QUALITY CHARACTERISTICS OF BISCUITS PRODUCED FROM COMPOSITE FLOURS OF WHEAT, CORN, ALMONDAND COCONUT

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Abstract
Micronutrient deficiency is prevalent in most developing countries hence combination of food groups in the production of biscuit was investigated. Five biscuit samples were produced from flour blends containing different combination of corn flour, whole coconut flour, defatted coconut flour, raw almond flour, roasted almond flour and wheat flour. The 100% wheat flour served as control. Proximate composition of various flour and biscuit samples were determined using standard procedures. The physical properties, mineral concentration as well as sensorial properties of the biscuit samples were also determined. Flour samples varied significantly ($p \leq 0.05$) in lipid, protein, fiber and ash. The results on the biscuit samples revealed the following ranges: physical properties: weight 12.33-16.18g, diameter 46.6-53.69mm, thickness 6.33-11.81mm, bulk density 0.59 to 0.69g/cm^3 and spread ratio 3.98-7.72; proximate parameters: moisture 1.10- 2.39%, ash 1.70- 3.88%, fibre 1.09- 2.95%, protein 9.73- 16.53%, fat 11.52-18.07% and carbohydrate 58.81-74.86%. Biscuit samples contained varying amounts of calcium, phosphorus, potassium, zinc and iron. Biscuit sample prepared from blend containing 50% corn flour, 20% whole coconut flour, 20% roasted almond flour and 10% wheat flour compared favourably with the control in terms of sensorial quality. The results obtained could be very valuable for local industries to partially or completely substitute wheat in production of snacks.

Keywords: Biscuit, physical properties, proximate composition, micronutrients, sensory properties

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1. INTRODUCTION

Snacks, the light, fast and ready-to-eat foods, are demanded in large quantities mainly in towns and city centres where people consume them as refreshments or quick foods, to quench hunger, or at times as a substitute for the real meal. In recent times, snack products are increasingly gaining global acceptance, due to job demands, convenience driven lifestyles and dietary habits (Okafor and Ugwu, 2014). Biscuits are produced from unpalatable dough formed by mixing various ingredients like flour, fat, sweeteners and water that is transformed into appetizing products through the application of heat in the oven (Olaye *et al.*, 2007). In Nigeria, consumption of biscuit is continually growing and there has been increasing reliance on imported wheat (Akpapunam and Darbe, 1994). The importance of wheat flour is mainly due to the fact it has unique ability to form a cohesive gluten network when worked with water. This simple discovery set the stage for the development of many yeast breads, biscuits, pastries, cakes, cookies and other baked products (Meyer, 1987).
Nowadays, efforts were aimed on steps to identify those non wheat sources that could be used in tropical countries to minimize the usage of wheat flour, thus affect savings in foreign exchange by limiting wheat importation. Surprisingly, only three percent of total consumption of wheat can be produced locally in Nigeria, therefore the industry can only thrive by utilization of locally available grains to partially or completely substitute wheat (Kent, 1984). Such non wheat flours are obtained from other cereals, legumes, tubers, and root crops, for example maize, sorghum, rice, soybean, sorghum, cassava, sweet potato, potato, plantain etc.
Several studies have reported on the nutritive potentials of oilseed cake such as groundnut cake, palm kernel cake and soya bean cake,

legumes such as bambara, cowpea and starchy staples like cassava, cocoyam and plantain commonly used as components of local snacks (Amefule and Obiola, 1998; Oluwole and Karim, 2006; Olapade and Adeyemo, 2014). Though, the utilization of these ingredients has gained ground in the production of snacks locally, but the use of composite flour of three important agricultural produce such as maize, almond and coconut remain lesser known.

Maize (*Zea mays*) is also referred to as corn, and both words are used as synonyms. Maize ranks as the second most widely produced cereal crop worldwide. Maize flour contains high levels of many important vitamins and minerals, including potassium, phosphorus, zinc, calcium, iron, thiamine, niacin, vitamin B_6 and folate (Watson, 1997).

