Production and quality evaluation of acha-cowpea-carrot based couscous

ABSTRACT

The quality of couscous produced from acha, cowpea and carrot flour blends were investigated. The chemical composition, functional and pasting properties of acha, cowpea and carrot flour blendsand sensory properties of the couscous prepared from acha, cowpea and carrot flour blends at ratios of 100:0:0; 90:5:5; 80:10:10; 75:15:10; 70:15:15; 65:20:15; 60:20:20; 55:25:20 and 50:25:25 were analyzed using standard methods.The moisture, crude protein, crude fat, ash and crude fibercontents increased from 9.38 to 14.49, 8.40 to 9.75, 1.59 to 2.62, 3.89 to 5.85 and 2.77 to 3.31% respectively with increase in the addition of cowpea and carrot flours. While the carbohydrates decreased from 73.97 to 63.98% with increase in the addition of cowpea and carrot flours. The sodium potassium, calcium, magnesium, zinc, iron and phosphorus contents of the couscous samples content ranged from 13.51 to 33.78, 89.10 to 128.44, 23.20 to 40.72, 1.80 to 4.44, 3.71 to 14, 125.72 to 196. 35 and 91.53 to 118.91 mg/100g, respectively.The average means scores for mouth feel, texture and flavor increased from 5.75 to 6.88, 6.00 to 7.18 and 6.68 to 6.94, respectively, with increases in cowpea flour from 5- 20% and decreased with further increase. The most acceptable and preferred couscous blend was that with 20% cowpea and 15% carrot flour with corresponding improvement of 12.38% protein and 44.18% fiber content. The acceptability of acha-cowpea-carrot flour blend couscous will greatly improve the nutritional intake of the consumers and as well reduce importation of wheat flour and encourage commercial growth of cowpea and carrot in Nigeria.

Key Word: Production, quality evaluation, acha-cowpea-carrot, couscous

INTRODUCTION

Couscous is made from durum wheat semolina and is reported to be rich in starch with low vitamins, minerals, dietary fibers, and phenolic compounds.Couscous is a traditional pasta like food which is commonly produced by using wheat semolina, *acha*, *millet* andsorghum in Africa and Asia(Coskun, 2013). Pasta, with legumes, herbs, and vegetables, was found as a complete, delicious, and healthy food (Kaur *et al.*, 2012). In recent years, different functional ingredients have been used to increase the nutritional as well as functional properties of pasta. Pasta has been enriched with some cereals, pseudo-cereals, legume flour, fruit, and vegetable powder as a source of fiber, minerals, antioxidants, and polyphenols: common bean flour (Gallegos-Infante *et al.*, 2010), carrot powder (Badwaik *et al.*, 2012), white bean, yellow pea and lentil (Wojtowicz & Moscicki, 2014).

Cowpea (*Vignaunguiculata*) is an indigenous tropical legume that produces pods and grain that are highly nutritious and valuable because it contributes to the livelihood of several millions of people in West and Central Africa. It is a rich source of protein up to 30% (Boukar *et al.,* 2010). Cowpea is of importance to livelihoods of relatively poor people in less developed countries of tropics especially where animal protein is not easily available for the family (Pindar *et al.,* 2018).Cowpea seed is also a good source of bioactive compounds such as flavonols and hydroxybenzoic acids, that can reduce the risk for physiological disorders such as obesity, dyslipidemia and cardiovascular complications (Sreerama *et al.,* 2012).

Carrot (*Daucus carota* L) is also one of the important nutritious root vegetables grown throughout the world. Carotenoids are potent antioxidants present in carrots which help to neutralize the effect of free radicals. Reports have showed that they have inhibitory mutagenesis activity thus, contributing to decrease risk of some cancers (Dias, 2012).

The consumers' quest for novel and other –free food, as well as wholegrain food has prompted the couscous industry to produce and market a number of products where traditional shapes have been maintained but durum wheat has been partially or totally replaced by other cereals, pseudo-cereals or other flours of vegetable origin, particularly legumes (Schoenlechner, 2016). Raw materials of vegetable origin could be a source of phytochemicals with promising biological effects. Among them, phenolic compounds have attracted attention as molecules able to improve the wellbeing and longevity of the human population (Ferreira*et al.,* 2017).

Hunger and malnutrition remain a serious problem in third world countries like Nigeria. Non-communicable diseases (NCDs), which were formerly regarded to be diseases of affluence, have also recently emerged as a major health problem to even resource-disadvantaged members of the society, especially in developing countries.

The emergence of novel fast food habits, associated with a reduced investment on food innovation, resulted in a reduced attractiveness of legume food products.Many legumes have, nevertheless, remained underexploited in most emerging and developed economies, partially due to the length of time required for their preparation and the need to remove undesirable beany flavors and ant nutritional compounds.

Most of the cereal based food consumed in Nigeria is made from wheat which is imported and drains a lot of foreign exchange. The inability of Nigeria to meet the increasing demand for pasta has in sequence called for research into alternative local source of flour for producing pasta like couscous.

Couscous is commercially produced with wheat which is imported as the major ingredient; and gluten in wheat has been linked to the cause of some ailments like Control of Vitamin A deficiency (VAD), iron deficiency anaemia (IDA) and iodine deficiency disorders (IDD) remain a big challenge for nutritionists and health workers.

Acha, cowpea and carrot are cultivated in Nigeria. These crops are naturally nutrient dense and can contribute immensely to good health. The crops are available and affordable all year round, but the masses are not aware of the numerous nutritional benefits to human health. Acha though potentially rich in nutrients, has been classified among the lost crops with the cultivation and processing at village level technology.

Withthegrowingdemandforadequatesuppliesoffoodtofeedtheeverincreasingworldpopulation,opportunitiesexistforfoodprocessorstodevelopnovelfoodsfortifiedwithlegumeingredientswhicharehealthyandconvenientandwhichtakeadvantageofthe techno-functionalpropertiesoflegumeflours.Severalstudieshavefocusedondevelopingnewproducts,suchaslow-fatmeatballs,extrudedsnacks,weaningfood,bread,andmacaroni,byusinglegumefloursasingredients.Furtherresearchisstillneededtoexpandtheavailabilityoftheselegumebasedproductsandtooptimizethequalityoftheselegume-basedproductsforspecific markets.Product such as couscous can be considered a convenient vehicle for the addition of micronutrients and protein to meet these consumer health demands.Couscous is progressing towards becoming a world renowned food.

In developing countries, where protein-calorie (PCM)and micro-nutrient (MNM) malnutrition are major problems, legumes may be considered as a substitute of the expensive and sometimes scarce animal protein, to complement cereals, in lysine balance and serve as a cheap source of dietary fibre, vitamins andantioxidant compounds with beneficial health effects in weight, intestinal function, glycaemia and LDL cholesterol levels.

Nowadays, the need for easy prepared meals increased due to the fast lifestyles and people are more aware about the importance of nutritionally valued products and its benefits to health. Growing concerns about the potential negative health impacts of consuming food with high amounts of fat and cholesterol has increased interest in using plant-derived foods such as legumes which contain low-fat and are cholesterol free in food formulation.Whole legumes can be milled into flour or fractionated into protein, starch and fiber fractions, and these components can be incorporated into commercial food products as functional or replacement ingredients, thereby facilitating their use.

