European Journal of Nutrition & Food Safety

Volume 15, Issue 8, Page 80-90, 2023; Article no.EJNFS.103012
ISSN: 2347-5641

Functional and Selected Chemical Properties of Wheat, Tropical Almond and Pawpaw Fruit Flours and Their Blends

J. Maboh [a*], M. I. Yusufu [b] and D. Ahure [c]

[a] Centre for Food Technology and Research, Benue State University, Makurdi, Nigeria.
[b] Department of Food Science and Technology, Federal Polytechnic, Idah, Kogi State, Nigeria.
[c] Department of Food Science and Technology, Federal University of Agriculture, Makurdi, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/EJNFS/2023/v15i81328

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/103012

Original Research Article

Received: 15/05/2023
Accepted: 17/07/2023
Published: 27/07/2023

ABSTRACT

Tropical Almond and pawpaw fruits are highly underutilized hence; the objectives were to improve their utilization in preparation of conventional foods. Six (6) blend samples A to F were formulated. Sample A (100 % wheat flour) was used as the control, B (60 % Wheat flour: 0 % Almond Flour: 40 % Pawpaw Flour), C (60 % Wheat flour: 10 % Almond Flour: 30 % Pawpaw Flour), D (60 % Wheat flour: 20 % Almond Flour: 20 % Pawpaw Flour), E (60 % Wheat flour: 30 % Almond Flour: 10 % Pawpaw Flour), F (60 % Wheat flour: 40 % Almond Flour: 0 % Pawpaw Flour). The functional, proximate and selected phytochemicals of the flours and their blends were evaluated using standard methods. Results showed that the bulk density, foaming capacity, water absorption capacity, oil absorption capacity, swelling capacity and gelation temperature of the flours ranged from 0.63-0.70 g/ml, 0.10-0.55 %, 1.15-2.65 ml/g, 0.46-1.65 ml/g, 0.10-2.90 ml/g and 86.00 ^{o}C-

---

**Corresponding author: Email: mabohjoyceline100@gmail.com;*

90.00 °C respectively. The proximate composition ranged from 6.27-9.77% for moisture, 2.01-5.80 % for ash, 6.56-37.6 % for fat, 0.35-1.12 % for fiber, 6.01-20.67 % for proteins 27.93-77.34 % for carbohydrates and 369.8-534.08 Kcal/100g of energy. The anti-nutrients content of the flours ranged from 0.70-0.90 mg/100g, 0.01-0.17 mg/100g, 0.20-0.96 % for oxalates, cyanide and tannins respectively. This research indicates that almond and pawpaw floor blends could serve as functional and nutritional ingredients in foods at 40 % and 10 % almond and pawpaw flours in wheat respectively.

Keywords: Tropical almond; pawpaw; underutilized; functional; proximate and phytochemicals.

1. INTRODUCTION

The food industry today is faced with consumer pressure for more natural foods that is foods with health promoting benefits. This has influenced the aims of the food industry which are fourfold; to extend shelf life (period during which the food remains wholesome) by preservation techniques, to increase variety in diet (in terms of eating, functional and organoleptic quality), to improve the nutritional quality of food and to generate income for the manufacturing industry. Each of these aims exists to a greater or lesser extent in all food processes, but the processing of a given product may emphasize some more than others.

Fruits are rich sources of micronutrients such as minerals and vitamins. They also contain carbohydrates in the form of soluble sugar, cellulose and starch Yusufu and Akhigbe, [1]. They constitute a very important part of the diet and also serve as food supplement and appetizer Renard et al [2]. *Carica papaya* (pawpaw) is an evergreen, tree-like herb, with a height of approximately 2-10 m tall. It contains white latex, a cylindrical stem of about 10-30 cm in diameter, hollow with prominent leaf scars and spongy-fibrous tissue. Pawpaw has an extensive rooting system. Its fruits are large and cylindrical, with a fleshy orange pulp, hollow berry and thin yellowish skin when ripe. The generic name is from the Latin word ‘Carica’, meaning ‘edible fig’, on account of the similarity of the leaves. It grows satisfactorily in a wide range of areas from the equatorial tropics to temperate latitudes Orwa et al [3]. Pawpaw belongs to the family Caricaceae and it is the most important in the family. It is the fourth most important tropical fruit around the globe Scheldeman et al [4] with its major producers in the world being Australia, United States, Philippines, Sri Lanka, South Africa, India, Bangladesh, Malaysia and a number of other countries in tropical America Anuara et al [5]. The pulp of pawpaw is most often consumed fresh either in slices, in chunks as dessert and can equally be processed into a variety of products such as cookies, jams, jellies, marmalade, candies and fruit juices Yusufu and Akhigbe, [1]. Pawpaw is highly rich in vitamins and minerals such as potassium, magnesium, iron and sodium. It also contains some active compounds such as ascorbic acid (vitamin C), which is an antioxidant, β-carotene, α-tocopherol, flavonoids, vitamin B1, papain and niacin Oloyede, [6]; Leontowicz et al [7]. Approximately, the chemical composition of pawpaw per 100g edible portion is; water 86.6g, protein 0.5 g, fat 0.3 g, carbohydrates 12.1 g, fiber 0.7 g, ash 0.5 g, potassium 204 mg, calcium 34 mg, phosphorus 11 mg, iron 1 mg, sodium 3 mg, vitamin A 450 mg, vitamin C 74 mg, thiamine 0.03 mg, niacin 0.5 mg and riboflavin 0.04 mg. The energy value is 200 kJ/100g. Major sugars are sucrose (48.3 %), glucose (29.8 %) and fructose (21.9 %) Orwa et al [3].

