half of the world's population. Besides energy, it is the richest source of minerals such as calcium, magnesium, phosphorus and traces of iron, copper, zinc and manganese (Tama's *et al*., 2009). Wheat (*Triticum aestivum* L.) is the most popular grain in the world and one of the most important staple foods (Tama's *et*

al., 2009). Wheat is a rich source of carbohydrates. It also contains proteins, fats, ash, fibers, vitamins, as well as minerals such as sodium, potassium, calcium, magnesium, iron, phosphorus, copper, zinc and manganese (Kumar *et al*., 2011).

Maize is among the stable food in most African countries and is produced in large quantities all over the world. It supplies more of the world's food energy than any other crop and is a rich source of vitamins, minerals, carbohydrates, fats, oils and proteins (Kouakou *et al*., 2008).

Potato tubers (*Solanum tuberosum*) is an important vegetable which has the richest source of ascorbic acid. Ascorbic acid is found in varieties of fruits and citrus-based juices. It is an important vitamin for improving the body's immune system and preventing scurvy in infants and is also used as an antioxidant for scavenging free radicals from the human body. According to (Vreugdenhil *et al*., 2007), potatoes provide about 40 per cent of the recommended daily intake in nutrition.

Bananas are one of the most popular fruits in the world. Fruits are rich in bioactive for improving human health, and there is considerable interest in producing new products with beneficial pharmacological effects (Hamid *et al*., 2020). In terms of nutrition, bananas are one of the world's most important food crops, rich in minerals, vitamins, carbohydrates, flavonoids, and phenolic compounds (Singh *et al*., 2018) and they are one of the most cultivated and consumed with the production rate of 25 %. They are widely available and economically viable fruit crops. After harvesting, ripe bananas have a shelf-life of five to ten days. They contain varying amounts of nutrients as well as vitamins and minerals which should be utilized in value-added products (Chuwa *et al*., 2022). The essential proteins, amino acids, vitamins (A, B_6, B_{12}, 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).

The present study used low-cost available food materials such as whole wheat, rice, golden maize, potatoes and bananas to develop nutritious ready-to-reconstitute instant weaning (Gruel) mix for infants in the age group of 6-9 months. The recipes of this food can be utilized by Government, NGO's and different agencies to formulate low-cost complementary food to alleviate malnutrition in infants in the least developing countries. This research aimed to develop an energy-rich instant weaning mix using locally available food materials to alleviate malnutrition in infants aged 6-9 months.

2. Materials and Methods

A local food market, Solan, provided whole wheat, rice, golden maize, potatoes, ripe banana fruits, skimmed milk powder and sugar. 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 glass 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, College of Horticulture Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni-173230, Solan-HP, India for products formulation, sensory and nutritional quality evaluation.

2.1 Preparation of food material

2.1.1 Preparation of cereal grain flours

The whole wheat flour was prepared using the standard method given by Kurahatti (2010). The wheat grains of known weight were cleaned to remove unwanted material, washed and soaked overnight (12 h) in warm water (1:2). The method described by Bazaz *et al*. (2016) was followed for the preparation of rice flour in which the known weight of grains was cleaned thoroughly to remove extraneous material. The grains were washed, drained and soaked in warm water (1:3) overnight (12 h). The known weight of maize grains was also soaked overnight (12 h) in warm water in the ratio (1:4). The grains of each crop after soaking were spread on the trays and dried in a mechanical dehydrator at 60 ± 2°C for 4 h or till constant weight was attained. The dried grains were ground in a mixer cum grinder (Havells, Model MX-1155) and passed through a 36 mm mesh sieve to get fine and uniform flour. The flours were packed in glass jars and ALP, sealed properly, labeled and stored under ambient condition for further use. The processing steps for the preparation of cereal grain flours are depicted in Figure 1.

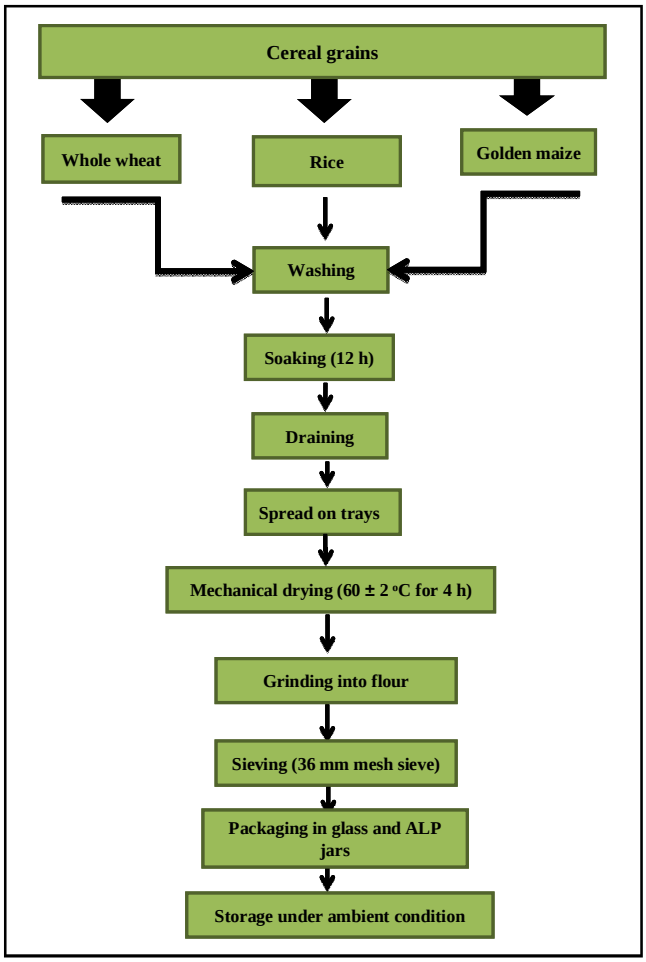

Figure 1: Unit operations for preparation of cereal grain flour.

