ORIGINAL RESEARCH ARTICLE

FUNCTIONAL AND SENSORY EVALUATION OF ENRICHED WEANING FOOD PRODUCED FROM CEREAL, LEGUME AND VEGETABLE

ABSTRACT

This study examined the functional and sensory properties of enriched weaning food produced from cereal, legume and vegetable. Maize, soybean and carrot were formulated into blends. Sensory evaluation, proximate and functional properties were determined. The data generated were analyzed. The results obtained showed that at 2 weeks, Samples D and F had the highest score (5.00) for colour quality while least score was recorded in sample E (2.00). At 4 weeks, Samples D and F had the same score (5.00) and Sample E also had the least colour score (2.00). At 0 week, there were no significant $(p>0.05)$ change in the texture among Samples A (4.00), B (5.00), C (5.00), D (5.00), and F (5.00). At 0 week, Samples C (5.00) and D (5.00) had the highest score for overall acceptability. The least moisture was seen in defatted soybean (5.07%), this was followed by fermented maize (9.71%) and the highest moisture content was observed in carrot (12.91%). Defatted soybean had the highest (41.2%) protein content next was carrot (10.63%) and the least was maize (6.14%) in that decreasing order. The highest (270%) water holding capacity was observed in Sample E, this was followed by Samples D (240%), C (240%), B (166%) and A (140%) in that decreasing order. The highest value for oil absorption was seen in Sample C (144%), this was followed by Sample A (121%), D (120%), B (105%) and E (90%) in that order. In this study products C and D were preferred as they were able to compete favourably with the commercial diet (F=control). However, product D was more preferred having the best color quality, texture quality as well as good functional properties. This study recommends the complementary of maize flour by the supplementation of carrot at 15% and soybean 20% inclusion level for better sensory and functional characteristics.

Key words: Sensory, sample, functional, weaning, cereal

INTRODUCTION

Breast milk is nutritionally adequate infant food for the first six months of life. It has adequate nutrients and immunological components that an infant needs to maintain a healthy living, promote growth and development. Breast milk also protects children from the leading causes of infant mortality which are upper respiratory infection and diarrhea [1]. However, after few months, breast milk will no longer be enough to meet the nutritional demands of the growing infant whose weight is expected to have doubled. At this stage complementary food needs to be introduced especially between the periods of 6 months to 2years, to form part of their diet. Consequent to the prevailing unfavourable economic conditions in developing countries of the world, Africa and Nigeria in particular, where over 40% of the population live below poverty line [2], the incidence of protein-energy malnutrition among different age groups especially infant with an estimated 400 million children reported to be malnourished worldwide is highly prevalent and on the increase on a daily basis [3, 4]

In some developing countries, the greatest problems affecting millions of people, particularly children, is low protein intake. Since cereals are low in protein, supplementing cereals with locally available legume that is high in protein increases protein content of cereal-legume blends. Many traditional fermentations had been upgraded to improved technology production systems and this has actually improved the well-being and economy of the people [5].

Cereals and legumes are main sources of nutrients to wean children in developing countries. Sorghum (*Sorghum bicolor*) is the major component of weaning foods commonly used in Nigeria, with a limited amount of dried – milk powder. However, such mixtures have been shown to be poor in protein content and quality [5]

Soybean (*Glycine max)* is an affordable quality protein source that is superior to other plant foods, it has good balance of the essential amino acids and it has sufficient amount of methionine lacking in plantain, making it a better supplement.

Carrot (*Daucus carota*) is an important vegetable containing bioactive compounds including carotenoids, and dietary fibers; providing appreciable functional characteristics with significant health promoting properties. The intake and usage of carrot and its products is increasing steadily due to its natural antioxidants and anticancer activities [6]

Beside protein and energy, infants in developing countries require more calcium, vitamin A and D, iron and some important trace element. These can be achieved by combination of local staples available in the country. Mixture of cereals with less expensive protein plant sources like legumes can be used. Cereals lack adequate lysine but have enough sulphur containing amino acids which are limited in legumes [7,8) whereas legumes are rich in lysine. The results of diet supplementation are highly beneficial, as the nutrient of the product is also improved. This project studied the sensory evaluation and functional properties of inexpensive, local and readily available raw materials which are nutritious infant food with long keeping qualities and increased overall consumer acceptability.

MATERIALS AND METHODS

Source of materials: Yellow maize (*Zea mays*), soybean (*Glycine max)* and carrot (*Daucus carota*) were purchased in Benin city and Auchi, Edo State, Nigeria.