Almond *(Terminalia catappa* Linn) is an underutilized crop which belongs to a group of nuts with hard shelled seeds enclosing a single edible kernel (Othmer, 1976). The almond tree also called Tropical almond, is primary a coastal tree belonging to the family *combretaceae* which is distributed throughout the tropics including Nigeria ecosystem (Adesina, 2013).The kernel is used by many rural dwellers in southern Nigeria to fortify the local complimentary foods, which are usually low in protein. The range of proximate composition of the kernel, which is considered to be of high nutritive value is as follows; protein 14.5- 23.4%, fat 21.6-22.0%, ash 3.5-4.1%, fiber 6.4-12.6 and carbohydrates 33.1-39.2% (Mbah *et al*., 2013).

The coconut (*Cocos nucifera)* which is a common feature in most markets within the tropics has been an important component of local diets. Coconut press cake is the by-product of coconut milk extraction, which has been dried, milled and used as an ingredient in breakfast cereals (Okafor and Usman, 2013). Sample of the fresh kernel have been found to consist an average of 48.0% moisture, 35.5% oil and 16.5% oil free residue (Solangi and Iqbal, 2011).

The different intervals of wheat flour, corn flour, almond flour, and coconut flour used in composite flours seek to establish the effect of the different ratio of each of flour on biscuit quality. It is expected that careful combination of these important food sources will produce food products to overcome micronutrient deficiencies which are the main public health problems among children.

2. MATERIALS AND METHODS

2.1. Materials

Materials viz., mature almond fruits, dehusked coconuts, shelled corn, and other ingredients such as wheat flour, sugar, food grade flavour, salt, baking powder and margarine were procured from local market in Osun state, Nigeria.

2.2. Preparation of corn flour

Dried yellow corn grains were manually sorted to remove unwholesome materials. The sorted grains were milled using laboratory attributed mill to produce corn flour (CF) and stored in air tight glass container until needed.

2.3. Preparation of almond flours

Matured almond fruits were sun dried to prevent rancidity of the kernel and to facilitate dehulling. The dried fruits were dehulled by cracking along the margins with a piece of pebble to obtain the brown spindle-shaped kernels. The kernels were dried at 60°C for 6 hr to 5% moisture level. The dried kernels were divided into two portions. One portion was milled into flour with a hammer mill to produce whole almond flour (WAF) and stored in glass container until needed. The second portion was roasted in an open iron pan at a temperature of 75 – 85°C with continuous stirring for 30 min until the seeds turned golden brown. After roasting, the kernels were allowed to cool to ambient temperature, milled (Wiley mill) to obtain roasted almond flour (RAF) and stored in glass container until needed.

2.4. Preparation of coconut flours

Dehusked coconuts were manually cracked and the endocarp detached using a knife. The endocarp was grated using manual grater and then divided into two portions: one portion was sun dried, milled and kept as whole coconut flour (WCF). The second portion was made into smooth paste using laboratory Moulinex blender and the milk separated using muslin cloth. The residue was dried in an air oven at 60°C for 10 hr, to a moisture content of 7%. The dried coconut residue lumps were milled using Brabender roller mill (Germany). The resulting partially defatted coconut flour (DCF) flour was stored in a glass container at room temperature until needed.

2.5. Preparation of blends

Wheat flour was blended with corn flour, whole almond flour, roasted almond flour, whole coconut flour and defatted coconut flour in different combination to obtain five (5) samples as shown in Table 1. Sample 2T served as control.