Recent research studies have, furthermore, suggested that consumption of legumes may have potential health benefits including reduced risk of cardiovascular disease, cancer, diabetes, hypertension, gastro-intestinal disorder, adrenal disease and reduction of LDL cholesterol. Such studies have spurred interest in using whole legumes and their fractions in developing a variety of novel food products.

Also in recent years, consumption of carrot and its related products has increased steadily due to the recognition of antioxidant and anticancer activities of ß-carotene. Nutritious food products utilizing carrot had been developed and accepted by consumers.

Consequently, consumption of carrot and its products would be very useful in alleviating vitamin A deficiency particularly, among children below six years and adults.

As the world population increases, increase in the commercial production of couscous, and its recognition all over the world will be supported by the studies of couscous. The broad objective of this study was to investigate the quality of acha-cowpea-carrot flourblends andcouscous.

MATERIALS AND METHODS

Materials and material preparation

Acha grains (*D.exilis*); cowpea (*Phaseleous vulgaris*) and carrot*(Daucus carota)* were purchased from Bukuru market in Jos South Local Government Plateau State Nigeria. Other ingredients like vegetable oil (kings), monosodium glutamate (maggi), salt (Dangote table salt and curry spice (Tiger) were also purchased in the same market.Wister Albino rats were purchased from Veterinary Research Institute Vom Jos.

Preparation of Acha flour: Preparation of acha flour was done by the method described by Olapade *et al.* (2012). The grains of acha were sorted manually, washed, destoned(manually), dried (oven for 4hrs 50mins at 40^0C), milled (Attrition mill model no 0712098) and sieved (0.3μm aperture) to produce acha flour and packaged (plasticbottles).

Preparation of cowpea flour: Preparation of cowpea flour was done by the method described by Olapade *et al.* (2012). The cowpeas were manually sorted, moistened(wet with portable water to soften the beans), de-husk manually(squeezing the beans in between two palms and husk removed by floatation).The clean seeds(husk freed) were cooked for ten minutes in boiling (100^{0}C) water; drained, air oven dried(45^{0}C for 8 hours). The dried beans were now milled (hammer mill), sieved (0.3µm aperture size) and stored in air tight container.

Preparation of carrot flour: Preparation of carrot flour was done by the method described by Olapade *et al.* (2012). The selected carrots were manually washed(portable water), sorted, sliced(manually), blanched(5 minutes), dried(oven for 10 hours at 40^{0}C), milled(Attritionmill model no 0712098), sieved(0.3nm aperture) to, produce carrot flour and packed(edible polyethylene transparent bag and stored at room temperature.

Production of acha-cowpea-carrot composite flours: Couscous samples were prepared as described by Talim (2012). Couscous samples were prepared from different blends of refined acha flour, cowpea flour and carrot powder in the respective ratios of 100:0:0; 90:5:5; 80:10:10; 75:15:10; 70:15:15;65:20:15;60:20:20;55:25:20 and 50:25:25.

The flour composite is sprinkled with clean water and rolled with hands to form small pellets. Dry flour was sprinkled to keep them separate, and then sieved with a 0.4um aperture sieve. Pellets too small to be finished granules of couscous fall through the sieve and are again rolled and sprinkled with dry flour and rolled again into pellets. The pellets were put into colander and steamed over a pot of boiling water for five minutes. It was then spread on stainless steel trays and dried in hot air oven of 45^{0}C for 35 minutes. It was allowed to cool and packaged in transparent polyethylene bags. Table 1 showed the blends of acha-cowpea-carrot composite flour..

Table 1: Recipe for production of cowpea-carrot-acha flour blends of couscous.

Treatments	Acha flour	cowpea flour	Carrot powder
C1	100	0	0
F1	90	5	5
F2	80	10	10
F3	75	15	10
F4	70	15	15
F5	65	20	15
F6	60	20	20
F7	55	25	20

F8	50	25	25

Methods

Determination of the proximate composition of flour blend couscous

The proximate (protein, fat, ash, fibre, carbohydrate moisture) composition of the blend couscous was determined using AOAC(2012) method.

Determination of the mineral content of the flour blend couscous

Wet ashing method was used. 1g of the dried powdered sample were digested with 10ml nitric acid and 5ml perchloric acid in 100ml digestion flask and allowed to stand overnight in fume cupboard. The mixture was heated until the yellowish fume and white dense fume of nitric and perchloric acid respectively ceased. The contents were cooled and filtered through whatman filter paper, transferred into sample bottles and made up to 100ml with deionized water. The iron, zinc, calcium, magnesium, manganese and copper content were analysed using Atomic Absorption Spectrophotometer (AOAC 2012).

Determination of the functional properties of flours and flour blends

Bulk Density: was determinedas described by Onwuka (2005). A graduated cylinder uiiu10ml was weighed dry and gently oiled with the flour sample. The bottom of the cylinder was tapped gently on a laboratory bench several times. This continues until no further diminution of the test flour in the cylinder after filling to mark, was observed. Weight of cylinder plus flour was measured and recorded.

Bulk density (g/ml) = $\frac{weight\ of sample\ (g)}{volume\ of\ sample\ (after\ tapping\ )}$

Water Absorption capacity: was determined according to the method described by Akubor (2005). One gram sample was mixed with 10-ml distilled water (specific gravity 0.904 kg/m^3) and allowed to stand at ambient temperature (B1$\pm$2^{0}C) for 30 minutes and then centrifuged at 3,000 pm for 30 minutes using centrifuge model 800D (Hettich, Universal 11. Herford, Germany). Water absorption capacity was expressed as percentage water bound per gram flour.

Water absorption capacity = $\frac{weight\ of\ water\ absorped\ \ x\ density\ of\ water}{sample\ \ weight\ (g)}$

Oil Absorption capacity: Oil absorption capacity as determined using the method of Ukabi *et al.*, (1990). One gram of the sample (100) was weighed into pre-weighed 15ml centrifuge tubes at 300rpm for 20minutes immediately after centrifugation, the supernatant was carefully poured into a 10ml graduated cylinder, and the volume was recorded (v2). Oil absorption capacity (milliliter of oil gram of sampled was calculated. OAC = $\frac{weight\ of\ oil\ absorbed\ (g) x\ density\ of\ water}{sample\ weight}$

Oil Absorption capacity = $\frac{V1-V2}{100}$

Oil absorption capacity was expressed as gram of oil bound per gram of the sample on a dry basis swelling index. The method was used.

Swelling capacity: The gel obtained from swelling index was used in calculating swelling capacity (Sc). The swelling capacity (SC) of the samples was determined by putting 25g of each sample in a 210ml measuring cylinder. Distilled water (150ml) was added and allowed to stand for four hours before observing the level of swelling. The swelling index was calculated.

SC = $\frac{\text{volume after soaking} - \text{volume before soaking}}{\text{weight of sample}}\ X\ 100$

Foam capacity: Foam capacity was determined according to the method described by Onwuka (2005). 2gm of flour sample was weighed and added to 50ml distilled water in a 100ml measuring cylinder. The suspension was mixed and properly shaken to foam and the total volume after 30 seconds was recorded. The percentage increase in volume after 30 seconds is expressed as foaming capacity.

Foaming capacity = $\frac{\text{volume after whipping} - \text{volume before whipping}}{\text{volume after whipping}}$

Emulsification capacity.

