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Quality Evaluation and Comparative Nutritional Assessment of Six Instant Weaning Foods Formulated from Selected Staple Foods and Protein Supplements

Dr. Ifemeje .J.C
Associate Professor, Department of Biochemistry,
Chukwuemeka Odumegu Ojukwu University, Uli, Anambra State, Nigeria
Innocent Oghale Ajawobu
Senior Lab. Technologist, Department of Pharmaceutical and Medicinal Chemistry,
Nnamdi Azikiwe University, Awka, Anambra State, Nigeria
Ajawobu N.J
Managing Director, Newlife Food Industries Nig. Ltd
Obosi, Onitsha, Anambra State,
Apollos O.A
Chief Officer, Department of Petroleum Analysis Lab,
Petroleum Training Institute, Effurun, Delta State, Nigeria

Abstract:
Inadequate and poor weaning practices in addition to malnutrition remains a serious public health challenge among the under-five in developing countries, Nigeria inclusive, since the commercial weaning foods are not quite affordable and to some extent not available to the common man. Hence this study is aimed at evaluating the Quality and comparatively assessing nutritional composition of six instant weaning foods formulated from selected staple foods and protein supplements. Six weaning foods formulated: three rice-lentil based (A-C) and three sweet potato-soybeans based (D-F) at the respective ratios of 70:10, 60:20 and 50:30 blended with groundnut, crayfish and smoked fish in varying quantity to make up the 100g. These blends were compared with a reference weaning diet (Nutrend- Maize-soybean blend). The nutritional composition, sensory acceptability and microbial count of the diets were investigated using standard methods. The results of the investigation showed that fat content of experimental diets ranged between 3.00_+ 0.01% to 7.51+_0.01%, moisture contents 6.58+0.09% to 8.02+0.04%, the protein contents between 9.12+0.07% to 17.73 + 0.02%. The proximate compositions of the experimental diets were within standard range except for diet E when compared with the reference diet. The same trend was observed with carbohydrates contents except for diet A. The assessment showed low fat to high carbohydrate and protein contents. The mineral contents were significantly higher than that of the reference except for phosphorus and potassium contents which were lower for the rice blends while the sweet potato blends were higher making them more fit in comparison to the reference especially diet F. Sensory evaluation panelists generally scored the sweet potato blends higher however, blend F was most preferred as compared to others scoring second to the reference. The microbial screening of the diets shows that all the blends A-F were fungi free even after 28 days of shelf life and it competed favourably with the reference. The study however revealed that the sweet potato – soybean based formulated weaning food may serve as a good substitute for commercial weaning foods for infants in developing countries.

1. Introduction

Human milk (breast milk) is the best food for babies and provides all the nutrients need for about the first six months of life [1]. Scientifically, it has been proven that this is the perfect food for the infants during the first six months of life [2]. It is found to contain nutrients that serve unique need for human infants such as essential polyunsaturated fatty acid (PUFA), certain milk proteins, minerals like iron and zinc in a readily absorbable form. It also contains immunological and bioactive substances [3].

The World Health Organization (WHO) also recommends exclusive breastfeeding for the first six months of life with the addition of complementary food (complementary weaning food) with continuous breast-feeding until the age of about two years [4].The growth of the infant in the first or second year is very rapid and breastfeeding alone will not meet the child nutritional requirement after about four months of age, the child needs supplementary feeding [5, 6].

Weaning has been described as the gradual substitution of the mother's milk with solid and semi-solid food in the infant diet in order to fulfill their growing needs. It is a process starting with the introduction of complementary food and ending with the complete cessation of breast-feeding [7]. When a baby reaches 4 to 6 months of age, breast milk alone is no longer sufficient to meet the nutritional requirements [8].

As a result, many brands of preparatory weaning foods have been developed and marketed in most countries including Nigeria [9]. In Nigeria, many attempts to produce weaning food which are quite rich in protein and other nutrients by combination of cereals and various sources of rich protein from animals, legumes and oilseeds has been reported [10].