2.1.2 Preparation of banana pulp

The procedure suggested by Chauhan and Jethva (2016) was followed for the preparation of ripe banana pulp. The ripe banana

fruits were washed, peeled and cut into slices (approximately 1 cm thick). The slices were blanched for 5 min in hot water, followed by steeping in 0.1 per cent potassium metabisulphite ($K_2S_2O_5$) solution. The treated banana slices were cooked and ground in a mixer cum grinder to form pulp which was packed in glass jars and ALP container and stored under refrigerated condition for further investigation. The unit operations for the preparation of ripe banana pulp are given in Figure 2.

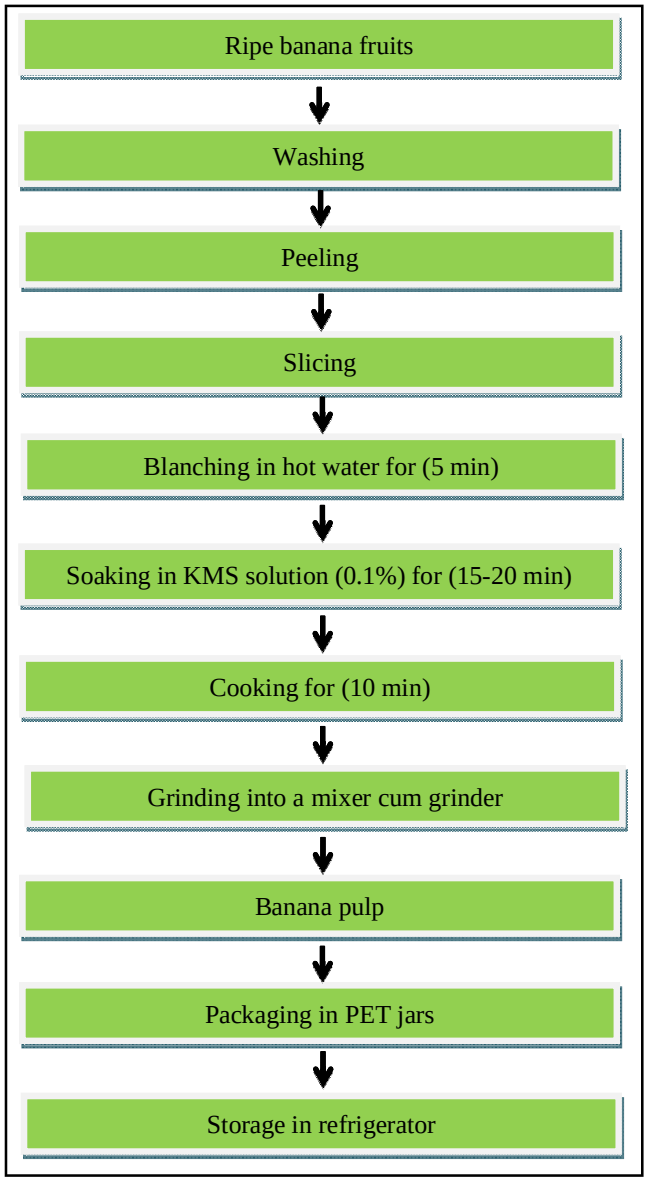

Figure 2: Unit operations for the preparation of banana pulp.

2.1.3 Preparation of mashed potatoes

The potatoes were prepared using the standard method given by Chuwa *et al.* (2020). The potatoes were washed, drained and peeled with the help of a potato peeler. The peeled potatoes were cut into small pieces of uniform size and soaked in 0.1 per cent potassium metabisulphite ($K_2S_2O_5$) solution for 15-20 min. The slices were cooked in a pressure cooker by adding water. The cooked potatoes were mashed with hand-operated steel mesh to obtain a fine mass. The mashed potatoes were packed in glass and ALP jars and stored in the refrigerator for further evaluation. The procedure for the preparation of mashed potatoes is outlined in Figure 3.