This was determined with the method described by Kausha *et al.*, (2012) with slight adjustment. Two grams of sample blend was blended with 25ml distilled water at room temperature for 30 seconds. The 10ml of refined soya oil was added and the blending continued for another 30 seconds before transferring into a centrifuge tube. Centrifugation was done at 640xg for 5 minutes the volume of oil separated from the sample after centrifuging was read directly from the tube. Emulsification capacity was expressed as the amount as the amount of oil emulsified and held per gram of sample.

Emulsification capacity (%) = $\frac{\text{Height of emulsified layer}}{\text{Ht of whole solution in the centrifuge tube}}$ x 100

Determination of pasting properties of the flour blends

Pasting characteristics were determined using a rapid visco analyzer (model RVA 3D + Newfort scientific Austrsl. Pasting characteristics were determined using a rapid visco analyzer (model RVA 3D + Newfort scientific Australia) and thermocline for windows program (version 1. 10); viscosity was expressed in RVU (rapid viscosity units) as described by AACC 2001. Acha-iron-bean-carrot couscous (2.5g of the sample of flour was weighed into a previously dried canister and 25ml of distilled water was dispersed into the canister containing the sample. The suspension was thoroughly mixed and the canister was fitted into the rapid visco analyzer as recommended. Each suspension was kept at 50^{o}c for 1min and then heated up to 95^{o}c within 3.5min, with a holding time of 2.5min, then cooled to 50c within 4min and finally held at 50c for 2min. the rotating speed was held constant at 960rpm for 10sec. and then maintained at 160rpm for the duration of the process. To prevent the activity of amylases 100umol silver nitrate per gram starch (dry basis) was added to the sample. Recorded parameters included peak viscosity, trough viscosity, breakdown, final viscosity, setback, peak time and pasting temperature, are read from the pasting profile with the aid of thermocline for windows software connected to a computer (Newport scientific 1998).

Sensory evaluation of the flour blend couscous

The couscous samples were stored in High density edible polyethylene bag for 2 months and analyzed monthly for sensory properties.

The 9-point hedonic scale assessment and the pares comparison tests were used as described by Ayo, et al (2018). A total of 20 untrained panelists from a cross-section of students and staff of the Department of biochemistry National Veterinary Research Institute Vom Jos, and staff and students of Plateau state college of Health Technology Zawan Jos Plateau state were selected based on their familiarity with couscous pasta the panelist scored coded couscous in terms of degree of flavor, mouth feel, appearance, texture, chewability and general acceptability. The 9-point hedonic scale used by the panelists for the evaluation range from 1-9 representing “disliked extremely“to “like extremely.The coded samples of couscous were served in clean flat plates, done in illuminated board room with fluorescent light at a time. Water was given to each panelist for oral rinsing in between tasting of the samples.

Experimental Design and Statistical Analysis

The experimental design for the study was completely randomized design. All the data that will be obtained from this study will be subjected to analysis of variance (ANOVA) using statistical package for Social Sciences (SPSS) software version 20. Different significantly means will be separated using Duncan's multiple range test

RESULTS AND DISCUSSIONS

Functional Properties of Acha, Cowpea and Carrot Flour Blends

The results of functional properties are shown in Table 2. The water absorption capacity, foaming stability and swelling index increased from 3.03 – 3.57, 66.00 – 79.05, and 7.01 – 8.07, respectively, while the oil absorption capacity, bulk density, emulsion activity, and foaming capacity decreased from 3.01 – 2.55, 0.92 – 0.81 ml/g, 62.00 – 56.88%, 6.95 – 4.03% and 7.01 – 8.07, respectively, with increase in added cowpea and carrot flours. Water absorption was higher for couscous, meaning that it has a higher cooking yield than pasta.

Functional properties of Flours are unique properties that are used for the development of several food products. Although the functional properties of food materials are attributed mainly to its protein, other components such as carbohydrate, fat and crude fibre make important contribution (Onimawo and Akubor, 2012). The 50:25:25% acha: cowpea: carrot flour sample had the highest value for water absorption, foam stability and swelling capacity and lowest value for bulk density, oil absorption,emulsion activity and foaming capacity. The results agreed with the reported values for acha-carrot flour byAyo and Gidado (2017) but oil absorption capacity.

Bulk density is significant in package design, storage and transport of foodstuff (Akpataand Akubor, 1999). This revealed that bulk density depends on the particle size and moisture content of flours. The high bulk density of flour could suggest their suitability for use in food preparations. On contrast, low bulk density would be an advantage in the formulation of complementary foods.

It is an indication of the porosity of a product which influences package design. Bulk density could be used in determining the packaging requirements of flour as it relates to the load the sample could carry if allowed to rest directly on one another. Bulk density also relates to the mouth feel and flavor of the food the flour is incorporated in. Low bulk density for flour would be an advantage in the preparation of complementary foods. Bulk density is affected by the moisture content and it reflects particle size distribution of the flavor. An increase in bulk density of flour enhances fat absorption (Onimawo and Akubor, 2012)

Water absorption capacity defines the ability of a product to associate with water under conditions where water is limited (Singh *et al.*, 2001). The highest water absorption capacity of the 100:25:25% acha-cowpea-carrot samples could be attributed to the presence of higher amount of fibre in this flour. Water absorption capacity is a critical function of protein in various food products like soups, dough and baked products (Adeyeye*et al.,* 1999).Water absorption property is a useful indication of whether protein can incorporated with aqueous food formulations, especially those involving dough handling such as processed cheese, sausages and bread dough. The interactions of proteins with water is important to properties such as hydration, swelling, solubility and gelation. Water absorption of food is a function of ionic strength, pH, temperature, size and shape of the protein molecule.

The oil absorption capacityof the flour blends was generally high. Oil absorption capacity is the ability of flour to absorb oil which is important as oil act as flavorsretainer and improves mouthfeel (Aremu *et al*., 2007). Water absorption capacity is the ability of a product to associate with water under limiting conditions. Flours with such high WAC as seen in this research work are very good in bakery products, because this will prevent staling by reducingmoisture loss (Singh et al., 2001).

The water and oil binding capacity of protein depend upon the intrinsic factors like amino acidcomposition, protein conformation and surface polarity or hydrophobicity (Singh *et al.,* 2001).The ability of the proteins of these flours to bind with oil could makes it useful in food systemwhere optimum oil absorption is desired. High oil absorption capacity could make flours suitable in facilitating enhancement in flavor and mouth feel when used in food preparation. The ability of protein to bind fat is an important property in food formulations since fats act as flavor retainer and increases the mouth of feel for food. Oil absorption capacity is requiring in ground meat formulations, meat replacers and extenders, doughnuts, salad dressing, pan cake, baked goods, mayonnaise and soups. Fats are used to give soft texture and good flavors to foods.

Highest emulsion activity (62.00%) was observed in 100% acha sample. Difference in the emulsion activity of the flours may be related to their solubility exhibited by the lowest emulsifying activity and highest emulsion stability. Hydrophobicity ofprotein has been found to influence their emulsifying properties (Kaushal*et al.,* 2012). These properties are influenced by many factors among which are solubility, pH and concentration. The capacity of protein to enhance the formation and stabilization of emulsions is important for many applications in food products like cake, coffee whiteners and frozen desserts. In these products, varying emulsifying and stabilizing capacity are required because of their various compositions and processes (Adebowale *et al.,* 1998).

