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Production and Evaluation of Nutritional Contents of Traditional Couscous from Sprouted Wheat Fortified with *Glycine max (L.) merr* (Soya Bean) and *Cucurbita pepo* (Pumpkin) Seeds

Raihanatu MB[1], Falmata AS[1], Bintu BP[1], Maryam BK[2], Hadiza Ahmed Ali[1], Comfort MB[1] & Modu S[1*]

[1] Department of Biochemistry, Faculty Science, University of Maiduguri, Nigeria

[2]Department of Biological Sciences, Faculty Science, University of Maiduguri, Nigeria

[*] Modu S, Department of Biochemistry, Faculty Science, University of Maiduguri, Nigeria

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Abstract

The study was carried to process, produce, and evaluate nutritional contents of traditional couscous from sprouted wheat (Triticum aestivum), fortified with Soya bean (Glycine max) and Pumpkin (Cucurbita pepo) seeds. The composite couscous blends were traditionally produced and compared with commercial couscous. The sprouted wheat couscous blends were blended in different ratios, they include; unprocessed (Raw wheat, 100), blend 1 (sprouted wheat mixed with soya bean and pumpkin seeds, 70:20:10), blend 2 (sprouted wheat mixed with soya bean, 60:40) and blend 3 (sprouted wheat mixed with pumpkin seeds, 60:40). Traditional wheat couscous blends were fed to experimental albino rats of wister strain weighing between (35 g and 45 g) for a period of 28 days. The nutritional and physiochemical analysis were determined using standard laboratory methods. The Statistical Package for Social Sciences (SPSS), version 20.0 was used to analyze the data collected which were expressed as means ± SE. One way analysis of variance (ANOVA) and Duncan's multiple range tests were used to compare the means obtained after each experiment. Differences were considered significant at $p < 0.05$. Processing (Sprouting) decreases the levels of anti-nutrients, mineral elements and vitamins. Supplementation with soya bean and pumpkin seeds increased the nutritional composition of the sprouted wheat couscous blends. Results of chemical composition showed that blend 2, recorded high protein (29.95%), fat (8.95%) and low carbohydrate content (49.56%), followed by blend 1 and then blend 3, while commercial couscous crude protein, fat and carbohydrate were 12.53%, 1.42% and 75.10% respectively. There was improved level of in vitro protein digestibility at 1 hour (76.64% to 98.59%) and at 6 hours (96.80% to 99.33%). Results of in vivo studies showed that raw wheat

couscous recorded protein quality when compared with spouted wheat couscous blends produced. The biological values of the composite couscous blends range from 95.04% to 95.73% and blend 2, recorded high net protein utilization (98.57%). In terms of sensory evaluation using hedonic method, blend 2 was most acceptable and differ significantly ($p < 0.05$) with other sprouted wheat couscous blends and commercial couscous. The cost of producing sprouted wheat couscous blends is cheaper than the commercial couscous. The study has therefore, revealed that with proper selection of locally available cereal, it is possible to produce nutritious complementary couscous blends that would be acceptable and nutritionally adequate to meet up the nutritional requirement for both children and adults. It also compares favourably with the commercial couscous in terms of nutrient contents.

Keywords

Sprouting, Wheat, Couscous blends, Pumpkin seeds, Soya bean and grits

1. Introduction

Couscous is defined as a grits form of either *Triticum aestivum* L. (wheat), *Pennisetum glaucum* L. (Millet), *Sorghum bicolorL.moench* (Sorghum) or *Zea mays L.* (Maize), it usually comes in coarse form which is steam cooked and eaten as a full meal. Couscous, is prepared traditionally from mono cereals which lack adequate nutrients for adults and children, there is need for fortification/blending with plant legumes to meet up the nutrients requirement that may be loss during processing and production. Couscous is served with vegetables, fish or meat. It can also be absorb in milk and sugar, it is a staple food of North Africa, and is very popular in West African countries. Wheat (*Triticum aestivum*) is the main raw material for the production of couscous commercially and traditionally. The grains were sprouted to reduce the anti-nutrients, improve protein digestibility and enhances the nutritional value of the couscous being produced. Fortification of couscous with *Glycine max* (Soya beans) and *Cucurbita Pepo* seeds (Pumpkin seeds) will further supplement the deficient nutrients that were lost in the process of production. Flour is inadequate in terms of some of the essential amino acids (lysine, threonine and methionine). Mono cereal (wheat) can be enhanced by the addition of legume flour. Amino acids balance of legume flour is good and its protein content is high (Lee et al., 1998). Today, in many countries including Turkey, couscous is made mechanically using extrusion technology and each couscous granule represents an aggregate of several semolina particles (Debbouz & Donnelly, 1996). A comparison of the characteristics of traditional and commercial wheat couscous has been made by Guezlane et al. (1986). These authors found a higher elasticity in the traditionally prepared sample and a lower one in the commercially processed one. Common wheat (*Triticum aestivum* L.) is a major cereal crop consumed in many parts of the world, accounting for 30% of the total grain consumption with an annual production of over 660 million tons worldwide (FAO, 2010). The origins of are thought to date back more than ten thousand years to the Levant region of the near east and Ethiopian highlands where remains of the wild progenitors of wheat have been discovered (Feldman & Kislev, 2007). Today, wheat is grown on the most land area of any commercial crop countries currently producing the most

wheat include China, India, European countries, and the United States (USDA, 2006). Wheat contributes more calories than any other cereal crops (Adom & Liu, 2002; Shewry, 2009). It is nutritious, easy for transportation and storage, and can be processed into different types of food products. Wheat is considered as a good source of protein, minerals, B vitamins and dietary fiber although the environmental conditions can affect nutritional composition of wheat grains with its essential coating of bran, indicating that it is a great health-building food (Shewry, 2007).

Soya bean is derived from seed *Glycine max (*L) merr of family –leguminosae or fabacae. Soya bean is known as the "Golden bean" or "the super legume" of the twentieth century. It represents an excellent source of unsaturated fatty acids, high quality proteins and fibers. Soya bean contains very small amounts of saturated fatty acids but do not contain any trans-fatty acids. Both omega-6 and omega-3 fatty acids such as linoleic acid (56% total fat) and alpha linolenic acid (7-8% of total fat) are present in soya bean. Cooked soya bean are rich in Iron, Phosphorus, Magnesium, vitamin B_2 (Riboflavin) and Folate. It is one of the best vegetarian sources of total protein containing all essential amino acids required in the human diets. Common food preparations of soya bean include edamme (Whole soybean), soy flour, soymilk, tofu (Fermanted soybean paste), soybean oil, soybean lecithin and soy sauce (Milland et al., 2014).

