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Evaluation of the Quality and Physicochemical Properties of *Carica Papaya* Seed Flour from Different Cultivars

Austin Ihemeje[1] and Odinakachi Theresa Okoronkwo[2*]

[1]*Department of Food Science and Technology, Imo State University, Owerri.*
[2]*Department of Food Science and Technology, University of Agriculture and Environmental Sciences, Umuagwo.*

*Corresponding author e-mail: tessynnamocha@gmail.com; theresa.nnamocha@uaes.edu.ng; Tel: (+234)0813-132-4776

Abstract

This study evaluated the physicochemical and food quality properties of three varieties of papaya seed flour from fresh, whole, mature, ripe and edible papaya fruits. The varieties include elongated papaya seed, elongated red papaya seed and round papaya seed. The papaya seed samples were processed into flour and then analyzed for proximate, vitamin, minerals and functional properties using standard analytical procedures. The result of the proximate composition showed; moisture (10.58-10.75%), protein (29.22-30.30%), fat (28.23-29.52%), ash (7.14-7.99%), fibre (5.99-6.81%) and carbohydrate(16.50-17.54%) respectively. The vitamin content of the pawpaw seed flour samples was found to be in the ranges of 38.62–43.24 µg/100g for vit. A, 0.13– 0.23mg/100g for vit. B1, 0.37– 0.52mg/100g for vit. B2 and 2.01–2.44mg/100g for vit. C, while the mineral contents vary from 1.89–2.69mg/100g(zinc), 51.63–53.23mg/100 (potassium), and 3.25–4.51mg/100g. These pawpaw varieties differ significantly ($P < 0.05$) in proximate, vitamin and mineral composition. The functional properties revealed; bulk density (30.71-33.74%), water absorption capacity (210.63-213.53%), oil absorption capacity (224.69–240.18%) and foaming capacity (6.91-9.52%). These findings underscore the potential for papaya seed flour in various industrial, nutritional, and pharmaceutical applications. Therefore, this research highlights the nutritional, pharmaceutical, functional, and economic importance of papaya seed flour.

Keywords: *Papaya, Physicochemical, Seed Flour, Nutritional and Pharmaceutical*

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1. Introduction

One of the most common problems in food processing is the disposal of the sub-products generated (Hussein *et al.*, 2011). This waste material produces ecological problems related to the proliferation of insects and rodents and economic burden because of transportation to repositories, therefore strategies for the profitable use of these materials are needed (Olorode *et al.*, 2014). In the food processing industry, edible portions of fruits are processed into products such as puree, canned slices, juice and pickles, whereas seeds are often discarded as waste since it is not currently utilized for commercial purposes (Ajila *et al.*, 2007) whereas (Olorode *et al.*, 2014) stated that seeds are promising source of useful compounds because of their favorable technological or nutritional properties (Olorode *et al.*, 2014).

Carica papaya is among the currently most important tropical fruits grown in Brazil and in the world. The fruit is mainly consumed fresh although it offers many industrial products. The processing of this fruit, as well as its fresh consumption, results in large amounts of waste, such as peels and seeds (Kure *et al.*, 2021). Papaya seeds are currently waste products as it is often discarded after eaten or processing. The seeds constitute 22% of the waste from papaya puree plant. Papaya seeds are recently gaining importance due to its medicinal value, since it had been used recently in curing sickle cell diseases, poisonous related renal disorder (Imaga *et al.*, 2009), and as anti-helminthes (Okeniyi *et al.*, 2007). Adequate results on the potentials of carica papaya seed flour and oil, such as their chemical (essential nutrient), physical and functional properties will create possibility for their use in food processes.

This study aims to explore the nutritional and functional properties of pawpaw seeds to assess their potential application in food and pharmaceutical industries. Furthermore, there will be reduction in disposal of papaya seed, check environmental contamination and obviously improve its economic importance.

