Production and Quality Evaluation of Functional Biscuits from Whole Wheat Flour Supplemented with Acha (Fonio) and Kidney Bean Flours

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ABSTRACT--- *Composite flours are used for bakery products to improve the nutritional value and reduce the reliance on wheat importation. The present study was aimed at assessing the effect of supplementing whole wheat flour with acha and red kidney bean flours on the physical properties, proximate composition, mineral and sensory characteristics of biscuits made from the blends. Blend ratios used were 100:00:00 (T_1, control sample), 75:25:00 (T_2), 75:00:25 (T_3) and 50:25:25 (T_4) (whole wheat: acha: kidney bean flour). The result showed that all the parameters varied with the composition of flours in the blends. The biscuit weight, diameter, thickness and spread ratio ranged from 16.32 to 19.08g, 4.02 to 4.40cm, 0.69 to 0.78cm and 5.33 to 6.38 respectively. Incorporation of kidney bean flour in the blends led to the reduction in spread ratio of the biscuit. The protein, fat, ash, crude fibre and carbohydrate contents in the biscuits ranged from 11.73 to 15.20%, 16.34 to 17.95%, 1.52%, to 1.73%, 1.65 to 1.80% and 63.36 to 68.70% respectively. Samples T_3 and T_4 with kidney bean flour incorporation had higher protein, dietary fibre and lower carbohydrate contents than samples T_1 and T_2 with no kidney bean flour incorporation. The calcium, potassium, magnesium, iron and zinc contents ranged from 36.14 – 45.72mg/100g, 105.40 – 128.72mg/100g, 29.60 – 46.81mg/100g, 3.89 – 5.12mg/100g and 2.01 –3.51mg/100g respectively. Incorporation of kidney bean flour enhanced the calcium, magnesium and iron contents in the biscuits. Sensory mean score values showed that samples T_3 and T_4 were the most preferred samples in terms of overall acceptability as their values were not significantly (p>0.05) difference from each other. It is evident from the study that acceptable biscuits of improved nutritional value and high dietary fibre content could be produced from whole wheat flour supplemented with acha and kidney beans flours. This will increase the utilization of these locally grown crops and reduce wheat importation into the country. The high fibre biscuit will also possess several health benefits.*

Keywords--- Biscuits, whole wheat flour, acha flour, kidney bean flour, nutritional composition, sensory characteristics
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1. INTRODUCTION

Biscuits are one of the popular wheat based snack foods consumed by a wide range of population in Nigeria, especially school children due to their affordability, convenience, shelf stable and nutritive value. Since biscuits are widely accepted and consumed by almost all profile of consumers from many countries, they therefore offer a valuable supplementation vehicle for nutritional improvement. The local production of wheat (major raw material for biscuit making) in Nigeria is far below domestic consumption due to unfavourable climatic conditions. Consequently, Nigeria like other tropical countries is still depending on wheat importation to augment local production and this places a considerable burden on the economy of the country. Compositing wheat flour with flours from locally available cereals, roots and legume crops has been encouraged since it reduces wheat importation [1].

The popularity of wheat grain for the production of confectionery products is because of the unique properties of its protein (gluten) which combines strength and elasticity to baked products including biscuit. Whole wheat is a concentrated source of essential nutritional components including minerals, vitamins, protein, fat and fibre while the refine flour is mostly starch [2]. Baked products made from whole meal wheat flour therefore contain higher minerals, vitamins and dietary fibre contents than products from white wheat flour [3]. Wheat also possesses several health benefits, especially when utilized as a whole grain product. Whole wheat products have been reported to provide protection against diseases such as constipation, ishaemia, heart disease, diverticulum, appendicitis, diabetes and obesity [4]. These benefits are attributed in part to the presence of different compounds such as dietary fibres, phytochemicals, protein, vitamins and minerals [5].

