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Full Length Research Paper

Production of complementary foods from cereals supplemented with legumes locally available in Tanzania

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Complementary foods in most developing countries are based on staple cereal or root crops. Although, commercial foods of high quality are occasionally available, they are often expensive and therefore unaffordable by low-income rural households. Different approaches are needed to offer families the opportunity to feed their infants on improved formulations using low cost and locally available staples. To improve the protein and energy intake of infants in Iringa region, Tanzania, nine complementary foods were formulated (F1-F9) based on maize, sorghum and finger millet as staples and common beans, cowpeas and green peas as protein supplements. The samples were germinated and spatially roasted to improve the nutritive value and sensory attribute of formulated recipes. The amounts of various staples (cereals) and supplements needed to provide 292 kcal of energy and raise the protein level to 8% Net Protein Energy (NPE) as one third of 6 month old infant's daily energy and protein requirement were calculated. The protein level was calculated on the basis of the most limiting amino acid in each mixture, using amino acid score. All the formulations were evaluated for their acceptability by both semi- and un-trained panelists using a five point hedonic scale. Although, many formulations were found to be organoleptically acceptable recording moderately to extremely like scores, generally formulations F3 (47 g maize + 11 g beans + 5 g oil + 12 g sugar) and F9 (47 g sorghum+11 g cowpeas+5 g oil+12 g sugar) were highly acceptable by both groups of panelists and scored significantly (P < 0.05) higher than the other formulated complementary foods. Their mean score ranged between 4.2 to 4.35 in terms of taste and general acceptability. Addition of sugar and oil was found to improve the sensory attribute of the formulated foods contributed to their higher acceptability.

Key words: Complementary foods, formulation, six month infant, energy, protein, cereals, legumes.

INTRODUCTION

The level of under nutrition among children remains unacceptable throughout the world, with large number of children living in developing world. Among developing countries, Tanzania is highly affected, having large numbers of malnourished children as it ranks 3rd within Africa (UNICEF, 2009). Complementary feeding period is the time when malnutrition starts in many infants, contributing significantly to the high prevalence of malnutrition in children less than 5 years of age worldwide (Daelmans and Saadeh, 2003). Poor feeding practices as well as lack of suitable complementary foods are responsible for under nutrition with poverty exacerbating the whole issue. The complementary foods are often of low nutritional quality and given in insufficient amounts. When introduced too early or too frequently, they displace breast milk (Villapando, 2000; WHO, 2002) as the main sources of nutrition in infants. Fortified nutritious commercial complementary foods are unavailable especially in the rural areas and where available, they are often too expensive and beyond the reach of most of families in Tanzania. Therefore, most

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complementary foods used are locally produced and based on local staple foods, usually cereals that are processed into porridges. Apart from their bulkiness reported as a probable factor in the etiology of malnutrition (WHO, 2001), cereal-based gruels are generally low in protein and are limiting in some essential amino acids, particularly lysine and tryptophan. Supplementation of cereals with locally available legumes rich in protein and lysine, although, often limiting in sulphur amino acids, increases the protein content of cereal- legume blends and their protein quality through mutual complementation of their individual amino acids. FAO/WHO/UNICEF (1971) emphasized the use of local foods formulated in the home and guided by the following principles: (i) high nutritional value to supplement breastfeeding, (ii) acceptability, (iii) low price, and (iv) use of local food items (Dewey and Brown, 2003; Pelto et al., 2003). The participation of young children's mothers in complementary food formulation and acceptability testing encourages them to gain nutrition knowledge and positive attitudes towards dietary improvements (Pelto et al., 2003). Therefore, the present study conducted formulation of complementary foods from cereals supplemented with legumes locally available in Iringa region, Tanzania to improve their energy and protein quality and evaluate their acceptability.