2. Materials and Methods

Fresh, whole, mature, ripe and edible *Carica papaya L.* fruits were obtained from Relief Market, Owerri, Imo State, Nigeria. The papaya seed flour was prepared aseptically. Papaya fruits were washed thoroughly with water. They were manually peeled using knife, cut; the seeds were extracted and washed with running water to remove mucilage. Subsequently, the seeds were spread on trays and dried (oven drying at 50°C for 72 h) (Uniscope Surgifriends Medicals, England). After drying, the samples were milled using a TECNAL mill (TE-631) and then sieved through 0.50 mm aperture sieve. Fine flour was obtained and packaged in airtight rubber containers.

The papaya seed flour oil was extracted from 500g of the crushed papaya seeds using 150cm^{3}of n-hexane solvent by means of soxhlet apparatus maintained at a constant temperature of 70° C for five to six hours to activate and release the oil molecule from the crushed seeds. The n-hexane method as described by AOAC, (2000) was adopted. Five hundred gram (500g) each of the papaya seed flours were soaked in n-hexane in a wide jar, covered air tightly and stored for 24 hours. The oil solution was pressed out using muslin cloth, and the oil was separated from the n- hexane by evaporation. At the end of the extraction process, the sample residue was removed from the thimble while the solvent used was recovered by means of rotary evaporator leaving the oil behind. The remaining solvent was evaporated to dryness by air.

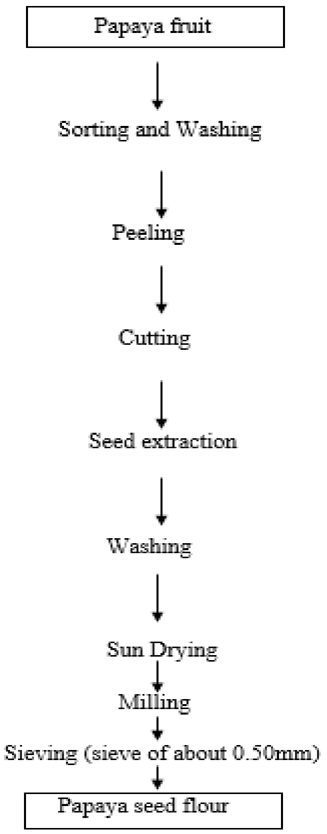

Figure 1: Production of pawpaw (*Carica papaya*) seed flour.

Proximate composition of papaya seed flour was determined according to the methods described by AOAC (2012) and Carbohydrate content was determined by difference as described by Ihekoronye and Ngody (1985). Water absorption capacity, oil adsorption capacity, bulk density and foaming capacity were determined according to the methods described by Onwuka, (2005). Swelling capacity was determined according to the method given by Robertson *et al.* (2000).

Vitamin A content of the papaya seed flour samples was determined using the method described by AOAC (2010). Thiamin content was determined using the spectrophotometric method described by AOAC (2010). Riboflavin content of was determined by the method described by AOAC (2010). Vitamin C (ascorbic acid) was determined by titrimetric method as described by AOAC (2010). For Dye standardization, five milliliter (5mL) of diluted standard ascorbic acid solution with 5 ml of 3% of meta-phosphoric acid was prepared. It was titrated with dye solution till pink color persisted for 10 seconds. Dye factor was calculated (mg of ascorbic acid per ml of dye) as follow: Dye Factor (D.F) = 0.5/Titration

In determination of mineral content of the papaya seed flours, five grams (5g) of the sample was heated gently over a Bunsen burner flame until most of the organic matter is destroyed (AOAC, 2010).

Data obtained from evaluations were analyzed using Analysis of Variance (ANOVA) according to the method of Iwe (2002) to determine the variance ratio. Sample means were compared to determine treatment effects. The Least Significance Difference (LSD) was calculated at 5% level of significance between means using Tukey test.

