International Journal of Food Science and Biotechnology
2017; 2(4): 106-113
http://www.sciencepublishinggroup.com/j/ijfsb
doi: 10.11648/j.ijfsb.20170204.12

Proximate Analysis and Formulation of Infant Food from Soybean and Cereals Obtained in Benue State, Nigeria

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To cite this article:

Ikese Chris Oche, Okoye Patrice-Anthony Chudi, Ubwa Simon Terver, Akende Samuel. Proximate Analysis and Formulation of Infant Food from Soybean and Cereals Obtained in Benue State, Nigeria. *International Journal of Food Science and Biotechnology*. Vol. 2, No. 4, 2017, pp. 106-113. doi: 10.11648/j.ijfsb.20170204.12

Received: April 19, 2017; **Accepted**: July 19, 2017; **Published**: August 15, 2017

Abstract: In a bid to stem the tide of infant malnutrition occasioned by the high cost of proprietary infant food in developing countries, the study formulated a nutritious infant food by beneficiating a cereal-legume composite prepared from short rice, yellow maize and soybean grains obtained in Benue State, Nigeria using crayfish, egg yolk and banana flavour. Among the cereals species compared by proximate analysis, short rice and yellow maize were found to be the most soybean-complementing cereal pair. The proximate compositions, caloric value and sensory properties of the formulated food were determined and statistically compared with their respective means in two common proprietary infant formulae sold in the market. The formulated food was found to compete favourably with both proprietary formulae as its proximate composition (protein; 16.71%, Carbohydrate; 55.51%, crude fat; 10.39%, crude fibre; 12.64%, ash; 4.20% and moisture; 10.55%) was quite comparable to the mean proximate composition of both proprietary formulae (protein; 15.63%, Carbohydrate; 64.42%, crude fat; 10.84%, crude fibre; 1.74%, ash; 3.03% and moisture; 4.35%). The formulated food complied with united nation's protein advisory group (PAG) recommendation for each proximate food component in infant food except in carbohydrate which was 9% less than the PAG benchmark for carbohydrates in infant food (65%). Accordingly, the caloric value of the formulated food (380 Kcal/100g) was less than the mean in both proprietary formulae (417 Kcal/100g). Sensory evaluation showed that with exception in flavour, the formulated food did not differ significantly (p=0.05) from the proprietary formulae in appearance, taste, after-taste, mouth-feel, colour and overall acceptability. Sensory judges had a higher preference for both proprietary formulae than for the formulated food because the residual flavour of the crayfish and egg yolk components were mildly perceivable. Most judges observed that the formulated food could be improved upon by further reducing its particle size to give it a much finer texture. The microbial shelf life of the formulated food was found to be 6 weeks from the date of formulation.

Keywords: Infant Malnutrition, Infant Food, Proprietary Formula, Proximate Composition

1. Introduction

Infant malnutrition is a state of impaired health in infants occasioned by not having enough to eat, not eating enough of the right kind of food and an inability to utilize the food eaten [1, 2]. Infant malnutrition is a major world health problem especially in developing countries [1] and the World Health Organization (WHO) have estimated that 150 million infants in developing countries are malnourished [2, 3]. Protein energy malnutrition (PEM) and iron deficiency are the most common forms of infant malnutrition in sub-Saharan Africa [1, 3]. Naturally, infant malnutrition sets in 6 months after birth, when birth weight has doubled and growth is rapid. From this point onward, breast milk alone is unable to meet the nutritional needs of the growing infant [1, 3, 4, 5] and complementary food or infant formula must be introduced [1, 5]. Ideally, formula should be a substitute for breast milk only in infants who cannot be fed at the breast, or for whom breast milk is not available [6] as with HIV-infected mothers and in cases involving maternal mortality where infant formulas must serve entirely as substitute for breast milk right from birth. However, the high cost of proprietary formula in developing countries continue to place them beyond the reach of low-income families who revert to poorly processed traditional foods [4, 5]. As such, the study is aimed at formulating a nutritious infant food from soybean and local cereals obtained in Benue State, Nigeria.

It is believed that the study will not only help provide a nutritious low cost alternative to costly proprietary formula, but it will further promote commercialization of locally grown cereals, provide comparative information on the proximate composition of locally grown cereal species in Benue State while availing useful data on the extent of nutrient losses/gain associated with different food processing strategies employed in the food formulation.

