*Original Research Article*

Composite Flour Formulated from Wheat, Acha and Date Fruit Improved on the Proximate and Functional Properties of the Flour.

**ABSTRACT**

The study evaluated the proximate composition of wheat flour, acha flour and date fruit flour individually before formulating them into composites flours and evaluated their proximate and functional properties respectively. The composite flour ratios produced of wheat:acha:date were 80g:10g:10g (sample B); 70g:20g:10g (sample C) and 60g:30g:10g (sample D). Sample A (the control) was 100g wheat flour. Standard methods were used in the determination of the proximate compositions and functional properties of the composite flour. Results of the proximate composition of individual flour were as follows: Acha flour had the highest values for ash (5.17%), crude protein (11.54%) and crude fat (3.39%) content, date palm fruit flour had the highest value for crude fibre (5.93%) and moisture content (11.85%) while wheat flour had the highest value for carbohydrate content (79.98%). The crude protein, ash, crude fibre, moisture and fat contents of all composite flour samples increased significantly from 10.17 - 15.18%, 3.02 - 4.15%, 3.40 - 4.31%, 7.11 - 8.62% and 1.82 - 3.10% respectively thus showing significant difference among the flour blends, while the carbohydrate contents decreased from 74.47 - 64.64% with increasing substitution of wheat flour with acha flour and date palm fruit flour. The increase in crude protein, ash and crude fibre in the flour blends indicates a flour rich in protein, minerals and fibre which are beneficial for health and general wellbeing. The functional properties of the composite flour also showed significance differences (p<0.05) in all the parameters determined: water absorption capacity (132. 70 – 157.00g/ml), oil absorption capacity (131.30 – 163.50g/ml), swelling capacity (16.06 - 22.14g/ml), bulk density (0.76 – 0.79g/ml) and foam capacity (13.07 - 17.68%).

Keywords: Acha, Date fruit, Flour, Composite Flour, Formulation, Proximate, Functional

**1.0 INTRODUCTION**

Flour is the powdery substance created when a dry grain is pulverized [1]. Composite flours can be defined as a mixture of different ratios of non – wheat flours obtained from roots and tubers, cereals, legumes, with or without the addition of wheat flour [2,3,4,5,6] to satisfy specific functional characteristics and nutrient composition [7]. Composite flour has better nutritional value concerning elements of minerals, vitamins, fibres and protein than flour milled from any specific cereal alone [8].

Wheat (*Triticum aestivum*) is known as one of the most important cereal crops that is imported from countries in temperate regions [9,10]. It contributes to 30% and 50% of the production and global grain trade respectively [11]. Wheat is high in carbohydrate but relatively low in quantity and quality in terms of protein content [12]. Earlier studies have reported that wheat is deficient in some essential amino acids, such as lysine, and dietary fibres [13,14].

Acha *(Digitaria exili*s), also known as “fonio” originated in West Africa. It grows on poor sandy soil, which often will not support the growth of some of the more popular cereals [15]. The grains are rich in amino acids; leucine (9.8%), methionine (5.6%) and valine (5.8%) and cysteine which are vital to human health but deficient in today’s major cereals [15]. The leucine and methionine found in Acha is greater than that found in other cereals [16] and it was also reported to contain almost twice as much methionine as egg protein does [17]. This implies that Acha is a very good source of protein. Acha grains contain substantial minerals (mostly iron, zinc, magnesium calcium and phosphorus) about 5% dry matter [18,19] thus it is sometimes considered as “a small seed with a big promise” [20].

*Phoenix dactylifera*, commonly known as the date palm [21] cultivated for its edible sweet fruit called dates Date fruits are regarded as complete food due to its high nutritional content. The primary carbohydrates are monosaccharides, comprising glucose (23-30%), fructose (19-28%), and non-starch polysaccharides (7-10%) of the fruit's total weight [22]. The sucrose content is negligible [23]. The protein in dates contains 23 types of amino acids, some of which are not present in the most popular fruits such as oranges, apples and bananas and date fruits are a good source of fiber [24, 25, 26, 27]. Date fruit contains a considerable amount of moisture (12-14), crude fibre (4.5 -5.0), protein (2.0 – 2.5), fat (1.8 – 2.4) and ash (1.7 – 1.9) which is essential for children’s growth and development [28]. Dates can be used to replace sugar since it has a lower glycemic index than any sugar alternatives [29,30,31]. The natural antioxidants in date powder can delay the oxidative rancidity of fats of stored foods (composite flour) thereby maintaining the products appeal and extending its shelf life and storage stability [32,33,28,34,35,36,37].

