

Nutritional Evaluation of Complimentary Food Produced from Malted Rice (*Oryza sativa*), Tiger Nut (*Cyperus esculentus*) and defatted Sesame Seeds (*Sesamum indicum*) flour blends Using Albino Rats

ABSTRACT

Complimentary food is any food or drink given to infants in addition to breast milk or formula when breast milk alone is no longer enough to meet their nutritional needs. This experiment was conducted to evaluate the nutritional qualities of complementary food produced from malted rice (*Oryza sativa*), tiger nuts (*Cyperus esculentus*) and defatted sesame seeds (*Sesamum indicum*) using Albino Rats. The complimentary foods were produced from varied ratios (100:0:0; 80:15:5; 70:25:5; 82.5:10:7.5; 80:10:10 and 77.55:10:12.5 respectively) of malted rice, defatted sesame seed and tiger nut flour with the aim of meeting the energy and protein needs of infants at age 6 to 24 months. The protein quality, serum biochemical and haematological indices of albino rat fed with prepared complimentary foods were determined using standard methods. *Ogi* and *Cerelac* were used as the control samples. The data obtained were analysed statistically using Statistical Package for Social Sciences (SPSS) (25.0). The data were subjected to a one-way analysis of variance (ANOVA) and the average mean scores separated using Duncan's Multiple Range Test (DMRT) at $p < 0.05$. The protein qualities: PER, NR, BV, NPU and TPU increased from 0.23 to 0.24, 1.48 to 3.00, 66.91 to 80.09, 0.64 to 0.67 and 64.38 to 70.92%, respectively, with increase in the added defatted sesame seed flour (0 to 25%) but decreased with addition of tigernut flour. The biochemical indices that is the total protein, albumin, ALP, ALT, AST, creatine and urea increased from 6.48 to 7.21 g/dL, 2.30 to 3.30 g/dL, 121.2 to 168.20, 5.30 to 6.20, 27.00 to 55.20, 21.21 to 26.07 and 4.90 to 5.10 μ L, respectively, with increase in the added defatted sesame seed flour (0 -25%) but decreased with added tiger nut (0-12.5%). The haematological parameters include WBC, RBC, HB, PCV, MCV, MCH and MCHC increased from 7.64 to 8.87 $\times 10^3$ mm³, 8.30 to 8.96 $\times 10^3$ mm³, 17.70 to 18.37 g/dl, 44.00 to 50.00%, 56.00 to 63.00 fl, 21.70 to 22.50 pg, 30.00 to 33.00 g/dL, respectively, with increase in the added defatted sesame seed flour (0 - 25%) but decreased with added tigernut flour (0 to 12.5%). The quality of the protein of the produced complimentary food is higher than the locally prepared *ogi* but compared favourably with the commercially produced *cerelac*.

Key words: protein quality, serum, biochemical, haematological parameters, albino rat

1.0 INTRODUCTION

Complementary food in the context of infant nutrition, refers to solid foods (locally or commercially) that are introduced to a baby's diet along with breast milk. These foods are introduced when the baby reaches 6 months of age, as recommended by World Health Organization (WHO, 2018).

Complementary feeding is the process starting when breast milk alone is no longer sufficient to meet the nutritional requirements of infants (Taha *et al.*, 2020) and therefore other foods and liquids are needed along with breast milk. Complementary feeding is thus the transition period from exclusive breastfeeding to the family diet.

Nutritionally, complementary foods provide additional energy and essential nutrients, (Moghaddam *et al.* (2015), support continued healthy growth and development (Wang *et al.*, 2019), prevent

m micronutrient deficiencies (ISDI, 2018), promote healthy eating habits (Boswell, 2021) and complement breastfeeding (Moghaddam *et al.*, 2015)

Adequate nutrition during infancy and childhood is fundamental to a child's development to its full potential. This is achieved by consuming balanced healthy diets and good knowledge of child feeding practices (Lutter, 2017). Despite the importance of good nutrition, it is evident that many families in developing countries including Nigeria are unable to feed their children with appropriate diet. This could result in protein energy deficiency in the diets as well as micronutrients deficiencies leading to endemic protein energy malnutrition (PEM) and health consequences (Onojo *et al.*, 2019).

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Traditional complementary foods (gruel) are of low nutritive value and are characterized by low protein; energy density, bulky and high viscosity which needs to be further diluted with water to give a consistency appropriate for a child's feeding. Hence it decreases the food nutrients **concentration** (Krebs *et al.*, 2018).