MATERIALS AND METHODS

Materials

Finger millet (*Eleusine coracona*), maize (*Zea mays*), sorghum (*Sorghum bicolor*), common beans (*Phaseolus vulgaris*), dried peas (*Pisum sativum*) and cowpeas (*Vigna unguiculata*) *,* and were purchased from local markets in Iringa, Tanzania. For the purpose of this study, nine complementary foods mix were formulated by mixing different staples and protein supplements and labeled as F1-F9. Fat/oil and sugar were added as energy supplements and to improve the sensory attribute of the formulated foods.

Preparation of the complementary food mixes

High quality cereals and legumes were carefully selected, sorted and washed. Legumes (common beans and cowpeas) were immediately sun-dried after washing. Sorghum, maize and finger millet were soaked overnight for germination. They were then spread on a wide wooden box sieve to drain and germination at room temperature. Germination was done to increase digestibility, bioavailability of vitamins, minerals, amino acids, proteins and phytochemicals, and decrease anti-nutrients and starch (Egli, 2001; Helland et al., 2002). The germinated cereals were again washed and sun-dried for 1 to 2 days depending on the intensity of sunlight. The cleaned beans and cowpeas were decorticated then roasted for about 5 min to improve the flavor of the gruel (Mitzner, 1984) prepared from these mixes. The above prepared food materials were milled to make flour for porridge preparation. Food mixes were obtained by blending different components of foods selected from the staple and protein supplements in the appropriate ratios according to their nutrient contributions in order to achieve a proper food mix that meets the energy and protein needs of a 6 month old baby. The ratios of the corresponding food mixes were obtained by graphical calculations.

Calculation of mixing ratios for the complementary foods

Two series of calculations were performed. First, the amounts of various staples (cereals) and supplements necessary to provide 292 kcal and raise the protein level to 8% NPE as one third of 6 month old baby energy and protein requirement per day was calculated. Then protein level was calculated on the basis of the most limiting amino acid in each mixture, using amino acid score as shown:

$$\text{Amino acid score} = \frac{\text{mg of AA in 1g of sample protein} \times 100}{\text{mg of AA in 1g reference protein}}$$

The NPE (%) of each essential amino acid were obtained from amino acid score by calculation using the following equation:

$$\text{NPE (\%)} = \frac{\text{AA score} \times \text{total protein energy (\%)}}{100}$$

Total Protein Energy (TPE) (%) was calculated with the aid of food composition tables and all mixture proportions were estimated from the graphs. For increasing energy density of food to reduce their bulkiness, fat and/or sugar was added according to the calculated amounts. New calculations were performed to maintain the NPE level at 8%; this gave a new protein level in the mixture. For example a mixture containing 292 kcal and 8% NPE, 23.36 kcal should come from protein. The new protein levels in the mixture were calculated as:

$$\text{Protein level (\%)} = \frac{(23.36 \times 100)}{292 - 45} = \frac{23.36 \times 100}{247} = 9.45\%$$

This protein level was after addition of 5 g of oil since addition of more oil or sugar would change the protein value above considerably. To maintain same protein level therefore only 5 g of oil was added to some mixes. The proportions and composition of complementary food mixes F1 to F9 that were formulated are shown in Table 1.

Sensory evaluation of complementary food mixes

The nine formulated complementary food mixes were prepared into gruels and subjected to sensory evaluation to test their acceptability using a five point hedonic scale, where 1= dislike extremely, 2 = dislike moderately, 3 = neither like nor dislike, 4 = like moderately and 5 = like extremely. A total of 60 panelists were used in this study: 40 from Kalenga village in Iringa (adult female, untrained) and 20 semi -trained final year undergraduate students of the department of Food science and Technology, Sokoine University of Agriculture, Morogoro, Tanzania. The use of adult females instead of the target recipients, children, was necessary because of their ability to objectively evaluate the sensory characteristics of the formulations.

Statistical analysis

The data includes mean scores for each sample as tested by both un-trained and semi- trained panelists. The results of sensory evaluation were split by panelist type and each group was individually subjected to one way analysis of variance (ANOVA) and

Table 1. Composition of formulated complementary foods. All samples were formulated to provide equal amount of energy and protein.

