Formulation and Evaluation of Complementary Food Produced from Fermented Brown Rice (*Oryza Glalerrima)*, Germinated Bambara Nut (*Vigna Subterranean)* Seed and Jute Leaf (*Corchorus Olitorius)* "Ewedu"

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***Abstract*: Formulation and Evaluation of Complementary Food Produced from Fermented Brown Rice (*Oryza Glalerrima)*, Germinated Bambara Nut (*Vigna Subterranean)* Seed and Jute Leaf (*Corchorus Olitorius)* "Ewedu" were evaluated. The result of this experiment was evaluated using standard procedure. A total of twenty (20) runs were generated with fourteen experimental combinations and six replicates at the centre point. The fermentation and germination times range from 24 to 72 hours while the quantity of jute leave ranges from 1-15%. The results of the proximate composition of the formulated weaning foods revealed that almost all the parameters studied had values within the FAO/WHO (1991) recommendation. The moisture content varied from 1.00 to 5.33%, protein from 15.07 to 24.95%, fat from 10.51 to 20.12%, fibre from 0.75 to 3.50%, ash from 1.74 to 3.50% and carbohydrate from 47.52- 64.97%. Significant differences (p<0.05) existed among the samples. The blending of fermented rice and germinated Bambara nut have helped to improve the nutrient density of complementary food and improve the nutrient intake of these products. The study also revealed the weaning foods made from the mixture of fermented brown rice, germinated Bambara nut at different times and the addition of jute leaf powder contained protein, fat and energy in amounts that were above the recommended values of FAO/WHO, (1991). The use of these locally available and affordable crops to formulate weaning food will help parents or families to the adequate utilization of the food materials.**

***Keywords*: Fermented, germinated, brown rice, Bambara nut time and weaning food**

I. INTRODUCTION

In many developing countries such as Nigeria, malnutrition is a common dietary problem that is said to be endemic Mbaenyi and Onweluzo (2010). It is characterized by micronutrient deficiency and protein-energy malnutrition. High malnutrition rates pose a significant burden on economic and social development Fottrell *et al* (2009). Achii (2005) and Allen (2006) also reported that one of the greatest problems affecting millions of people, particularly children are lack of iron, zinc, calcium, riboflavin, vitamin A, and vitamin Cand inadequate protein intake in items of quality and quantity. The critical period when children develop malnutrition coincides with the introduction of complementary foods, which are nutritionally inadequate in many developing countries (Khanam *et al.*, 2011). Infancy is a period of rapid physical growth as well as physiological, immunological and mental development when nutritional requirements are at their highest Dipika *et al* (2013) reported that there is a need for nutritionally balanced, energy-dense, easily digestible foods with functional benefits to be formulated. Ajibola *et al (*2016) reported that weaning or complementary foods are specifically formulated with appropriate nutritional quality to provide additional energy and nutrients to complement the family foods derived from the local diet by providing those nutrients which are either lacking or are present in insufficient quantities.

Brown rice is nutritionally excellent and health claims associated with eating this type of rice Khairal *et al (*2007) such as a good source of fibre, which help in reducing high cholesterol levels, normalizing bowel function, reducing constipation and also increase sensitivity to insulin which lowers the glycemic index of the diet Khairal *et al (*2007). Gbenye *et al.* (2016) reported that bambara nuts have very high nutritive value with 65% carbohydrate,19% protein, 6.5% oil and also contain minerals like calcium (85.5 -99.0% (mg/100g), iron (5.1 -9.0% (mg/100g), potassium (11.45 -14.36% (mg/100g), and sodium (2,9 -10.6% (mg/100g). USDA (2016) reported that jute leaf contains vitamins A (32.14%), B6 (38.15%), C (31.89%), K (78.33%), and iron (34.13%) respectively. Germination and Fermentation of legumes and cereals are excellent sources of nutrients such as protein, dietary fibre, fat, minerals and vitamins (Ohtsubo *et al*., 2005).

