

MICRONUTRIENT AND ANTI-NUTRIENT PROPERTIES OF COMPOSITE FLOUR AND BREAKFAST CEREAL FROM MALTED SORGHUM (*Sorghum bicolor*), TIGER NUT (*Cyperus esculentus*) AND CASHEW NUT (*Anacardium occidentale*)

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Abstract

This study investigated the mineral, vitamins and anti-nutrient composition of composite flour and breakfast cereals formulated from malted Sorghum, tiger nut and cashew nut flour. The composite flour was formulated and mixed in the ratio 100:0:0, 65:05:30, 60:10:30, 55:15:30, 50:20:30 (malted sorghum, tiger nut, and cashew nut). The samples were analyzed for minerals, B vitamins and anti-nutritional properties. The

mineral properties evaluated ranged as follows: Magnesium (42.56 to

Introduction

Breakfast cereals are convenience food that requires little or no further processing. Odimegwe, Ofoedu, Umelo, Eluchie, Alagbasol,, Njoku and Ozoani (2019) defined it as dry cereal which had been processed into different forms by soaking, grinding, rolling,

71.24 mg/100g and 55.70 to 102.44 mg/100g), potassium (415.15 to 622.46 mg/100g and 565.39 to 721.34 mg/100g), calcium (225.34 to 294.23 mg/100g and 332.03 to 428.23 mg/100g), zinc (4.36 to 7.24 mg/100g and 8.57 to 14.25 mg/100g), and iron (5.26 to 8.36 mg/100g and 8.38 to 15.13 mg/100g). The B vitamins ranged thus: Thiamin (B1) (0.16 to 0.24 mg/100g and 0.23 to 0.77 mg/100g), Riboflavin (B2) (0.33 to 0.55 mg/100g and 1.04 to 1.57 mg/100g), Niacin (B3) (0.28 to 0.38 mg/100g and 0.46 to 1.39 mg/100g), Folate (B9) (0.35 to 0.66 mg/100g and 0.65 to 1.06mg/100g) and Cobalamin (B12) (0.09 to 0.37mg/100g and 0.21 to 0.49mg/100g) and the anti-nutritional properties ranged thus: Tannin (0.74 to 1.74 mg/100, 0.33 to 0.73 mg/100g), oxalate (0.67 to 1.67 mg/100g, 0.22 to 0.45 mg/100g), Phytate (0.67 to 1.67 mg/100g, 1.03 mg/100g) for the flour blends and breakfast cereal respectively. The mineral and vitamin composition of the flour blends and breakfast cereals increased with increase addition of tiger nut flour and constant cashew nut flour with higher concentration in the breakfast cereal showing it was not affected by high temperature. The anti-nutritional properties of both the flour and breakfast cereals were low and within the acceptable range, results showed decrease in the breakfast cereal which can be attributed to high temperature during processing.

Key words: Composite Flour, Breakfast Cereals, Sorghum, Tiger Nut, Cashew Nut.

flaking, or shredding before roasting or puffing. They are divided into hot cereals which require further processing and ready-to-eat (RTE) which does not require further processing. According to Anne, Victor and Edikan, (2019) many nutritionist regard breakfast as the

most important meal of the day, because it breaks the night fasting periods, replenishes the supply of glucose to boost energy levels and alertness and provides essential nutrients required for good health. O'Neil, Byrd-Bredbenner, Hayes, Dana, Klinger and Stephenson-Martin, (2014) also reported that breakfast is associated with healthier macro- and micronutrient intakes, body mass index and lifestyle; it improves cognitive function, intuitive perception and academic performance as well as extended benefits related to diet quality and weight management.

Cereal, which form the bulk of the food we eat is high in carbohydrate, low in protein, fat and micronutrients. Most breakfast cereals found in the market today are mainly from cereal grains which are mostly carbohydrate and do not give the essential nutrients needed by the body, although they are fortified with vitamins but are usually not enough. To improve the nutritional value of our breakfast cereals they have to be combined with protein-rich food to enrich the cereals, and provide the missing nutrients. Animal protein such as eggs, meat, milk, etc. which are very good sources of protein are expensive so there is need to get the needed protein and micro nutrients from protein rich plant foods (Abubakar, Atiku, Alhassan, Mohammed, Garba and Gwarto, 2017). There are lots of protein rich under-utilized crops like cashew. A blend of sorghum, tiger nut and cashew nut will produce a nutrient packed breakfast cereal.