Main Ingredients	Formulation name	Mixing ratios (in gram and percentage)
Maize + Beans	F1	75 g maize + 8 g beans (90.4 maize, 9.6% beans
	F2	61 g maize + 10 g beans + 12 sugar (73.5% maize, 125 beans, 14.5% sugar)
Finger millet + Dried peas	F3	47 g maize + 11 g beans + 5 g oil + sugar(62.7% maize, 14.6%, beans, 6% sugar
	F4	80 g finger millet + 11 g peas (88g finger millet, 12% dried peas)
	F5	64 g finger millet + 12 g peas + 12 g sugar (72.8% finger millet, 13.6% dried peas, 13.6%
Sorghum + Cowpeas	F6	59 g finger millet + 12 g peas + 5 g oil + 12 g sugar (67% finger millet, 13.6%, dried peas, 5.8% oil, 13.6% sugar)
	F7	81 g sorghum + 8 g cowpeas (91% sorghum, 10.8%, 14.5% sugar)
	F8	62 g sorghum + 9 g cowpeas + 12 g sugar (74.7% sorghum, 10.8% cowpeas, 14.5% sugar)
	F9	47 g sorghum + 11 g cowpeas + 5 g oil + 12 g sugar (62.7% + sorghum, 14.6% cowpeas, 6.7% Oil, 16% sugar

Tukey's HSD test was used to determine the differences of the mean scores for appearance, smell, taste, consistency, and general acceptability at P 0.05 using SPSS 13.0 (SPSS software for Windows, release 13.0, SPSS Inc., USA).

RESULTS

Compositions of the formulated complementary foods are given in Table 1. The amounts of various staples (cereals) and supplements (legumes) were calculated to provide 292 kcal and raise the protein level to 8% NPE as one third infants energy and protein requirement per day (Dewey and Brown, 2003). The protein level was obtained on the basis of the most limiting amino acid in each mixture, using amino acid score since protein quality in plant-based products is constrained by amino acid composition. To combat the problem of under-nutrition, the mixing ratios were formulated to contain enough energy and protein to meet the daily requirements of infant from 6 month of age.

The results of sensory evaluation by semi-trained and untrained panelist are presented in Tables 2 and 3, respectively. The data shows average likeness of the formulated complementary foods with respect to taste, smell, appearance, mouth feel and general acceptability. Mean scores ranges of attributes evaluated were: taste (2.40 to 4.45), appearance (2.70 to 4.40), smell (2.25 to 4.00), mouth feel (2.05 to 4.05), consistency (2.35 to 4.20) and general acceptability (2.25 to 4.35) for semi trained panelists. For the untrained panelists, the scores were: taste (1.90 to 4.43), appearance (2.60 to 3.83) smell (2.25 to 3.90) mouth feel 1.88- 3.93) consistency (2.40 to 3.73) and general acceptability (2.25 to 4.33).

Taste

Taste is an important parameter when evaluating sensory attribute of food. The product might be appealing and having high energy density but without good taste, such a product is likely to be unacceptable. With exception of formulation F3 *(*47 g maize + 11 g beans + 5 g oil + 12 g sugar*),* both semi- trained and untrained panelists rated formulation F9 (47 g sorghum+11 g cowpeas + 5 g oil + 12 g sugar) significantly higher ($P < 0.05$) than the rest of tested formulations in terms of their taste. The mean score for formulation F9 was 4.45 and 4.43 for semi-trained and untrained panelists, respectively. Formulation F3 scored 4.35 and 4.38 for semi-trained and un-trained panelists respectively, but the scores were not significantly different ($P > 0.05$) from formulation F9 in terms of taste. The favorable tastes of these formulations were probably enhanced by addition of sugar and oil. On the other hand, formulation F4 (80 g finger millet + 11 g peas) was significantly more disliked than the rest of formulated complementary foods by both semi-trained

Table 2. Mean scores of sensory evaluation of porridge prepared from samples formulated as tested by semi- trained panelists.

