CHEMICAL COMPOSITION OF COMPLEMENTARY FOOD PRODUCED FROM MALTED RICE (Oryza sativa), TIGER NUTS (Cyperus esculentus) AND DEFATTED SESAME SEEDS (Sesamum indicum) FLOUR BLENDS

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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 chemical composition 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 of malted rice, tiger nut and defatted sesame seed flours (100:0:0; 80:15:5;70:25:5; 82.5:10:7.5; 80:10:10 and 77.55:10:12.5, respectively). *Ogi* and *Cerelac* were used as the control sample. The chemical composition of prepared complimentary food was determined using standard methods. The data obtained were analysed statistically using Statistical Package for Social Sciences (SPSS) (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 moisture, ash, protein and energy content of the produced complimentary food increased from 6.08 to7.18, 1.67 to 3.39, 9.06 to 20.83, 2.22 to 7.52, 2.22 to 5.62, 57.90 to76.94 g/100g and 363.38 to 398.35Kcal/g, respectively, with increase in the defatted sesame seed flour. However, addition of tiger nut flour ranged from 6.27 to 7.06, 2.04 to 2.32, 15.10 to 16.35, 5.42 to 5.69, 5.80 to 7.14, 63.06 to 64.64g/100g and 380.66 -388.77k/cal. The mineral content increased showed significantly (p<0.05) higher values in sample with 70:25:5 for Na, Cu and Fe in comparative with CERELAC that also had higher values in terms of K, Zn, Ca and P Generally the molar ratio of the mineral concentration in this work Na/K, Ca/P, Ca/K, Zn/Cu and Fe/Cu agreed with the Nutrient Reference Values (NRV). The essential amino acid: leucine the most abundant EAA and tryptophan the lowest EAA ranged from 7.67 to 9.34 and 2.19 to 2.58/100g respectively, with increase in the added defatted sesame seed and tiger nut flour. The phytate, oxalate, saponin and tannin content of the produced complementary food generally ranged from 1.22 to 3.0%9, 0.30 to 1.53%, 0.14 to 0.32% and 0.85 to 2.03mg/100g, respectively all values are within safe range for consumption.

Key words: Chemical composition, malted rice, tiger nut, defatted sesame, complimentary food

Introduction

The significance of introducing nutritious and diverse complementary food to an infant cannot be underestimated as such requires a devoted mechanism that involves a proper combination of locally inexpensive and readily available cereal-legume-based grains to provide quality protein and other nutrients that will meet the growing demands of an infant (National Nutrition and Health Survey (NNHS) 2018). 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.

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 (WHO, 2018).

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 Survey, 2018). Some of the investigations by researchers ((Awogbenja *et al.* 2020).

The enrichment of cereal-based food with other protein sources such as legumes and oilseeds has also received considerable attention (Okoye *et al.,* 2018). Therefore, this study looked at the nutrients and their diversities in the grains to be used in producing the complementary food namely malted rice, tiger nut, and defatted sesame seeds.

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 (Leterme *et al.,* 2015). Rice 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.

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 (Muhimbula *et al.,* 2018). Complementary feeding is the vulnerable period of transition from exclusive breastfeeding to family diet (Pelto *et al.,* 2013). Inappropriate feeding practices during the first two years of life are a major cause of under nutrition in infants and young children. Other causes of under nutrition are inadequate nutrient and energy intakes, diseases resulting from poor complementary feeding practices, such as giving children foods of poor quality; feeding them (infants) inadequately and disregarding food and water safety (Stewart *et al.,* 2013).

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.

Materials and Methods

Materials

Materials and material preparations

Rice, tiger nut, and sesame seeds (*Oryza sativa, Cyperus esculentus, Sesamum indicum L*) were purchased from Yelwa Tudu market in Bauchi State. Rice paddy was prepared as described 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 ± 1^0C, and then it was removed and kilned. Kilning was performed in a hot air oven at temperatures between 60-70^0C 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) (Fig 4). 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 were 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 seed flour was produced as described by Oladele *et al.* (2014) (Fig 4). 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.

Formulation of Complementary food sample from malted rice, tiger nuts and defatted sesame seeds flours

Malted rice, tiger nuts and the sesame seeds were mixed together to get the complementary food.

2.1.4 Formulation of Blend

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 Rice1), 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 and7.5% 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.

2.2 Methods

2.2.1 Determination of the Nutrient Composition of Complementary Food Samples

The Nutrient (proximate, mineral, anti-nutrient, amino acid, phytochemicals) composition of malted rice, defatted sesame seeds and tiger nuts flour of the formulated food samples were determined using appropriate analytical methods.