Malnutrition has been an issue in developing countries like Nigeria, Akinlolu and Stephen (2019) reported malnutrition as a dominant cause of morbidity, mortality and lost potentials in today's children putting them at risk of long term deficit in cognitive development. To ensure a healthy breakfast with appropriate nutrients this research aims at

producing breakfast cereals from blends of sorghum (*Sorghum bicolor*), tiger nut (*Cyperus esculentus*) and cashew nut (*Anacardium occidentals*) all under-utilized crops with complementary nutrients to reduce malnutrition.

Sorghum (*Sorghum bicolor*) is an underrated nutrient-rich cereal grain. It is a versatile crop that can be grown as a grain, forage or sweet corn. It is converted into syrup that is used to sweeten many processed (Staughton, 2021). It is rich in vitamins like B1, B2, B5, and B6 playing an essential role in metabolism, neural development, and minerals such as Copper, iron, zinc, Phosphorus, Magnesium. It is an excellent source of fibre, antioxidant and protein (Davidson, 2021). Sorghum is rich in phenolic compounds which act as an antioxidant that reduces some forms of inflammation, it is used as animal feed and as a natural and cost effective fuel source, and it is gluten-free (Staughton, 2021).

Tiger nut (*Cyperus esculentus*) is an edible tuber with a slightly sweet nutty flavor, it can be consumed raw, roasted, dried, or as tiger nut milk or oil (Rita, 2009). Tiger nut tubers are rich in vitamin B1 which helps central nervous system to function properly and also help the human body undergo stressful condition (Maduka and Ire, 2018). The Vitamin C in tiger nut is a good antioxidant, promotes iron absorption and helps in maintaining vitamin E levels essential for the immunological system and tissue preservation (Roselló-Soto *et al.*, 2019)

Tiger nut tubers are good benefit for the bones, tissue repair, muscles, and body development due to its richness in phosphorus, potassium, calcium, magnesium and iron necessary (Mohdaly, 2019). Potassium plays a role in many enzymatic responses and significant physiological processes such as nerve conduction, heart rhythm, and muscle contraction (Mohdaly, 2019) They are rich in heart healthy fats; they

improve vein and artery flexibility and blood circulation, which may reduce risk of heart disease (Alina, 2022). Tiger nut tuber contains digestive enzymes such as catalase, lipase and amylase; these enzymes help to alleviate indigestion, flatulence and diarrhoea, it defends the internal mechanisms and prevents constipation and diarrhea (Maduka and Ire, 2018).

Cashew nut (*Anacardium occidentale*) is a kidney shaped seed with a slightly sweet flavor, satisfying crunch and buttery texture (Hill, 2019). Cashew nut is an excellent source of nutrient containing 18.22g of protein, 27.13g of carbohydrate and 46.91 g fat per 100g, the fat in cashew are unsaturated and are cholesterol free (Zarqa, Mohammed, Mohammed, Marium, Mohammed, Aamir, Mohammed, Hina, Fahad and Mohammed, 2021). It is a good source of calcium, copper, zinc, iron, magnesium and manganese, important for energy production, brain health, immunity and bone health (Petre, 2020). Cashew nuts contains large amount of trace minerals like copper which can helps for proper cognitive functions, it also lowers the risk of infection. Phosphorus helps to keep our bones and teeth strong, and zinc helps to boost immunity and help injuries to heal quickly (Ritesh *et al.*, 2020).

They are low in sugar, a good source of fibre, heart-healthy fat and plant protein. They are also good source of copper, magnesium, manganese nutrients important for energy, brain health, immunity and bone health (Petre, 2020)

Materials and Method

Sample Collection

White sorghum and brown tiger nut were purchased from central market in Kaduna state while cashew nut was purchased from Otukpa in Benue state Nigeria.

Preparation of Flour

Sorghum was cleaned and washed, the grains were then soaked for 16 h in 10 litres of clean water. The soaked grain was drained and spread on jute bag to sprout for 48 h, the malted grains were dried in an oven at 50 °C after which the roots and shoots were removed and winnowed. The dried kernel was milled into flour and packaged as described by Feyera, (2021). Tiger nut grains were cleaned, sorted, washed, dried, milled and packaged as described by Adejuyitan, (2011). Cashew nuts were cleaned, washed, sundried, and roasted using open pan roasting for 15 min. This was followed by breaking and separation with a wood hammer. The roasted nuts were oven-dried, peeled, and the kernel milled, and packaged (Ojinnaka and Agubolum, 2013).

