Viscosity and Nutritional Evaluation of Rats Fed with Complementary Foods Produced From Broken Fractions of Improved Rice Cultivars, Soybeans and Sorghum Malt

Canadian Journal of Agriculture and Crops
Vol. 4, No. 2, 208-217, 2019
e-ISSN: 2518-6655

(Corresponding Author)

Charles Bristone[1]
Mamudu Halidu Badau[2]
Joseph Uchechi Igwebuike[3]
Nahemiah Danbaba[4]

[1,2]Department of Food Science and Technology, Faculty of Engineering, University of Maiduguri, Maiduguri, Nigeria.
[1]Email: bristonecharles@yahoo.com Tel: +2347036423913
[2]Email: mamudubadau@gmail.com Tel: +2348064191868
[3]Department of Animal Science, Faculty of Agriculture, University of Maiduguri, Maiduguri, Nigeria.
[3]Email: igwebuike8@gmail.com Tel: +2348141970027
[4]Food Technology and Value Addition Program, National Cereals Research Institute, Badeggi, Bida, Niger State, Nigeria.
[4]Email: dnahemiah@gmail.com Tel: +2348039736494

ABSTRACT

This study examines the use of broken fractions of rice, soybean and sorghum as low cost materials for production and formulation of complementary foods. Percentage broken fractions of grains, purity of grains, viscosities of formulations, experimental feeding parameters using *Wistar* rats were evaluated. Five out of the formulations were selected based on their composition and were evaluated on weanling rats for their nutritional significance. Results of broken fractions of rice cultivars ranged from 28.83 to 92.30%, purity of grains 97.72 to 99.86%, viscosity of gruels at 10% and 20% level of concentration were 662.02 to 1949.40 and 1845.03 to 2714.03 C_p respectively, while protein efficiency ratio (PER) of blends ranges between 1.47 to 2.00. Higher percentage broken fractions were observed in FARO 44 and 52 and purity of grains are more than 97% in all the cultivars. There was significant reduction of viscosity of gruels containing malt. Slightly low PER was observed in formulation containing indigenous rice than the other formulations produced from improved rice cultivars. No mortality was recorded in rats throughout the period of experimental feeding study.

Keywords: *Rice, Complementary food, Sorghum, Soybean, Viscosity, Feeding, Growth, Infant, Dietary.*

DOI: 10.20448/803.4.2.208.217
Citation | Charles Bristone; Mamudu Halidu Badau; Joseph Uchechi Igwebuike; Nahemiah Danbaba (2019). Viscosity and Nutritional Evaluation of Rats Fed with Complementary Foods Produced From Broken Fractions of Improved Rice Cultivars, Soybeans and Sorghum Malt. Canadian Journal of Agriculture and Crops, 4(2): 208-217.

Funding: This research is funded by Canadian International Development Agency and Africa Rice Center under the project 'Enhancing food security in Africa through the improvement of rice post-harvest handling, marketing and the development of new rice-based products'.
Competing Interests: The authors declare that they have no competing interests.
History: Received: 20 August 2019/ Revised: 24 September 2019/ Accepted: 29 October 2019/ Published: 2 December 2019
Publisher: Online Science Publishing

Highlights of this paper

- This study examines the use of broken fractions of rice, soybean and sorghum as low cost materials for production and formulation of complementary foods.

1. INTRODUCTION

The shortage of food production over the years, especially in developing countries is a matter of serious concern. There are serious cases of starvation and malnutrition related issues in the developing regions of the world which need to be addressed [1, 2]. In North - eastern Nigeria due to the ongoing man made conflicts, over 2.2 million persons have been displaced and hunger and malnutrition related problems have reached devastating state which requires immediate response and solutions [3].

In Nigeria, rice production has increased over the decade and has become an important food security crop for combating of hunger and malnutrition. In this case, the National Cereals Research Institutes (NCRI), which has the mandate for the genetic improvement of rice in Nigeria with its partners, have developed over sixty improved varieties of rice from *Oryza glaberrima* gene pool that would withstand low inputs coupled with savage climate in order to improve food supply and curtail human suffering [4]. But still the national rice production is not enough to meet the national demand. These have resulted in massive scale importation of rice to fill the annual deficit [5, 6].