2.2.1 Proximate Determination of the food samples
The proximate (moisture, ash, crude protein, crude fat, crude fiber and carbohydrate) composition of the food samples was determined using the standard procedures of Association of Official Analytical Chemists (AOAC, 2012).

2.2.2. Determination of Energy Values
Energy value was estimated using Atwater's conversion factor as adopted by Ijarotimi. (2022). The calorific value (kCal/ 100 g) of the complementary food samples were calculated using the three groups of nutrients, which provide the body with energy that is carbohydrates, fats and proteins. The factor: One gram of carbohydrate (C) was assumed to give 4 kCal. Energy; one gram of fat (F) 9 kcal energy and one gram of protein (P) 4 kCal. (4 x proteins, 9 x fats and 4 x carbohydrates)

Calculation

$$Energy\ value = (P\ x\ 4) + (F\ x\ 9) + (C\ x\ 4)\ in\ {}^{kCal}/_{100\ g}\ of\ sample$$

Where;
P = Protein content (%).
F = Fat content (%).
C = Available total carbohydrate (%).

2.2.3 Determination of Amino Acid Content

Aremu *et al.* (2015) ensure the grain sample is finely ground or homogenized to ensure uniformity for subsequent analyses. Perform acid hydrolysis of the sample using Hydrochloric Acid (HCl) at 160˚C for 1hour. This breaks down proteins into individual amino acids. Derivatize the amino acids using Phenyl Isothiocyanate (PITC) reagent to make them detectable by the High-performance Lipid Chromatography (HPLC) system. Inject the hydrolysed and derivatised sample into an HPLC system equipped with an amino acid analysis column. Set up the system for chromatographic separation and detection of amino acids. Run the HPLC analysis to separate the individual amino acids present in the sample. Measure the concentrations of individual amino acids by comparing the peak areas or heights obtained from the chromatogram to calibration curves generated from known standards.

2.2.4 Determination of Mineral Composition
The mineral content: include calcium, magnesium, potassium, copper, zinc, iron, lead, aluminium, sodium and phosphorus .of the food samples were analysed using the wet digestion techniques of Association of Analytical Chemist (AOAC, 2012)

2.2.5 Determinations of Anti-Nutrient Composition
Phytate, tannin, oxalate and saponin were determined as described by Awogbenja et al (2020). Kaur *et al* (2015) and AOAC (2012), respectively.

3.0 RESULTS AND DISCUSSION

3.1 Nutrient composition of the Produced Complementary Food from Malted Rice, Defatted Sesame and Tiger nut flour

The results of proximate analysis of the complementary food produced from malted rice, defatted sesame seeds and tiger nut is presented in Table 1. The results observed showed significant (p< 0.05) differences in values obtained in all the samples. The moisture, ash, crude protein, crude fat, crude fibre, carbohydrate and energy content of all the samples assessed ranged from 6.08 to 7.18, 1.67 to 3.39, 9.06 to 20.83, 2.22 to 7.52, 2.22 to 5.62, 57.90 to 76.94 g/100g and 363.38 to 398.35Kcal/g, respectively, with increase in the defatted sesame seed flour. However, addition of tiger nut flour ranged from 6.27 to 7.06, 2.04 to 2.32, 15.10 to 16.35, 5.42 to 5.69, 5.80 to 7.14,63.06 to 64.64g/100g and 380.66 to 388.77k/cal, while cerelac and ogi ranged 4.17 to 6. 77, 1.10 to 1.92, 6.71 to 17.89, 3.58 to 6.99, 0.90 to 4.31, 65.71 to 80.94g/100g and 400.35 to 434.90k/cal.

The results of nutrient compositions of the complementary food produced from malted rice, defatted sesame seed and tiger nut flour blends is presented in Table 1. Significant differences (p < 0.05) exist in moisture content of the samples. It was observed that sample 100:0:0 had moisture content of 7.18 %. This variation indicates that MR1 had the highest moisture content and may be adduced to the malting processing. MRDST3 (70:25:5) sample having the lowest value (6.082%) due to addition of defatted sesame seeds flour. Meanwhile the control samples had moisture content cerelac (4.17±0.16%) and Ogi (6.77%) The values of this study are higher than the nutrient reference value (NRV) by FAO/WHO (1991). Moisture content of this study agreed with report by Charles et al., (2024). It is reported that that low moisture level of food could give the food long keeping period (Bristone *et al*. 2024). Moisture content affects the quality and palatability of complementary food which plays a significant role in determining the shelf life of the food according to Verma and Srivastav (2017). The results obtained in this study were higher than the FAO/WHO recommended values (of less than 5% for infant foods FAO/WHO (1991).). Therefore, there is need for further drying of the ingredients so as to meet up with acceptable standard of moisture level in complementary foods and for which will completely discourage microbial growth, spoilage and chemical reaction.