Pumpkin (*Cucurbita pepo*) is a cultivated plant of the genus Cucurbita. It yields varieties of winter squash and pumpkin, both a shrubby and creeping plant, ovoid or conical shape, pointed at the apex and with longitudinal grooves, thus resembling a spinning top(1-2). The mature or young fruit and the seeds of C. pepo, as well as to a lesser extent the flowers and young tips of the stems, are eaten in many parts of its native distribution area and in other regions of the world (Jeffery, 1986). In Nigeria, the different parts of *Cucurbita pepo* are edible: the pulp, seed and leaves. They are used to prepare different types of dishes.

The pumpkin seed is valued in regard to nutritional points. Several studies have reported the chemical composition and oil characteristics of the pumpkin seed from different origins and varieties (Lazos, 1986; Stevenson et al., 2007). The four fatty acids presented in significant quantities are palmitic, stearic, oleic, and linoleic acids (Stevenson et al., 2007). The pumpkin seed is a good source of potassium, phosphorus, magnesium, and also contains moderately high amounts of other trace minerals (calcium, sodium, manganese, iron, zinc, and copper) and these elements make pumpkin seed valuable for food supplements (Lazos, 1986).

Raw or roasted pumpkin seeds are used as a snack food for human consumption in many cultures all over the world. The kernels of pumpkin seeds have been utilized as flavour enhancers in gravies and soups, and used in cooking, baking and ground meat formulations as a nutrient supplement and a functional agent (Tsaknis et al., 1997; El-Adawy & Taha, 2001).

1.1 Objectives of the Study

The objectives of the study are to:

i. Produce traditional couscous from sprouted mono cereals fortified with soya bean and pumpkin

seeds.

ii. Determine proximate, mineral element, vitamin and anti-nutrients compositions of the couscous blends.

iii. Determine *in vitro* protein digestibility of the couscous blends.

iv. Determine endogenous urinary nitrogen and metabolic faecal nitrogen for protein quality.

v. Carry out sensory evaluation of the couscous blends.

2. Materials and Methodology

2.1 Sources of Raw Materials

The samples (Wheat, Soybean, Pumpkin seeds and Commercial couscous) used for this study were obtained at the open market (Monday Market, and Gamboru Market). They were authenticated by a seed breeder at the Lake Chad Research Institute, Maiduguri, Borno State, Nigeria.

2.2 Sample Preparation

The cereal (Wheat) was sprouted for 3 days, while the Soya bean was soaked overnight, drained, air dried, roasted, and grounded into coarse form and then steam cooked. The pumpkin seeds was also soaked in water, washed, drained, air dried in an open shed, roasted, grounded into coarse form and then steam cooked. The steam cooked soya bean and the pumpkin seeds were also air dried and packaged.

2.3 Sprouting

Ten kilograms (10 kg) of each cereal grains were sorted out and cleaned with water. The grains were then soaked overnight, and the following morning the cereals were washed with water, drained, and then transferred onto wetted jute bag and placed it in an air tight jar. The various samples of cereal grains were sprouted on wet jute bags for 72 hours at room temperature. The samples were removed from the jute bag, air dried and grinded into fine grits.

2.4 Soaking and Roasting

Ten kilograms (10 kg) of soya beans were soaked in tap water for 8 hours and washed with more water, air dried in an open shade for 48 hours and then roasted (Soaking and roasting were intended to remove the beany flavour). Ten kilograms (10 kg) of Pumpkin seeds were also soaked in water for 2 hours, washed, air dried in an open shade and roasted. The soya bean and the pumpkin seeds were then grounded into fine grits; sieved and steam cooked for 20-30 minutes. They were then air dried in an open shade for 48 hours and then packaged.

2.5 Production of Couscous

The cereal grains were sorted out and cleaned, sprouted at room temperature, air dried in an open shade, grinded into fine grits, sieved and then, water, a pinch of salt and small quantity of oil were added into the grits, mixed thoroughly with hand and then place in a steam cooking pot and steam cooked for 20-30minutes at low temperature the result is the “traditional couscous” which is then air dried in an open shade for 48 hours, sieved and finally packaged in a container (Fatima, 2013).

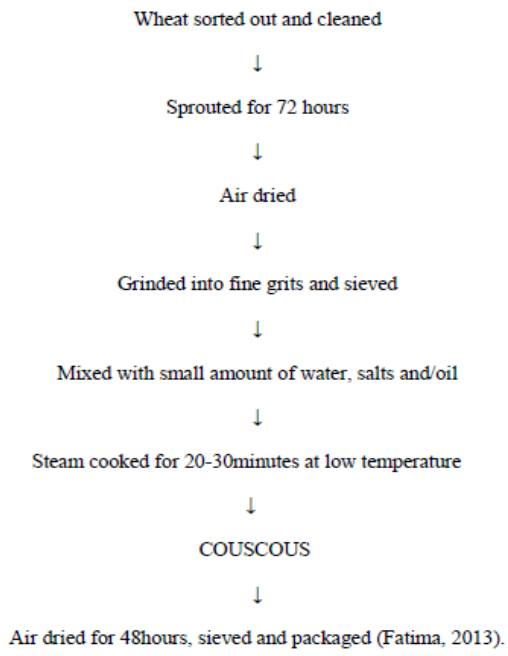

Figure 1. Flow Chart for Production of Traditional Couscous

2.6 Formulation/ Blending (Fortification) of Couscous with Soya bean and Pumpkin seeds.

The cereals were blended based on ratio 70: 20:10, (70 g of the wheat was mixed with 20 g of soya bean and 10 g of pumpkin seeds), 60:40 (60 g of the wheat was mixed with 40 g of soya bean without pumpkin seeds) and 60:40 (60 g of wheat was mixed with 40 g of pumpkin seeds without soya bean) respectively.

2.7 Animal Experimentation/Nutritional Studies

Eighty five (85) albino rats of 35-45 g were obtained from the animal house unit of the Department of Biochemistry, University of Maiduguri. The rats were randomly assigned into four (100, 70:20:10, 60:40 and 60:40) dietary treatment groups of 5 rats per group. The rats in each group were housed together in standard plastic laboratory cages with stainless steel covers and were offered with their respective experimental diets and water *ad libitum* after one week of acclimatization period to the laboratory environment. The feeding trials lasted for four weeks (28 days).

The feed intake was determined as the differential between the quantity of feed served and the quantity of feed left over. The changes in weight were determined by weighing the rats at the commencement of the feeding trial and thereafter on a weekly basis until termination of the experiment. The faecal and urine of the rats were collected on daily basis for 7adys (week four) for determination of percentage Nitrogen using Kjeldahl method (AOAC, 1990).

Another group of 5 rats with same weight of the initial eighty five rats were fed with protein-free diet (1% or 2%), also their faecal and urine samples were analysed for percentage nitrogen to calculate for endogenous and metabolic nitrogen in biological assay.

2.8 Measures of Protein Quality

Quality and digestibility of protein are two major determinants whether the dietary protein intake can furnish adequate level of essential amino acids to satisfy their function in the body.