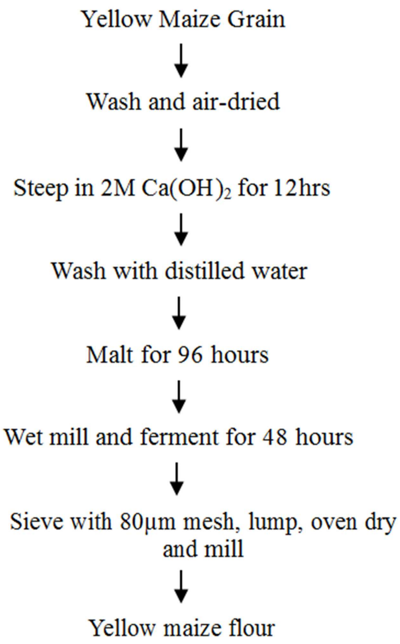

Figure 1. *Preparation of Yellow Maize flour.*

2. Materials and Methods

2.1. Sample Procurement

The under-listed grain samples were procured from local markets across Benue State, Nigeria, separately composited according to variety and a representative 2kg sample of each species composite was drawn for proximate analysis and subsequent feed formulation. Chicken eggs, crayfish, banana flavour, and two common proprietary formulae (designated as infant formula A and B) were procured in addition to long, short and brown rice (Oryza sativa), white and red sorghum (Sorghum vulgare and Sorghum dochna respectively), Pearl millet (Pennisetum glaucum), wheat (Triticum aestivum), white and yellow maize (Zea rugosa and Zea indentata respectively) and Soybeans (Glycine max).

2.2. Proximate Analysis

Proximate analysis was performed on the soybean and cereal grain species, flour forms of short rice, yellow maize, soybean, the formulated infant food, infant formula A and B. Moisture, ash, crude fibre, crude fat and crude protein were determined in triplicates using standard methods prescribed by Association of official analytical chemists (AOAC) [7]. Total carbohydrate was determined by difference [1].

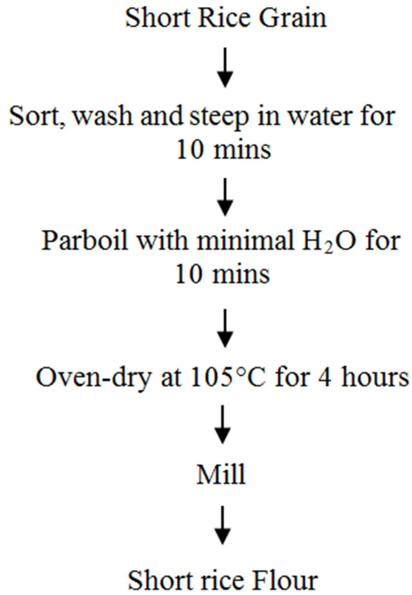

Figure 2. *Preparation of Short Rice flour.*

2.3. Preparation of Flours

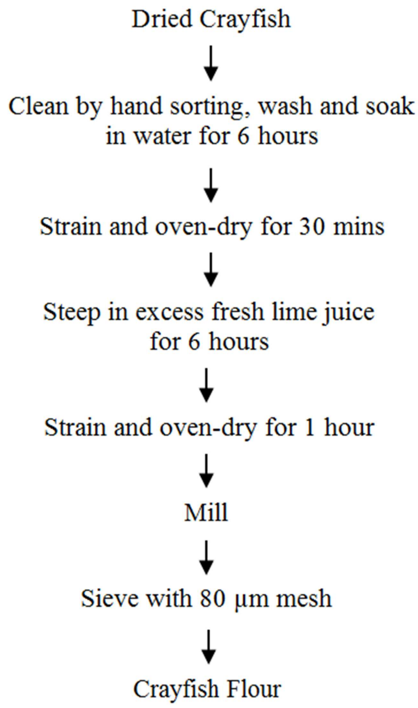

Figure 3. *Preparation of Crayfish Flour.*

Following the proximate analysis of all grains species, Cereal flours, were made from two of the most soybean-complementing cereals (yellow maize and short rice), crayfish, Soybean and egg yolk as described in Figures 1, 2, 3, 4 and 5 respectively.