Tropical almond also known as *Terminalia catappa* belongs to the family *Combretaceae*. Almond is known to have three (3) nuts producing varieties of which some are edible and others non-edible. One variety of almond produces edible sweet nuts, another produces non-edible bitter and poisonous nuts, while the third variety is a blend of both sweet and bitter almonds. Almond is native to western and central Asian countries. It is a small deciduous tree that usually grows to about 4-10 m tall with a trunk diameter of about 30cm. Its fruits are 3.5 to 6.0 cm long drupe, with a soft outer cover. They are known to survive best in well-drained soil of light to medium texture Mushtaq et al [8]. Almond consists mainly of three parts, that is, the kernel or meat, mid shell and outer green shell with a thin leathery layer called brown skin or seed coat. Almond seeds are a good source of proteins, edible oils and fats as well as they are rich in vitamins, minerals and fiber in the diets Salawu et al [9]. It is also potential raw materials for local industries where it is used to compliment local foods that are low in protein. They can be eaten either raw or in roasted form Shahid et al [10].

Tropical almond and pawpaw could become a functional food ingredient as well as protein source for human consumption. The utilization of tropical almond fruits and pawpaw flours in wheat for food preparation will depend on the knowledge of functional and chemical properties of the flour blends. This study therefore aimed at evaluating the functional and chemical properties of flours produced from blends of wheat, tropical almond and pawpaw.

2. MATERIALS AND METHODS

2.1 Source of Raw Materials

Pawpaw fruits (fresh, mature, firm and partially ripe) and almond kennels were purchased from railway market, Makurdi, Benue State, Nigeria. Wheat flour, margarine, baking powder, sugar, eggs and salt were gotten from Wurukum market. All these were then taken to the CEFTER food laboratory in Chemistry Department, Benue State University (BSU) where preparation, processing and analysis was carried out.

2.2 Preparation of Raw Materials

2.2.1 Preparation of pawpaw flour and almond kernel flour

Pawpaw and almond kernel flours were produced as shown on Figs. 1 and 2.

2.3 Blend Formulation

A flour blend of wheat, almond and pawpaw flour was formulated to obtain six (6) samples. The blends are shown in Table 1.

2.4 Analytical Methods

2.4.1 Determination of functional properties of flours

Functional properties such as bulk density, water absorption, oil absorption and foaming capacity of the flours and their blends were determined according to the method described by Onwuka, [13].

2.4.2 Determination of proximate composition of flour blend

This analysis was aimed at determining the amount of nutrients. These were determined according to standard methods AOAC, [14]. Total carbohydrate content was calculated using the following formula.

$$\%\text{Carbohyddrate} = 100\% - (\%\text{Moisture} + \%\text{Fat} + \%\text{Protein} + \%\text{Crudefibre} + \%\text{Ash} \quad (1)$$

The energy value was determined using the attwater factor viz.

$$\text{Energy value (Kcal/100g)} = 9\times \%\text{fat} + 4 \times \%\text{protein} + 4 \times \%\text{carbohydrate} \quad (2)$$

2.4.3 Determination of anti-nutritional factors of flour

The oxalate, tannins, and cyanides content of the flour were determined through the following methods;

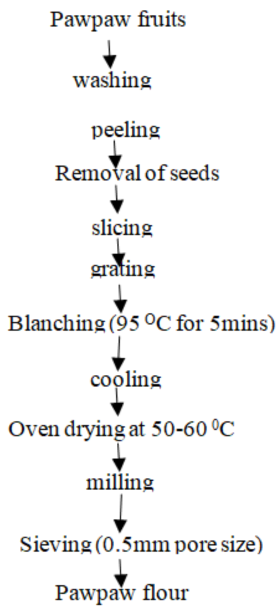

Fig. 1. Flow chart for the production of pawpaw flour

Source: Yusufu & Akhigbe [1]; FAO [11]

Oxalates and tannin content were determined respectively using the Dye and burn methods according to Krishnaiah et al [15].

Cyanide was equally determined according to Chaouali et al [16].

The phenolic compounds were determined according to the method reported by Laddomada et al [17], while the total flavonoids content was determined using aluminum chloride calorimetric method based on the methodology reported by Afify et al [18] with some modifications. All the analyses were repeated three times and the mean value of absorbance obtained.

Table 1. Flour blend formulation

Sample	Wheat flour (%)	Almond flour (%)	Pawpaw flour (%)
A	100	0	0
B	60	0	40
C	60	10	30
D	60	20	20
E	60	30	10
F	60	40	0

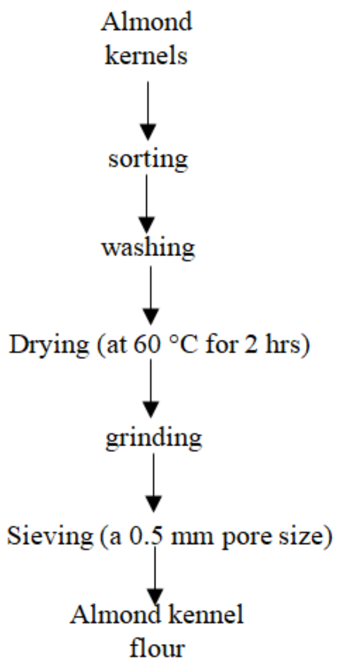

Fig. 2. Flow chart for the production of almond kernel flour
Source :Guyih et al [12]