2.6. Production of biscuit

Biscuits were produced from the blends using the method described by Onabanjo (2014). All the ingredients were weighed accurately. The pre-weighed flour, sugar, salt and baking powder were mixed thoroughly. The shortening (margarine) was added to the mixture and mixed until uniform smooth dough was obtained. The dough was then transferred to a clean tray and gently rolled using a roller. The dough sheath was cut into round shapes using a cutter. Shaped dough pieces were placed into a greased pan, kept at a normal room temperature for 2 hr to allow proper dough leavening and baked in a preheated laboratory oven operating at 217°C for 12 min. After baking the biscuits were allowed to cool and packed in high density polyethylene film and stored at room temperature for subsequent analyses. The biscuit samples produced from 100% wheat flour served as control.

Table 1: Laboratory formulations (%) of raw materials used in biscuit production

Sample	WF	WCF	DCF	WAF	RAF	CF	Bakingpowder	Sugar	Butter	Flavour
2P	7.55	7.55	-	-	7.55	52.83	0.94	3.77	18.87	0.94
2S	7.55	-	11.32	11.32	-	45.29	0.94	3.77	18.87	0.94
2R	7.55	15.09	-	-	15.09	37.74	0.94	3.77	18.87	0.94
2S	7.55	-	18.87	18.87	-	30.19	0.94	3.77	18.87	0.94
2T	75.48	-	-	-	-	-	0.94	3.77	18.87	0.94

WF- Wheat flour; CF- Corn flour; WCF-Whole coconut flour; DCF- Deffated coconut flour; WAF- Whole almond flour; RAF- Roasted almond flour.

2.7. Determination of proximate composition

The proximate composition (moisture, protein, fat, ash and fiber) of different flour and biscuit samples were determined using standard procedures (AOAC, 2005). Carbohydrate content was determined by difference. The energy value was estimated (kcal/g) by multiplying the percentage crude protein, crude lipid and carbohydrate by the recommended factor (2.44, 8.37 and 3.57 respectively) as described by Ekanayake *et al*. (1999). All analyses were carried out in triplicate.

2.8. Determination of mineral composition

Analysis of potassium content of the samples was carried out using flame photometry (AOAC, 2005). The other elemental contents (Ca, Mg, Fe and Zn) were determined, after wet digestion of sample ash with an atomic absorption spectrophotometer (Hitachi Z6100, Tokyo, Japan). All the determinations were carried out in triplicates.

2.9. Determination of physical properties

Physical properties of the biscuit samples were determined according to AACC (2000) methods. The weight of three biscuits from each sample was determined on an electronic weighing balance (Mettler, Germany) and average recorded in grams (g). The analysis was carried out in triplicate. The diameter of biscuit samples was determined using a Vernier calliper with zero error. Three well-formed biscuit samples from each sample were arranged edge to edge and their diameter was determined and the average taken and recorded in millimetre (mm). The analysis was carried out in triplicate. The thickness of the biscuit samples was measured using a micrometer screw gauge (zero error). Thickness was measured by stacking three well-formed biscuits on top of one another, then restacking in a different order and measuring them to get the average in millimetres. The analysis was carried out in triplicate. The spread ratio of the biscuit samples was determined by dividing the average value of the diameter by average value of thickness of same biscuit samples. The bulk density was determined using the method as described by Okaka and Potter (1987). A known weighed amount of milled biscuit samples was poured into a clean and dry measuring cylinder. The measuring cylinder containing the milled biscuit sample was tapped slightly several times and stopped when there was no further reduction in volume of milled biscuit. The final volume was recorded and bulk density (g/cm^3) was calculated using the formula below:

$$\text{Bulk density} = \frac{\text{Weight of milled sample before tapping}}{\text{Volume of milled sample after tapping}} \quad (1)$$

2.10. Sensory evaluation

Sensory evaluation of biscuit samples from various flour blends was conducted using untrained 25-member panel. The panel comprised a broad cross section of adult population (students and staff) of the Bowen University, with panellists spread across a wide range of age, education and income groups. Biscuit samples were prepared a day ahead of sensory evaluation and stored at room temperature. Samples were served in a randomized order on a tray, with portable water and spit cup for rinsing mouth in between tasting of samples to minimize rating errors, due to carry over of perceived attributes of previous sample. The panellists were asked to evaluate each sample based on the following parameters of aroma, colour, texture, crispiness and overall quality using a 5-point Hedonic scale (5- like extremely and 1- dislike extremely) as described by Onwuka (2005).