Protein Efficiency Ratio (PER):

PER was calculated as described by Osborne et al. (1919)

$$\text{PER} = \frac{\text{gain in body weight (g)}}{\text{protein consumed (g)}}$$

Biological Value (BV)

Biological value is then calculated using Thomas-Mitchell (1924) method as follows;

$$\text{BV} = \frac{\text{NI} - (\text{FN} - \text{MFN}) - (\text{UN} - \text{EUN}) \text{ x}100}{\text{NI} - (\text{FN} - \text{MFN})}$$

Where NI = Nitrogen intake

FN = Nitrogen voided through faeces

UN = Nitrogen excreted through urine

MFN = Metabolic faecal nitrogen

EUN = Endogenous urinary nitrogen

Apparent Digestibility (AD)

Was calculated using the formular.

$$\text{AD} = \frac{\text{NI} - \text{FN x } 100}{\text{NI}}$$

True Digestibility (TD)

The amount of faecal nitrogen excreted when the subject is consuming either a protein –free diet, or a diet with just enough of a highly digestible protein to prevent excessive loss by the body protein. Thus, true digestibility can be calculated as follows:

$$\text{TD} = \frac{\text{NI} - (\text{FN} - \text{MFN}) \text{ x } 100}{\text{NI}}$$

Net Protein Utilization (NPU)

NPU was calculated using a method described by Bender and Miller (1953).

$$\text{NPU} = \frac{\text{NI} - (\text{FN} - \text{UN}) \text{ x } 100}{\text{NI}}$$

2.9 Proximate Analysis

The determination of moisture content, ash, crude protein, fat, crude fiber, carbohydrate and energy (Kcal) were carried out according to AOAC (2002).

2.9.1 Moisture Content

Five grams (5.0 g) of samples were weighed into a Petri dish and dried in an oven at 105^0C. After 2 hours the samples were removed, cooled in a dessicator and weighed. The process of weighing and cooling were repeated several times until a constant weight was obtained. The moisture contents were calculated using the formula.

$$\%\text{Moisture content} = \frac{\text{weight of sample after drying x } 100}{\text{weight of sample before dying}}$$

2.9.2 Ash Content

Two grams (2.0 g) of samples were placed in a weighed crucible completely combusted at 550-600^{0}C in a muffle furnace, percentage of ash of the samples were calculated using the formula;

$$\% \text{ Ash} = \frac{W1-W2 \times 100}{W}$$

Where W_1 = weight of sample + crucible before ashing

W_2 = weight of sample + crucible after ashing

W = Weight of Sample

2.9.3 Crude Protein

One gram (1.0 g) of the samples were weighed into a digestion tube and one digestion Tablet and 20 ml of conc. H_2SO_4 was added and digested at 420^{0}C using digestion block. The samples were digested, cooled and diluted with 80 ml of distilled water for 4 hours. The samples were then distilled with NaOH and boric acid and titrated using 0.1N HCl. The crude protein content of the samples were calculated using the formula.

$$\% \text{ Crude protein} = \frac{(A-B) \times N \times F \times 6.25 \times 100}{\text{Mg of sample}}$$

Where;

A = Titrated values

B = Blank

N = Normality of Acid used

F = factor 14.007

6.25 = constant

2.9.4 Fat Content

Two grams (2.0 g) of the samples (Couscous blends) were weighed and transferred into a fat free extraction thimble plugged tightly with cotton wool. The thimble was placed in the soxhlet extraction chamber and 25 mls of petroleum ether was added until it siphoned over, more ether was also added till the barell of soxhlet chamber was half full with ether. The condenser was detached, heat source was adjusted, flask containing the sample was removed and it content poured into a stock ether bottle. The condenser was detached again to the soxhlet chamber and the flask was also connected to the soxhlet and heat source was readjusted from 30^{0}C to 60^{0}C and the distillation process was continued until all the ether in the flask have practically dried. The flask containing the sample was then transferred into oven and the samples were dried to a constant weight at a temperature 105^{0}C.

The samples were removed and transferred to the dessicator for cooling and weighing immediately for determination of ash content.

$$\% \text{ Fat} = \frac{W2-W1 \times 100}{W3}$$

Where; W_1 = weight of flask

W_2 = weight of Fat + Flask

W_3 = weight of sample

2.9.5 Crude Fiber

The crude fiber were determined using trichloroacetic acid digestion method by refluxing two grams (2.0 g) of samples (Couscous blends) in 100 ml of digestion reagent, for exactly 40minutes, counting from the time boiling commences. The flask was removed from the mantle heater and cooled under a tap. The samples were then filtered using 15 cm of No. 4 white man filter. The samples were then washed six times with hot water and once with petroleum spirit. The filter paper was opened and the residues of the samples were removed using a spatula and transferred to a weighed petri dish and dried at 105^0C overnight. The samples were removed, cooled in a dessicator and weighed, then ashed at 600^0C. The samples were allowed to cooled and re-weighed again.

The percentage crude fibers of the samples were calculated as a difference in weighing multiply by 100.

$$\% \text{ Crude fiber} = \frac{W2 - W3 \times 100}{W1}$$

W_1 = weight of the sample

W_2 = weight after extraction and drying + Crucible

W_3 = weight of the ash + crucible

2.9.6 Total Carbohydrate

The total carbohydrate content were estimated as the difference between 100 and the total sum of moisture, fat, protein, crude fibre and ash (AOAC, 2002).

2.9.7 Total Energy

The total energy or the caloric values were estimated by calculation using the water quantification factors of 4, 9 and 4 kcal/100 g respectively for protein, fat and carbohydrate.

2.10 Determination of in Vitro Protein Digestibility

In vitro protein digestibility was determined by (Nills, 1979).

The nitrogen of the undigested samples was determined by Kjeldahl method (AOAC, 1990).

$$\% \text{ in vitro protein digestibility} = \frac{CP1 - CP2 \times 100}{CP1}$$

Where, CP_1= Total protein of unprocessed couscous

CP_2 = Total protein after digestion with trypsin.

2.11 Determination of Anti-Nutrients Contents

2.11.1 Determination of Tannin Contents

Assay by Vanillin-hydrochloric acid. Method: quantitative (Price et al., 1978).

The absorbance of the standard solutions, sample extract and sample blank was read in spectrophotometer at 500 nm exactly 20 minutes after incubation.

CALCULATION

$$\frac{Au}{Cu} = \frac{Astd}{Cstd}$$

$$Cu = \frac{Au \times Cstd = mg/g}{Astd}$$

Where Au= Absorbance of unknown

Cu= Concentration of unknown

Astd = Absorbance of standard

Cstd = Concentration of standard

Tannin (% reduction)

$$\% \text{ reduction} = \frac{\text{CRS} - \text{CPS x } 100}{\text{CRS}}$$

Where CRS = Concentration of raw sample

CPS = Concentration of processed sample.

2.11.2 Determination of Phytic Acid

Phytic acid was determined by a method as described by (Davies & Reid, 1979).