Wheat flour alongside sugar are major raw materials used in the baking industry but wheat contains gluten and a high level of carbohydrate which has a negative effect for people with gluten intolerance and can cause diabetes and celiac disease thus diabetics are therefore afraid to consume baked goods which makes their diet limited, unappealing and monotonous Acha and date fruits are our own indigenous crops but they have been underutilized as flours for baking despite the fact that they are readily accessible, gluten free, energy densed and highly nutritious.

**2.0 MATERIALS AND METHODS**

**2.1 Procurement of raw materials**

Wheat flour, Acha grain (*Digitaria exilis*) and Date palm fruit (*Phoenix datylifera*) was purchased from North Bank Market. Procured raw materials were taken to the Food Processing Laboratory, University of Agriculture for processing. All chemicals used were of analytical grade.

**2.2 Preparation of raw materials**

**2.2.1 Preparation of Acha flour**

Acha flour was prepared according to the procedure reported by Olagunju *et al*. [38] with slight modification. The Acha grains were washed with tap water to separate stones and sand, then, they were dried in the cabinet dryer at 50 oC for 6 hours. The resultant dried Acha was milled and sieved into flour using the hammer mill with 0.5 mm screen size.

**2.2.2 Preparation of Date fruit flour**

The Date fruit flour (powder) was prepared according to Ikechukwu *et al*. [39] with slight modification. The date palm fruit was de-seeded, sorted and washed. The sorted deseeded broken dates are then oven dried at 80 oC for 2 hours. The dried dates are milled then sieved to date palm powder. The date flour is then packaged in a sealed plastic and stored at 4 oC.

**2.3 Formulation of the composite flours**

The composite flour from wheat ,acha and date fruit was prepared as presented in Table 1. The composite flours were blended in the ratios of 80:10:10 as sample 70:20:10 as sample C and 60:30:10 as sample D. Sample A was 100 g wheat flour and it served as the control. The flours were thoroughly mixed to obtain a homogenous blend and stored at ambient temperature (30±2 oC) in air tight container.

Table 1: Formulation of the composite flours of wheat, acha and date fruit

Sample Wheat Flour (g) Acha Flour (g) Date Palm Fruit Flour (g)

A 100 0 0

 B 80 10 10

 C 70 20 10

 D 60 30 10

KEY: A - 100 g Wheat flour (Control)

B - 80 g Wheat Flour; 10 g Acha Flour; 10 g Date Flour

C - 70 g Wheat Flour; 20 g Acha Flour; 10 g Date Flour

D - 60 g Wheat Flour; 30 g Acha Flour; 10 g Date Flour

**2.4 ANALYSIS**

**2.4.1** **Determination of proximate analysis of the individual flours of wheat, acha and date fruits and the composite flours**

The moisture, protein, fat, ash, and crude fiber contents were determined following the procedure outline by AOAC [40], while carbohydrate was calculated by difference [39].Ihekoroney

**2.4.2 Determination of functional properties of the composite flours**

**(a) Water absorption capacity**The method of Iwe [41] was adopted in the determination of water absorption capacity. One (1g) gram of sample was weighed into a conical graduated centrifuge tube and thoroughly mixed with 10ml distilled water for 30seconds using a warring whirl mixer. The sample was then allowed to stand for 30 minutes at room temperature and then centrifuged at 5,000rpm for 30 minutes. The volume of free water (supernatant) was read directly from the graduated centrifuge tube. Absorption capacity is expressed as grams of water absorbed (or retained) per gram sample.

$$Water Absorption Capacity=Amount of water absorbed total free x Density Water$$

$$WAC=\frac{\left(weight tube+sediment\right)-\left(Weight of empty tube\right)}{Weight of Sample} $$

**(b) Oil absorption capacity**

The method of Iwe [41] was adopted in the determination of oil absorption capacity. One (1g) gram of sample was weighed into a conical graduated centrifuge tube and thoroughly mixed with 10ml of oil for 30seconds using a warring whirl mixer. The sample was then allowed to stand for 30minutes at room temperature and then centrifuged at 5,000rpm for 30minutes. The volume of free oil (supernatant) was read directly from the graduated centrifuge tube. Absorption capacity is expressed as grams of oil absorbed (or retained) per gram sample.