2.11. Statistical analysis

Data obtained were statistically analyzed using a one-way analysis of variance (ANOVA) and means were separated by Duncan's New Multiple Range Test (DNMRT) using the Statistical Package for Social Sciences (SPSS) version 17. Significance was accepted at 0.05 probability level.

3. RESULTS AND DISCUSSION

3.1. Proximate composition

Results of the proximate composition of flour samples are presented in Table 2. There was significant difference ($p \leq 0.05$) among the samples. Raw almond flour had highest moisture content, while defatted coconut flour contained the least. The moisture content of the flour samples ranged from 7.38-11.93% which was within the recommended moisture levels of less than 14% to prevent microbial growth and chemical changes during storage (Shahzadi *et al*., 2005). Corn flour had the lowest protein content (3.15%) followed by wheat flour (9.46%).This was expected because both are cereal grains while coconut and almond are oilseeds. Consequently, oilseeds have more protein than cereals although the prevalent protein in wheat occurs as gluten which is needed in baking. Fat content of the flour samples ranged from 0.96% to 50.92% being lowest for wheat and highest for roasted almond flour. The ash content of flour samples ranged from 0.47-5.27%. The highest ash content was observed in whole coconut flour but not statistically different from defatted coconut flour. However, raw and roasted almond flours had significant higher ash content than corn flour and wheat flour. The fiber content of the flour samples ranged from 0.14% to 11.13%. Defatted coconut flour had the highest fiber content which was significantly different from whole coconut flour, while the lowest value was observed in wheat flour. With respect to carbohydrate content, it was observed that corn flour had the highest value of 82.62%, followed by wheat flour (78.71%), whole coconut flour (49.32%) and defatted coconut flour (46.48%). Raw and roasted almond flour had carbohydrate content of 11.95% and 9.04% respectively.

Table 2: Proximate composition of different flour as raw materials for composite flours

Flour	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	Carbohydrate (%)
WF	10.27±0.03[c]	0.47±0.11[a]	9.46±0.14[b]	0.96±0.04[a]	0.14±0.01[a]	78.71[e]
CF	11.44±0.04[e]	0.62±0.01[b]	3.15±0.55[a]	1.96±0.22[b]	0.21±0.01[b]	82.62[f]
WCF	7.46±0.02[b]	5.27±0.04[ef]	20.12±0.04[c]	8.57±0.02[d]	9.26±0.04[e]	49.32[d]
DCF	7.38 ±0.02[a]	5.15±0.04[e]	24.51±0.04[f]	5.35±0.03[c]	11.13±0.04[f]	46.48[c]
WAF	11.93±0.03[f]	2.69±0.02[c]	22.98±0.13[e]	48.13±0.02[e]	2.43±0.03[c]	11.95[b]
RAF	10.88±0.04[d]	4.56±0.02[d]	20.45±0.26[cd]	50.92±0.01[f]	4.15±0.04[d]	9.04[a]

Values are mean + standard deviation of triplicate determinations. Means with different superscript within the same column differ significantly($p \leq 0.05$).WF- Wheat flour; CF- Corn flour; WCF-Whole coconut flour; DCF- Deffated coconut flour; WAF- Whole almond flour; RAF- Roasted almond flour.