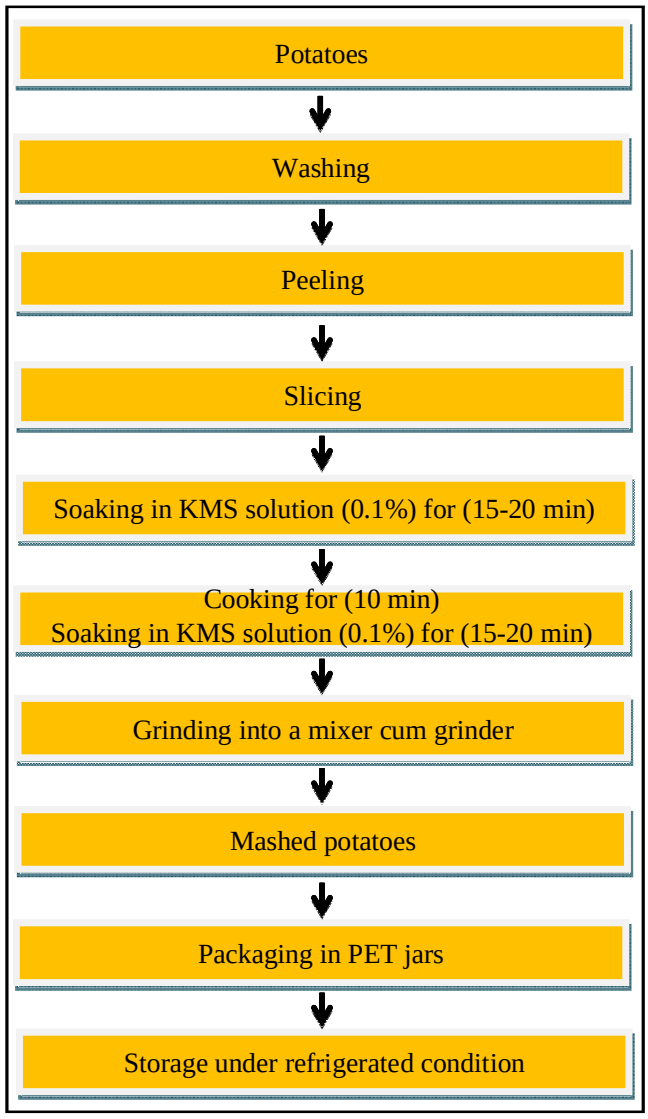

Figure 3: Unit operations for preparation of mashed potatoes.

2.1.4 Standardization of ready-to-reconstitute instant weaning (gruel) mix

2.1.4.1 Standardization of recipe for preparation of ready-to-reconstitute instant weaning (gruel) mix using whole wheat flour

Whole wheat flour was used as the main ingredient in the base recipe. While the amounts of mashed potatoes and banana pulp were varied while skimmed milk powder and sugar remain the same (Table 1). 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 whole wheat flour is mixed with the rest of the ingredients. The mixture was added to water and cooked on a medium flame for 15 min. The gruel was cooled under ambient condition and spread in aluminium trays and kept in a

dehydrator at 60 ± 2°C for 24 h till constant moisture was attained. The dried mixture (gruel) was cooled under ambient condition and ground in a mixer cum grinder (Havells, Model MX-1155) and passed through a 36 mm mesh sieve to get fine and uniform ready to reconstitute the gruel mix. The gruel mix was packed in glass jars and ALP, sealed properly, labelled and stored under ambient condition for further use. The gruel mix was reconstituted with hot water and saved for panelists to taste and rate. Based on the highest sensory scores, a panel of judges identified the best recipe and designated it as blend A for further investigation.

Table 1: Standardization of recipe for preparation of ready-to-reconstitute instant weaning (gruel) mix using whole wheat flour

Ingredients	Recipe (R_0)	Recipe (R_1)	Recipe (R_2)	Recipe (R_3)	Recipe (R_4)	Recipe (R_5)
Whole wheat flour (g)	35	40	50	55	65	70
Banana pulp (g)	35	30	25	20	15	10
Mashed potato (g)	30	30	25	25	20	20
Sugar powder (g)	60	60	60	60	60	60
Skimmed milk powder (g)	80	80	80	80	80	80

2.1.4.2 Standardization of amount of water and reconstitution time for preparation of ready-to-reconstitute instant weaning (gruel) mix for serving

The different combinations of hot water and time for reconstitution as detailed in Table 2 for the 100 g mix selected under Section 2.1.4.1 for serving were used. The mix of different combinations was prepared by adding the prescribed amount of hot water with constant stirring to get a smooth consistency. The instant weaning (gruel) mix was saved for the panelists for sensory evaluation. The best combination was chosen and utilized in subsequent experiments to make it ready to reconstitute the instant weaning (gruel) mix.

Table 2: Standardization of amount of water and reconstitution time for preparation of ready-to-reconstitute instant weaning (gruel) mix for serving

Quantity of mix (g)	Amount of hot water (ml)	Time of reconstitution (minutes)
100	50	2
100	75	3
100	100	4
100	125	5

Table 3: Standardization of recipe for preparation of ready-to-reconstitute instant weaning (gruel) mix using whole wheat flour supplemented with rice flour

Ingredients	Recipe (R_0)	Recipe (R_1)	Recipe (R_2)	Recipe (R_3)	Recipe (R_4)	Recipe (R_5)
Whole wheat flour (g)	50	40	30	20	10	0
Rice flour (g)	0	10	20	30	40	50
Banana pulp (g)	25	25	25	25	25	25
Mashed potato (g)	25	25	25	25	25	25
Sugar powder (g)	60	60	60	60	60	60
Skimmed milk powder (g)	80	80	80	80	80	80