Soybean Grains
↓
Clean and sort by manual handpicking
↓
Wash and soak in water for 14 hours
↓
Strain and blanch for 20 mins
↓
Dehull and wash severally with water
↓
Boil for 15 mins and air dry for 48 hours
↓
Roast and Mill
↓
Sieve with 80 µm mesh
↓
Soybean Flour

Figure 4. *Preparation of Soybean Flour.*

Chicken Eggs
↓
Hard Boil in Water for 20 mins and recover yolk
↓
Cut yolk in pieces and oven-dry for 3 hours
↓
Steep in excess fresh lime juice for 6 hours
↓
Strain and oven-dry for 1 hour
↓
Mill
↓
Sieve with 80 µm mesh
↓
Egg yolk Powder

Figure 5. *Preparation of Egg yolk Powder.*

2.4. Calculation of Blend Proportion for Food Formulation

Let; S = soybean
M = yellow maize
R = short rice
Total balance:

$$S + M + R = 100g \quad (1)$$

Component on protein

$$0.3553S + 0.0680M + 0.0099R = 20 \quad (2)$$

Component on fat

$$0.1678S + 0.0331M + 0.0178R = 10 \quad (3)$$

Equation (1) ×0.0099

$$0.0099S + 0.099M + 0.0099R = 0.99 \quad (4)$$

Equation (1) ×0.0178

$$0.0178S + 0.0178M + 0.0178R = 1.78 \quad (5)$$

Equation (2) – Equation (4)

$$0.3454S + 0.0581M = 19.01 \quad (6)$$

Equation (3) – Equation (5)

$$0.15S + 0.015M = 8.22 \quad (7)$$

Equation (6) ×0.0153

$$0.00528462S + 0.00088893M = 0.290853 \quad (8)$$

Equation (7) × 0.0581

$$0.008715S + 0.00088893M = 0.472582 \quad (9)$$

Equation (8) – Equation (9)

$$-0.0034038S = -0.186729$$

Therefore: S = 54.34%
Put S = 54.43% into Equation (6)

$$0.0581M = 0.21$$

Therefore M = 3.61%
Put S = 54.43 and M = 3.61 into Equation (1)

$$54.43 + 3.61 + R = 100$$

Therefore R = 41.96%
Hence;

Soybean =54.43%

Yellow maize =3.61%

Short Rice =41.96%

2.5. Feed Formulation

The cereal-Legume composite (CLC) was formulated by blending the flours produced according to equation (10). Thereafter, the infant food was formulated by beneficiating the CLC according to equation (11).

$$CLC = X\%\ Rf + Y\%\ Mf + Z\%\ Sf \quad (10)$$

$$FIF = 92\%\ CLC + 2.5\%\ EY + 2.5\%\ CFh + 3\%\ BF \quad (11)$$

Where: Rf, Mf, Sf, EY, CFh, BF represent short rice flour, yellow maize flour, soybean flour, egg yolk powder, crayfish powder and banana flavour respectively. X=41.96%, Y=3.61% and Z=54.43% are the respective blend proportions of short rice, yellow maize and soybean flours in the cereal-legume blend. FIF is the formulated infant food. The blend proportions were mathematically derived by simultaneous equation and material balance as earlier shown.

2.6. Sensory Evaluation

For the sensory evaluation, 445.2 g of the formulated food was constituted in 375 mL of boiling water with addition of 24.1g of sugar to obtain the formulated food gruel. Infant formula A and B were also made into gruel form according to the manufacturer's instructions. Infant formula A, B and the formulated food gruels were coded A, B and C respectively and presented to a panel of 20 untrained judges all of whom were nursing mothers experienced in infant formula-feeding. The following sensory attributes were scored by the panel using a 7-point hedonic scale; appearance, flavour, tastes, mouth feel, after-taste, colour and overall acceptability. The mean scores of the formulated food attributes was then statistically compared with those of infant formula A and B using one-way ANOVA.

2.7. Microbial Analysis

The formulated food was packaged in a sterile aluminium foil immediately after formulation and a 3g portion was analysed for total bacterial count (TBC), total coliform count (TCC) and total fungal count (TFC) immediately after the food was formulated and again at 2 weeks interval for 10 weeks using the methods described by Amankuwa et al [8].