Poor combination and formulation have partly contributed to the poor performance of complementary food that leads to malnutrition (Solomon, 2005). Traditionally, the diets of most human societies consist of a starchy plant staple, food such as cereal that is generally used is known to be relatively low in lysine and tryptophan, but fair in Sulphur containing amino acids (methionine and cysteine) in the legume (Michaelsen *et al. (*2009) and FAO/WHO (2004). Okoye (1992) reported that the presence of non-nutrient constituents (antinutritional factors) in plant-based foods has been shown to also negatively influence the bioavailability of nutrients. The short period of exclusive breastfeeding, low dietary intake, poor absorption of some micronutrients, and poor bioavailability of nutrients in complementary foods also cause malnutrition (Lutter and Rivera, 2003). In Nigeria, and indeed most developing countries, the underlying problems have been identified to include poverty, high cost of animal protein, inadequate nutrient intake particularly, period of rapid growth and complementary feeding in infants, ignorance about nutrient values of foodstuffs (SCN, 2004) and WHO, 2000) Poor processing methods and hygiene have also been identified as other factors responsible for low nutrient density in local complementary foods. Ajibola *et al*. (2016) reported that several food processing techniques and preparation methods can be used at the household level to enhance the bioavailability of micronutrients, nutrient density, food safety, storage stability, palatability and convenience food suitable for infants in plant-based diets.) The combination of cereals and legumes with fruits or vegetables increases the protein and vitamin content of cereal fruit blends and pre-processed by the combination of some methods dehulling, milling, soaking, fermentation, and germination will reduce the problem of anti-nutritional factors and enhance their functionality, nutritional values and sometimes reduces the fibre content to acceptable levels (Achi,2005). Ajibola *et al.* (2016) reported that since germination is cheap and more effective in improving nutritional value it will be used in the formulation and fortification of vegetables to contribute to the nutrition of people.

Uche *et al* (2016) reported that since animal protein is beyond the reach of poor people, their primary protein supply should come from plant base products such as bambara nut (*(Vigna. subterranea*), brown rice and jute leaf *(Corchorus olitrius).* Fermentation also improves protein quality, digestibility, vitamin B content, keeping quality. and microbiological safe. The problem of malnutrition will be reduced if complementary food is formulated with brown rice, bambara nut and *Corchorus olitrius* which can be readily prepared, available, affordable, and contains reasonable nutrients. Investigating the effect of processing on the nutritional and the anti-nutritional components of fermentation of brown rice, germination of bambara nut and jute leaves *Corchorus olitorius)* will help to increase the awareness of not only these crops but also their nutritional capabilities. In view of the numerous usefulness attributes of bambara nut, brown rice and *Corchorus olitrius* both in terms of their nutritional composition and their availability, it is necessary to carry out researches that will help to optimize their benefits, especially in Nigeria where malnutrition occurrences are on the high side.

II. MATERIALS AND METHODS

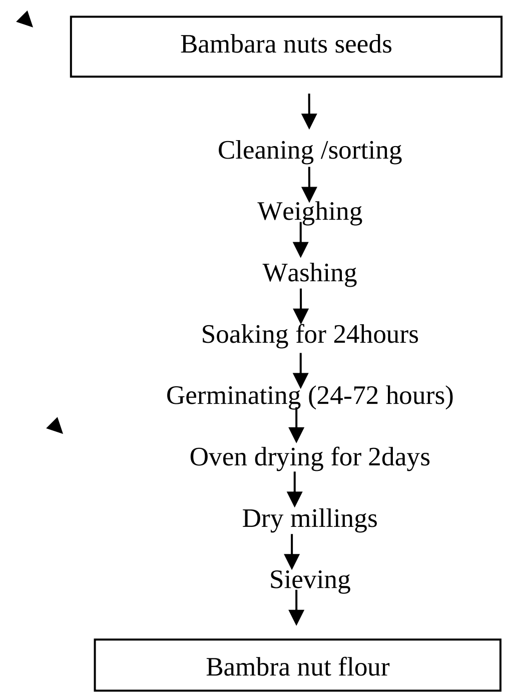
Bambara nuts (*Vigna subterranea*L. Verdc), Brown rice (*Oryza glalerrima*) and *Corchorus olitorius*leaf "(ewedu)" **t**hat was used were purchased from a local retailer at the Meat market, in Abakaliki, Ebonyi State, Nigeria.

Sample Preparation

The grains were properly sorted and cleaned before processing into flour and kept in air-tight plastic containers at room temperature.

Preparation of bambara groundnuts flour

The method described by Mbata *et al*, (2009) was used. A Bambara groundnut seed of five kilograms (5kg) already cleaned and sorted was divided into five equal parts, 1kg each. The samples were weighed and soaked in a plastic bucket containing 3000 ml of tap water and steeped for 12 hours at room temperature (28 ± 2°C). For every two hours of soaking the steeped water was discarded by decantation and it continued until 12 hours completed, the steeped grains were germinated for 24, 36, 48, 62 and 72 hours by spreading them on a clean sack bag and water were been spread on them every four hours until each germination time was reached and thereafter were oven dried for 2days at 55^{0C}using Griffin and George oven (serial number 780055 Britain). The germinated bambara nuts seeds were then milled using a disc attrition mill (No.2A premier mill, Hunt and Co, UK) in Soil Science Laboratory, Ebonyi State University Abakaliki, Nigeria. The milled flour was then sieved through a fine mesh (1mm) to obtain the bambara nuts flour. The flours were packaged in airtight containers and stored for analysis.