The crude ash content ranged from 1.10 to 3.39% which fall within the recommended levels of 3% (FAO 2004). The high ash content signifies the presence of minerals from added defatted sesame seed, and low value showed lower or no addition of defatted sesame seeds flour. The results of this study showed significant (p<0.05) different in all the samples and agreed with the results recorded by Nyadroh *et al*. (2021) with values 0.95 to 1.27% respectively. Meanwhile Obasi *et al.*(2018) reported much higher levels of ash than in this study.

Crude protein level increase from 9.06 to 20.83%. The increase is as a result of added sesame seed and tiger nuts flour. This substantial difference suggests that defatted sesame seed flour is particularly rich in protein. This result confirm the observations from several authors that showed protein contents of two or more plant-based food materials, particularly cereal-legume combinations, are usually better than those produced from a single cereal, or other plant based food materials (Dada *et al*., 2023; Gemede, 2020). Malting also bring about increase in protein level of grains. In a similar study, by Osuji et al. (2019) malting was reported to have increased protein contents (6.99 to 9.39), the slight increase in protein agreed with this study. Protein content in cereals for infants varies widely Ijarotimi and keshinro (2013). Protein is vital macronutrient required for the growth and development of infants and young children (6 – 24 months). Adequate levels of protein content in foods are important for curbing protein-energy malnutrition, especially in developing countries where basic staple foods are commonly cereals and tubers. World Food Programme (WFP, 2021). Inadequate protein has been the backbone for the decline growth among children especially after breastfeeding (that is at the time of initiation of complementary foods). The attending outcome of malnutrition has been mortality which has been on the increase in some parts of Africa especially the war/terrorism ridden region of Nigeria (Adeoye, 2018). The samples in this study contained reasonable amount of protein which met the recommended allowance for infant and young children (FAO/WHO 1991).

Fat in the blend comes from added oil seeds (defatted sesame seeds). Higher fat content can enhance energy density but may also affect the texture and flavor profile of the food product Adeoye *et al*., 2018. The result of this study agreed with values reported by (Gemede, 2020). FAO/WHO 1991 reported that the fat content of complementary diets should range from 10 to 25%.

Fibre content varies from different grain. The results in this study agreed with values reported by:Olapade, (2020): and Adesanmi, (2020). Higher fibre, is often associated with high ratio of cereal grains with low addition of legume such as in one of the control sample ogi. Fibre contributes to the dietary bulk of food play an important role in the body of an infants, children or adults. Dietary fibre promotes gut health (Gibney *et al.,* 2009). Low fibre content in complementary food reduces the bulkiness of the food and increase nutrient density, high digestibility and absorption of essential nutrients such as protein and mineral (Odinakachukwu *et al.,* 2014). This is particularly important because of the small stomach capacity of the infants according to Rajeshwari *et al*. (2010). The recommended limit of fibre in complementary foods is less than 5% (Codex Alimentarius Commission, 2015).

Carbohydrate is an important nutrient in the body. It was observed that the 80% values obtained for Ogi showed that Ogi is primarily carbohydrate-based, which could be beneficial for energy provision but may lack other essential nutrients if not balanced properly. The 65% carbohydrate content in cerelac may be as a result of processing methods. Products that undergo extensive drying may retain higher carbohydrate levels due to reduced moisture. Equally Cerelac are designed to be energy-dense and may have higher carbohydrate content to meet the need of targeted population (for growth and development of infants). 70:25:5 low content of carbohydrate may be due added of defatted sesame seed flour. The results of this study agreed with reports from Ijarotimi, (2022):Adedayo *et al*., (2021). Rice carbohydrates is always considered superior in quality (Upadhyay and Karn 2018). Carbohydrates provides heat and energy for all forms of bodily activities Deficiency can cause the body to convert proteins and body fat to produce needed energy, thus leading to depletion of body tissues.

Energy values 363 to 388 (kcal/g/100) of the complementary food is slightly lower than the reference value (425cal/1g) by FAO/WHO (1991). High energy density is crucial for infant foods as they require more calories per gram for growth and development. The results of the study showed significant ($p<0.05$) difference in all value of the produced complementary food blends. (Malted Rice 75, Defatted Sesame seeds 25 and Tiger nut 5%) had relatively high value among complementary food blend due to the 25% added defatted Sesame seeds. While one the control sample cerelac had the energy value 400kcal this may be because of the type of raw material used. The result of this finding agreed with result from Ijarotimi, (2022).

