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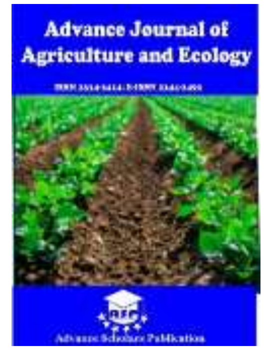


# CHEMICAL COMPOSITIONS OF WHEAT, AFRICAN BREADFRUIT, SPROUTED SOYBEANS, UNRIPE PLANTAIN FLOURS, AND CARROT JUICE

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***Keywords;*** *Composition, Flours, Sprouted, Juice.*

***Abstract:***
***Background:*** *Chemical composition is the breakdown of consumable materials to their primary chemical components, essential for various bodily functions. Industrial processes determine these compositions through chemical reactions, with carbohydrates derived from other components.*
***Objective:*** *The study evaluated the chemical compositions of wheat, African breadfruit, sprouted soybeans, unripe plantain flours, and carrot juice.*
***Materials and Methods:*** *Wheat grain, African breadfruit, soybean, unripe plantain, and carrot were purchased from Umuahia main market, Abia State. Preparation of flour from processed unripe plantain and durum wheat were done using Kitchenseer method, preparation of African breadfruit flour was done using Priyanka et al. method, preparation of sprouted soybeans flour was done using Uzo-Peters and Akinola method, and preparation of carrot juice was done using Sharma et al. method. Chemical analysis for each food material was done using Association of Official Analtyical Chemist International (AOAC International) method and Statistical Package for Social Sciences (SPSS, Version 20.0) was used to analyze for significance of chemical analysis.*
***Results:*** *The chemical content of durum wheat flour (DWF), African breadfruit (ABF), sprouted soybeans flour (SSF), unripe plantain flour (UPF), and carrot juice (CJ) were –*

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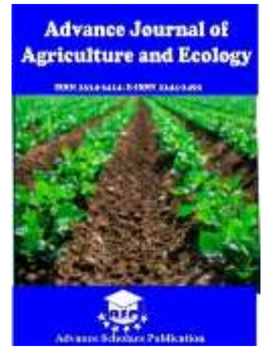


*Moisture content ranged from 6.40% in sprouted soybean flour (SSF) to 10.27% in durum wheat flour (DWF), there were significant difference ($p<0.05$) in the moisture content of the samples. Protein content of the samples ranged between 38.00% in sprouted soybeans flour (SSF) to 2.73% in unripe plantain flour (UPF). Calcium content were 1.06mg/100g in African breadfruit (ABF) to 69.40mg/100g in UPF (unripe plantain flour) (69.40mg/100g) was significantly higher ($p<0.05$) than the calcium content of the other samples. Iron content ranged from 0.59mg/100g in ABF to 2.04mg/100g in UPF. Carrot juice content phosphorous 52.01mg/100g, calcium 15.41mg/100g, magnesium32.07mg/100g and iron 1.43mg/100g. Beta carotene content of the flour samples ranged 2.89µg in DWF to 0.90µg in UPF. Thiamin content ranged from 5.10mg/100g in DWF to 0.19mg/100g in UPF. Riboflavin ranged from 3.90mg/100g in DWF to 1.89mg/100 in UPF. Vitamin contents of carrot juice were 13.26µg beta carotene, 20.10mg/100g vitamin C, 4.56mg/100g Niacin, 5.82mg/100g Riboflavin. Tannin content ranged from 0.87mg/100g in DWF (durum wheat flour) to 3.37mg/100g in SSF (sprouted soybean flour). Phytate ranged from 2.68mg/100g in DWF to 0.20mg/100g in SSF. Oxalate ranged from 7.02mg/100g in DWF to 1.03mg/100g in UPF. Carrot juice anti-nutrient content was tannin 2.12mg/100g, 0.51mg/100g of Phytate and 1.06mg/100g of Oxalate. Flavonoid content of the flour ranged from 1.72mg/100g in ABF to 0.85mg/100g in UPF. Polyphenol content ranged from 83.72mg/100g in DWF to 2.04mg/100g in ABF.*
***Conclusion:*** *The flours and juice produced are of high quality as the nutritional value was affected following the production course. This research is of great benefit to food industries, as healthier and high quality flours and juice were produced and which will serve confectionaries and pastas productions.*

## INTRODUCTION

Chemical composition, this analysis method breaks down consumable materials to their primary components, providing insights into packaged food contents [1]. Industrial processes determine these compositions through chemical reactions, with carbohydrates derived from other components [1]. As Nilusha et al. [2] highlight, the ingredients used in pasta preparation significantly influence its physical, chemical, and textural properties. Incorporating unconventional ingredients can alter pasta quality, necessitating research into innovative ingredients to enhance dough quality and produce nutritious pasta variants with superior attributes. Functional characteristics pertain to the vital physicochemical attributes of foods that showcase intricate interactions between their structures, molecular configurations, compositions, and how these components interact with their surroundings and testing conditions [3, 4]. Awuchi, Igwe, and Echeta [4]

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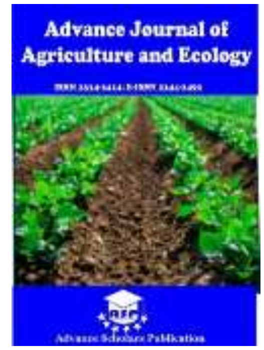


highlighted that these properties encompass aspects like swelling, water and oil absorption, emulsion activities and stability, foam properties, gelatinization, density, preservation, and more. These characteristics define a food's structure, texture, nutritional value, and its overall appeal. These properties are discerned through sensory, physical, and chemical assessments. Other functional attributes include solubility, water retention, elasticity, and the capacity to absorb fats or form emulsions [3, 5]. Components like carbohydrates, proteins, fats, moisture, and additives like sugar alcohols influence these properties [6, 7]. For example, sprouting soybeans can alter the functional properties of flours and related products.

Wheat stands as a historical global staple, addressing civilization's food needs for over 10,000 years [8]. Among various wheat species, common durum wheat or *Triticum turgidum* durum is predominant [1, 8]. Currently, wheat ranks as the top globally produced food crop, historically offering unparalleled nutrients through bread [8]. Additionally, the blending of wheat flour with other flours, termed composite flour, is common, incorporating ingredients like legumes, maize, soybean, and cassava [2]. The nutritional profile of 100 grams of Durum Wheat Flour was examined by Arnarson [9] and Dan-Brennam [10], covering aspects like calories = 340, moisture content = 11%, protein = 13,2%, carbohydrates = 72grams, sugars 0.4grams, fiber = 10.7grams, fats = 2.5grams, calcium = 145mg, magnesium = 136mg, phosphorous = 352mg, potassium = 376mg, folate = 39mch, niacin = 5.5mg, thiamin = 0.5mg, and amino acid = 6.3 – 10.6%. Durum wheat flour has oxalate content of 75mg/100g [11], phytate content of 3.68mg/100g [12], flavonoids content of 0.96mg/100g [13], and polyphenols content of 295.01mg/100g [13].