At family level, among all cereals, rice is known to be the number one grain consumed by most groups of people and is also considered as the first choice for infants' formulae [4, 7]. Nonetheless, infants and children continue to be the number one vulnerable population in the developing countries despite government effort for food security. There are many research works on complementary foods; each of those has specific objectives. Recent studies by our research teams [7-9] addressed similar challenges; targeting dual approach to broken rice value addition, improvements of nutrition and sustainable food security. The current study therefore was designed to further ascertain the nutritional and viscosity properties of several rice-based complementary foods using animals feeding experiments. It is our hope that this research will provide a novel food formulation that will support children feeding in many low income communities of Nigeria and developing countries having similar food habit and culture.

2. MATERIALS AND METHODS

2.1. Raw Materials

The materials used for this study include broken fractions from milled four (4) rice (*Oryza sativa* L.) cultivars, soybeans and sorghum (*Sorghum bicolar* L.). The four improved rice cultivars (FARO 44, FARO 52, NERICA L-34 and NERICA L-19) were obtained from the National Cereals Research Institute, Badeggi, Niger State, Nigeria, while non improved local cultivar (*Yar Mubi*), soybeans (*Yar Jalingo*) and sorghum (Early maturing sorghum, commonly called *Wata Uku-Yar Hong*) were procured from Maiduguri Monday market. All materials were cleaned manually and packaged in a plastic container until required for experiment.

2.2. Laboratory Rats

Sixty (60) albino rats (21 days old male *Wistar* strain) were procured from the National Veterinary Research Institute, Vom, Jos, Nigeria. Commercial rat food (Grower's Mash) was obtained from Abakpa, a local feed store in Kaduna, Nigeria.

2.3. Percentage Purity and Broken Fractions of Rice Cultivars

The percentage purity and broken fraction of rice cultivars was determined using 100 g total weight of the rice. The broken rice was separated from the 'head rice' and pure rice was separated from the contaminants. The percentage purity and broken fraction was calculated as described by Livingstone [10].

$$Percentage\ purity = \frac{weight\ of\ pure\ rice\ grains}{Original\ weight\ of\ grains} \times \frac{100}{1}$$

$$Percentage\ broken\ fraction = \frac{weight\ of\ broken\ rice\ grains}{Original\ weight\ of\ grains} \times \frac{100}{1}$$

2.4. Toasting and Milling of Rice Cultivars

Rice cultivars (20 kg) were toasted in an open thick aluminum pot at 120°C for 20 minutes. Temperature was regulated through stirring of rice and also constant increase and decrease of heating flame where there was need. Hand thermometer was used to monitor temperature fluctuation [11, 12]. Toasted rice samples were milled into fine flour and let to pass through 0.8 mm mesh size screen (Hammer mill: Christy hunt agricultural Limited, Foxhills Ind., East Scunthorpe, South Humbers. DE. DN15 8QW, England). They were later packaged in a plastic container and stored in iron cupboard (34 ± 2°C) until when needed for use [13].

2.5. Dehulling, Toasting and Milling of Soybeans

Soybeans were first sorted, washed and soaked for five hours in a clean water of three times its weight by volume until the coat become soaked and wet to assist in removal of some soluble anti-nutrients and to facilitate decortication. These were further washed, drained and partially sun-dried. The soybeans splits (dehulled) were then toasted at surface temperature of 180 ± 5°C for 30 minutes in an open thick aluminum pot [13, 14] and milled and packaged as described by Badau, et al. [13].

2.6. Malting of Sorghum and Milling

The sorghum grains were first screened and washed to remove contaminants and any seemingly dormant grains (i.e. floating grains). The cleaned grains were steeped inside sufficient clean water to cover the surface of the grains completely at room temperature for 12 hours. The steeping process was interrupted after every 6 hours by draining. An "air - rest" period of one hour each for every interruption was provided until the grain has reached about 42% moisture content [13, 15-17]. The grains were wrapped in a wet piece of cotton cloths and placed in a wet jute bag to provide about 3 to 5 cm depths of the placed grains. The grains were germinated at room temperature (32 ± 2°C) for a period of 2 days. During germination, small quantity of water was spread on the germinating grains using manual hand spray [13, 15-17]. At the end of germination, the germinated grains were dried to moisture content of 5.25 ± 0.2 at 30 ± 2°C for 36 hours. The germinated dried grains were polished using piston and mortar for detachment of roots and rootlets, and then winnowed leaving behind kernels which were further sieved through 0.8 mm mesh size. The polished malt was milled and packaged as described by Badau, et al. [13].