Fermented maize flour preparation

Two and half (2.5) kilogram of maize was prepared by the traditional wet milling process. During this process, the maize was sorted, washed and steeped in sufficient water at room temperature for 72 hours. The water for steeping was changed daily and on the 3rd day, it was drained and wet milled with a disc attrition mill. A muslin cloth was used to sieve the wet milled slurry/ gruel . The slurry was allowed to settle overnight and the supernatant decanted. The wet cake was recovered by squeezing excess water with muslin cloth and sun-dried for three days. It was later dried in a cabinet drier at 50ºC for 8 hours. The meal was further dried-milled with a hammer mill and sieved. The fermented maize flour was packed in cellophane and stored in a cool dry place until needed for product formulation.

Preparation of Carrot Flour

Carrot flour was prepared according to the method described by [9]. One kilogram of carrot was washed with distilled water to remove extraneous materials and cut into slices before grating. The grated carrot was spread evenly on trays and dried in an oven at 40 ± 2°C. The dried carrot was removed from oven when constant weight was attained. Dried carrot was milled in a grinder to form powder and stored in air tight food grade plastic containers.

Preparation of Defatted Soybean Flour

Defatted soya bean flour was produced using the method described by [10] with slight modification. 2 Kg of soybean seeds was manually sorted and washed in water, manually dehulled and dried in cabinet dryer at 45 ºC. The dried seeds were milled using blender (Flourish BL-Y44S) and made to pass through 150 µm mesh sieve in order to obtain full-fat soybean flour. The full-fat soybean flour was defatted using soxhlet extraction with hexane as the solvent. The defatted soybean flour was packaged in an air tight container for further analysis.

Table 1: Formulation of fermented maize, defatted soybean and carrot complementary food

	Levels of substitution		
Sample Id	Fermented maize flour	Defatted soy flour	Carrot powder
A	100.00	0.00	0.00
B	85.00	10.00	5.00
C	60.00	30.00	10.00
D	65.00	20.00	15.00
E	50.00	50.00	0.00

Sensory evaluation: Sensory evaluation for the formulated weaning meals was conducted at 0, 2 and 4 weeks by 10 Staff from Food Technology Department using a 5-point Hedonic scale, with score ranging from Like extremely (5) to dislike extremely (1). The evaluated parameters were Colour, texture, taste, consistency, and overall acceptability.

Determination of functional properties

Foaming capacity: The method of [11] was used for the determination of the foaming capacity of the samples with modifications. Two (2) g of flour sample was mixed with 100 ml distilled water and the suspension was mixed with a kitchen blender. The suspension was transferred into a 250 ml graduated cylinder. Volume of the mixture was recorded before and after mixing and the experiment was done in triplicate. The foaming capacity was calculated using the equation: Foaming capacity (%) = $(V_1-V_2)/V_{3)}) \times 100$ V1 is the volume of initial mixture. V_2 is the volume of the mixture after mixing and V_3 is the volume of the foam after 5 hours.

Water absorption capacity: Water absorption capacity (WAC) was carried out according to the method described by [12] 10 ml of distilled water was added to 1 g of the sample in a beaker. The suspension was stirred using magnetic stirrer for 3 min. The suspension obtained was thereafter centrifuged at 2,058 × g for 30 min and the supernatant was measured into a 10 ml graduated cylinder. The absorbed water by the flour was considered as the change between the initial volume of the water and the volume of the supernatant. The water density was taken as 1.0 g/ml.

$$\text{WAC}=\frac{weight\ of\ sample\ (g)}{volume\ of\ water\ used-volume\ of\ unabsorbed\ (ml)}\ x\ 100$$

Oil absorption capacity: Oil absorption capacity (OAC) which is an index of the amount of oil retained within a protein matrix under certain conditions was determined according to the method described by [12]. 10 ml of oil known specific gravity was added to 1 g of sample in a beaker. The suspension was stirred using magnetic stirrer for 3 min. The suspension obtained was thereafter centrifuged at 3500 rpm for 30 min and the supernatant was measured into a 10 ml graduated cylinder. The density of oil used was 0.931 g/ml. The change between the original volume of the oil and the volume of the supernatant was calculated as the oil absorbed by the flour.

$$\text{OAC}=\frac{weight\ of\ sample\ (g)}{volume\ of\ water\ used-volume\ of\ unabsorbed\ (ml)}\ x\ 100$$

Swelling power: Swelling power (Sp) was determined using the modified method of [13] with slight modification. Two and fifty (2.5) g of the sample was measured in a 50 ml graduated cylinder. About 30 ml was added and mixed until homogeneity was reached. The mixture was then left to settle for 24 h, and the final volume (vf) occupied by the sample was measured. The swelling capacity was obtained as follows:

$$Swelling\ power\ (\%) = \frac{W2-W1}{sample\ weight}\times 100$$

PROXIMATE COMPOSITION

The moisture, protein, fat, fiber and ash contents of the samples were determined as described by[14]. The carbohydrate was estimated by difference.