$$Oil Absorption Capacity=Amount of Oil Absorbed Total free x Density Oil$$

**(c) Determination of bulk density**

The procedure of Iwe et al. [42] was employed to determine the bulk density of the samples. 50 g flour sample was put into a 100 ml measuring cylinder. The cylinder was tapped several times on a laboratory bench to a constant volume. The volume of sample was recorded. The cylinder was severally tapped against a table until there was no further change in volume.$Bulk Density \left(\frac{g}{cm3}\right)=\frac{Weight of sample}{volume of sample after tapping}$

**(d) Foaming capacity:**

The foaming capacity was determined using the method described by Onwuka [43] with slight modification. Two grams (2g) of wheat -acha-date composite flour sample was added to 50ml of distilled water at 30 ± 2°C in a 100 ml graduated cylinder. The suspension was mixed and shaken manually for 5min to foam. The volume of foam at 0second after whipping was expressed as foaming capacity using the formula;$Foam capacity=\frac{Volume of foam after whipping}{Volume of mixture}$ x 100

The volume of foam was recorded at different time intervals (5, 10, 15 and 20 seconds) after whipping to determine the foam stability as percent of the initial foam volume.

**(e) Swelling index:**

The swelling index was determined using the method described by Olapade et al. [44] with slight modification. One gram (1 g) of wheat- acha -date composite flour sample was mixed with 10ml of water in a weighed centrifuge tube. The tube was heated in water bath at 85°c for 15 min and then centrifuged at 2000 rpm for 30 min. The clear supernatant was decanted and discarded. The adhering drops of water was removed and then weighed. Swelling capacity was expressed as percent swelled per gram flour.

**2.5 Statistical Analysis**

Triplicate data obtained were subjected to statistical analysis using the Statistical Package for the Social Science (SPSS), version 28. The analysis of variance (ANOVA) were used to determine significance difference between the mean (P<0.05) while the means was separated using Duncan Multiple Range Test (DMRT).

**3.0 RESULTS AND DISCUSSION**

**3.1 Proximate composition of individual flours of wheat, acha and date fruit**

The proximate composition of the individual flours of Wheat flour, Acha flour and Date fruit flour are presented in Table 2. The moisture content ranged from 7.11% - 11.85% with Date palm fruit flour having the highest value and Wheat flour having the lowest value. The crude protein ranged from 5.66% - 11.54% with Acha flour having the highest value and Wheat flour having the lowest value. The crude fat ranged from 0.24% - 3.39% with Acha flour having the highest value and Date flour having the lowest value. The crude fibre ranged from 1.90% - 5.93% with Date palm fruit flour having the highest value and Wheat flour having the lowest value. The ash content ranged from 2.98% - 5.17% with Acha flour having the highest value and Date palm fruit flour having the lowest value. There was no significant difference (p<0.05) between Wheat flour and Date fruit flour in ash content. The carbohydrate content ranged from 63.34% - 75.98% with Wheat flour having the highest value and Date fruit flour having the lowest value. From the result, it was observed that Wheat flour was higher in carbohydrate content; Acha flour was higher in ash content, crude protein and crude fat while Date fruit flour higher in moisture and crude fiber.

The ash content of Acha flour, also known as Fonio flour typically ranges between 1% and 6% depending on the variety and processing methods [45]. A higher ash content can affect the texture, flavor and nutritional value of any product baked using Acha flour due to the increased presence of bran (and sometimes germ and outer endosperm) [46]. Gislen [46] also reported that a lower ash content means that the flour is more highly refined (that is, a lower extraction rate). Chinma *et al.* [47] reported that high ash content is an indication of increased mineral content capable of solving malnutrition problems. Thus, it can then be said that the Acha flour is undoubtedly rich in minerals and when consumed is capable of solving malnutrition problems. Ayo *et al.* [48] reported that Acha seeds contain 8.79% protein and may be up to 11.89% in some black varieties and Ayo *et al.* [15] also reported that Acha grains are rich in amino acids; leucine (9.8%), methionine (5.6%), valine (5.8%) and cysteine which are vital to human health but deficient in today’s major cereals. The protein content of fonio was reported by Temple and Bassa [17] and Jideani and Akingbala [16] to be like that found in white rice and it contain almost twice as much methionine as egg protein does [17]. The high protein, low carbohydrate flour (Acha flour) has been reported by Dabel *et al.* [49] to have more nutritional advantage over the Wheat flour especially for individuals with health problems that may require protein – rich and low – carbohydrate foods such as diabetics. Ghmini *et al.* [50] reported that Date fruit contains 6.5 – 11.5% dietary fiber with a large portion being insoluble fiber. The fiber in dates can promote healthy digestion by adding bulk to stool and preventing constipation [50]. According to Al-Shahib and Marshall [24], date fruits are a good source of fibre [25,26,27]. While dates are naturally sweet, the fibre helps slow down the absorption of sugar making them a better choice than refined sugar [51, 52].