2.7. Complementary Food Formulations

The prepared flour samples were formulated into different blends using broken fractions rice flour and soybeans in the ratio of 100:0 with and without malt and also broken fractions rice flour and soybeans in the ratio of

70:30 with and without malt as described by Almeida-Dominguez, et al. [18] and Badau, et al. [13]. A 5 x 2 x 2 factorial experiment in a completely randomize design was used as described by Gomez and Gomez [19] and Mead, et al. [20]. In each 100 g mix of the complementary foods, there is 94.4 g rice flours, 5.00 g vitamin A fortified sugar and 0.60 g iodized salt Figure 1 for the first formulations. The second formulations contained 89.40 g rice flours, 5.00 g "power flour", 5.00 g vitamin A fortified sugar, 0.60 g of iodized salt and the third formulations contained 66.08 g rice flour, 28.32 g soybeans, 5.00 g vitamin A fortified sugar and 0.60 g iodized salt. The fourth formulations contained 62.58 g rice flour, 26.82 g soybeans flour, 5.00 g "power flour," 5.00 g of vitamin A fortified sugar and 0.6 g iodized salt. During the mixing process, rice and soybeans flours were first blended before adding sugar, salt and finally "power flour". The mixtures were thoroughly blended to obtained uniform particle size distribution. The five rice flours and that of soybean were blended with or without malt flour. This was done to obtain a total of twenty formulations as described by Badau, et al. [13].

Figure-1. Formulated rice-based complementary foods in plastic containers.
Source: Plastic containers from left to right are NERICA L-34, NERICA L-19, LOCAL rice, FARO 52 and FARO 44 (i.e. Rice and soybeans 70:30 with malt).

2.8. Preparation of Weaning Gruel for Viscosity Determination

The gruels of the complementary food formulations were prepared (with and without malt) by dissolving 40 and 20 g of blends into 200 ml of distilled water each to give 20% and 10% (w/v) concentration respectively. These were heated inside coded aluminum cans placed inside water bath (model, HWS26, B. Bran Scientific and instrument company, England) at 95°C for 7 minutes, for a better reconstitution and cooking. Their various viscosities were measured at 32.1°C and 28.9°C for 20% and 10% concentration respectively using rotational viscometer (KENEMATCA, AG, Switzerland, Type model Visco STAR+L/Serial: VSCL 110 458) as described by Badau, et al. [8].

2.9. Protein Efficiency Ratio (PER)

Six sets of male weanling rats from the same colony (21 days old) were used and each rat was housed in individual plastic cages at average temperature of 28 ± 2°C, humidity 29 ± 1%. The initial average weight of rats is 49.34 ± 5.92 g. Each set contain 10 rats per assay group. Rats were acclimatized for seven days. Five formulated diets and one commercial rat food (control) were used for this study. The formulations used for PER study are those with rice and soybeans 70:30 with malt. Casein control diet was not used instead growers mash (control) containing 15.50 g protein which are available and have proven suitable as rat food for experimental studies was used. Each diet was measured (i.e. 20 g) into several portions to facilitate feeding and recording of results. Each rat was provided with 20 g feed each time, but feeds were either replenished or weighed out (residual feeds) when there is need. Subsequently, one set of rats were allowed to continue feeding on the reference commercial rat food (control) while the five sets were fed on the test diets (containing test protein). Summations were done every week. Rats feeding pattern were *ad libitum* (both feeds and water).

The weight of each rat was recorded at the beginning of the assay, body weight and food intake were measured at regular intervals of every one week during the course of the 28-days feeding period. Feces were not collected for reasons primarily of time, cost and basal diet required. PER was calculated as the weight gain of rat per g protein (%N x 6.25) fed [21-23].

$$Feed\ conversion\ ratio\ (FCR) = \frac{Feed\ intake\ (g)}{Weight\ gain\ (g)}$$

$$Feed\ efficiency\ (FE) = \frac{Weight\ gain\ (g)}{Food\ intake(g)}$$

$$Protein\ efficiency\ ratio\ (PER) = \frac{Weight\ gain\ (g)}{Protein\ consumed(g)}$$

2.10. Statistical Analysis

Data were subjected to analysis of variance and means were separated by Duncan's Multiple Range Test (DMRT) at 5% significance level [24].

3. RESULTS AND DISCUSSION

3.1. The Percentage Purity and Broken Fractions of Rice Cultivars

The result of the physical properties of the milled rice cultivars based on percentage purity and broken fractions are presented in Table 1. These results indicate significant (P<0.05) variation among the rice cultivars. Percentage purity is significantly higher (99.86%) in NERICAL-34 and lowest (97.72%) in LOCAL rice cultivar, while broken fraction was higher in FARO 44 (92.30%) but not significantly different from FARO 52 (90.81%). LOCAL rice cultivar had the least broken fractions, followed by NERICA L- 34 and NERICA L 19.