The major risk factors associated with infants and early childhood mortality and morbidity are poor infant feeding practices, production hygiene as well as childhood and maternal body health under nutrition [11].

Malnutrition is a major health problem in developing countries such as Nigeria and contributes to infant mortality, poor physical and intellectual development of infants as well as lowered resistance to diseases and consequently retarded development. This has become a persistent problem for children in developing countries [12].

In developing countries, 70% of weaning foods are supplied by cereals, which are relatively poor source of protein [13]. Formulating and development of nutritious weaning foods from locally and readily available raw materials have received a lot of attention in many developing countries [14]. Apart from protein and energy in infant diet need, calcium, iron, and trace elements can be obtained by combining local staple. Unfortunately, the traditional methods also used in the preparation of these food are accompanied by severe nutrient lose which affect the nutrient quality of the diet then leading to a vicious circle of malnutrition and infection possibly leading to death, resulting to high mortality and morbidity amongst weaning age children [15].The Protein Advisory Group guidelines for weaning foods should be 20% of Protein, Fat level of up to 10%, Moisture Content 5% to 10% and Total Ash Content not more than 5% [16].

Several studies have reported that most of the weaning foods consumed by children in many parts of developing countries are deficient in essential macronutrients and micronutrients [17]. The commercial weaning foods such as Cerelac, Nutrend and Phosphatine are expensive and out of reach to low income earners in developing countries. This unavailability of nutritious food and high cost of commercial weaning foods and animal protein are major causes of PEM in children [13].

Therefore, it is necessary to develop a nutrient-dense, safe, affordable, and accessible complementary food from locally produced ingredients using household or small to medium scale production technologies as a vital and sustainable approach to address the problem of malnutrition. This has been ongoing for over 15-20 years now using different food class blend [18].

2. Materials and Methods

2.1. Sample Collection, Preparation, Processing and Formulation

2.1.1. Sample Collection

2.1.1.1. The Collection of the Six Selected Food Crops

Rice (*Oryza sativa*), Lentils (*Lens culinans*), Soy-beans (*Glycine max*), Crayfish (*Astacus fluviatilis*), Dried smoked Cat-fish, Groundnut (*Arachis hypogaea*) and Sweet Potatoes (*Ipomoea batatas*- light purple species) were all purchase from Osse Market Onitsha, Anambra State, Nigeria.

2.1.2. Sample Preparation and Processing

- Soybean: The 2kg soybean was weighed, sorted, washed and soaked for 3hours. Thereafter it was de-shelled and parboiled in boiling water for 30minutes after which it was de-shelled again before sun drying for 24 hours and oven dried at 70^{o}C for 24 hours also making 48 hours of drying. This was then blended and sieved; this was then packaged and stored in a freezer for use as demand arises.
- Rice: The 2 kg rice was weighed, sorted, washed and parboiled in boiling for 25 minutes. Thereafter it was sun dried for 48 hours and oven dried at 70^{o}C for 24 hours totaling 72 hours. After which it was blended and sieved then packaged.
- Sweet Potato: Exactly, 8 kg sweet potatoes was weighed, washed and then de-shelled. It was then cut to smaller pieces weighed again of which it now weighed after which it was washed and cooked for 25 minutes in boiling water. It was then removed and sun dried for 48 hours and oven dried at 70^{o}C for 24 hours. After which it was now blended, sieved and packaged.
- Lentils; Exactly, 1 kg lentils were weighed, then rinsed and parboiled in boiling water for 25 minutes and sun dried for 24 hours and oven dried at 70^{o}C for 24 hours totaling 48 hours. It was blended, sieved and packaged. (The type used is a mixture of green and black coloured shades)
- Crayfish: Exactly, 300g crayfish was weighed, then sorted and sun dried for 48hours after which it was blended, sieved and packaged
- Groundnut: A weight of 510g of groundnut was sorted and soaked for 30minutes in slightly salty water, thereafter sun dried for 48 hours. After which it was blended and packaged.
- The Fish Meal: The smoked fishes weighing 380g was broken open, the head and some unwanted parts removed. It was the pounded bit to piece in a mortar using the pestle and sun dried for 48 hours, after which both flesh and bones were blended and packaged to make the fishmeal