The emulsifying activity measures the maximum oil addition until phase secretion occurs while emulsion stability measures the tendency for the emulsion to remain unchanged. The emulsion activity relates to the ability of the protein to lower the tension at the interface of water oil. The stabilizing effect of proteins on emulsion is due to the protective barrier around fat droplets that prevent their coalescence (Onimawo and Akubor, 2012).

Thecapacity of protein to aid the formation and stabilization of emulsion is important on cakes, batters, milk, mayonnaise, salad dressing, comunited meat and frozen desserts. The efficiency of emulsification by seed proteins varies with the type of protein, its concentration and solubility, pH, ionic strength, viscosity of the system, temperature and method of preparation of the emulsion. Soluble proteins are surface active and known to promote oil in water emulsions (Onimawo and Akubor, 2012).

A relationship between emulsifying activity and nitrogen solubility is consistent with the need of the protein molecules to diffuse to the oil-water interface of an emulsion. Increase in protein concentration facilitates absorption of protein resulting in enhanced stability of emulsion. The pH or the medium indirectly affects emulsion activity of proteins by influencing protein stability (Onimawo and Akubor, 2012).

Foaming capacity and foam stability are used as indices of formability of protein dispersion. Proteins foams are important in many processes in the beverage and food industries and this has stimulated interest in their formulation and stability. Foams are used to improve texture, consistency and appearance of food. Foams in food system are found commonly in baked, confectionary and other foods.

Formability is thus related to the rate of decrease of surface tension of the water interface caused by absorption of protein molecule. The foaming capacity versus pH profile, suggesting that foaming property is also dependent on solubilized proteins foaming capacity of legume seed flour concentration dependent. The superiority of soyflour to other legume seed flours in foaming property is due to high protein content of soyflour. Foam stability is reduced heat processed flour. This si attributed to the denaturation of the proteins on heating that became less soluble. Foam stability is affected by protein denaturation, with native protein giving higher stability than denatured protein (Onimawo and Akubor, 2012).

The acha-cowpea-carrot (75:25:25%) sample had the highest swelling capacity (8.58 ml/g). The swelling capacity of flours depends on size of particles, types of variety and types of processingmethods or unit operations. The foam capacity (FC) decreased from 6.95 to 4.08. 100:0% acha sample obtained the highest foam capacity.High swelling capacity has been reported as part of the criteria for a good quality product (Nlba *et al*., 2001). The swelling capacity of the flour samples can be compared with results reportedby Adeyanju*et al*. (2018).

Table 2:Functional Propertiesof Acha, Cowpea and Carrot Flour Blends

	Treatments					
Treatments	A	B	C	D	E	F
WAC (ml/g)	$3.03^{c}\pm0.21$	$3.04^{c}\pm0.30$	$3.11^{c}\pm0.36$	$3.29^{b}\pm0.93$	$3.29^{b}\pm0.03$	$3.57^{a}\pm0.04$
OAC(ml/g)	$3.01^{a}\pm0.22$	$2.54^{b}\pm0.50$	$2.53^{b}\pm0.10$	$2.55^{b}\pm0.50$	$2.55^{b}\pm0.50$	$2.68^{b}\pm0.04$
BD (g/cm^3)	$0.92^{a}\pm0.05$	$0.91^{a}\pm0.55$	$0.80^{b}\pm0.05$	$0.82^{b}\pm0.48$	$0.82^{b}\pm0.48$	$0.81^{b}\pm0.01$
EAC (%)	$62.00^{a}\pm1.09$	$59.05^{b}\pm1.18$	$56.01^{c}\pm1.18$	$56.88^{c}\pm1.02$	$56.88^{c}\pm1.02$	$57.61^{c}\pm0.04$
FC(ml/g)	$6.95^{a}\pm0.28$	$4.82^{b}\pm0.59$	$4.23^{c}\pm0.59$	$4.18^{c}\pm0.81$	$4.08^{c}\pm0.11$	$4.13^{c}\pm0.03$
FST (%)	$66.00^{b}\pm0.88$	$71.00^{ab}\pm0.48$	$75.03^{a}\pm0.48$	$77.02^{a}\pm0.93$	$77.02^{a}\pm0.93$	$79.05^{a}\pm1.02$
SC (ml/g)	$7.01^{d}\pm1.03$	$7.52^{c}\pm0.49$	$7.56^{c}\pm0.49$	$7.58^{c}\pm0.20$	$8.08^{a}\pm0.50$	$8.58^{a}\pm0.04$

Values are means ± standard deviation of triplicate determinations. Values in the same row with different superscripts are significantly different ($p<0.05$).

Key:

A = Couscous prepared from 100% acha flour (control sample)

B = Couscous prepared from 90% acha flour, 5% cowpea flour and 5% carrot flour

C = Couscous prepared from 75% acha flour, 15% cowpea flour and 10% carrot flour

D = Couscous prepared from 70% acha flour, 15% cowpea flour and 15% carrot flour

E = Couscous prepared from 65% acha flour, 20% cowpea flour and 15% carrot flour

F = Couscous prepared from 50% acha flour, 25% cowpea flour and 25% carrot flour

Pasting properties of Acha, Cowpea and Carrot Flour Blends

Substitution of cowpea and carrot flours to acha flour significantly ($p < 0.05$) decreased peak viscosity (from 90.67 to 87.33 RVU), trough viscosity (from 82.67 to 74.08 RVU), final viscosity (from 175.75 to 160.08 RVU) and setback viscosity (93.08 to 86.00 RVU), peak time (5.07 – 5.73 min) and pasting temperature (from 88.80 to 81.45^{o}C) of acha flour (Table 3) while breakdown viscosity significantly ($p < 0.05$) increased (from 8.00 to 13.25 RVU).

This similar to result reported by ayo 2017 which shows that the peak viscosity, trough viscosity,breakdown, final viscosity, and setback decreased from 216.83±0.06 – 143.21±0.05, 142.17±0.04 – 105.46±0.02, 74.67±2.60 – 37.75±2.72, 351.58±0.09 – 207.71±0.07, and209.42±0.06 102.25±0.05 RVU, respectively. But only different in breakdown viscosity.

The results of pasting properties of acha- cowpea- carrot blends are similar to the findings of Adeyanju *et al.* (2018) from wheat, acha and pigeon pea flour blends.Pasting properties are dependent on the rigidity of starch granules, with consequent effect on the granule swelling potential and the amount of amylose leaching out in the solution (Morris, 1990). The high content of starch in the 100:0:0% acha-cowpea-carrot sample, compared to other samples may contribute to some extent, to the higher pasting viscosity observed, which could be the resultant effect of decrease in viscosities with decrease in the acha flour proportion.High values of breakdown, associated with high peak viscosities could be related to the degree of swelling of the starch granules during heating. The peak viscosity often correlates with the quality of end-product and also provides an indication of the viscous load likely to be encountered by a mixing cooker (Sanaa and El-Sayed, 2004). The lower setback viscosities of acha starches could make the suitable for preparing gels with tendencies to synerese (Jideani and Akingbala, 1993).

Pasting time of fonio grains reported by Jideani *et al.* (1996) was significantly higher than that obtained in this study which could be due to climatic and soil factors. A higher pasting temperature indicates high water-binding capacity, higher gelatinization tendency and lower swelling property of starch-based flour due to high degree of associative forces between starch granules (Adebowale *et al.*, 2005). Pasting temperature is one of the properties which provide an indication of the minimum temperature required for sample cooking, energy costs involved and other components stability. Therefore, from the results obtained, inclusion of cowpea and carrot flours could be said to cook longer with more energy consumption, thereby increasing time and cost.