Table-1. Percentage purity and broken fraction of different rice cultivars.

Rice cultivars	Purity (%)	Broken fraction (%)
FARO 44	99.62 ± 0.01b	92.30 ± 2.05a
FARO 52	99.78 ± 0.01ab	90.81 ± 0.81a
NERICA L-34	99.86 ± 0.01a	52.24 ± 1.96c
NERICA L-19	99.77 ± 0.02ab	70.92 ± 0.90b
LOCAL rice	97.72 ± 0.20c	28.83 ± 1.11d

Source: Each value is a mean ± SD of triplicate determinations. Mean values in a column followed by the same letter are not significantly (P>0.05) different according DMRT.

During rice milling process, brown rice is generally dry-milled to produce white rice for human consumption. During this process, the bran, aleurone and germ layers are removed and the polished endosperms are marketed as white rice or polished rice which is classified according to sizes as head rice (whole endosperm) and as various classes of broken rice as 'second heads', 'screening' and 'brewers' rice, depending on the size of the particle. The broken rice fractions have low market value and it is generally not used for human consumption in countries having sufficient quality rice production. At the international market, it was reported that rice is marketed according to three main properties: size, colour and condition of damaged kernel and these properties are therefore key quality traits [9, 25-27].

These results obtained can be assessed based on the above criteria. Those that have high percentage purity will also have high market value and low percentage purity will have low market value. Normally, the higher the test weight, the higher the quality, and the lower the test weight, the lower the quality and decreases dramatically as grain deteriorates. Despite this fact, the higher the broken fractions the lower the quality, and the lower the broken fractions the higher the quality and so grains with high broken fractions deteriorate more rapidly [25-27]. Henry and Kettlewell [26] reported that grain especially wheat that contain no more than 0.4% damaged kernels of the total weight, is regarded as grade 1. Ndindeng, et al. [27] classified highly broken rice fractions as 75 to 80%, moderately broken fractions of rice 45 to 70% and law broken fraction of rice 23 to 30%. This classification brought about another group of excessively broken fraction of rice from 80 to 100% as observed in Table 1.

3.2. Viscosity (Centipoises) of Complementary Food Formulations

Table 2 indicates the result of viscosity values (centipoises) of complementary food formulations. The result indicates significant (P<0.05) variation both at 10 and 20% level (W/V) of concentration. Viscosity values of formulations containing soybeans were observed to be higher than those without soybeans and also significant reduction of viscosity of formulations containing sorghum malt. This also indicated that the heat used for the preparation of gruel did not hinder the effect of sorghum malt enzymes. However, irregular pattern of viscosity among some set were observed and it may be attributed to differences in heat distribution or penetration across the aluminum cans that were used for preparation of the gruels as described by Ibarz and Barbosa-Cánovas [28] and so caused malt or enzymes to have significant effects on formulations.

Malt was reported to cause liquefaction of gruel due to enzymes action and increases energy density of gruel by reduction in the dietary bulk [15, 18]. This has an important role in infant's diet. May researchers recommended suitable viscosity for feeding babies between 1000 and 3000 centipoises [15]. All viscosities of formulations are within the prescribed range of values. Most importantly, there was an indication in viscosity reduction of blends containing malt as compared with the controls (blends without malt). This study together with the ones described in many studies indicated significant effect of malt on the reduction of viscosity of gruel heated with malt and those heated and cooled before adding malt [8, 15, 18].