3. RESULTS AND DISCUSSION

3.1 Functional Properties of Wheat, African Almond and Pawpaw Flour and their Blends

The results for the functional properties of the flours and their blends are shown in Table 2. Functional properties are essential physicochemical properties of the flour that reflect the complex interactions between the structures, molecular conformation, compositions and physicochemical properties of flour components with the nature of the environment and conditions in which these are measured and associated Suresh and Samsher, [19]; Awuchi et al [20]. Functional characteristics are required to predict and precisely evaluate how new proteins, fat, carbohydrates and fibre may behave in specific food systems as well as demonstrate whether or not such can be used to stimulate or replace conventional protein, fat, carbohydrates and fibre (Awuchi et al [20]. They also describe the behavior of ingredients during preparation and cooking and how they affect the finished products in terms of appearance, feel and taste. The following functional properties were evaluated;

The bulk density (the mass of many particles of flour material divided by the total volume they occupy) was 0.70 g/ml for wheat flour, 1.00 g/ml for almond flour and 0.63 g/ml for pawpaw flour. For the flour blends, the bulk density increased from 0.63 g/ml to 0.69 g/ml showing a significant difference (p<0.05) from sample C to F. It increased as the percentage of almond flour increased or with a decrease in pawpaw flour. This variation maybe due to the difference in the particle size of the flour blends. It could also be as a result of the high protein content of the almond flour. The results reported are in line with that reported by Awuchi et al [20]; Yusufu and Akhigbe [1]. Akubor and Owuse [21] also recorded similar results with a bulky density between 0.85 g for tomato peel flour and 0.68 g for wheat flour. Bulk density reflects the relative volume or capacity of the required packaging material. The higher the bulk density of the flour, the denser the packaging material required for packaging. It also indicates the porosity of a food product which impacts the design of the package and type of the packaging material required Iwe et al [22].

The foaming capacity of flour is a measure of the amount of interfacial area created by whipping the flour. Protein is mainly responsible for foaming. Foaming capacity and stability generally depend on the interfacial film formed by the proteins Mauer, [23]. The foaming capacity of the samples ranged from 0.10 % to 0.55 %. Almond flour showed the highest foaming capacity (0.55 %), followed by wheat flour (0.30 %) and the least by pawpaw flour (0.10 %). The foaming capacity increased from sample B to F as the percentage of almond flour increased. This increase could be attributed to the high protein content of almond. This makes it suitable for use in the food industry. Good foam capacity and stability are desired attributes for flours intended for use in the production of various baked products such as cakes, muffins, akara, cookies, etc. El-Adawy [24].

A significant (p<0.05) water absorption capacity of 1.55 ml/g was recorded in wheat flour, 1.15 ml/g in almond four and 2.50 ml/g in pawpaw flour. Meanwhile for the flour blends, a significant (p<0.05) decrease in water absorption capacity from 3.45ml/g in sample B to 2.03 ml/g in sample F was recorded as the percentage of pawpaw flour reduced in the samples. Water absorption capacity is the amount of water (moisture) taken up by food/flour to achieve the desirable consistency. It is influenced by factors such as starch, proteins and water binding ingredients such as fibre. The significantly high-water absorption capacity in pawpaw flour could be due to the presence of more hydrophilic constituents than in wheat and almond flour. It could also be related to its low moisture content and fibre content. A similar trend was reported by Yusufu and Akhigbe [1]. It is also in line with the range 1.19 to 4.31 mL/g recorded by Guyih et al [12].

Oil absorption capacity (OAC) is the binding of fat by the non-polar side chain of proteins. Almond flour recorded the highest oil absorption capacity (1.25 ml/g) followed by wheat flour (1.16 ml/g) while pawpaw flour recorded the least (0.46 ml/g) oil absorption capacity. No significant difference was recorded from sample A to C, while a significant increase (p<0.05) was noticed from sample D as the percentage of almond flour increases. The increase in the oil absorption capacity could be likened to the increase in proteins which contains non-polar side chains that bind the oil hydrocarbon side chains in foods and flours. The oil absorption capacity of almond was slightly higher than 1.10 ml/g reported by Guyih et al [12]. OAC is an essential functional property that contributes to enhancing mouth feel while retaining the flavor of the food Iwe et al [22]. The flours with high OAC are potentially beneficial in structural interactions in foods especially for improvement of palatability and flavor retention particularly in bakery products where fat absorption is desirable Suresh et al [25].

The swelling capacities of wheat, almond and pawpaw flours were 1.26 ml/g, 0.10 ml/g and 2.90 ml/g respectively. The swelling capacities of flours are influenced by the particle size, species variety and method of processing Suresh and Samsher [19]. The swelling capacity of the flour blends decreased as the percentage of pawpaw flour decreased from sample B to F with a significant difference (p<0.05) between the samples. The high swelling capacity of wheat and pawpaw flour could be as a result of their fine particle sizes and high-water absorption capacities.