In light of the above nutritional challenges, quite a number of studies have investigated ways of formulating quality complementary foods through a combination of available plant-based foods **such as rice, tigernut and sesame seed**, to meet the nutritional needs of infants and **under-five children**.

Rice (*Oryza sativa*) is a cereal grain cultivated and used as a starchy staple food probably by more than half of the world population primarily due to its versatility and **availability**. It has carbohydrates contents of 70-80 % of its dry weight, 5-7% protein, and 1% fat (Letermeet *et al.*, 2015). Gupta *et al.*, (2010) stated that malting is the controlled germination of cereals, to ensure a given desirable physical and biochemical change within the grain, which is then stabilized by grain drying. When rice is malted it will result in the production **of enzymes that can break down the complex carbohydrates and proteins**, making them more easily digestible and potentially making it easier for infants to digest and absorb nutrients (Tamang *et al.*, 2016).

Tiger nuts are grown for its nutritional and health benefits (Asareet *et al.*, 2020). It contains significant amounts of **fibre 35%**, unsaturated fat and moderate amounts of protein (Rosell, 2020). The tuber contains 45 % carbohydrate, 30 % fat, 7 % protein, 3 % ash and 14.8 % crude Fibre. Tiger nut flour is also a natural sweetener (Sabah *et al.*, 2019).

Sesame seed contains 50-60% oil, 21-25% protein, and 20–25% carbohydrate and is a rich source of iron, magnesium, copper and calcium (Gebremichael, 2017). It is reported that defatted sesame flour contains 55.70% protein, 29.10% carbohydrate, 9.83% ash and 1.64% crude fibre (Chinmaet *et al.*, 2012).

There is presently limited information on the combination of these ingredients such as malted rice, tiger nut and defatted sesame seeds.

Several types of commercial complementary foods marketed in many countries including Nigeria are nutritious but expensive for most average families. Hence, many families depend on inadequately processed and low-quality traditional complementary foods for their children (Amankwahet *et al.*, 2017; Muhimbulaet *et al.*, 2018). World Health Organization (WHO, 2015) recommends that children should

take adequate, safe and appropriate complementary foods from six months onwards while continuing to be breastfed until two years of age (PAHO, 2013; Stewart *et al.*, 2013). Breastfeeding and appropriate complementary feeding, as well as improving the quality of foods given to children, are some of the most prominent interventions to reduce child mortality and morbidity (Bhutta *et al.*, 2018). Early childhood is a critical period for growth and neurodevelopment. An appropriately formulated complementary food can provide the necessary nutrients and energy to support optimal physical and cognitive development, potentially reducing the risk of malnutrition and developmental delays (Bhutta *et al.*, 2013). Malnutrition remains a significant public health challenge, particularly in developing countries. The period of complementary feeding is crucial for child development, as inadequate nutrition during this phase can lead to long-term health issues such as stunted growth and cognitive impairments (Adedayo *et al.*, 2021). Complementary foods made from locally available ingredients like rice, tiger nuts, and sesame seeds can provide essential nutrients that are often lacking in conventional diets.

The selected ingredients—malted rice, tiger nuts, and defatted sesame seeds—are rich in essential nutrients. Malted rice provides carbohydrates and is a source of energy. The malting process enhances its digestibility and nutritional value by increasing the availability of vitamins and minerals (Okoye *et al.*, 2021). Tiger nuts is known for their high fibre content, tiger nuts also provide healthy fats, vitamins (such as E), and minerals (like magnesium) that are beneficial for growth and development (James *et al.*, 2018).

Defatted sesame seeds are an excellent source of protein and contain important micronutrients such as calcium and iron, which are vital for bone health and preventing anaemia in children. Combining these ingredients can create a balanced profile of macronutrients (carbohydrates, proteins, fats) along with essential vitamins and minerals necessary for infants' growth. Many commercially available complementary foods are prohibitively expensive for low-income families. By utilizing locally sourced ingredients that are affordable, this research supports the development of cost-effective food solutions that can be easily accessed by communities facing economic constraints (Adedayo *et al.*, 2021). This approach not only promotes better nutrition but also encourages local agricultural practices. The malting process used in preparing rice can improve the bioavailability of nutrients by breaking down anti-nutrients that inhibit mineral absorption. Additionally, blending these ingredients may enhance the overall nutrient profile through synergistic effects, making the final product more beneficial than its

individual components. This aspect is crucial for developing foods that meet the dietary requirements of growing children. The broad objective of this study was to produce and evaluate the nutritional qualities of complementary food from malted rice, tiger nuts and defatted sesame seeds using albino rats.