	Taste	Appearance	Smell	Mouth feel	Consistency	General acceptability
F1	2.40^{e}	3.30^{d}	3.35^{d}	2.60^{d}	2.35^{e}	2.85^{d}
F2	3.60^{c}	3.85^{c}	3.80^{b}	3.45^{b}	3.05^{c}	3.50^{b}
F3	4.35^{a}	4.00^{c}	4.00^{a}	4.05^{a}	3.40^{b}	4.20^{b}
F4	1.75^{f}	2.70^{e}	2.25^{e}	2.05^{e}	2.90^{d}	2.25^{e}
F5	3.60^{c}	3.15^{d}	3.15^{d}	2.70^{d}	3.20^{c}	3.10^{c}
F6	3.25^{c}	3.25^{d}	3.20^{d}	2.85^{c}	3.20^{c}	2.95^{c}
F7	2.70^{d}	3.25^{d}	3.45^{c}	3.05^{c}	2.85^{d}	2.80^{d}
F8	4.00^{b}	4.35^{a}	3.60^{c}	3.60^{b}	2.75^{d}	3.40^{b}
F9	4.45^{a}	4.40^{a}	3.95^{a}	4.05^{a}	4.20^{b}	4.35^{a}

Means bearing different superscripts on the same column are significantly different ($p < 0.05$). F1-9 are the complementary foods formulation names as detailed in Table 1.

Table 3. Mean scores of sensory evaluation of porridge made from different formulations as tested by un-trained panelists.

	Taste	Appearance	Smell	Mouth feel	Consistency	General acceptability
F1	2.38^{c}	3.20^{c}	3.25^{d}	2.43^{d}	3.38^{b}	2.45^{e}
F2	3.75^{b}	3.53^{b}	3.45^{c}	3.58^{b}	3.40^{b}	3.73^{b}
F3	4.38^{a}	3.78^{a}	3.75^{b}	3.80^{a}	3.73^{a}	4.28^{a}
F4	1.90^{e}	2.60^{d}	2.25^{f}	1.88^{e}	2.80^{c}	2.43^{e}
F5	3.35^{c}	3.33^{b}	2.88^{e}	2.73^{c}	3.38^{b}	3.18^{d}
F6	3.88^{b}	3.75^{a}	3.50^{c}	3.66^{b}	2.38^{b}	3.40^{c}
F7	2.05^{d}	2.68^{d}	2.75^{e}	2.20^{d}	2.40^{c}	2.25^{e}
F8	3.83^{b}	3.45^{b}	3.65^{b}	3.85^{a}	3.43^{c}	3.18^{d}
F9	4.43^{a}	3.83^{a}	3.90^{a}	3.93^{a}	3.73^{a}	4.33^{a}

Means bearing different superscripts on the same column are significantly different ($p < 0.05$). F1-9 are the complementary foods formulation names as detailed in Table 1.

and untrained panelists and scored 1.75 and 1.90 respectively. With exception of formulations F1, F4 and F7, the rest of formulations scored > 3.0 indicating that most of the formulated mixes were on average likeable by both group of panelists (Tables 2 and 3).

Appearance

Appearance is important attribute in food choice and acceptance. Outcome of sensory evaluation indicated that some samples were similar in appearance while others differed significantly. With exception to formulation F8 (62 g sorghum + 9 g cowpeas + 12 g sugar), both panelists rated formulation F9 (47 g sorghum + 11 g cowpeas+5 g oil + 12 g sugar) significantly higher ($P < 0.05$) than the rest of tested recipes. The mean score for formulation F9 was 4.40 and 3.83 for semi-trained and untrained panelists, respectively. Formulation F8 scored 3.45 and 4.35 for untrained and semi-trained panelists respectively. With both groups of panelists, formulations F8 and F9 were equally preferred in terms of appearance ($P > 0.05$). Generally, F8 and F9 were formulated using sorghum and cowpeas which were found to be more appealing and liked by majority of the panelists. Formulation F4 scored poorly in terms of appearance of and was below average with mean scores of < 3.0 by both groups of panelists. With the exception of formulations F4 and F7, and F4 which scored poorly by the un-trained panelist and semi-trained panelist respectively, the rest of samples scored > 3.0 indicating that most of the formulated mixes were on average appealing (Tables 2 and 3).

