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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(12): 2259-2265

www.thepharmajournal.com
Received: 20-10-2021
Accepted: 22-11-2021

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Development and nutritional evaluation of ready-to-cook porridge mix as a weaning food for infants

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Abstract
The Ready-To-Cook Porridge Mix (RTCPM) is a dry mixture of food ingredients used in the preparation of ready to serve porridge. In the current study, RTCPM was made by substituting broken wheat with germinated chickpea and green gram flour at different proportions of 100:00, 90:10, 80:20, 70:30, 60:40 and 50:50 respectively. Sugar, refined oil and ripe pumpkin powder were kept constant and added to each recipe during the preparation of porridge for serving. The porridge was prepared and subjected to a panel of ten judges for sensory evaluation. The best recipes (T_0, T_1 &T_2) i.e. base recipe (broken wheat with ripe pumpkin powder) control, broken wheat replaced with germinated chickpea and broken wheat substituted with germinated chickpea four were chosen and products were prepared, packed in glass jars and laminated aluminium pouches (ALP) for nutritional quality evaluation. Based on the statistical analysis, significant differences were observed in all sensory parameters in RTCPM for serving. Recipe V (T_2) awarded the highest sensory parameters for colour (8.38), texture (8.83), taste (8.85) and overall acceptability (8.88). In nutritional characteristics recipe V (T_2) had highest chemical parameters closely to recipe V (T_1) for moisture of 2.91 and 2.94, ash of 2.28 and 2.36, crude fibre of 3.15 and 2.98, crude fat of 4.89 and 4.92, crude protein of 17.29 and 18.23 and total carbohydrates 70.58 and 69.53 per cent. The β-carotene 3.06 and 2.44 mg/100 g and total energy of 376.35 and 376.38 Kcal/100 g were recorded in T_1 and T_2, respectively. The overall results of this study demonstrated that the RTCPM could be used as a nutritious weaning food for infants to ameliorate malnutrition in low income countries.

Keywords: Broken wheat; germinated green gram flour; germinated chickpea flour; ready-to-cook porridge mix; nutritional quality

1. Introduction
Malnutrition is a condition caused by a shortage of nutrients in the body. Children under the age of five are mostly vulnerable, particularly in underdeveloped nations. Stunting (a chronic form of malnutrition), wasting, and underweight are three observable signs in youngsters (acute forms of malnutrition). These are the most prevalent health-related conditions among young children in low-income nations, particularly among children from low-income families with other socioeconomic challenges (Vollmer *et al*., 2014) [1]. Marasmus, kwashiorkor, anaemia, rickets, and blindness are all common among malnourished children (Chuwa *et al*., 2020) [2]. Due to a lack of body immunity stability, malnourished children have a higher chance of dying from diarrhoea, malaria, or pneumonia than children with ideal nutritional condition (Chuwa *et al*., 2020; Masanja *et al*., 2008) [2, 3]. Malnutrition, as previously noted, is ubiquitous and comes in various forms (under and over-nutrition), and no place in the world is immune in some way. It can affect people from infancy to old age, people from all walks of life, affluent and poor people, men and women.
The main risk factors for malnutrition include nutritional inadequacy due to insufficient food intake during the complementary period (6-23 months), illnesses, and impairments (Kumssa *et al*., 2015) [4]. Malnutrition is caused by a variety of factors that vary by area, including culture, beliefs, knowledge, skills, attitudes, and practices, particularly infant and young child feeding (IYCF) practices (De Onis and Branca, 2016) [5]. Micronutrient deficiencies cause malnutrition in children under the age of five, resulting in anaemia, rickets, clouded eyesight, and weakened immune systems, exposing them to a high risk of morbidity and mortality. Other conditions that can impact both adults and children include mild and severe underweight, overweight, and obesity. Malnutrition is a severe health concern that affects newborns and young children in impoverished nations (Black *et al*., 2013; Steiber *et al*., 2015) [6, 7].
Protein-energy malnutrition, iron deficiency, vitamin A deficiency, iodine deficiency disorders, and zinc deficiency have been identified as prevalent forms of malnutrition by the WHO, 2020) [8].

Even if clinically normal, a consumer may be malnourished if their diet lacks these essential nutrients. Protein-energy malnutrition, more than any other type of malnutrition, is the leading cause of death in children under the age of five. For optimal growth and development, an infant's nutritional status becomes critical (physical and mental).