3. 2: Mineral compositions (mg/100g) of the Produced Complementary Food from Malted Rice, Defatted Sesame and Tiger nut Flour

The minerals composition of the produced complementary food from malted rice, defatted sesame seeds and tiger nut is presented in Table 2. The results showed that the mineral compositions of the produced complementary food was significant ($p<0.05$). Minerals composition in the produced complementary food are Na, K, Mg, Cu, Zn, Ca, Fe, and P ranged from 118.4 to 170.2, 150.5 to 488.6, 9.2 to 15.4, 0.37 to 1.00, 1.7 to 3.27, 322.7 to 372.8, 12.0 to 15.0 and 215.5 to 260.6mg/100g, respectively with increase from 0 to 25% defatted sesame seed flour. And also 129.0 to 144.5, 175.6 to 216.5, 13.3 to 13.7, 0.57 to 0.65, 1.47 to 1.90, 322.7 to 359, and 12.1 to 230.9mg/100g, respectively with added tiger nut flour from 5-12.5%. While Na, K, Zn, Ca, Fe and P concentration of the control samples cerelac and ogi ranged from 140.8 to 142.9, 101.4 to 623.0, 0.77 to 4.67, 67.9 to 601.5, 0.23 to 7.40 and 87.9 to 405.1mg/100g, respectively.

Generally the molar ratio of the mineral concentration in this work Na/K, Ca/P, Ca/K, Zn/Cu and Fe/Cu ranged 0.3 to 0.7, 1.4 to 1.6, 0.8 to 2.6, 2.6.1 to 4.5, 15 to 32.4 2mg/100g, respectively, agreed with the Nutrient Reference Values (NRV). The molar ration of the control samples (cerelac and ogi) Na/K, Ca/P, Ca/K ranged from 0.2 to 1.4, 0.7 to 1.5, 0.7 to 0.9mg/100g, respectively. The addition of defatted sesame seeds flour and tiger nut flour had significant effect $p<0.05$ on all the assed mineral.

The mineral composition of the produced complementary food from malted rice, defatted sesame seed and tiger nut is presented in Table 4.7. The mineral concentration of the produced complementary food Calcium, phosphorous, and zinc were found to be higher due to added defatted sesame and tiger nuts flour. Value of iron (15mg/100g) that meet the recommended standard levels for infant's (15-16mg/100g) (WFP, 2021; FAO/ WHO, 1991). Sodium concentration in the produced complementary food samples are greater than that found in celerac (140.8mg/100g) and Ogi (142.9mg/100g). The sodium concentration are attributed to added tiger nut 5% and defatted sesame 25%, which agreed with the findings from the complementary food by Adedayo *et al.* (2021) and a significant higher values reported by Ikunjelola and Ogumba (2018). The potassium concentration are lower in the produced complementary

The Na/K and Ca/P molar ratios values of 0.3 to 0.7 and 1.4 to 1.6mg/100g were recorded for the produced food samples respectively, these are within the recommended values<1 and >1. This is beneficial, because it would not pose unnecessary stress on the immature heart of the infant, and thereby causing heart damage (Ijarotimi *et al.,* 2022). Food is termed "poor" if Ca/P ratio is less than 0.5, and considered "good" if the ratio is above one (>1), and Ca/P ratio above two (>2) this could help to increase the absorption of calcium in the small intestine (Awogbenja et al., 2020). The results of Ca/P ratios observed in this study in the produced complementary food were not only good, but also an indication that it could help to improve the intestinal absorption of calcium as well as promote bone, and teeth development in children Ikunjelola and Ogumba (2018).

Studies have shown that the commonly use complementary foods in developing countries are usually poor in essential minerals such as calcium, iron, and zinc, due to the fact that cereals, and tuber-based foods are high in anti-nutritional factors that constitute these staples as well as processing methods (Gibson *et al.,* 1998; FAO/WHO, 2001; Anigo *et al.,* 2010). Calcium requirements for the first 2 years of life increase by about 10 -50%, therefore, a positive calcium balance is required for growth (FAO/WHO, 2001: Oyarekua, 2013). Calcium is known to play an important role in the development of the body structure, bone, and teeth, the maintenance of healthy nerves and muscles as well as blood clotting (Al-Mamun and Ghani 2017). Its deficiency can result in rickets in infants and children. Interestingly, previous studies reported that iron and zinc are required for blood formation and brain development (Makori *et al*., 2017).

