Protein Quality, Serum Biochemical and Haematological Parameters of Albino rats fed with Complementary Food Produced from Malted rice (*Oryza sativa*),Tigernut (*Cyperus esculentus*) and Defatted Sesame seeds(*Sesamum indicum)*flour

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)*.The complimentary food 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 albino rat fed with prepared complimentary food were determined using standard methods. *Ogi* and *Cerelac* were use as the control sample. The data obtained were analysed statistically using Statistical package for social sciences (25.0). The data was 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 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 deceased with addition of tigernut flour.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%). WBC, RBC, HB, PCV, MCV, MCH and MCHC I] increased from 7.64 to 8.87 x 10^3 mm^3, 8.30 to 8.96 x10^3 mm^3, 17.70 to 18.37 g/dl, 44.00 to 50.00%, 56.00 to 63.00 fl,21.70 to 22.50pg, 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 produced complementary food proof superiority over the locally prepared ogi and compare 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 of Complementary foods provide additional energy and essential nutrients,(Moghaddam *et al*. (2015), support continued healthy growth and development: (Wang *et al.,* 2019), prevent 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 appropriate diet this result in protein energy deficiency in the diets as well as deficiencies micronutrients; leading to endemic protein energy malnutrition (PEM) and health consequences (Onojo*et al.,* 2019).

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 (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 to meet the nutritional needs of infants and under-five children (Nutrition and Health

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 (Leterme *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 certain enzymes that can break down 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 (Asare *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 sweeter (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 (Chinma*et al.,* 2012) which if added to recipes; can give the right balance of nutrients to a food product.

There is presently limited information on the combination of these ingredients: malted rice, tiger nut and defatted sesame seeds. However, complementary food to be produced from the combination of these locally available raw materials (rice, tiger nuts and sesame) will be nutrient-dense because of its diversity in nutrients. Hence, this research is aimed at evaluating the nutrient composition, functional properties and bioavailability of complementary foods produced from malted rice, tiger nuts 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 (Amankwah *et al.,* 2017: Muhimbula*et al.,* 2018). World Health Organization (WHO, 2015) recommends that children should receive 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). Complementary feeding includes a complex set of behaviours that is not only about what is fed, but also how, when, where and why (Pelto *et al.,* 2013).

The general objective of this study was to produce and evaluate the nutritional qualities of complementary food from malted rice, tiger nuts and defatted sesame seeds.

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.

2.0MATERIALS AND METHODS

2.1 Materials and Material Preparation

Sesame oil was extracted from incubation centre in Jos, Plateau State. Proximate composition was analysed in Ta'al Laboratory Lafia. Amino Acid composition and Anti- nutrient factor were analysed in priority lab in Jos. Mineral analysis was done in centre for post-harvest Markudi Benue state.

Rice (*Oryza sativa)*, tiger nut (*Cyperus esculentus)*, and sesame seeds (*,Sesamum indicum L*) were purchased from Yelwa Tudu market in Bauchi State. While Albino Rats were procured from National Veterinary Research Institute Vom Jos, Plateau State all in 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. Then the cleaned paddy was steeped inside sufficient clean water that covered the surface of the grains completely. It will be kept at 29 ± 2^{0} C with good air circulation for 24 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 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 ± 1^{0}C, and then it was removed and kilned. Kilning was performed in a hot air oven at temperatures between 60-70^{0}C for about 2-3 hours. The kilned sample was polished by detaching the roots and rootlet

Tiger nut flour was prepared as described by Onuoha (2016). A dry tiger nut tuber was sorted and unwanted materials like stones, pebbles and other foreign seeds were removed. The tubers are de-hulled and washed with clean water and dried in an oven at 80˚C. The dried nuts was milled and sieved through 0.4 size sieve. The resultant flour was packed in polyethylene bag and stored in plastic container with air-tight lid at room temperature.

Sesame seeds preparation was done as described by Oladele *et al.* (2014). Sesame seeds were sorted to remove impurities such as stones and dust. Water was sprinkled on it and then dehulled using mortar and pestle. The dehulled sesame was winnowed with a tray pan to remove husk. The seeds blanched for 5 minutes and then dried in an oven at 60˚c. The seeds were milled and the oil extracted to have the cake.

2.1.1. Formulation of Blend

The composition of blends was developed using the results of proximate composition determination of each food material. Then formulation of the complementary diets was done by blending different components of the prepared food samples 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). RDST3(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 and 12.5% 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 acclamation.

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.

***2.1.2.2Procurement 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 metalic 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 8thOcterber 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 are 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 = Malter Rice 77.5+Defatted Sesame 5+ Tigernut 12.5%
iv. Group 4 = Cerelac
v. Group 5 = Ogi

Formulated complementary food was 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 stabilised on the standard laboratory feed for seven days, followed by a day of starvation before introducing the complementary blend. Weighed diets and water were given *ad libitum* for 21 days and unconsumed diets were collected and weighed at the end of every day. The animals' weight was measured, and each group's urine and faeces were gathered and combined. The AOAC (2012) technique was used to analyze the nitrogen content of the urine and faeces.

***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

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

The weight gained, excreted faeces and urinary nitrogen will be used to evaluate protein qualities of the formulated foods. And would be determined and used to calculate the nutritional quality indices; 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.

2.2.2Determination 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^{o}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 28days of experimental period, three albino rats from each treatment are fasted overnight with excess of water *ad libitum* and sacrifice under 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*et al*., 2016). 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).

3.0RESULTS 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, 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, with added tiger nut flour, 0.54 to 0.82 and 19.65 to 76.21, 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.