2.12 Determinations of Mineral Elements

Atomic absorption spectrophotometer (AAS) AA 6800 series shimazocorp was used for the determination of Ca, Na, K, Fe, Mg, F and Zn. As described by (Wittmas et al., 1981).

2.13 Determination of Vitamin Contents

Vitamin B1, B2, B6, folate and C were determined by a method as described by (Angelika et al., 2001). The actual concentration of the vitamins was calculated using bear Lambert's law; A = abc.

2.13.1 Determination of Vitamin A

Vitamin A was determined using HPLC (Angelika et al., 2001).

2.13.2 Determination of Percentage Nitrogen

Percentage Nitrogen for Urine and Faecal of the test animals was determine as described by AOAC (1990).

% N was calculated using the formula;

$$\%N = \frac{(A-B) \text{ x N x F x}100}{\text{Mg of sample}}$$

Where; A= ml of acid for titrating the sample

B = ml of acid for titrating blank sample

N = Normality of acid used for titration

F = Factor (14.007)

2.14 Sensory Evaluation

Fifteen panelists evaluated the sensory properties of cooked samples by using nine (9) hedonic scale from 9 (like extremely) to 1 (dislike extremely) for colour, texture, aroma, taste and overall acceptability of the couscous samples. Replication was achieved by the five different couscous samples being evaluated by fifteen panelists (Penfield & Campbell, 1990).

2.15 Statistical Analysis

The Statistical Package for Social Sciences (SPSS), version 20.0 was used to analyze the data collected which were expressed as means ± SE. One way analysis of variance (ANOVA) and Duncan's multiple range tests were used to compare the means obtained after each experiment. Differences were considered significant at $p < 0.05$.

3. Results

Table 1 shows the results of proximate nutrient composition of raw wheat couscous, sprouted wheat couscous, sprouted wheat couscous blends compared with commercial couscous. The moisture contents of raw wheat couscous and sprouted wheat couscous are 8.90% and 7.54% respectively. The moisture content of sprouted wheat couscous blends were 7.07%, 8.01% and 6.78% respectively. The commercial couscous moisture content was 9.16%. The ash content of raw wheat couscous and sprouted wheat couscous are 1.89% and 2.38% respectively. Sprouted wheat couscous blends ash contents were 2.64%, 3.16% and 2.98% respectively. The commercial couscous ash content was 0.83%. Crude protein of raw wheat couscous and sprouted wheat couscous are 12.86% and 5.46%. The sprouted wheat couscous blends protein content were 27.21%, 29.95% and 20.85% respectively. The commercial couscous crude protein was 12.53%. Crude fat of raw wheat couscous and sprouted wheat couscous are 1.42% and 2.92% respectively. Sprouted wheat couscous blends fat content were 7.48%, 8.95% and 8.35% respectively. The commercial couscous crude fat was 1.42%. Crude fiber of the raw wheat couscous and sprouted wheat couscous are 0.52% and 2.68% respectively. Sprouted wheat couscous blends crude fiber were 0.27%, 0.31% and 1.65% respectively. The commercial couscous crude fiber was 0.97%. Total carbohydrate of raw wheat couscous and sprouted wheat couscous are 74.41% and 79.04% respectively. Sprouted wheat couscous blends carbohydrate were 55.33%, 49.56% and 59.40% respectively. Commercial couscous carbohydrate was 75.10%. Energy (kcal) content of raw wheat couscous and sprouted wheat couscous are 361.89 and 364.54 respectively. The energy (kcal) of sprouted wheat couscous blends were 397.24, 398.54 and 396.11 respectively while the commercial couscous energy content was 363.20 kcal.

Table 1. Chemical Composition of Raw Wheat Couscous, Sprouted Wheat Couscous, Sprouted Wheat Couscous Blends

Sample	Raw	Sprouted	Blend 1	Blend 2	Blend 3	GPC
Moisture (%)	8.90 ± 0.02^{e}	7.54 ± 0.01^{c}	7.07 ± 0.01^{b}	8.01 ± 0.01^{d}	6.78 ± 0.01^{a}	9.16 ± 0.01^{f}
Ash (%)	1.89 ± 0.2^{b}	2.38 ± 0.02^{c}	2.64 ± 0.01^{d}	3.16 ± 0.01^{f}	2.98 ± 0.00^{e}	0.83 ± 0.02^{a}
Protein (%)	12.86 ± 0.01^{c}	5.46 ± 0.02^{a}	27.21 ± 0.01^{e}	29.95 ± 0.01^{f}	20.85 ± 0.01^{d}	12.53 ± 0.01^{b}
Fat (%)	1.42 ± 0.01^{a}	2.92 ± 0.02^{b}	7.48 ± 0.01^{c}	8.95 ± 0.02^{e}	8.35 ± 0.01^{d}	1.42 ± 0.01^{a}
Fiber (%)	0.52 ± 0.01^{c}	2.68 ± 0.01^{f}	0.27 ± 0.01^{a}	0.31 ± 0.01^{b}	1.65 ± 0.01^{e}	0.97 ± 0.01^{d}
Carbohydrate (%)	74.41 ± 0.04^{d}	79.04 ± 0.04^{f}	79.04 ± 0.04^{f}	79.04 ± 0.04^{f}	79.04 ± 0.04^{f}	75.10 ± 0.04^{e}
Energy (kcal)	361.89 ± 0.16^{a}	364.24 ± 0.21^{c}	397.48 ± 0.07^{e}	398.54 ± 0.15^{f}	396.11 ± 0.04^{d}	363.2 ± 0.11^{b}

Values are recorded as Mean ± SEM, n=4

Values on the same row with different superscript are significantly different ($P < 0.05$)

Blend 1 (Sprouted wheat mixed with soya bean and pumpkin seeds, 70:20:10)

Blend 2 (Sprouted wheat mixed with soya bean, 60:40)

Blend 3 (Sprouted wheat mixed with pumpkin seeds, 60:40)

GPC (Golden penny couscous)