A growing child requires macro and micronutrients such as calcium, potassium, sodium, iron, zinc, iodine, magnesium, vitamin A, vitamin B, vitamin C, vitamin E and vitamin K, in addition to energy and protein. These are vital minerals and vitamins that must be included in one's daily diet and are necessary for the proper functioning of the body's metabolism and systems. Similarly, grains and legumes are important sources of energy, protein, dietary fibre, vitamins, minerals, and phytochemicals in children, as well as boosting their bioavailability (Gatahun *et al*., 2015; Shiriki *et al*., 2015) [9, 10].

These requirements are met through the consumption of foods such as cereals, legumes, fruits, vegetables and skim milk powder, which should be incorporated in various additional food formulations for infants and children. Using a combination of dietary variety, food fortification, and supplemental food aid, different countries have successfully reduced newborn and young child hunger and malnutrition (World Food Programme and UNICEF, 2006) [11]. Plant-based supplemental foods can be a successful technique for reducing childhood malnutrition in underdeveloped nations if the majority of the population can afford them. One strategy to reduce malnutrition in a sustainable fashion is to make diversified complementary foods that are both hygienically and nutritionally adequate to meet the daily recommended dietary needs of fast-growing infants and young children utilizing locally available traditional and indigenous foods (World Health Organization, 2008) [12]. The study's major goal was to create a wheat-based complementary food (RTCPM) for newborns in underdeveloped countries with higher protein content (from germinated green gramme and chickpea flour). Furthermore, the findings of this study will aid in the modification and diversification of traditional weaning food recipes offered to newborns and children in low income nations.

2. Materials and Methods

Broken wheat, green gram, *desi* chickpea, ripe pumpkin fruits, refined oil and sugar were procured from a local food market, Solan. All chemicals and reagents used in this study were of analytical grade and were purchased from Loba Chemie, International Scientific and Surgicals, Solan (HP). The packaging material such as glass jars and Aluminium Laminated Pouches (ALP) were also procured from the same dealer. All treatments and analyzes were done using three replicates and results were reported on a dry weight basis.

2.1 Preparation of food material

2.1.1 Broken wheat

The preparation of broken wheat was done following (Ikese *et al*., 2016) [13].

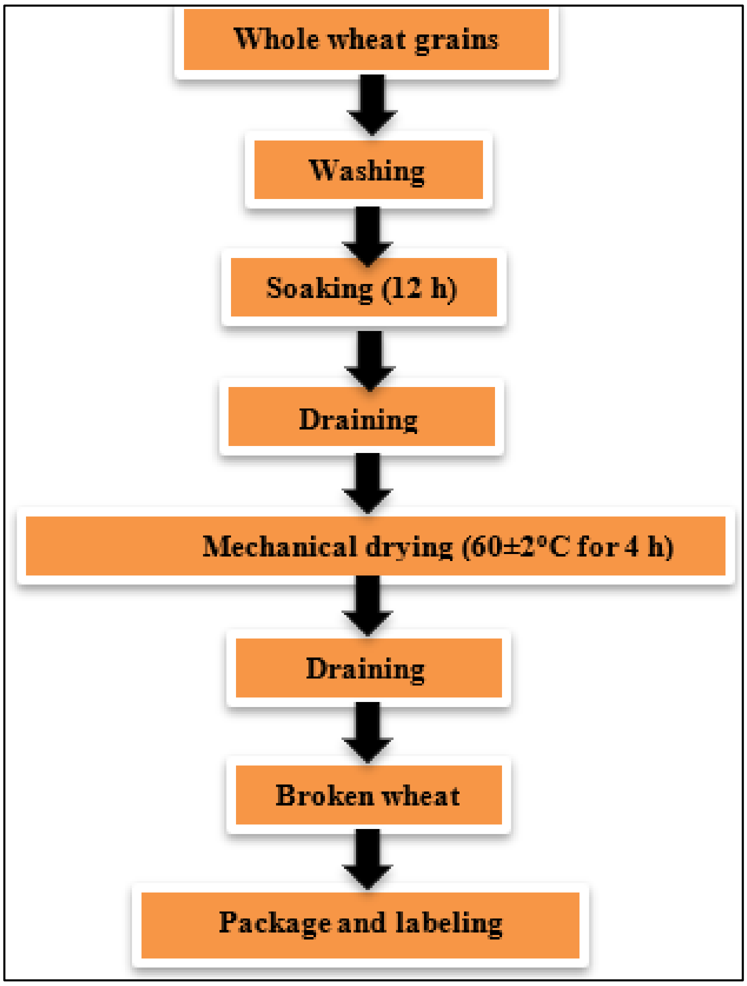

Fig 1: Unit operations for the preparation of broken wheat

2.1.2 Legumes flour
The preparation of germinated green gram flour was followed by method suggested by Dipnaik and Bathere (2017) [14] while Desalegn (2015) [15] described the procedures for the preparation of germinated chickpea four.