Gelatinization temperature ranged from 86.00 ^{o}C to 90.00 ^{o}C with almond flour having the least gelatinization temperature and pawpaw flour having the highest. The temperature reduced with a reduction in pawpaw flour among the samples. The results were higher than the 65.40 ^{o}C to 71.55 ^{o}C reported by Jimoh [26]. It was equally higher than 65.33 ^{o}C to 68.83 ^{o}C reported by Apotiola & Fashakin [27]. Gelatinization temperature is the temperature at which the gelatinization of starch takes place. The gelatinization temperature of starch depends on the plant type and amount of water present, pH, salt concentration and types, sugar, protein, and fat in the recipe. Starch gelatinization improves and increases the availability of starch for hydrolysis by amylase. Gelatinization of starch is often used in cooking in food industries to ease starch digestibility and also to thicken/bind water in sauce, soup etc. Awuchi et al [28].

3.2 Anti-nutrient and Antioxidant Content of the Flours and their Blends

The results of the anti-nutrient composition of the flours and their blends are presented in Table 3. Anti-nutritional factors are associated with compounds or substances of natural or synthetic origin. They interfere with the absorption of nutrients and reduce the intake of nutrients, digestion and utilization and may produce adverse effects Aneta and Dasha, [29].

The oxalate content of wheat flour was 0.08 mg/100g that of almond flour 0.90 mg/100g and pawpaw flour 0.70 mg/100g. The oxalate content of wheat was far below the 35-270 mg/100g for grains, while that of almond is below 40-490 mg/100g reported by Aneta and Dasha [29] for nuts. That of pawpaw is equally lower than the 3.81 mg/100g reported by Ekissi et al [30] for the mature pulp of pawpaw. The oxalate content increased significantly (p<0.05) from sample C to F as the amount of almond flour reduces. The low oxalate values obtained is advantageous to man as lethal dose reported for man should be

Table 2. Functional properties of wheat, African almond and pawpaw flour and their blends

Sample	BD (g/ml)	FC (%)	WAC (ml/g)	OAC (ml/g)	SC ml/g	GT ^{o}C
A	$0.70^{d}\pm0.00$	$0.30^{b}\pm0.00$	$1.55^{d}\pm0.00$	$1.16^{c}\pm0.01$	$1.26^{b}\pm0.01$	$88.00^{b}\pm0.50$
B	$0.63^{a}\pm0.00$	$0.10^{a}\pm0.00$	$3.45^{f}\pm0.05$	$0.65^{b}\pm0.05$	$3.00^{g}\pm0.00$	$90.00^{e}\pm0.00$
C	$0.63^{a}\pm0.00$	$0.10^{a}\pm0.00$	$2.60^{e}\pm0.00$	$1.10^{c}\pm0.00$	$2.56^{e}\pm0.01$	$88.50^{c}\pm0.50$
D	$0.67^{b}\pm0.00$	$0.16^{b}\pm0.01$	$2.65^{e}\pm0.05$	$1.10^{c}\pm0.00$	$2.30^{d}\pm0.00$	$88.50^{c}\pm0.00$
E	$0.69^{c}\pm0.00$	$0.55^{c}\pm0.05$	$2.15^{c}\pm0.01$	$1.35^{e}\pm0.05$	$1.75^{c}\pm0.00$	$88.40^{d}\pm0.00$
F	$0.69^{c}\pm0.00$	$0.55^{c}\pm0.05$	$2.03^{b}\pm0.01$	$1.65^{f}\pm0.05$	$0.10^{a}\pm0.00$	$86.20^{a}\pm0.00$
AF	$1.00^{e}\pm0.00$	$0.25^{b}\pm0.00$	$1.15^{a}\pm0.05$	$1.25^{d}\pm0.01$	$0.10^{a}\pm0.00$	$86.00^{a}\pm0.00$
PF	$0.63^{a}\pm0.00$	$0.10^{a}\pm0.00$	$2.50^{g}\pm0.00$	$0.46^{a}\pm0.01$	$2.90^{f}\pm0.00$	$90.00^{d}\pm0.00$

Key; A- 100% Wheat Flour, B- 60% Wheat flour: 0% Almond Flour: 40% Pawpaw Flour, C- 60% Wheat flour: 10% Almond Flour: 30% Pawpaw Flour, D- 60% Wheat flour: 20% Almond Flour: 20% Pawpaw Flour, E- 60% Wheat flour: 30% Almond Flour: 10% Pawpaw Flour, F- 60% Wheat flour: 40% Almond Flour: 0% Pawpaw Flour. AF- Almond Flour, PF- Pawpaw Flour. Values represent mean±SD of triplicate determinations. Means in the same column with different superscripts are significantly different at p<0.05

between 2 to 5 g/kg Adejumo et al [31]. This implies the cookies are safe from the stand point of oxalate level. Oxalate is known to form complexes with most essential trace elements such as calcium resulting to unavailability for enzymatic and other metabolic activities Onwuka [13].

The results showed that the cyanide content ranged from 0.01 mg/100g to 0.17 mg/100g. The value of cyanide increased as the percentage substitution of almond increased. These results were similar to the 0.12 to 0.13 mg/100g reported by Guyih et al [12] for wheat, almond and carrot flours. It is slightly higher than the 0.02 to 0.03 mg/100g reported by Adejumo et al [31]. However, HCN content of flour was below the human toxicity (lethal dose 30-210 mg HCN) level and points to its usefulness in infant food formulations since infant lack the enzyme needed to detoxify HCN Umezuruike et al., [32].