STATISTICAL ANALYSIS

Data generated were subjected to one-way analysis of Variance (ANOVA) in randomized block to test significant variations (P<0.05) among mean values obtained. The values used for each treatment were in triplicate. Where significant differences existed Duncan's multiple range test was applied to indicate where the differences occurred using Genstat statistical package 2005, 8^{TH} edition (Genstat Procedure Library Release PL16). Also, data were represented by simple descriptive bar chart.

RESULTS AND DISCUSSION

The analysis of variance showed that there was significant difference ($p<0.05$) in the nutritive composition of the major raw materials used in this study (Table 2). The least moisture was seen in defatted soybean (5.07%), this was followed by fermented maize (9.71%) and the highest moisture content was observed in carrot (12.91%). The highest protein content was defatted soybean (41.2%) next was carrot (10.63%) and the least was maize (6.14%) in that decreasing order. The same trend was observed for ash with soybean having the highest ash content (8.87%) next was carrot (7.07%) and the least was maize (1.13%). The least fiber (2.46%) and carbohydrate (28.29%) were from defatted soybean. Fermented carrot had the least fat content (5.19%).

Table 2: Proximate composition of raw plant materials used

	Treatments			
Proximate parameter	Fermented maize	Defatted Soybean	Carrot	SED
Moisture (%)	9.71^{b}	5.07^{c}	12.91^{a}	0.03
Protein (%)	6.14^{c}	41.2^{a}	10.63^{b}	0.02
Ash (%)	1.13^{c}	8.87^{a}	7.07^{b}	0.02
Fiber (%)	1.09c	2.46^{b}	6.50^{a}	0.01
Fat (%)	11.39^{b}	14.11^{a}	5.19^{c}	0.03
Carbohydrate (%)	70.54^{a}	28.29^{c}	57.70^{b}	0.05

Means with the same superscript along the rows are not significantly different ($p>0.05$)
SED=Standard error of difference of means

The analysis of variance for sensory evaluation shows that there were significant differences ($p<0.05$) among the flour blends.

At 0 week, Samples C and D had the highest score (5.00) for colour (Figure 1). However, it was not significantly different ($p>0.05$) from Sample A (4.00), B (4.00) and F(4.00), while Sample E had the least score (3.00) and was significantly different from the Samples C and D. At 2 weeks, the results showed that Samples D and F had the highest and same score (5.00), but were not significantly different ($p>0.05$) from sample B and C which also had the same score (4.00). The least score was recorded in sample E (2.00). At 4 weeks, Samples D and F had the same score (5.00) and was not significantly different (p>0.05) from Samples B (4.00) and C (4.00), while Sample E also had the least colour (2.00). The best colour quality observed in Sample D could be attributed to the inclusion of carrot at the highest level (15%). Carrot which is a good source of beta-carotene must have enhanced its colour which agreed with the report by [15]. According to [16] colour and appearance are improved with the addition of carrot.