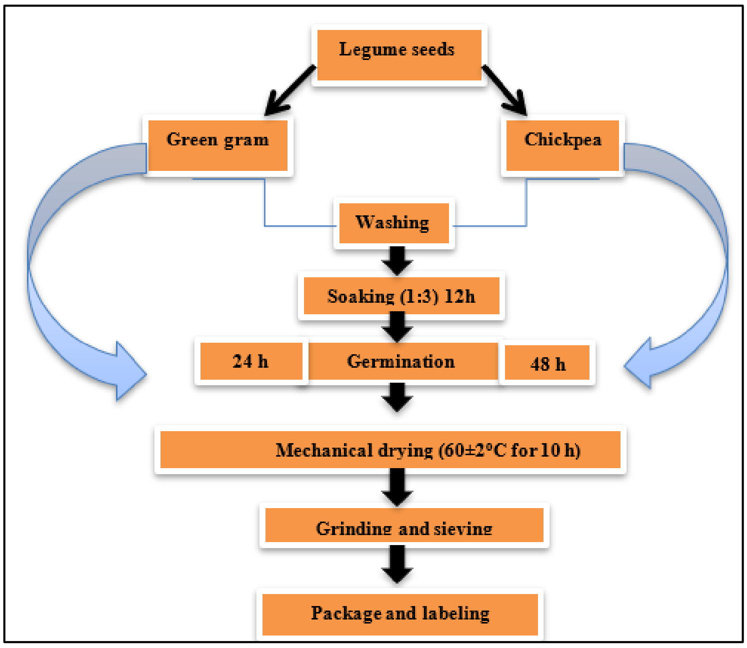

Fig 2: Unit operations for the preparation of legume flours

2.1.3 Ripe pumpkin powder
The methods demonstrated by Dhiman *et al*. (2017) [16] used for the preparation of ripe pumpkin powder.

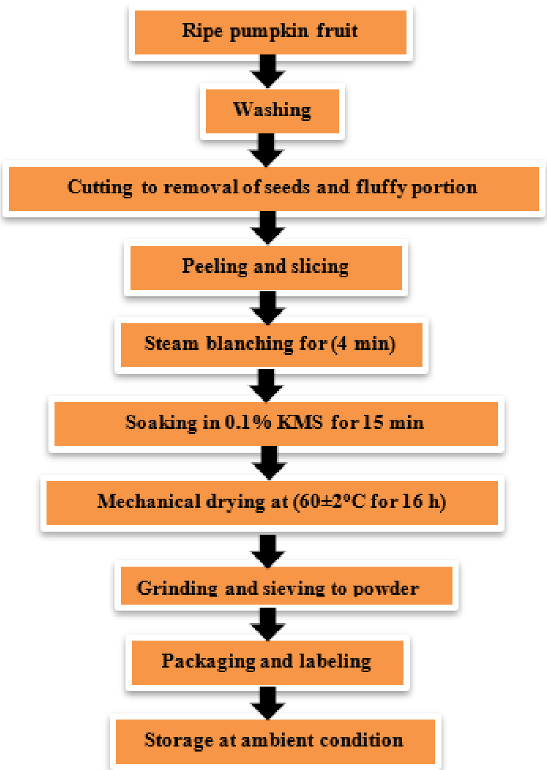

Fig 3: Unit operations for the preparation of pumpkin powder

2.2 Products formulation
2.2.1 Formulation of a base recipe
The broken wheat was standardized by formulating six recipes with various proportion of ripe pumpkin powder and keeping constant the rest of the ingredients. The time for cooking and the amount of water used was standardized after several preliminary trials. The best recipe (recipe III) was awarded the highest overal sensory parameters was used as standard recipe (Table 1) for the preparation of RTCPM for serving and storage and reffered to as T_0