Table 4: Standardization of ready-to-reconstitute instant weaning (gruel) mix supplemented with golden maize flour

Ingredients	Recipe (R_0)	Recipe (R_1)	Recipe (R_2)	Recipe (R_3)	Recipe (R_4)	Recipe (R_5)
Whole wheat flour (g)	50	40	30	20	10	0
Golden maize flour (g)	0	10	20	30	40	50
Banana pulp (g)	25	25	25	25	25	25
Mashed potato (g)	25	25	25	25	25	25
Sugar powder (g)	60	60	60	60	60	60
Skimmed milk powder (g)	80	80	80	80	80	80

Table 5: Sensory scores of ready-to-reconstitute instant weaning (gruel) mix supplemented with rice and golden maize flour

Recipes	Colour	Texture	Taste	Overall acceptability
R_0	7.60 ± 0.12^e	7.60 ± 0.11^e	7.60 ± 0.17^e	7.60 ± 0.72^e
R_1	8.40 ± 0.18^c	8.23 ± 0.28^c	8.48 ± 0.22^b	8.00 ± 0.19^d
R_2	8.15 ± 0.16^d	8.48 ± 0.17^b	8.25 ± 0.14^c	8.30 ± 0.08^c
R_3	8.50 ± 0.04^b	8.13 ± 0.36^d	8.63 ± 0.35^a	8.55 ± 0.05^b
R_4	8.88 ± 0.09^a	8.55 ± 0.05^a	8.03 ± 0.12^d	8.80 ± 0.19^a
R_5	7.63 ± 0.14^e	7.25 ± 0.08^f	7.50 ± 0.58^f	7.40 ± 0.06^f
$CD_{0.05}$	**0.62**	**0.65**	**0.66**	**0.58**

R_0 (50% wheat flour + 25% banana pulp + 25% mashed potatoes); T_1 (40% wheat flour + 5% rice flour + 5% golden maize flour + 25% banana pulp + 25% mashed potatoes); R_2 (30% wheat flour + 10% rice flour + 10% golden maize flour + 25% banana pulp + 25% mashed potatoes); R_3 (20% wheat flour + 15% rice flour + 15% golden maize flour + 25% banana pulp + 25% mashed potatoes); R_4 (10% wheat flour + 20% rice flour + 20% golden maize flour + 25% banana pulp + 25% mashed potatoes); R_5 (0% wheat flour + 25% rice flour + 25% golden maize flour + 25% banana pulp + 25% mashed potatoes)Data represented in Table 5 are the average pooled values (mean ± SD), the value with the same lowercase letter on superscript in the same column are non-significant at 0.05% level of significance.

2.1.4.3 Standardization of ready-to-reconstitute instant weaning (gruel) mix using whole wheat flour supplemented with rice flour

The standard recipe under Section 2.1.4.1 was used for the preparation of ready-to-reconstitute instant weaning (gruel) mix for serving by replacing whole wheat flour with rice flour at different proportions (Table 3) and keeping other ingredients constant. A panel of judges tasted the prepared weaning mix and gave them a rating. The chosen recipe is referred to as blend B for further investigations.

2.1.4.4 Standardization of ready-to-reconstitute instant weaning (gruel) mix using whole wheat flour supplemented with golden maize flour

To conduct this experiment, the whole wheat flour of the standard recipe selected under Section 2.1.4.1 was replaced with golden maize flour in varied ratios (Table 4). A panel of judges assessed the gruel mix for sensory qualities. The selected recipe was taken as blend C for further studies.

2.1.4.5 Standardization of ready-to-reconstitute instant weaning (gruel) mix using whole wheat flour supplemented with rice and golden maize flour

The gruel mix recipe standardized under section 2.1.4.1 was taken as the standard recipe to conduct this experiment. The whole wheat flour was replaced with rice and golden maize flour as shown in Table 5. The best recipe was selected and referred to as blend D for further investigations.

2.2 Chemical analysis

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

2.3 Sensory evaluation

Ready to reconstitute instant weaning (gruel) mix made by adding 75 ml of hot water to 100 g of mix with constant stirring for 3 minutes till became smooth. Panelists were asked to score the gruel mix 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 determine 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 used to separate the means for comparison.

3. Results

3.1 Standardization of recipe for preparation of ready-to-reconstitute instant weaning (gruel) mix using whole wheat flour

The recipe for the reread-to-reconstitute instant weaning (gruel) mix was standardized by comparing the results of several treatment combinations (Table 1). The sensory evaluation of the ready-to-reconstitute instant weaning (gruel) mix for serving was conducted by a panel of judges, and the findings are shown in Table 6. The highest sensory scores for colour were recorded in R_2 (8.76), followed by R_4 (7.72), R_1 (7.62), R_0 (7.39), R_3 (7.29) and R_5(7.00). In texture, the highest sensory scores were recorded in R_2 (8.78), followed by R_3 and R_5 (7.73), R_4 (7.70), R_1 (7.53) and R_0 (7.39). For taste, the highest sensory scores were recorded in R_2 (8.50), followed by R_4 (7.51), R_1 (7.46), R_3 (7.45), R_0 (7.39) and R_5 (7.25). Overall acceptability, the highest sensory scores were recorded in R_2 (8.75), followed by R_4 (7.64), R_3 (7.61), R_2 (7.49), R_0 (7.39) and R_5 (7.04). Statistical analysis recorded significant differences in sensory scores of all the parameters. For the preparation of ready-to-reconstitute instant weaning (gruel) mix for serving the amount of hot water and

time for reconstitution were standardized by comparing different combinations (Table 2). The best combination was found to be 75 mL of hot water, for a mix of 100 g mix in 3 min. This combination was used for the preparation of ready-to-reconstitute instant weaning (gruel) mix for serving in the base recipe and other subsequent experiments.