2.0 MATERIALS AND METHODS

2.1 Materials and Material Preparation

Rice (*Oryza sativa*), tiger nut (*Cyperus esculentus*), and sesame seeds (*Sesamum indicum* L) were purchased from YelwaTudu market, Bauchi State, Nigeria. While albino rats were procured from National Veterinary Research Institute Vom Jos, Plateau State, Nigeria.

Rice paddy was prepared using the method of Owusu *et al.* (2014). The rice cultivar was winnowed to remove contaminants such as stones, dust, damaged paddy, etc. Paddy rice was washed twice with clean water, steeped (portable water) and allowed to stand at $29 \pm 2^{\circ}$ C for 24 hours. An "air-rest" period of one hour each for every interruption was provided until the grain reached about 42% moisture content (Marconi *et al.*, 2017). The steeped paddy was then drained and wrapped in a wet jute bag that provided about 3 to 5 cm depths. The grains germinated for another 48 hours at $29 \pm 1^{\circ}$ C, and then it was removed and kilned ($60-70^{\circ}$ C for about 2-3 hours), polished by detaching the roots and rootlet and milled and sieved to produce flour.

Tiger nut flour was prepared as described by Onuoha (2016). Dry tiger nut tubers were sorted, de-hulled and washed (portable water), oven dried (80° C), milled and sieved (through 0.4 size sieve) to produce flour, packed in polyethylene bag and stored at room temperature.

Sesame seeds preparation was done as described by Oladele *et al.* (2014). Sesame seeds were cleaned and sorted, moisten, de-hulled manually (using mortar and pestle), winnowed, blanched (for 5 minutes), oven dried (60° c), milled and the oil extracted and the cake dried.

2.1.1. Formulation of Blend

The formulation of the complementary diets was done by blending the prepared materials in the appropriate ratios according to their proximate composition in order to achieve the desired food balancing that meets the energy and protein needs of infants at age 6 and 24 months as adopted by Kikelomo *et al.* (2021). The upper limit used in the study are malted rice (80%), defatted sesame seeds (15) tiger nut (5%), the lower limit is 77.5, 10 and 12.5%, respectively. The respective samples: MR1 (100% malted rice), MRDST2 (80% malted rice, 15% defatted sesame seeds and 5% tiger nut).

MRDST3(75% malted rice, 20% defatted sesame seeds and 5% tiger nut), MRDST4(82.5% malted rice, 10% defatted sesame seeds and 7.5% tiger nut), MRDST5 (80% malted rice, 10% defatted sesame seeds and 10% tiger nut) and MRDST6 (77.5% malted rice,10% defatted sesame seeds and12.5% tiger nut) were prepared with reference to 18 % RDA for protein, *400Kcal; *9% fat. Glucose (5%), sucrose (10%), cellulose (5%), vegetable oil(5%), min,vit.Premix(3%), NaCl (0.2%) were added to the above flour blends and fed to the albino rat after period of acclimation.

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2.1.2 Animal Experimentation

2.1.2.1 The Study Area

The study was carried out in the Pharmacology Department, Faculty of Pharmaceutical Sciences University of Jos, Plateau State.

2.1.2.2 Procurement and Housing Albino rats: 20 Albino rats were procured from the National Veterinary Research Institute, Vom, and Plateau State. The rats were housed in clean metallic cages in clean well ventilated room for the period of one week to acclimatize and three weeks for the experiment. Izal was used to disinfect the room. The experiment was carried out from 8th October to 5st October 2024 in the animal section of the Pharmacology Department in University of Jos. Water was given *ad libitum* throughout the feeding period. The rats were divided into three groups of 5 rats each as described by Ijarotimi, (2022). The rats were fed with the different blends of complementary food including the control. The blends were:

- i. Group 1 MRDST2=Malted Rice 80+ Defatted Sesame15+ Tiger nut 5%,
- ii. Group 2 MRDST3=Malted Rice75+Defatted Sesame 20+ Tigernut 5%
- iii. Group 3 MRDST = Malted Rice 77.5+Defatted Sesame 5+ Tigernut 12.5%
- iv. Group 4 = *Cerelac*
- v. Group 5 = *Ogi*

Formulated complementary food were prepared by incorporating basal diet to achieve an iso-nitrogenous diet of 10 % protein level. The rats were grouped in to five and each group had four albino rats housed in metabolic cage. They were housed in Perspex sheet metabolic cages. Before feeding with the experimental diets, the rats were allowed to stabilize on the standard laboratory feed for seven days, starved for day, introduced to the complementary flour blends. Weighed diets and water were given *ad libitum* for 21 days and left overs diets were collected and weighed at the end of each day. The animal's weight was measured, and each group's urine and faeces were collected and using the AOAC (2012) technique to analyzed the nitrogen content.