African breadfruit, scientifically known as *Treculia africana Dcene*, belongs to the Moracea family. Its seeds contain about 17-25% protein and 11% crude fat, along with vital vitamins and minerals [14]. Rafiq et al. [15] highlighted its significance due to its abundance in tropical regions, affordability, and versatility in culinary applications. Despite its nutritional benefits, its amino acid composition, notably low in sulphur amino acids and high in lysine, arginine, and histidine, presents challenges. This amino acid profile makes it less optimal as a sole food source, especially for infants. However, when combined with cereals like wheat, as in bread formulations, this deficiency can be mitigated [14]. African breadfruit can be prepared in various ways such as boiling, roasting, or frying. Given its availability and nutritional richness, especially in fiber, vitamins

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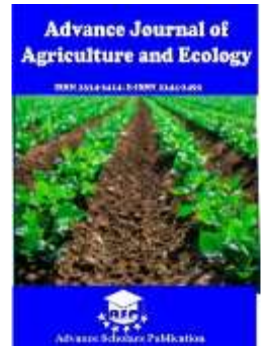


like C, potassium, and flavonoids, it stands out as a beneficial gluten-free food option. Nutritional Content of African Breadfruit Flour per 100 grams as Adeyeye and Adesina [16] and Ojokoh et al. [17] conducted evaluations on the nutritional content of Durum Wheat Flour, focusing on components values of 1.56gm of fat, 2.45gm of protein, 77.1gm of carbohydrates, 4.71gm of ash, 9.54gm of fiber, 0.61mg of calcium, 0.59mg of magnesium, 75,9mg of phosphorous, 0.65mg of potassium, and 41,0mg of amino acid. African breadfruit flour has oxalate content of 15mg/100g [17], phytate content of 0.55mg/100g [17], flavonoids content of 2.6mg/100g [18], and polyphenols content of 3.45mg/100g [18].

Soybean, recognized as Glycine max L, is a notable crop in both the pulse and oilseed categories [19]. This plant, part of the Papilionaceous family, is an upright annual herb reaching up to 1.5 meters in height, with pods containing typically 3 to 4 beans of varying colors [19]. Legumes often referred to as pulses, peas, or beans, are edible seeds from leguminous plants of the leguminosae family, which encompasses numerous species [19]. Soybean's composition of 40% protein and 20% fat positions it significantly against malnutrition challenges, though it contains anti-nutrients like phytates and saponins. These can be reduced through processes like sprouting; enhancing the soybean's nutritional and functional attributes [1]. Sprouting involves soaking and allowing grains or seeds to germinate, improving digestibility and nutrient availability. This process also enhances amino acid content and vitamin availability [20].

Sprouting, as described by Śca et al. [21], is an approach to leverage the inherent advantages of a natural process. Seeds inherently contain all the essential nutrients for the embryo's growth, which remains dormant until triggered by moisture, typically from rainfall [21]. This rain-induced germination prompts the emergence of the embryo from its outer shell. When foods are termed "sprouted," it means they've undergone a process mimicking seed soaking to initiate sprouting [21, 22]. This method, applied to various grains, seeds, nuts, and legumes, enhances nutrient extraction and availability [21, 22].

Benefits of sprouting [21, 22. 23] includes: neutralization of enzyme inhibitors, enhanced digestibility, reduction in gluten, elimination of anti-nutrients, boosting nutritional value through sprouting, potential benefits for diabetics through sprouting, and sprouted foods and cooking efficiency. Nutritive value of 100grams of sprouted soybeans flours according to Śca et al. [21] are carbohydrate = 6.7gm, fiber

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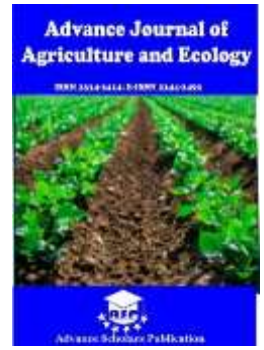


= 1gm, protein = 9.16gm, fat = 4.7gm, folate = 12.0mcg, zinc = 0,82mg, vitamin A = 0.70mcg, thiamin = 0.119mg, niacin = 0.805mg, vitamin c = 10.8mg, calcium = 46.30mg, sodium = 4.90, potassium = 196.40mg, and magnesium = 25.20mg. Sprouted soybeans flour has oxalate content of 58mg/100g [24], phytate content of 0.26mg/100g [17], flavonoids content of 1.04mg/100g [24], and polyphenols content of 19.67mg/100g [18].

Plantain belong to the Musacace family, plantain is cultivated extensively in tropical and subtropical regions worldwide and is particularly significant in Nigeria, ranking third in sustainability after yams and cassava [25, 26]. Musa Paradisiaca, commonly known as plantain, serves as a vital starchy staple for numerous Nigerians, with an annual production of approximately 63 million tons. While the majority, around 90%, is consumed domestically, a mere 10% contributes to export earnings [28]. This fruit is nutritionally dense, offering essential nutrients such as iron, zinc, potassium, and sodium. In Nigeria and other West African regions, unripe plantains are processed into flour and utilized in various forms, including food, beverages, medicines, and flavorings [25, 26]. Given the high anti-nutrient content in legumes like soybeans, sprouting emerges as a viable processing method, reducing anti-nutritional factors while enhancing nutritional value. Production predominantly occurs in Nigeria's southern states, reflecting its widespread consumption as a staple [25]. The nutritional attributes of unripe plantain flour per 100grams have been analyzed by Marengo [27, 28], encompassing parameters like energy = 126.6kcal, moisture = 59.4g, protein = 7.7g, carbohydrate = 24,4g, ash = 1.5g, fiber 1.4g, potassium = 120mg, magnesium = 275mg, phosphorous = 185mg, iron = 2,53mg, sodium = 80mg, calcium = 66.6mg, zinc = 3.7mg, vitamin c – 23mg, vitamin A = 63ug, and vitamin b6 = 0.29mg. Unripe plantain flour has oxalate content of 2.87mg/100g [29], phytate content of 42.6mg/100g [12], flavonoids content of 0.86mg/100g [30], and polyphenols content of 41.03mg/100g [18].

Carrot, scientifically termed *Daucus carota L*, is a globally recognized root vegetable, rich in β-carotene, fiber, and various micronutrients [31]. With its high water content of 88%, it also contains essential sugars like glucose, fructose, and sucrose. Carrots are abundant sources of vital minerals and vitamins, including potassium, Vitamin A, B6, K, and C. Notably, the presence of carotenoids, especially β-carotene, contributes to its anti-cancer, antioxidant, and immune-boosting properties. Furthermore, the antifungal properties of carrots can be

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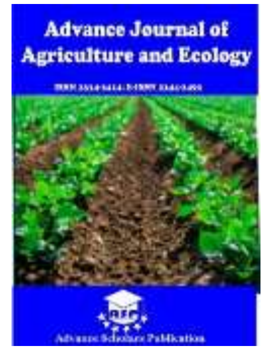


attributed to carotol [31]. Carrot juice stands out as a favored vegetable drink, abundant in natural β- and α-carotene [32]. Enzymatic processes in fruit processing, particularly with carrots, aim to enhance both juice yield and β-carotene content [32]. Nutritive value of carrot juice per 100ml according to Ware [33] are 94kcal of energy, 2.24g of protein, 0.35g of fat, 21.9g of carbohydrate, 1.89g of fiber, 275mg of potassium, 20.1mg of vitamin C, 0.217mg of vitamin B1, 0.512mg of vitamin B6, 2.290mcg of vitamin A, and 36.6mcg of vitamin K. Carrot juice has oxalate content of 2.5mg/100g [34], flavonoids content of 3.98mg/100g [11], and polyphenols content of 26.09mg/100g [12].