In this study, the tannin content ranged between 0.20 % for wheat flour, 0.96 % for almond and 0.34 % for pawpaw flour. Tannin concentration increased significantly in the flour blends from 0.28 % in sample C to 0.36 % in sample F as percentage almond increases. This implies that almond has higher levels of tannins than pawpaw flour. These values are lower than 0.47 mg/g and 2.06 mg/g for wheat flour and germinated horse gram flour respectively, reported by Moktan and Ojha [33]. Nwachukwu et al [34] reported a tannin content of 0.24 mg/100g for Aduh flour. Tannins are anti-nutritional factors that form insoluble complexes with digestive enzymes and inhibit iron bioavailability. According to WHO, tannin level in foods below 5 mg/100g are safe for human consumption. This implies that the tannin content for wheat, almond and pawpaw flours used in this research are safe for consumption.

Results of total phenols showed a significant difference (*p*<0.05) between the individual flours. Wheat flour contained 0.66 mg/100g, almond flour 3.66 mg/100g and pawpaw flour 3.19 mg/100g. Its content increased from 1.40 mg/100 to 1.44 mg/100g in the flour blends with increase almond concentration since it’s richer in phenols than pawpaw. The phenolic content obtained from this study was similar with 0.51 to 1.24 mg/g and 0.21 to 2.35 mg/g reported by Kiin-Kabari et al [35]; Onwuka [36]. The values were lower than 6.7 ± 0.2 to 9.4 ± 0.1 mg/100g reported by Khan et al [37]. Polyphenols have been reported to have antioxidant and antimicrobial activity and can help fight against inflammation, degenerative diseases and allergies.

Flavonoids are antioxidants and have been reported to lower cholesterol, inhibit tumor formation, decrease inflammation and protect against cancer, heart diseases among others Onimawo and Akubor [38]. In this study, wheat flour recorded a flavonoid content of 0.88 mg QE/g, almond flour 7.40 mg QE/g and pawpaw flour 2.35 mg QE/g. The flavonoid content in the flour blends increased significantly from 0.88 to 1.47 mg QE/g with increase in the percentage of almond flour. These were in line with the 7.04 ± 0.02 mg/100g reported by Khan et al [37].

3.3 Proximate Composition of the Flours and their Blends

The results of the proximate composition of wheat, almond and pawpaw flours and their blends are shown in Table 4. The value for moisture ranged from 6.27 % to 9.77 % for the samples with wheat flour having the lowest value and almond flour having the highest value. Significant difference occurred among the samples. The moisture contents of the flours and their blends were similar to 8.57 to 10.00 % reported by Igbabul et al [39]. Peter-Ikechukwu et al [40] reported a moisture content of 8.25 to 11.15 % for date fruit pulp, toasted watermelon seed and wheat flour and their blends. The low values of moisture content in this study will enhance the storability and keeping quality of the products.

Ash content of any food is a measure of the total amount of minerals within the food produce. The ash content of the flours and their blends ranged from 2.01 % in wheat flour to 5.80 % in pawpaw flour. It increased significantly ($p<0.05$) from 2.20 % in sample E to 3.11 % in sample D. Samples having high percentage of pawpaw flour had a high ash content than those with almond. This was expected as pawpaw flour is rich in minerals. The results were in line with the 3.34 % to 5.84 % reported by Peter-Ikechukwu et al [40]. Awuchi [28] recorded ash content between 1.23 % to 2.42 % for soybean and wheat flour blends.

The results showed that the fat content ranged from 6.56 % in pawpaw flour to 37.63 % in almond flour. A significant increase was recorded between the samples from sample B (7.06 %) to F (36.56 %). This equally was expected as the percentage of almond flour in the samples increased. The high fat content of almond makes it desirable for products such as biscuits as it makes the texture soft.

Percentage fibre ranged from 0.35 % in wheat flour to 1.12 % in almond flour. The fibre content increased significantly from 0.57 % in sample B to 0.68 % in sample D as the percentage of almond flour increased in the flour blends. The results were coherent with the 0.84% to 1.23% reported by Ocheme et al [41] for wheat and groundnut protein concentrate flour blends. It was less than the 1.53 % to 3.67 % reported by Peter-Ikechukwu et al [40].

For proteins, a significant ($p<0.05$) difference was recorded between the samples. The highest protein content of 20.67% was recorded in almond flour. The protein content increased from 6.01 % to 14.55 % from sample A to F with increase substitution of almond flour in the flour blends. This is obviously because almond is a very rich source of proteins. A protein content of 20.45 and 22.98 % was reported by Makinde and Adeyemi [42] for roasted and whole almond flour respectively and 11.91 to 22.18 % reported by Stoin et al [43-46].

A significant ($p<0.05$) difference in carbohydrate was recorded among the samples. It ranged from 27.93 % in almond flour to 77.34 % in wheat flour. No significant increase was recorded between sample C and D, while it increased significantly from sample E to F. The results obtained were coherent with those of Ocheme et al [41] for wheat and groundnut protein concentrate flour blends. Apotiola and Fashakin, [27] also reported a carbohydrate content between 66.82-78.10 % for cocoyam flour, wheat flour and soybean flour blends. A significant difference in energy was recorded and it ranged from 369.8-534.08 Kcal/100g.