2.1.2.3 Ethical Clearance: An Ethical clearance certificate was obtain from the Ethical committee, Animal Experimental Unit, University of Jos, Plateau State with the Ref. No: F17-00379

2.2 Methods

2.2.1 Nutrient Digestibility and Utilisation by Albino Rats Fed on the Diet

The weight gained, excreted faeces and urinary nitrogen are used to evaluate protein qualities of the formulated foods, and are used also to determine and calculate the nutritional quality (protein quality); biological value (BV), nitrogen retention (NR), feed efficiency (FE), net protein utilisation (NPU), true protein digestibility (TPD) and protein efficiency ratio (PER) were determined by AOAC (2012) method.

2.2.2 Determination of Biochemical Parameters of the Blood of Rats Fed on Formulated Complementary Diet

2.2.2.1 Preparation of serum

Determination of alanine aminotransferase (ALT) aspartate aminotransferase (AST) alkaline phosphate (ALP) creatinine (CREA)

Serum was separated from the blood samples by centrifugation at 3000 x g for 15 minutes. The separated serum sample were transferred into dry, clean serum tubes, stoppered and stored in the refrigerator at 2-4°C till it was used for testing (not more than 24 h). The alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphate (ALP), and creatinine (CREA) were determined as described by Reitman and Frankel (1957). The urea level was determined as described by Fawcett (1960) using commercially available kits (Randox Laboratories, Antrim, UK). Albumen content was determined as described by Weis (1965) as modified by Doumas (1971).

2.2.3 Haematological Indices Determinations

At the end of 28 days of experimental period, three albino rats from each treatment are fasted overnight with excess of water *ad libitum* and sacrifice using chloroform anaesthesia. The blood samples were collected through cardiac puncture with a syringe and poured into heparinized and non-heparinized tubes. The non-heparinized tubes were allowed to clot for 25min and sera was obtained, and the blood samples were stored in a deep freezer prior to haematological and biochemical analyses (Ijarotimi, 2022). The analyses were carried out at the Medical Laboratory Unit of National

Veterinary Research Institute Vom Jos, Plateau State. The haematological indices, that is, pack cell volume (PCV), red blood cells (RBC), pack cell volume (PCV), haemoglobin concentration (HBC), white blood cells (WBC); Mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concern (MCHC) and means corpuscular volume (MCV) were determined as described by (Ijarotimi,2022).

3.0 RESULTS AND DISCUSSION

3.1 Protein Quality and Metabolisable Energy of the Albino rats Produced Complementary Food, *Cerelac* and *Ogi*

The Feed Efficiency Ratio (FER), Nitrogen Retention (NR), Biological Value (BV), Net Protein Utilization (NPU), Protein Efficiency Ratio (PER) and True Protein Digestibility (TPD) in the produced complementary food (Table 1) ranged from 0.21 to 0.23, 1.12 to 3.00, 73 to 85, 58 to 80, 0.60 to 0.67 and 58 to 70 mg/100g, respectively, with added defatted sesame seed flour and ranged from 0.15 to 0.28, 0.00 to 1.32, 17.64 to 81.71, 16.58 to 71.56 mg/100g, with added tiger nut flour, 0.54 to 0.82 and 19.65 to 76.21 mg/100g, respectively, for *cerelac* and *ogi*.

The Protein Advisory Group (PAG) guidelines (1991) recommend a PER of not less than 2.1 preferably not less 2.3 for complementary foods (PAG, 1971), while FAO/WHO (1989) recommended values of 70%, and 2.10 for BV, and PER, respectively. All the formulated diets were higher than the PAG, and FAO/WHO recommended values for BV and slightly lower than recommended PAG for PER. Therefore, they met the required standards of BV and PER. According to Oser (1959), a protein material is said to be of good nutritional quality when its BV is 70%, and above.