3. Results and Discussion

Proximate Composition of Papaya Seed Flours

The result of the proximate analysis carried out on the papaya seed flour samples were reported as shown in table 1 below;

Moisture content of papaya seed flours

Moisture content of the papaya seed flour samples ranges from 10.58-10.75%. The values include 10.66%, 10.58% and 10.75% for papaya seed samples A, B and C respectively. The values had slight variation hence the statistical analysis revealed that there were no significant ($p>0.05$) difference among all the seed samples. The Dwarf papaya seed (C) recorded the highest (10.75%) moisture content followed by the Red lady papaya seed (A) with value 10.66% while the Hybrid red lady papaya seed had the least value (10.58%). High moisture content of vegetables enhance the growth of microorganisms Oluwagbenle *et al.* (2019). The moisture content in this study is low compared to 11.02% reported by Makanjuola and Makanjuola (2018) on the analysis of pawpaw seed and skin but close to 10.00% found in the study by Oyeleke *et al.*, (2013). According to Makanjuola and Makanjuola (2018), low moisture contents generally are an indication of high shelf life especially for foods that are properly packaged against external condition. Similarly, Ayaz *et al.*, (2006) said that low moisture content of the matured unripe seed means it can be stored for a longer period than ripe and overripe ones because of its better resistance to microbial attack.

Fat content of papaya seed flours

Fat content of the papaya seed samples ranges from 28.23-29.52%. There were no significant (P>0.05) difference between papaya seed samples B and C but sample A differed significantly (p<0.05) from the other samples in terms of fat. The Red lady papaya seed had the highest fat content (29.52%) followed by the Dwarf papaya seed with value 28.28% while the Hybrid red lady papaya seed recorded the lowest fat content (28.23%). This implies that the elongated red pawpaw seed contains less fat compared to the elongated yellow ripe and Dwarf papaya seeds. The result for the fat content the pawpaw seed disagree with the general observation that vegetables are low lipid containing foods Sotelo *et al.* (2007). According to Oyeleke (2013) fat content of a sample is important because it determines its palatability and papaya seeds at different ripening stages can be good sources of fat to the populace. The fat content in this study is similar to 28.62% found by Makanjuola and Makanjuola (2018) while analyzing papaya seed. Fat is very vital since it provides the body with tremendous amount of energy (Jacob *et al.*, 2015).

Ash content of papaya seed flours

It was revealed that ash content of the papaya seed flour samples is within 7.14-7.97%. The values include 7.37%, 7.97% and 7.14% for Red lady papaya, Hybrid red lady papaya and Dwarf papaya seeds respectively. Statistically, there were significant (p<0.05) difference among all the pawpaw seed samples. It was revealed that the least (7.14%) ash content of the pawpaw seed samples was recorded in the Dwarf papaya seed followed in ascending order by the Red lady papaya seed with value 7.37% while the Hybrid red lady papaya seed had the highest ash content of 7.97%. The implication is that in terms of ash content, the Hybrid red lady papaya seed is a better source compared to the other pawpaw seed samples. According to Makanjuola and Makanjuola (2018), papaya skin exhibited high amount of ash (11.03%) than that of seed (5.22%). High mineral elements in food enhance growth and development, and also catalyses metabolic processes in human body (Jacob *et al.*, 2015). Ash is the inorganic content of a material which does not volatilize after subjecting the sample to high temperature (Elinge *et al.*, 2012).

Table 1: Proximate composition of papaya seed flour samples

Parameter	Samples			
	A	B	C	LSD
Moisture Content (%)	$10.66^{a}\pm0.03$	$10.58^{a}\pm0.13$	$10.75^{a}\pm0.04$	0.23
Fat (%)	$29.52^{a}\pm0.06$	$28.23^{b}\pm0.06$	$28.28^{b}\pm0.02$	0.13
Ash (%)	$7.37^{b}\pm0.05$	$7.97^{a}\pm0.03$	$7.14^{c}\pm0.04$	0.03
Fibre (%)	$6.18^{b}\pm0.03$	$6.81^{a}\pm0.01$	$5.99^{c}\pm0.00$	0.04
Protein (%)	$29.75^{b}\pm0.01$	$29.22^{c}\pm0.01$	$30.30^{a}\pm0.06$	0.10
CHO (%)	$16.50^{c}\pm0.03$	$17.18^{b}\pm0.04$	$17.54^{a}\pm0.07$	0.18

Values are means of triplicate analysis and standard deviation. Means with different superscript along the columns are significantly (P < 0.05) different.