This study is geared towards analyzing the proximate (moisture, protein, fat, fiber, ash, carbohydrate), vitamin (beta carotene, C, $B_1$, $B_2$, $B_3$), and mineral (phosphorous, calcium, magnesium, iron) content, assessing the functional attributes (bulk density, oil absorption capacity, water absorption capacity, emulsion capacity, and pH) of the flours, and determining the anti-nutrient (tannin, phytate, oxalate) levels in the flours.

## MATERIALS AND METHODS

**Procurement of materials:** Carrot (*Daucus carota*), durum wheat (*Triticum turgidum durum*), African breadfruit (*Treculia Africana Decne*), soy beans (*Glycine max*), and unripe plantain (*Musa paradisiaca*) were purchased from Umuahia main market, Urbani, Umuahia, Abia State.

**Ethical approval:** Ethical Approval clearance was gotten from Federal Medical Center, Umuahia, Abia State for approval of the research before it was carried out and with approval clearance number: **FMC/QEH/G.596/Vol.10/529**

**Preparation of Flour from Processed Unripe Plantain using Kitchenseer Method [35]:** Ten kilograms (10kg) (30 fingers) of Unripe Plantain were plucked from the bunch , washed in room temperature water, peeled, sliced (manually) into chips, dried at 100°C for 1 hour using moisture dehydrating oven and allowed to cool. Then, milled using the milling machine (flour mill, INCH-16), and sieved with mesh screen (300nm size). The flour was measured, package and stored in an airtight container for laboratory analysis and production of pastas.

**Preparation of Durum Wheat Flour using Kitchenseer Method [35]:** Three and half kilograms (3.5kg) of Durum Wheat were sorted and milled into flour using the milling machine (flour mill, INCH-16) and sieved with mesh screen (300nm size) then stored in an airtight container for analysis and production of pastas.

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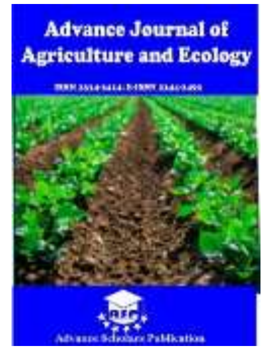


**Preparation of African Breadfruit Flour using Priyanka et al. Method [13]:** Four kilograms (4kg) of African Breadfruit was dehulled, sorted, and dehydrated in moisture oven at 50°C for 30 minutes. It was milled into flour using the milling machine (flour mill, INCH-16) and sieved with mesh screen (300nm size), then stored in an airtight container for analysis and production of pastas.

**Preparation of Sprouted Soybeans Flour using Uzo-Peters and Akinola Method Sprouting of Soybeans [36]:** Soybean seeds were sorted and cleaned to remove spoilt grains, stones, and other foreign materials, 5kg of the sorted soybeans were soaked in water at room temperature for 3hours and then the soaked soybeans were drained and spread on a sieve clothe and covered the soaked soybeans, giving room for ventilation, and the soaked-drained soybeans were sprinkled with water every 6hours for 48hours until they sprouted.

**Processing of Sprouted Soybeans Flour:** The sprouted soybeans were washed, drained, and dried in moisture oven at 100°C for 1hour, they were milled into sprouted soybean flour (SSF) using milling machine (flour mill, INCH-16) and sieved with mesh screen (300nm size), then stored in an airtight container for analysis and production of pastas.

**Preparation of Carrot Juice using Sharma et al. Method [34]:** Carrot (root vegetable) were washed and sponged properly to remove dirties, the back was peeled/scraped off, then sliced in smaller particles to fit into the juice extractor, the juice extractor extracted the juice separately and the chaff separately for 10minutes, the juice was collected in a clean container for analysis and production of pastas immediately.

**Chemical analysis:** Proximate analysis was determined using the method described by AOAC [37]. Crude protein, fat, fiber, and ash were determined. Carbohydrate was determined by difference.

The mineral content of the test samples was determined by the dry ash extraction method after which specific mineral elements was determined according to the method by AOAC [37].

The composition of the water-soluble vitamins from the samples were determined by the method described by AOAC [37] for riboflavin, thiamin, and niacin while the ascorbic acid was by Barakat titration method as described by AOAC [37] and vitamin A was determined by method described by AOAC [37].

Anti-nutrients were determined using AOAC method [37].

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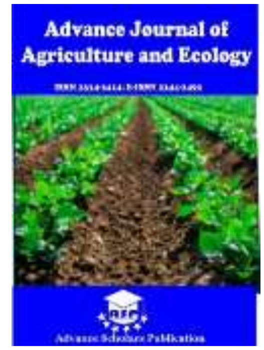


AOAC method [37] was used to determine phytochemicals.

**Functional Analysis:** Bulk density of the flour samples was determined as described by Onimawo and Egbekun [38].

The oil absorption capacity of the flour samples was determined using the method described by Sosulski, et al. [39].

The water absorption capacity of the flour samples was determined using the method described by Sosulski, et al., [39].

Emulsion capacity of the flour samples was determined using the method described by Onimawo and Egbekun [38] with slight modification.

**Microbial Analysis of Samples**

**Preparation of Culture Media:** The culture media was prepared according to the manufacturer's instruction and was autoclaved at 121°C for 15minutes. It was allowed to cool to a temperature of 35°C before pouring into petri dishes. The potatoes Dextrose Agar for the mould and yeast count was prepared according to the manufacturer's instruction. The sample plated and incubated at room temperature 27°C for 72h.

**Microbial Load Count:** The pour plate method as described by AOAC International [37] was used to determine the load count.

**The pH Measurement**: A 10% w/v suspension of the sample was prepared in distilled water. It was mixed thoroughly in a warring micro blender, and then the pH was measured using a good pH meter [40].

**RESULTS**

**Proximate composition of flour samples and carrot juice** are shown in table 1. The moisture content ranged from 6.40% in sprouted soybean flour (SSF) to 10.27% in durum wheat flour (DWF). There was significant ($p<0.05$) in the moisture content of the samples. Thus, samples sprouted soybeans flour (SSF) and African breadfruit flour (ABF) with moisture content 6.40% and 9.50% respectively will have a longer shelf-life than the rest of the samples. According to Wheat Quality Council (2023) Flour specifications usually limit the flour moisture to 14% or less. It is in the miller's interest to hold the moisture as close to 14% as possible.

The protein content of the samples ranged between 38.00% in sprouted soybeans flour (SSF) to 2.73% in Unripe plantain flour (UPF) which is significant ($p<0.05$).

The fat content of the samples ranged from 0.63% in unripe plantain flour (UPF) to 20.00% in sprouted soybeans flour (SSF). There was significant difference ($p<0.05$) in the fat content of the samples. The fat content of unripe

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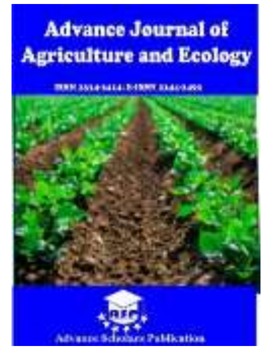


plantain flour (UPF) (0.63%) was significantly lower (p> 0.05) than the fat content of other samples which indicated that unripe plantain has lesser fat content.