2.8. Statistical Analysis

Statistical analysis was performed using IBM SPSS version 21 statistical software. The means and standard deviations of all results were calculated. The results were subjected to one way- analysis of variance to determine if they were significantly different at P=0.05. The Turkey test was also used to separate significantly different means.

3. Results and Discussion

3.1. Proximate Composition of Cereals and Soybean Grains Obtained in Benue State

Table 1. *Proximate composition of Cereals and Soybean Grains obtained in Benue State.*

S/N	Grain Species	Moisture (%)	Ash (%)	Fat (%)	Fibre (%)	Protein (%)	Carbohydrate (%)
1.	Long Rice	12.20^{c} ± 0.13	0.53^{a} ± 0.05	2. 00^{a} ± 0.06	0.21^{a} ± 0.11	4.73^{a} ± 0.01	80.33^{e} ± 0.09
2.	Short Rice	11.20^{d} ± 0.06	0.50^{a} ± 0.04	2.10^{a} ± 0.12	0.30^{a} ± 0.05	4.66^{a} ± 0.08	81.24^{f} ± 0.05
3.	Brown Rice	12.15^{c} ± 0.09	0.70^{a} ± 0.04	2.00^{a} ± 0.08	0.32^{a} ± 0.04	4.71^{a} ± 0.02	80.12^{e} ± 0.10
4.	White Sorghum	11.00^{d} ± 0.07	2.20^{c} ± 0.03	3.04^{b} ±0.01	2.11^{c} ± 0.10	9.23^{b} ± 0.10	72.41^{d} ± 0.12
5.	Red Sorghum	10.54^{c} ± 0.15	1.40^{b} ± 0.09	3.72^{c} ± 0.13	1.64^{b} ±0.06	10.40^{c} ± 0.09	72.30^{d} ± 0.05
6.	White Maize	12.62^{b} ± 0.06	1.30^{b} ± 0.13	4.21^{d} ±0.06	3.00^{d} ±0.10	10.87^{c} ± 0.45	68.00^{b} ± 0.15
7.	Yellow Maize	10.74^{c} ± 0.13	1.20^{b} ± 0.09	4.62^{e} ± 0.04	2.00^{c} ± 0.15	10.66^{c} ± 0.07	70.78^{c} ± 0.03
8.	Wheat	14.42^{a} ± 0.10	1.40^{b} ± 0.09	2.21^{a} ± 0.12	1.83^{b} ±0.13	12.37^{d} ± 0.13	67.77^{b} ± 0.12
9.	Millet	9.49^{f} ± 0.34	2.22^{c} ± 0.01	3.63^{c} ± 0.06	2.10^{c} ± 0.07	10.35^{c} ± 0.12	72.21^{d} ± 0.06
10.	Soybean	10.10^{g} ± 0.07	3.80^{d} ± 0.04	18.10^{f} ±0.09	3.12^{d} ±0.12	39.21^{e} ± 0.12	25.67^{a} ± 0.05

Values are Mean ± Standard deviation of triplicate determinations.
Mean values with identical superscripts in the same Column are not significantly different (p=0.05)

Table 2. *Mean Proximate composition of the best Possible Cereals-Soybean composite.*