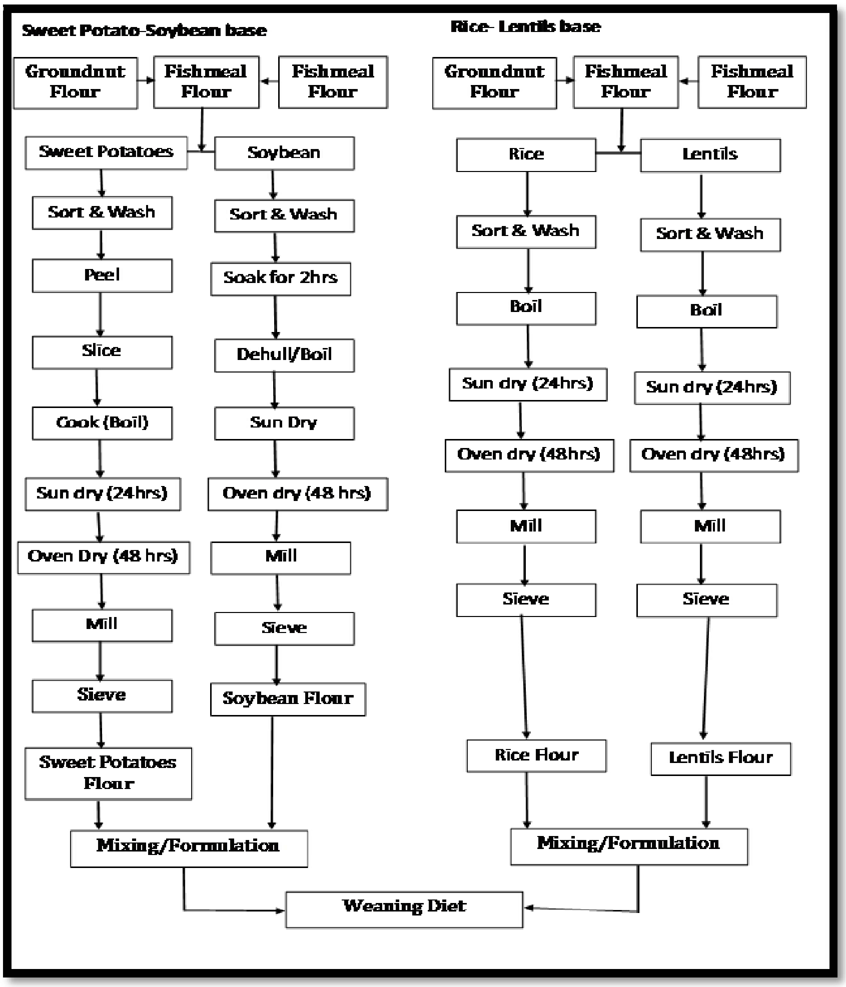

Figure 1: Flow Chart on Preparation of the Various Foods

2.1.2.1. Blends Formulation

BLEND	RICE	LENTILS	S.POTATO	S.BEAN	G/NUT	C/FISH	F/MEAL	REMARK
A	70	10	-	-	5	15	-	100g
B	60	20	-	-	5	10	5	100g
C	50	30	-	-	5	-	15	100g
D	-	-	70	10	5	15	-	100g
E	-	-	60	20	5	10	5	100g
F	-	-	50	30	5	-	15	100g

Table 1: Composition of Formulated Food Constituents/100 G

The rows represent the 100 g composition that makes for each blend.
The columns represent the two-based formula samples A-C are different shades of the rice base blend while samples D-F are the different shades of the sweet potato base blends.
Physicochemical Analysis

2.1.3. Proximate Contents Analysis

The proximate composition of the food blends was analyzed by the method of Association of Official Analytical Chemists [19]. The samples were analyzed for proteins, fats, crude fibre, moisture, ash and carbohydrates.

2.1.4. Mineral Contents Analysis

Mineral contents of the samples were determined using Buck scientific flame Atomic Absorption Spectrophotometer[20].