The crude fiber content was 0.49% in unripe plantain flour (UPF) which is the lowest; there is no significant difference between the fiber contents of sprouted soybean flour (SSF) 2.00% and durum wheat flour (DWF) 1.51%.

The ash content of the samples ranged from 0.82% in durum wheat flour (DWF), 2.00% in African breadfruit (ABF), 2.11% in unripe plantain flour (UPF) and 2.50% in sprouted soybeans flour (SSF) which are significantly difference (p<0.05).

The carbohydrate content of sample unripe plantain flour (UPF) 73.61% and durum wheat flour (DWF) 73.57% has no significant difference (P> 0.05) while there is significant difference (p<0.05) between samples African bread fruit flour (ABF) 51.12% and SSF 31.10%.

The moisture content of sample carrot juice (C-JUICE) was 89.60% .The crude protein content value was 0.60%, 0.20% crude fat, 1.00% fiber content, 0.70% ash content, and 7.90% carbohydrate content.

**Table 1: Proximate Composition of the Flour Samples and Carrot Juice**

| Samples | Moisture (%) | Protein (%) | Fat (%) | Fiber (%) | Ash (%) | Carbohydrate (%) |
|---|---|---|---|---|---|---|
| **DWF** | $10.27^{a}\pm0.03$ | $11.92^{c}\pm0.05$ | $1.76^{c}\pm0.04$ | $1.51^{a}\pm0.02$ | $0.82^{d}\pm0.00$ | $73.57^{b}\pm0.03$ |
| **ABF** | $9.50^{c}\pm0.05$ | $24.80^{b}\pm0.02$ | $11.18^{b}\pm0.02$ | $1.40^{c}\pm0.02$ | $2.00^{c}\pm0.02$ | $51.12^{c}\pm0.04$ |
| **SSF** | $6.40^{d}\pm0.00$ | $38.00^{a}\pm0.03$ | $20.00^{a}\pm0.02$ | $2.00^{a}\pm0.03$ | $2.50^{a}\pm0.01$ | $31.10^{d}\pm0.05$ |
| **UPF** | $10.13^{b}\pm0.02$ | $2.73^{d}\pm0.02$ | $0.63^{d}\pm0.02$ | $0.49^{b}\pm0.01$ | $2.11^{b}\pm0.04$ | $83.61^{a}\pm0.04$ |
| **C-JUICE** | 89.60±0.05 | 0. .60±0.01 | 0.20±0.02 | 1.00±0.04 | 0.70±0.05 | 7.90±0.05 |

**Values are mean ± Std. Dev. of triplicate samples. $^{a-d}$Means with similar superscripts in the same column are not statistically significantly different (P>0.05).**
**DWF = Durum Wheat Flour**

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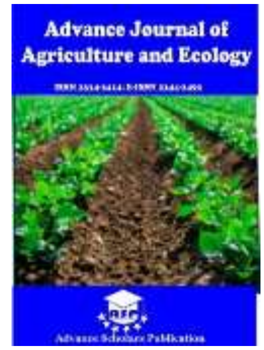


**ABF = African Breadfruit Flour**
**SSF = Sprouted Soybeans Flour**
**UPF = Unripe Plantain Flour**
**C-JUICE = Carrot juice**

**Mineral content of the flours and carrot juice** are shown in Table 2. There is significant difference ($p<0.05$) in phosphorous content of sprouted soybeans flour (SSF) sample 122.40mg/100g and durum wheat flour (DWF) 37.60mg/100g.

The calcium range of the samples were 1.06mg/100g to 69.40mg/100g, while calcium content of sample unripe plantain flour (UPF) (69.40mg/100g) was significantly higher ($p<0.05$) than the calcium content of the rest samples.

The magnesium content of the sample unripe plantain flour (UPF) (21.02mg/100g) was significantly higher ($p<0.05$) than the magnesium content of other samples. Amongst all samples, unripe plantain flour (UPF) has the highest magnesium content while African breadfruit (ABF) has the least magnesium content (0.96mg/100mg), because plantain is high in magnesium.

The iron content of the sample ranged from (0.59mg/100) in African breadfruit (ABF) to (2.04mg/100g) in sample unripe plantain flour (UPF). UPF has the highest iron content while African breadfruit (ABF) has the least iron content. There is significant difference ($p<0.05$) in iron content of UPF and ABF.

Phosphorous was (52.01mg/100g) iron (1.43mg/100g); calcium 15.41mg/100g and magnesium 32.07mg/100g.

**Table 2: Mineral Composition of the Flour Samples and Carrot Juice**

| Samples | Phosphorous (mg/100g) | Calcium (mg/100g) | Magnesium (mg/100g) | Iron (mg/100g) |
|---|---|---|---|---|
| **DWF** | $37.60^{d}\pm0.05$ | $31.01^{c}\pm0.50$ | $13.62^{c}\pm0.08$ | $1.36^{c}\pm0.03$ |
| **ABF** | $68.90^{c}\pm0.04$ | $1.06^{d}\pm0.03$ | $0.96^{d}\pm0.06$ | $0.59^{d}\pm0.02$ |
| **SSF** | $122.40^{a}\pm0.06$ | $46.30^{b}\pm0.02$ | $20.00^{b}\pm0.04$ | $1.92^{b}\pm0.01$ |
| **UPF** | $120.11^{b}\pm0.16$ | $69.40^{a}\pm0.03$ | $21.02^{a}\pm0.11$ | $2.04^{a}\pm0.01$ |
| **C-JUICE** | $52.01\pm0.03$ | $15.41\pm0.05$ | $32.07\pm0.01$ | $1.43\pm0.04$ |

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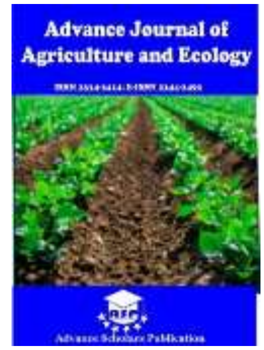


**Values are mean ± Std. Dev. of triplicate samples. [a-d]Means with similar superscripts in the same column are not statistically significantly different (P>0.05).**
**DWF = Durum Wheat Flour**
**ABF = African Breadfruit Flour**
**SSF = Sprouted Soybeans Flour**
**UPF = Unripe Plantain Flour**
**C-JUICE = Carrot juice**

**The vitamin content of the flour samples and carrot juice** are shown in table 3. Vitamin A content ranged from 0.90µg in sample unripe plantain flour (UPF) to 6.20µg in sample sprouted soybeans flour (SSF). There was no significant difference (p>0.05) in the vitamin A content of sample DWF (2.89µg) and sample ABF (2.62µg). The beta carotene content of unripe plantain flour (UPF) (0.90µg) was significantly lower (p<0.05) than the beta carotene content of other samples.