Table 6: Sensory scores of standardized recipe for preparation of ready-to-reconstitute instant weaning (gruel) mix using whole wheat flour

Recipes	Colour	Texture	Taste	Overall acceptability
R_0	7.39 ± 0.14^d	7.39 ± 0.19^e	7.39 ± 0.06^c	7.39 ± 0.32^c
R_1	7.62 ± 0.06^c	7.53 ± 0.33^d	7.46 ± 0.09^b	7.49 ± 0.18^c
R_2	8.76 ± 0.22^a	8.78 ± 0.15^a	8.50 ± 0.21^a	8.75 ± 0.55^a
R_3	7.29 ± 0.17^e	7.73 ± 0.16^b	7.45 ± 0.35^b	7.61 ± 0.09^b
R_4	7.72 ± 0.11^b	7.70 ± 0.12^c	7.51 ± 0.10^b	7.64 ± 0.10^b
R_5	7.00 ± 0.32^f	7.73 ± 0.08^b	7.25 ± 0.37^c	7.04 ± 0.13^d
CD $_{0.05}$	**1.03**	**1.07**	**0.94**	**0.81**

R_0 (35% wheat flour + 35% banana pulp + 30% mashed potatoes); R_1 (40% wheat flour + 30% banana pulp + 30% mashed potatoes; R_2 (50% wheat flour+ 25% banana pulp + 25% mashed potatoes); R_3 (55% wheat flour + 20% banana pulp + 25% mashed potatoes); R_4 (65% wheat flour + 15% banana pulp + 20% mashed potatoes); R_5 (70% wheat flour + 10% banana pulp + 20% mashed potatoes). Data represented in Table 6 are the average pooled values (mean ± SD), the value with same lowercase letter on superscript in the same column are non-significant at 0.05% level of significance.

3.2 Standardization of ready-to-reconstitute instant weaning (gruel) mix using whole wheat flour supplemented with rice flour

The recipe for making an 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 were recorded in R_4 (8.50), followed by R_5 (7.88), R_0 (7.60), R_1 and R_3 (7.38) and R_2 (7.20). In texture, the highest sensory scores were recorded in R_4 (8.45), followed by R_5 (7.80), R_0 (7.60), R_1 and R_3 (7.33) and R_2 (7.15). For taste, the highest sensory scores were recorded in R_4 (8.90), followed by R_3 (8.53), R_2 (8.28), R_5 (8.00), R_1 (7.83) and R_0 (7.60). Overall acceptability, the highest sensory scores were recorded in R_4 (8.95), followed by R_3 (8.58), R_2 (8.33), R_5 (8.05), R_1 (7.88) and R_0 (7.60). Statistical analysis recorded significant differences in sensory scores of all the parameters.

Table 7: Sensory scores of ready-to-reconstitute instant weaning (gruel) mix supplemented with rice flour

Recipes	Colour	Texture	Taste	Overall acceptability
R_0	7.60 ± 0.16^c	7.60 ± 0.16^c	7.60 ± 0.16^f	7.60 ± 0.16^f
R_1	7.38 ± 0.25^d	7.33 ±0.27^d	7.83 ± 0.11^e	7.88 ± 0.10^e
R_2	7.20 ± 0.32^e	7.15 ± 0.33^e	8.28 ± 0.57^c	8.33 ± 0.52^c
R_3	7.38 ± 0.21^d	7.33 ± 0.23^d	8.53 ± 0.33^b	8.58 ± 0.28^b
R_4	8.50 ± 0.24^a	8.45 ±0.23^a	8.90 ± 0.06^a	8.95 ± 0.05^a
R_5	7.88 ± 0.29^b	7.80 ±0.33^b	8.00 ± 0.41^d	8.05 ± 0.37^d
CD $_{0.05}$	**0.66**	**0.68**	**0.84**	**0.79**

R_0 (50% wheat flour + 25% banana pulp + 25% mashed potatoes); R_1 (40% wheat flour + 10% rice flour + 25% banana pulp + 25% mashed potatoes); R_2 (30% wheat flour + 20% rice flour + 25% banana pulp + 25% mashed potatoes); R_3 (20% wheat flour + 30% rice flour + 25% banana pulp + 25% mashed potatoes); R_4 (10% wheat flour + 40% rice flour+ 25% banana pulp + 25% mashed potatoes); R_5 (0% wheat flour + 50% rice flour + 25% banana pulp + 25% mashed potatoes) Data represented in Table 7 are the average pooled values (mean ± SD), the value with same lower case letter on superscript in the same column are non-significant at 0.05% level of significance.