Table 3. Anti-nutrients and photochemical content of the flours and their blends

Sample	Oxalate (mg/100g)	Cyanide (mg/100g)	Tannins (mg/100g)	Total Phenols(mg/100g)	Total Flavonoid(mgQE/g)
A	$0.08^{a}\pm0.01$	$0.01^{a}\pm0.00$	$0.20^{a}\pm0.00$	$0.66^{a}\pm0.01$	$0.88^{a}\pm0.00$
B	$0.40^{d}\pm0.00$	$0.06^{d}\pm0.00$	$0.36^{d}\pm0.00$	$1.44^{c}\pm0.00$	$1.36^{d}\pm0.01$
C	$0.21^{b}\pm0.01$	$0.04^{b}\pm0.00$	$0.28^{b}\pm0.02$	$1.40^{b}\pm0.02$	$0.88^{a}\pm0.01$
D	$0.30^{c}\pm0.00$	$0.05^{c}\pm0.00$	$0.34^{c}\pm0.01$	$1.44^{c}\pm0.00$	$0.98^{b}\pm0.01$
E	$0.30^{c}\pm0.00$	$0.05^{c}\pm0.00$	$0.34^{c}\pm0.01$	$1.44^{c}\pm0.00$	$1.32^{c}\pm0.02$
F	$0.40^{d}\pm0.00$	$0.06^{e}\pm0.00$	$0.36^{d}\pm0.00$	$1.67^{d}\pm0.01$	$1.47^{c}\pm0.00$
AF	$0.90^{f}\pm0.00$	$0.17^{g}\pm0.01$	$0.96^{e}\pm0.00$	$3.66^{f}\pm0.01$	$7.40^{f}\pm0.05$
PF	$0.70^{e}\pm0.00$	$0.13^{f}\pm0.01$	$0.34^{f}\pm0.00$	$3.19^{e}\pm0.00$	$2.35^{e}\pm0.09$

Key; A- 100% Wheat Flour, B- 60% Wheat flour: 0% Almond Flour: 40% Pawpaw Flour, C- 60% Wheat flour: 10% Almond Flour: 30% Pawpaw Flour, D- 60% Wheat flour: 20% Almond Flour: 20% Pawpaw Flour, E- 60% Wheat flour: 30% Almond Flour: 10% Pawpaw Flour, F- 60% Wheat flour: 40% Almond Flour: 0% Pawpaw Flour. AF- Almond Flour, PF- Pawpaw Flour. Values represent mean±SD of triplicate determinations. Means in the same column with different superscripts are significantly different at p<0.05.

Table 4. Proximate composition of wheat, African almond and pawpaw flours and their blends

				%			Kcal/100g
Sample	**Moisture**	**Ash**	**Fat**	**Fibre**	**Protein**	**Carbohydrate**	**Energy**
A	6.27^{a}±0.01	2.01^{a}±0.00	8.02^{b}±0.02	0.35^{a}±0.01	6.01^{a}±0.00	77.34^{g}±0.02	405.58^{c}±0.07
B	8.94^{cd}±0.01	3.00^{d}±0.04	7.06^{b}±0.00	0.77^{d}±0.00	6.42^{b}±0.02	73.81^{f}±0.29	384.46^{b}±0.65
C	6.83^{b}±0.18	3.09^{ab}±0.06	21.76^{c}±0.00	0.57^{b}±0.00	10.70^{c}±0.06	57.05^{d}±0.04	466.84^{e}±0.28
D	7.72^{c}±0.21	3.11^{c}±0.03	24.58^{d}±0.01	0.58^{b}±0.01	13.02^{d}±0.00	50.99^{d}±0.14	477.26^{f}±0.83
E	8.12^{d}±0.01	2.20^{b}±0.03	29.13^{e}±0.01	0.68^{c}±0.01	14.39^{e}±0.02	32.61^{b}±0.22	450.17^{d}±0.12
F	8.69^{f}±0.20	2.62^{c}±0.08	36.56^{f}±0.01	0.87^{e}±0.00	14.55^{e}±0.01	36.71^{c}±0.12	534.08^{g}±1.06
AF	9.77^{f}±0.08	2.88^{d}±0.09	37.63^{g}±0.03	1.12^{f}±0.08	20.67^{g}±0.04	27.93^{a}±0.02	533.07^{g}±33.18
PF	9.28^{e}±0.02	5.80^{e}±0.15	6.56^{a}±0.00	0.67^{c}±0.01	15.08^{f}±0.05	62.61^{e}±8.33	369.8^{a}±0.30

Key; A- 100% Wheat Flour, B- 60% Wheat flour: 0% Almond Flour: 40% Pawpaw Flour, C- 60% Wheat flour: 10% Almond Flour: 30% Pawpaw Flour, D- 60% Wheat flour: 20% Almond Flour: 20% Pawpaw Flour, E- 60% Wheat flour: 30% Almond Flour: 10% Pawpaw Flour, F- 60% Wheat flour: 40% Almond Flour: 0% Pawpaw Flour. AF- Almond Flour, PF- Pawpaw Flour

Values represent mean±SD of triplicate determinations. Means in the same column with different superscripts are significantly different at $p<0.05$