The vitamin C content ranged from 0.94mg/100g to 10.80mg/100g in durum wheat flour (DWF) sample and unripe plantain flour (UPF) (0.94mg/100g) is lowest among other samples. The vitamin C content of SSF (23.04mg/100g) is significantly different (p<0.05) from other samples.

The $B_1$ content ranged from 0.19mg/100g to 5.10mg/100g in unripe plantain flour (UPF) samples and durum wheat flour (DWF) respectively. There was significantly difference (p<0.05) in Niacin $B_1$ content of the samples.

The $B_2$ content of durum wheat flour (DWF) was (3.90mg/100g) and SSF (3.84mg/100g).There was significant difference (p>0.05) in the samples. Sample unripe plantain flour (UPF) (0.85mg/100g) has the lowest vitamin $B_2$ content.

The $B_3$ content ranged from 0.85mg/100g to 5.81mg/100g in samples unripe plantain flour (UPF) and durum wheat flour (DWF) respectively. The Niacin content of the samples were significantly difference (p<0.05).

The vitamin C content of sample carrot juice (C-JUICE) was (20.10mg/100g), vitamin A was (13.39mg/100g), vitamin $B_3$ content (10.40mg/100g), vitamin $B_2$ was (5.82mg/100g) and vitamin $B_1$ (4.56mg/100g).

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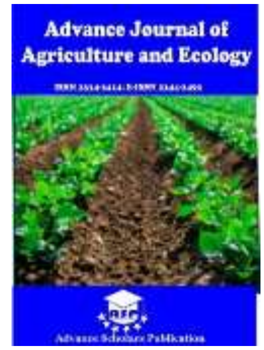


**Table 3: Vitamin Composition of the Flour Samples and Carrot Juice**

| Samples | Vitamin-A (Beta Carotene) (µg) | Vitamin-C (Ascorbic Acid) (mg/100g) | Thiamin (Vitamin $B_1$) (mg/100g) | Riboflavin (Vitamin $B_2$) (mg/100g) | Niacin (Vitamin $B_3$) (mg/100g) |
|---|---|---|---|---|---|
| **DWF** | $2.89^{b}\pm0.06$ | $0.94^{d}\pm0.06$ | $5.10^{a}\pm0.02$ | $3.90^{a}\pm0.03$ | $5.81^{a}\pm0.02$ |
| **ABF** | $2.62^{b}\pm0.35$ | $1.88^{c}\pm0.00$ | $1.95^{c}\pm0.01$ | $2.48^{b}\pm0.02$ | $1.80^{c}\pm0.00$ |
| **SSF** | $6.20^{a}\pm0.10$ | $23.04^{a}\pm0.03$ | $2.11^{b}\pm0.01$ | $3.84^{a}\pm0.10$ | $2.42^{b}\pm0.02$ |
| **UPF** | $0.90^{c}\pm0.01$ | $10.80^{b}\pm0.06$ | $0.19^{d}\pm0.07$ | $1.89^{c}\pm0.01$ | $0.85^{d}\pm0.01$ |
| **C-JUICE** | $13.29\pm0.01$ | $20.10\pm0.00$ | $4.56\pm0.06$ | $5.82\pm0.03$ | $10.40\pm0.00$ |

**Values are mean ± Std. Dev. of triplicate samples. $^{a-d}$Means with similar superscripts in the same column are not statistically significantly different (P>0.05).**
**DWF = Durum Wheat Flour**
**ABF = African Breadfruit Flour**
**SSF = Sprouted Soybeans Flour**
**UPF = Unripe Plantain Flour**
**C-JUICE = Carrot juice**

**Anti-nutrient composition of flour samples and carrot juice:** Table 4 shows anti-nutrient composition of flour samples and carrot juice. The tannin content ranged from 0.87mg/100g in durum wheat flour (DWF) to 3.37mg/100g in sprouted soybean flour (SSF). The value in sprouted soybean flour (SSF) 3.37mg/100g was significantly higher ($p<0.05$) than the tannin contents in the other samples while African breadfruit flour (ABF) and unripe plantain flour (UPF) has values of 2.34mg/100 and 1.83mg/100g respectively.

The phytate contents of the flour samples were 2.68mg/100g for durum wheat flour (DWF) which was higher than other flour samples such as African breadfruit flour (ABF) with value of 0.68mg/100g, sprouted soybean flour (SSF) with value of 0.20mg/100g, and unripe plantain flour (UPF) with value of 2.12mg/100g.

Oxalate composition of flour samples has a very high value of 7.02mg/100g in durum wheat flour (DWF) which was significant ($P<0.05$) and low value of 1.03mg/100g in unripe plantain flour (UPF). The other samples were 3.72mg/100g in ABF and 1.26mg/100g in SSF.

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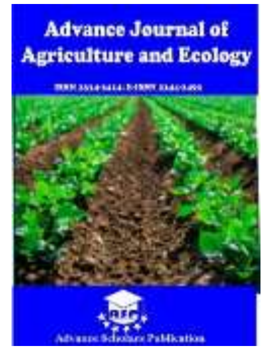


Tannin content was 2.12mg/100, Phytate was 0.51mg/100g and the oxalate was 1.06mg/100g for carrot juice.

**Table 4: Anti-Nutrient Composition of the Flour Samples and Carrot Juice**

| Samples | Tannin (mg/100g) | Phytate Content (mg/100g) | Oxalate (mg/100g) |
|---|---|---|---|
| **DWF** | $0.87^{d}\pm0.01$ | $2.68^{a}\pm0.07$ | $7.02^{a}\pm0.01$ |
| **ABF** | $2.34^{b}\pm0.02$ | $0.68^{c}\pm0.12$ | $3.72^{b}\pm1.02$ |
| **SSF** | $3.37^{a}\pm0.01$ | $0.20^{d}\pm0.08$ | $1.26^{c}\pm0.04$ |
| **UPF** | $1.82^{c}\pm0.04$ | $2.12^{b}\pm0.03$ | $1.03^{d}\pm0.01$ |
| **C-JUICE** | $2.12\pm0.01$ | $0.51\pm0.03$ | $1.06\pm0.01$ |

**Values are mean ± Std. Dev. of triplicate samples. $^{a-d}$Means with similar superscripts in the same column are not statistically significantly different (P>0.05).**
**DWF = Durum Wheat Flour**
**ABF = African Breadfruit Flour**
**SSF = Sprouted Soybeans Flour**
**UPF = Unripe Plantain Flour**
**C-JUICE = Carrot juice**

**Phyto-chemical composition of flour samples and carrot juice:** Table 5 shows phyto-chemical composition of the flour samples. There was no significant difference (p>0.05) between samples sprouted soybean flour (SSF) 0.99mg/100g, unripe plantain flour (UPF) 0.99mg/100g and durum wheat flour (DWF) 0.72mg/100g in flavonoid content.

Polyphenol content of sample durum wheat flour (DWF) was 83.72mg/100g is significantly higher (p<0.05) than the other samples. Samples African breadfruit flour (ABF), sprouted soybean flour (SSF), unripe plantain flour (UPF), 2.04mg/100, 12.16mg/100g and 40.17mg/100g respectively.

Phyto-chemical compositions of the carrot juice are polyphenol content was 15.01mg/100g and the flavonoid content was 3.71mg/100g.