Note: A = Red lady papaya seed; B = Hybrid red lady papaya seed; C = Dwarf papaya seed

Fibre content of papaya seed flours

Fibre content of the papaya seed samples is within 5.99-6.81%. There were significant differences (p<0.05) among the pawpaw seed flour samples in terms of fibre content. The result indicates that Hybrid red lady papaya seed (B) had the highest (6.81%) fibre content followed by the Red lady papaya seed (6.18%) while the least fiber content of the pawpaw seeds was recorded in the Dwarf papaya seed. According to Jacob *et al.* (2015), it is believed that fibre reduces the level of cholesterol in human blood and decreases the likelihood of different cancers. This implies that Hybrid red lady papaya seed flour (sample B) may perform this function more when compared to papaya seed flour samples A and C respectively. Fibre content of 25.23% for papaya seeds reported by Makanjuola and Makanjuola (2018) is higher than the values in this work. According to Eromosele and Eromosele (1993) fibre helps in the maintenance of human health and has been known to reduce cholesterol level in the body. High fibre foods expands the inside wall of the colon, causing the passage of waste, thus making it an effective anti-constipation agent.

Protein content of papaya seed flours

The protein content of the papaya seed samples is within 29.22-30.30%. The values are 29.75%, 29.22% and 30.30% for Red lady papaya (A), elongated red papaya (B) and Dwarf papaya (C) seed flours respectively. It was observed statistically that the papaya seed flour samples recorded significant differences (p<0.05) in their protein composition. The result indicates that the Hybrid red lady papaya seed (sample B) recorded the least protein (29.22%) while the Dwarf papaya seed (sample C) had the highest (30.30%) protein content. Makanjuola and Makanjuola (2018) found out that protein contents for both papaya seeds and skin were 27.42% and 13.64% respectively indicating a higher protein presence in *papaya* seeds. Protein is an essential component of diet needed for the survival of both animal and human (Pugalenthi *et al.*, 2004).

Carbohydrate content of papaya seed flours

The values of the carbohydrate content of the papaya seed samples include 16.50%, 17.18% and 17.54% for samples A, B and C respectively. Statistically, there were significant differences (p<0.05) among the papaya seed flour samples. The Red lady papaya seed flour (sample A) was found to contain the lowest carbohydrate compared to the samples B and C. The Dwarf papaya seed had the highest value (17.54%) followed by the Hybrid red lady papaya seed with value (17.18%). This value is high compared to 13.00% reported by

Oyeleke (2013) who found out that the carbohydrate content of unripe papaya seed reduced from 23.10% - 13.00% in ripe mature seed. The decrease in carbohydrate content may be attributed to enzymatiuc activities that utilizes carbohydrate as the source of energy during ripening process (Oyeleke, 2013). However, the carbohydrate content observed in this research is low compared to 19.71% for papaya seed flour stated by Makanjuola and Makanjuola (2018).

Vitamin analysis of papaya seed flours

The result of the vitamin analysis carried out on the papaya seed flour samples were reported below in table 2;

Vitamin A content of papaya seed flours

The vitamin A content of the papaya seed samples ranges from 38.62-43.24µg/100g. The values are high compared to the other vitamins analysed. Also, it was observed the vitamin A content of the papaya seed samples recorded variations hence, there were significant (p<0.05) difference among all the pawpaw seed flour samples. The result indicates that the Red lady papaya seed had the highest (43.24µg/100g) vitamin A content while the Dwarf papaya seed recorded the least value (38.62µg/100g). This shows that Red lady papaya seed flour is a good source of vitamin A compared to samples B and C. Vitamin A is a fat soluble vitamin and a powerful antioxidant. It plays a critical role in maintaining healthy vision, neurological function, healthy skin and support immune function. Also, it reduces inflammation through fighting free radical damage (Abitogun *et al.*, 2010).