Table 1: The broken wheat Ready-To-Cook Porridge

	Treatments					
Ingredients	**Recipe I (T_0)**	**Recipe II (T_1)**	**Recipe III (T_2)**	**Recipe IV (T_3)**	**Recipe V (T_4)**	**Recipe VI (T_5)**
Broken wheat (g)	100	100	100	100	100	100
Pumpkin powder (g)	15	20	25	30	35	40
Sugar powder (g)	58	58	58	58	58	58
Refined oil (mL)	16	16	16	16	16	16

2.2.2 Formulation of broken wheat RTCPM replaced with germinated green gram flour
The broken wheat standardized in (Table 1) was substituted with germinated green gram flour at different ratios (Table 2) while other ingredients were kept as constant. The (recipe V) received highest sensory scores was taken for further investigation and reffered to as T_1

Table 2: The broken wheat Ready-To-Cook Porridge replaced by green gram flour

Ingredients	Recipe I (T_0)	Recipe II (T_1)	Recipe III (T_2)	Recipe IV (T_3)	Recipe V (T_4)	Recipe VI (T_5)
Broken wheat (g)	100	90	80	70	60	50
Germinated green gram flour (g)	0	10	20	30	40	50
Pumpkin powder (g)	25	25	25	25	25	25
Sugar (g)	58	58	58	58	58	58
Refined oil (mL)	16	16	16	16	16	16

2.2.3 Formulation of broken wheat RTCPM replaced with germinated chickpea flour

The broken wheat standardized in (Table 1) was substituted with germinated chickpea flour at different percentage (Table 3). The rest of the ingredients were kept as constant. The (recipe V) awarded highest sensory scores taken for further studies and reffered to as T_2

Table 3: The broken wheat Ready-To-Cook Porridge replaced by chickpea flour

Ingredients	Recipe I (T_0)	Recipe II (T_1)	Recipe III (T_2)	Recipe IV (T_3)	Recipe V (T_4)	Recipe VI (T_5)
Broken wheat (g)	100	90	80	70	60	50
Germinated chickpea flour (g)	0	10	20	30	40	50
Pumpkin powder (g)	25	25	25	25	25	25
Sugar (g)	58	58	58	58	58	58
Refined oil (mL)	16	16	16	16	16	16

2.2.4 Chemical and nutritional analysis

The moisture content (%) in different samples was evaluated as per the method of AOAC (2012) [17], Ash content (%) was determined gravimetrically (AOAC, 2012) [17], Crude fibre (%) was analyzed as per (AOAC, 2010) [18], Crude fat (%) was determined using (AOAC, 2009) [19] method. Crude protein (%) was determined by following the method given in AOAC (2012) [17], Ranganna (2009) [20] procedure was employed in the in scrutinizing β-carotene (mg/100 g), Total carbohydrates (%) was calculated by differential method (AOAC, 2006) [21] and expressed in percentage; Total energy (Kcal/100 g) was calculated by differential method (AOAC, 2006) [21]

2.2.5 Sensory evaluation

RTCPM for serving was prepared by adding 600mL of water to 100 g of porridge mix followed by cooking in a medium induction for 15 minutes till thick consistency and served hot to the panelists within 10 minutes of preparation. Panelists were asked to evaluate the porridge for the following sensory attributes on a 9-point Hedonic scale; colour, texture/body, taste and overall acceptability (1=dislike extremely, 5=neither like nor dislike, 9 = like extremely), as described by Meilgaard, Civille, and Carr (1999) [22].

2.2.6 Statistical analysis

The chemical parameters were analyzed by Complete Randomized Design (CRD) and sensory evaluation was analyzed using Randomized Block Design (RBD) as described by Cochran and Cox (1967) [23] and Mahony (1985) [24] respectively. The means were separated for comparison by Tukey's honest significant difference (HSD) and the statistical significance was defined as $p \leq 0.05$.