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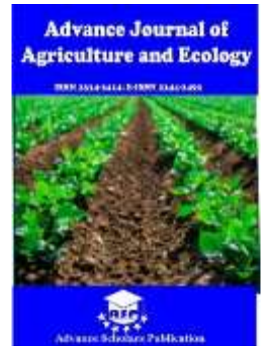


**Table 5: Phyto-Chemical Composition of the Flour Samples**

| Samples | Flavonoids (mg/100g) | Polyphenols (mg/100g) |
|---|---|---|
| **DWF** | $0.72^{b}\pm0.07$ | $83.72^{a}\pm0.06$ |
| **ABF** | $1.72^{a}\pm0.80$ | $2.04^{d}\pm0.07$ |
| **SSF** | $0.99^{b}\pm0.05$ | $12.16^{c}\pm 0.50$ |
| **UPF** | $0.85^{b}\pm0.14$ | $40.17^{b}\pm0.56$ |
| **C-JUICE** | 3.71±0.03 | 15.01±0.82 |

**Values are mean ± Std. Dev. of triplicate samples. $^{a-d}$Means with similar superscripts in the same column are not statistically significantly different (P>0.05).**
**DWF = Durum Wheat Flour**
**ABF = African Breadfruit Flour**
**SSF = Sprouted Soybeans Flour**
**UPF = Unripe Plantain Flour**
**C-JUICE = Carrot juice**

**Functional properties of flour samples and carrot juice:** Table 6 shows some functional properties of the flours and carrot juice. The bulk density ranged from 0.42g to 2.13g and sample durum wheat flour (DWF) 2.13g was significantly higher (p<0.05) than the bulk density of the other samples. There was no significant difference (p>0.05) between samples African breadfruit flour (ABF) 0.74g and unripe plantain flour (UPF) 0.76g in bulk density.

The percentage of oil absorption capacity ranged from 1.13% to 2.92% in durum wheat flour (DWF) and unripe plantain flour (UPF) respectively and there was no significant difference (p>0.05) between durum wheat flour (DWF) 1.13% and African breadfruit flour (ABF) 1.56%, also there is no significant difference (p>0.05) between 2.51% in sprouted soybean flour (SSF) and 2.92% in unripe plantain flour (UPF).

The water absorption capacity of the flour samples ranged from 1.41% in durum wheat flour (DWF) and 1.89% in African breadfruit flour (ABF) and there is no significant difference (p>0.05) in all the samples.

The percentage emulsion capacity of the flour ranged from 20.94% to 50.52% in sample unripe plantain flour (UPF) and sprouted soybean flour (SSF) respectively. Sample sprouted soybean

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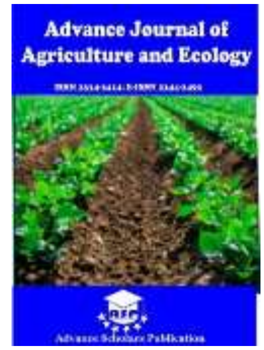


flour (SSF) 50.52% is significantly higher ($p<0.05$) than the rest samples.

The pH of the flour samples ranged from 5.80 in African breadfruit flour (ABF) to 6.80 in durum wheat flour (DWF) and there was no significant difference ($p>0.05$) in the pH values of samples sprouted soybean flour (SSF) 6.00, UPF 6.10 and DWF 6.80.

Sample C-JUICE bulk density was 0.75g, oil absorption capacity was 1.82%, water absorption capacity was 23.14%, emulsion capacity was 32.17% and pH was 6.60.

**Table 6: Functional Properties of the Flour Samples and Carrot Juice**

| Samples | Bulk Density (g) | Oil Absorption Capacity (%) | Water Absorption Capacity (%) | Emulsion Capacity (%) | pH Measurement |
|---|---|---|---|---|---|
| **DWF** | $2.13^{a}\pm0.01$ | $1.13^{b}\pm0.19$ | $1.41^{a}\pm0.15$ | $25.08^{c}\pm0.19$ | $6.80^{a}\pm0.03$ |
| **ABF** | $0.74^{b}\pm0.02$ | $1.56^{b}\pm0.25$ | $1.89^{a}\pm0.96$ | $32.40^{b}\pm0.01$ | $5.80^{b}\pm0.02$ |
| **SSF** | $0.42^{c}\pm0.01$ | $2.51^{a}\pm0.09$ | $1.80^{a}\pm0.14$ | $50.52^{a}\pm0.02$ | $6.00^{a}\pm0.01$ |
| **UPF** | $0.76^{b}\pm0.03$ | $2.92^{a}\pm0.85$ | $1.70^{a}\pm0.40$ | $20.94^{d}\pm0.00$ | $6.10^{a}\pm0.01$ |
| **C-JUICE** | $0.75\pm0.00$ | $1.82\pm0.05$ | $23.14\pm0.01$ | $32.17\pm0.18$ | $6.60\pm0.04$ |

**Values are mean ± Std. Dev. of triplicate samples. $^{a-d}$Means with similar superscripts in the same column are not statistically significantly different ($P>0.05$).**
**DWF = Durum Wheat Flour**
**ABF = African Breadfruit Flour**
**SSF = Sprouted Soybeans Flour**
**UPF = Unripe Plantain Flour**
**C-JUICE = Carrot Juice**

## DISCUSSION

The moisture contents of all the flour samples were less than 14%. This is an advantage because low moisture content increases the amount of dry solids in flour and the longer the shelf life of the flour. The miller will always be interested to keep the moisture close to 14% or less. Flour with high moisture is not stable at room temperature, because organisms naturally present in the flour will start growing and produce off odors and flavours [10]. This result is line with past works [10, 17] which reported moisture content of wheat flour (14.02%). Wheat flour specifications usually limit the flour moisture to 14% or less [1].

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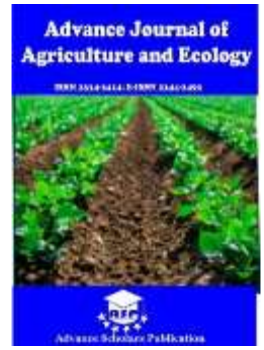


It is in the miller's interest to hold the moisture as close to 14% as possible.

Sprouted soybeans flour (SSF) has the highest protein content amongst the other flour samples and this is in line with the ranged 18.4% in soybeans [16]. Sprouting process improves the protein content of foods. The flour sample of UPF has low protein of 2.73% which is in accordance with the figure of 2.05% in previous work [27]. Protein helps repairs and build body tissues, it drives metabolic reactions, maintains pH and fluid balance, also keeps the immune system strong, it also transports and stores nutrients and can act as an energy source [27].

The high fat content of unripe plantain flour (UPF) and low fat content of sprouted soybeans flour (SSF) is in line with the values (0.58%) reported in extant works [9, 10]. Unripe plantain has lesser fat content due to it's unripen state and sprouting slightly increase fat contents of Soybeans [9]. Fat is an essential nutrient which helps deal with taste and satiety of food material consumption [13, 17].

The low crude fiber content of SSF reported in this study is in line with past study [9] which reported 2% crude fiber in soybeans powder. The crude fiber content of unripe plantain flour (0.49%) reported in this study is similar to the result (0.49%) reported in unripe plantain flour [33].