Acha (*Digitaris exilis*), also called fonio or "hungry rice" is an annual crop indigenous to West Africa where it is cultivated for its straw and edible grains [6]. It belongs to the Poaceae family. It is widely cultivated and consumed in the

Northern part of Nigeria. Acha has tiny grains and is consumed whole or milled into flour and can be processed into a variety of preparations such as gruel, porridges, alcoholic and non-alcoholic beverages [7]. The proximate analysis of the grain revealed that it contains 7.9% protein, 1.8% fat, 71% carbohydrate and 6.8% fibre [8]. The protein content is high in methionine and cysteine which are vital for human health and lacking in most cereals [9, 10]. It is higher in calcium, magnesium, iron and copper but lower in potassium, sodium, lead and manganese than most cereals [11]. Consumption of acha as whole grain makes it an excellent source of dietary fibre which is good for individuals suffering from obesity and diabetes. Ibrahim and Saidu [12] reported that undehulled acha has the ability to control blood sugar level and can be recommended to individuals suffering with diabetes. In spite of its nutritional and health benefits, acha remains one of the neglected and underutilized grains in Nigeria.

Kidney bean (*Phaseolus vulgaris*) is one of the most widely cultivated and consumer food legumes and is a vital source of protein (22.7%), B-vitamins and minerals [13]. It is one of the tropical legumes that can be used to enhance the protein content in the diet of low and medium income earners who cannot afford protein from conventional animal source because of their high prices in Nigeria. The presence of complex carbohydrate and dietary fibre in kidney beans contribute to its low glycemic index, which has been proved to be associated to reduce the risk of heart disease, diabetes and obesity [14]. Red kidney beans have low sodium content and saturated fatty acid but are rich in unsaturated fatty acids especially linoleic acid [15]. In spite of its high nutritive and health benefits, raw kidney beans contain large amount of anti-nutritional factors including phytic acid, hemagglutinins, trypsin inhibitors, tannins and saponin which can affect the absorption of protein and certain minerals [16]. Traditional processing methods such as soaking, boiling, germination and fermentation have been proven to be effective in reducing or eliminating anti-nutritional factors present in legumes [17, 18].

Wheat and acha flours are high in carbohydrate but low in protein content. Blending of cereal flour with legume flour such as kidney bean flour with high protein content would help to improve the nutritional value of the product and could be used to alleviate the problem of protein energy malnutrition still prevalent in our communities. The aim of the present study was to evaluate the physical properties, nutritional composition and sensory characteristics of biscuits produced from whole wheat flour supplemented with acha and kidney bean flours.

2. MATERIALS AND METHODS

2.1 Materials Procurement
Whole wheat grains and kidney beans were purchased from Itam market in Uyo metropolis of Akwa Ibom State, while acha grains were purchased from a local market in Jos, Plateau State, Nigeria. Ingredients used for biscuit making (butter, egg, sugar, baking powder, sodium bicarbonate and vanilla) were purchased from a supermarket in Uyo, Akwa Ibom State, Nigeria.

2.2 Preparation of Materials
2.2.1 Preparation of Wheat Flour
The whole wheat grains were processed into flour following the method described by Ndife *et al.* [19]. The grains were cleaned from dirt by sorting out contaminants such as sticks, leaves and sand, washed in potable water and dried at 55°C in a conventional air oven (model pp, 22 US, Genlab, England). The grains were then milled in attrition mill, sieved to pass through 425μm aperture screen, packaged in an air tight container, labeled and stored at 4°C for subsequent use.

2.2.2 Preparation of Acha Flour
Acha flour was prepared following the method described by Olapade and Aworh [20]. The grains were cleaned by manually removing extraneous materials like chaff, stone and stalks. This was followed by washing in potable water and stones removed by sedimentation. The washed grains were dried in an oven at 55°C, milled using attrition mill, sieved through 425μm mesh screen, packaged in an air tight container, labeled and stored at 4°C for subsequent use.

2.2.3 Preparation of Kidney Bean Flour
The method described by Chaudhary and Sharma [21] was followed in the preparation of red kidney bean flour. The beans were thoroughly cleaned, blanched in hot water (1:5w/v) at 100°C for 30min, drained, washed with fresh water and soaked overnight at room temperature (27±2°C). The soaked water was drained off, beans were manually dehulled and dried in a conventional oven (model pp, 22 US, Genlab, England) at 55°C. The dried beans were milled, sieved to pass through 425μm mesh screen, packaged in an air tight container, labeled and stored at 4°C for subsequent use.

2.2.4 Supplementation of Whole Wheat Flour with Acha and Kidney Bean Flours.
The blending ratios used for the present study are as shown in Table 1. The 100% whole wheat flour (T_1) served as the control sample.