Table 1: Nutrient composition of the Produced Complementary Food from Malted Rice, Defatted Sesema and Tiger nut (g/100 g)

Samples	Materials (%) M:D:T	Moisture	Ash	Crude protein	Crude fat	Crude fiber	Carbohydrate	Energy
MR1	100:0:0	7.18 ±0.41^{a}	1.67±0.07^{f}	9.06±0.06^{e}	2.22±0.10^{f}	2.21±0.45^{a}	76.94±0.95^{c}	363.38±0.35^{d}
MRDST2	80:15:5	6.85±0.20^{bc}	2.34±0.31^{b}	18.27±0.21	6.11±0.21^{c}	5.84±0.18^{d}	59.59±0.35^{d}	381.99±0.3^{c}
MRDST3	70:25:5	6.08±0.02^{de}	3.39±0.16^{a}	20.83±0.12^{a}	7.52±0.29^{a}	5.62±0.05^{de}	57.90±0.407^{d}	398.35±0.67^{b}
MRDST4	85.5:10:7.5	7.06±0.50^{b}	2.04±0.06^{d}	15.10±0.18^{d}	5.69± 0.28^{d}	7.14±0.26^{b}	63.34±0.87^{c}	380.66± .54^{d}
MRDST5	80:10:10	6.42±0.09^{d}	2.32±0.25^{b}	16.04±0.03^{cd}	5.42±0.18^{d}	6.75±0.58^{c}	63.06±0.96^{c}	382.43±0.07^{c}
MRDST6	77.5:10:12.5	6.27± 0.12^{d}	2.26±0.24^{c}	16.38±0.33^{c}	5.66±0.53^{cd}	5.80±0.24^{d}	64.64±0.04^{b}	388.72±0.3^{c}
CERELAC	-	4.17±0.16^{e}	1.92±0.34^{e}	17.89± 0.22^{c}	6 .99±0.38^{b}	4.31±0.29^{e}	65.71±0.66^{b}	434.90±0.09^{a}
OGI	-	6.77±0.37^{c}	1.10±0.05^{g}	6.71±0.32^{f}	3.58±0.24^{e}	0.90±0.01^{f}	80.94±0.53^{a}	400.35±0.17^{b}
NRV		5	3	18	10-25	10-15	64	425
P-Value		0.0000*	0.00010	0.0000*	0.0017*	0.0000*	0.0000*	

Data presented as the mean ± standard deviation with different alphabetical superscripts in the same column significantly different ($p < 0.05$)

MR=malted Rice 100%, MRDST2=Malted Rice 80+ Defatted Sesame15+ TIgernut 5%, MRDST3=Malted Rice70+Defatted Sesame 25+ Tigernut 5%, MRDST4= Malted Rice 82.2+ Defatted Sesame 10+ Tigernut7.5%, MRDST5Malted Rice=80+ Defatted Sesame10+ Tigernut 10, NMRDST6=Malted Rice77.5+ Defatted Sesame10+ Tigernut12.5%. NVR = Nutrient Reference Value

Table 2: Mineral Compositions (mg/100g) of the Produced Complementary Food from Malted Rice, Defatted Sesame Tiger nut flour

Nutrients	MRSDR 1 100:0:0	MRDST2 80:15:5	MRDST 3 70:25:5	MRDST 4 82.5:10:7.5	MRDST 5 80:10:10	MRDST 6 77.5:10:12.5	Cerelac	Ogi	NRV	P. Value
Na	118.4±3.18^{f}	153.4±2.1^{b}	170.2±0.02^{a}	129.0±2.9^{e}	133.8±0.21^{d}	144.5±3.0^{c}	140.8±0.8^{cd}	142.9±0.2^{c}	296	0.0000*
K	150.5±1.95^{f}	242.2±0.1f^{c}	488.6±4.2^{b}	175.6±0.3^{e}	181.7±1.5^{e}	216.5±0.0^{d}	623.0±0.7^{a}	101.4±0.7^{g}	516	0.0000*
Mg	9.2±0.22^{e}	12.4±0.2^{d}	15.4±0.3^{b}	13.3±0.2^{c}	13.6±0.6^{c}	13.7±0.2^{c}	_	_	76	0.0000*
Cu	0.37±0.2^{d}	0.67±0.3^{b}	1.00±0.0^{a}	0.57±0.0^{c}	0.59±0.0^{c}	0.65±0.0^{b}	_	1.10±0.1^{a}	0.89	0.0000*
Zn	1.7±0.26^{e}	2.80±0.2^{c}	3.27±0.2^{b}	1.47±0.2^{f}	1.77±0.3^{e}	1.90±0.1^{d}	4.67±0.3^{a}	0.77±0.0^{g}	3.2	0.0000*
Ca	340.5±22.4^{c}	351.6±22.7^{c}	372.8±2.8^{b}	322.7±0.2^{e}	341.3±0.0^{de}	359.6±0.0^{c}	601.5±0.2^{a}	67.9±0.2^{g}	500	0.0000*
Fe	12.0±0.17^{e}	13.9±0.2^{c}	15.0±0.7^{a}	12.1±0.1^{e}	12.86±0.2^{d}	14.1±0.1^{b}	7.40±0.3^{f}	0.23±0.1^{g}	16	0.0000*
P	215.5±0.03^{e}	247.0±0.0^{c}	260.6±0.4^{b}	225.6±0.0^{cd}	229.5±0.1^{cd}	230.9±0.2^{cd}	405.1±0.9^{a}	87.9 ±0.4^{f}	456	0.0000*
Na/K	0.7	0.6	0.3	0.7	0.7	0.7	0.2	1.4	<1.00	
Ca/P	1.6	1.4	1.4	1.4	1.5	1.6	1.5	0.7	>1.00	
Ca/K	2.6	1.5	0.8	1.8	1.5	1.6	0.9	0.7	2.2-6.2	
Zn/Cu	4.5	4.1	3.2	2.6	3.0	2.9	-	0.8	2.0-4.0	
Fe/Cu	32.4	20.7	15	21.2	21.6	21.7	-	0.2	21.6	