The ash contents of all the flour were below 3%, and this is in consonance with the previous finding [13]. Sprouted soybeans has elevated ash content because the process of sprouting usually elevate the protein content of soybeans [13]. In similar vein, durum wheat flour (DWF) has as low as 0.82% ash content which affirms the values given past research [10]. Ash contents are usually low in flours due to flour conversion processes [27].

The carbohydrate content of unripe plantain flour (UPF) is relatively high and this tally with past finding which has a value of (71.02%) [10]. Unripe Plantain is classified as carbohydrate food and little wonder it has more of carbohydrate content despite its unripe state [17]. Sprouted soybeans flour (SSF) has 31.10% carbohydrate content and a past work [27] asserted that sprouting dose not only increases protein content, but also reduce carbohydrate content. Although the carbohydrate content of soybean was reduced by sprouting process. Whereas the value (32.11%) from sprouted soybeans was similar to the value (32.20%) gotten on germinated grains [13].

The moisture content of Carrot Juice has high content of carbohydrate with value of 7.90%, this is so because carrot is a good source of energy, which contains a lot of sucrose [8]. The moisture content of 89.60% in carrot juice is in line with

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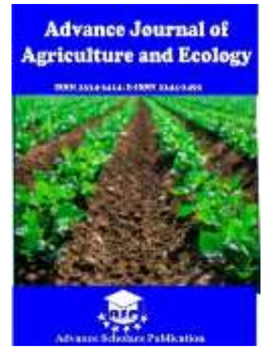


previous finding [7] which reported 90.01% moisture in carrot juice. Carrot is a vegetable with plenty fluid [5]. Biochemically, carrot is a rich source of β-carotene, fiber and many essential micronutrients and functional ingredients. The presence of high concentrations of carotenoids, especially β-carotene in carrot roots makes them to inhibit cancers, free radical scavengers, anti-mutagenic and immune-enhancers [22].

The high phosphorous content of sprouted soybeans flour (SSF) (122.40mg) was in consonance with the values (123.40mg) [10]. Phosphorous is also among the minerals increased by sprouting [17]. Durum wheat flour (DWF) has always shown lowered quantity of phosphorous (37.60mg) [33]. This is similar to the findings of this study which is also similar with the previous work [10], which reported phosphorous content of durum wheat 35.45mg.

Unripe plantain has always been reported to have high calcium content of 65.30mg/100g [10], and this study confirmed such value with the value of 69.40mg/100g. Calcium is essential for bone and teeth formation and calcium is needed for muscle contraction, for functioning of neuro transmitters and its deficiency is higher than other minerals [16, 18]. African breadfruit flour (ABF) has the least calcium content (1.06mg/100g) and this is similar to the past finding of (1.07mg/100g) [34]. Processing techniques can easily decrease some mineral contents in African breadfruit as reported [28] has values of (1.08mg/100g) in African breadfruit flour.

Magnesium content of unripe plantain flour (UPF) was high and this is in conscience with past work [22] which reported similar values of 21.00mg/100g.

Iron deficiency is a micro nutrient of high interest among Disease Related Malnutrition [32], and the utilization of composite flour sample with added values of iron becomes important [28, 39]. Research works have pointed out that African breadfruit has lesser iron content of 1.74mg/100g [19, 4].

The low mineral content of carrot juice reported in this study might be due to processing techniques employed. The phosphorous content of carrot juice is similar to values 50.89mg/100g as reported in past research [23]. The low content of iron (1.43mg/100g) which is in contracts with present and past literature [15, 25] which reported value of (05mg/100g) which is relatively lower than the value gotten in this study. The highest level of iron (2.04mg/100g) in this work is close to the (2.53mg/100g) in the research conducted on the benefit of unripe plantain flour.

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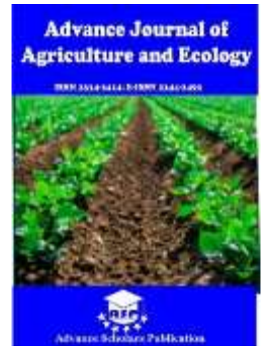


According to Prabhanjan et al. (1995) cited in Irwin et al. [25] reported that carrot juice processing techniques (processing of carrot roots to carrot juice) is likely to affect mineral composition of carrot juice. Calcium, magnesium and phosphorous content of carrot juice gotten is in line with past studies [31, 33] which reported 50.89mg/100g in carrot juice.
Beta carotene content of sprouted soybeans flour (SSF) was the highest value (6.20µg) and it is in line with the past work [34] which reported (6.20µg). Beta carotene is essential for good vision, healthy skin, reproduction, growth, hair and nail, it also balances energy level in the human body and its deficiency causes keratomalacia (night blindness) [26, 28]
Low vitamin C observed in durum wheat flour (DWF) is in line with the values of 0.90mg and 0.97mg reported [9, 19]. High vitamin C content of sprouted soybeans flour (SSF) is in line with previous findings [20, 26, 29] with values of 20.56mg, 21.45mg and 23.10mg respectively. Vitamin C helps in maintenance of healthy gum, fast wound healing and also in absorption of non-heme iron. Vitamin C is a good source of antioxidant and its deficiency causes scurvy [17].
Durum Wheat Flour (DWF) content of vitamin $B_1$ (5.10mg/100g) in this study, which could be as a result of not cooking the sample as reported in wheat [14, 28]. Vitamin $B_2$ content (3.90mg/100g) of Durum Wheat Flour is high when compared with (0.1mg/100g) previous findings [23, 31].
Unripe plantain flour has low vitamin $B_2$ content of (1.89mg/100g), which is similar to (1.87mg/100g) as reported [27]. Vitamin $B_3$ content of Durum Wheat Flours is high and this finding supports already existing literature which showed synonymous with values (1.1mg/100g) as reported [8]. B Vitamins are necessary for energy release from carbohydrates, protein, and fat [18].
The Beta carotene content of the carrot juice was in conformity with previous findings of (3.78mg/100g) in carrot fruit [33]. Vitamin C content of carrot (20.10mg/100g) were similar to the past finding [22]. Vitamin $B_1$ were reported to be (4.56mg/100g) in this study which is higher than the figure (1.24mg/100g) reported in carrot flour [20]. Vitamin $B_2$ content (5.87mg/100g) as reported in this study is similar to the extant finding [11]. Vitamin $B_3$ content of carrot juice were (10.41mg/100g) in this research, which is similar to the findings of (11.01mg/100g) in carrot juice as reported [18, 33].
Tannin content of sprouted soy beans (SSF) was at 3.3 7mg/100g as the study shows and this is in line with the findings of (3.79mg/100g) as reported [28] which has tannin content of

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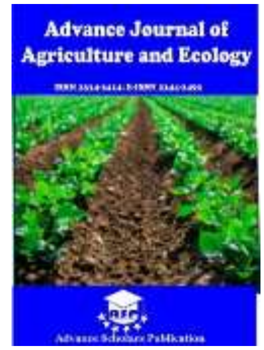


sprouted soybeans not above 3.5mg/100g; sprouting has been said to reduce anti-nutrients in soybeans [21] and compared with the tannin content of non-sprouted soybeans which ranges between 9.56mg/100g to 5.98mg/100g [24]. The lesser value of durum wheat (DWF) – 0.87mg/100g was similar to the past findings [12, 19] which have slightly higher values of 2.06mg/100g and 1.87mg/100g respectively. This difference can be linked to the different processing method used in converting the durum wheat to flour.