4. CONCLUSION

This work succeeded in producing flour blends from wheat, tropical almond and pawpaw flours. Sample E (60% Wheat flour: 30% Almond Flour: 10% Pawpaw Flour) and sample F (60% Wheat flour: 40% Almond Flour: 0% Pawpaw Flour) rated best in terms of the nutritional value of the flours and therefore can be recommended for large scale commercial purposes. Substitution of wheat flour with tropical almond and pawpaw flours significantly improved the proximate parameters and also better functional properties. The use of these flour blends in suitable proportions in bakery products would enhance dietary quality and minimize post-harvest loss of these crops.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Yusufu MI, Akhigbe AO. The production of pawpaw enriched cookies: functional, physico-chemical and sensory characteristics. Asian Journal of Agriculture and Food Science. 2018;2(2):100-105.
2. Renard D, Mahaut L, Noack F. Crop diversity buffers the impact of droughts and high temperatures on food production. Environmental Research Letters. 2023; 18(2023):1-8.
3. Orwa C, Muua A, Kindt R, Jamnadass R, Anthony S. Agroforestry data base: A tree reference and selection guide version. 4th edition. World Agroforestry Centre, Kenya; 2009.
4. Scheldeman X, Willemen L, Coppens EG, Romeijn-Peeters E, Restrepo MT, Romero MJ, Jiménez D, Lobo M, Medina CI, Reyes C, Rodríguez D, Ocampo JA, Van Damme P, Goetgebeur P. Distribution, diversity and environmental adaptation of highland papayas (Vasconcellea spp) in tropical and subtropical America. Biodiversity and Conversion. 2007;16(6):293–310.
5. Anuara NS, Zaharia SS, Taiba IA, Rahaman MT. Effect of green and ripe carica biscuits made from wheat supplemented with watermelon rinds and orange pomace flour blends. Food and Nutrition Sciences. 2008;12(2157-944X): 332–341.
6. Oloyede IO. Chemical profile of unripe pulp of *Carica papaya*. Journal of Nutrition. 2005;4(6):379–361.
7. Leontowicz M, Leontowicz H, Drzewiecki Jastrzebski J, Haruenkit Z, Poovarodom R, Park S, Jung YS, Kang ST, Trakhtenberg S. Two exotic fruits positively affect rat's plasma composition. Food Chemistry. 2007;102(14):192–200.
8. Mushtaq A, Khaliq M, Saeed A, Azeem MW, J, Ihene BG. Almond (*Purunus amygdalus* L.): A review on health benefits, nutritional value and therapeutic applications. International Journal of Chemistry and Biochemical Science. 2015; 8(2015):103–106.
9. Salawu RA, Onyegbula AF, Lawal IO, Akande SA, Oladipo AK. Comparative study of the nutritional, phytochemical and mineral compositions of the nuts of tropical almond (*Terminalia catappa*) and sweet almond (*Prunus amygdalus*). Ruhuna Journal of Science. 2018;9(2536–8400): 70–77.
10. Shahid M, Tahreem JM, Wajiha S, Muhammad QA. A critical review on varieties and benefits of almond (*Prunus dulcis*). Acta Scientific Nutritional Health. 2019;3(11):70–72.
11. FAO. The state of the world's land and water resources for food and agriculture: Managing systems at risk. Rome (Italy). 2013:ISBN 92-5-104005-2.
12. Guyih MD, Ahure D, Eke MO. Production and quality evaluation of cookies from wheat, almond seed and carrot flour blends. International Journal of Food Science and Biotechnology. 2020;5(4):55–61.
Available:https://doi.org/10.11648/j.ijfsb.20200504
13. Onwuka GI. Food analysis and instrumentation*:* Theory and practice. Naphthali Print, Lagos. 2005a:95-96.
14. AOAC. Official Methods of Analysis (17th ed.); 2010.
15. Krishnaiah D, Devi T, Bono A, Sarbatly R. Studies on phytochemical constituents of six Malaysian medicinal plants. Journal of Medicinal Plant Resources. 2009;3(2):67–72.
16. Chaouali N, Ines G, Amira D, Fathia K, Anouer N, Wafa M, Ines B, Hayet G, Abderazzek H. Potential toxic levels of cyanide in Almonds (*Prunus amygdalus*), apricot kernels (*Prunus armeniaca*), and almond syrup. Hindawi; 2013.