Table 1:	Blending ratio of whole wheat, acha and kidney bean flours		
Sample Codes	**Whole Wheat Flour**	**Acha Flour**	**Kidney Bean Flour**
T_1	100.00	00.00	00.00
T_2	75.00	25.00	00.00
T_3	75.00	00.00	25.00
T_4	50.00	25.00	25.00

2.2.5 *Ingredients Formulation for Biscuit Production*

The formulation used by Man *et al.* [22] as shown in Table 2 was followed in the preparation of the biscuits.

Table 2: Ingredient formulation (g) for biscuit production

Parameters	T_1	T_2	T_3	T_4
Flour	100	100	100	100
Butter	20	20	20	20
Sugar	17	17	17	17
Egg	40	40	40	40
Sodium bicarbonate	8	8	8	8
Honey	27	27	27	27
Vanilla essence	9	9	9	9

2.2.6 *Preparation of Biscuits*

The biscuits were produced following the creamy method described by Man *et al.* [22]. The butter, honey and granulated sugar were creamed together until light and fluffy. Flour, sodium bicarbonate, egg and vanilla essence were added to the cream and mixed in a bowel mixer to form dough. The dough was rolled to a uniform thickness, cut to a uniform diameter and baked in an oven at 180°C for 15 minutes, cooled at ambient temperature (27°C), packaged in high density polyethylene, labeled and stored at ambient temperature for various determinations.

2.3 *Methods of Analysis*
2.3.1 *Determination of Physical Characteristics*

Weight of the biscuit was measured using a digital weighing balance and mean values of five individual biscuits recorded. The biscuit diameter was determined by placing six biscuits horizontally (edge to edge) in a row and the diameter was measured with a digital vernier caliper with 0.01mm accuracy [22]. The mean value was recorded as the diameter of the biscuits. Thickness of biscuit was determined by stacking six biscuits, one on top of another and the average thickness was taken using digital vernier caliper with 0.01mm accuracy [22]. The mean value was recorded as the thickness of the biscuit. The spread ratio was calculated as the average diameter/thickness [23].

2.3.2 *Determination of Nutrient Composition of biscuits:*

Moisture, crude protein, fat, ash and crude fibre were determined by the methods described in AOAC [24]. Carbohydrate content was calculated by difference [25]. Energy value was calculated using Atwater factor formula [26]. Mineral content (Ca, K, Mg, Fe and Zn) were determine using atomic absorption spectrophotometer (UNICAM Model 939, UK) as described in AOAC [24].

2.3.3 *Sensory Evaluation*

The sensory evaluation of the biscuits was performed by 20 semi-trained pannel of judges drawn from the University Community, University of Uyo, Uyo, Nigeria. All panelists were regular consumers of biscuits and were familiar with sensory quality attributes of biscuits. The evaluation was conducted using the nine-point hedonic scale ranging from 1 (disliked extremely) to 9 (liked extremely) [27]. The samples were coded with three digit random numbers and presented in identical containers. Questionnaire for entering scores and potable water for mouth rinsing between tasting were made available to the panelists. Each sample was rated for appearance, taste, texture, crispiness and overall acceptability.

2.4 *Statistical Analysis*

Triplicate data were subjected to a one-way analysis of variance (ANOVA) using SPSS statistical package version 18 (SPSS, Inc, Chicago, USA). Significant differences between means were determined with Duncan's Multiple Range Test (DMRT) at $p < 0.05$.

3. RESULTS AND DISCUSSION

3.1 Physical Characteristics of Biscuits

The mean values of physical characteristics of 100% whole wheat biscuit (control) and biscuits from composite flours are presented in Table 3. The result showed that all the characteristics determined varied with the composition of different flours in the blends. The weight of the biscuits ranged from 16.32 to 19.08g with sample T_2 as the heaviest biscuit while sample T_3 had the least weight. Addition of acha flour caused significant ($p<0.05$) increase in the weight of the biscuit while incorporation of kidney bean flour caused significant ($p<0.05$) reduction in the weight of biscuits. This observation is in agreement with the report by Thongram *et al.* [28] who recorded reduction in the weight of cookies as a result of supplementation of wheat flour with legume flours. Variation in the weight of biscuits could be attributed to differences in the water holding capacity of the flours used [28].