The peak viscosity indicates the strength of pastes formed from gelatinization during food processing. It also reflects the extent of granule swelling (Giami, 2004) and could be

Parameters

indication of the viscous load likely to be encountered during mixing.

Also the setback value ranged from 86.00-93.08 RVU. The highest set back value was recorded for 100% acha and the lowest set back value was recorded for 50% acha, 25% cowpea and 25% carrot flours.

Peak viscosity is an index of the capacity of starch-based food to swell freely before their physical breakdown (Sanni *et al*., 2006; Adebowale *et al*., 2008). The breakdown value ranged from 8.00 to 13.25 RVU. Adebowale *et al*. (2005) suggested that as breakdown in viscosity increased, the ability of the sample to withstand heating and shear stress during cooking decreased. The final viscosity is a measure of the stability of granules. The final viscosity ranged from 160.08 to 175.75 RVU. Shimels *et al*. (2006) reported that final viscosity is necessary to indicate the ability of starch to form various paste after cooling and that less stability of starch paste is commonly accompanied with the high value of breakdown.

The higher the setback, the lesser the retrogradation of the flour paste during cooling and the lower the stalling rate of the product made from the flour (Adeyemi and Idowu, 1990). The peak time of the flour blends ranged from 5.07 to 5.60 min. Peak time is the time at which the peak viscosity occurred in minutes and this is a measure of the cooking time of the flour (Adebowale *et al*., 2005). The pasting temperature of the flour blends ranged from 81.45 to 88.80 °C. The pasting temperatures for the samples were quite higher than values obtained for acha-carrot flour blend (Ayo and Gidado, 2017).

Couscous does not require extrusion, but steaming before drying, and hence it presents a high degree of gelatinized starch, together with a higher capability of water absorption when rehydrated during cooking. On the other hand, pasta and couscous produced by gluten-free cereals, pseudocereals and legumes require appropriate formulations (addition of protein extracts that imitate gluten, thickeners or pre-gelatinized starch) and processing conditions (hydrothermal treatment/cooling that induces starch gelatinization/retrogradation, extrusion cooking, and high temperature drying that induces protein denaturation) to assure the tightness of the gluten-free structure that prevents leaching and break-up during cooking.

Treatments	Peak (RVU)	Trough (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Set back (RVU)	Peak time (Min)	Pasting temperature (^{o}C)
A	90.67^{a}±0.86	82.67^{a}±0.89	8.00^{b}±0.96	175.75^{a}±1.09	93.08^{a}±1.18	5.60^{a}±1.18	88.80^{a}±1.02
B	89.92^{a}±0.12	79.00^{a}±0.47	10.92^{b}±0.77	165.00^{b}±0.34	86.00^{b}±0.52	5.73^{a}±0.88	86.25^{a}±0.41
C	89.83^{a}±0.93	77.25^{ab}±0.30	12.58^{a}±0.89	163.33^{b}±0.28	86.08^{b}±0.59	5.50^{ab}±0.21	84.80^{b}±0.81
D	89.16^{a}±0.26	76.42^{ab}±0.55	12.74^{a}±0.96	163.17^{b}±0.88	86.75^{b}±0.48	5.30^{b}±0.48	83.65^{b}±0.93
E	88.67^{a}±1.15	75.75^{b}±0.43	12.92^{a}±0.28	162.50^{ab}±1.03	86.75^{b}±0.67	5.07^{c}±0.49	81.45^{c}±0.07
F	87.33^{a}±1.15	74.08^{b}±0.48	13.25^{a}±0.07	160.08^{b}±1.03	86.00^{b}±0.49	5.07^{c}±0.11	81.45^{c}±0.44

TABLE 3: Pasting properties of Acha, Cowpea and Carrot Flour Blends.

Values are means ± standard deviation of triplicate determinations. Values in the same column with different superscripts are significantly different ($p<0.05$)

Key:

A = Couscous prepared from 100% acha flour (control sample)

B = Couscous prepared from 90% acha flour, 5% cowpea flour and 5% carrot flour

C = Couscous prepared from 75% acha flour, 15% cowpea flour and 10% carrot flour

D = Couscous prepared from 70% acha flour, 15% cowpea flour and 15% carrot flour

E = Couscous prepared from 65% acha flour, 20% cowpea flour and 15% carrot flour

F = Couscous prepared from 50% acha flour, 25% cowpea flour and 25% carrot flour

Proximate Composition of Couscous Prepared from Acha, Cowpea and Carrot Flour Blends

The proximate composition of the couscous samples was presented in Table 4. Significant differences ($p < 0.05$) were observed in moisture, crude protein, crude fat, ash, crude fibre and carbohydrate contents of the couscous samples.

The moisture, crude protein, crude fat, ash and crude fibre contents increased from 9.38 – 14.49, 8.40 – 9.75, 1.59 – 2.62, and 3.89 -5.85 and 2.77 - 3.31% respectively with increase in the addition of cowpea and carrot flours,while the carbohydrates decreased from 73.97 – 63.98 with increase in the addition of cowpea and carrot flours.

Results indicated that as the level of cowpea flour inclusion increased, the crude protein, fibre and fat content also increased. This was in consonance with the findings of Ibidapo (2017) who observed increase in moisture, protein, fat, fibre and ash contents when supplemented with cowpea flour and carrot powder for biscuit production.

A significant difference ($p > 0.5$) existed in the ash contents of the samples. The increased ash content which is an index of mineral content was due to high percentage of minerals content present in carrot powder. The protein is important for tissue replacement, deposition of lean body mass and growth. Fat is important in the diets of infants and young children as it provides essential fatty acids, facilitates absorption of fat soluble vitamins, enhances dietary energy density sensory qualities and the prevention of undesirable weight gain in infants.

Though, fibre may help to increase the nitrogen utilization and absorption of some other micronutrients. The carbohydrate content of the samples decreased with increase in cowpea and carrot substitution. acha is mostly a carbohydrate food hence the reduction in acha content resulted in decrease in carbohydrate content of the samples. The carbohydrate content of samples with inclusion of cowpea flour and carrot flour were different ($P \leq 0.5$) from that of the control acha (100.00%).

The increase in moisture content could be due to the relative increase in the fibre content of the added carrot. Fibres have the ability of absorbing moisture. The crude fibre increased with increase in added carrot powder. This could be due to the presence of high dietary fibre content in carrot vegetables (Villanueva-Suárez, 2003). Accurately measuring the fibre content of foods is critical to making a sound benefit claim, whether it is a nutrient claim, structure-function claim, or health claim (Mermelstein, 2009).

Ash content indicates the presence of mineral matter in food. Increase in ash content indicates that samples with high percentage of ash will be good sources of minerals. The carbohydrate decreased with increase in cowpea and carrot flour addition.

The carbohydrate contents of these samples are an indication that the products are good sources of energy.

The fiber contents of all the couscous samples were within the Recommended Daily Allowance which should not exceed 5 g dietary fiber per 100 g dry matter (FAO/WHO 1994). Increase in ash content could make the product sources of minerals as observed by previous work reported by De Lemen *et al*. (2003).