Vitamin B1 (thiamine) content of papaya seed flours

The values of the vitamin B1 content of the seed samples include 0.23mg/100g, 0.13mg/100g and 0.15mg/100g for Red lady papaya, Hybrid red lady papaya and Dwarf papaya seeds respectively. It was observed that the vitamin B1 values were the least of all the vitamin parameters analyzed. Statistically, there were no significant differences (p>0.05) between samples B and C but sample A differed (p<0.05) from the other papaya seeds. The highest (0.23mg/100g) vitamin B1 content was found in the Red lady papaya seed while the least (0.13mg/100g) was recorded in the Hybrid red lady papaya seed. This implies that Hybrid red lady papaya seed is low in vitamin B1 compared to other papaya seeds analyzed. According to Ayaz *et al.* (2006) thiamin (vitamin B1), is dubbed "essential" because it is needed by the body but not created by it, therefore it must be obtained through the diet to provide what needs to be digested. Thiamine plays an important role in the utilization of carbohydrate for supply of energy, where it functions as the coenzyme thiamine pyrophosphate, or cocarboxylase, in the oxidation of glucose (Norman and Joseph, 2007). Absence of vitamin B1 results in a specific deficiency disease called beriberi.

Table 2: Vitamin composition of the papaya seed flours

Parameter	Samples			
	A	B	C	LSD
Vit. A (µg/100g)	43.24^{a}$\pm$0.06	40.13^{b}$\pm$0.02	38.62^{c}$\pm$0.03	0.13
Vit. B1 (mg/100g)	0.23^{a}$\pm$0.03	0.13^{b}$\pm$0.02	0.15^{b}$\pm$0.03	0.07
Vit. C (mg/100g)	2.44^{a}$\pm$0.04	2.01^{c}$\pm$0.05	2.22^{b}$\pm$0.01	0.12
Vit. B2 (mg/100g)	0.52^{a}$\pm$0.02	0.37^{b}$\pm$0.03	0.42^{b}$\pm$0.01	0.06

Values are means of triplicate analysis and standard deviation. Means with different superscript along the columns are significantly different (P < 0.05).
Note: A = Red lady papaya seed; B = Hybrid red lady papaya seed; C = Dwarf papaya seed

Vitamin C (Ascorbic acid) content of papaya seed flours

From Table 3, the vitamin C content of the papaya seed samples is within 2.01- 2.44mg/100g. The values of the vitamin C content of the papaya seed samples include 2.44mg/100g, 2.01mg/100g and 2.22mg/100g for samples A, B and C respectively. Statistically, there were significant differences (p<0.05) among all the papaya seed samples in terms vitamin C. The Hybrid red lady papaya seed (sample B) was found to contain the lowest (2.01mg/100g) vitamin C compared to the Red lady papaya and Dwarf papaya seeds. It was observed that sample A had the highest value (2.44mg/100g) followed by sample C with value (2.22mg/100g). Pinnamaneni (2017) stated that vitamin C is one of papaya's strong points, with a whopping 144 percent of the daily recommended value per serving, making it an excellent infection fighter as well as a free radical-scavenging antioxidant, which further supported the values obtained in this study especially for the Red lady papaya seed. Vitamin C is an important water-soluble vitamin that had being implicated in many life processes apart from its antioxidant property (Abitogun *et al.*, 2010).

Vitamin B2 (riboflavin) content

From Table 2 above, the range of the riboflavin content of the papaya seed samples is from 0.37-0.52mg/100g. The statistical analysis show that there were significant differences (p<0.05) among the papaya seed samples in terms of vitamin B2. The Hybrid red lady papaya seed (sample B) recorded the lowest (0.37mg/100g) vitamin B2 content followed in ascending order by the Dwarf papaya seed (sample C) with value 0.42mg/100g while the highest vitamin B2 of the papaya seed samples was found in the Red lady papaya seed (sample A) with value 0.52mg/100g. This implies that the Red lady papaya seed is a good source of vitamin B2 compared to the Hybrid red lady papaya and Dwarf papaya seeds. The United State recommended dietary allowance (USRDA) for vitamin B2 is 1.70 mg/100g (Usman, 2012) this implies that all the papaya seed samples analyzed does not contain vitamin B2 in respect to recommended level. Riboflavin helps in the oxidation processes of living cells and is essential for cellular growth and tissue maintenance in living things (Norman and Joseph, 2007).