Preparation of Brown Rice Flour

The method of fermentation adopted by Mbaeyi-Nwaoha and Obetta (2016) was used. Five (5) kilograms of cleaned whole grains were divided into five parts and were steeped in tap water in plastic buckets. The buckets were covered with aluminium foil and the contents were allowed to ferment at room temperature (29^0C ± 2^0C) for 24-72 hrs. The steeped water was decanted and the fermented rice was washed and placed on aluminium foils and oven-dried at 55^0C until properly dried. The dried samples were milled using an attrition mill. The flours were passed through a sieve to get a particle size of 0.384mm using a shaker (CretSch Machinery Co Ltd Model 300T) in the Food Science and Technology Laboratory to get 0.384mm using number 1 and packaged in plastic contains

Brown Rice
↓
Cleaning/sorting
↓
Weighing
↓
Washing
↓
Fermentation (24-72 hours)
↓
Washing
↓
Oven drying 55ºC for 2days
↓
Dry milling
↓
Sieving
↓
Brown Rice Flour

Preparation of leaves

The method adopted by Mbaeyi-Nwaoha and Obetta (2016) was used. A known quantity of *Corchorus olitorius*"(ewedu)" leaves (6000 g) was purchased and cleaned, sun-dried, and milled using a disc attrition mill (No.2A premier mill, Hunt and Co, UK) in Soil Science Laboratory, Ebonyi State University Abakaliki, Nigeria. The flours were sieved with 1 mm sieve to yield leaf powder. The leaf powder was packaged in airtight container and stored for analysis.

Corchorus olitorius"(ewedu)"
↓
Sorting /Plucking
↓
Washing
↓
Sun-drying
↓
Milling
↓
Sieving
↓
Corchorus olitorius leaf powder

Determination of Proximate Analysis

The samples were analyzed for proximate composition which includes moisture, ash, crude protein, crude fibre and carbohydrate using the method described by AOAC, (2010).

Statistical Analysis

Analyses were determined in triplicates and the Data were analyzed using the Analysis of Variance (ANOVA) statistical method (Statistical Analysis System version 9.2 program, SAS Inc., (2008), USA.). Means were separated using Duncan's multiple-range tests. Significant differences were established at $P<0.05$.

III. RESULTS AND DISCUSSIONS

Proximate Composition of Weaning Food Formulated from Germinated Barrmbara Nut, Fermented Brown Rice and Jute leaf flour

The proximate composition of Weaning Food Formulated from Germinated Barrmbara Nut, Fermented Brown Rice and Jute leaf flour blends are presented in Table 1