There were no significant difference in total and daily weight gain within the 1st and 2nd weeks which could be due to the absorption of nutrients which may be same across diets as the rats' digestive systems acclimate to the new food sources. This could lead to comparable weight gain despite varying formulations as reported by Shima *et al.* (2019). The formulated complementary food samples recoded low weight gain. The control samples *cerelac* (14.09) likely has a higher nutritional density and higher than *ogi*. This agreed with the report of Onuoha *et al.* (2014) that *cerelac* is formulated to provide essential nutrients that increase rate of growth, leading to greater weight gain in rats. The protein quality in *cerelac* could be superior due to its formulation, which is designed for growth and

development (Shimaet *et al.*, 2019). The produced complimentary food had significant effect on the FER and NR of the fed rats. This could be due to the added defatted sesame seeds flour and tiger nuts respectively. The increase in BV (85mg/100g) in MRDST3 (70:25:5) could be due to the added defatted sesame seed flour. There was decrease in the same for MRDST6 (77.5:10:12.5) with 73.45mg/10g due to increase in added tiger nuts flour.

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Table 1: Protein Quality, and Metabolisable Energy Evaluation of the Albino rats fed with the Produced Complementary, Cerelac and Ogi

| | MRDST2 | MRDST3 | MRDST6 | Cerelac | Ogi NRV | P. value |
|----------------------|--------------------------|-------------------------|-------------------------|--------------------------|---------------------------|----------------------|
| | 80:15:5 | 70:25:5 | 77.5:10:12.5 | | | |
| Parameters | | | | | | |
| Daily wt gain | 11.94±0.56 ^c | 13.71±0.39 ^b | 10.23±0.32 ^d | 14.09±0.16 ^a | 8.94.73±0.29 ^e | 0.0681 ^{NS} |
| Food intake | 52.64±1.15 ^{bc} | 56.25±0.57 ^b | 50.93±0.57 ^c | 60.55±0.03 ^a | 30.04±1.15 ^d | 0.0000* |
| FER | 0.23±0.00 ^c | 0.24±0.00 ^b | 0.21±0.00 ^d | 0.28±0.00 ^a | 0.15±0.00 ^e | 0.0000* |
| NR | 1.48±0.57 ^b | 3.00±0.57 ^a | 1.12±0.01 ^d | 1.32±0.01 ^c | 0.00±0.00 ^e | 0.0000* |
| BV | 77.23±1.15 ^{bc} | 85.52±0.57 ^a | 73.45±1.73 ^c | 81.71±0.58 ^{ab} | 17.64±1.15 ^d | >70 0.0000 |
| NPU | 66.91±1.15 ^c | 80.09±2.88 ^a | 58.31±1.73 ^d | 71.56±0.58 ^b | 16.58±0.58 ^e | 0.0000* |
| PER | 0.64±0.00 ^c | 0.67±0.11 ^b | 0.60±0.06 ^d | 0.82±0.57 ^a | 0.54±0.01 ^e | 2.10 0.0070* |
| TPD | 64.38±2.31 ^c | 70.92±0.58 ^b | 58.90±0.58 ^d | 76.21±0.57 ^a | 19.65±1.15 ^e | |
| Organs weight | | | | | | |
| Heart | 0.70±0.05 ^c | 1.80±0.11 ^a | 0.60±0.05 ^d | 1.21±0.00 ^b | 0.60±0.05 ^e | 0.0093* |
| Kidney | 0.59±0.02 ^b | 0.85±0.02 ^a | 0.45±0.02 ^c | 0.45±0.02 ^d | 0.20±0.01 ^e | 0.0280* |
| Liver | 1.50±0.58 ^c | 2.90±0.58 ^a | 1.00±0.58 ^d | 2.36±0.57 ^b | 1.04±0.02 ^d | 0.0000* |

Means±SE with different alphabetical superscripts in the same row are significantly different at (P<0.05), Wt= Weight, wk= week FER=Feed Efficiency Ratio, NV=Nitrogen Retention, BV= Biological Value, NPU= Net Protein Utilisation, PER= Protein Efficiency Ratio, TPD=True Protein Digestibility.

MRDST2= Malted Rice 80%+Defatted Sesame 15%+Tiger nut5%

MRDST3= Malted Rice 75%+Defatted Sesame10%+Tiger nut5%,

MRDST6= Malted Rice 77.5%+Defatted Sesame10%+Tiger nut 12.5%

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The nitrogen protein utilization (NPU), protein efficiency ratio (PER), and true protein digestibility (TPD) of food formulations can vary significantly depending on their composition and the specific ingredients used. The highest values of BV, NPU, PER, and TPD in MRDST3 in the current study could be attributed to the enzymic degradation of macromolecules of protein, and carbohydrate into smaller units, thereby increasing in the surface area of substances that facilitated digestion, and subsequent absorption by the experimental rats. These observations agreed with the reports of Ijarotimi and Olopade (2009) and Gernahet *et al.* (2012) that reported significant increase in PER in rats. Also, the relatively high NV, BV, NPU, PER, and TPD observed in the sample Malted Rice 75% + Defatted Sesame 25% + Tiger Nut 5% could be attributed to a more favourable balance of protein sources (sesame seed), optimal carbohydrate levels, enhanced digestibility through processing methods, and potential synergistic effects among ingredients that improve nutrient absorption and utilization (Emurotu2017).