3. Results and discussion

Chemical and sensory characteristics of Ready-To-Cook Porridge Mix

The sensory scores for porridge were appended in Figure 1, 2 and 3. Based on the statistical analysis, significant differences were observed in all sensory parameters. In a base recipe (Fig 1), the highest sensory scores were revealed in T_2 for colour (8.13), texture/body (8.14), taste (8.41) and overall acceptability (8.49). In broken wheat porridge replaced with germinated chickpea flour (Fig 2) the highest sensory scores were recorded in T_4 for colour (8.11), texture/body (8.10), taste (8.40) and overall acceptability (8.48) while broken wheat porridge supplemented with germinated green gram flour (Fig 3) the highest sensory scores were discovered in T_4 for colour (8.38), texture/body (8.83), taste (8.85) and overall acceptability (8.88). All products were liked very much by panelist. These observations are supported by different authors: Ahmad *et al*. (2013) [25] made three weaning meal samples with a variety of rice flour, gramme flour, and papaya powder, as well as an equal amount of milk powder. The sensory evaluation found that all three samples had sensory qualities such as colour, aroma, taste and overall acceptability in the range of 6-7. Balasubramanian *et al*. (2014) [26] created a weaning diet with malted pearl millet and barley levels that varied. The overall acceptance of the product was assessed using a 9-point hedonic scale. For those formulae with a larger percentage of malted millet flour, acceptability ranged from moderate to extremely high. Zema *et al*. (2015) [27] made complementary food porridge samples from composite flours of germinated maize, pumpkin pulp, and seed (80%: 10%: 10%, 60%: 20%:% and 40%: 30%: 30%). The sensory panel members appreciated all of the sensory features, according to the results of the sensory study. Blends with more pumpkin pulp and seeds, on the other hand, scored higher in terms of appearance.

The data appended in Table 4 shows the chemical characteristics of RTCPM. There were no significant different observed in moisture content across the three treatments, which varied from 2.85 to 2.94 per cent. The moisture levels determined in this study were lower than 8.4 to 13.7 g/100 g reported by Asare *et al*. (2004) [28] and also those suggested by Codex Alimentarius (15.5 g/100 g) for wheat flour (CODEX, 1985) [29]. The roasting of broken wheat and legume flours before mixing with other ingredients during preparation of mix may be the reason for low moisture content in the present study. Many food powders have a moisture content of (5%) or less (Intipunya and Bhandari, 2010) [30]; the lower the moisture content of RTCPM, 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) [30]. The significance different was noted in mean ash content between T_0, T_1, and

T_2. The highest mean ash content was recorded in T2 (2.36%) and minimum was found in T_0 (1.77%). Supplementation of broken wheat with (40%) germinated chickpea flour and green gram flour raise the ash content of RTCPM compared to control. These results are in agreement with Dahiya and Kapoor (1994) [31], Suma (1998) [32], Rana *et al*. (2015) [33] and Gitau (2018) [34] who found the similar tendency in weaning mix.

In the current investigation, T_1 had the highest mean crude fibre content (3.15%), whereas T_0 had the lowest (1.72%). These findings are in consistency to those analyzed by Kshirsagar *et al*. (1994) [35], Suma (1998) [32], Ijarotimi *et al*. (2006) [36], Rana *et al*. (2015) [33] and Gitau *et al*. (2018) [34]. The mean crude fat was ranging from 3.79 to 4.92 per cent in the present study. In their research studies, Kshirsagar *et al*. (1994) [35], Ijarotimi *et al*. (2006) [36], Rana *et al*. (2015) [33] and Gitau (2018) [34] found the similar pattern. The fat content in the current study was significantly greater than the limits indicated for 9–11-month-old infants' daily lipid needs (Dewey and Adu-Afarwuah, 2008) [37] for infants.

The mean crude protein was significantly found to be highest in T_2 (18.23%) and lowest in T_0 (14.98%). The substitution of (40%) germinated green gram and chickpea flour in RTCPM contributed to a significant increase in protein content of T_1 and T_2. The protein content of RTCPM in the present study was similar to that of Suma (1998) [32], Ijirotimi *et al*. (2006) [36], Rana *et al*. (2015) [33], Gitau (2018) [34] in porridge mix. Nutritionally, protein content in all treatments is above the recommended daily intake (RDI) for protein needed from complementary foods suggested by Garrow *et al*. (1999) [38] in nutrient intakes for protein in g/day for infants and children 12.7g/day (4-6 months), 13.7g/day (7-9 months), 14.9 g/day (10-12 months) and 14.5 g/day (1-3 years).