The moisture, protein, fat, ash, fiber and carbohydrate composition of biscuit samples is as presented in Table 3. There was a significant difference ($p \leq 0.05$) in moisture content among all blends as a result of variation in ingredients. The moisture level in the composite biscuits increased as the substitution with corn flour increased. Consequently, sample 2P contained the highest water level (2.39%). This is attributed to high water binding capacity of corn flour which retained higher moisture content in end products. Corn flour could absorb water up to 50% of its weight during mixing because of physical immobilization of water in the void space between the granules (Gobbetti and Ganzle, 2013).The protein content of the biscuit samples ranged from 9.73 to 16.53%. This implies that they are good sources of protein; however, the observed differences in the crude protein content may be due to varying ingredient proportions. The lowest protein content was observed in the biscuit samples prepared from sample 2T (control) compared to other samples. This is expected because almond flour and coconut flour have appreciable quantity of protein compared to wheat and corn as shown in Table 1. Consequently, addition of almond flour and coconut flour to cereal based snacks could be a good option to provide better overall essential amino acid balance, helping to overcome the protein calorie malnutrition in developing countries.

The fat content in the biscuit samples ranged between 11.52 and 18.07%, with highest value in sample 2R, followed by sample 2S and 2Q respectively. The lowest value of fat was recorded in biscuits made from 100% wheat flour (sample 2T). The observed differences in the fat content of the samples could be due to substitution effect, as a result of the higher fat content of almond flour and coconut flour respectively. Similar observation was reported when wheat flour was substituted with cassava/soybean/mango flour (Chinma and Gemah, 2007). However, it is imperative to note that the high fat content observed in the biscuit samples will affect the shelf stability. The ash contents of the samples were significantly ($p \leq 0.05$) different from each other with a range of1.70 to 3.88%. The highest value was observed in sample 2S followed by sample 2R and 2Q, while lowest value was reported in sample 2T (control). The highest value recorded in sample 2S could be due to the inclusion 25% almond flour and 25% defatted coconut flour in its formulation. The fiber content of the biscuit samples, which ranged from 1.09 to 2.95%, differed significantly ($p \leq 0.05$) from each other due to varying ingredient proportions. Sample 2R contained the highest amount of fiber with lowest value recorded for sample 2T (control). The significant difference between sample 2R and the other samples could be explained by the level of coconut flour and roasted almond flour presented in the blend. The increased fiber content of composite flour biscuits has several health benefits, as it will aid in the digestion in the colon and reduce constipation often associated with whole wheat biscuit. The carbohydrate content of the biscuit samples ranged from 60.11 to 74.86%. This implies that the snacks are good sources of energy needed for normal body metabolism. The significant variation (p≤0.05) in carbohydrate content may be attributed to alterations in other constituents.

The energy value of the biscuit samples ranged from 384.9.7 to 396.21 kcal. Sample 2R contained the highest value while sample 2Q had the least. However, the values were lower than those reported for cold extruded and baked ready-to-eat snacks from blends of breadfruit, cashew nut and coconut (Okafor and Ugwu, 2014). Energy content of food is essential in dealing with problems associated with normal nutrition, under nutrition and obesity.

Table 3: Proximate composition of biscuit samples produced from different flour blends

Sample	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	Carbohydrate (%)	Energy (kcal)
2P	2.39±0.02[e]	2.73±0.02[b]	11.78±0.03[c]	12.87±0.02[b]	1.40±0.02[b]	69.60±0.53[d]	384.93[b]
2Q	2.23±0.02[d]	3.62±0.02[c]	11.65±0.03[b]	13.44±0.02[c]	1.73±0.03[c]	67.34±0.39[c]	381.32[a]
2R	2.03±0.02[c]	3.79±0.01[d]	14.35±0.02[d]	18.07±0.02[e]	2.95±0.01[e]	58.81±0.57[a]	396.21[e]
2S	1.53±0.01[b]	3.88±0.01[e]	16.53±0.03[e]	15.99±0.01	1.96±0.02[d]	60.11±0.16[b]	388.76[d]
2T	1.10±0.02[a]	1.70±0.01[a]	9.73±0.02[a]	11.52±0.02[a]	1.09±0.02[a]	74.86±0.04[e]	387.41[c]