Smell

Smell is an integral part of taste and general acceptance of the food before it is put in the mouth. It is therefore an important parameter when testing acceptability of formulated foods. Results of sensory evaluation indicated that smell of certain samples varied significantly ($P <$

0.05) from others. Generally, F3 and F9 scored significantly higher (3.95 to 4.00) ($P < 0.05$) in terms of smell than the rest of formulations by semi-trained panelists. However, with untrained panelists only F9 was rated significantly higher ($P < 0.05$) than the rest of the samples followed by F3 at second position. With the exception of F4, F5 and F8 which scored below the average 3.0, the rest of samples were rated well in terms of smell by both group of panelist and recorded above average score.

Mouth feel

The results revealed that no significant differences ($P > 0.05$) were observed by semi-trained panelist between F3 and F9 in terms of mouth feel and both were highly liked as indicated by higher scores of 4.05. Likewise, although F3 and F9 were ranked a little lower (3.80 to 3.93) by untrained panelists, the differences were not significant ($P > 0.05$). However, their scores for mouth feel were significantly higher than the rest of samples ($P < 0.05$) as ranked by both groups of panelists. The mean score of formulations F1, F4, F5 and F6 was below the average (< 3) indicating that based on this test parameter these formulations were not liked by the panelists.

Consistency

Further, this study aimed at assessing maternal preferences for consistency of formulated complementary foods. In present study, semi-trained panelists showed significantly higher preference ($P < 0.05$) for formulation F9 (mean score 4.2) compared to the rest of other formulated complementary foods. Formulations F3 and F9 were highly and significantly preferred by untrained panelists (mean score 3.73) than the rest of formulations ($P < 0.05$). However, F3 and F9 did not differ significantly ($P > 0.05$) in terms of consistency as assessed by untrained panelist. The favorable tastes of these samples were probably enhanced by addition of sugar and oil that resulted into their thin consistency. On the other hand, formulations F1 and F7 were significantly more disliked ($P < 0.05$) than the rest of the formulations by both groups of panelists. Both formulations scored below the average (< 3.0).

General acceptability

Generally, formulated complementary foods F3 and F9 were highly acceptable by both groups of panelist with mean scores (4.35, 4.20) and (4.33, 4.28) for semi-trained and untrained panelists, respectively. Their acceptability levels were significantly higher ($P < 0.05$) than the rest of samples. Formulations F1, F4 and F7 were significantly disliked by both panelist as compared to the rest of samples, and they scored below the average (< 3).

DISCUSSION

It appears that, in addition to a sufficient energy density, sensory qualities of complementary food formulations corresponding to food preferences of infants are of the highest importance. Sensory evaluation is easy in its principle but its implementation in the field is often complicated because of low literacy among the rural mothers' and the difficulty for them to understand some sensory testing methods. The present study therefore used both semi-trained panelist from Department of Food Science and Technology, Sokoine University of Agriculture and mothers (un-trained) from Kalenga village, Iringa. It was expected that the results by two groups would be significantly different. However, in contrast, there was not much such difference between the two groups of panelist. Complementary food formulations with addition of sugar and oil were found to be more tasty, appealing, and having good consistency than those without sugar and oil, indicating that inclusion of sugar and oil not only increased the energy density of the porridge but enhanced the taste and characteristic improved flavor thus differentiating them from other formulations. Generally, the mean scores of all formulations with sugar and oil were accepted (Tables 2 and 3), showing that judged by these sensory attribute, inclusion of oil and sugar is very important in the acceptability of product by target groups. In addition to sugar and oil, samples formulated using sorghum and cowpeas were found to be more appealing and were liked by majority. Similar results were reported by Martin et al. (2010) in study assessing nutrient content and acceptability of soybean based complementary foods.