In the current study, the mean β-carotene values (1.92, 3.06 and 2.44 mg/100 g) were perceived in T_0, T_1 and T_2 respectively. The treatments T_0, T_1 and T_2 had total carbohydrates (72.11, 70.58 and 69.53%) and total energy of (387.53, 376.35 and 376.38 Kcal/100 g) respectively. Butte (1999) [39] 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 obtained in this study is above the Butte (1999) [39] recommendations of infants and children. In their study studies, Suma (1998) [32], Ijirotimi *et al*. (2006) [36], Ahmed *et al*. (2008) [40], Rana e*t al*. (2015) [33], Gitau (2018), Haile and Shufa (2019) [41], and Ajifolokun *et al*. (2019) [42] all found the same pattern. WHO (1998) [43], WHO/UNICEF (1998) [44] and Garrow *et al*. (1999) [38] all recommend the same amount of β-carotene and total calories for infants and children, which is consistent with this study's findings.

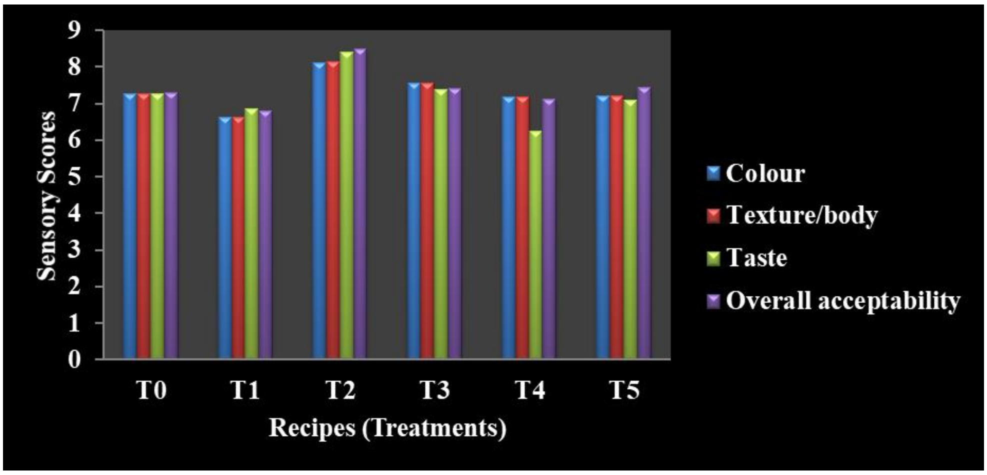

Fig 1: Sensory scores* for broken wheat porridge (base recipe) Recipes (BW: Broken wheat; RPP: Pipe pumpkin powder) T_0: (100BW:15RPP), T_1: (100 BW: 20 RPP), T_2: (100BW:25 RPP), T_3: (100BW:30 RPP), T_4: (100BW:35 RPP) T_5: (100BW:40 RPP)

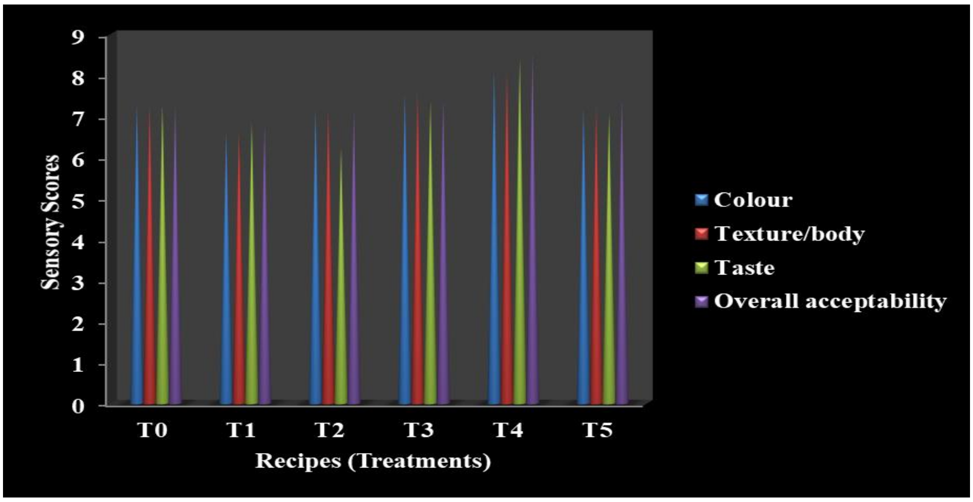

Fig 2: Sensory scores* for broken wheat porridge supplemented with germinated chickpea flour Recipes (BW: Broken wheat; CPF: Germinated chickpea flour) T_0: (100BW:0GCPF), T1: (90 BW: 10GCPF), T_2: (80BW:20GCPF), T_3: (70BW:30GCPF), T_4: (60BW:40GCPF), T5: (50BW:50GCPF)