S/N	Cereal-Legume combination	Moisture (%)	Ash (%)	Crude Fibre (%)	Crude Fat (%)	Protein (%)	Total Carbohydrate (%)
1.	Soy-Millet-White Maize	10.73^{b} ±1.65	2.44^{c} ±1.26	2.74^{f} ±0.55	8.63^{a} ±8.20	20.14^{d} ±16.15	55.00^{b} ±25.74
2.	Soy-Short Rice-Yellow Maize	10.68^{b} ± 0.55	2.00^{c} ±1.73	1.80^{f} ± 1.41	8.27^{a} ± 8.60	18.18^{d} ±18.46	60.60^{b} ±29.53
3.	Soy-Red Sorghum-Millet	10.04^{b} ± 0.52	2.47^{c} ± 1.21	2.28^{f} ± 0.75	8.90^{a} ± 8.33	20.20^{d} ±16.64	54.81^{b} ±26.89
4.	Soy-White Maize-Yellow Maize	11.15^{b} ± 1.30	2.10^{c} ± 1.74	2.70^{f} ± 0.61	8.97^{a} ± 7.90	20.24^{d} ±16.42	54.01^{b} ±25.28
5.	Soy-Long Rice-Millet	10.59^{b} ± 1.42	2.18^{c} ±1.63	1.81^{f} ± 1.47	7.91^{a} ± 8.86	18.09^{d} ±18.49	59.40^{b} ±29.49
6.	Soy-Short Rice-Wheat	11.90^{b} ± 2.24	1.90^{c} ± 1.70	1.75^{f} ±1.41	7.47^{a} ± 9.20	18.74^{d} ±18.13	58.22^{b} ±28.98
7.	Soy-Wheat-Millet	11.33^{b} ± 2.68	2.47^{c} ± 1.21	2.35^{f} ± 0.68	7.98^{a} ± 8.80	20.64^{d} ±16.11	55.21^{b} ±25.68
8.	Soy-Yellow Maize-Wheat	11.75^{b} ± 2.33	2.13^{c} ± 1.44	2.31^{f} ± 0.70	8.31^{a} ± 8.56	20.74^{d} ±16.01	54.74^{b} ±25.22
9.	Soy-Red Sorghum-White Maize	11.08^{b} ± 1.34	2.16^{c} ± 1.41	2.58^{f} ± 0.82	8.67^{a} ± 8.16	20.16^{d} ±16.49	55.32^{b} ±25.77
10.	Soy-Wheat-Brown Rice	12.22^{b} ± 2.16	1.96^{c} ± 1.62	1.75^{f} ± 1.40	7.43^{a} ± 9.23	18.76^{d} ±18.11	57.85^{b} ±28.54
11.	Soy-White Sorghum-Yellow Maize	10.61^{b} ± 0.46	2.40^{c} ± 1.31	2.41^{f} ± 0.61	8.58^{a} ± 8.27	19.70^{d} ±16.11	56.28^{b} ±26.62
12.	Mean composition in 5 Proprietary formulae	4.35^{a} ± 0.05	2.90^{c} ± 0.51	1.74^{f} ± 0.09	10.84^{a} ±0.4	15.63^{d} ±0.15	67.99^{a} ± 0.59
13.	PAG Guideline Values	< 1	< 5	< 5	10	20	65

Note: Values are Mean ± Standard deviation.
Mean values with identical superscripts in the same Column are not significantly different (p=0.05)

The proximate compositions of cereals and soybean grains obtained in Benue State are shown in Table 1 above. Table 2 shows the proximate compositions of different combinations of the most suitable feed raw materials for the food formulation.

Table 1 Show that soybean is highest in crude protein, fibre, fat and ash (39.21%, 3.12%, 3.80% and 18.10% respectively) but lowest in total carbohydrate (25.67%) compared with any of the grains analysed and in the right blend proportion, will adequately fortify these cereals with these nutrients (except carbohydrate).

Also, an inverse relationship exists btw the carbohydrate and protein contents in the grains analysed. For instance, Short rice is highest in carbohydrate (81.24%) but lowest in protein (4.66%), and soybean is highest in protein (39.21%) but lowest in carbohydrate (25.67%). Therefore, the choice of cereal species pair to blend with soybean must be that which most complement soybean rather than the most nutritious cereals pair. The most complementing cereal pair for soybean will be the most carbohydrate -rich cereal analysed and another with appreciable nutrient levels. The results in Table 1 and the computations in Table 2 show that short rice and yellow maize make the cereal pair that most adequately complement soybean. This is because the average nutrient composition of this grain combination approximates more closely than that of any other to the mean nutrient levels in proprietary formula and to PAG recommended nutrient levels in infant food. Moreover, yellow maize is more preferred than wheat and millet which contain gluten [9] and goitrogens [10].