Formulation of Composite Flour

Composite flour was formulated by mixing malted sorghum flour, tiger-nut flour, and Cashew nut flour in the following ratios: 65:05:30, 60:10:30, 55:15:30 and 50:20:30 as shown in Table 1. One hundred percent (100%) sorghum flour served as the control.

Table 1: Composite Flour Formulation

Samples	Sorghum flour	Tiger nut flour	Cashew nut flour
BPC	100	0	0
BP1	65	5	30
BP2	60	10	30
BP3	55	15	30
BP4	50	20	30

Breakfast cereals production

The procedure described by Odimegwu *et al.* (2019) was used in the production of breakfast cereals. The breakfast cereal was prepared by mixing the formulated composite flours (SF, TF, and CNF) with sugar, salt, and water. The resultant batter was poured thinly on a clean flat

greased stainless tray and placed in the oven (gas oven) until a semi-dried product was obtained. The semi-dried products were cut into shapes with a sharp stainless knife and placed back into the oven for further drying and toasting at 280 °C. The dried products were cooled and packaged in polythene bags

Determination of mineral elements

The mineral composition of each sample was determined by ashing method followed by spectrophotometric reading of the level of mineral. Triplicate samples (1 g) of each sample were ashed in a muffle furnace at 450 °C for 5-6 h. The ashed samples and silica dishes were removed and transferred into the desiccators to cool after which the samples were dissolved with 1 ml of 0.5 % HNO₃. Little distilled water was added and filtered into a clean small plastic bottle using number 43 Whatman filter. Distilled water was later used to dilute the solution up to 50 ml. Atomic absorption spectrophotometer (Buck 201, VGP) was used in determining the mineral content (AOAC, 2015). Mineral determined were calcium, potassium, magnesium, zinc, and iron.

The mineral content was calculated using the formula below:

When R = Solution concentration, V = Volume of sample digested, D = Dilution factor, and Wt = Weight of sample.

Determination of vitamins

The B group vitamins were extracted according to (AOAC, 2015). 2 g of sample was placed in 25 ml of H₂SO₄ (0.1 N) solution and incubated for 30 min at 121 °C. Then, the contents were cooled and adjusted to pH 4.5 with 2.5 M sodium acetate, and 50 mg Takadiastase enzyme was added. The preparation was stored at 35 °C overnight. The mixture was then

filtered through a Whatman No. 4 filter, and the filtrate diluted with 50 ml of distilled water and filtered again through a micropore filter (0.45 μm). Twenty microliters of the filtrate were injected into the HPLC system. Quantification of vitamin B content was accomplished by comparison to vitamin B standards. Standard stock solutions for thiamine, riboflavin, niacin, folate and cobalamin was prepared according to specifications. Chromatographic separation was achieved on a reversed phase- (RP-) HPLC column (Agilent ZORBAX Eclipse Plus C18; 250 $\times$ 4.6 mm i.d., 5 μm) through the isocratic delivery mobile phase (A/B 33/67; A: MeOH, B: 0.023 M H₃PO₄, pH = 3.54) at a flow rate of 0.5 ml/min. Ultraviolet (UV) absorbance was recorded at 270 nm at room temperature.

Determination of Anti-Nutritional Factors

Determination of tannins concentration

Tannin was determined using Burns method in Krishnaiah, *et al* (2009). 5 g of the dried sample was treated with 50 ml methanol and kept for 24 h before filtration. 5 ml of freshly prepared vanalin hydrochloric acid was added and the solution was allowed to stand for 20 min for color development. The absorbance was measured at 550 nm using spectronic 20 and the machine value was used in calculating the tannin content.

Where;

C_1 = Conc. of tannic acid, C_2 =Conc. of base, V_1 =Volume of tannic acid,
 V_2 = Volume of base

Determination of oxalate concentration

Oxalate concentration was determined using the Dye method according to Krishnaiah, *et al* (2009). 2.5 g of the sample were extracted with dilute HCl. 5 ml of concentrated ammonia and precipitated with CaCl₂ as calcium oxalate. The precipitate was washed with 20 ml of 25 % H₂SO₄ and dissolved in hot water before titrating with 0.05 N KMnO₄ to determine the concentration of oxalate.