Several studies have been carried out by researchers to improve the nutritional value and structure of couscous. Celik et al. (2004) produced traditionally Turkish couscous using different flours (soyflour and oat flour) and eggs. The nutrient composition of traditional couscous was 90.6%; dry matter, 11.27%; protein, 2.58%; fat, 71.80%; carbohydrate, In a study conducted by Tarim (2012), tomatoes, carrots, red pepper, beetroot, spinach and nettle (*Urtica* spp.) purees have been used in couscous production in order to increase its nutrional value, appearances and comsumption. According to the analysis result of fresh couscous samples moisture contents changed between 10.59 and 11.48%; ash content, 1.10 to 1.18%; fat, 1.80 to 2.56%; protein, 9.41 to 11.08%.

Table 4: Proximate Composition of Couscous Prepared from Acha, Cowpea and Carrot Flour Blends

	Parameters					
Treatments	Moisture(%)	Protein (%)	Fibre(%)	Ash (%)	Fats (%)	Carbohydrates(%)
A	$9.38^{f}\pm1.74$	$8.40^{e}\pm1.14$	$1.59^{e}\pm1.24$	$3.89^{d}\pm0.34$	$2.77^{b}\pm1.21$	$73.97^{a}\pm1.36$
B	$12.89^{e}\pm0.82$	$8.51^{e}\pm0.95$	$1.89^{d}\pm0.96$	$4.95^{c}\pm1.22$	$3.15^{a}\pm0.18$	$68.61^{b}\pm1.18$
C	$13.22^{d}\pm0.86$	$8.81^{d}\pm0.37$	$2.02^{c}\pm0.77$	$5.19^{bc}\pm0.34$	$3.20^{a}\pm0.08$	$67.56^{b}\pm0.88$
D	$13.55^{c}\pm0.93$	$9.08^{c}\pm0.29$	$2.16^{c}\pm0.89$	$5.56^{b}\pm0.45$	$3.26^{a}\pm0.09$	$66.39^{b}\pm0.59$
E	$14.14^{b}\pm0.26$	$9.44^{b}\pm1.03$	$2.34^{b}\pm0.96$	$5.77^{a}\pm1.21$	$3.29^{a}\pm0.08$	$65.02^{bc}\pm0.48$
F	$14.49^{a}\pm0.69$	$9.75^{a}\pm0.66$	$2.62^{a}\pm0.28$	$5.85^{a}\pm1.09$	$3.31^{a}\pm0.09$	$63.98^{c}\pm0.49$

Values are means ± standard deviation of triplicate determinations. Values in the same column with different superscripts are significantly different ($p<0.05$).

Key:

A = Couscous prepared from 100% acha flour (control sample)

B = Couscous prepared from 90% acha flour, 5% cowpea flour and 5% carrot flour

C = Couscous prepared from 75% acha flour, 15% cowpea flour and 10% carrot flour

D = Couscous prepared from 70% acha flour, 15% cowpea flour and 15% carrot flour

E = Couscous prepared from 65% acha flour, 20% cowpea flour and 15% carrot flour

F = Couscous prepared from 50% acha flour, 25% cowpea flour and 25% carrot flour

Mineral Composition of Couscous Prepared from Acha, Cowpea and Carrot Flour Blends

The mineral composition of the couscous samples was presented in Table 5. Significant differences ($p < 0.05$) were observed in sodium, potassium, calcium, magnesium, zinc, iron and phosphorus contents of the couscous samples. The sodium potassium, calcium, magnesium, zinc, iron and phosphorus contents of the couscous samples content ranged from 13.51- 33.78 mg/100g, 89.10 – 128.44 mg/100g , 23.20 – 40.72 mg/100g, 1.80 – 4.44 mg/100g, 3.71 – 14.08 mg/100g, 125.72 – 196. 35 mg/100g and 91.53-118.91 mg/100g respectively. A significant increase ($p < 0.05$) was observed in the sodium, calcium, magnesium, zinc contents with increase in cowpea and carrot flours substitutions.

A significant decrease ($p < 0.5$) existed in the potassium, iron and phosphorous contents of the samples with the increase in cowpea and carrot flours substitutions/

Table 5: MineralComposition of Couscous Prepared from Acha, Cowpea and Carrot Flour Blends(mg/100gm)

Treatments	Parameters						
	Sodium	Potassium	Calcium	Magnesium	Zinc	Iron	Phosphorus
A	13.51^{d}±1.74	128.44^{a}±1.14	23.20^{c}±1.24	1.80^{d}±1.21	3.71^{d}±1.36	196.35^{a}±1.36	118.91^{a}±0.93
B	20.23^{c}±0.86	108.72^{bc}±0.95	32.02^{b}±0.96	2.81^{c}±1.09	8.86^{c}±1.18	154.26^{b}±1.18	105.12^{b}±1.02
C	24.50^{bc}±0.86	104.52^{bc}±0.37	35.61^{ab}±0.77	3.52^{b}±0.34	11.48^{b}±0.88	143.38^{bc}±0.88	102.38^{b}±0.41
D	27.50^{b}±0.93	98.86^{c}±0.29	36.37^{ab}±0.89	3.92^{ab}±0.28	11.44^{b}±0.59	136.44^{c}±0.59	98.23^{b}±0.81
E	31.25^{a}±0.26	94.66^{c}±1.03	39.97^{a}±0.96	4.23^{a}±0.88	14.06^{a}±0.48	134.06^{c}±0.48	95.68^{bc}±0.93
F	33.78^{a}±1.15	89.10^{c}±0.66	40.72^{a}±0.28	4.44^{a}±1.03	14.08^{a}±0.49	125.72^{d}±0.49	91.53^{c}±0.50

Values are means ± standard deviation of triplicate determinations. Values in the same column with different superscripts are significantly different ($p<0.05$).

Key:

A = Couscous prepared from 100% acha flour (control sample)

B = Couscous prepared from 90% acha flour, 5% cowpea flour and 5% carrot flour

C = Couscous prepared from 75% acha flour, 15% cowpea flour and 10% carrot flour

D = Couscous prepared from 70% acha flour, 15% cowpea flour and 15% carrot flour

E = Couscous prepared from 65% acha flour, 20% cowpea flour and 15% carrot flour

F = Couscous prepared from 50% acha flour, 25% cowpea flour and 25% carrot flour

Inclusion of cowpea and carrot flours increased the sodium, calcium, magnesium and zinc content of couscous produced from acha, cowpea and carrot blends. Sodium is essential for the control of blood pressure. It is an electrolyte that controls the extracellular amount of fluid in the body and is needed for hydration. In addition, sodium stimulates the muscles and nerves. The sodium content of most dishes analysed can be considered relatively low compared with the RDA of 1.5 g/day. Barring excessive use of dietary salt and sodium-containing compounds such as monosodium glutamate (MSG) used in cooking, consumption of these dishes cannot be an issue of concern or a risk factor for for cardiovascular disease (CVD). Excessive sodium intake has been associated with high blood pressure and stiffening of arterial walls and therefore a risk factor for CVD (Ha, 2014).

Calcium is the most abundant mineral in the body and it function include regulating muscular contractions including heartbeat, blood clotting and formation of strong bones and teeth (WHO 2004a and b).