Table 2 shows the mineral elements of raw wheat couscous, sprouted wheat couscous, sprouted wheat couscous blends compared with commercial couscous. Raw wheat couscous and sprouted wheat couscous had sodium (Na) content of 14.81mglg and 17.49 mg/g respectively. Sprouted wheat couscous blends recorded sodium values of 20.41 mg/g, 19.83 mg/g and 36.00 mg/g respectively. Commercial couscous sodium ion content was 21.23 mg/g. Potassium (K) content of raw wheat couscous and sprouted wheat couscous are 2.62 mg/g and 5.91 mg/g respectively. Sprouted wheat couscous blends potassium (k) content were 20.81 mg/g, 1.65 mg/g and 1.33 mg/g respectively potassium content of commercial couscous was found to be 2.34 mg/g. Calcium (Ca) values of raw wheat couscous and sprouted wheat couscous are 2.41 mg/g and 2.54 mg/g respectively. Sprouted wheat couscous blends recorded Ca values of 4.50 mg/g, 2.93 mg/g and 21.03 mg/g respectively. Commercial couscous Ca content was 2.62 mg/g. Raw wheat couscous and sprouted wheat couscous recorded Zinc (Zn) values of 1.27 mg/g and 0.42 mg/g respectively. Sprouted wheat couscous blends Zn values were 0.60 mg/g, 0.53 mg/g and 0.22 mg/g. Raw wheat couscous and sprouted wheat couscous recorded magnesium (mg) values of 0.81 mg/g, 0.75 mg/g and 1.41 mg/g respectively. Sprouted wheat couscous blends mg values were 1.41 mg/g, 1.01 mg/g and 7.03 mg/g respectively. Commercial couscous had a Zn value of 0.78 mg/g. The iron (Fe) content of raw wheat couscous and sprouted wheat couscous are 0.15 mg/g and 0.55 mg/g respectively. Sprouted wheat couscous blends Fe content were 0.68 mg/g, 0.44 mg/g and 0.70 mg/g respectively. Commercial couscous Fe content was found to be 0.71 mg/g.

Table 2. Mineral Elements of Raw Wheat Couscous, Sprouted Wheat Couscous, Sprouted Wheat Couscous blends Compared with Commercial Couscous

Mineral Elements (mg/g)	Raw	Sprouted	Blend 1	Blend 2	Blend 3	GPC
Na	14.81 ±0.01^{a}	17.49 ±0.00^{ab}	20.41 ±0.01^{c}	19.83 ±0.01^{bc}	86.0 ±2.00^{d}	21.23 ±0.01^{c}
K	2.62 ±0.01^{d}	5.91 ±0.00^{e}	20.81 ±0.01^{f}	1.63 ±0.01^{b}	1.33 ±0.01^{a}	2.34 ±0.01^{c}
Ca	2.41 ±0.01^{a}	2.54 ±0.00^{b}	4.50 ±0.01^{e}	2.93 ±0.01^{d}	21.03 ±0.00^{f}	2.62 ±0.01^{c}
Zn	1.27 ±0.01^{f}	0.42 ±0.01^{b}	0.60 ±0.01^{e}	0.53 ±0.01^{c}	0.22 ±0.01^{a}	0.56 ±0.01^{d}
Mg	0.81 ±0.00^{c}	0.75 ±0.00^{a}	1.41 ±0.01^{e}	1.01 ±0.00^{d}	7.03 ±0.01^{f}	0.78 ±0.01^{b}
Fe	0.15 ±0.00^{a}	0.55 ±0.01^{c}	0.68 ±0.01^{d}	0.44 ±0.01^{b}	0.70 ±0.01^{d}	0.71 ±0.01^{d}

Values are recorded as Mean ± SEM, n=4

Values on the same row with different superscript are significantly different (P< 0.05)

Blend 1 (Sprouted wheat mixed with soya bean and pumpkin seeds, 70:20:10)

Blend 2 (Sprouted wheat mixed with soya bean, 60:40)

Blend 3 (Sprouted wheat mixed with pumpkin seeds, 60:40)

GPC (Golden penny couscous).

Table 3 shows vitamins content of raw wheat couscous sprouted wheat couscous, sprouted wheat couscous, sprouted wheat couscous blends and commercial couscous. Vitamin A content of raw wheat couscous and sprouted wheat couscous are 13.58 µg/g and 12.99 µg/g respectively. Sprouted wheat couscous blends vitamin A content were 7.76 µg/g, 14.59 µg/g and 6.67 µg/g respectively. Commercial couscous vitamin A content was found to be 14.23 µg/g. Vitamin B1 (Thiamine) content of raw wheat couscous and sprouted wheat couscous are 0.13 µg/g and 0. 33 µg/g respectively. Sprouted wheat couscous vitamin B1 contents were 2.62 µ g/g, 2.74 µg/g and 2.72 µg/g respectively. Commercial couscous vitamin B1 content was 0.23 µg/g. Vitamin B2 (riboflavin) content of raw wheat couscous and sprouted wheat couscous are 1.34 µg/g and 0.94 µg/g respectively. Sprouted wheat couscous blends vitamin B2 contents were 2.23 µg/g, 2.24 µg/g and 10.82 µg/g respectively. Commercial couscous vitamin B2 was found to be 0.64 µg/g. Vitamin B6 (Pyridoxine) contents of raw wheat couscous and sprouted wheat couscous are 20.23 µg/g and 10.13 µg/g respectively. Sprouted wheat couscous blends vitamin B6 contents were 23.53 µg/g, 20.44 µg/g and 28.40 µg/g respectively. Commercial couscous vitamin B6 was found to be 0.33 µ g/g. Folic acid contents of raw wheat couscous and sprouted wheat couscous are 3.84 µg/g and 6.95 µg/g respectively. Sprouted wheat couscous blends folic acid contents were 10.63 µg/g, 28.13 µg/g and 25.50 µg/g respectively. Commercial couscous folic acid was found to be 5.54 µg/g. Vitamin C content of raw wheat couscous and sprouted wheat couscous are 19.79 µg/g and 13.35 µg/g respectively. Sprouted wheat couscous blends vitamin C contents were 19.61 µg/g, 13.39 µg/g and 152.14 µg/g respectively. Commercial couscous vitamin C content was found to be 13.37 µg/g.

Table 3. Vitamins Contents of Raw Wheat Couscous, Sprouted Wheat Couscous, Sprouted Wheat Couscous Blends Compared with Commercial Couscous

Vitamin (µg/ g)	Vit. A	Vit. B1	Vit. B2	Vit. B6	Folic Acid	Vit. C
Raw Wheat	13.58 ±0.01^{d}	0.13 ±0.01^{a}	1.34 ±0.02^{c}	20.23 ±0.01^{c}	3.84 ±0.01^{a}	19.79 ±0.20^{b}
Sprouted	12.99 ±0.01^{c}	0.33 ±0.01^{c}	0.94 ±0.01^{b}	10.13 ±0.01^{b}	6.95 ±0.02^{c}	13.35 ±0.02^{a}
Blend 1	7.76 ±0.01^{b}	2.62 ±0.02^{d}	2.23 ±0.01^{d}	23.53 ±0.01^{e}	10.63 ±0.01^{d}	19.61 ±0.22
Blend 2	14.57 ±0.02^{f}	2.74 ±0.01^{e}	2.24 ±0.01^{d}	20.44 ±0.01^{d}	28.13 ±0.01^{f}	13.39 ±0.02^{a}
Blend 3	6.67 ±0.02^{a}	2.72 ±0.02^{e}	10.82 ±0.01^{e}	28.40 ±0.01^{f}	25.50 ±0.01^{e}	152.14 ±0.01^{c}
GPC	14.23 ±0.01^{e}	0.23 ±0.01^{b}	0.64 ±0.02^{a}	0.33 ±0.01^{a}	5.54 ±0.01^{b}	13.37 ±0.01^{a}