Determination of phytate concentration

Phytate was determined using anion exchange method following Ma, *et al* (2005). Samples were weighed accurately (1.0 – 2.0 g) and transferred into 100 ml conical flasks. A total of 40 – 50ml of Na₂SO₄ (100 g/ l) HCl (1.2 %) was added. Flasks were capped and shaken vigorously for 2h on a rotator at ambient laboratory temperature. The supernatant was then filtered through qualitative filter paper no 4. A total of 10ml of the filtered extract was diluted to 30 ml with distilled water after mixing with 1ml of 0.75 M NaOH and then passed through an anion resin column (resin AG1-X4, ~ 100 – 200 mesh, Biorad Laboratory Inc., column 0.8 x 10 cm). The column was washed before using 0.5 M NaCl solution and deionized water. After sample application, the column was washed with 15 ml of distilled water and 20 ml of 0.05 M NaCl solution in order to remove the inorganic phosphate. The retained phytic acid was eluted with 0.7 M NaCl. The post-column reagent made up as a 0.03 % FeCl₃ solution containing 0.3 % sulphosalicylic acid. A total of 4 ml of the reagent was added into 5 ml of collected eluate and centrifuged at 3000 rpm for 10 min. The absorbance of the supernatant was measured at 500 nm using a

spectrophotometer. A calibration curve for the colorimetric method was obtained using sodium phytate standards (P-8810 Sigma, USA)

Results and Discussion

Mineral Composition of Composite flour and breakfast cereal

Table 2 presents the mineral composition of composite flour and breakfast cereal, There was significant difference ($p < 0.05$) in the mineral composition of the flour and the breakfast cereals, the values increased with increase addition of the tiger nut flour and constant cashew nut flour.

Mineral nutrients are very significant and vital constituents of the diet, needed for a wide variety of essential and metabolic and/or structural functions in the body. They help the body to grow, develop and stay healthy. Inadequate intakes of minerals have been associated with severe malnutrition, increased disease conditions and mental impairment (Abulude, 2005). From the result of mineral composition of composite flour and breakfast cereals, it was observed that the mineral content of the cereals was higher than that of the flour blends, this could be attributed to nutrient concentration and high temperature during flaking just as Anuoye *et al.* (2010) reported that increase in extrusion temperature could lead to increase in amount of trace elements in extruded products. All minerals showed increase in concentration as the ratio of tiger nut increased; the same increase was reported by Adebowale *et al.* (2016) and Adegunwa *et al.* (2017) as tiger nut flour was increased.

Magnesium is a cofactor in more than 300 enzyme systems that regulate diverse biochemical reactions in the body, including protein synthesis, muscle and nerve function, blood glucose control, and blood pressure

regulation (Rude, 2012). It works with calcium to assist in muscle contraction, blood clotting, and the regulation of blood pressure and lung functions (Swaminathan, 2003). The Magnesium content of the composite flour ranged from 42.56 to 71.24 mg/100g while that of the breakfast flakes ranged from 55.70 to 102.44 mg/100g with the control having the least value. Adegunwa *et al.* (2017) also observed increase in magnesium content of the flour but lower values, with increase substitution of tiger nut flour: from 30.65 to 49.98 mg/100g, the values obtained was lower than the recommended dietary allowance (RDA) for children which is 130mg (4-8years) and 240mg (9-13years). However 100g of the breakfast cereal can provide about 52.04 to 78.80% of daily magnesium intake for a child 4 -8years

Potassium is found naturally in many foods and as a supplement, is important in maintaining osmotic pressure and acid-base balance (Okache *et al.* 2020). The Potassium content of the composite flour ranged from 415.15 to 622.46 mg/100g while that of the breakfast flakes ranged from 569.39 to 721.34 mg/100g, lower values of (107.0-238.0 mg/100g) were recorded from breakfast cereals made from sorghum and pigeon pea (Mbaeyi, 2005). Insufficient intake can increase blood pressure, kidney stone risk, bone turnover, urinary calcium excretion and salt sensitivity (IOM, 2005). The recommended daily allowance for potassium: age 4-8years 2,300mg, 9-13years 2,500mg.

Calcium Calcium is important for developing and maintaining bones and teeth and for supporting the healthy functioning of muscles, nerves and heart (Soetan *et al.*, 2010). The Calcium content of the breakfast composite flour ranged from 225.34 to 294.23 mg/100g while that of the flakes ranged from 332.03 to 428.23 mg/100g, the calcium values

were very close to values of 138.0 to 214.3 mg/100g and 305.0 to 382.0 reported by Adebowale *et al*, (2016) Adequate dietary intake of calcium is required throughout life to prevent low bone mineral density, risk of bone fragility and osteoporosis at a mature age (Lily *et al*, 2017). The RDA for calcium 4-8years 1000mg and 9- 13years 1300mg (IOM, 2011), values obtained were lower than the RDA for calcium.

