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Research Paper

Nutritional and sensory evaluation of carrot flour-incorporated complementary food mixtures for infants

M. R. Roshana[1*] and T. Mahendran[2]

[1] Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka
[2] Department of Agricultural Chemistry, Faculty of Agriculture, Eastern University, Sri Lanka
[*] Corresponding Author: mrroshana30@gmail.com https://orcid.org/0000-0002-8634-6699

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Abstract: Complementary foods are foods other than breast milk or infant formula introduced to an infant to provide nutrients. The present research was carried out to formulate a low cost complementary food that provides recommended levels of protein, vitamin and minerals for children less than two years old. The complementary food mixtures (CFM) were prepared from unpolished parboiled red rice (UPRR), germinated green gram (GG) and carrot flour (CF) in the ratios of 100:00:00, 80:10:10, 70:20:10, 60:30:10, 50:40:10 and 40:50:10, respectively. The mixtures were analyzed for nutritional qualities such as moisture, ash, protein, fat, fiber and β-carotene, organoleptic characteristics of colour, texture, taste, aroma and overall acceptability and microbial studies to assess the suitability of these CFMs for consumption and its shelf life. The compositional analysis of the CFM revealed that the moisture, ash, protein and fiber content increased from 5.67 to 6.38%, 1.14 to 2.57%, 8.63 to 16.87% and 0.52 to 2.15%, while fat and β-carotene content decreased from 2.83 to 1.86% and 31.45 to 29.37% respectively with the increasing of the GG flour from 10 to 50%. The sensory assessment showed that, there were significant differences ($p<0.05$) among the treatments and the CFM formulated with 30% GG flour was well acceptable in terms of colour, texture, taste, aroma and overall acceptability compared to other treatments. There were no total plate counts observed in the formulated CFMs. The mixture of 60% UPRR, 30% GG and 10% CF is found to be superior based on the quality characteristics and could be suitable for consumption up to 14 weeks without any significant changes in the quality.

Keywords: Carrot Flour, Complementary Food, Germinated Green Gram, Nutritional Enrichment, Parboiled Red Rice

Introduction

Protein-energy malnutrition (PEM) is the most lethal form of malnutrition (Tiencheu *et al*., 2016). Cereals form the major part of most complementary mixes and contribute to 70-80% of daily energy intake. Therefore, supplementing with legumes improves the nutritional quality of cereals by complementing their limited amino acids, lysine and tryptophan (Ijarotimi and Aroge, 2005). However, cereal-legume based complementary foods are deficient in essential micronutrients such as vitamin A. Vitamin A deficiency is a major public health problem in developing countries (Bonsi *et al*., 2014). One way to increase vitamin A intake of infants is to incorporate high carotenoid food in their diet.

The children in most of the developing countries including Sri Lanka suffer from malnutrition due to the improper eating habits adopted during the weaning period. The critical period where children develop malnutrition coincides with the introduction of complementary foods, which are nutritionally inadequate in many developing countries (Khanam *et al*., 2011). Further, these children suffer from other deficiencies like vitamin A, calcium, iron, riboflavin, etc. The ability of breast milk to meet the requirements for macronutrients and micronutrients becomes limited with the increasing age of infants.

Complementary foods are expected to be high in energy density, containing all essential amino acids, required vitamins and minerals and safe level of anti-nutritional components while retaining the qualities for palatability (Abeshu *et al*., 2016). Thus, timely introduction of complementary food during infancy is necessary for both nutritional and developmental reasons (Agostoni *et al*., 2008). However, the capacity of a complementary diet to meet the protein-energy requirements of infants depends on its nutritional quality (Kamchan *et al*., 2004). The nutrient content of complementary foods should be adequate and diverse enough to meet the child's nutritional needs. Infants and young children are vulnerable to inadequate nutrient intake during the period of complementary feeding (6 -23 months), the needs of nutrients during this period is very high to support the high rate of growth while the supply is insufficient to meet the demand (Michaelsen, 2015). Therefore, a complementary food mixture made from the combination of unpolished parboiled red rice with germinated green gram and carrot flour provides a diet which is nutritionally enriched with protein and vitamin A.