Values are recorded as Mean ± SEM, n=4

Values on the same column with different superscript are significantly different (P< 0.05)

Blend 1 (Sprouted wheat mixed with soya bean and pumpkin seeds, 70:20:10

Blend 2 (Sprouted wheat mixed with soya bean, 60:40)

Blend 3 (Sprouted wheat mixed with pumpkin seeds, 60:40)

GPC (Golden penny couscous)

In vitro protein digestibility of raw wheat couscous, sprouted wheat couscous, sprouted wheat couscous blends compared with commercial couscous are presented in Table 4 *In vitro* protein digestibility of raw wheat couscous at 1 hour and 6 hours are 94.57% and 97.39% respectively. While sprouted wheat couscous *in vitro* protein digestibility at 1 hour and 6 hours are 98.22% and 89.76% respectively. Sprouted wheat couscous blends *in vitro* protein digestibility at 1 hour were 76.64%, 98.59% and 88.29% and at 6 hours were 96.80%, 99.33% and 97.49% respectively. While commercial couscous *in vitro* protein digestibility at 1 hour and 6 hours are 97.17% and 97.64% respectively.

Table 4. *In vitro* Protein Digestibility of Raw Wheat Couscous, Sprouted Wheat Couscous, Sprouted Wheat Couscous Blends Compared with Commercial Couscous

Digestibility (%)	Raw	Sprouted	Blend 1	Blend 2	Blend 3	GPC
1 hour	94.57 ± 0.01^{d}	98.22 ± 0.01^{c}	76.64 ± 0.01^{a}	98.59 ± 0.01^{f}	88.29 ± 0.02^{b}	95.17 ± 0.02^{e}
6 hours	97.39 ± 0.01^{c}	89.76 ± 0.01^{a}	96.80 ± 0.02^{b}	99.33 ± 0.01^{f}	97.49 ± 0.01^{d}	97.64 ± 0.01^{e}

Values are recorded as Mean ± SEM, n=4

Values on the same row with different superscript are significantly different (P< 0.05)

Blend 1 (Sprouted wheat mixed with soya bean and pumpkin seeds, 70:20:10)

Blend 2 (Sprouted wheat mixed with soya bean, 60:40)

Blend 3 (Sprouted wheat mixed with pumpkin seeds, 60:40)

GPC (Golden penny couscous)

Table 5 shows anti-nutrients content of raw wheat couscous, sprouted wheat couscous, sprouted wheat couscous blends compared with commercial couscous. Tannin contents of raw wheat couscous and sprouted wheat couscous are 5.33 mg/g and 2.06 mg/g respectively. Sprouted wheat couscous blends tannin contents were 4.10 mg/g, 3.27 mg/g and 2.27 mg/g respectively. Commercial couscous tannin contents was 0.62 mg/g. Phytic acid content of raw wheat couscous and sprouted wheat couscous are 0.34 mg/g and 0.98 mg/g respectively. Sprouted wheat couscous blends phytic acid were 0.53 mg/g, 0.55 mg/g and 0.21 mg/g respectively. Commercial couscous phytic acid was found to be 0.98mg/g.

Table 5. Anti- Nutrients Contents of Raw Wheat Couscous, Sprouted Wheat Couscous, Sprouted Wheat Couscous Blends Compared with Commercial Couscous

Anti-nutrients (mg/g)	Raw	Sprouted	Blend 1	Blend 2	Blend 3	GPC
Tannin	5.33 ± 0.01^{f}	2.06 ± 0.01^{b}	4.10 ± 0.1^{e}	3.27 ± 0.01^{d}	2.27 ± 0.01^{c}	0.62 ± 0.02^{a}
Phytic acid	0.34 ± 0.01^{b}	0.98 ± 0.01^{d}	0.53 ± 0.01^{c}	0.55 ± 0.00^{c}	0.21 ± 0.01^{a}	0.98 ± 0.01^{d}

Values are recorded as mean ±SE, n=4

Values on the same row with different superscript are significantly different (P<0.05)

Blend 1 (sprouted wheat mixed with soya bean and pumpkin seeds (70:20:10)

Blend 2 (sprouted wheat mixed with soya bean, 60:40)

Blend 3 (sprouted wheat mixed with pumpkin seeds, 60: 40)

GPC (Golden Penny couscous)

Table 6 **s**hows protein quality of raw wheat couscous and sprouted wheat couscous blends. Raw wheat couscous feed intake and weight gain are 41.79g and 327.54g respectively. Sprouted wheat couscous blends feed intake were 39.86g, 38.10g and 40.00g and weight gain were 327.77g, 334.93g and 255.70g respectively. Protein efficiency ratio (PER) of raw wheat couscous was 7.84% while sprouted wheat couscous blends PER were 8.22%, 8.79% and 6.40% respectively. Biological value (BV) raw wheat couscous was 97.68% while BV of sprouted wheat couscous blends were 95.73, 95.04% and 95.69% respectively. Apparent digestibility (AD) of raw wheat couscous was 96.85% while sprouted wheat couscous blends AD were 93.53%, 91.95% and 93.46% respectively. True digestibility (TD) of raw wheat couscous was 99.35% while sprouted what couscous blends TD were 97.58%, 96.17% and 97.47% respectively. Net protein utilization (NPU) of raw wheat couscous was 98.27% while sprouted wheat couscous blends NPU were 95.09%, 98.57% and 95.65% respectively.

Table 6. Protein Quality of Raw Wheat Couscous and Sprouted Wheat Couscous Blends

Parameter	Raw Wheat	Blend 1	Blend 2	Blend 3
Feed intake (g)	41.79 ± 0.02^{c}	39.86 ± 0.19^{b}	38.10 ± 0.36^{a}	40.00 ± 0.12^{b}
Weight gain (g)	327.54 ± 0.02^{b}	327.77 ± 0.02	334.93 ± 0.01^{c}	255.70 ± 0.26^{a}
Protein efficiency ratio (%)	7.84 ± 0.00^{b}	8.22 ± 0.04^{c}	8.79 ± 0.01^{d}	6.40 ± 0.00^{a}
Biological Value (%)	97.68 ± 0.01^{d}	95.73 ± 0.01^{c}	95.04 ± 0.01^{a}	95.67 ± 0.01^{b}
Apparent digestibility (%)	96.85 ± 0.01^{d}	93.53 ± 0.01^{c}	91.95 ± 0.01^{a}	93.46 ± 0.01^{b}
True digestibility (%)	99.35 ± 0.01^{d}	97.58 ± 0.01^{c}	96.17 ± 0.02^{a}	97.47 ± 0.02^{b}
Net protein utilization (%)	98.27 ± 0.01^{c}	95.09 ± 0.01^{a}	98.57 ± 0.01^{d}	95.56 ± 0.01^{b}

Values on the same row with different superscript are significantly different ($P<0.05$)

Blend 1 (sprouted wheat mixed with soya bean and pumpkin seeds (70:20:10)

Blend 2 (sprouted wheat mixed with soya bean, 60:40)

Blend 3 (sprouted wheat mixed with pumpkin seeds, 60: 40)

Table 7 shows sensory scores of raw wheat couscous, sprouted wheat couscous blends compared with commercial couscous. In terms of all the attributes tested, blend 2 was most acceptable by the panelists and was significantly different ($P<0.05$) from the data obtained on raw wheat couscous, blend 1, blend 3 and commercial couscous. In all, the samples were accepted with exception of blend1 which recorded lowest values.