Iron is an important component of the red blood cells. It is reported as the most common micronutrient deficiency in the world, affecting about 20%-50% of the world population especially women and children in developing nations (Oyegoke *et al*, 2020). Iron is essential in human diet for the respiration process, the transport of oxygen in the blood and in the oxygenation of red blood cells; its deficiency often leads to anemia, tissue inflammation and fatigue (Soetan *et al*, 2010). The Iron content of the flour ranged from 5.26 to 8.36 mg/100g while that of the flakes ranged from 8.38 to 15.13 mg/100g, lower values of 1.67 to 2.72 mg/100g for composite flour and 1.98 to 4.68 mg/100g for extrudate was reported by Adebowale *et al*. (2016). According to Abbaspour *et al*, (2014) iron can form free radicals, its concentration in body tissues must be tightly regulated because in excessive amounts, it can lead to tissue damage. The average daily Iron intake from foods is 11.5 to 13.7 mg/day, children aged 2 - 11years, 15.1mg/day 12 -19years and 16.3 -18.2 mg/day in men and 12.6 -13.5 mg/day in women. Values obtained in this study were within the RDA of iron.

Zinc is found as component of more than 300 enzymes and hormones and plays a crucial part in the health of our skin, teeth, bones, hair, nails, muscles, nerves and brain function as well as it is essential for growth (Ch.Bimola *et al*, 2014). Zinc is essential for the synthesis of

DNA and RNA, protein, insulin, and for proper functioning of immunity system and for activation of over 80 enzymes (Lily *et al*, 2017). The Zinc content of the composite flour ranged from 4.36 to 7.24 mg/100g while that of the flakes ranged from 8.57 to 14.25 mg/100g. Lower values of 0.25 to 0.67 mg/100g were reported by Adegunwa *et al*. (2017). The zinc values obtained in this study were within the RDA for iron which varies from 5mg in infants to 15mg in adults.

Table 2: Mineral Composition of Flour Blends and Breakfast Cereals (mg/100g)

Sample	Magnesium	Potassium	Calcium	Zinc	Iron
Flour Blend					
BFC	42.56 ^a ±0.01	415.15 ^a ±0.01	225.34 ^a ±0.01	4.36 ^a ±0.01	5.26 ^a ±0.01
BF1	53.27 ^b ±0.02	475.87 ^b ±0.01	235.22 ^b ±0.00	5.67 ^b ±0.02	6.53 ^b ±0.01
BF2	64.60 ^c ±0.03	494.32 ^c ±0.02	240.00 ^c ±0.00	6.26 ^c ±0.01	6.65 ^c ±0.01
BF3	68.12 ^d ±0.01	611.36 ^d ±0.01	284.63 ^d ±0.01	6.92 ^d ±0.01	7.89 ^d ±0.01
BF4	71.24 ^e ±0.01	622.46 ^e ±0.01	294.23 ^e ±0.01	7.24 ^e ±0.01	8.36 ^e ±0.01
LSD	0.03	0.02	0.01	0.01	0.01
Breakfast cereals					
BPC	55.70 ^a ±0.02	565.39 ^a ±0.01	332.03 ^a ±0.01	8.57 ^a ±0.01	8.38 ^a ±0.00
BPI	67.65 ^b ±0.01	597.34 ^b ±0.02	375.85 ^b ±0.00	9.35 ^b ±0.01	8.55 ^b ±0.00
BP2	81.34 ^c ±0.01	671.63 ^c ±0.01	411.22 ^c ±0.01	12.65 ^c ±0.00	9.86 ^c ±0.01
BP3	85.34 ^d ±0.01	695.35 ^d ±0.01	469.03 ^d ±0.01	12.98 ^d ±0.01	13.55 ^d ±0.01
BP4	102.44 ^e ±0.01	721.34 ^e ±0.00	482.23 ^e ±0.01	14.25 ^e ±0.00	15.13 ^e ±0.01
LSD	0.02	0.02	0.01	0.01	0.01

Values represent mean $\pm$ standard deviations of triplicate determinations. Means in the same column with different superscript are significantly different at ($p < 0.05$)

key

BFC/BPC: Control Sample =100% Sorghum, BF1/BP1: Composite flour/breakfast sample1=65:05:30. BF2/BP2: composite flour/breakfast sample2 = 60:10:30. BF3/BP3: composite flour/breakfast sample3= 55:15:30. BF4/BP4: composite flour/breakfast sample4= 50:20:30

Ratio: Malted sorghum: Tiger nut: Cashew nut flour.