Table-2. Viscosity of different gruels of complementary foods

Formulations	10%	20%
Rice and soybeans 100:0 without malt (Rice: 100, SB: 0, SM: 0)		
I. FARO 44	1656.53 ± 3.26^{d}	2509.50 ± 1.54^{h}
II. FARO 52	1483.73 ± 3.76^{g}	2006.63 ± 3.33^{j}
III. NERICA L-34	1489.50 ± 1.41^{f}	2176.43 ± 1.80^{i}
IV. NERICA L-19	1488.24 ± 1.72^{f}	2178.20 ± 3.21^{i}
V. LOCAL RICE	1278.13 ± 0.15^{i}	1969.69 ± 1.12^{l}
Rice and soybeans100:0 with malt (Rice: 100, SB: 0, SM: 5)		
VI. FARO 44	1483.43 ± 2.10^{g}	1999.17 ± 4.31^{k}
VII. FARO 52	1066.17 ± 4.71^{k}	1868.57 ± 0.81^{n}
VIII. NERICA L-34	1065.63 ± 1.02^{k}	1875.43 ± 0.93^{m}
IX. NERICA L-19	1055.10 ± 1.18^{l}	1855.47 ± 3.74^{o}
X. LOCAL RICE	1056.70 ± 2.98^{l}	1845.03 ± 1.27^{p}
Rice and soybeans 70:30 without malt (Rice: 70, SB: 30, SM: 0),		
XI. FARO 44	1718.33 ± 0.67^{c}	2657.43 ± 0.40^{b}
XII. FARO 52	1641.80 ± 1.51^{e}	2714.03 ± 0.47^{a}
XIII. NERICA L-34	1949.40 ± 0.52^{a}	2657.60 ± 0.46^{b}
XIV. NERICA L-19	1821.73 ± 1.38^{b}	2651.03 ± 0.93^{c}
XV. LOCAL rice	1365.10 ± 0.00^{h}	2651.50 ± 0.92^{c}
Rice and soybeans 70:30 with malt (Rice: 70, SB: 30, SM: 5)		
XVI. FARO 44	1231.57 ± 0.31^{j}	2585.60 ± 0.95^{g}
XVII. FARO 52	662.50 ± 0.70^{o}	2648.90 ± 0.10^{c}
XVIII. NERICA L-34	1279.47 ± 0.12^{i}	2594.13 ± 0.64^{f}
XIX. NERICA L-19	1050.77 ± 0.29^{m}	2609.40 ± 0.35^{e}
XX. LOCAL rice	702.17 ± 0.32^{n}	2632.00 ± 1.25^{d}

Each value is a mean ± SD of triplicate determinations. Mean in a column not followed by a common letter are significantly (P<0.05) different. SB = Soybeans, SM = Sorghum malt.

3.3. Nutritional Evaluation of Complementary Food Formulations

Table 3 indicates the result of nutritional evaluation of complementary food formulations (Rice and soybeans 70:30 with malt) and that of the control diet (Growers mash). The result of this study showed significant ($p<0.05$) difference in the overall food intake and weight gain of rats, except for the initial weight, week 2 weight gain and week1 feed intake. Protein Efficiency Ratio (PER) ranged from 1.47 to 2.00. Blend containing the local rice cultivar had the least PER. During the period of this study, there was no mortality or external clinical symptom was observed.

PER is a biological assay is being used to assess the protein quality of any food. It was reported that the better the nutritional quality of the test protein to be evaluated, the more rapidly the experimental animals will grow. Many researches recommended Protein Efficiency Ratio (PER) of not less than 2.2 and preferably greater than 2.3 for complementary foods. The Protein Advisory Group of the United Nation (PAG) and the general US Department of Agriculture (USDA) made similar recommendation [29]. The absolute PER value of blends of FARO 44, NERICA L 34 and NERICA L-19 are slightly closer to those recommended levels. However, the closer the PER of a certain food to the standard casein control diet (i.e. 2.5), the more it indicates high biological value in terms of essential amino acid make up and digestibility [23, 30].

It may be possible, substantial vitamins have been destroyed as a result of severe heat used for processing. So fortification of these blends with essential vitamins would ameliorate the Protein Efficiency Ratio (PER) as recommended. Besides this, variations in Protein Efficiency Ratio among individual rats have been reported and may be due to what has been described as over or underestimation problem, due to the relatively higher need of the rapidly growing weanling rat for certain dietary essential amino acids [23].

4. CONCLUSION AND RECOMMENDATONS

Broken fractions of improved rice cultivars, soybeans and sorghum malt were processed and formulated. Broken fractions of rice cultivars used for this study were classified. Two among the rice cultivars were observed excessively broken. Results obtained from formulations of blends indicated significant reduction of viscosity of the prepared gruels with sorghum malt. This activity as observed did not stop during heating of gruels. The Protein Efficiency Ratio of blends indicated that these blends would fully support growth of infants, especially if fortified with essential vitamins. More importantly, no mortality or external clinical symptoms were observed among rats. Similar products from broken fractions of rice can be produced in abundance. If this is done, it will help to remove marketing gaps (i.e. market value) between low and high grade rice. Therefore, low income farmers will get the benefits of their farm produce and consumers' products such as infants' foods will be available in our market.