3.3 Standardization of ready-to-reconstitute instant weaning (gruel) mix supplemented with golden maize 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 were recorded in R_3 (8.93), followed by R_2 (8.48), R_1 (8.18), R_4 (8.10), R_0 (7.60) and R_5 (7.25). In texture, the highest sensory scores were recorded in R_3 (8.85), followed by R_2 (8.40), R_1 (8.10), R_4 (8.03), R_0 (7.60) and R_5 (7.60). For taste, the highest sensory scores were recorded in R_3 (8.88), followed by R_2 (8.53), R_1 (8.03), R_0 (7.60), R_4 (7.45) and R_5 (7.08). Overall acceptability, the highest sensory scores recorded in R_3 (8.80), followed by R_2 (8.55), R_1 (8.03), R_0 (7.60), R_4 (7.40) and R_5 (7.08). Statistical analysis recorded significant differences in sensory scores of all the parameters.

Table 8: Sensory scores of ready-to- reconstitute instant weaning (gruel) mix supplemented with golden maize flour

Recipes	Colour	Texture	Taste	Overall acceptability
R_0	7.60 ± 0.03^d	7.60 ± 0.19^d	7.60 ± 0.24^d	7.60 ± 0.07^d
R_1	8.18 ± 0.08^c	8.10 ± 0.33^c	8.03 ± 0.19^c	8.03 ± 0.09^c
R_2	8.48 ± 0.17^b	8.40 ± 0.07^b	8.53 ± 0.05^b	8.55 ± 0.38^b
R_3	8.93 ± 0.31^a	8.85 ± 0.08^a	8.88 ± 0.37^a	8.80 ± 0.31^a
R_4	8.10 ± 0.22^c	8.03 ± 0.55^c	7.45 ± 0.16^e	7.40 ± 0.15^e
R_5	7.25 ± 0.15^e	7.18 ± 0.11^e	7.08 ± 0.11^f	7.08 ± 0.16^f
CD $_{0.05}$	**0.72**	**0.77**	**0.68**	**1.06**

R_0 (50% wheat flour + 25% banana pulp + 25% mashed potatoes); R_1 (40% wheat flour + 10% rice flour+ 25% banana pulp + 25% mashed potatoes); R_2 (30% wheat flour + 20% rice flour+ 25% banana pulp + 25% mashed potatoes); R_3 (20% wheat flour + 30% golden maize flour+ 25% banana pulp + 25% mashed potatoes); R_4 (10% wheat flour + 40% rice flour+ 25% banana pulp + 25% mashed potatoes); R_5 (0% wheat flour + 50% rice flour+ 25% banana pulp + 25% mashed potatoes)Data represented in Table 8 are the average pooled values (mean ± SD), the value with the same lowercase letter on superscript in the same column are non-significant at 0.05% level of significance.

3.4 Standardization of ready-to-reconstitute instant weaning (gruel) mix supplemented with rice and golden maize flour

The recipe for the preparation of ready-to-reconstitute instant weaning (gruel) mix supplemented with rice and golden maize flour (Table 9). The prepared ready-to-reconstitute instant weaning (gruel) mix for serving was subjected to a panel of judges for sensory evaluation and the results are depicted in Table 9. The highest sensory scores for colour were recorded in R_4 (8.88), followed by R_3 (8.50), R_1 (8.40), R_2 (8.15), R_5 (7.63) and R_0 (7.60). In texture, the highest sensory scores were recorded in R_4 (8.55), followed by R_2 (8.48), R_1 (8.23), R_3 (8.13), R_0 (7.60) and R_5 (7.25). For taste, the highest sensory scores were recorded in R_3 (8.63), followed by R_1 (8.48), R_2 (8.25), R_3 (8.03), R_0 (7.60) and R_5 (7.60). Overall acceptability, the highest sensory scores were recorded in R_4 (8.80), followed by R_3 (8.55), R_2 (8.30), R_1 (8.00), R_0 (7.60) and R_3 (7.40). Statistical analysis recorded significant differences in sensory scores of all the parameters.

Table 9: Sensory scores of ready-to-reconstitute instant weaning (gruel) mix supplemented with rice and golden maize flour

Recipes	Colour	Texture	Taste	Overall acceptability
R_0	7.60 ± 0.12^e	7.60 ± 0.11^e	7.60 ± 0.17^e	7.60 ± 0.72^e
R_1	8.40 ± 0.18^c	8.23 ± 0.28^c	8.48 ± 0.22^b	8.00 ± 0.19^d
R_2	8.15 ± 0.16^d	8.48 ± 0.17^b	8.25 ± 0.14^c	8.30 ± 0.08^c
R_3	8.50 ± 0.04^b	8.13 ± 0.36^d	8.63 ± 0.35^a	8.55 ± 0.05^b
R_4	8.88 ± 0.09^a	8.55 ± 0.05^a	8.03 ± 0.12^d	8.80 ± 0.19^a
R_5	7.63 ± 0.14^e	7.25 ± 0.08^f	7.50 ± 0.58^f	7.40 ± 0.06^f
CD $_{0.05}$	**0.62**	**0.65**	**0.66**	**0.58**

R_0 (50% wheat flour + 25% banana pulp + 25% mashed potatoes); R_1 (40% wheat flour + 5% rice flour + 5% golden maize flour + 25% banana pulp + 25% mashed potatoes); R_2 (30% wheat flour + 10% rice flour + 10% golden maize flour + 25% banana pulp + 25% mashed potatoes);R_3 (20% wheat flour + 15% rice flour + 15% golden maize flour + 25% banana pulp + 25% mashed potatoes);R_4 (10% wheat flour + 20% rice flour + 20% golden maize flour + 25% banana pulp + 25% mashed potatoes); R_5 (0% wheat flour + 25% rice flour + 25% golden maize flour + 25% banana pulp + 25% mashed potatoes)Data represented in Table 9 are the average pooled values (mean ± SD), the value with the same lowercase letter on superscript in the same column are non-significant at 0.05% level of significance.