Values are mean + standard deviation of triplicate determinations. Means with different superscript within the column row differ significantly (p ≤0.05). 2P- 70% corn flour, 10% whole coconut flour, 10% roasted almond flour and 10% wheat flour; 2Q- 60% corn flour, 15% defatted coconut flour, 15% almond flour and 10% wheat flour; 2R- 50% corn flour, 20% whole coconut flour, 20% roasted almond flour and 10% wheat flour; 2S- 40% corn flour, 25% defatted coconut flour, 25% almond flour and 10% wheat flour; 2T- 100% wheat flour (control).

3.2. Mineral composition

The mineral concentrations of biscuit samples are as shown in Table 4. The results indicated that range of calcium, magnesium, potassium, iron and zinc was 3.68-8.66mg/100g, 2.42-5.70mg/100g, 5.64-10.17mg/100g, 1.45-6.74mg/100g and 3.27-7.85mg/100g respectively. The increase in mineral content in composite flour biscuits could be due to higher concentrations in almond flour, coconut flour and maize flour compare to wheat flour. Almond flour is an excellent source of calcium, magnesium, phosphorus and potassium but poor source of iron (Olatidoye *et al.*, 2012). The coconut meat (11-12 month) contains sodium, potassium, calcium, magnesium and cobalt as reported by Solangi and Iqbal (2011).Likewise, maize flour contains high levels of many important minerals, including potassium, phosphorus, zinc, calcium and iron (Watson, 1997). Thus, these flours could be composited with wheat flour to improve nutritional quality of resultant food products.

Minerals are important in the diet because of their various functions in the body. They serve as cofactors for many physiologic and metabolic functions. However, the concentration of these elements in all the blends is quite low. This implies that biscuits should not be eaten alone, but other dietary sources of essential mineral elements should be consumed to meet the daily body requirement.

3.3. Physical properties

Baking quality of biscuits, such as weight, diameter, thickness, bulk density and spread ratio, were affected by the level of non wheat flours in the products (Table 5). The weight and diameter of the biscuit samples ranged between 12.33-16.18g and 49.60-53.69mm respectively. The 100% wheat biscuit (blend 2T) was heaviest among the samples. The diameter of biscuit samples increased with the inclusion of non wheat flours compared to the control. It has been reported that substitution of wheat flour resulted in lower protein gluten and subsequent decrease in viscosity of cookies dough (Miller *et al.*, 1997). Consequently, low dough viscosity results in high flow rate (spread rate) of the dough and contributes to large diameter of composite flour biscuits. Thickness was significantly different among the biscuit samples. The thickness of sample 2T (7.81mm) was highest, while the lowest value was observed in sample 2P (6.33 mm). The decrease in the thickness of composite flour biscuits compared to the control (blend 2T) was due to the dilution of gluten. Moreover, the high water absorption characteristic of fiber as found coconut flour and almond flour could attract more water, thus, the dough viscosity decreased leading to decreased thickness.

Table 4: Mineral composition of biscuit samples produced from different flour blends (mg/100g)

Sample	Calcium	Potassium	Magnesium	Iron	Zinc
2P	5.55 ± 0.06^{b}	6.77 ± 0.05^{b}	2.90 ± 0.05^{b}	2.14 ± 0.02^{b}	3.78 ± 0.03^{b}
2Q	6.52 ± 0.02^{c}	8.44 ± 0.02^{c}	3.68 ± 0.02^{c}	3.30 ± 0.06^{c}	4.84 ± 0.01^{d}
2R	7.48 ± 0.04^{d}	9.56 ± 0.03^{d}	4.14 ± 0.02^{d}	4.55 ± 0.06^{d}	4.45 ± 0.43^{c}
2S	8.66 ± 0.02^{e}	10.17 ± 0.03^{e}	5.70 ± 0.02^{e}	6.74 ± 0.02^{e}	7.85 ± 0.01^{e}
2T	3.68 ± 0.03^{a}	5.64 ± 0.02^{a}	2.42 ± 0.03^{a}	1.45 ± 0.05^{a}	3.27 ± 0.03^{a}