The significant differences observed in organ weights (heart, kidney, and liver) of albino rats fed with different formulated samples of malted rice, defatted sesame, and tiger nut flour could be due to several factors related to nutritional composition, bioactive compounds, and metabolic responses induced by the diets. The formulation with 70% malted rice, 25% defatted sesame, and 5% tiger nut may provide a different balance of protein and energy compared to the other formulations. Higher protein content can lead to increased organ growth and overall body weight due to enhanced metabolic activity and tissue synthesis (Dada *et al.*, 2023). Defatted sesame contributes essential fatty acids and other nutrients which may influence organ weight. The varying percentages of defatted sesame across the formulations could affect lipid metabolism and storage in the liver. Tiger nuts contain antioxidants and phytochemicals that can impact organ health positively. The formulation with a higher proportion of malted rice could alter the availability of these compounds, affecting how they are metabolized and utilized by the body (Adesanmi *et al.*, 2020).

The fibre content from tiger nuts may influence gut health and nutrient absorption, which in turn affects organ weights. Increased fibre can improve digestive health and nutrients absorption into the bloodstream, potentially impacting organ size (Dada *et al.*, 2023; Adesanmi *et al.*, 2020). Diets rich in certain nutrients can stimulate hormonal responses that promote growth in specific organs. For instance, higher protein diets are known to stimulate insulin-like growth factors (IGFs), which could lead to increased organ weights.

The increased weights of heart, kidney, and liver observed in rats fed the 75% malted rice sample showed its positive effects on potential of nutrient utilization and metabolic health. This could indicate a more favourable balance of nutrients that supports organ development but may also raise questions about long-term health effects if such diets are used extensively in feeding practices.

3.2 Serum Biochemical Parameters of the Albino rats fed with the Produced Complementary Food from Malted rice, Defatted Sesame seed and Tiger nut, Cerelac and Ogi

Serum Biochemical parameters of the produced complementary food from malted rice, defatted sesame seeds and tiger nuts, is presented in Table 2. The results obtained showed significant effects of the complimentary foods on the serum, biochemical parameters, total protein, albumin, ALP, ALT, AST, creatinine and urea which ranged from 5.51 to 7.21, 2.30 to 3.30, 121.20 to 168.20, 1.60 to 6.20, 24.07 to 55.20, 20.00 -26.07 and 2.70 – 5.10mg/100g, respectively, while, cerelac and ogi range 3.00 -3.22, 16.30 – 121.32, 1.06 – 7.55, 16.09 – 55.17. 24.23 – 25.20 and 1.86 – 1.94mg/100g, respectively. However, most of the values are within the range for nutrient reference value.

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Table 2: Serum Biochemical composition of the Albino rats fed with the produced complimentary food

| Parameters | MRDST2 | MRDST3 | MRDST6 | Cerelac | Ogi | NRV | P. value |
|----------------------|--------------------------|--------------------------|--------------------------|--------------------------|-------------------------|-----------|----------|
| | 80:15:5 | 70:25:5 | 77.5:10:12,5 | | | | |
| Total protein (g/dL) | 6.48±0.57 ^{ab} | 7.21±0.58 ^a | 5.51±0.58 ^{ab} | 4.06±0.57 ^b | 3.87±0.58 ^b | 5.6-7.6 | 0.0079* |
| Albumin(g/dL) | 2.30±0.57 ^b | 3.30±1.73 ^a | 2.70±0.58 ^{ab} | 3.22±1.15 ^c | 3.00±0.57 ^c | 3.8-4.8 | 0.0000* |
| ALP (μ/L) | 121.20±0.61 ^c | 168.20±0.61 ^a | 128.17±0.89 ^b | 121.32±0.65 ^c | 16.30±0.57 ^d | 56.8-128 | 0.0000* |
| ALT(μ/L) | 5.30±0.58 ^c | 6.20±0.58 ^c | 1.60±0.57 ^d | 7.55±0.58 ^a | 1.06±0.58 ^b | 17.5-30.2 | 0.0000* |
| AST(μ/L) | 27.00±0.57 ^c | 55.20±0.42 ^a | 24.07±0.58 ^d | 55.17±0.60 ^a | 16.09±0.58 ^b | 45.7-80. | 0.0000* |
| Creatinine(mg/dl) | 21.20±0.42 ^a | 26.07±1.16 ^a | 20.00±1.73 ^a | 25.20±1.17 ^b | 24.23±2.29 ^b | 7.0-20.0 | 0.0000* |
| Urea (mg/dl) | 4.90±0.57 ^a | 5.10±0.58 ^a | 2.70±0.57 ^{ab} | 1.86±0.57 ^b | 1.94±0.58 ^b | 1.5 -4.0 | 0.0045* |