3.5 Chemical characteristics of ready-to-reconstitute instant weaning (gruel) mix

The ready-to-reconstitute instant weaning (gruel) mix selected from the base recipe (Blend A), ready-to-reconstitute instant weaning (gruel) mix supplemented with rice flour (Blend B), ready-to-reconstitute instant weaning (gruel) mix supplemented with golden maize flour (Blend C) and ready-to-reconstitute instant weaning (gruel) mix supplemented with rice and golden maize flour (Blend D) were analyzed for different chemical characteristics (Table 10).

Table 10: Chemical characteristics of ready-to-reconstitute instant weaning (gruel) mix

Parameters	Recipes			
	Blend A	Blend B	Blend C	Blend D
Moisture (%)	4.05 ± 0.29[a]	4.06 ± 0.28[a]	4.04 ± 0.34[a]	4.08 ± 0.37[a]
Crude protein (%)	12.93 ± 1.75[a]	11.48 ± 1.78[b]	11.95 ± 1.25[b]	11.64 ± 0.61[b]
Crude fat (%)	3.97 ± 0.02[b]	3.49 ± 0.03[b]	4.15 ± 0.04[a]	3.92 ± 0.09[b]
Crude fibre	5.12 ± 0.01[b]	4.79 ± 0.08[d]	5.88 ± 0.31[a]	5.25 ± 0.39[c]
Total carbohydrates (%)	74.26 ± 1.96[c]	76.38 ± 0.08[a]	75.22 ± 2.12[b]	75.69 ± 1.16[b]
β-carotene (mg/100 g)	1.22 ± 0.01[a]	1.13 ± 0.01[b]	1.32 ± 0.02[a]	1.18 ± 0.02[b]
Ash (%)	4.96 ± 0.34[a]	4.80 ± 0.04[b]	4.93 ± 0.08[a]	4.82 ± 0.07[b]
Total energy (Kcal/100 g)	363.72 ± 4.12[a]	363.11 ± 1.65[a]	361.41 ± 3.99[b]	363.26 ± 1.73[a]

R_0 (50% wheat flour + 25% banana pulp + 25% mashed potatoes); R_1 (40% wheat flour + 10% rice flour+ 25% banana pulp + 25% mashed potatoes); R_2 (30% wheat flour + 20% rice flour + 25% banana pulp + 25% mashed potatoes); R_3 (20% wheat flour + 30% golden maize flour + 25% banana pulp + 25% mashed potatoes); R_4 (10% wheat flour + 40% rice flour + 25% banana pulp + 25% mashed potatoes); R_5 (0% wheat flour + 50% rice flour + 25% banana pulp + 25% mashed potatoes) Data represented in Table 10 are the average pooled values (mean ± SD), the value with the same lowercase letter on superscript in the same column are non-significant at 0.05% level of significance.

4. Discussion

4.1 Sensory scores of ready-to-reconstitute instant weaning (gruel) mix using whole wheat flour

In Table 6, the highest scores for colour, texture, taste and overall acceptability were noted as 8.76, 8.78, 8.50, and 8.75, respectively in weaning mix of recipe R_2. Based on the highest sensory scores, R_2 was selected and referred to as Blend A (50% wheat flour + 25% banana pulp + 25% mashed potatoes) for conducting further experiments.

4.2 Sensory scores of ready-to-reconstitute instant weaning (gruel) mix using whole wheat flour supplemented with rice flour

Data in Table 7 revealed significantly higher scores for colour (8.50), texture (8.45), taste (8.90) and overall acceptability (8.95) were awarded to treatment R_4. 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 R_4 (10% wheat flour + 40% rice flour + 25% banana pulp + 25% mashed potatoes) was selected on the basis of sensory scores and referred to as Blend B for further evaluation.

4.3 Sensory scores of ready-to-reconstitute instant weaning (gruel) mix using whole wheat flour supplemented with golden maize flour

The data (Table 8) showed significant differences among all the different treatments. It can be seen that the treatment R_3 got the highest overall acceptability score of 8.80, followed by 8.55 (R_2), 8.03 (R_1), 7.60 (R_0), 7.40 (R_4) and 7.08 (R_5). The ready-to-reconstitute instant weaning (gruel) mix of recipe R_3 obtained 8.93, 8.85, 8.88 and 8.80 scores for colour, texture, taste and overall acceptability, respectively. Keeping in view the highest overall acceptability scores, treatment R_3 was selected and referred to as Blend C (20% wheat flour + 30% golden maize flour + 25% banana pulp + 25% mashed potatoes) for further evaluation.