3.2. Proximate Composition of Raw Grains and Flours of Soybean, Yellow Maize and Short Rice

Table 3. *Proximate composition of grain and flour forms of soybean, yellow maize and short rice.*

		Soybean (Glycine max)		Yellow maize (Zea indentata)		Short rice (Oryza japonica)	
S/N	**Constituent**	**Grain**	**Flour**	**Grain**	**Four**	**Grain**	**Flour**
1.	Moisture (%)	$10.10^{a} \pm 0.07$	$8.30^{b} \pm 0.13$	$10.74^{c} \pm 0.06$	$11.23^{d} \pm 0.12$	$11.20^{d} \pm 0.10$	$9.57^{e} \pm 0.08$
2.	Ash (%)	$3.80^{a} \pm 0.01$	$1.70^{b} \pm 0.05$	$1.20^{c} \pm 0.09$	$1.02^{d} \pm 0.04$	$0.50^{e} \pm 0.08$	$0.78^{f} \pm 0.04$
3.	Crude Fibre (%)	$3.12^{a} \pm 0.10$	$4.73^{b} \pm 0.06$	$2.00^{c} \pm 0.06$	$3.56^{d} \pm 0.12$	$0.30^{e} \pm 0.10$	$0.27^{e} \pm 0.02$
4.	Crude Fat (%)	$18.10^{a} \pm 0.04$	$16.78^{b} \pm 0.11$	$4.62^{c} \pm 0.12$	$3.31^{d} \pm 0.08$	$2.10^{e} \pm 0.08$	$0.99^{f} \pm 0.10$
5.	Crude Protein (%)	$39.21^{a} \pm 0.09$	$35.53^{b} \pm 0.01$	$10.66^{c} \pm 0.09$	$6.80^{d} \pm 0.05$	$4.66^{e} \pm 0.13$	$1.79^{f} \pm 0.13$
6.	Total Carbohydrate (%)	$25.67^{a} \pm 0.11$	$32.96^{b} \pm 0.09$	$70.78^{c} \pm 0.08$	$74.78^{d} \pm 0.09$	$81.24^{e} \pm 0.10$	$86.60^{f} \pm 0.07$

Values are Means ± Standard deviations.
Mean values with identical superscripts in the same row are not significantly different (p=0.05)

The proximate compositions of raw grains and flours forms of soybean, short rice and yellow maize selected for the infant food formulation are as presented in Table 3. Table 3 show that for the most part, raw grains are higher in protein, fat, ash and moisture than their corresponding flours but the reverse is the case with carbohydrate and fibre components. The observed nutrient depreciations in the flours are due to nutrient losses associated with food processing methods employed in the conversion of raw grains into their corresponding flour [1, 11, 12]. This suggests that the lost food component may have been present in larger amounts in the morphological fraction of the grain that the processing method sort to get rid of.

Carbohydrate and fibre appreciation in the flours suggest that the processing methods concentrated these food constituents and as such, it is pointless to treat carbohydrate as a nutrient constraint (a limiting factor in the blend simultaneous equation) since both cereal flours contain carbohydrate in excess of the PAG recommendation (65%). The decline observed in protein and fat content of the flours justify their treatment as nutrient constrains especially as both cereal flours analysed fell below the PAG recommendation for protein and fat in infant food.

3.3. Impact of Cereal-Legume Blend Beneficiation on the Proximate Composition of the Formulated Infant Food

Table 4. *Impact of beneficiation on the formulated infant food.*

S/N	Food Constituent	Cereals-Legume composite	Formulated Infant food	Impact on food component
1.	Moisture (%)	10.05 ± 0.13	10.55 ± 0.07	+ 0.5
2.	Ash (%)	2.62 ± 0.29	4.20 ± 0.12	+ 1. 58
3.	Crude Fibre (%)	2.10 ± 0.10	2.64 ± 0.08	+ 0.54
4.	Crude Fat (%)	10.17 ± 0.07	10.39 ±0.06	+ 0.22
5.	Crude Protein (%)	20.65 ± 0.09	16.71 ± 0.15	- 3.94
6.	Total Carbohydrate (%)	54.41 ± 0.15	55.51 ± 0.09	+ 1.1

The impact of the Cereals-legume blend beneficiation on the proximate composition of the formulated food is shown in Table 4. Table 4 show that an 8% beneficiation window in the cereal-legume composite using crayfish, egg yolk powder and banana flavour will have the most incremental effect on the ash content (1.58% increment) and the most depreciative effect on the protein content (3.94% depreciation) of the resulting infant food. This suggests that the added flavour, crayfish and egg yolk powders combined, are richest in ash (minerals) but lacking in protein, possibly from nutrient losses associated with deodorizing the crayfish and egg yolk powders.