5. ACKNOWLEDGEMENT

This study is one of the 'Development of new rice-based products from broken rice fraction' components. We also acknowledge the National Cereals Research Institute, Badeggi for providing the rice varieties and its processing.

Table-3. Nutritional evaluation of complementary food formulations.

Parameters	**Groups and feeds used (formulations of rice and soybeans 70:30 with malt i.e. Rice: 70, SB:30, SM: 5)**					
	XVI FARO-44	**XVII FARO-52**	**XVIII NERICA L-34**	**XIX NERICA L-19**	**XX LOCAL rice**	**XXI Growers mash**
Initial Weight (g)	47.09 ± 9.14	52.98 ± 16.28	47.02 ± 6.01	51.91 ± 4.50	49.42 ± 4.17	51.14 ± 4.46
Final Weight (g)	49.36 ± 9.35^{b}	56.72 ± 8.14^{ab}	54.45 ± 10.44^{ab}	62.54 ± 10.37^{a}	56.23 ± 7.02^{ab}	60.87 ± 6.25^{a}
Acclimatization Weight (g)	90.49 ± 20.99^{c}	103.04±19.12^{abc}	99.76 ± 20.50^{bc}	112.66 ±18.02^{ab}	96.77 ± 13.36^{bc}	118.36 ± 14.32^{a}
Acclimatization Weight Gain(g)	2.27 ± 1.24^{b}	7.83 ± 4.79^{ab}	7.47 ± 6.49^{ab}	10.62 ± 9.38^{a}	6.81 ± 5.90^{ab}	10.53 ± 6.31^{a}
Weight Gain (g)	41.11 ±13.55^{b}	46.23 ± 13.25^{b}	45.32 ± 13.56^{b}	50.13 ± 10.16^{ab}	40.54 ± 7.79^{b}	57.49 ± 10.28^{a}
Week 1 Weight Gain (g)	16.88 ± 8.74^{b}	18.54 ± 5.25^{ab}	17.55 ± 5.84^{b}	23.30 ± 5.90^{a}	15.43 ± 4.88^{bc}	10.94 ± 2.19^{c}
Week 2 Weight Gain (g)	12.88 ± 5.43	16.61 ± 6.28	15.25 ± 4.77	17.76 ± 8.43	14.15 ± 3.97	16.61 ± 5.14
Week 3 Weight Gain (g)	2.27 ± 2.36^{d}	7.16 ± 5.11^{bc}	8.46 ± 3.93^{b}	2.33 ± 2.01^{d}	4.43 ± 1.97^{cd}	22.31 ± 3.79^{a}
Week 4 Weight Gain (g)	9.08 ± 2.90^{a}	3.83 ± 2.21^{b}	4.06 ± 4.75^{b}	6.67 ± 5.80^{ab}	6.74 ± 2.67^{ab}	24 ± 3.74^{ab}
Acclimatization Feed Intake (g)	22.99 ± 4.50^{b}	45.17 ± 13.86^{a}	42.12 ± 13.61^{a}	41.55 ± 15.96^{a}	40.18 ± 16.18^{a}	43.09 ± 12.29^{a}
Week 1 Feed Intake (g)	30.00 ± 11.42	39.50 ± 14.57	38.00 ± 12.30	40.00 ± 11.14	35.00 ± 6.62	39.15 ± 13.54
Week 2 Feed Intake (g)	25.10 ± 9.66^{d}	51.00 ± 16.16^{ab}	41.00 ± 13.87^{bc}	40.00 ± 13.52^{bc}	35.00 ± 5.01^{cd}	60.95 ± 18.00^{a}
Week 3 Feed Intake (g)	25.00 ± 10.38^{c}	40.00 ± 18.50^{b}	37.00 ± 10.50^{b}	40.01 ± 12.90^{b}	40.00 ± 12.34^{b}	70.00 ± 13.88^{a}
Week 4 Feed Intake (g)	39.49 ± 7.81^{bc}	37.70 ± 7.03^{bc}	29.62 ± 10.84^{c}	36.69 ± 9.54^{bc}	43.63 ± 12.72^{b}	67.39 ± 12.83^{a}
Total Feed Intake (g)	119.59±22.84^{c}	168.21±33.44^{b}	145.63±34.06^{bc}	156.70 ± 16.97^{b}	153.63 ± 22.13^{b}	238.39 ± 46.64^{a}
Mortality	Nil	Nil	Nil	Nil	Nil	Nil
Acclimatization Protein Intake(g)	3.45 ± 0.67^{b}	6.78 ± 2.08^{a}	6.32 ± 2.04^{a}	6.23 ± 2.39^{a}	6.03 ± 2.43^{a}	6.46 ± 1.84^{a}
Total Protein Intake (g)	20.33 ± 3.88^{d}	30.28 ± 6.02^{b}	24.76 ± 5.79^{cd}	28.21 ± 3.09^{bc}	27.66 ± 3.98^{bc}	35.76 ± 7.00^{a}
Feed Conversion Ratio (FCR)	3.04 ± 0.59^{c}	3.72 ± 0.41^{ab}	3.30 ± 0.49^{bc}	3.21 ± 0.51^{c}	3.85 ± 0.55^{a}	4.16 ± 0.44^{a}
Feed Efficiency (FE)	0.34 ± 0.06^{a}	0.27 ± 0.03^{bc}	0.31 ± 0.04^{ab}	0.32 ± 0.06^{a}	0.26 ± 0.04^{c}	0.24 ± 0.03^{c}
Acclimatization PER	0.64 ± 0.26^{b}	1.07 ± 0.44^{ab}	1.06 ± 0.59^{ab}	1.41 ± 0.77^{a}	0.99 ± 0.52^{ab}	1.52 ± 0.54^{a}
Protein Efficiency Ratio (PER)	2.00 ± 0.36^{a}	1.51 ± 0.17^{ab}	1.82 ± 0.26^{a}	1.78 ± 0.30^{ab}	1.47 ± 0.19^{c}	1.53 ± 0.35^{bc}