Mineral analysis of the papaya seed flours

Zinc composition

From Table 3, the zinc content of the papaya seed samples is within 1.89-2.69mg/100g. The values are; 2.42mg/100g, 2.69mg/100g and 1.89mg/100g for Red lady papaya, Hybrid red lady papaya and Dwarf papaya seeds respectively. Statistically, there were significant differences ($p<0.05$) among all the papaya seed samples in terms of zinc. The highest value (2.69mg/100g) was recorded in the Hybrid red lady papaya seed (sample B) while the least (1.89mg/100g) was found in the Dwarf papaya seed (sample C). According to Abitogun *et al*. (2010) although the value may be low it plays a major role in normal body development since zinc is essential element in protein and nucleic acid synthesis. Zinc boosts the health of our hairs, plays a role in the proper functioning of some sense organs such as ability to taste and smell (Payne 1990), helps in carbohydrate and protein metabolism and also assists in metabolism of vitamin A from its storage site in the livers and facilitates the synthesis of DNA and RNA necessary for cell production (Guthrie, 2000).

Potassium composition

The values of the potassium content of the papaya seed samples include 51.63mg/100g, 53.23mg/100g and 51.80mg/100g for samples A, B and C respectively. Potassium had the highest value of all the mineral parameters analysed for the papaya seed samples. The range is from 51.63mg/100g to 53.23mg/100g. The statistical analysis show that there were significant differences ($p<0.05$) among all the papaya seed samples. The Hybrid red lady papaya seed (sample B) was found to have the highest (53.23mg/100g) potassium followed by the Dwarf papaya seed (sample C) with value 51.80mg/100g while the least value 51.63mg/100g was recorded in the Red lady papaya seed (sample C). The potassium content is low compared to 720.83mg/100g in papaya seed and 504.33mg/100g in papaya skin reported by Makanjuola and Makanjuola (2018). Potassium is available in several foods like fruits, dairy products and vegetables and its recommended daily intake value stands at 3500mg (Oluwagbenle *et al.,* 2019). Potassium is very important in maintaining body fluid volume and osmotic equilibrium, the pH of the body, regulation of muscles and nerve irritability, control of glucose absorption and enhancement of normal retention of protein during growth (Oluwagbenle *et al.,* 2019).

Calcium composition

The result show that the calcium content of the papaya seed samples is from 3.31- 4.51mg/100g. The statistical analysis revealed there were significant difference ($p<0.05$) among all the papaya seed samples. It was observed that comparatively, Red lady papaya seed (sample A) is not a good source of calcium hence it recorded a very low value of 3.31mg/100g followed in ascending order by the Dwarf papaya seed (sample C) with value (3.25mg/100g) while the highest calcium of the papaya seed samples was recorded in the Hybrid red lady papaya seed (sample B). The calcium content is low compared to 6.41mg/100 reported by Makanjuola and Makanjuola (2018). Ayaz *et al.* (2006) reported calcium content ranging from 14.28-60.03 mg/100g which are higher than the values recorded in this study. Calcium is a major constituent of bones and helps the body to; contract correctly, blood clotting and nerves to convey stimulus efficiently. Also, it is essential for disease prevention and control thus, may therefore making papaya seed flour a medicinal substance (Aliyu, 2008).

Table 3: Mineral composition of the papaya seed flours (mg/100g)

Parameter	Samples			
	A	B	C	LSD
Zinc (mg/100g)	$2.42^{b}\pm0.07$	$2.69^{a}\pm0.05$	$1.89^{c}\pm0.03$	0.17
Potassium (mg/100g)	$51.63^{c}\pm0.02$	$53.23^{a}\pm0.06$	$51.80^{b}\pm0.03$	0.13
Calcium (mg/100g)	$3.31^{b}\pm0.03$	$4.51^{a}\pm0.01$	$3.25^{c}\pm0.04$	0.04
Iron (mg/100g)	$2.01^{b}\pm0.07$	$2.44^{a}\pm0.01$	$1.81^{c}\pm0.03$	0.08
Magnesium (mg/100g)	$1.07^{c}\pm0.04$	$1.84^{a}\pm0.02$	$1.31^{b}\pm0.01$	0.09

Values are means of triplicate analysis and standard deviation. Means with different superscript along the columns are significantly different ($P < 0.05$).