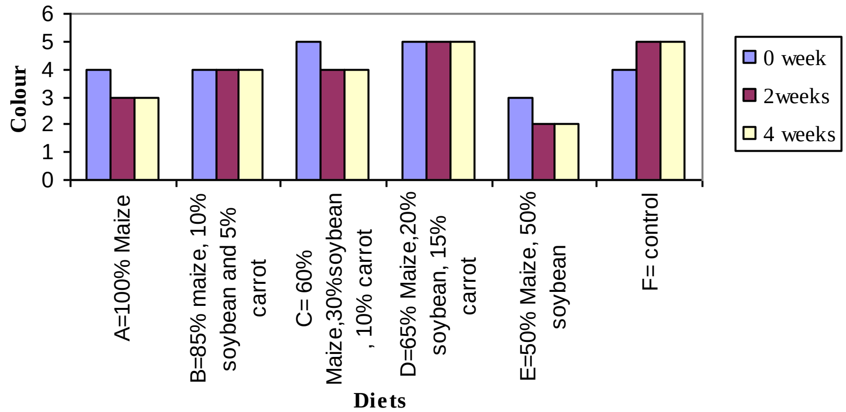

Figure 1: Colour of formulated and control diets

At 0 week, there were no significant differences (p>0.05) in the texture among Samples A (4.00), B (5.00), C (5.00), D (5.00), and F (5.00) (Figure 2), but were significantly different (P<0.05) from Sample E (3.00). At 2 weeks there was also no significant difference (p>0.05) in texture among Samples A (4.00), B (5.00), C (4.00), D (5.00), and F (5.00) except Sample E (2.00). This trend continued in 4 weeks with Sample E having the least score (2.00) and was significantly different (P<0.05) from Samples A, B, C and F. The best texture was recorded in sample D at the end of 2 weeks (5.00).

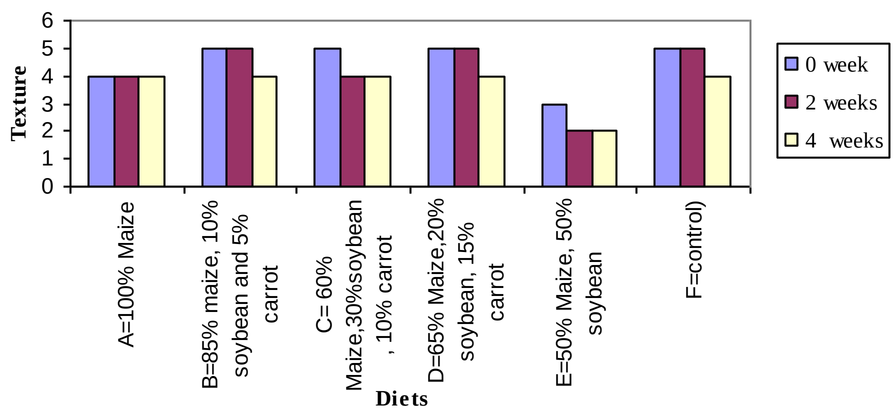

Figure 2: Texture of formulated and control diets

A very important parameter for accessing sensory attributes in food is Taste; it is an important property, because it stimulates the child's likeness and acceptance for the food. Actually, an appealing product that meets nutrient requirements but without good taste, would likely not be accepted. There were no significant differences (p>0.05) in taste among Samples A (4.00), B (4.00), C (5.00), D (5.00) and F (5.00) at 0 week, but Sample E (2.00) was significantly (p<0.05) different from other samples. However, at 2 and 4 weeks, Sample A (3.00) was significantly different (p<0.05) from Samples C (5.00), D (5.00) and F (5.00), while there were no significant differences (p>0.05) in taste between Samples A (3.00) and B (4.00). There were also no significant differences (p>0.05) among Samples B, C, D and F throughout the experimental period. The best taste was recorded in Samples C, D and F at 0, 2 and 4weeks (Figure 3). Although, it was not significantly different (p>0.05) from Samples A (4.00) and B (4.00) at day 0 and 4 weeks.

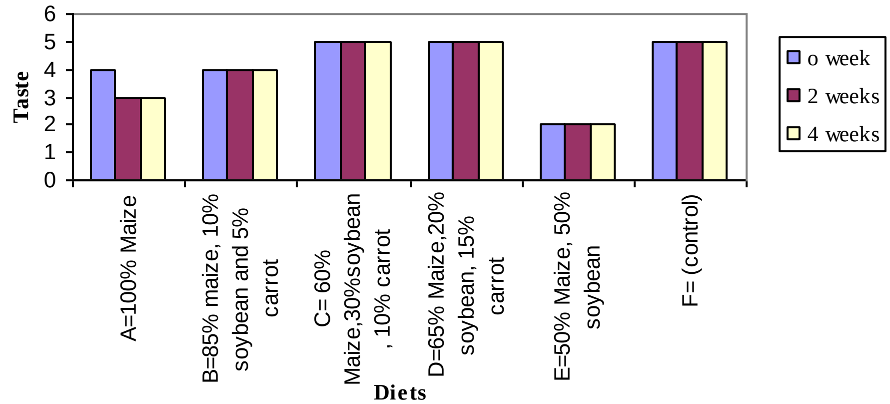

Figure 3:Taste of formulated and control diets

The way food feels in the mouth is very necessary in a complementary food as it will determine the quantity of food a child would consume, since they can only swallow a smooth gruel not a coarse one [17].