Table 3: **Physical properties of biscuits made from whole wheat flour supplemented with acha and kidney bean flours**

Parameters	Sample Codes			
	T_1	T_2	T_3	T_4
Weight (g)	17.63±0.02	19.08±0.05	16.32±0.02	16.94±0.08
Diameter (cm)	4.38±0.06	4.40±0.04	4.16±0.11	4.02±0.03
Thickness (cm)	0.71±0.04	0.69±0.10	0.78±0.06	0.74±0.05
Spread Ratio	6.17±0.03	6.38±0.02	5.33±0.05	5.43±0.04

Values are means ± SD (standard deviation) of triplicate determinations. Means on the same row with different superscripts are significantly different at $p<0.05$. T_1 = 100% whole wheat flour biscuit; T_2 = 75% whole wheat, 25% acha and 0% kidney bean flours blend biscuit; T_3 = 75% whole wheat, 0% acha, and 25% kidney beans flours blend biscuit; T_4 = 50% whole wheat, 25% acha and 25% kidney bean flours blend biscuit.

The diameter and thickness of the biscuits ranged from 4.02 – 4.40cm and 0.69 – 0.78cm respectively. Biscuits from the blends that contained kidney bean flour (T_3 and T_4) exhibited significantly ($p<0.05$) lower diameter but higher thickness than the control biscuit (T_1) and biscuit from the composite of 75% wheat and 25% acha flours [T_2]. The maximum diameter was observed in sample T_2 (4.40cm) and minimum in sample T_4 (4.02cm). The maximum thickness was observed in sample T_3 (0.78cm) and minimum in sample T_2 (0.69cm). These variations in biscuit diameter and thickness were reflected in the spread ratio which was calculated by dividing diameter by thickness of the biscuits. Spread ratio has long been used as an important characteristic for determining the quality of flour for cookies/biscuit production [29]. Biscuits with higher spread ratio values are considered to be more desirable than those with lower values [30, 31]. In the present study, sample T_3 exhibited the least spread ratio (5.33) while sample T_2 had the highest spread ratio (6.38). Other researchers [28, 30, 32, 33] also reported that biscuits/cookies from blends with legume seed flour incorporation had lower spread ratio than those from 100% wheat flour. The decrease in spread ratio of kidney bean flour supplemented biscuits might be due to the availability of more hydrophilic sites that compete for limited free water in the biscuit dough due to high protein content in the flour [34]. According to Zucco *et al.* [31] and Tiwari *et al.* [32], for the blend containing legume flour, the increasing number of hydrophilic sites available due to increased protein content competes for the limited free water in the dough thereby affecting the spread ratio.

3.2 Proximate Composition of Produced Biscuits

The proximate composition of the prepared biscuits is presented in Table 4. The result showed that the proximate composition of the biscuits varied with the composition of flours in the blends. The protein and carbohydrate contents in the biscuits ranged from 11.73 to 15.20% and 63.36 to 68.70% respectively. Sample T_3 had the highest protein (15.20%) and lowest carbohydrate contents (63.36%) while sample T_2 had the least protein content (11.73%) and highest carbohydrate content (68.70%). Incorporation of kidney bean flour in the blends caused significant ($p<0.05$) increase in the protein content in the biscuits. This could be attributed to higher amount of protein content in kidney bean flour relative to the other two flours. Kidney bean has been reported to contain 25.78% protein [35] relative to 13.07% reported for whole wheat flour [36] and 7.90% reported for acha flour [8]. According to Tharanathan and Mahadevamma [37], legumes generally contain more protein than cereals. The observed higher protein and lower carbohydrate contents in kidney bean flour supplemented biscuits (T_3 and T_4) relative to the biscuits from blends with no kidney bean flour incorporation (T_1 and T_2) are in agreement with the reports from other researchers [28, 33, 36]. The result suggests that whole wheat biscuits supplemented with red kidney bean flour may be useful as food supplement for the alleviation of protein malnutrition in vulnerable group.