Table 7. Sensory Scores of Raw Wheat Couscous, Sprouted Wheat Couscous Blends Compared with Commercial Couscous

Sample	Raw Wheat	Blend 1	Blend 2	Blend 3	GPC
Colour	7.92 ± 0.01^{c}	7.59 ± 0.01^{b}	8.34 ± 0.01^{e}	7.48 ± 0.01^{a}	7.98 ± 0.02^{d}
Texture	8.14 ± 0.01^{d}	5.49 ± 0.02^{a}	7.61 ± 0.01c	6.49 ± 0.02^{b}	8.19 ± 0.01^{e}
Aroma	7.94 ± 0.01^{d}	7.41 ± 0.01^{b}	7.66 ± 0.01^{c}	6.62 ± 0.02^{a}	8.32 ± 0.01^{e}
Taste	8.21 ± 0.01^{d}	8.46 ± 0.01^{e}	7.68 ± 0.01^{c}	6.89 ± 0.02^{a}	7.02 ± 0.02^{b}
Overall acceptability	7.94 ± 0.01^{d}	4.82 ± 0.02^{a}	8.22 ± 0.02^{e}	5.54 ± 0.01^{b}	7.32 ± 0.01^{c}

Values are recorded as Mean ± SEM, n=15

Values on the same row with different superscript are significantly different ($P< 0.05$)

Blend 1 (Sprouted wheat mixed with soya bean and pumpkin seeds, 70:20:10)

Blend 2 (Sprouted wheat mixed with soya bean, 60:40)

Blend 3 (Sprouted wheat mixed with pumpkin seeds, 60:40)

GPC (Golden penny couscous)

4. Discussion

4.1 Proximate Composition of Raw Wheat Couscous, Sprouted Wheat Couscous, Sprouted Wheat Couscous Blends Compared with Commercial Couscous

Table 1 shows that commercial couscous recorded the highest moisture content (9.16%). The ash content of the sprouted wheat couscous blends increased significantly ($P<0.05$) with addition of soya bean and pumpkin seeds combined and separately. The high protein and fat contents in the composite couscous could have come from the soya bean which is known to contain high protein and fat contents (Chike & Anita, 2016). Dietary fiber of blend 3 (1.65%) was higher than other samples. Fiber enhances the gastro intestinal tract (GIT), aids or helps normal bowel movement thereby reducing constipation problems. The lower content of carbohydrate in the sprouted wheat couscous blends could be due to the soya bean and pumpkin seeds that contributed high protein and low carbohydrate (Chike & Anita, 2016). The energy (kcal) of the couscous blends range from 361.89 to 398.54. The differences in the caloric value were associated with composition with each of the sprouted wheat couscous blends.

The results of mineral elements on raw wheat couscous sprouted wheat couscous, sprouted wheat couscous blends compared with commercial couscous were shown on Table 2 It was observed that sprouting (processing method) have increased the levels of Na, K, Ca and Fe and decreases the levels of Zn and Mg. Fortifications of sprouted wheat couscous with soya bean and pumpkin seeds had improved the mineral composition of the couscous blends produced traditionally. Blend 3 was found to have higher levels of Na, Ca, Mg and Fe followed by blend 2 and then blend 2. Commercial couscous had almost the same trend (values) of mineral elements as in sprouted wheat couscous blends produced traditionally. Celeik et al. (2004) reported that addition of soy flour increased nutritional values (protein,

Ca, K and Fe levels) of couscous and this was agreed with this study.

Table 3 shows the vitamins (A, B1, B2, B6, Folic acid and C) of raw wheat couscous, sprouted wheat couscous, sprouted wheat couscous blends compared with commercial couscous. It was observed that, the Vitamin A content of raw wheat couscous (13.58 μg/g) was higher than the sprouted what couscous (12.99 μg/g). Sprouted wheat couscous blend 2 had the highest Vitamin A (14.23 μg/g). There was significant difference ($P<0.05$) among the sprouted wheat couscous blends and the commercial couscous. Vitamin B1 (thiamine) contents of raw wheat couscous (0.13 μg/g) was lower than the sprouted wheat couscous (0.33 μg/g), the sprouted wheat couscous blends vitamin B1 contents are in close range from 2.62 μg/g and 2.74 μg/g and there was no significant difference between blend 2 and blend 3 vitamin B1 contents while the commercial couscous vitamin B1 (0.23 μg/g) was found to be lower than the sprouted wheat couscous blends vitamin B1 contents. Vitamin B2 (riboflavin) contents of raw wheat couscous (1.34 μg/g) was higher than the sprouted wheat couscous (0.94 μg/g), processing method (sprouting) had reduced the vitamin B2 content while on addition of soya bean and pumpkin seeds blend 3 had the highest contents of vitamin B2 while blend 1 and blend 2 are in close range while the commercial couscous vitamin B2 (0.64 μg/g) was Lower than the vitamin B2 content of the sprouted wheat couscous blends produced traditionally.

Vitamin B6 (pyridoxine) content of raw wheat couscous (20.23 μg/g) was higher than the sprouted wheat couscous (10.13 μg/g) fortification of sprouted wheat couscous with soya bean and pumpkin seeds had improved the vitamin B6 content of the sprouted wheat couscous blends, blend 3 had the highest vitamin B6 (28.40 μg/g) followed by blend 1 (23.53μ g/g) and the least was blend 2 (20.44 μg/g), while commercial couscous vitamin B6 (0.33 μg/g) was lower than the sprouted wheat couscous blends produced traditionally. Folic acid content of raw wheat couscous (3.84 μg/g) was lower than the sprouted wheat couscous (6.95 μg/g), fortification of sprouted wheat couscous had improved the folic acid contents. Blend 2 had the highest folic acid value (28.13 μg/g) followed by blend 3 (25.03 μg/g) and then blend 1 (10.63 μg/g) while commercial couscous folic acid content (5.54 μg/g) was lower than the sprouted wheat couscous blends produced traditionally and there was significant difference ($P<0.05$) among the sprouted wheat couscous blends and the commercial couscous used for comparison. Vitamin C content of raw wheat couscous (19.79 μg/g) was higher than the sprouted wheat couscous (13.35 μg/g) while sprouted wheat couscous blend 3 had the highest vitamin C content (152.14 μg/g) followed by blend 1 (19.61 μg/g) and then blend 2 (13.39 μg/g) and there was no significance difference between blend 2 vitamin C content and that of commercial couscous.