Data presented as the mean ± standard deviation with different alphabetical superscripts in the same row are significantly different ($p < 0.05$) *CODEX CAC/GL.08, (1991) (World Food Programme, 2021). NRV -= Nutrient Reference Value

MR=malted Rice 100%, MRDST2=Malted Rice 80+ Defatted Sesame15+ Tiger nut 5%, MRDST3=Malted Rice70+Defatted Sesame 25+ Tiger nut 5%, MRDST4= Malted Rice 82.2+ Defatted Sesame 10+ Tigernut7.5% , MRDST5Malted Rice=80+ Defatted Sesame10+ Tiger nut 10, MRDST6=Malted Rice77.5+ Defatted Sesame10+ Tigernut12.5%.

3.3: Amino Acid Composition (g/100g) of Protein of the Formulated Food Samples from Malted Rice, Defatted Sesame Seed and Tiger Nuts) Blends

The amino acid profile of the produced complementary food and the control samples are represented in Table 3. The essential amino acid: leucine, lysine, isoleucine, Phenylalanine, valine, methionine, histidine, threonine and tryptophan values ranged from 7.67 to 9.34, 3.78 to 4.56, 3.34 to 3.31, 3.90 to 4.47, 4.22 to 4.73, 1.17 to 1,41, 2.19 to 2.58, and 0.75 to 1.23g/100g respectively, with increase in the added defatted sesame seed flour and tiger nut flour. The control samples ranged from 3.51 to 4.57, 0.51 to 4.24, 1.33 to 4.34, 3.55 to 4.46, 1.86 to 4.72, 1.10 to 1.71g/100g.

The Amino Acid profile of the produced complementary food from malted rice, defatted sesame seed and tiger nuts is presented in Table 4.The amino acid profile of the produced complementary food had significant ($p<0.05$) different in all samples. Essential amino acids are vital organic compounds that the human body cannot synthesize in sufficient quantities, necessitating their intake through diet (Hou ***et al., 2018)*** The total amino acid were significantly higher in (malted rice 70%: defatted sesame seeds 25% and Tiger nuts 5%) with values 36.6%. This value is slightly higher than the nutrient reference value of 36.0% recommended by FAO/WHO 1991. The most abundant essential amino acid is leucine with the highest concentration in the MRDST3 (9.34%) followed by MRDST2 (9.05 %), while, the values in the control sample cerelac 4.57% and Ogi 3.51%. The values in this study agreed with the report by Ijarotimi, (2022) . Leucine is very important for muscle development, protein synthesis and overall metabolic health.Tryptophan is the lowest essential amino acid has the lowest value in Malted rice (0.75) this agreed with report by Ijarotimi (2022) Tryptophan help make melatonin that help in sleep and wake up cycle. Nutritionally, studies have showed that adequate intake of essential amino acids are required in infants to prevent stunted growth and cognitive retardation (Semba *et al*. 2016). The amino acid values in this study agreed with the reports by Balarabe *et al*. (2023).This results indicates that these complementary foods could be adequate in providing essential amino acids required for normal growth and cognitive development in infant and young children.