The protein quality of the produced complementary food from malted rice, defatted sesame seed and tiger nut is presented in Table 2the no difference in total and daily weight gain within the 1^{st} and 2^{nd} weeks could be due to absorption of nutrients which may be similar 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 but higher than *ogi*, and this is similar to the report of Onuoha *et al.* (2014) who stated that *cerelac* is formulated to provide essential nutrients that promote faster 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 (Shima *et al*., 2019). The FER, NR in the produced food had significant (<p 0.05). This is due to added defatted sesame seeds flour and tiger nuts respectively. The BV (85) in MRDST3 (70:25:5) showed high protein content this could be because of the added defatted sesame seed four. There was decrease in MRDST6 (77.5:10:12.5) value at 73.45 due to decreased in defatted sesame flour and increase in added tiger nuts flour respectively.

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
	100:0:0	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	0.0028^{NS}
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 Value, NPU, BV= Biological Value
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%

The nitrogen protein utilization (NPU), protein efficiency ratio (PER), and true protein digestibility (TPD) of food formulations can vary significantly based 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 for a facilitated digestion, and subsequent absorption by the experimental rats. These observations are in agreement with the reports of Ijarotimi and Olopade (2009); Gernah*et al.* (2012) that reported significant increases in PER in rats. Also, the higher NV, BV, NPU, PER, and TPD observed in the formulation with Malted Rice 75% + Defatted Sesame 25% + Tiger Nut 5% compared to others can be attributed to a more favourable balance of protein sources, optimal carbohydrate levels, enhanced digestibility through processing methods, and potential synergistic effects among ingredients that improve nutrient absorption and utilization. The result is in line with the report of Emurotu (2017) who stated that the proportion of defatted sesame and tiger nut in the formulations influences the overall protein content and quality and that defatted sesame seeds are rich in protein, while tiger nuts provide dietary fibre and fat. The higher percentage of defatted sesame in the produced complementary food (25%) likely dilutes the overall protein concentration compared to the first formulation where it is lower (10%) but still sufficient to enhance NV and BV (Emurotu, 2017).

The differences in organ weights (heart, kidney, and liver) observed in albino rats fed different formulations of malted rice, defatted sesame, and tiger nut flour can be attributed 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 might 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 lead to better digestive health but may also influence how nutrients are absorbed 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 heart, kidney, and liver weights observed in rats fed the 75% malted rice formulation suggest potential implications for understanding 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 SerumBiochemical 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 differences ($p<0.05$) in all the serum biochemical parameters total protein, albumin, ALP, ALT,AST, creatinine and urea ranged from 5.51 to 7.21, 2.30 to 3.30, 121.20 to 168, 1.60 to 6.20, 24.07 to 55.20, 20.00 -26.07 and 2.70 – 5.10, 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 – 1.94, respectively. However, most of the values are within the range for nutrient reference value.

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

Parameters	MRDST2 80:15:5	MRDST3 70:25:5	MRDST6 77.5:10:12,5	Cerelac	Ogi	NRV	P. value
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 ($P<0.05$), 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%,
MRDST3= Malted Rice 77.5%+Defatted Sesame10%+Tiger nut 12.5%

The serum biochemical composition of the produced complementary food from malted rice, defatted sesame seed and tiger nut is presented in 4.11. The differences in total protein, albumin, alkaline phosphatase (ALP), aspartate aminotransferase (AST), creatinine, and urea levels between the added defatted sesame and tiger nut flour can be attributed to variations in their ingredient compositions and the nutritional profiles of each component which is similar with the findings of Charle*et al.* (2024). The MRDST2/MRDST6 had 10%, and MRDST3 25%defatted sesame flour. Defatted sesame is known for its high protein content; therefore, increasing its proportion to enhance 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%Contributes additional nutrients but is relatively low in protein compared to sesame (Charle and Jibrilla, 2017). The protein quality and digestibility can vary significantly based on the 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 the method of malting, the quality of sesame seeds, and the processing of tiger nuts can all impact nutrient profiles. One might expect that increasing malted rice would raise protein levels, the changes in proportions of defatted sesame and its higher protein content in the first formulation likely lead to a more balanced nutrient profile, resulting in higher values for total protein, albumin, ALP, AST, creatinine, and urea compared to the second formulation.

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 differences ($p<0.05$) in 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($x10^{3}$ 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(x10^{3}mm^3) while ogi showed higher values in MCV 30.00 fl and lower in WBC 1.05(x10^{3}mm^3).

The haematological parameters of the produced complementary food from malted rice, defatted sesame seed and tiger nut flour is presented in Table 4. 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 have lower of these micronutrients, impacting their ability to enhance 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 properties of animals fed within 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 indicated that animals consuming the formulated complementary food exhibited higher values for haemoglobin, packed cell volume and mean corpuscular haemoglobin concentration compared to those consuming Ogi (Ijarotimi*and* Keshinro 2012).The elevated levels of haematological parameters suggest that the formulated complementary food can contribute positively to improving iron status and overall health in children, potentially reducing anaemia prevalence (Ijarotimi*and* Keshinro 2012).

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

Parameters	Samples MRDST2 100:0:0	MRDST3 70:25:5	MRDST6 77.5:10:12.5	Cerelac	Ogi	NRV	P. value
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	0.8154^{NS}
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), 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%,
MRDST6= Malted Rice 77.5%+Defatted Sesame10%+Tiger nut 12.5%

CONCLUSION

The results of research established the possibility of producing qualitative and acceptable complementary food produced from malted rice, tiger nut and defatted sesame seed flour, compared favourably with *cerelac*and relatively of higher quality than ogilocally 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 ogiand 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 indicated that such formulations not only meet but may exceed 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.

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