SAMPLE CODE	MOISTURE (%)	PROTEIN (%)	FAT (%)	CRUDE FIBRE (%)	ASH (%)	CARBOHY DRATE (%)	ENERGY (kcal)
A,34/34,4	$2.00^f \pm 0.00$	$15.07^h \pm 0.24$	$12.00^i \pm 0.00$	$3.50^a \pm 0.00$	$2.50^e \pm 0.00$	$64.93^a \pm 0.24$	$428.00^i \pm 0.00$
B,62/34,4	$3.50^e \pm 0.00$	$17.23^g \pm 0.29$	$11.03^k \pm 0.03$	$0.75^f \pm 0.00$	$2.50^e \pm 0.00$	$64.97^a \pm 0.03$	$428.00^i \pm 0.00$
C,34/62,4	$2.00^f \pm 0.00$	$18.06^f \pm 0.29$	$12.89^g \pm 0.11$	$1.00^e \pm 0.00$	$2.50^e \pm 0.00$	$63.55^c \pm 0.18$	$443.00^e \pm 0.00$
D,62/62,4	$4.75^c \pm 0.05$	$20.79^c \pm 0.32$	$10.51^l \pm 0.01$	$1.00^e \pm 0.00$	$1,74^h \pm 0.06$	$61.09^f \pm 0.43$	$422.50^k \pm 0.00$
E,34/34,12	$1.50^g \pm 0.00$	$18.14^f \pm 0.19$	$15.00^c \pm 0.00$	$1.00^e \pm 0.00$	$2.50^e \pm 0.00$	$61.87^e \pm 0.19$	$455.33^b \pm 0.29$
F,62/34,12	$4.96^{bc} \pm 0.40$	$18.07^f \pm 0.13$	$12.01^i \pm 0.01$	$1.75^c \pm 0.25$	$3.00^b \pm 0.00$	$60.16^g \pm 0.41$	$420.00^m \pm 0.00$
G,34/62,12	$4.13^d \pm 0.13$	$24.95^a \pm 0.44$	$11.51^j \pm 0.02$	$1.23^d \pm 0.03$	$2.00^g \pm 0.00$	$56.44^i \pm 0.02$	$427.50^j \pm 0.00$
H,62/62,12	$4.75^c \pm 0.25$	$24.09^b \pm 0.16$	$20.00^a \pm 0.00$	$1.00^e \pm 0.00$	$2.50^e \pm 0.00$	$47.52^j \pm 0.26$	$487.92^a \pm 0.00$
I,24/48,8	$5.50^a \pm 0.29$	$21.12^c \pm 0.07$	$14.00^d \pm 0.00$	$1.00^e \pm 0.00$	$2.75^d \pm 0.00$	$56.14^i \pm 0.07$	$433.00^h \pm 0.00$
J,72/48,8	$3.88^d \pm 0.13$	$18.61^e \pm 0.08$	$11.50^j \pm 0.05$	$1.00^e \pm 0.00$	$2.50^e \pm 0.00$	$62.76^d \pm 0.10$	$424.00^k \pm 0.00$
K,48/24,8	$4.04^d \pm 0.29$	$18.00^f \pm 0.15$	$13.02^f \pm 0.12$	$1.00^e \pm 0.00$	$2.50^e \pm 0.00$	$61.65^e \pm 0.40$	$433.65^g \pm 0.00$
L,48/72,8	$1.00^h \pm 0.00$	$18.12^f \pm 0.26$	$13.50^e \pm 0.00$	$1.00^e \pm 0.00$	$3.25^b \pm 0.02$	$64.13^a \pm 0.26$	$450.00^d \pm 0.00$
M,48/48,1	$2.00^f \pm 0.00$	$16.98^g \pm 0.39$	$12.50^h \pm 0.00$	$1.00^e \pm 0.00$	$2.25^f \pm 0.00$	$64.39^a \pm 0.03$	$441.50^f \pm 0.00$

N,48/48,15	5.13[ab] ±0.13	21.03[c] ± 0.32[c]	11.50[j] ± 0.00	2.00[b] ± 0.00	3.50[a] ± 0.00	56.88[h] ± 0.39	414.50[n] ± 0.00
O,48/48,8	3.22[e] ± 0.06	19.79[d] ± 0.22	17.00[b] ± 0.00	1.00[e] ± 0.00	2.25[f] ± 0.43	56.27[i] ± 0.02	457.00[b] ± 0.00
TOTAL	3.48 ± 1.42	19.34 ± 2.60	13.19 ± 2.46	1.28 ± 0.68	2.55 ± 0.45	60.22 ± 4.70	437.72 ± 18.46
FAO/ WHO	< 5	>15	10 -25	< 5	< 3	64	400- 425

Values with the different superscripts on the same column are significantly different at P<0.05.

The moisture content ranged from 1.00 to 5.33% with sample (48/72/8) having the lowest value of 1.00% while sample I (24/48/8) had the highest 5.33% moisture content. The moisture content of the formulation is almost within the maximum range of less than 5% as recommended by FAO/WHO (1991). The protein content of the formulations ranges from 15.07 to 24.95%. Sample G 34hours /62hours /12g of jute leaf had the highest (24.95%) protein content while sample A had the lowest (15.07%) protein content. Samples DIJN are not significantly different from each other.

The protein content of the formulations was significantly higher when compared with FAO/WHO (1991) recommendation and Rashmi *et al* (2011) who reported that the protein content of 15.11 to 15.94% weaning food prepared from wheat, green gram and groundnut cake. Therefore, the blending of fermented rice and germinated bambara nut has helped to improve the nutrient density of complementary food and improve the nutrient intake of these products. The fat content of the formulation ranges from 10.51 to 20.12%. Sample H (62g of fermentation, 62g of germination and 12g of jute leaf) had the highest fat content while sample D (62/62/8) had the lowest fat. The fat content is within the recommended value of between (10 to 25%) FAO/WHO (1991) and it is also higher than the values of 3.03 – 8.08%as reported by Akinola *et al* (2014) who produced weaning food from soybean, millet, guinea corn, maize, groundnut, crayfish and carrot blend. This may be because fermentation and germination increase the fat content of this work as it is significantly higher.