Each value is a mean ± SD of ten determinations. Mean values in a row not sharing a common superscript letters are significantly ($P < 0.05$) different. Note: SB = Soybeans, SM = Sorghum *malt*.

REFERENCES

[1] M. A. Asma, E. B. Elfadil, and A. EL-Tinay, "Development of weaning food from sorghum supplemented with legumes and oil seeds," *Food and Nutrition Bulletin*, vol. 72, pp. 26-34, 2006.Available at: https://doi.org/10.1177/156482650602700104.

[2] A. Adebayo-Oyetoro, O. Olatidoye, F. Ogundipe, O. Ogundipe, O. Balogun, F. Bamidele, and A. Faboya, "Evaluation of proximate composition and functional properties of Ofada rice (Oryza sativa) flour blended with bambara groundnut (Vigna subterranean L)," *Journal of Agriculture and Veterinary Sciences*, vol. 3, pp. 60-66, 2011.

[3] Action Against Hunger, "Annual report," pp. 1 - 49. Retrieved: http://www.actionagainsthunger.org. [Accessed June 15th, 2017], 2015.

[4] B. Aluko, "High expectations as Nigeria plans increased rice production. Nigerian Tribune, African Newspapers of Nigerian Ltd, Ibadan." Retrieved: www.tribune.com.nglinder.php/feature. [Accessed June 20th, 2012], 2010.

[5] O. Olatoye, "About rice production and processing. Nigerian tribune, African newspapers of Nigerian Ltd, Ibadan." Retrieved: www.tribune.Com.ng/index.php/wealth cre. [Accessed June 22nd, 2012], 2011.

[6] N. Danbaba, A. Maji, I. Nkama, M. Abo, H. Hauwawu, K. Fati, and B. Abiwon, "Processing characteristics, grain quality and end-use quality of hybrids and common improved rice (Oryza sativa L.) varieties from Nigeria," *Nigerian Food Journal*, vol. 34, pp. 91-104, 2016.

[7] N. Danbaba, I. Nkama, M. H. Badau, and A. S. Ndindeng, "Development, nutritional evaluation and optimization of instant weaning porridge from broken rice fractions and bambara groundnut (Vigna subterranean L. Verdc) blends," *Nigerian Food Journal*, vol. 33, pp. 116 - 132, 2016.

[8] M. H. Badau, C. Britone, and J. I. N. Danbaba, "Production, viscosity, microbiological quality and sensory properties of comolementary food blends of improved rice cultivars, soybeans and sorghum malt," *Pakistan Journal of Nutrition*, vol. 15, pp. 846-856, 2016.Available at: https://doi.org/10.3923/pjn.2016.849.856.

[9] C. Bristone, M. H. Badau, J. U. Igwebuike, and N. Danbaba, "Physicochemical and manufacturing cost elements of complementary food formulations from broken fraction of rice cultivars, soybean and sorghum malt," *Croatian Journal of Food Science and Technology*, vol. 11, 2019.