Note: A = Red lady papaya seed; B = Hybrid red lady papaya seed; C = Dwarf papaya seed

Iron content of papaya seed flour samples

The iron content of the papaya seed samples ranges from 1.81-2.44mg/100g. The statistical analysis revealed that there were significant differences ($p<0.05$) among the papaya seed flour samples. The result indicates that the Dwarf papaya seed (sample C) recorded the least (1.81mg/100g) iron content followed by the Red lady papaya seed (sample A) with value 2.01mg/100g while the highest value (2.44mg/100g) was found in the Hybrid red lady papaya seed (sample B). The implication is that the Hybrid red lady papaya seed is a better source of iron compared to samples A and C. Iron is very important as it helps in the formation of blood, in the transfer of oxygen and carbon dioxide from one tissue to another (Guthrie, 2000). Iron deficiency results in impaired learning ability, anaemia and behavioral problems in children (MacDonald, 1995).

Magnesium content of papaya seed flour samples

The magnesium content of the pawpaw seed samples ranges from 1.07-1.84mg. The values include 1.07mg/100g, 1.84mg/100g and 1.31mg/100g for Red lady papaya, Hybrid red lady papaya and Dwarf papaya seeds respectively. The pawpaw seed samples recorded significant ($p<0.05$) difference among all in terms of magnesium. The result indicates that the Dwarf papaya seed (sample C) recorded the highest (1.84mg/100g) magnesium content while the lowest (1.07mg/100g) was found in the Red lady papaya seed (sample A). This implies that the Hybrid red lady papaya seed is a better source of magnesium compared to samples A and C. The daily value for magnesium is 400mg for adults and children aged 4 and older (Jacob *et al.*, 2019) this implies that papaya seed samples analyzed may not be a good source of daily required magnesium. Magnesium is beneficial to blood pressure and helps to prevent sudden heart attack, cardiac arrest and stroke. Like calcium, magnesium is an important component of bone and contributes to its structural development. While calcium stimulates muscles, magnesium relaxes the muscles (Guthrie, 2000).

Functional Properties of Papaya Seed Flour

Table 4 below relates the functional properties of the various papaya seed flour samples analyzed;

Bulk density

The values of the bulk density of the papaya seed samples are 30.71%, 31.36% and 33.74% for samples A, B and C respectively. The values range from 30.71% - 33.74%. There were variations hence statistically the papaya seed samples differ significantly ($p<0.05$) among each other in terms of bulk density. It was observed from the result that the Dwarf papaya seed (sample C) was found to have the highest 33.74% bulk density followed by the Hybrid red lady papaya seed with value 31.36% while the Red lady papaya seed (sample A) recorded the lowest (30.71%) bulk density. The relatively high bulk density of the Dwarf papaya seed indicates that its packaging would be economical as observed by Osundahunsi and Aworh (2002). Derikachar (2000) reported that traditional technologies which will lower bulk density in weaning food should be adopted. The lower the bulk density, the higher the amount of flour particles that can bind together leading to higher energy values.

Water absorption capacity of papaya seed flour samples

The range of the water absorption capacity of the papaya seed samples is from 210.63% - 213.53%. The values include 213.53%, 210.63% and 211.34% for samples A, B and C respectively. The statistical analysis revealed that there were significant differences ($p<0.05$) among the papaya seed samples in terms of water absorption capacity. According to Adegunwa et al. (2011), water absorption capacity is dependent on factors like particle size, amylose/amylopectin ratio and molecular structures of component flours. The Red lady papaya seed was found to have high (213.53%) capacity to absorb water compared to other papaya seed flours while the lowest (210.63%) water absorption capacity was recorded in the Hybrid red lady papaya seed. According to Seena and Sridha (2005) high water absorption causes high retention of water without dissolution of protein, thus increasing the body and viscosity of gel. Variation observed in water absorption capacity could be due to differing particle sizes and starch components of the pawpaw seed flours.