Iron is the most common micronutrient deficiency in the world. Women of childbearing age are the highest-risk group because of menstrual blood losses, pregnancy, and lactation. Iron conveys the capacity to participate in redox reactions to a number of metalloproteins such as haemoglobin, myoglobin, cytochrome enzymes, and many oxidases and oxygenases. It is required for many proteins and enzymes, notably haemoglobin to prevent anaemia. Anaemia has been shown to be linked maternal mortality and premature child birth (Carriaga *et al.*, 1991). Low potassium is associated with a risk of high blood pressure, heart disease, stroke, arthritis, cancer, digestive disorders, and infertility. For people with low potassium, improved diets or potassium supplements to prevent or treat some of these conditions may be recommended. Potassium was below the recommended levels in the analysed food samples. There is abundant evidence that a reduction in dietary sodium and increase in potassium intake decreases BP, incidence of hypertension, and morbidity and mortality from CVD (Whelton and He 2014).

Zinc is a component of more than 100 enzymes, among which are DNA polymerase, RNA polymerase, and transfer RNA synthetase. Zinc deficiency has its most profound effect on rapidly proliferating tissues with growth retardation in children with mild deficiency. More severe deficiency results in growth arrest, teratogenicity, hypogonadism and infertility, poor wound healing, diarrhea, dermatitis on the extremities and around orifices, glossitis, alopecia, loss of dark adaptation, and impaired cellular immunity (Ringsted *et al.*,1990). Zinc supplements in diet reduced diarrhoea in infants (Sazawal *et al.,* 1996) while Zinc showed an inverse relationship with dental carries.

Anemia arises from impaired utilization of iron and is therefore a conditioned form of iron deficiency anemia. The result of the present study indicates that copper content is sufficient in most Nigerian dishes analysed. A WHO (1996) report has earlier suggested that people living in many developing countries do not get enough copper even in the absence of an apparent sign of deficiency.

Micronutrients are a diverse array of dietary components necessary to sustain health. The physiologic roles of micronutrients are as varied as their composition; some micronutrients are used in enzymes as either coenzymes or prosthetic groups, others as biochemical substrates or hormones; in some instances, the functions are not well defined. Under normal circumstances, the average daily dietary intake for each micronutrient that is required to sustain normal physiologic functions is measured in milligrams or smaller quantities. Deficiency of some essential micronutrients in the Nigerian diet and their possible health problems are highlighted in this study. The deficiency of I, Fe and Zn is graver among young children and women of childbearing age(Coskun, 2013). Remedial measures for combating their deficiency include recommendation for the consumption of supplements or fortified foods, fortification of flour and other essential food components. This in the long run would help in successfully mitigating human suffering from micronutrient deficiency disorders as well as in maintaining sustainable human health in Nigerian societies(Coskun, 2013). The addition of soy and oat flours increased protein content and Ca, K and Fe levels (Coskun, 2013).Dietary fibre is present in it in good amounts which is helpful for lowering cholesterol level. It is also a source of trace mineral molybdenum which is rarely found in other vegetables.

Sensory Propertiesof Acha-cowpea- Carrot Flour Blend couscous

The mean sensory scores on the organoleptic preference for different couscous samples are shown in Table 6. The average meansensory scores for different levels of cowpea flour and carrot powder incorporated couscous, for all the sensory attributesevaluated were more than the minimum acceptable score of6. The average means scores for mouth feel, texture and flavor increased from 5.75 to 6.88, 6.00 to 7.18 and 6.68 to 6.94, respectively, with increases in cowpea

Treatments	Parameters					
	Appearance	Flavor	Mouthfeel	Texture	Chewability	General Acceptance
C1	6.19a±2.74	5.94^{a}±2.14	5.75a±2.32	6.25c±2.21	6.39b±2.36	6.70a±1.93
F1	6.19a±1.83	6.63^{d}±1.54	5.81a±2.29	6.00a±2.22	6.36ab±1.50	6.78a±1.50
F2	6.44b±1.82	6.69^{d}±1.78	6.63c±1.41	6.13b±1.45	6.44b±1.55	6.85b±2.14
F3	6.44b±1.86	6.81^{e}±1.87	6.73d±2.13	6.56e±2.09	6.55c±2.18	7.03b±2.31
F4	6.50b±1.86	7.00^{f}±1.37	6.86d±1.77	6.66f±1.34	6.60c±1.87	7.16c±1.46

Table 6:Sensory Propertiesof Acha-cowpea- Carrot Flour Blend couscous

F5	6.48b±1.93	6.94^{f}±1.29	6.88d±0.89	6.68f±1.28	6.58c±1.59	7.17c±1.81
F6	6.44c±1.21	6.38^{c}±2.03	6.44b±2.06	6.55e±1.88	6.40b±1.41	7.00b±2.00
F7	7.38c±1.15	6.31^{b}±1.66	6.40b±1.28	6.54e±1.61	6.31a±1.49	6.84b±1.50
F8	7.40c±1.03	6.06^{a}±1.69	6.43b±1.75	6.48d±1.17	6.31a±1.30	6.76a±1.15

Values are means ± standard deviation. Values in the same column with different superscripts are significantly different ($p<0.05$).

Key:

C1 = Couscous prepared from 100% acha flour (control sample)

F1 = Couscous prepared from 90% acha flour, 5% cowpea flour and 5% carrot flour

F2 = Couscous prepared from 80% acha flour, 10% cowpea flour and 10% carrot flour

F3 = Couscous prepared from 75% acha flour, 15% cowpea flour and 10% carrot flour

F4 = Couscous prepared from 70% acha flour, 15% cowpea flour and 15% carrot flour

F5 = Couscous prepared from 65% acha flour, 20% cowpea flour and 15% carrot flour

F6 = Couscous prepared from 60% acha flour, 20% cowpea flour and 20% carrot flour

F7 = Couscous prepared from 55% acha flour, 25% cowpea flour and 20% carrot flour

F8 = Couscous prepared from 50% acha flour, 25% cowpea flour and 25% carrot flour

flour from 5- 20% and thereafter decreased with further addition. This blend flour couscous (20% cowpea and 15% carrot) is the most preferred of the blends. The result revealed that there were no significantdifferences in all the sensory attributes evaluated up to 20% added cowpea flour. This is comparable with theresults obtained by some authors using wheat, cowpea and carrot compositeflours for the production of biscuits (Ibidapo *et al.,* 2017).The blend flour couscous with 20% cowpea and 15% carrot and the most preferred of the blends contains 9.44% protein, 2.34% fibre and 5.77% ash content.

CONCLUSIONS

To supply world population with nutritional, functional, convenient and ready-to-eat bean based food alternatives, quality parameters must be studied in a concerted action of different stakeholders.This study has shown that complementary couscous of acceptable quality can beproduced from composites grits of acha, cowpea and carrot flour blends. The functional properties of the blends had potential for pasta production. Though the blend products were generally acceptable, the product containing 65% acha flour, 20% cowpea flour and 15% carrot flour was the most preferred. Substitution of cowpea and carrot flour into acha flour should be encourage, since it willserve as a food base approach to ameliorate micronutrients deficiency in children and adults.More research should be conducted, as there are limited data available on couscous blends.

REFERENCES

Adebowale A, Adegote M T, Sanni S A, Adegungwa M O, (1998). Functional Properties and Biscuit Making Potentials of Sorghum-Wheat Flour Composite. American Journal of Food Technology. 7(6): 372-379

Adebowale, A. A., Adegoke, M. T., Sanni, S. A., Adegunwa, M. O., Fetuga., G. O. (2008) Functional properties and biscuit making potentials of sorghum-wheat flour composite. *American J. Food Technol*.; 7(6):372-379.