LSD: Least Significant Difference

Table 3: Vitamin Composition of Flour Blends and Breakfast Cereal (mg/100g).

Sample	Thiamin (B1)	Riboflavin (B2)	Niacin (B3)	Folate (B9)	Cobalamin (B12)
Flour Blend					
BFC	0.16 ^a ±0.00	0.33 ^a ±0.00	0.28 ^a ±0.01	0.35 ^a ±0.01	0.09 ^a ±0.00
BF1	0.19 ^a ±0.01	0.38 ^b ±0.01	0.29 ^b ±0.00	0.49 ^b ±0.01	0.16 ^b ±0.00
BF2	0.21 ^c ±0.01	0.41 ^c ±0.01	0.31 ^c ±0.00	0.52 ^c ±0.01	0.19 ^c ±0.01
BF3	0.22 ^d ±0.00	0.43 ^d ±0.01	0.32 ^d ±0.00	0.67 ^d ±0.02	0.22 ^d ±0.01
BF4	0.24 ^e ±0.01	0.55 ^e ±0.01	0.38 ^e ±0.00	0.66 ^e ±0.00	0.37 ^e ±0.01
LSD	0.00	0.00	0.00	0.00	0.00
Breakfast cereals					
BPC	0.23 ^a ±0.01	1.04 ^a ±0.01	0.46 ^a ±0.01	0.65 ^a ±0.01	0.21 ^a ±0.00
BP1	0.32 ^b ±0.01	1.15 ^b ±0.01	0.66 ^b ±0.01	0.69 ^b ±0.01	0.36 ^b ±0.00
BP2	0.43 ^c ±0.01	1.21 ^c ±0.01	1.03 ^c ±0.01	0.74 ^c ±0.01	0.42 ^c ±0.01
BP3	0.62 ^d ±0.01	1.44 ^d ±0.01	1.37 ^d ±0.01	0.78 ^d ±0.01	0.45 ^d ±0.00
BP4	0.77 ^e ±0.01	1.57 ^e ±0.01	1.39 ^e ±0.01	1.06 ^e ±0.01	0.49 ^e ±0.01
LSD	0.00	0.00	0.00	0.00	0.00

Values represent mean $\pm$ standard deviations of triplicate determinations. Means in the same column with different superscript are significantly different at ($p < 0.05$)

key

BFC/BPC: Control Sample =100% Sorghum, BF1/BP1: Composite flour/breakfast sample1=65:05:30. BF2/BP2: composite flour/breakfast sample2 = 60:10:30. BF3/BP3: composite flour/breakfast sample3= 55:15:30. BF4/BP4: composite flour/breakfast sample4= 50:20:30

Ratio: Malted sorghum: Tiger nut: Cashew nut flour.

LSD: Least Significant Difference

Table 4: Anti-nutritional Composition of Flour Blend and Breakfast Cereals (mg/100 g)

Sample	Tannins	Oxalates	Phytate
Flour Blend			
BFC	0.74 ^a $\pm$ 0.01	0.32 ^a $\pm$ 0.01	0.67 ^a $\pm$ 0.02
BF1	0.97 ^b $\pm$ 0.01	0.35 ^b $\pm$ 0.01	0.82 ^b $\pm$ 0.01
BF2	1.33 ^c $\pm$ 0.01	0.41 ^c $\pm$ 0.01	1.02 ^c $\pm$ 0.01
BF3	1.56 ^d $\pm$ 0.01	0.53 ^d $\pm$ 0.01	1.45 ^d $\pm$ 0.02
BF4	1.74 ^e $\pm$ 0.02	0.67 ^e $\pm$ 0.01	1.67 ^e $\pm$ 0.01
LSD	0.00	0.00	0.00
Breakfast cereal			
BPC	0.33 ^a $\pm$ 0.01	0.22 ^a $\pm$ 0.02	0.35 ^a $\pm$ 0.01
BP1	0.56 ^b $\pm$ 0.02	0.28 ^b $\pm$ 0.02	0.58 ^b $\pm$ 0.01
BP2	0.65 ^c $\pm$ 0.01	0.33 ^c $\pm$ 0.01	0.74 ^c $\pm$ 0.01
BP3	0.78 ^d $\pm$ 0.01	0.38 ^d $\pm$ 0.01	0.88 ^d $\pm$ 0.01