4.4 Sensory scores of ready-to-reconstitute instant weaning (gruel) mix using whole wheat flour supplemented with rice and golden maize flour

Significant differences in scores of various treatments can be seen from the data (Table 9). The highest overall acceptability score of 8.80 was given to R_4, followed by R_3 (8.55), R_2 (8.30), R_1 (8.00), R_0 (7.60) and R_5 (7.40). The scores obtained by treatment R_4 for colour, texture and taste were 8.88, 8.55, 8.63, 8.80 and 8.80, respectively. Based on the highest overall acceptability score, treatment R_4 was selected and referred to as Blend D (10% wheat flour + 20% rice flour + 20% golden maize flour + 25% banana pulp + 25% mashed potatoes) for conducting further studies.

4.5 Chemical characteristics of ready-to-reconstitute instant weaning (gruel) mix

The ready-to-reconstitute instant weaning (gruel) mix selected from the base recipe (Blend A), ready-to-reconstitute instant weaning (gruel) mix supplemented with rice flour (Blend B), ready-to-reconstitute instant weaning (gruel) mix supplemented with golden maize flour (Blend C) and ready-to-reconstitute instant weaning (gruel) mix supplemented with rice and golden maize flour (Blend D) were analyzed for different chemical characteristics (Table 10). The range of moisture content in this study is similar to the range of Khatun *et al.* (2013) and Ogbonna *et al.* (2010), while lower than the range analyzed by Asare *et al.* (2004) and those suggested by Codex Alimentarius (CODEX, 1985). The proper drying of gruel mix and packaging immediately of the mixed powder in ALP and glass jars maybe prevent the absorption of moisture from the environment in the present investigation. The lower the moisture content of the instant muffin mix, the better the shelf life of product quality, as chemical and physical deterioration is less likely at such low moisture content (Intipunya and Bhandari, 2010). Blend A with 50% whole wheat flour had a significantly higher amount of protein as compared to other Blends. The increase in protein content may be due addition of skimmed milk powder and high protein in whole wheat as compared to rice and golden maize. According to US Dairy Export Council (2005), skimmed milk powder has a protein content ranging from 34 -37 %. The protein analyzed in this study was lower than that

investigated by Haque *et al*. (2013) and Satter *et al*. (2013). Nutritionally, protein content in all Blends is above the amount recommended for daily intake (RDI) for protein needed from complementary foods by Dewey and Adu-Afarwuah (2008) for infants and children in the age group of 6 to 8 months. The range of fat obtained in this research study is lower than the range given by Haque *et al*. (2013) and in the range of Khatun *et al*. (2013). This range is significantly higher than the limits indicated for 9-11-month-old infants' daily lipid needs (Dewey and Adu-Afarwuah, 2008). The amount of crude fibre range of the present study surpasses the amount investigated by Satter *et al*. (2013), Haile and Getahun (2018) and in the range of Prasanna *et al*. (2020) in the instant muffin mix. The results of the present study for total carbohydrates are higher than the range of Khatun *et al*. (2013) and Bekele and Shiferaw (2020). The higher carbohydrate content in the current study may be due to high glycemic index foods (white, rice and golden maize used in the formulation of instant weaning (gruel) mix. The results for β-carotene are lower than the value recommended by WHO (2001); and ICMR (2010), for β-carotene intake per day, *i.e*., 4.20 mg/day for infants and children in the age group of 7-12 months. The children will get more vitamin A from the mother's breast milk to meet the daily requirement for vitamin A. The range of ash content in the present study is in line with the results analyzed by Pandey and Singh (2019) and Prasanna *et al*. (2020), but lower than the range given by Bamisaye *et al*. (2014). The total energy content in the current study on Blend A and B differs significantly from Blend C and D. These results are lower in the range of Bekele and Shiferaw (2020), but meet the daily requirement of energy intake for infants in the age group of 6-9 months as recommended by Butte (1999) and above the recommendation of ICMR (2010) for children (6-12 months).

5. Conclusion

To address the challenges of malnutrition in low-income countries the development of a weaning mix using local food materials available in the community will be sustainable solution as compared with other strategies. The ready-to-reconstitute instant weaning (gruel) mix formulated in this research could be used to combat malnutrition in infants in low income families. It contains nutrient which mostly satisfies the daily requirement of infants such as protein, fat, fibre, carbohydrates, ash and total energy. The mix, therefore recommended to Government and non-Governmental Organizations (NGOs) to alleviate malnutrition in young children.

Acknowledgements

We would like to express our deepest appreciation to Dr Yashwant Singh Parmar University College of Horticulture and Forestry in Himachal Pradesh, India, for providing all of the necessary facilities and support for this study and to the Director General Dr Geofrey Mkamilo from Tanzania Agricultural Research Institute for permission to conduct this research work.

Conflict of interest

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

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Citation **Caresma Chuwa, Paul Saidia and Anju K. Dhiman (2022). Formulation, nutritional and sensory evaluation of ready-to-reconstitute instant weaning mix. Ann. Phytomed., 11(2):602-611. http://dx.doi.org/10.54085/ap.2022.11.2.74.**