**Table 2: Proximate Composition of Individual Flours of Wheat flour, Acha flour and Date Fruit Flour**

Flour Ash Crude Fat Crude Fibre Crude Protein Moisture Carbohydrate

Wheat 3.02b±0.02 1.82b±0.03 1.90c±0.02 10.17b±0.05 7.11c±0.01 75.98a±0.09

Acha 5.17a±0.03 3.39a±0.03 2.50b±0.01 11.54a±0.04 9.52b±0.03 67.88b±0.03

Date 2.98b±0.03 0.24c±0.01 5.93a±0.08 5.66c±0.04 11.85a±0.01 63.34c±0.11

Values are Means ± Standard Deviation of Triplicate Determination. Values followed by thesame subscript (s) within the same column are not significantly different at 5% probability level.

**3.2** **Proximate Composition of Wheat flour, Acha flour and Date Fruit Composite flour**

The proximate composition of Wheat, Acha and Date fruit composite flour are presented in Table 3. The moisture content ranged from 7.11% - 8.62% with sample D (60g Wheat flour,30g Acha flour, 10g Date flour) having the highest value and sample A (100g Wheat flour - the control) having the lowest value. The crude protein ranged from 10.17% - 15.18% with sample D (60g Wheat flour,30g Acha flour, 10g Date flour) having the highest value and sample A (100% Wheat flour - the control) having the lowest value. The crude fat ranged from 1.82% - 3.10% with sample D (60g Wheat flour,30g Acha flour, 10g Date flour) having the highest value and sample A (100g Wheat flour - the control) having the lowest value. The crude fibre ranged from 3.40% - 4.31% with sample D (60g Wheat flour,30g Acha flour, 10g Date flour) having the highest value and sample A (100g Wheat flour - the control) having the lowest value. The fact that sample D had the highest fiber content was expected because when individual flours were evaluated, Date fruit flour had the highest fibre content then Acha flour followed lastly by Wheat flour as shown in Table 2 above. Sample A (the control) that contained only Wheat flour as expected had the lowest value for fibre content. The ash content ranged from 3.02% - 4.15% with sample D (60g Wheat flour,30g Acha flour, 10g Date flour) still having the highest value and sample A (100g Wheat flour - the control) having the lowest value. The carbohydrate content ranged from 64.64% - 74.47% with sample D (60g Wheat flour,30g Acha flour, 10g Date flour) having the lowest value and sample A (100g Wheat flour - the control) having the highest value. From the result, it can be observed that the carbohydrate content decreased with increased substitution of Wheat flour with Acha flour and date fruit flour in samples B - D while the crude protein, crude fat, crude fiber, ash content and moisture content increased with increased substitution of Wheat flour with Acha flour and date palm fruit flour in samples B – D.

The result obtained from the flour blend just further proved that the result obtained from the proximate composition of the individual flour (Table 2 above) was accurate because for the individual flours, acha flour had the highest values for crude protein, crude fat and ash content while date flour had highest values for moisture content and crude fibre. When these individual flours were combined or blended, it was only expected that the flour blended samples maintain their composition and qualities so it was no wonder that sample D (60g wheat flour, 30g acha flour and 20g date fruit flour) had the highest values of crude protein, crude fat, ash, moisture and crude fibre content. Several researchers had reported the acha seed and date fruit to contain protein in varying percentages [15,17, 24,25,26,27,48] thus, the increase in protein content observed when Wheat flour was substituted with Acha flour and date flour could be due to the fact that Acha and Dates individually are rich in protein and when combined, it is only expected that the protein content in the flour will increase in quantity and the flour blend will be of higher proteinous quality. It is noteworthy to state that the samples with higher values of protein and ash content had lower values of carbohydrates. The high protein, low carbohydrate flour samples (sample B – D) has nutrition advantage over the wheat flour (sample A) especially for individuals with health problems that may require protein – rich and low – carbohydrate foods such as diabetics [49]. The increased ash content is an indication of increased mineral content capable of solving malnutrition problems [47].