Values are mean + standard deviation of triplicate determinations. Means with different superscript within the same column differ significantly ($p \leq 0.05$). 2P- 70% corn flour, 10% whole coconut flour, 10% roasted almond flour and 10% wheat flour; 2Q- 60% corn flour, 15% defatted coconut flour, 15% almond flour and 10% wheat flour; 2R- 50% corn flour, 20% whole coconut flour, 20% roasted almond flour and 10% wheat flour; 2S- 40% corn flour, 25% defatted coconut flour, 25% almond flour and 10% wheat flour; 2T - 100% wheat flour (control).

The bulk density of the snack samples ranged from 0.59-0.69 g/cm^3 with sample 2Q having the highest value, while sample 2S had the least. The composite flour biscuits had significantly higher value of spread ratio (7.70-8.78) than control (6.35). The low spread factor value of the control sample showed that starch polymer molecules in wheat flour are highly bound with the granules and swelling is limited when heated. On cooling, the starch rapidly forms a rigid gel with capacity characteristics of large molecular aggregates (Priestley, 1979). However, substitution with other flours affects the rheological properties of the fortified wheat flour dough and its subsequent finished products (Eliasson, 1990). The increase in spread ratio is an indication of poor cohesions of the net work of the protein and carbohydrates which are the principal nutrients in the products. The poor cohesion could allow the outflow of some ingredients such as sugar that could melt at the high temperature of baking hence increasing the spread ability of the material as reported by Ayo and Nkama (2003).

Table 5: Physical properties of biscuit samples produced from different flour blends

Sample	Weight (g)	Diameter (mm)	Thickness (mm)	Bulk density (g/cm^3)	Spread ratio
2P	12.91 ± 0.02^{ab}	53.22 ± 1.03^{c}	6.33 ± 0.02^{ab}	0.66 ± 0.03^{b}	8.41 ± 0.02^{d}
2Q	12.33 ± 0.06^{a}	53.64 ± 0.87^{c}	6.11 ± 0.11^{a}	0.69 ± 0.01^{b}	8.78 ± 0.02^{e}
2R	13.85 ± 0.02^{bc}	51.66 ± 0.08^{b}	7.04 ± 0.06^{b}	0.67 ± 0.02^{b}	7.34 ± 0.11^{b}
2S	14.24 ± 0.04^{c}	53.69 ± 0.71^{d}	6.97 ± 0.22^{b}	0.59 ± 0.01^{a}	7.70 ± 0.02^{c}
2T	16.18 ± 0.02^{d}	49.60 ± 1.16^{a}	7.81 ± 0.13^{c}	0.63 ± 0.01^{ab}	6.98 ± 0.03^{a}

Values are mean + standard deviation Means with different superscript within the column differ significantly($p \leq 0.05$). 2P- 70% corn flour, 10% whole coconut flour, 10% roasted almond flour and 10% wheat flour; 2Q- 60% corn flour, 15% defatted coconut flour, 15% almond flour and 10% wheat flour; 2R - 50% corn flour, 20% whole coconut flour, 20% roasted almond flour and 10% wheat flour; 2S- 40% corn flour, 25% defatted coconut flour, 25% almond flour and 10% wheat flour; 2T- 100% wheat flour (control).