The phytate content of durum wheat flour (DWF) (2.68mg/100g) was higher than the values (1.67mg/100g) in wheat reported [11, 31]. Previous works stated that phytate contents are not purely static in values as it depends on the varieties of wheat used as well as the season in which the durum wheat was harvested, and the duration it took from harvesting to processing into flour [2, 5]. African breadfruit flour (ABF) has low phytate content of 0.68mg/100g which is same with previous researches [11, 16, 17].

Durum wheat flour (DWF) has a high value of oxalate anti-nutrient at the value of 7.02mg/100g is similar with past findings values (6.78mg/100g) [24, 25] but not in line with the previous finding value of (3.94mg/100g) in wheat flour [34]. The variant values can be explained based on the varieties of durum wheat used, as different varieties have varying degrees of oxalate composition [31].

Unripe plantain flour (UPF) has low value (1.03mg/100g) of oxalate content, this finding was not in accordance with the low value of boiled plantain value (0.8mg/100g) past findings [15, 22]. The oxalate composition of plantain flour is usually low [34].

Carrot juice has low values of anti-nutrients due to its high moisture content and presence of vitamins (beta carotene) and minerals [25]. The values of all the anti-nutrients were less than 2.50mg/100g and this value is in line with the past research findings [12, 19] on carrot and carrot juice whose anti-nutrient composition were 2.25mg/100g.

The flavonoid composition of sprouted soybeans flour (SSF), unripe plantain flour (UPF), durum wheat flour (DWF) and African breadfruit flour (ABF) with values of flavonoid (0.99mg/100g), (0.85mg/100g), (0.72mg/100g) and (1.72mg/100g) respectively. This value is in consonance with the findings (1.46mg/100g) in composite flour formulated with wheat flour, plantain flour and soybeans flour [13, 18, 24]. Lesser values (0.09mg/100g) of flavonoids in flours are linked to the flour processing techniques employed as it greatly affects flavonoid composition of flour samples [11].

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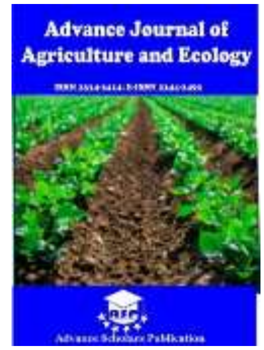


Polyphenol content of durum wheat flour (DWF) has value of 83.72mg/100g, which is high and this value were similar to extant findings (83.72mg/100g) [12, 30], which is higher than other previous findings (50.04mg/100g) [32, 34]. The variance in values can be attributed to differences in seasons, varieties, and geographical location where the durum wheat was grown [29].

Polyphenol content of carrot juice value (15.01mg/100g) was high and it is in line with past findings [26, 28, 34] while its flavonoids content has value of 3.71mg/100g which also in lieu with previous findings (4.01mg/100g) [13, 22]. Carrot juice has shown higher and significant values of phyto-chemicals such as flavonoids and polyphenols [20]; this explains while this study has such high values in its phyto-chemical composition.

The bulk density of flour sample of durum wheat flour (DWF) (2.13g) was high and significant and it is not farfetched from previous findings [11, 12] which have similar values. Durum Wheat is basically starchy food/staple [1]; the high bulk density of durum wheat flour (DWF) might be as a result of its high starch content. Sprouted soybeans flour has the least bulk density value (0.42g). This is in line with the past findings [3, 13]; this might be due to sprouting which the soybean was subjected to.

Oil absorption capacity of unripe plantain flour (UPF) was highest in value (2.92%) and this supports the past works [14, 18] which stated that unripe plantain usually has higher percentage of oil absorption capacity of 2.80%; while durum wheat flour (DWF) has the least value of oil absorption capacity (1.13%) which is consonance with the previous researches [9, 10].

The water absorption capacity of flour sample African breadfruit flour (ABF) has the value 1.89% which is in same vein with the values (1.90%) gotten in extant works [17, 21]. But there were no much differences in values with the flour samples which are explained by past study [29], which suggested that processed flours often have low percentages of water absorption capacity.

Sprouted soybeans flour (SSF) has the highest value of emulsion capacity (50.52%) which is not in line with previous findings (09.89%) [18, 26]. Soybeans have always been known to have very high emulsion capacity due to the presence of oils in it [20]. Thus, the high value in this study is not out of place.

Flour samples were all in the middle range of pH, that is, it was not high nor was it too low. Processed flours always have medium pH scale, it is neither acidic nor alkaline [18]. Low pH in flour is an indication that the flour sample will have a longer shelf life [30].

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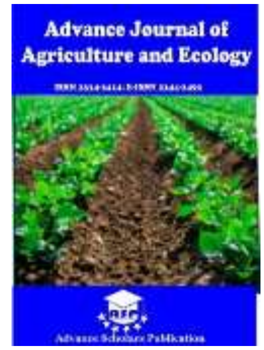


The bulk density, oil absorption capacity, water absorption capacity, emulsion capacity and pH (0.75g, 1.82%, 23.14%, 32.17%, and 6.60pH respectively) of carrot juice were all at their expected values which is in consonance with previous literatures [13, 26, 29] (1.01g, 1.84%, 24.12%, 32.14% and 6.57pH) was of the opinion that carrot is a vegetable and majorly made up of fibers and minerals which can affect its functional properties.

**CONCLUSION**

The overall nutritional values of the products are adequate and can benefit its consumers by improving their nutritional statues; also, the flour blends can be used in the baking industries. We recommend the production of flours from our staples which will serve as alternative composite flour for food industries with low cost rates; this in turn will not only reduce the prices of flour by-products but also increase the nutritional contents of such flour by-products which will benefit consumers at large.

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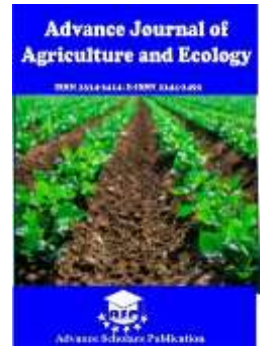


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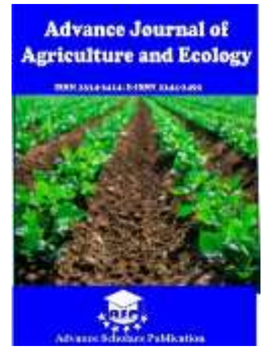


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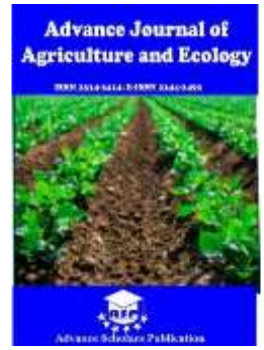


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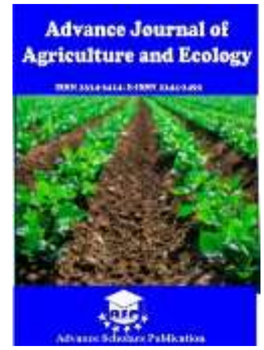


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