Protein and vitamin A found in high amounts in germinated green gram and in carrot flour, respectively, contributing to their favourable amounts in the complementary food mixture. To overcome this problem, the present study was designed to formulate a low cost complementary foods that provide recommended levels of protein, vitamin and minerals for children. This complementary food mixture (CFM) can be used as a low cost nutritious food for babies, especially among the low income families. This CFM is easy to prepare and easy to consume with affordable price.

Materials and Methods

Preparation of raw materials for the formulation of complementary food

Rice grains were cleaned, air dried for 48 hrs at 30±1 °C, roasted, ground and screened through 1 mm sieve to obtain flour. Green gram was soaked in water for 8 hrs, allowed to germinate for three days, air dried for 48 hrs at 30±1 °C, the testa and roots were removed, roasted, ground and sieved through 1 mm sieve to obtain flour. Carrots were washed, peeled and sliced into 1 mm thickness. Later, the carrot slices were dried using a dehydrator and ground and sieved through 1 mm sieve to get uniform size flour.

Preparation of instant complementary food

The complementary food was prepared by using unpolished parboiled red rice flour, germinated green gram flour and carrot flour in different combinations. In the formulation, the total amount of unpolished parboiled red rice flour and germinated green gram flour were kept at 90% and amount of carrot flour was maintained at 10% constant level. All the formulations were prepared within the range of Recommended Daily Allowance for infants up to 2 years.

Experimental plan

The CFMs of each combination was packed separately in aluminium laminated packaging material and labelled individually. These CFMs were assessed for nutritional and organoleptic qualities. Experimental formulations are shown in Table 1.

Nutritional analysis of formulated complementary food

The complementary foods were analyzed for moisture, ash, fat, protein and fiber using the recommended AOAC (2002) method initially immediately after formulation at two weeks interval and β-carotene was analyzed spectrophotometrically (Cisneros-Zevallos *et al*., 2005) initially after formulation at one month interval. Analyses were carried out for three replicates for each treatment.

Table 1: Experimental Formulations

Ingredients	**Treatment**					
	T_1 (Control)	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**
% of Unpolished Parboiled Red Rice Flour	100	80	70	60	50	40
% of Germinated Green Gram Flour	0	10	20	30	40	50
% of Carrot Flour	0	10	10	10	10	10

Sensory evaluation

The sensory evaluation was carried out to assess the quality attributes such as colour, texture, taste, aroma and overall acceptability by a semi-trained panel of consisting 30 members using a seven-point hedonic scale. The rating of the samples are ranged from 1 (Dislike very much) to 7 (Like very much). Three digit number coded samples and questionnaire were given to panel members at a time and they were asked to rate their hedonic response on the scale. Sensory evaluation was conducted between 9.00 to 11.00 am.

Determination of microbial quality

Total plate count method was performed for the complementary food mixtures after the formulation. Standard plating on Nutrient Agar known as total plate count method was carried out to study the microbial properties of the prepared complementary food mixtures. The complementary food formulations were used to prepare the dilutions of 10^{-1}, 10^{-2} and 10^{-3} and microbial counts were triplicated. The total plate count was determined by counting the colonies formed with microorganisms.

Statistical analysis

Data of the sensory evaluation and nutritional analysis were analyzed by Analysis of Variance (ANOVA) ($p = 0.05$). Mean separation was done with Duncan's Multiple Range Test (DMRT) for nutritional analysis. Data related to sensory evaluation was analyzed using the Tukey's studentized test. Both nutritional and organoleptic analysis was done through Statistical Analysis System (SAS) software statistical package.

Results and Discussion

Nutritional qualities of freshly made CFMs

Moisture content: The moisture content increased gradually from 5.67% to 6.38% with the increase in proportion of germinated green gram flour from 0 to 50% (Table 2). The CFMs significantly differed ($p<0.05$) in their moisture contents. These moisture contents compared well with the values reported (3.00-7.80%) for complementary foods by Wadud *et al*. (2004).

The moisture content of CFMs increased with the increase in concentration of germinated green gram flour. This is attributed to high water binding capacity of germinated green gram flour which is retained higher moisture content in the formulated products.