**Table 3: Proximate Composition of Wheat, Acha and Date fruit composite flour**

Samples Ash Crude Fat Crude Fibre Crude Protein Moisture Carbohydrate

A 3.02c±0.02 1.82d±0.03 3.40d±0.00 10.17d±0.05 7.11d±0.01 74.47a±0.11

B 3.30bc±0.04 2.20c±0.03 3.56c±0.01 11.39c±0.08 8.05c±0.05 71.50b±0.21

C 3.62b±0.33 2.51b±0.05 4.00b±0.00 14.34b±0.04 8.37b±0.03 67.16c±0.45

D 4.15a±0.13 3.10a±0.01 4.31a±0.02 15.18a±0.06 8.62a±0.02 64.64d±0.24

Values are Means ± Standard Deviation of Triplicate Determination. Values followed by thesame subscript (s) within the same column are not significantly different at 5% probability level.

KEY

A - 100g Wheat flour (Control)

B - 80g Wheat Flour; 10g Acha Flour; 10g Date Flour

C - 70g Wheat Flour; 20g Acha Flour; 10g Date Flour

D - 60g Wheat Flour; 30g Acha Flour; 10g Date Flour

**3.3 Functional Properties of Wheat, Acha and Date Fruit composite flour**

The functional properties of the flour blends of Wheat, Acha and Date palm fruit are presented in Table 4. The Water Absorption Capacity of the flour blends ranged from 132. 70 – 157.00g/ml with Sample B (80g Wheat Flour, 10g Acha Flour and 10g Date Flour) having the least value and Sample A (100g Wheat flour - the control) having the highest value. Water Absorption capacity is the ability of the flour to take up water and swell, which is useful for increasing food uniformity. Wheat contains elastic gluten protein, gliadins and glutenins [53,54,55] which when mixed with water produces a relatively large loaf volume with a regular, finely vesiculated crumb structure. This could be one of the reason why sample A (100g Wheat flour) had the highest value for Water Absorption Capacity. Ayo and Gidado [56] also reported that the highest Water Absorption Capacity could be attributed to the presence of higher amount of carbohydrate (starch) and fibre in the flour thus, it can also be said that the high Water Absorption Capacity for Sample A (100g Wheat flour - the control) could also be related to the high quantity of Carbohydrate (starch) in the Wheat Flour [12,57]. The Oil Absorption Capacity of the flour blends increased significantly (p<0.05) from 131.30 – 163.50g/ml with Sample A (the control) having the least value and Sample D (60g Wheat Flour, 30g Acha Flour and 10g Date flour) having the highest value. Oil Absorption Capacity is the ability of the flour to entrap oil and flours with higher protein and fat contents tend to have higher oil absorption capacity [58]. As observed in the samples, the increase in the substitution of Wheat flour with Acha flour and Date flour, the higher the Oil Absorption Capacity and as reported by Ayo *et al*. [48], Acha seed contains protein and Dates have been reported by Al – Shahib and Marshall [24] to contain about 23 amino acids [25,26,27] thus, it can be understandable why sample D which had the highest quantity of Acha flour, had the highest value of Oil Absorption Capacity. It is noteworthy to observe the accuracy of the results obtained from the proximate evaluation of the composite flour (Table 3 above) where it was established that the samples (B – D) that had acha and date fruit flour had more protein and fat content than sample A and according to Sankhon [58], flours with higher protein and fat contents tend to have higher oil absorption capacity which has been established in the result above. According to Ayo and Gidado [56] and Bello and Ekeh [60], flours with high oil capacity could be suitable in enhancing flavor and mouth feel when used in food preparation. There was significance difference in the Swelling Capacity of the flour blends as sample A (100g Wheat flour - the control) had the highest value (22.14g/ml) and sample D had the lowest value (16.08 g/ml). The swelling capacity or swelling power is the ability of the flour to swell when heated above its gelatinization range, which is a measure of hydration capacity [60,61]. As reported by Villarino *et al*. [53], Barak *et al*. [54] and Catassi *et al.* [55], wheat contains elastic gluten protein, gliadins and glutelins which when mixed with water produces a relatively large loaf volume (swells) while acha does not contain any glutelin and gliadin protein which are constituent of gluten [62,63]. This statement goes in accordance with the result gotten as sample A that contained only Wheat flour had the highest swelling capacity. Ayo and Gidado [56] also stated that the swelling capacity of flours depends on the size of the particle, types of variety and the types of processing methods or unit operations and it was noticed that as more grams of Acha was added to the flour blends, the swelling capacity decreased so it is possible that one of the listed factors might have also been fundamental in enabling Sample A to have the highest swelling index. The Foam Capacity of the flour blends significantly increased (p<0.05) from 13.0- 17.68% for Sample A (100g Wheat flour - the control) and sample D (60g Wheat flour, 30g Acha flour and 10g Date flour) respectively. The foaming capacity is the ability of the flour to maintain air bubbles in suspension, which is dependent on the protein and other components in the flour [64]. Ojinnaka *et al.* [65] reported that protein enhances foam capacity and Asif – Ul- Alamet *et al*. [65] also reported that the foaming of a flour is dependent on the flexibility of protein molecules which decrease the surface tension of the water. Also, the result obtained in the proximate analysis of individual flours and flour blends showed that Acha flour had more crude protein content than wheat flour and sample D (60g Wheat flour, 30g Acha flour and 10g Date fruit flour blend) had more crude protein than sample A (100g Wheat flour - the control) respectively thus, the highest foaming capacity recorded in sample D (60g Wheat flour,30g Acha flour, 10g Date flour) can be due to the high protein content in Acha and Dates as reported by Ayo *et al*. [48] and Al – Shahib and Marshall [24] respectively. The Bulk Density of the flour blends ranged from 0.76 – 0.79 g/cm3with sample B (80g Wheat flour, 10g Acha flour and 10g Date flour) having the least value and sample A (100g Wheat flour - the control) having the highest value. There was significant difference among the bulk density of the flour. The Bulk density indicates the relative volume that plays an important role in package design, storage and transportation of foodstuff [59,66,67,68] and it is dependent on the particle size and moisture content of the flours. Knowing that wheat contains gluten [53,54,55] could be the very reason why Sample A had the highest bulk density. Akpata and Akubor [66] reported that low bulk density is important in the formulation of complementary foods while high bulk density of flour could suggest their suitability for use in food preparations. Oladele and Aina [67] reported that low bulk density is a desirable factor in food formulation especially food with less retrogradation. Retrogradation is a reaction that takes place when the amylose and amylopectin chains in cooked gelatinized starch realign themselves as the cooked starch cools [70]. Retrogradation of starch is often considered an undesirable process because it is directly related to the stalling or aging of bread [71].