The amino acids valine, leucine and isoleucine are utilized for their ability to alleviate fatigue while phenylalanine is necessary for the synthesis of a pigment called melanin that contributes to eye, hair and skin colour. Lysine is an essential amino acid necessary for growth, tissue repair, and the production of hormones, enzymes, and antibodies. Glutamic acid is the most abundant amino acid essential for neural communication as stated by Abiodun *et al.*(2019). Glutamic acid serve as ammonia transporters to the liver and kidney for urea synthesis (Holeček, 2023). The production of glutamic acid through fermentation by lactic acid bacteria (LAB) is gaining interest in food science. This method not only enhances the nutritional profile of fermented foods but also contributes to the production of bioactive compounds like GABA, which may offer additional health benefits (Zareian *et al.,* 2012). Aspartic Acid is important for hormone production and nervous system function (Holeček, 2023).

3.4 Anti-nutrient Composition of the Produced Complementary Food from Malted Rice Defatted Sesame Seed and Tiger nut

Anti- nutrient Composition of the produced Complementary Food from Malted Rice Defatted Sesame Seed Tiger nut is presented in Table 4. The added defatted sesame seed and tigernut flour has a significant effect ($p<0.05$) on the anti-nutrient content of the produced samples. The phytate, oxalate, saponin and tannin content of the formulated complementary food generally ranged from 1.22 to 3.09%, 0.30 to 1.53%, 0.14 to 0.32 and 0.85 to 2.03mg/100g, respectively, while cerelac and ogi ranged 3.77 to 5.24 %(phytate), 0.05 - 0.25% (saponin). 0.06 and 0.09% (tannin).

Phytate was significantly ($p<0.05$) lower in the produced complementary food samples, lower than the control samples cerelac and ogi due to added defatted sesame seed and tiger nut at different ratios in line with the established safe permissible limits of 0-5% for phytates in foods (Awogbenja *et al.,*2020) .

Table 3: Amino Acid Composition (g/100g) of Protein of the Produced Complementary Food from Malted Rice, Defatted Sesame seed and Tiger nut Flour

Amino Acid	MR 1 100:0:0	MRDST 2 80:15:5	MRDST 3 70:25:5	MRDST 4 85.5:10:7.5	MRDST 5 80:10:10	MRDST 6 77.5.10:12.5	cerelac	Ogi	NRV	P. value
Essential Amino Acid										
Leucine	8.65±0.01[bc]	9.05±0.02[b]	9.34±0.02[a]	7.67±0.0[de]	8.29±0.02[c]	7.75±0.09[d]	4.57±0.16[e]	3.51±0.02[f]	7.3	0.0000*
Lysine	3.79±0.00[d]	4.36±0.03[b]	4.56±0.14[a]	4.02±0.01[cd]	3.78±0.02[d]	4.07±0.14[cd]	4.24±0.08[c]	0.51±0.00[e]	6.4	0.0000*
Isoleucine	3.34±0.02[d]	3.49±0.01[c]	4.35±0.13[a]	3.40±0.02[bcd]	3.70±0.05[bc]	3.81±0.08[b]	4.34±0.07[a]	1.33±0.02[e]	3.1	0.0000*
Phenylalanine	4.04±0.02[cd]	4.22±0.03[b]	4.47±0.02[a]	3.90±0.02[d]	3.95±0.05[cd]	3.90±0.05[b]	4.46±0.01[a]	3.55±0.00[e]	6.9	0.0000*
Valine	4.22±0.01[d]	4.53±0.02[b]	4.73±0.01[a]	4.37±0.01[c]	4.40±0.01[c]	4.42±0.04[c]	4.72±0.06[a]	1.86±0.02[e]	3.6	0.0000*
Methionine	1.17±0.29[d]	1.31±0.00[bc]	1.41±0.01[b]	1.21±0.01[c]	1.23±0.01[c]	1.26±0.02[c]	1.71±0.06[a]	1.10±0.00[d]	2.5	0.0000*
Histidine	2.23±0.02[cd]	2.37±0.01[b]	2.58±0.02[a]	2.19±0.03[cd]	2.25±0.01[d]	2.29±0.01[c]	2.11±0.01[e]	0.24±0.00[f]	1.0	0.0000*
Threonine	3.37±0.02[d]	3.57±0.00[c]	3.72±0.01[ab]	3.36±0.01[d]	3.42±0.05[f]	3.46±0.01[d]	3.83±0.07[a]	1.75±0.00[e]	3.7	0.0000*
Tryptophan	0.75±0.00[d]	1.03±0.01[b]	1.23±0.00[a]	0.93 ±0.01[c]	0.95±0.02[bc]	0.97±0.03[c]	1.25±0.00[a]	0.74±0.01[e]	1.5	0.0000*
TEAA	31.56±0.39	33.93±0.12	36.39±0.36	31.23±0.11	31.61±0.22	32.45 ±0.39	31.06±0.56	13.26±0.07	36	0.0000*