[10] A. S. Livingstone, *Studies on malting of wheat and development of health foods based on malted wheat, discipline of cereal science and technology*. Mysore, India: Al Food Technological Research Institute, Research Project, 1991.

[11] K. Foster-Powell, S. H. Holt, and J. C. Brand-Miller, "International table of glycemic index and glycemic load values," *American Society for Clinical Nutrition*, vol. 76, pp. 23 - 27, 2002.

[12] G. Eshun, N. K. Baffour, and P. Y. Ackah, "Nutrient content and sensory acceptability of a weaning diet formulated from mixtures of soya bean, groundnut and rice," *African Journal of Food Science*, vol. 5, pp. 870-877, 2011.Available at: https://doi.org/10.5897/ajfs11.121.

[13] M. H. Badau, I. A. JideanI, and I. Nkama, "Rheological behaviour of weaning food formulations as affected by addition of malt," *International Fournal of Food Science & Technology*, vol. 41, pp. 1222-1228, 2006.Available at: https://doi.org/10.5897/ajfs11.121.

[14] M. O. Iwe, *The science and technology of soybeans Chemistry, nutrition, processing, utilization*. Umahia, Nigeria: Rojoint Communications Services Ltd, 2003.

[15] A. C. Mosha and U. Svanberg, "Preparation of weaning foods with high nutrient density using flour of germinated cereals," *Food and Nutrition Bulletin*, vol. 5, pp. 10-14, 1983.

[16] C. Gupta and S. Sehgal, "Development, acceptability and nutritional value of weaning mixtures," *Plant Foods for Human Nutrition*, vol. 41, pp. 107-116, 1991.Available at: https://doi.org/10.1007/bf02194079.

[17] J. S. Hough, *The biotechnology of malting and brewing" Trumpington street.* Cambridge: Cambridge University Press, 1992.

[18] H. D. Almeida-Dominguez, S. O. Serna-Saldivar, M. H. Gomez, and L. W. Rooney, "Production and nutritional value of weaning foods from mixtures of pearl millet and cowpeas," *Cereal Chemistry*, vol. 27, pp. 14 - 18, 1993.

[19] A. K. Gomez and A. A. Gomez, *Statistical procedure for agricultural research*, 2nd ed. New York: John Willey, 1983.

[20] R. Mead, R. N. Curnow, and A. M. Hasted, *Statistical methods of agriculture and experimental biology.* London: Chapman and Hall, 1993.

[21] A. I. Ihekoronye and P. O. Ngoddy, *Integrated food science and technology for the tropics.* London and Oxford: Macmillan Education Ltd, 1985.

[22] M. Katsumata, H. Yano, and T. Kawashima, "The effects of hot environment on body composition of growing rats," *Journal of Tropical Agriculture*, vol. 1, pp. 7 - 8, 1986.

[23] S. S. Nielsen, *Introduction to the chemical analysis of food.* New Delhi: CBS Publisher Darga Ganj, 2002.

[24] D. E. Duncan, "Multiple range and multiple F-tests," *Biometrics*, vol. 11, pp. 1 – 42, 1955.

[25] D. F. Houston, *Rice chemistry and technology," American association of cereals chemist.* Minnesota: Inc, St. Paul, 1992.

[26] R. J. Henry and P. S. Kettlewell, *Cereal grain quality.* London, U. K: Chapman and Hall, 1996.

[27] S. Ndindeng, D. Mapiemfu, W. Fantong, V. Nchinda, Z. Ambang, and J. Manful, "Postharvest adaptation strategies to the effects of temperature variations and farmer-miller practices on the physical quality of rice in Cameroon," *American Journal of Climate Change*, vol. 3, pp. 178 - 192, 2014.Available at: https://doi.org/10.4236/ajcc.2014.32017.

[28] A. Ibarz and G. V. Barbosa-Cánovas, *Unit operations in food engineering.* Boca Raton, Florida: Printed in the United States of America CRC Press LLC, 2000.

[29] N. A. Tekyiwa and W. P. Annorey, *Development and quality evaluation of a soy-fortified Ghanaian weaning food*: Old United Nations University, 2012.

[30] A. Thathola and S. Srivastava, "Physico-chemical properties and nutritional traits of millet-based weaning food suitable for infants of the Kumaon hills, Northern India," *Asia Pacific Journal of Clinical Nutrition*, vol. 11, pp. 28 - 32, 2002.Available at: https://doi.org/10.1046/j.1440-6047.2002.00251.x.