For consistency, there were no significant differences (p>0.05) among the products A(4.00), B(4.00),C (4.00),D (4.00),and F (4.00) throughout the period except for Sample E at 0 week (2.00), 2 weeks (2.00) and 4weeks (2.00) (Figure 4).

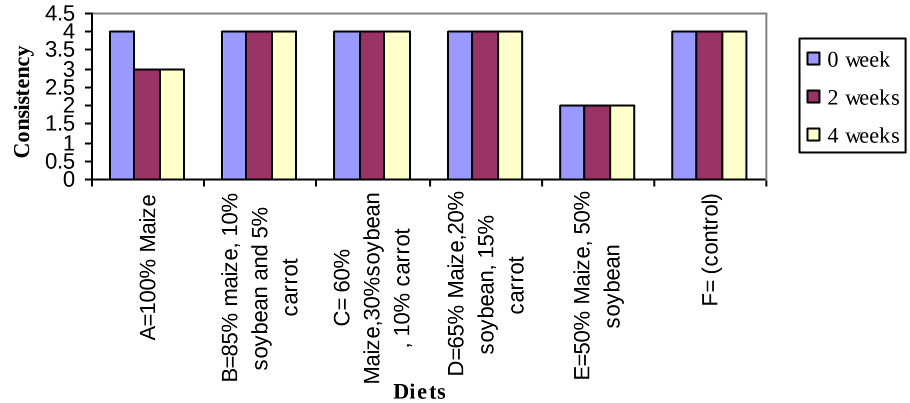

Figure 4: Consistency of formulated and control diets

At 0 week, Samples C (5.00) and D (5.00) had the highest score for overall acceptability and were not significantly different (p>0.05) from Samples A (4.00), B (4.00) and F (4.00) except Sample E (2.00) which had the least score (Figure 5). This was possible because Samples C and D had carrot inclusion at 10% and 15% which influenced the water absorption capacity (WAC) of the products (Table 1) thereby enhancing the consistency. Throughout the period Sample E had the least score (2.00) for overall acceptance. This could be attributed to high level (50%) inclusion of soybean which resulted in Beany flavor common in soybean

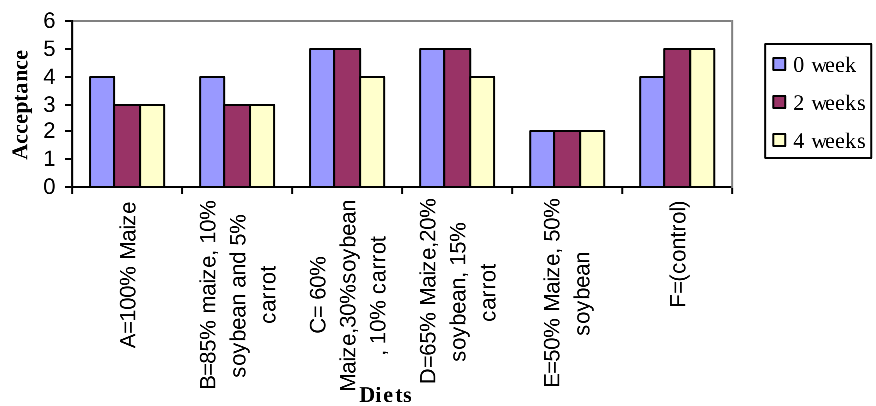

Figure 5: Overall acceptance of formulated and control diets

Table 3: Functional properties of complementary food from maize flour supplemented with soybean and carrot

Functional properties	Samples					
	A	B	C	D	E	SED
WAC (%)	140.0^{d}	166.0^{c}	240.0^{b}	240^{b}	270^{a}	5.01
OAC (%)	121.0^{b}	105.0^{bc}	144.0^{a}	120.0^{b}	90.0^{c}	0.77
Solubility (%)	9.0^{b}	6.0^{b}	7.0^{bc}	19.0^{a}	6.0^{c}	0.97
Swelling power 60^{o}C	272.0^{a}	256.0^{b}	227.0^{cd}	233.0^{c}	223.0^{d}	2.63
Swelling power 70^{o}C	415.0^{a}	415.0^{a}	332.0^{b}	274.67^{c}	278.0^{c}	2.25
Foam capacity (%)	0.0	0.0	0,0	0.0	0.0	0.0
Foam stability (%)	0.0	0.0	0.0	0.0	0.0	0.0

Means with the same superscript along the rows are not significantly different ($p>0.05$). Group A = whole maize 100%; Group B = 85% maize, 10%soybean and 5%carrot. Group C = 60% maize, 30%soybean and 10%carrot; Group D = 65%maize, 20%soybean and 15% carrot; Group E = 50%maize and 50%soybean, Group F = Cerelac (control). SED = Standard error difference of means

There were significant differences ($p<0.05$) in the functional properties of the complementary food of maize supplemented with soybean and carrot (Table 3).