Data presented as the mean ± standard deviation with different alphabetical superscripts in the same row are significantly different (p≤ 0.05) and NS=Not Significant. MR=malted Rice 100%, MRDST2=Malted Rice 80+ Defatted Sesame15+ TIgernut 5%, MRDST3=Malted Rice75+Defatted Sesame 20+ Tigernut 5%, MRDST4= Malted Rice 85.2+ Defatted Sesame 10+ Tigernut7.5% MRDST5Malted Rice=80+ Defatted Sesame10+ Tigernut 10, MRDST6=Malted Rice77.5+ Defatted Sesame10+ Tigernut12.5%. TEAA=Total Essential Amino Acid, TNEAA=Total Non-Essential Amino Acid, TAA=Total Amino Acid, RV=Reference Value, RDA= Recommended Dietary Allowances Source- Institute of Medicine of the National Academies 2005

Table 4: Anti- nutrient Composition of the produced Complementary Food from Malted Rice, Defatted Sesame Seed and Tiger nut Flour

Anti-nutrients	MR1 100:0:0	MRDST2 80:15:5	MRDST3 70:25:5	MRDST4 82.5:10:7.5	MRDST5 80:10:10	MRDST6 77.5:10:12.5	Cerelac	Ogi	NRV	P. value
Phytate (%)	3.09±0.04[c]	1.22±0.14[f]	1.61±0.05[e]	3.04±0.05[c]	1.51±0.05[e]	2.74±0.01[d]	3.77±0.02[b]	5.24±0.12[a]	**0.18-4.51**	0.0000*
Oxalate (%)	0.30±0.14[d]	1.53±0.01[a]	1.41±0.01b[c]	1.51±0.02[b]	1.25±0.02[d]	1.43±0.01[c]	0.05±0.00[f]	0.25±0.08[e]	0.05	0.0000*
Saponins(%)	0.14±0.00[e]	0.32±0.01[ab]	0.21±0.00[d]	0.26±1.00[c]	0.34±1.00[a]	0.30±1.00[b]	-	-	**0.92**	0.0000*
Tannin (mg/100g)	0.85±0.02[e]	1.77±0.01[b]	1.17±0.02[d]	1.45±0.03[c]	2.03±0.04[a]	1.42±1.00[c]	0.06±0.00[f]	0.09±0.00[f]	**1.5-2.5**	0.0000*

Means (±SEM) with different alphabetical superscripts in the same row are significantly different at (P<0.05).
MR1= Malted Rice 100%, MRDST2= Malted Rice 80%+Defatted Sesame 15%+Tiger nut5% , MRDST3= Malted Rice 70%+Defatted Sesame25%+Tiger nut5%, MRDST4= Malted Rice 82.5%+Defatted Sesame 10%+Tiger nut7.5% , MRDST5= Malted Rice 80%+Defatted Sesame 10%+Tiger nut10%, MRDST6= Malted Rice 77.5%+Defatted Sesame 10%+Tiger nut 12.5

Phytates bind minerals like iron and zinc and lower or hinder their bioavailability, this could be resolved by adopting processing techniques such as malting, de hulling, fermentation and defatting thereby releasing mineral elements that would have been unavailable before processing (Anaemene *et al*.,2024). Oxalate recorded in this study agreed with the study by (Ijarotimi et al., 2022). High oxalate level can interfere with calcium absorption and may contribute to kidney stone formation (Anaemene *et al*., 2024). Saponin is also present in low levels (0.14 - 0.30%) levels within the safe level of saponin at <1. The result of this study agreed with report by Ayo *et al*., (2024b), and however values for cerelac and ogi were below detectable limit. Evidence has shown that saponin exhibits antioxidant properties; and it has ability to prevent certain diseases (cancer and inflammation) and hence advocate for low intakes of saponin to prevent and manage overweight/obesity and other associated diseases is necessitated (Adebimpe 2019). Tannin are phenolic compound that occur in the husk of grain. Tannin decreases protein digestibility and decrease growth rate. Tannin can be bitter and can reduce the palatability of food soaking it overnight can reduce it level (Ijarotimi et al., 2022).

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 ogi locally produced. Chemical composition including the protein, fiber, mineral(potassium, calcium, zinc, phosphorous) and essential amino acid profile / composition which are of significant importance to complementary food were greatly improved and the anti-nutritional factors and health benefits of the produced complimentary food. This research highlights the potential for developing affordable and nutrient-dense alternatives to commercially available products that often do not adequately address malnutrition.

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