The fibre content of this formulation ranges from 0.75 to 3.50%. Sample A (34/34/4) had the highest followed by Sample N (48/48/15) which had 2.0% fibre content and Sample B (62/34/4) had the lowest fibre content. It is observed that only samples A, B and N are significantly different from others. but sample N had the highest percentage of jute leaf of 15 grams. The fibre content of this work is within the range of values gotten from Rashmi *et al* (2011) who reported fibre content to be between 1.50 to 1.55% but it is lower than the value of 2.61 to 4.38% as reported by Mbaeyi-Nwaoha and Obetta (2016) who produced weaning food from millet, pigeon pea and seedless breadfruit leaf powder blends. The ministry of health, Nigeria (2012) reported that a child could get protein energy malnutrition when weaning food does not contain a sufficient amount of protein and energy. Protein-energy malnutrition can cause inadequate intake of food. The disease that can be associated is communicable diseases like diarrhoea and respiratory tract infection. The average ash content of the formulated weaning food ranged from 1.74 to 3.50% with sample N (48/48/15) having the highest value of 3.50% and sample D (62/62/8) having the lowest value of 1.74%. Samples of DFLN are statistically different from other samples. It was observed that sample N has the highest percentage of jute leaf 15g which shows a highly significant effect on ash content. It is also observed that some values are significantly higher than FAO/WHO (1991) recommendation. It is also higher than the values (1.40 to 1.70%) reported by Okpala and Ekwueme (2017).

The carbohydrate content of the formation ranges from 47.52- 64.97%. Sample A, B, L, M (34/34/4), (62/34/4), (48/72/8) and (48/48/1) are significantly different. Samples A, B, L, M. had the highest carbohydrate content of 64.97% and sample H (62/62/12) had the lowest carbohydrate content of 47.52%. It is observed that only four samples are within the recommendations of 64% carbohydrate. The values obtained for the formations were higher than the 54.14- 63% reported by Akinola *et al* (2014) for weaning food made from soybean, millet, guinea corn, maize and groundnut flavour blend. The values obtained in this work are lower than 76. 01- 77.14% reported by Rashmi *et al* (2010) for weaning food made from wheat, green gram and groundnut cake flour blend and it is also lower than the 73.36 to 7.19% reported by Mbaenyi-nwaoha and Obelta (2016) for weaning food produced from unfermented and fermented millet flour.

The carbohydrate content of the flours varied with different fermentations and germination periods. There was a reduction of the carbohydrate content of 62/62/12 sample of (N) at 62 hours of fermentation, 62 hours of germination and 12g of jute leaf powder. The reduction in carbohydrates could be attributed to the possible hydrolysis of complex carbohydrates to simple sugars, which were used for metabolic processes Nnam, (2001) as reported by Mbaeyi-nwaoha and Obetta (2016).

It is also lower than 63.50- 76.02% reported by Ikujenlola *et al* (2013) for weaning food produced from maize varieties and pumpkin flour blends. Energy- the result of the formulated food shows an energy content ranging from 442.50- 487.92 Kcal. Sample H (62/62/12) had the highest energy content while sample D (62/62/4) had the lowest energy content. It is observed that sample H had the highest protein, fat and lowest in carbohydrate. The energy content is above the recommended FAO/WHO (1991) value of 400- 425 Kcal for weaning food. All the energy values of the 15 weaning foods were greater than the values 331.83- 368 Kcal reported by Tiencheu *et al* (2016) for weaning food made from egg white, fermented maize, paw paw, and beans flour blend. It is also higher than 376- 380Kcal reported by Rashmi *et al* (2010) for weaning food produced from breadfruit and soya bean flour blend.

IV. CONCLUSIONS

This study has shown that fermentation of brown rice, germination of Bambara nut and addition of jute leaf powder had positive effects on the proximate composition of the weaning foods produced. The study also revealed the weaning foods made from the mixture of fermented brown rice, germinated bambara nut at different times and the addition of jute leaf powder contained protein, fat and energy in amounts that were above to recommended values. The mixture, ash and carbohydrate were within the recommended values. The weaning foods produced show appropriate nutritional quality to provide additional energy and nutrients to complement the family foods in developing countries.

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