3.4. Proximate Composition and Caloric Value of Formulated Infant Food, Proprietary Formula and PAG Recommendations

Table 5. *Proximate composition and Caloric Content of Formulated infant food, Proprietary formulae and PAG recommendations.*

S/N	Food component	Formula A	Formula B	Mean Level in proprietary formulae	Formulated Infant food	PAG Recommended Level (%)
1.	Moisture (%)	$5.18^{a} \pm 0.03$	$3.52^{b} \pm 0.09$	$4.35^{a} \pm 1.17$	$10.55^{c} \pm 0.07$	5 to 10
2.	Ash (%)	$1.20^{a} \pm 0.05$	$4.86^{b} \pm 0.07$	$3.03^{c} \pm 2.58$	$4.20^{b} \pm 0.12$	≤ 5
3.	Crude Fibre (%)	$2.27^{a} \pm 0.09$	$1.20^{b} \pm 0.11$	$1.74^{b} \pm 0.75$	$2.64^{a} \pm 0.08$	< 5
4.	Crude Fat (%)	$9.47^{a} \pm 0.12$	$12.21^{b} \pm 0.03$	$10.84^{c} \pm 1.93$	$10.39^{c} \pm 0.06$	10
5.	Crude Protein (%)	$15.23^{a} \pm 0.13$	$16.03^{b} \pm 0.10$	$15.63^{a} \pm 0.56$	$16.71^{c} \pm 0.15$	20
6.	Total Carbohydrate (%)	$66.65^{a} \pm 0.11$	$62.18^{b} \pm 0.13$	$64.42^{a} \pm 1.57$	$55.51^{c} \pm 0.09$	65
7.	Caloric Value(Kcal/100g)	410	420	410	380	

Values are Means ± Standard deviations of triplicate determinations.
Mean values with identical superscripts in the same row are not significantly different (p=0.05)

Table 5 shows the proximate composition and caloric value of the formulated infant food, proprietary formulae and PAG recommendations. Table 5 show that;

Moisture in the formulated food (10.55%) is higher than the mean moisture in both proprietary formulae (4.35%) but comparable with PAG benchmark for moisture in infant food (10%). This implies that the formulated food will be more susceptible to microbial degradation and will likely have a shorter shelf life than the proprietary food.

Ash content in the formulated food (4.20%) is higher than the mean ash content in both proprietary foods (3.03%) and complies with PAG benchmark for ash in infant food (≤ 5.0%). This implies that the formulated food can be expected to contain more minerals than both proprietary formulae.

Crude Fibre content in the formulated food (2.64%) is higher than the mean crude fibre in both proprietary formulae (1.74%) and complies with PAG recommendation (< 5%). This implies that the formulated food will better promote laxation, bacterial colonization and maturation of the gastro intestinal tract, but may interfere with mineral absorption more by adsorption [13].

Crude fat content in the formulated food (10.39%) is comparable to the mean crude fat level in both proprietary formulae (10.84%) and yet comply with PAG recommendations for fat in infant food (10%). This indicate that the formulated food can sufficiently provide the requisite energy from fat.

The protein content of the formulated food (16.71%) is less than the PAG benchmark for protein (20%) in infant food, but is higher than the mean protein content in both proprietary formulae (15.63%). However, since there are no documented cases of protein-energy malnutrition in infants fed with these proprietary formulae over the years despite having lower protein content than the PAG benchmark, the formulated food given its higher crude protein content can be expected to produce even better outcome.

The total carbohydrate in the formulated food (55.51%) is only about 9% less than the mean total carbohydrate in both proprietary formulae (64.42%) and also less than the PAG benchmark for carbohydrate in infant food (65%), but an energy inadequacy is unlikely as the caloric value of the formulated food (380 Kcal/100g) is comparable to that of both proprietary formulae (410 Kcal/100g). Also, gluconeogenesis allows for biosynthesis of glucose from non-carbohydrate food components like protein should the need arise.