Water absorption capacity (WAC) consists of adding water or an aqueous solution to material, followed by centrifugation and quantification of the water retained by the pelleted material in the centrifuge tube [18]. Water absorption capacity referred to the ability of the flour or starch to hold water against gravity that can comprise of bound water, hydrodynamic water, capillary water and physically entrapped water [19].

The highest water holding capacity (WAC), 270% was observed in Sample E, this was followed by Samples D (240%), C (240%), B (166%) and A (140%) in that decreasing order. The high WAC in Sample E reflected the high inclusion of soybean (50%) to maize. These results showed that soybean at 50% (high fiber content) results in high WAC by influencing the availability of hydrophilic constituents in flours. This agreed with the work of [15] that more availability of hydrophilic constituents (polysaccharides) resulted in flours with high water absorption [20]. The low WAC in Sample A (140%) which had 0% soybean and 0% carrot could be attributed to its high starch content (100%) causing significant reduction in WAC which agreed with the work of [21] who reported that high fiber and starch contents results in highwater binding capacity. Similarly, [22] reported that the ability of flour to absorb water had a significant correlation with its starch content. WAC is essential in bulking and consistency of products, as well as in baking application [23]. Water absorption characteristics represent the ability of a product to associate with water under conditions where water is limiting, such as dough and pastes [24].

The highest value for oil absorption was seen in Sample C (144%), this was followed by Sample A (121%), D (120%), B (105%) and E (90%) in that decreasing order. This study showed that carrot at 10% (Sample C) to flour improves the OAC which could be attributed to the physical entrapment of oil. It is an important functional property as the ability of flours to absorb and retain oil may enhance flavour retention and improve mouth feel [25].

The highest solubility value was seen in Sample D (19%) which was significantly different ($p<0.05$) from the solubility of other products, it was followed by Samples A (9%), C (7%) while B (6%) and E (6%) in that decreasing order. However, Sample B was not significantly different ($p>0.05$) from sample E.

Swelling power (SP) is the ability of a Sample to absorb water undisturbed under a room temperature. The swelling power shows the degree of the water absorption of the starch granules in the flour [26]. The swelling capacity at 60^{o}C and 70^{o}C increased with increasing amount of fermented maize inclusion from 272$^{\%}$ to 415$^{\%}$; 256% to 415%; 227% to 332% for samples A, B and C respectively. The least swelling capacity at 60^{o}C was sample E (223%) while at 70^{o}C the least was sample D (274%). At 70^{o}C, SC of Samples B (415%), C (332%) and D (374.6%) decreased with increasing level of carrot inclusion i.e. B (5%), C (10%) and D (15%) respectively. The results show that supplementation of the composite flour with carrot and soy bean flours resulted in low swelling power. This finding disagreed with the work of [27] who reported that the inclusion of carrot and soybean in flour results to high SP. Also complementary foods do not require high swelling capacity as the food would absorb more water and have less solid resulting in low nutrient density for infants [28]. Besides, this study showed that SP increased with increase in temperature (60^{o}C to 70^{o}C). The foaming capacity measures the amount of interfacial area created by protein during foaming [29]. The foam capacity and foam stability for all the samples was zero.

CONCLUSION

Composite flours have been used extensively and successfully in the production of food products. The functional properties of composite flour are an essential parameter to produce various food products that are good qualities in terms of appearance, organoleptic, and acceptance from consumers. This study has shown that soybean flour and carrot are good complementary flours to improve the functional, nutritive and sensory properties of cereal-based weaning food blends. The low nutritional quality of cereals can be improved through supplementation with blends of defatted soybean and carrot flours. In this study products C and D were preferred as they were able to compete favourably with the commercial diet (F=control). However, product D was more preferred having the best color quality, texture quality as well as good functional properties.

RECOMMENDATION

Weaning food has always been produced from cheap and available plant materials such as cereal (maize). However, maize alone results in malnutrition in children. Hence this study recommends the complementary of maize flour by the supplementation of carrot at 15% and soybean 20% inclusion level for better sensory, nutritive and functional properties.

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