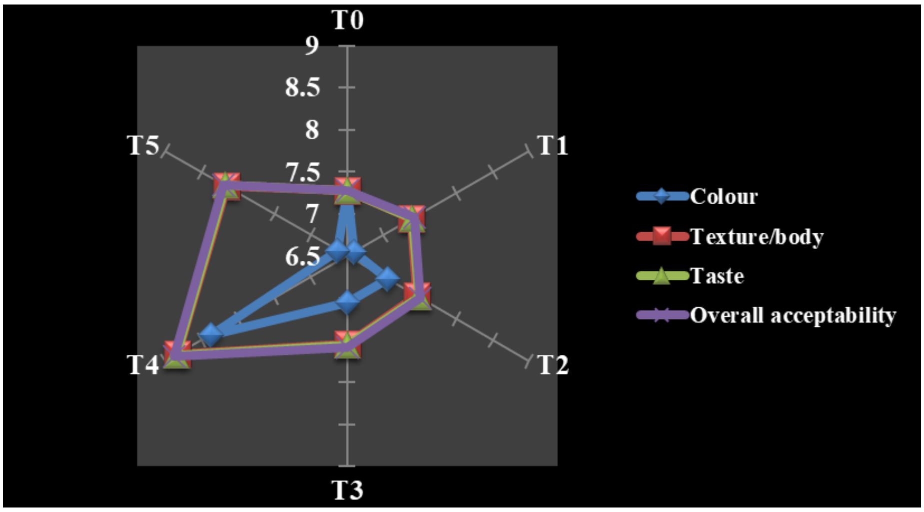

Fig 3: Sensory scores* for broken wheat porridge supplemented with germinated green gram flour Recipes (BW: Broken wheat; GGGF: Germinated green gram flour) T_0: (100BW:0GGGF), T_1: (90 BW: 10 GGGF), T_2: (80BW:20GGGF), T_3: (70BW:30GGGF), T_4:(60BW:40GGGF),T_5: (50BW:50GGGF)

Table 4: Chemical Characteristics of Ready-To-Cook Porridge Mix

Parameters	Treatments		
	T_0	T_1	T_2
Moisture (%)	2.85±0.03^a	2.91±0.30^a	2.94±0.27^a
Ash (%)	1.77±0.18^a	2.28±0.02^b	2.36±0.26^b
Crude fibre (%)	1.72±0.18^a	3.15±0.13^b	2.98±0.19^b
Crude fat (%)	3.79±0.51^a	4.89±0.70^b	4.92±0.04^b
Crude protein	14.98±0.05^a	17.29±0.48^b	18.23±0.50^b
β-carotene (mg/100 g)	1.92±0.06^a	3.06±0.17^b	2.44±0.05^{ab}
Total carbohydrates (%)	72.11±0.65^b	70.58±0.93^a	69.53±0.91^a
Total energy (Kcal/100 g)	387.53±6.34^b	376.35±6.19^a	376.38±6.13^a

Where, T_0 (100% broken wheat), T_1 (60% broken wheat +40% germinated chickpea flour), T_2 (60% broken wheat +40% germinated green gram flour), Means sharing the same superscript letter in rows are not significantly different from each other (Tukey's HSD test, $p \le .05$).

4. Conclusions

The development of high-protein weaning foods (RTCPM) with enhanced nutritional and sensory attributes is imperative in addressing stunting and wasting in young children in low-income countries. All RTCPM developed in this study contained significant levels of proteins (14.98–18.23%) and met the RDI of protein in complementary foods. The addition of germinated green gram and chickpea flour was shown to have a significant effect on most nutrients, particularly protein, fat, ash, fibre, total carbohydrates and total energy which is important in addressing protein-energy malnutrition (PEM) issue in infants and children under 5 years old. The overall acceptability scores of all RTCPM were in the range of 6.78 to 8.88, on a 9-point Hedonic scale. This product can be used in low-income countries to combat Protein Energy Malnutrition (PEM) in infants.

5. Acknowledgment

We would like to thank Dr Krishan Datt Sharma Head of Department Food Science and Technology for allowing the use of his research laboratory facilities to accomplish this reseach study.

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