Oil absorption capacity

The values of the oil absorption capacity of the papaya seed flour samples range from 224.6-240.18%. The values recorded variations hence there were significant ($p<0.05$) difference among the pawpaw seed samples. The result revealed that the elongated ripe papaya seed had the least (224.69%) capacity to absorb oil followed in ascending order by the Dwarf papaya seed with value 227.33%. The Hybrid red lady papaya seed recorded the highest (240.18%) ability to absorb oil. This trend is not unexpected since the Hybrid red lady papaya seed had the lowest water absorption capacity. According to Apotiola (2013), reduction in oil absorption capacity could be due to conformational imbalance between hydrophilic and hydrophobic components of flour blends. Oil absorption capacity (OAC) of flour is important as it improves the mouth feel and retains the flavor.

Table 4: Functional properties of papaya seeds (%)

Parameter	Samples			
	A	B	C	LSD
Bulk Density (%)	$30.71^c\pm0.03$	$31.36^b\pm0.05$	$33.74^a\pm0.07$	0.15
WAC (%)	$213.53^a\pm0.18$	$210.63^c\pm0.02$	$211.34^b\pm0.05$	0.34
OAC (%)	$224.69^c\pm0.06$	$240.18^a\pm0.06$	$227.33^b\pm0.03$	0.17
Emulsion capacity (%)	$8.70^b\pm0.01$	$9.59^a\pm0.03$	$8.44^c\pm0.04$	0.10
Foaming capacity (%)	$6.91^c\pm0.02$	$9.52^a\pm0.02$	$7.13^b\pm0.02$	0.05

Values are means of triplicate analysis and standard deviation. Means with different superscript along the columns are significantly ($P < 0.05$) different.
OAC = Oil absorption capacity
WAC = Water absorption capacity
Note: A = Red lady papaya seed; B = Hybrid red lady papaya seed; C = Dwarf papaya seed

Emulsion capacity

The values of the emulsion capacity of the papaya seed flour samples are 8.70%, 9.59% and 8.44% for samples A, B and C respectively. The values range from 8.44% - 9.59%. There were slight variations and statistically the papaya seed samples differed significantly ($p<0.05$) in terms of emulsion capacity. It was observed from the result that the Red lady papaya seed (sample B) was found to have the highest 9.59% emulsion capacity followed by the Red lady papaya seed with value 8.70% while the Dwarf papaya seed (sample C) recorded the lowest (8.44%) emulsion capacity.

Foaming capacity

The foaming capacity of the papaya seed samples is within 6.91-9.52%. The values are 6.91%, 9.52% and 7.13% for pawpaw seed samples A, B and C respectively. All the seed samples according to the result recorded significant differences ($p<0.05$). Foam ability is related to the rate of decrease in the surface tension of the air water interface caused by absorption of protein molecules (Achinewhu *et al.*, 2000). The result indicates that the Hybrid red lady papaya seed had the highest (9.52%) ability to form foam compared to the Red lady papaya and the round yellow papaya seeds. The lowest foaming ability was found in the Red lady papaya seed.

Foaming capacity contribute to dough formation and stability (Olapade and Oluwole, 2013). High foaming capacity is a criterion for good quality product (Achinewhu *et al.*, 2000). This implies that the flour of the Hybrid red lady papaya seed will function better in food product formulation where foam formation is paramount.

4. Conclusion

This noble and novel research has definitely opened us up to the overall quality and importance of papaya seed flour of different cultivars. Papaya seeds which are mostly regarded as waste thus causing environmental and ecological problems, contains essential nutrients cum qualities that are useful to human and animals for healthy living. The papaya seeds especially the elongated yellow ripe and round yellow ripe seeds are good sources of fat, ash, fibre, protein, vitamins A and C. However, their moisture content is moderate thus its shelf-life is sure stable. The potassium content is also commendable and this could be of nutritional benefits to human health. These potential flours produced from the papaya seed varieties could find application in food formulation due to their functional properties especially bulk density, water absorption capacity and foaming capacity. This research doubtlessly revealed the importance of papaya seeds based on their nutrient composition and functional properties.

Recommendations

Further research and development work should be carried out to determine the nutritional quality and sensory evaluation of food produced from papaya seed flour as an innovation and variety in the food industry.

Declarations

Competing Interest

The authors declare no competing interest.

Authors' Contributions

Both authors contributed equally to the research process, literature writing, review and editing of the article.

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