Table 4: **Proximate composition of biscuits made from whole wheat flour supplemented with acha and kidney bean flours (dry matter basis)**

Parameters	Sample Codes			
	T_1	T_2	T_3	T_4
Crude Protein (%)	$12.05^c \pm 0.03$	$11.73^d \pm 0.05$	$15.20^a \pm 0.02$	$14.93^b \pm 0.08$
Crude fat (%)	$16.82^c \pm 0.011$	$16.34^c \pm 0.09$	$1.95^a \pm 0.00$	$17.41^b \pm 0.04$
Ash (%)	$1.58^c \pm 0.07$	$1.52^c \pm 0.02$	$1.69^b \pm 0.04$	$1.73^a \pm 0.02$
Crude fibre (%)	$1.65^c \pm 0.15$	$1.71^b \pm 0.08$	$1.80^a \pm 0.20$	$1.76^b \pm 0.14$
Carbohydrate (%)	$67.90^a \pm 0.06$	$68.70^a \pm 0.10$	$63.36^b \pm 0.05$	$64.17^b \pm 0.03$
Caloric value (kcal/100g)	$471.18^a \pm 0.12$	$468.78^b \pm 0.07$	$475.79^a \pm 0.14$	$473.09^a \pm 0.11$

Values are means ± SD (standard deviation) of triplicate determinations. Means on the same row with different superscripts are significantly different at p<0.05. T_1 = 100% whole wheat flour biscuit; T_2 = 75% whole wheat, 25% acha and 0% kidney bean flours blend biscuit; T_3 = 75% whole wheat, 0% acha, and 25% kidney beans flours blend biscuit; T_4 = 50% whole wheat, 25% acha and 25% kidney bean flours blend biscuit.

The fat content in the biscuits ranged from 16.34 to 17.95%. Sample T_3 had the highest fat content (17.95%) while sample T_2 had the lowest fat content (16.34%). The fat content in the control sample was 16.82%. Biscuits from the blends that contained kidney bean flour (T_3 and T_4) had significantly (p<0.05) higher fat content than the control sample (T_1). Igbabul *et al.* [38] had similarly reported that cookies from composite of wheat, cocoyam and African yam bean had higher fat content than 100% wheat cookies. Fat is a rich source of energy and also serves as carriers of fat soluble vitamins A, D, E and K [39]. It also serves as a lubricating agent that improves the mouth feel, flavour and palatability of foods [39]. However, high level of fat in food products could lead to rancidity and development of unpleasant odour/flavour.

The ash content of the biscuit ranged from 1.52 to 1.73%. Sample T_2 had the lowest ash content (1.52%) while sample T_4 recorded the highest ash content (1.73%). The value for the control sample was 1.58% which was higher than 0.64% reported by Awan *et al.* [36] for whole wheat biscuits but lower than 1.63% and 2.31% reported by Peter *et al.* [40] and Ajibola *et al.* [41] for whole wheat cookies and biscuits respectively. The ash content of a food sample is an index of the mineral element of such food. It is evident from the result that biscuit produced from composite of whole wheat, acha and kidney bean flours blend (T_4) would provide more mineral elements to the consumers than the rest of the biscuits.

The crude fibre content in the biscuits ranged from 1.65 to 1.80%. The control sample (T_1) had the least crude fibre value (1.65%) while sample T_3 had the highest value (1.80%). The crude fibre content of the 100% whole wheat biscuit (1.65%) was higher than 1.59% reported for whole wheat cookies [40] but lower than 2.45% reported by Ajibola *et al.* [41] for whole wheat biscuit. The crude fibre values of the composite biscuits were significantly (p<0.05) different from that of the control sample. Dietary fibre has been shown to have a great impact on the health of the consumers. The presence of high dietary fibre in food products is essential owing to its ability to facilitate bowel movement (peristalsis), bulk addition to food and prevention of constipation [42]. Also, the risk of mortality and morbidity from cardiovascular disease, stroke, diverticulitis, colon cancer and diabetes is reduced when high fibre diet is consumed [43, 44].

Biscuits are energy giving foods that are consumed mostly in-between meals. The caloric value of the prepared biscuits ranged from 468.78 to 475.79kcal/100g. The protein, fat and carbohydrate constituents contributed to the energy value of the biscuits with fat as the major contributor (9kcal/g) while protein and most carbohydrate have about 4kcal/g. Hence, in this study, sample T_3 with the highest fat value also recorded the highest energy value while the least energy value was for sample T_2 with the least fat content. Similar observation was reported by Farzana and Mohajan [45].