Means±SE with different alphabetical superscripts in the same row are significantly different at (P<0.05), ALP = alkaline phosphatase, ALT = alanine transaminase, AST = aspartate aminotransferase

MRDST2= Malted Rice 80%+Defatted Sesame 15%+Tiger nut5%

MRDST3= Malted Rice 75%+Defatted Sesame10%+Tiger nut5%,

MRDST3= Malted Rice 77.5%+Defatted Sesame10%+Tiger nut 12.5%

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The serum biochemical composition of the produced complementary food from malted rice, defatted sesame seed and tiger nut is presented in Table 2. The effects of the complimentary foods on total protein, albumin, alkaline phosphatase (ALP), aspartate aminotransferase (AST), creatinine, and urea levels of the serum of the rats can be attributed to variations in their ingredient compositions and the nutritional profiles of each component which agreed with the findings of Charleet *al.* (2024). Defatted sesame is known for its high protein content; therefore, increasing overall protein levels, but it may also dilute other components like albumin and enzymes. The added tiger nuts flour in MRDST2 (7.5%), MRDST6 (12.5%) did not increase protein content as it does for sesame supplementation (Charle and Jibrilla, 2017). The protein quality and digestibility can vary significantly based on the food source. Defatted sesame is rich in essential amino acids and can enhance total protein levels when included in higher amounts. The activity of enzymes such as ALP and AST can be influenced by the presence of specific nutrients or compounds in the ingredients. For instance, malted rice may have varying enzyme activity based on its processing and fermentation conditions. The biological variability of ingredients can lead to differences in nutrient absorption and utilization. Factors such as malting of sesame seeds, and the processing of tiger nuts can all impact nutrient profiles. These factors could effects the total protein, albumin, ALP, AST, creatinine, and urea.

3.3 Haematological parameters of the Albino rats fed with the Produced Complementary Food from Malted rice, Defatted Sesame seed and Tiger nut flour

Haematological parameters of the formulated complementary food produced malted rice, defatted sesame seeds and tiger nuts and control (cerelac and Ogi) is presented in Table 3. The results obtained showed significant effects of the complimentary foods on all the haematological parameters. The WBC, RBC, HB, PVC, MCV, MCH, MCHC of the blood of rat fed with complimentary food ranged from 6.64 to 8.87, 7.33 to 8.96($\times 10^3 \text{ mm}^3$), 16.67 to 18.37(g/dl), 42 to 50%, 50.00 to 63.00(fl), 20.10 to 22.50(pg), 35.00 to 43.00(g/dL), respectively. However, cerelac and ogi values ranged from 89.00(fl) in MCV highest value and RBC 7.45($\times 10^3 \text{ mm}^3$) while ogi showed higher values in MCV 30.00 fl and lower in WBC 1.05($\times 10^3 \text{ mm}^3$).

The haematological parameters of the produced complementary food from malted rice, defatted sesame seed and tiger nut flour are presented in Table 3. The observed results indicated that cerelac exhibits a higher white blood cell (WBC 13.90) count compared to produced complementary

foods from malted rice, defatted sesame seeds, and tiger nuts because cerelac had high Nitrogen Retention (1.32) and TPD (76.21). Cerelac is fortified with essential vitamins and minerals that support immune health, such as vitamin A, vitamin C, and zinc. These nutrients are crucial for the production and function of white blood cells. However, the local produced complementary food (ogi) have lower micronutrients, impacting their ability and enhancing immune responses effectively. Higher protein quality in cerelac may contribute to better immune function and, consequently, a higher WBC count which is similar to the report of Ijarotimi and Keshinro (2012). The haematological parameters of animals fed with the produced complementary diets from malted rice, defatted sesame seeds, and tiger nuts were found to be significantly higher than those fed the control samples: cerelac and Ogi in terms of haemoglobin, packed cell volume and mean corpuscular haemoglobin concentration. This showed that the produced complementary food is beneficial. The study showed that animals consuming the formulated complementary food to have exhibited higher values for haemoglobin, packed cell volume and mean corpuscular haemoglobin concentration (Ijarotimi and Keshinro 2012). The increase in the levels of haematological parameters showed that the formulated complementary food can contribute positively to the improving of iron status and overall health in children and potentially reducing anaemia prevalence (Ijarotimi and Keshinro 2012).