2.1.5. Sensory Analysis

Sensory evaluation was carried out by reconstituting 100g of each formulated sample and nutrend. This was mixed with 400ml of boiled treated water, thereafter 5g of mixture of granulated sugar and powdered milk to enhance taste of the formulated diets (A-F) were added to the porridge. The formulated diets were evaluated alongside with a commercial complimentary food (Nutrend-G) which also prepared same way as the formulated except no addition of sugar and milk. The samples (A-G) were served hot. Sensory evaluation was carried out by a trained 20 Man panel comprising students (Under-graduates and post graduates), mothers and staff of the Dept. of Biochemistry, Chukwuemeka Odumegu Ojukwu University, Uli Anambra State using a 9-point Hedonic scale rating for colour, taste, aroma, texture and overall acceptability. The evaluation was done in the Lab. Room of the Biochemistry Department [21].

2.1.6. Microbial Analysis

The freshly prepared formulations (A-F) and the commercial sample (G) were subjected to microbial screening immediately where they were tested for bacteria and fungi. Serial dilutions were made from 1g of each sample dissolved in 9ml of distilled water. Using the pour plate method as described by [13], each diluent was plated out on a plate count agar bacteria count at a temperature of 35-37oC and 25-27oC for fungi. Plates were observed daily for 3 days (72 hours) for the presence of countable colonies. Colonies developed after incubation was counted. The same was done after 28 days of preparation after been kept in an airtight container kept in a fridge

2.1.7. Method of Data Analysis

Results gathered from the study were presented as mean ± standard error of mean (SEM) of sample size of among various groups (A-H) were compared using one-way analysis of variance (ANOVA) followed by post hoc turkey's test for multiple comparison. P<0.05 was considered to be statistically significant, while p>0.05 were considered to be statistically non-significant. Statistical package for social science (SPSS-20, for windows) was the software used for data analyses [7].

3. Results and Discussion

3.1. Proximate Composition of the Diets

From Table 3 below, Moisture content was significantly higher at (*p<0.05) for formulated feeds in groups A – F when compared with those of standard feed in group G respectively.

Fat contents for the diets in groups A-C were significantly lower while those of groups D and E were higher when compared with the standard feed. However, group F show no significant difference in comparison.

The protein content was higher for groups A, B and F but lower for groups C-E in comparison with that of the standard feed.

The carbohydrate content significant difference for groups A-E while group F no significant difference (P< 0.05) comparing with the standard feed.

The ash contents of feed in groups A – E, except group F were significantly lower (*P< 0.05) than ash content of the standard feed in group G.

Crude fiber of feed in groups A – D, except groups E and F were significantly lower (*P<0.05) than ash content of the standard feed in group G.

Moisture and carbohydrate contents are significantly higher in the formulated foods than the standard

Moisture and fat contents were higher for groups D and E.

The results of the proximate compositions of the various weaning diets and the commercial brand (control) as shown in Table 2, the proximate values compared with previously reported work by [7]. The moisture content of the formulated diets were significantly higher than that of the control at p>0.05 however, according to [22] he reported that moisture content is used as a quality factor for prepared cereal which should have 3-8% moisture content which all satisfied except for diet D and E which were 8.02 and 8.01. The lower the moisture content of a weaning food the higher positive effect on the shelf life time, higher moisture content will have shorter lifespan [23].

The fat contents of the weaning diets show that the rice blends A-C has lower fat contents when compared to the sweet potato blends and the control however, with increased carbohydrate content. The fat contents corresponded to recommended fat level for weaning foods which should be less than 10% if not it will affect shelf stability leading to quick spoilage [24]. The carbohydrate levels of all the diets and the control were higher than the lower limit for carbohydrates (41.3 to 73.79g) of the Codex Alimentarius Standards [25] however; they are all lower than the higher limit making them fit for consumption without any implication. The crude fibre content for all the samples is below 8-10% recommended allowance even though they are significantly different from each other at p>0.05 that is the rice blends from the sweet potato blends [23]. If it is higher, some fibre related fractions such as polyphenols and non-starchy polysaccharides would have bound to minerals such as calcium, zinc and iron making them unavailable for human nutrition [26] and can impair protein and mineral digestion [27].Therefore, all diets and control are fibre balanced as weaning food.