Ash content: The ash content is an important nutritional indicator of mineral content and a quality parameter that determines contamination with foreign matters (Mishra *et al*., 2014). The ash content gradually increased from 1.14 to 2.57% with the increase in proportion of germinated green gram flour from 0 to 50% (Table 2). The increase in the ash content could be due to the higher mineral content of green gram (Mubarak, 2005). Similar increase in ash content have been reported by Yaseen *et al*. (2014) in green gram.

Protein content: A gradual increase in the protein content was observed from 8.63 to 16.87% with the increase in proportion of germinated green gram flour from 0 to 50% (Table 2). The increase in protein content in germinated green gram incorporated mixtures is in agreement with results reported for weaning foods formulated from sprouted wheat and lentil flour (Khatun *et al.*, 2013), and for sprouted green gram seeds (Mubarak, 2005; Ghavidel and Prakash, 2007).

Table 2: Nutritional Composition of the Formulated Complementary Food Mixtures

Treatments	Moisture (%)	Ash (%)	Protein (%)	Fiber (%)	Fat (%)
T_1	5.67 ±0.04^f	1.14±0.03^f	8.63±0.08^f	0.52±0.02^a	2.83±0.02^f
T_2	5.81±0.03^e	2.05±0.04^e	10.42±0.09^e	1.25±0.07^b	2.65±0.03^e
T_3	5.98±0.01^d	2.18±0.02^d	12.37±0.1^d	1.43±0.03^c	2.44±0.01^d
T_4	6.11±0.03^c	2.28±0.02^c	14.78±0.12^c	1.75±0.08^d	2.25±0.05^c
T_5	6.24±0.03^b	2.39±0.03^b	15.63±0.16^b	1.97±0.04^e	2.09±0.04^b
T_6	6.38±0.04^a	2.57±0.03^a	16.87±0.12^a	2.15±0.02^f	1.86±0.03^a

The values are means of triplicates ± standard error. Within a column, means followed by the same letters are not significantly different at p=0.05 (T_1 = 100% UPRR; T_2 = 80% UPRR 10% G 10% CF; T_3 = 70% UPRR 20% GG 10% CF; T_4 = 60% UPRR 30% GG 10% CF; T_5 = 50% UPRR 40% GG 10% CF; T_6 = 40% UPRR 50% GG 10% CF)

Germination has been reported to improve the protein content and quality of food products (Fasasi, 2009). Proteolytic enzymes improves amino acid availability mainly lysine, methionine and tryptophan (Bolanle *et al.*, 2012).

Fat content: The fat content decreased gradually from 2.83 to 1.86% gradually with the increase in proportion of germinated green gram flour and decrease in proportion of unpolished parboiled red rice (Table 2). The results followed a similar pattern to that of Ghavidel and Davoodi (2011) who reported 1.36% fat in complementary food processed using wheat and green gram. The decrease in oil contents on sprouting may be attributed to their utilization in the sprouting process as energy sources (Kumar *et al.*, 2006).

Fiber content: The fiber content increased from 0.52 to 2.15% with the increase in proportion of germinated green gram flour from 0 to 50% (Table 2). Hussain *et al.* (2012) also reported that the fiber content increased from 1.36 to 1.81% in a formulation of wheat and lentil-based complementary food flour. This could be due to the increase in the proportion of germinated green gram flour and carrot flour in the CFM.

β-Carotene content: In CFM, carrot flour was maintained at a constant (10%) level. The carotene content gradually decreased from 31.45 to 29.37mg/kg with the increase in proportion of germinated green gram flour from 10 to 50% (Figure 1). This is probably due to the higher β-carotene content in the unpolished parboiled red rice than the germinated green gram. This finding is closely related with those of Okudu *et al.* (2017). The carotene content of the control treatment was 9.03 mg/kg. Carrot is a good source of β-carotene and its addition to CFM must have increased the amounts of the β-carotene value. In its active form, vitamin A has a significant role play in biochemical or physiological actions in vision, growth and development and immunity (FNB, 2001).

Organoleptic evaluation of complementary food mixture

The sensory evaluation of freshly made CFM showed that there were significant differences between the treatments as the proportion of germinated green gram flour was increased from 0-50% for colour, texture, taste, aroma and overall acceptability (Table 3).