BP4	0.73 ^e ±0.01	0.45 ^e ±0.01	1.03 ^e ±0.02
LSD	0.00	0.00	0.00

Values represent mean $\pm$ standard deviations of triplicate determinations. Means in the same column with different superscript are significantly different at ($p < 0.05$)

Key

BFC/BPC Control Sample = 100% Sorghum, BF1/BP1- composite flour/breakfast Sample 1 = 65:05:30, BF2/BP2 - composite flour/breakfast Sample 2 = 60:10:30 BF3/BP3 - composite flour/breakfast Sample 3 = 55:15:30 BF4/BP4- composite/breakfast Sample 4 = 50:20:30 in ratio: Malted Sorghum: Tiger nut: Cashew nut flour.

LSD: Least Significant Difference

Vitamin composition of composite flour and breakfast cereal

Table 3 presents the vitamin composition of composite flour and breakfast cereal, There was significant difference ($p < 0.05$) in the vitamin composition of the flour and the breakfast cereals, the values increased with increase addition of the tiger nut flour and constant cashew nut flour. It was also observed that the flakes had higher vitamin content than its composite flour. Vitamins are micro nutrients essential for the body's healthy development, some work as cofactors or coenzymes in many metabolic processes, if their supply is not enough it results in deficiency. Akram, 2020).

Vitamin B₁ (thiamine) content of the composite flour ranged from 0.16 to 0.24 mg/100g while that of the breakfast flakes ranged from 0.23 to 0.77 mg/100g, lower levels of .018 to 0.034 mg/100g was reported by Adegunwa *et al.* (2017) on plantain-tiger nut flour blend. The RDA for

vitamin B₁ is 0.6 mg/100g/day for 4 to 8years, 0.9 mg/100g/day for 9-13years and 1.2 mg/100g/day for adult. The results obtained from vitamin B₁ content from this study can are lower than the RDA for VitaminB₁; however it can provide an adult with about 21.3% to 64% of vitamin B₁ to the body and more for children. Thiamine plays a critical role in energy metabolism and in the growth, development and function of cell. It helps the body maximize the use of carbohydrates, a major source of energy, it is also important for the proper functioning of the heart nervous system, and muscle coordination (Eze *et al.*, 2020).

Vitamin B₂ (Riboflavin). The vitamin B₂ content obtained in this study varied from 0.33 to 0.55 mg/100g for the flour blends and 1.04 to 1.57 mg/100g for the breakfast flakes, closer range of levels 1.46 -1.86 mg/100g was reported by Rehab *et al.* (2017) on wheat, maize, rice, lentil, bean, chickpeas and kidney beans breakfast blend. The RDA for Vitamin B₂ is 0.9 mg/100g/day for age 9 -13 and 0.6 mg/100g/day for ages 4 to 9. The values obtained from this study for the breakfast cereals are higher than the RDA. Riboflavin is important for body growth, it helps in red blood cell production, aids in the release of energy from protein, converts carbohydrates into glucose for energy production, and neutralizes free radicals hence acts as anti-oxidant. (Pinto and Rivlin, 2013)

Vitamin B₃ (Niacin) The vitamin B₃ content obtained in this study varied from 0.25 to 0.38 mg/100g for the flour blends and 0.46 to 1.39 mg/100g for the breakfast flakes, higher range of levels 3.94 - 4.64mg/100g was reported by Rehab *et al.* (2017). The RDA for Vitamin B₃ is 12 mg/100g/day for age 9 -13 and 8mg/100/day for ages 4 to 9. The values obtained from this study for the breakfast cereals can provide children with about 5.75 to 11.58% of Niacin intake per day.

Niacin helps lower LDL cholesterol, lowers risk of cardiovascular diseases, and eases arthritis (Lule *et al.*, 2016).

Vitamin B₉ (Folate) The folate content of the composite flour ranged from 0.25 to 0.66 mg/100g while that of the breakfast flakes ranged from 0.65 to 1.06 mg/100g, lower values of 0.487-0.585 mg/100g was reported by Rehab *et al.* (2017). The RDA for vitamin B₉ is 0.2 mg/100g/day for 4 to 8years and 0.3 for 9-13years and 0.4 mg/100g/day for adult. The values obtained from this study are higher than the RDA requirement for all groups. Folate helps in DNA replication, metabolism of vitamins and amino acids helps to reduce risk of spina bifida (neural tube defects) in neonates when taken by pregnant mothers (Kunisawa *et al.*, (2012).