3.3 *Mineral Content in the Biscuits*

The mineral content of the prepared biscuits is presented in Table 5. The result showed that the quantity of mineral element (Ca, K, Mg, Fe and Zn) in the biscuits varied with the composition of flours in the blends used for their production. This could be attributed to the variation in these mineral elements in the different flours used in the composite flour formulation. Potassium was the most abundant mineral elements in all the biscuits and was followed by calcium and magnesium while zinc was the least in value. Potassium content in the biscuits ranged from 105.40 to 128.72mg/100g. Sample T_3 had the least value while the highest value was for sample T_1. The potassium values were significantly (p<0.05) different from each other. Potassium intake is required in relatively large amount in the body because it functions as an important electrolyte in the nervous system and has also been shown to exert a powerful, dose-dependent inhibitory effect on sodium sensitivity [46]. Liu *et al.* [47] reported that increasing the potassium intake of hypertensive rats that were fed high sodium diets lowered blood pressure, reduced incidence of stroke and stroke related death, and prevented cardiac hypertrophy, mesenteric vascular damage and renal injury.

Table 5: **Mineral content of biscuits made from whole wheat flour supplemented with acha and kidney bean flour (mg/100g)**

Parameters	Sample Codes			
	T_1	T_2	T_3	T_4
Calcium	$36.14^d \pm 0.11$	$40.38^c \pm 0.02$	$43.09^b \pm 0.06$	$45.72^a \pm 0.05$
Potassium	$128.72^a \pm 0.05$	$116.06^c \pm 0.08$	$105.40^d \pm 0.10$	$120.68^b \pm 0.10$
Magnesium	$29.60^d \pm 0.10$	$35.40^c \pm 0.05$	$46.81^a \pm 0.08$	$41.30^b \pm 0.02$
Iron	$4.07^c \pm 0.09$	$3.89^d \pm 0.03$	$5.12^a \pm 0.03$	$4.91^b \pm 0.04$
Zinc	$3.51^a \pm 0.06$	$2.01^c \pm 0.04$	$2.15^c \pm 0.05$	$2.89^b \pm 0.11$

Values are means $\pm$ SD (standard deviation) of triplicate determinations. Means on the same row with different superscripts are significantly different at $p<0.05$. T_1 = 100% whole wheat flour biscuit; T_2 = 75% whole wheat, 25% acha and 0% kidney bean flours blend biscuit; T_3 = 75% whole wheat, 0% acha, and 25% kidney beans flours blend biscuit; T_4 = 50% whole wheat, 25% acha and 25% kidney bean flours blend biscuit.

Calcium content in the biscuits ranged from 36.14 to 45.72mg/100g with sample T_1 having the least value while sample T_4 had the highest value. Biscuits from the composite flours that contained kidney bean flour (T_3 and T_4) exhibited higher calcium content than those with on kidney bean flour incorporation (T_1 and T_2). Souci *et al.* [48] noted that red kidney beans are the best source of essential minerals including calcium, potassium, magnesium, phosphorus and iron. Calcium plays important role in blood clotting, muscle contraction, and in certain enzymes in metabolic processes [49].

The magnesium content in the biscuits ranged from 29.60 to 46.8/mg/100g with the control biscuit (T_1) having the lowest value while sample T_3 had the highest value. The values for magnesium in the biscuits were significantly ($p<0.05$) different from each other. Magnesium is important for bone health; is needed as a cofactor for numerous reactions in the body and is also essential for nerve and muscle conductivity [50]. High amount of magnesium, potassium and calcium have been reported to reduce blood pressure in humans [51].

The iron content in the biscuits ranged from 3.89 to 5.12mg/100g. The lowest value was for sample T_2 while the highest value was for sample T_3. Biscuits that contained red kidney bean flour (T_3 and T_4) had significantly higher iron content than the control sample (T_0) and sample T_2. Red kidney bean has been reported to be a good source of iron [48]. The zinc content in the biscuits ranged from 2.01 to 3.51mg/100g. The control sample (T_1) had the highest value while the least value was for sample T_2. Iron and zinc which are known to be limiting in the diet of infants and young children are critical micronutrients for growth, development, immunity and health of infants. Iron is needed for the formation of hemoglobin, the component of blood cell that carries oxygen in the blood stream throughout the body [50]. Adequate iron in the diet is essential to minimize the incidence of iron deficiency anemia, which is considered as the most common nutritional disorder worldwide [52].