3.4. Sensory evaluation

Mean score for sensory evaluation of biscuit given in Table 6 revealed significant differences ($p \leq 0.05$) between treatments for sensory attributes like aroma, taste, colour, texture, crispiness and overall acceptability. Sensory rating of biscuit for colour shows that sample 2T was rated highest (4.95), followed by sample 2R (4.73) and sample 2P (4.50) while sample 2Q was rated lowest (4.40). Colour is very important parameter in judging properly baked biscuits that not only reflect the suitable raw material used for the preparation but also provides information about the formation and quality of the product. Darker colour was observed with composite flour biscuits compared to the control. The change in colour may be due to the non enzymatic reaction between reducing sugar molecules and additional protein in coconut flour and almond flour respectively. The observed darker colour of biscuits produced from composite flours has been earlier reported by Neha and Ramesh (2012). Evaluation of taste showed that sample 2R had the highest mean score of 4.28 closely followed by sample 2T (4.20) and sample 2P (4.15). A significant difference ($p \leq 0.05$) however occurred between these samples and other two samples**.** The decline in taste could be ascribed to the effect of non-enzymatic browning reactions resulting from the reaction between amino acids and free sugars causing slight bitterness during baking**.** However, the preference of sample 2R over other samples could probably be due to addition of roasted almond nut and whole coconut flour in its formulation, which improved its taste.

In terms of aroma, composite flour biscuits were rated higher compared to the control. Similar observation was noted by supplementing wheat flour with mustard protein concentrate and cotton seed flour in the production of cookies (Rajput, 1988). The crispiness of the products was remarkably accepted as sample 2T had a mean value of 4.65 closely followed by sample 2R (4.60) and sample 2Q (4.53) respectively. However, the observed decrease in crispiness with substitution with non wheat flours levels may be due to moisture uptake by such flours (Wade, 1988). Considering the texture of the biscuits, sample 2T (control) was rated highest (4.50) while the lowest score was obtained in sample 2S (3.45). Similar observation was reported by Rajput (1988). The decline in texture of the composite flour biscuits may be attributed to the high crude fiber content of other flours apart from wheat, which makes the texture less tender. For the overall acceptability, sample 2T was rated highest (4.60) while sample 2S was lowest (3.75). In earlier studies, Gambus *et al.* (2003) observed similar decrease in the sensory attributes of the biscuits when wheat flour was substituted with increasing levels of flaxseed flour, matric flour and cowpea flour. It is important to note that modification in production process and slight change in the physical, chemical properties of ingredients in blended foods may also affect the sensorial quality.

Table 6: Sensory evaluation of biscuit samples produced from different flour blends

Sample	Aroma	Colour	Texture	Crispiness	Taste	Overall acceptability
2P	4.55^{d}	4.50^{b}	4.00^{c}	4.45^{b}	4.15^{b}	4.32^{b}
2Q	4.50^{c}	4.40^{a}	3.70^{b}	4.53^{c}	4.08^{a}	4.35^{c}
2R	4.63^{e}	4.73^{c}	4.12^{d}	4.60^{d}	4.28^{d}	4.40^{cd}
2S	4.45^{b}	4.42^{a}	3.45^{a}	4.22^{a}	4.02^{a}	3.75^{a}
2T	4.40^{a}	4.95^{d}	4.50^{e}	4.65^{de}	4.20^{c}	4.65^{e}

Means with different superscript within the same column differ significantly($p \leq 0.05$).2P- 70% corn flour, 10% whole coconut flour, 10% roasted almond flour and 10% wheat flour; 2Q- 60% corn flour, 15% defatted coconut flour, 15% almond flour and 10% wheat flour; 2R- 50% corn flour, 20% whole coconut flour, 20% roasted almond flour and 10% wheat flour; 2S- 40% corn flour, 25% defatted coconut flour, 25% almond flour and 10% wheat flour; 2T- 100% wheat flour (control).

4. CONCLUSION

This present study shows that there is potential for different combinations of corn flour, almond flour and coconut flour to replace wheat flour in biscuit production. Biscuit samples of adequate nutritional and sensorial qualities were produced from composite flours along with other ingredients. The results obtained could be very valuable in decision making for industries that want to take nutritional advantage of indigenous cereal crops to partially or completely substitute wheat flour in baking.

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