Fibre is an important dietary component in preventing overweight, constipation, cardiovascular disease and diabetes and colon cancer [28]. The protein content of all the diets and the control fell within the recommended ranges of 10-20% as stated by the Protein Advisory Group [24], the same too with the ash content that fell within the 1-5% range [24]. It was observed that sample F compared significantly with the control for all proximate parameters,

Formulation Blend	Moisture content (g/100g)	Fat content (g/100g)	Ash content (g/100g)	Crude fiber (g/100g)	Protein content (g/100g)	Carbohydrate content (g/100g)
A	7.19 ± 0.16*	3.00 ± 0.01*	1.99 ± 0.01*	1.73 ± 0.26*	16.42 ± 0.01*	69.67 ± 0.36*
B	7.00 ± 0.00*	4.00 ± 0.00*	2.09 ± 0.04*	4.54 ± 0.04*	16.13 ± 0.02*	66.23 ± 0.04*
C	7.93 ± 0.06*	4.34 ± 0.16*	2.50 ± 0.01*	4.44 ± 0.06*	13.81 ± 0.00*	66.98 ± 0.11*
D	8.02 ± 0.04*	7.51 ± 0.01*	2.50 ± 0.01*	5.16 ± 0.15*	11.38 ± 0.05*	65.44 ± 0.16*
E	8.01 ± 0.06*	7.00 ± 0.00*	2.31 ± 0.16*	7.05 ± 0.05	9.12 ± 0.09*	66.36 ± 0.09*
F	6.99 ± 0.03*	5.50 ± 0.00*	2.80 ±0.06	6.76 ± 0.12	17.73 ± 0.02*	60.22 ± 0.17*
G	6.58 ± 0.09	6.00 ± 0.00	2.91 ± 0.00	7.217 ± 0.02	14.84 ± 0.02	62.45 ± 0.13

Table 2: Proximate Analyses of Various Formulated Feed

The rows represent the proximate constituents per formulated blend while the column represents the flow of the individual proximate parameter across formulated blends. The same is applicable to all other table below.
Values are presented as mean ± Standard error of mean (SEM), n =3. *P< 0.05: Statistically significantly different from group G. P>0.05: Not statistically significantly different from groups G.

3.2. Mineral Contents

From Table.2 below, Sodium content was significantly higher in groups B-F (*p<0.05) when compared to sodium content of the standard feed in group G, while that of group A was significantly (*p<0.05) lower when compared to the standard feed in group G. Similar trend was observed for potassium content.
Phosphorus contents in groups B, D, E and F were significantly higher (*P< 0.05) than Phosphorus content of the standard feed in group G, while those of groups A and C were significantly (*p<0.05) lower when compared to the standard feed in group G.

Potassium contents in groups A-C were not significantly different while those of groups D-F were significantly higher than the standard feed.

Magnesium contents in groups B, C and F were significantly (*P< 0.05) lower than magnesium contents of the standard feed in group G, while those of groups D and E were significantly (*p<0.05) higher when compared to the magnesium content of the standard feed in group G. Magnesium content in group A was not significantly (p>0.05) different from that of group G but statistically the difference in Magnesium content is not really significant because the ranges are closed.

Zinc contents in groups A-C were significantly lower (*P< 0.05), while D-F were not so significantly different when compared to zinc content of the standard feed in group G.