Available:https://doi.org/10.1155/2013/610648

17. Laddomada B, Durante M, Mangini G, D'Amico L, Lenucci MS, Simeone R, Piarulli L, Mita G, Blanco A. Genetic variation for phenolic acids concentration and composition in a tetraploid wheat (*Triticum turgidum* L.) collection. Genetic Resource and Crop Evolution. 2016; 64(3):587–597.
18. Afify AE, El-Beltagi HS, El-Salam SM, Omran AA. Biochemical changes in phenols, flavonoids, tannins, vitamin E, β–carotene and antioxidant activity during soaking of three white sorghum varieties. Asian Pacific Journal of Tropical Biomedicine. 2012;2(3):203–209.
19. Suresh C, Samsher. Assessment of functional properties of different flours. African Journal of Agricultural Research. 2013;8(38):4849–4852. Available:https://doi.org/10.5897/AJAR2013.6905
20. Awuchi CG, Igwe VS, Echeta CK. The functional properties of foods and flours. International Journal of Advanced Academic Research. 2019;5(11):139-154.
21. Akubor PI, Owuse AU. Chemical composition, functional and biscuit making properties of tomato peel flour. South Asian Journal of Food Technology. Environ. 2020;6(1):874–884.
22. Iwe AN, Onyeukwu MO, Agiriga U. Proximate, functional & pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour. Cogent Food & Agriculture. 2016;2(11):42-49. Available:https://doi.org/10.1080/23311932.2016.1142409
23. Mauer L. Foaming capacity and foam stability. In Encyclopedia of Food Sciences & Nutrition (2nd ed.); 2003.
24. El-Adawy TA. The characteristics and the composition of watermelon, pumpkin, & paprika seed oils and flours. Journal of Agricultural and Food Chemistry. 2001;49: 1253–1259. Available:http://dx.doi.org/10.1021/jf001117
25. Suresh C, Samsher S, Durvesh K. Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. Journal of Food Science and Technology. 2015;56(2):3681–3688. Available:https://doi.org/10.1007/s13197-014-1427-2
26. Jimoh MO. Quality evaluation of cookies made from wheat flour fortified with tiger nut flour and date palm fruit. European Journal of Food Science and Technology. 2021;9(3):35–52.
27. Apotiola ZO, Fashakin JF. Evaluation of cookies from wheat flour, soybean flour and cocoyam flour blends. Journal of Food Science and Quality Management. 2013a;14(2013):2224–6088.
28. Awuchi CG. Proximate composition and functional properties of different grain flour composites for industrial applications. International Journal of Food Sciences. 2019;2(1):43–64.
29. Aneta P, Dasha M. Antinutrients in plant-based foods. The Open Biotechnology Journal. 2019;13:68–76. Available:https://doi.org/10.2174/1874070701913010068
30. Ekissi ESG, Koffi EA, Konan OH, Gbotognon OJ, Kouadio NP. Composition of organic acids and anti-nutritional factors of papaya (*Carica papaya* l. var solo 8) at different stages of maturity. World Journal of Pharmaceutical and Medical Research. 2020;6(12).
31. Adejumo P, Adejumo A, Edebiri O, Olukoya FO. Effect of unripe banana and pigeon pea flour on the chemical, anti-nutritional and sensory properties of whole wheat-based cookies. GSC Advanced Research and Reviews. 2020;4(1):17-23.
32. Umezuruike AC, Nwabueze T, Akobundu EN. Anti nutrient content of food grade flour or roasted African breadfruit seeds produced under extreme condition. Academia Journal of Biotechnology. 2016; 4(5):194–198. Available:https://doi.org/10.15413/ajb.2015.0240
33. Moktan K, Ojha P. Quality evaluation of physical properties, antinutritional factors, and antioxidant activity of bread fortified with germinated horse gram (*Dolichus uniflorus*) flour. Food Science & Nutrition. 2016;4(5):766–771.
34. Nwachukwu CN, Njoku CC, Anusionwu JC. Anti- (*Dioscorea bulbifera*) and its performance as wheat substitute in bread production. International Journal of Innovative Food, Nutrition & Sustainable Agriculture. 2020;8(3):36–42.
35. Kiin-Kabari DB, Mbanefo CU, Akusu OM. Production, nutritional evaluation and acceptability of cookies made from a blend of wheat, African walnut, and carrot flours.

Asian Food Science Journal. 2021;20(6): 60–76.
36. Onwuka GI. Food analysis and instrumentation. Theory and practice. naphthali print, lagos. 2005b:133-137.
37. Khan MS, Samina KY, Sani S, Mohd R. Determination of Total phenolic content, total flavonoid content and antioxidant activity of various organic crude extracts of *Licuala spinosa* leaves from Sabah, Malaysia. ASM Science. Journal. 2018; 11(3):53-58.
38. Onimawo I, Akubor PI. Food chemistry. (Integrated approach with biochemical background). 2nd ed, Joytal Printing Press, Agbowo; 2012.
39. Igbabul B, Bello F, Ekeh CN. Composition and functional properties of wheat, sweet potato and hamburger bean flour blends. Global Advanced Research Journal of Food Science and Technology. 2014;3(4): 118–124.
40. Peter-Ikechukwu A, Ogazi C, Uzoukwu A, Kabuo N, Chukwu MN. Proximate and functional properties of composite flour produced with date fruit pulp, toasted watermelon seed and wheat. J Food Chem Nanotechnol. 2020;6(3):159-166.
41. Ocheme O, Adedeji O, Chinma C, Yakubu C, Ajibo UH. Proximate composition, functional, and pasting properties of wheat and groundnut protein concentrate flour blends. Food Science and Nutrition. 2018; 6(5):1173– 1178.
42. Makinde FM, Adeyemi AT. Quality characteristics of biscuits produced from composite flours of wheat, corn, almond and coconut. Annals. Food Science and Technology. 2018;19(2):216-224.
43. Stoin D, Jianu C, Mișcă C, Bujancă G, Rădulescu L. Effect of almond flour on nutritional, sensory and bakery characteristics of gluten-free muffins. International Multidisciplinary Scientific GeoConference-SGEM. 2018;18(6.4):127-134.
Available:https://doi.org/10.5593/sgem2018V/6.4/S08.017
44. Fellows P. Food Processing Technology Principles And Practice 2nd Edition. Wood head Publishing Limited and CRS Press LLC, Washington DC. 2000: 98.
45. Sengev IA, Gernah DI, Bunde-Tsegba MC. Physical, chemical and sensory properties of cookies produced from sweet potato and mango mesocarp flours. African. Journal of Food, Agriculture, Nutrition and Development. 2015;15(5):270-275.
46. Uzo-Peters PI, Ola ST. Proximate Composition and functional properties composite sorghum-okara flour and sensory evaluation of local snack product (SOSA). Agrosearch. 2020;20(1): 158–167.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/103012