Microbial quality

There was no microbial growth in freshly made CFMs. Due to the preliminary processes such as air drying and roasting at high temperature eliminated a large number of micro-organisms. Therefore, the population of microorganisms in relation to moisture content was not high enough to produce any harmful effect in the porridge mixtures.

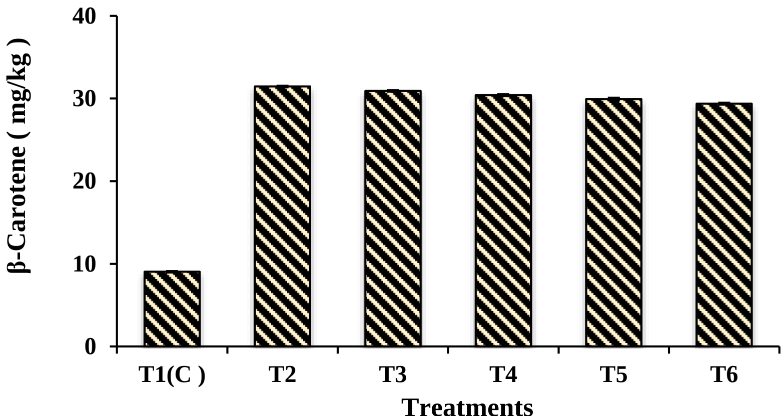

Figure 1: The β-Carotene Content of Freshly made Complementary Food Mixtures (CFMs). The values are means of triplicates. The vertical bars indicate the standard error of the means (T_1-100% UPRR; T_2-80% UPRR 10% GG 10% CF; T_3- 70% UPRR 20% GG 10% CF; T_4- 60% UPRR 30% GG 10% CF; T_5-50% UPRR 40% GG 10% CF; T_6-40% UPRR 50% GG 10% CF)

Table 3: Sensory Evaluation of Freshly made Complementary Food Mixtures

Treatments	Colour	Texture	Taste	Aroma	Overall acceptability
T_1(Control)	4.93 ± 0.19^{bc}	4.10 ± 0.23^{cd}	2.83 ± 0.21^{d}	2.73 ± 0.21^{d}	3.80 ± 0.15^{d}
T_2	4.07 ± 0.19^{d}	3.97 ± 0.22^{d}	3.70 ± 0.23^{c}	4.23 ± 0.22^{c}	4.57 ± 0.23^{c}
T_3	5.77 ± 0.12^{a}	5.73 ± 0.13^{a}	5.93 ± 0.13^{a}	5.43 ± 0.12^{ab}	5.47 ± 0.14^{ab}
T_4	6.03 ± 0.12^{a}	5.93 ± 0.14^{a}	6.10 ± 0.14^{a}	5.90 ± 0.12^{a}	6.03 ± 0.15^{a}
T_5	5.37 ± 0.16^{ab}	5.27 ± 0.17^{ab}	5.53 ± 0.17^{a}	5.07 ± 0.18^{b}	5.27 ± 0.12^{b}
T_6	4.63 ± 0.19^{cd}	4.73 ± 0.19^{bc}	4.63 ± 0.15^{b}	4.93 ± 0.12^{b}	4.87 ± 0.12^{bc}

The values are means of 30 replicates ± standard error. Within a column, means followed by the same letters are not significantly different at p=0.05 (T_1 = 100% UPRR; T_2 = 80% UPRR 10% GG 10% CF; T_3 = 70% UPRR 20% GG 10% CF; T_4 = 60% UPRR 30% GG 10% CF; T_5 = 50% UPRR 40% GG 10% CF; T_6 = 40% UPRR 50% GG 10% CF)

Conclusion

The study revealed that incorporating unpolished parboiled red rice flour with germinated green gram flour and carrot flour as a source of energy, protein and carotenoids respectively which could help in alleviating protein-energy malnutrition and vitamin A deficiency amongst the growing children. The formulated complementary food contained nutrients to satisfy the recommended dietary requirement and easily affordable. Thus the highly nutritive, low cost complementary food incorporating unpolished parboiled red rice flour with germinated green gram flour and carrot flour would ensure the rapid growth of infants and finally, help to reduce malnutrition situation and give extra support to nourishment for the infants.

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