Adeyemi I A, and Idowu M A, (1990). The evaluation of pregelatinitized maize flour in the development of maissa, a baked product. Nig. Food J. 8:63-73

Adeyeye A, Osibanjo O, (1999). Residues of organochloric Pesticides in fruits, vegetables and tubers from Nigerian markets. 231(2) 227-233

Akpata M I, and Akubor P I, (1999). Chemical Composition and Selected Functional Properties of Sweet Orange (Citrus Sinensis) Seed Flour. Plant Food for Human Nutrition. 54: 353-362.

AOAC (2012): Official Methods of Analysis, 19th Ed. Washington, D.C Association of Analytical Chemistry,

Aremu M O, Olaofe O, Akintayo E T, (2007). Functional Properties of some Nigerian Varieties of legume seed flours and flour concentration effect on foaming and gelation. J. Food Tech. 5(2) 109-115

Ayo, J. A. and Gidado, F. E. (2017). Physicochemical, Phytochemical and Sensory Evaluation of Acha-Carrot Flours Blend Biscuit. *Current Journal of Applied Science and Technology*, 25(5): 1-15

Ayo, J. A., Adedeji, E. O. and Okpasu, A. A. (2018). Phytochemical, oligosaccharides, *in-vitro* starch/protein digestibility and elemental composition of Acha-moringa flour blend. *Trends in Science & Technology Journal*,3(1), 65 – 72.

Badwalk L S, Borch P k, Das A (2013). Influence of germination on nutritional composition, antioxidant activities total phenolic and microbial of bamboo shoo shoot. Food Science and Tech Res. 20:225-262

Celik M, (2004). Effects of compost, mycorrhiza, manure and fertilizer on some physical properties of a chromoxerert soil. Soil and Tillage Research. 78(1): 59-67

Coskun M (2013). Involvement of JAK/STAT signaling in the pathogenesis of inflamentary bowels dishes. Pharmocol. Res. 76:1-8

Dias, J.S. (2012) Major Classes of Phytonutriceuticals in Vegetables and Health Benefits: A Review. Journal of Nutritional Therapeutics, **1**, 31-62.

Gallegos-Infante J A, Rocha-Guzman N E, Gonzalez-Laredo R F, Ochoa A, (2010). Quality of spaghetti pasta containing Mexican common bean flour (Phaseolus Vulgaris. L). J. foodchem. 199(4)112-119

Giami S Y, Amasisi T, Ekiyor G, (2004). Comparison of bread making properties of composite flour from kernels of roasted and boiled African breadfruit (Treculia africanadecne) seeds. Journal of Raw Material Research 1, 16-25.

.FAO/WHO (1994). Food consumtion and exposur assessment of chemicals: report of a (FAO/WHO) consultation, Geneva, Switzerland. WHO/FSF/FOS/ 97.569p

Ferreira, I.C.F.R., Martins, N. & Barros, L. (2012). Phenolic compounds and its bioavailability: In vitro bioactive compounds or health promoters? Advances in Food Nutrition Reserve, 82, 1–44

Ibidapo, O. P., Ogunji, A., Akinwale, T., Owolabi, F., Akinyele, O. and Efuribe, N. (2017). Development andQuality Evaluation of Carrot Powder and Cowpea Flour Enriched Biscuits. *International Journal of Food Science and Biotechnology,* 2(2), 67-72.

Kausar, H., Parveen, S., Muhammad Maaz Aziz**, M. M.** and Saeed**,** S**. *(*2012).** Production of carrot pomace powder and its utilization in development of wheat flour cookies. ***J Agric. Res., 56(1):49-56***

Mermelstein, N. H. (2009). Analyzing for resistant starch. *Journal of Food Technology*, 63:80-84.

Olapade AA, Aworh OC, Oluwole OB. (2012).Quality attributes of biscuit from acha (Digitaria exilis) flour supplemented with cowpea (Vigna Unguiculata) flour. *African Journal of Food Science and Technology*.2:198-203.

Onimawo, A I. and Akubor, P I. (2012). Food Chemistry (integrated Approach with Biochemical Background). Food and Nutrition Sciences, 12(9)

Onwuka, G. I. (2005). Food analysis and instrumentation: Theory and practice. Nigeria: Naphathali Prints. 95-96.

Schoenlenchner R. (2016). Properties of Pseudocereals, selected specialty cereals and legumes for food processing with special attention to gluten-free products. Die Bodenkultur 64(4) 341-348

Screerama N Y, Sashiala V B, Pratape V M, (2012). Phenolic compounds in cowpea and horse gram flour: Evaluation of their antioxidant and enzyme inhibitory properties associated with hyperglycemic and hypertension. J.Foodchem. 133(1)156-162

Shimelis A E, Mersha M, Sudip K R, (2006). Physico-chemical Properties, Pasting Behaviour and Functional Characteristics of Flours and Starches from Improved Bean (Phaseolus Vulgaris L.) Varieties Grown in East Africa. Food Engineering and Bioprocess Technology. 31(2): 223-241

Pindar, H., Kamai, N., Kanampiu, F. &Kamara, A. Y. (2018). Valueaddition to grain legume processing of cowpea, groundnut, and soybean to smallholder farmers in Borno State. International Institute of Tropical Agriculture, Kano, Nigeria. 27 pp.

Pindar, H., Kamai, N., Kanampiu, F. &Kamara, A. Y. (2018). Valueaddition to grain legume processing of cowpea, groundnut, and soybean to smallholder farmers in Borno State. International Institute of Tropical Agriculture, Kano, Nigeria. 27 pp.

.Sazawal, S., Black, R. E., Bhan, M. K., Jalla, S., Bhandari, N., Sinha, A. and Majumdar, S. (1996). Zinc supplementation reduces the incidence of persistent diarrhoea and dysentery among low socioeconomic children in India. *Journal of Nutrition*,126, 443-50.

Singh, K., Singh, N., Chandy, A. and Maniganha, A. (2012) *In Vivo* Antioxidant and Hepatoprotective Activity of Methanolic Extracts of *Daucus carota* Seeds in Experimental Animals. *Asian Pacific Journal of Tropical Biomedicine*, **2**, 385-388.

Ringstad, J., Aaseth, J. and Alexander, J. (1990). Problems on excess of inorganic chemical compounds for mankind. In: LAG, *J*. (Ed.), pp. 25-36, Geomedicine. CRC, Boca Raton.

Tarim, S. (2012). A Research On Coloured Couscous Production Using Various Vegetable Puree Namik Kemal University Graduate School Of Nature And Applied Science Main Science Branch Of Food Engineering M.Sc Thesis Tekurdag Turkey.

Villanueva-Suarez M J, Redondo-Cuenca A, Rodriguez-Sevilla M D, (2003). Characterization of nonstarch polysaccharides content from different edible organs of some vegetables, determined by GC and HPLC: Comparative study. J. Agric. Food Chem. 24; 51 (20): 5950-5

Whelton, P. K. and He, J. (2014): Health effects of sodium and potassium in humans. *Current Opinion in Lipidology*, 25, 75-79

World Health Organisation, Food and Agriculture Organization of the United Nations. (2004). Vitamin and mineral requirements in human nutrition. 2nd ed. Report of a joint FAO/WHO expert consultation. Bangkok: FAO/WHO.

World Health Organization. (1996). Trace elements in human nutrition and health. Geneva.