**Table 4: Functional Properties of wheat, acha and date fruit composite flour**

Samples WAC OAC SC FC BD

 (g/ml) (g/ml) (g/ml) (%) (g/cm3)

A 157.00a±1.73 131.30d±1.16 22.14a±0.12 13.07d±0.13 0.79a±0.003

B 132.70d±1.02 146.30c±1.16 21.14b±0.02 14.44c±0.07 0.76d±0.004

C 141.00c±0.00 157.30b±1.16 18.32c±0.02 16.56b±0.10 0.77c±0.002

D 143.50b ±1.16 163.20a±1.61 16.08d±0.07 17.68a±0.09 0.78b±0.003

Values are Means ± Standard Deviation of Triplicate Determination. Values followed by thesame subscript (s) within the same column are not significantly different at 5% probability level.

KEY:

WAC = Water Absorption Capacity, OAC = Oil Absorption Capacity, SC = Swelling Capacity, FC = Foaming Capacity and BD = Bulk Density

KEY

A - 100g Wheat flour (Control)

B - 80g Wheat Flour; 10g Acha Flour; 10g Date Flour

C - 70g Wheat Flour; 20g Acha Flour; 10g Date Flour

D - 60g Wheat Flour; 30g Acha Flour; 10g Date Flour

**4.0 CONCLUSION**

This study determined the proximate and functional properties of the flour and composite flour of wheat, acha and date palm fruit respectively. Substituting wheat flour with acha flour and date fruit flour improved the nutritional quality and functional properties of the flour with respect to ash, crude protein, crude fibre content, bulk density and foam capacity respectively. Composite flour of wheat, acha and date fruit flour (Sample B – D) when used in baking will not only improve the nutritional quality of the baked goods but also improve the shelf life of the product due to its low bulk density thus less retrogradation and the antioxidants that are in date fruits. Based on the results obtained, composite flour of wheat, acha and date palm fruit flour should be produced and used in the food industry at up to 40g substitution of wheat flour. Sample D is highly recommended for large scale production.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author (s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text –to – image generators have been used during thr writing or editing of the manuscripts.

**FURTHER RESEARCH/STUDIES**

Though it was postulated that the shelf life of the flour and product made from it to have an improved shelf life, more work should be done in the area of shelf life and storage stability to be able to ascertain the exact shelf life of the individual flour (Acha flour and Date flour respectively) and the flour blends for mass production

More work should also be carried out in ascertaining the appropriate packaging material that will keep the individual flours and flour blend whole to their expected shelf life.

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