Results of *in vitro* protein digestibility of raw wheat couscous, sprouted wheat couscous, sprouted wheat couscous blends compared with commercial couscous are presented on Table 4 *in vitro* protein digestibility of raw wheat couscous at 1 hour (94.57%) and 6 hours (97.39%) and sprouted wheat couscous at 1 hour (98.22%) and at 6 hours (89.76%) respectively. This showed that digestibility of raw wheat couscous increases with increased in time. Sprouted wheat couscous digestibility at 1 hour (98.22%) was higher than that of 6 hours (89.76%), the differences in percentage may be as a result of

the crude protein contents in the sprouted wheat couscous. Sprouted wheat couscous blends *in vitro* protein digestibility showed a significant difference ($P<0.05$) among the sprouted wheat couscous blends and also between the sprouted couscous blends and the commercial couscous. Blend 2 had highest *in vitro* protein digestibility at 1 hour (98.59%) and at 6 hours (99.33%), followed by blend 3 at 1 hour (88.29%) and at 6 hours (97.49%) and least was blend 1 at 1 hour (76.64%) and at 6 hours (96.80%), while commercial couscous had *in vitro* protein digestibility at 1 hour (95.17%) and at 6 hours (97.64%) respectively.

Raw wheat couscous had high tannin (5.33 mg/g) than the sprouted wheat couscous (2.06 mg/g), this showed that sprouting had significantly reduced the tannin content while phytic acid content of sprouted wheat couscous (0.98 mg/g) was higher than the raw wheat couscous (0.34 mg/g). Sprouted wheat couscous blends tannin contents (4.10 mg/g, 3.27 mg/g and 2.27 mg/g) were significantly different ($P<0.05$), while commercial couscous tannin (0.62 mg/g) and phytic acid (0.98 mg/g) were lower than the values found in sprouted wheat couscous blends. The differences could be as a result of addition of soya bean and pumpkin seeds to the sprouted wheat couscous to complement the nutritional value of the traditional couscous blends produced.

Feed intake of raw wheat couscous (41.79 g) was higher than the values found in sprouted wheat couscous blends which ranged between 38.10 g to 40.00 g. Weight gain of raw wheat couscous (327.54 g) was not significant with the weight gained in blend1 (327.77 g) but there was significant difference ($P<0.05$) among the sprouted wheat couscous blends. Blend 2 had the highest weight gain (334.93 g). PER of raw wheat couscous (7.84%) was lower than the PER of blend 1 (8.22%) and blend 2 (8.79%) but higher than the PER of blend 3 (6.40%). Biological value (BV) of raw wheat couscous (97.68%) was higher than the BV of sprouted wheat couscous blends which ranged from 95.04% to 95.73% and are statistically significant ($P<0.05$). Apparent digestibility (AD) of raw wheat couscous (96.85%) was higher than the AD of the sprouted wheat couscous blends which range from 91.95% to 93.53% while true digestibility (TD) of raw wheat couscous (99.35%) was also higher than the TD of the sprouted wheat couscous blends which range from 96.17% to 97.58%. Net protein utilization (NPU) of raw wheat couscous (98.27%) was higher than the NPU of blend 1 (95.09%) and blend 3 (95.65%) and lower than the NPU of blend 2 (98.57%) which are all significantly different ($P<0.05$).

4.2 Sensory Evaluation

Fifteen panelists evaluated the sensory properties of cooked couscous samples by using Nine (9) hedonic scale from 9 (like extremely) to 1 (dislike extremely) for colour, texture, aroma, taste and overall acceptability of the couscous samples. Replication was achieved by the five different couscous samples being evaluated by fifteen panelists (Penfield & Campbell, 1990). In terms of all the attributes tested, blend 2 was most acceptable by the panelists and was significantly different ($P<0.05$) from the data obtained on raw wheat couscous, blend 1, blend 3 and commercial couscous. In all, the samples were accepted with exception of blend1 which recorded lowest values.

5. Conclusion

This study has shown that complementary couscous of acceptable quality can be produced from composites grits of wheat, soya bean and pumpkin seeds. Sprouting significantly reduced the levels of antinutrients, mineral elements and vitamins while supplementation of mono cereals with soya bean and pumpkin seeds have improved the nutritional value of the sprouted couscous blends produced traditionally.

The results of proximate composition showed significant increase in ash contents, crude protein, fat content and low carbohydrate contents in all the sprouted mono cereal couscous blends produced traditionally. Commercial couscous recorded lowest proximate values compared to sprouted couscous blends.

Results of mineral elements studied (Na, K, Ca, Zn, Mg and Fe) showed a significant decrease in some mineral elements, while supplementation of sprouted mono cereal with soya bean and Pumpkin seeds have significantly increased levels (Na, Ca, Mg, and Fe), with blend 3 of all the sprouted mono cereal recorded higher values of the mineral elements.

Results of vitamins analyzed (Vit. A, vit.B1, vit.B2, vit.B6, folic acid and vit.C) showed a significant difference ($P>0.05$) among the sprouted mono cereal couscous blends compared with commercial couscous. Blend 3 of all the mono cereal couscous blends recorded high levels of vitamins (vit. B2, vit B6, folic acid and vitamin C). Commercial couscous vitamin contents were lower or within a close range with the mono cereal couscous blends.

In vitro protein digestibility of each of the sprouted mono cereal couscous blends occurred at a range of 76% to 99% at 1 hour and 6 hours respectively.

The results of anti-nutrients showed that raw mono cereals contained higher tannin and phytic acid, while sprouting reduced the levels of these anti-nutrients and supplementation with soya bean and pumpkin seeds significantly enhanced the nutritional values of the sprouted mono cereal couscous blends produced. Commercial couscous recorded lowest tannin content (0.6 ± 0.02^{a}).

Biological assay (*in vivo* studies) showed high protein quality in raw and sprouted mono cereal couscous blends. Blend 1 if each of the sprouted mono cereal couscous blends recorded high PER, BV, AD, TD, and NPU.

In term of sensory score evaluation provides acceptability therefore, nutritious and acceptable complementary couscous blends can be produced from sprouted mono cereals fortified with soya bean and pumpkin seeds. The cost of producing traditional couscous blends is cheaper than commercial couscous.

5.1 Recommendation

I. It is therefore recommended that, proper processing method (s) before production and consumption of couscous blends be encourage, as it will reduces the levels of antinutrients and the absorption and utilization of minerals and vitamins will be maximized.

II. Fortification of sprouted mono cereals with soya bean and pumpkin seeds be encourage, since it will

serve as a food base approach to ameliorate micronutrients deficiency in children and adults.

III. More research should be conducted, as there are limited data available on couscous blends.

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