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Table 3: Haematological parameters of the Albino rats fed with the Produced Complementary Food, Cerelac and Ogi

| Parameters | Samples | | | | | NRV | P. value |
|---|--------------------------|-------------------------|--------------------------|-------------------------|-------------------------|-----------|----------|
| | MRDST2 | MRDST3 | MRDST6 | Cerelac | Ogi | | |
| | 80:15:5 | 70:25:5 | 77.5:10:12.5 | | | | |
| WBC (x10 ³ mm ³) | 7.64±0.58 ^c | 8.87±0.57 ^b | 6.64±0.57 ^d | 13.90±0.57 ^a | 1.05±0.57 ^e | 6.6-12.6 | 0.0000* |
| RBC (x10 ³ mm ³) | 8.30±0.57 ^b | 8.96±0.57 ^a | 7.33±0.58 ^d | 7.45±0.58 ^c | 6.00±0.57 ^e | 6.76-9.75 | 0.0002* |
| HB (g/dl) | 17.70±0.58 ^a | 18.37±0.88 ^a | 16.67±0.58 ^{ab} | 12.30±0.57 ^c | 11.30±0.58 ^d | 11.5-16.1 | 0.0000* |
| PCV (%) | 44.00±0.57 ^{bc} | 50.00±0.58 ^a | 40.00±0.59 ^d | 42.00±1.15 ^c | 37.00±1.15 ^e | 37.6-50.6 | 0.0002* |
| MCV(fl) | 56.00±1.73 ^c | 63.00±1.73 ^b | 50.00±2.89 ^d | 89.00±1.15 ^a | 90.00±1.73 ^a | 50.0-77.8 | 0.0000* |
| MCH(pg) | 21.70±1.15 ^c | 22.50±1.15 ^b | 20.10±0.57 ^d | 29.70±0.58 ^a | 30.00±1.73 ^a | 16.0-23.1 | 0.0002* |
| MCHC (g/dL) | 30.00±1.15 ^b | 33.00±1.73 ^a | 27.00±2.88 ^c | 33.10±1.73 ^a | 23.70±1.73 ^d | 28.2-34.1 | 0.0175* |

Means±SE with different alphabetical superscripts in the same row are significantly different at (P<0.05), WBC= White blood cell, RBC= Red blood cell, HGB= Haemoglobin, PCV= Packed cell volume, MCV= Mean corpuscular volume, MCH= mean corpuscular haemoglobin, MCHC= mean corpuscular haemoglobin concentration

MRDST2= Malted Rice 80%+Defatted Sesame 15%+Tiger nut5%

MRDST3= Malted Rice 75%+Defatted Sesame10%+Tiger nut5%,

MRDST6= Malted Rice 77.5%+Defatted Sesame10%+Tiger nut 12.5%

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CONCLUSION

The results of this research established the possibility of producing qualitative and acceptable complementary food produced from malted rice, tiger nut and defatted sesame seed flour and which compared favourably with cerelac and relatively of higher quality than ogil locally produced.

The nutritional qualities including the weight gain with feeding, net protein utilization (NPU), and the hematological /biochemical parameters obtained with feeding of the albino rat compared favorably with standards / nutrient reference values and superior to that of cerelac and ogi. The hematological parameters of the rat fed with the produced complementary foods are superior to that of ogi and compared favorably with the reference standard values.

The evaluation of complementary food produced from malted rice, tiger nut, and defatted sesame seed flour demonstrated that these locally sourced ingredients can significantly improve the nutritional profile of complementary foods. The findings showed that formulated complimentary food adequately meet the nutritional requirements recommended for infants aged 6-24 months. This research highlights the potential for developing affordable and nutrient-dense alternatives to commercially available products that often do not adequately address malnutrition. Furthermore, the successful incorporation of these ingredients into palatable formulations suggests their viability as sustainable solutions to combat malnutrition in developing regions. Future studies could focus on long-term feeding trials to further assess health outcomes and optimize these formulations for broader applications in infant nutrition. Overall, this research supports the strategic use of local agricultural resources to enhance dietary quality and promote better health outcomes for vulnerable populations.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (Chat GPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Completing Interest

Authors have declared that NO competing interest exist.

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