The mineral composition of the dietary samples as shown in Table 4.2 showed significant higher level of sodium for groups B-F when compared with the control while group A significantly lower at (p<0.05) when compared with the control group. Phosphorus contents in groups B, D-F were significantly higher (p<0.05) than that of the control group while those of groups A and C were significantly lower. Magnesium contents in group B, C and F were significantly lower than that of the control while those of groups D and E were significantly higher when compared to that of the control but that of group A was not significantly different at (p<0.05). It is observed that for zinc apart from group A all the others met the recommended daily requirement of 10mg/100g [28].
The Sodium and Magnesium contents of all the diets were within range as they all met the range as reported by [29, 30] that from 9-11 months of life the amount of mineral that should be provided by complimentary foods is high 97% for iron,86% for zinc, 81% for phosphorus, 76% for magnesium, 73% for sodium and 72% for calcium and all fell within this range except group A. Potassium content was higher for group D-F while groups A-C were not significantly different at p>0.05 when compared with the control, this is due to the fact that sweet potato is high in potassium aside lentils and soybean [31].

The phosphorus content obtained from the study indicated that all diets are stable except for group C as it could not contribute up to 40% of RDA of the 200-1000mg/day needed in children and adults [32]. Phosphorus is important in the synthesis of phospholipids and phosphor- proteins viz-healthy bones and teeth [33]. Zinc is a vital nutrient required for the structural and functional integrity of biological membrane maintaining homeostasis regulation of insulin and the regulation of glucose utilization by muscles, fat cells and in the detoxification of free radicals. The tolerance upper level for zinc is 40mg/day of which the results from the study showed compliance for all diets and control [34].

Mineral Content ( )					
Formulation Blend	**Sodium**	**Phosphorus**	**Potassium**	**Magnesium**	**Zinc**
A	66.40 ± 0.01	399.64 ± 0.01*	15.04 ± 0.00*	66.95 ± 0.06	9.63 ± 0.03**
B	68.40 ± 0.02	434.20 ± 0.21*	17.06 ± 0.02*	66.65 ± 0.01	8.89 ± 0.01**
C	68.09 ± 0.09	299.79 ± 0.03**	20.17 ± 0.19*	66.62 ± 0.02	9.79 ± 0.01**
D	67.84 ± 0.01	446.22 ± 0.01*	45.30 ± 0.02**	67.37 ± 0.01	17.10 ± 0.11*
E	67.56 ± 0.00	436.78 ± 0.03*	40.23 ± 0.04**	67.27 ± 0.02	14.85 ± 0.02*
F	67.29 ± 0.03	425.05 ± 0.05*	39.17 ± 0.03**	66.44 ± 0.02	12.43 ± 0.03*
G	66.95 ± 0.05	429.26 ± 0.01	15.75 ± 0.03	66.85 ± 0.01	20.62 ± 0.02

Table 3: Mineral Content of Various Formulated Foods
*Values Are Presented as Mean ± Standard Error of Mean (SEM), N =5. **P< 0.05: Statistically Significantly Different from Group G. P>0.05: Not Statistically Significantly Different From Group G*

3.3 Sensory Evaluation

From Table 4 below;

Color: Average color scores of various formulated feeds in groups A- E, except group F were significantly lower (*P< 0.05) than average color score of the standard feed in group G.

Texture: Average texture scores of various formulated feeds in groups A- C, except groups D, E and F were significantly lower (*P< 0.05) than average texture score of the standard feed in group G.

Aroma, Taste and Total score: Average aroma and total scores of various formulated feeds in groups A- F were significantly lower (*P< 0.05) than average aroma, taste and total score of the standard feed in group G respectively even though group F was quite comparable with the standard feed.

The results of the sensory evaluation on the diets in comparison with the control as shown in table 4.6 reveals that all the diets were significantly different for colour, aroma and taste at p>0.05 except for sample F. Sample A-C were least accepted for colour and aroma this might be suggestive to the presence of high phytate content present in rice than sweet potato as shown in table 4.3, the crayfish and soybean ratio, the drying temperature and duration as this can affect colour [13]. However, from the index the colour rating the colour ratings of the evaluated samples were within the cceptable limits and therefore would still be appreciated to infants but could be further improved by adjusting processing conditions. The consistency of texture of the formulated diets were not significantly low for the sweet potatoes blend compared to the rice blend and in comparison, to the control diet which is an important parameter to determine the consistency of the flour. A very thick consistency would need increased efforts to swallow and therefore may limit the food intake in young children who have not fully developed their ability in this aspect [35]. The taste and aroma of the control sample has the best rating when compared with the formulated diets this is mostly due to the flavouring addition in the product as infants and some adults alike are most likely to reject unflavoured foods.