3.5. Sensory Evaluation of Formulated Infant Food

Table 6. *Mean scores from sensory evaluation of formulated infant food and proprietary infant formulae using 7-Point hedonic scale.*

S/N	Sensory Attribute	Formula A	Formula B	Formulated infant food
1.	Appearance	$6.2^{a} \pm 0.9$	$6.3^{a} \pm 1.1$	$5.8^{a} \pm 1.4$
2.	Flavour	$6.4^{b} \pm 0.8$	$5.8^{b} \pm 1.2$	$5.0^{c} \pm 1.4$
3.	Taste	$6.0^{a} \pm 1.2$	$6.5^{a} \pm 0.7$	$5.6^{a} \pm 1.9$
4.	Mouth-feel	$6.1^{d} \pm 0.8$	$6.7^{d} \pm 0.7$	$5.9^{d} \pm 0.8$
5.	After-Taste	$5.9^{f} \pm 1.2$	$6.5^{f} \pm 0.7$	$5.8^{f} \pm 1.4$
6.	Colour	$5.9^{c} \pm 1.1$	$5.9^{c} \pm 1.3$	$5.5^{c} \pm 1.6$
7.	Overall acceptability	$6.3^{e} \pm 0.9$	$6.6^{e} \pm 0.6$	$5.9^{e} \pm 1.6$

Values are means ± standard deviations of 20 determinations
Means with identical superscripts in the same row are not significantly different (p=0.05)

With exception of flavour, the results in Table 6 show that in appearance, taste, after-taste, mouth-feel, colour and overall acceptability, the mean scores of the formulated food do not differ significantly (p=0.05) from those of the proprietary infant formula. Thus with regard to these attributes, the formulated food can be said to compare favourably with those of the proprietary formula. However, the judges had a higher preference for both proprietary formulae than they had for the formulated food because some judges were able to perceive the residual flavour of the crayfish and egg yolk components. Most judges observed that the formulated food could be improved upon by further reducing its particle size to give it a much finer mouth-feel/texture.

3.6. Microbial Shelf Life Assessment

Table 7. *Microbial Shelf life Assessment of formulated infant food.*

S/N	Duration of storage (weeks)	Total Bacteria Count{TBC}(Cfu/g)	Total Coliform {TC} (Cfu/g)	Total Fungal count{TFC}(Cfu/g)
1.	0	1.4×10^2	$< 5 \times 10^1$	1.9×10^1
2.	2	2.5×10^3	$< 5 \times 10^1$	3.2×10^2
3.	4	3.8×10^3	$< 5 \times 10^1$	9.0×10^2
4.	6	1.9×10^4	$< 5 \times 10^1$	5.8×10^3
5.	8	1.2×10^5	$< 5 \times 10^1$	3.9×10^4
6.	10	1.9×10^5	$< 5 \times 10^1$	5.4×10^4

ICMSF guidelines: $< 10^5$ Cfu/g = Satisfactory, 10^5 to $<10^6$ Cfu/g = Borderline, $\geq 10^6$ Cfu/g = Unsatisfactory

Table 7 is an assessment of the microbial shelf life of the formulated food. Going by International Commission for Microbiological Specification for Foods (ICMSF) guidelines, between week 0 and week 6 TBC, TC and TFC in the formulated food were within satisfactory levels ($<10^5$ Cfu/g) and the formulated food is safe to consume within this period. Beyond week 6, the TBC slipped into the borderline region (10^5 to$<10^6$ Cfu/g) even when TC and TFC are still within the satisfactory range so that the food may still be consumed without adverse effect. However because most infants have an immune system that is not fully developed, it will be unwise to put them at risk and it is best to peg the shelf life to a duration within which the formulated food is without a doubt, safe to consume and this is 6 weeks immediately after production.

4. Conclusion

The study successfully formulated a highly nutritious infant food from soybean, yellow maize and short rice obtained in Benue State, Nigeria. The proximate composition of the formulated food was found to be comparable with the mean proximate composition of infant formula A and B as there was mostly no significant difference between them (p=0.05). The formulated food mostly complied with PAG recommendations for infant food except that it fell short in carbohydrate composition. Sensory assessment showed that with the exemption of flavour, in appearance, taste, after-taste, mouth-feel, colour and overall acceptability, the formulated food did not differ significantly (p=0.05) from the proprietary infant formulae. But judges had a higher preference for the proprietary formulae than for the formulated food because the residual flavour of the crayfish and egg yolk components were still slightly perceived. The microbial shelf life of the formulated food is 6 weeks from the date of production.

Acknowledgements

This research work was funded entirely by Tertiary education trust fund (TETFUND)

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