3.4 *Sensory Evaluation of the Biscuits*

Sensory evaluation of any food item is an essential component of food product development as it is used to evaluate the acceptability or otherwise of the product. In the present study, mean scores of sensory attributes of the produced biscuits are presented in Table 6.

Table 6: **Mean sensory scores for biscuits made from whole wheat flour supplemented with acha and kidney bean flours**

Parameters	Sample Codes			
	T_1	T_2	T_3	T_4
Appearance	$7.15^a \pm 0.20$	$7.00^a \pm 0.15$	$7.45^a \pm 0.17$	$7.08^a \pm 0.14$
Taste	$6.45^b \pm 0.14$	$6.30^b \pm 0.23$	$7.00^a \pm 0.14$	$6.80^a \pm 0.09$
Texture	$6.40^b \pm 0.15$	$6.20^b \pm 0.19$	$7.51^a \pm 0.21$	$6.35^b \pm 0.13$
Crispiness	$5.75^b \pm 0.30$	$6.36^a \pm 0.26$	$6.50^a \pm 0.30$	$6.72^a \pm 0.15$
Overall acceptability	$6.90^b \pm 0.19$	$6.70^b \pm 0.12$	$7.25^a \pm 0.15$	$7.00^a \pm 0.20$

Means on the same row with different superscripts are significantly different at $p<0.05$. T_1 = 100% whole wheat flour biscuit; T_2 = 75% whole wheat, 25% acha and 0% kidney bean flours blend biscuit; T_3 = 75% whole wheat, 0% acha, and 25% kidney beans flours blend biscuit; T_4 = 50% whole wheat, 25% acha and 25% kidney bean flours blend biscuit.

The result showed that the mean scores by the panelists for appearance, taste, texture, crispiness and overall acceptability varied among the samples. Appearance and taste are important sensory characteristics that affect the acceptability of any food product by the consumers. Mean score values for appearance ranged from 7.00 to 7.43 and were not significantly ($p>0.05$) difference from each other. The mean score values for taste ranged from 6.30 (T_2) to 7.00 (T_3). The taste score values for samples T_3 and T_4 were not significantly ($p>0.05$) difference from each other but were significantly higher than the mean score values for samples T_1 and T_2. The scores for texture and crispiness of the biscuits ranged from 6.20 (T_4) to 7.51 (T_3) and 5.75 (T_1) to 6.72 (T_4) respectively. The texture of sample T_3 was the most preferred

as the mean score value (7.51) was significantly higher than the rest of the samples. The control sample (T_1) had the least mean score (5.75) for crispiness and the value was significantly ($p<0.05$) lower than the rest of the samples. Scores for crispiness for samples T_2, T_3 and T_4 were however not significantly ($p>0.05$) difference from each other. The mean score values for overall acceptability ranged from 6.70 (T_2) to 7.25 (T_3). This indicates that biscuits from all the formulations were acceptable as they received scores greater than 5 (neither like nor dislike). However, sample T_3 with the highest score (7.25) was the most preferred sample in terms of overall acceptability while sample T_2 with the score of 6.70 was the least preferred sample. Overall acceptability mean scores for samples T_3 and T_4 were not significantly ($p>0.05$) difference from other.

4. CONCLUSION

The study has shown that acceptable biscuits of improved nutritional quality and high dietary fibre content could be produced from blends of whole wheat, acha and kidney bean flours. Production of biscuits from whole wheat flour supplemented with acha and kidney bean flours will help to reduce dependence on wheat flour thereby reducing wheat importation into the country. It will lead to increased utilization of acha and kidney bean and farmers will be encouraged to produce more and generate more income. The high protein content in kidney bean incorporated biscuits could be used to alleviate the problem of protein-energy malnutrition that is still common in most of our communities. Also, the high dietary fibre of the biscuits would provide some health benefits to the consumers.

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