Vitamin B₁₂ (cobalamin), the vitamin B₁₂ content obtained in this study varied from 0.09 to 0.37 mg/100g for the flour blends and 0.21 to 0.49 mg/100g for the breakfast flakes. The RDA for Vitamin B₁₂ is 1.8 mg/100g/day for age 9 -13 and 1.2 mg/100/day for ages 4 to 9. The values obtained from this study for the breakfast cereals can provide children ages 4 to 9 with about 17.5 to 40.83% of vitamin B₁₂ intake per day. Cobalamin helps in brain function and synthesis of red blood cells (Kelly *et al.*, 2006).

Anti-nutritional composition of flour blends and breakfast cereal

Table 4 presents the Anti-nutritional Composition of Composite flour and breakfast cereal, There was significant difference ($p < 0.05$) in the anti-nutrient properties of the flour and the breakfast cereals. The values reduced in the flakes compared to the flour. The presence of anti- nutrients in foods could hinder the efficient utilization, absorption or digestion of some nutrients and thus, reduce their bioavailability (Adeniji *et al.*, 2007).

Tannin: the tannin content of sorghum, tiger nut and cashew flour blends ranged from 0.74 to 1.74 mg/100g while that of the breakfast flakes ranged from 0.33 to 0.73 mg/100g, a gradual increase of the tannin content was observed with increase in the level of the tiger nut and constant cashew nut flour. These results were low compared to 3.62 to 6.09 mg/100g and 2.46 to 5.37 mg/100g reported by Adebowale et al., (2016) for high quality cassava and tiger nut flour blend and extruded snack. There was decrease in tannin content of the flakes compared to the flour this could be attributed to processing methods as processing methods helps to reduce the amount of anti nutritional factors. The finding of the present study was in agreement with Adebowale et al., (2016) who reported that the amount of tannin in composite flour increased as the amount of tiger nut flour increased. Tannins interfere with proteins, causing a decrease in digestibility and also prevent dietary iron absorption in the body (Gemedie and Ratta, 2014).

Oxalate: The oxalate content of sorghum, tiger nut and cashew nut flour and breakfast cereal ranged from 0.22 to 0.45 mg/100g and 0.32 to 0.67 mg/100g respectively. The values increased with addition of tiger nut flour and constant cashew nut flour: Higher values of 3.53 to 3.79 mg/100g and 0.47 to 1.47 mg/100g was reported by (Awolu et al., 2017, and Usman et al., 2015) on maize, soybean, tiger nut flour blend and local rice, soybean and defatted coconut flour blend respectively. The oxalate values in this study were low and within the acceptable range, they were however slightly higher in the breakfast cereals than the composite flour. Oxalates when present in large quantity in foods (above 50mg/100g) chelate some metal ions and render them insoluble and hence, the metal ions cannot be absorbed in the intestine

(Sanni et al., 2013). High oxalate diet can increase the risk of renal calcium absorption and has been implicated as a source of kidney stone (Gwer *et al.* 2020).

Phytate: the phytate content of sorghum, tiger nut and cashew flour blends ranged from 0.67 to 1.67 while that of the breakfast flakes ranged from 0.33 to 1.03%, a gradual increase of the phytate was observed with increase in the level of the tiger nut and constant cashew nut flour. There was decrease in the phytate result obtained for the flakes compared to the flour content this can be attributed to processing method of high temperature. Omosebi et al. (2008) reported that, extrusion process brought about significant reduction in the phytic acid content of complementary diet from quality protein maize and soybean protein concentrate. The results fell within the range of 0.32 to 1.90 and 0.27 to 1.54 mg/100g reported by Adebowale et al., (2016) higher results 158.93 to 191.33 mg/100g and 175 to 203.10 mg/100g was reported by et al., 2005). It is important to lower the phytic acid to enhance bioavailability of minerals. According to Reddy, (2002) the average intake of phytate was estimated to be 2,000 -2,600 mg for vegetarian diet and inhabitants of rural areas of developing countries and 150-1,400 mg for mixed diet. The value of phytate obtained in this study is within the acceptable limits. Findings by Batista et al., (2010) pointed out that phytic acid is an important antioxidant and additive, with applications in the manufacture of many novel food products such as pasta, bread, fish paste, meat, fruits and vegetables.

Conclusion

Composite flour and breakfast cereals produced from malted sorghum, tiger nut and cashew nut had good mineral and vitamin B content which

increased with addition of tiger nut flour. The anti nutritional properties of the flour and breakfast cereals were low and within acceptable range, making them good and fit for consumption,

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