Roasting of samples done for the legumes had an important improvement on the flavor of the formulations (Mitzner et al., 1984). Although all supplements were roasted, formulations containing cowpeas and common beans were significantly more liked than the rest of the formulated complementary food formulations. Generally, sugar is by far the most important addition to complementary foods and is commonly added to improve the flavour and to encourage infants to eat while fat acts as flavor retainer and increases the mouth feel of foods (Walker and Pavitt, 2007) . Although, formulations F1, F4 and F7 without sugar and oil) gave the same protein and energy for a 6 month baby, they were generally not well accepted in terms of taste, smell and consistency as compared to the rest of formulations. It should be noted that sugar does not only add sweetness to the food but is also very important for the flavor of the food product. Oil also improves the taste/flavor of the product and reduces bulkiness of starchy food in the mixture (Walker and

Pavitt, 2007). Fat and oils improve the smoothness of the porridges and delay the swelling of the starch granules thus restricting too much binding of water to the starch. Therefore, addition of sugar and oil to the porridge mixture influences cooking characteristics and taste of the food especially starch containing foods. However, although both of these substances will increase the energy density and sensory attribute of porridge, they have to be used in accordance with calculated ratios as they tend jeopardize an infant's protein intake when added at high levels. Germination also improves the consistency, mouth feel and taste of the product (Egli, 2001; Helland et al., 2002). In the present study all the cereals used were germinated. Several studies have shown that germination improves the nutritive value and sensory attribute of cereals and legumes. Germination has also been found to decrease the levels of anti-nutritional factors present in cereals and maximizes the levels of some of the utilizable nutrients (Mohamed et al., 2007). Inyang and Zakari (2008) reported that sensory panelists highly rated formulations from germinated grains for all the sensory parameters investigated.

In present study, sensory characteristics of formulated complementary foods were only assessed by a single approach that is commonly employed in developing countries; the sensory evaluation or consumer studies with mothers. This approach has some limitation as its implementation in the field is often complicated because of mothers' illiteracy and the difficulty for them to understand some sensory testing methods (Serge, 2001). In addition, it only gives information on the mothers' preferences but none on the true preferences of children or on the gruel acceptability by children. Consumer studies with mothers can be used to know their acceptance to give a kind of gruel to their child but the validity of this approach is limited by the reliability of their answers (Serge, 2001). A second approach that involves measuring food intake is often difficult and expensive as the consumption surveys have to be carried out in free living conditions following standardized protocols which require numerous surveyors and laboratory facilities for some necessary analysis (Vieu et al., 2001). Consequently, the present study and most of the studies carried out in developing countries still adopt the first approach with fairly good results.

Conclusion

The complementary food formulations in the present study were based on locally available low-cost food materials commonly consumed in Iringa, Tanzania. The mixing ratios constituted formulations that had enough energy and protein to meet the energy and protein requirements for 6 month infants as recommended for complementary foods. Therefore, the formulated food mixes are potentially suitable for use as complementary foods in rural Iringa, Tanzania, and other areas with similar local food sources. Sensory evaluation done on all the recipes revealed that addition of sugar and/or oil to the products significantly improved their organoleptic quality and contributed to their high acceptance. The fact that these recipes are inexpensive, locally available and nutritious makes them potentially effective in solving some of the nutrition problems facing infants and children in Iringa region and other areas of Tanzania. Further studies to explore the possibility of improving locally formulated complementary foods for other age groups are needed to help combat the rampant malnutrition in Tanzania and other developing countries.

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