The overall acceptance and mouth-feel, consistency attributes increases down the line from A-G except for group B that was highly unaccepted however, the sweet potatoes blends were more accepted even though group F was most preferred in comparison with to the control. It was also observed that the whole fishmeal blend group C and F was preferred to the crayfish blend of group A and E. In the overall acceptability ratings there was not much significant difference (p>0.05) between group F and G.

Formulation Blend	**Color**	**Texture**	**Taste**	**Aroma**	**Acceptability**
A	5.90 ± 0.37*	5.75 ± 0.39*	5.10 ± 0.38*	6.45 ± 0.25*	5.85 ± 0.28*
B	5.65 ± 0.32*	5.90 ± 0.35*	5.05 ± 0.40*	5.50 ± 0.29*	5.65 ± 0.32*
C	6.65 ± 0.15*	6.25 ± 0.38*	6.15 ± 0.48*	6.35 ± 0.25*	6.40 ± 0.31*
D	6.85 ± 0.27*	7.25 ± 0.24	6.05 ± 0.45*	6.50 ± 0.27*	6.40 ± 0.34*
E	6.75 ± 0.38*	6.95 ± 0.27	6.60 ± 0.35*	6.55 ± 0.23*	6.65 ± 0.30*
F	7.65 ± 0.25	7.25 ± 0.22	7.90 ± 0.24	7.40 ± 0.26	7.05 ± 0.35
G	8.40 ± 0.17	8.15 ± 0.17	8.55 ± 0.14	8.45 ± 0.14	8.55 ± 0.17

Table 4: Sensory Evaluation
*Values Are Presented as Mean ± Standard Error of Mean (SEM), N =20. *P< 0.05: Statistically Significantly Different from Group G.P>0.05: Not Statistically Significantly Different From Groupg*

3.4. Microbial Screening

The microbial screening was conducted on the freshly prepared diets and the after four-week's storage of the diets to determine shelf life strength and their wholesomeness for consumption and the data presented in tables 4.4 and 4.5. The bacteria counts were low< 10cfu/ml, with no viable count for fungi for the freshly prepared diets as shown in plate 4.1 to 4.6. However, for a food product to be good for consumption it should have microbial count below

1×105cfu/ml which tallies with the recommended standard for bacteria contaminants limit of less than 106cfu/ml for food [35].

Basically the bacteria found is Bacilluscereus and subtilis plates 4.7 and 4.8 which are common bacteria found in food, Bacilluscereus is short and are spore forming bacteria that can withstand harsh conditions although they are not so a threat while the subtilis are long and slender rods which under heat can be denatured however, at a higher temperature of drying the bacteria load can further be reduced in addition to good manufacturing practices plus high standard of personal hygiene. The morphological and biochemical identification test shows absence of indicator organisms (Coliforms)- E.coli and Salmonella spp., which is indicative of sterility and fitness for consumption without challenge. Generally, from the study the bacterial counts were low<10cfu/ml and zero fungal presence. The international microbiological standard recommends a bacteria contaminants limit of less than 106cfu/ml for food [35]. That is to say, the whole groups passed the microbial screening test.

Total Viable Count (Organisms/ml)				
	Bacteria		**Fungi**	
Formulation Blend	**Day 1**	**Day 28**	**Day 1**	**Day 28**
A	4×10^2	Uncountable, Above 400		
			0	0
B				
	4×10^2	Above 400	0	0
C				
	4×10^2	Above 400	0	0
D				
	4×10^2	Above 400	0	0
E				
	4×10^2	Above 400	0	0
G				
	0.5×10^2	2×10^2	0	0

Table 5: Microbial Screening

Acceptable Limits for Bacterial Counts for Bacillus Cereus and Other Bacillus Spp in Instant Foods or Foods Generally Should Be ($<10^3$ Cfu Per Gram) (Msg, 2001)

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