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Chemical Composition of Papaya (*Carica papaya*) Seeds

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ABSTRACT

Defatted and undefatted seeds of papaya (Carica papaya) *were analyzed for proximate composition, some toxicants, sugar composition, mineral content, physico-chemical properties of the seed oil and the fatty acid spectrum of the seed oil. The seed is a rich source of proteins (27·8% undefatted, 44·4% defatted), lipids (28·3% undefatted) and crude fibre (22·6% undefatted, 31·8% defatted). Of the toxicants estimated, glucosinolates occur in the highest proportion. The seed is low in free monosaccharides. Sucrose is the predominant sugar (75·0% of total sugars). Mineral content is generally low. However, Ca and P occur in appreciable quantities (17 340 μg/g and 10 250 μ/g, respectively). The seed oil is low in iodine value (74·8), free fatty acids (0·94%) and carotene (0·02 μg/g). The major fatty acid is C18:1 (79·1%).*

INTRODUCTION

Papaya (*Carica papaya*) is a widespread plant which grows wild in many parts of the tropics and does well on almost every type of soil in the rain forest zone. Papaya is important for its fruit and it is only recently that it has been cultivated for this purpose. This new trend is an indication of

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increased consumption due to better awareness of the importance of the fruit in the diet of the third world countries, such as Nigeria. In Nigeria, like most other countries, the seeds of papaya fruits (about 15% of the wet weight) are discarded. Evidently, this is because of bad experiences when they are consumed by humans or animals. However, in order to make more efficient use of papaya, it is worth investigating the use of the seeds.

As part of a study on the utilization of papaya seeds, the chemical composition of the seeds is now reported with a view to evaluating both nutrients and toxicants, if any.

MATERIALS AND METHODS

Preparation of the seed meal

Mature *Carica papaya* fruits were collected from various locations in Oyo and Ondo states of Nigeria. The fruits were cut into two longitudinal halves and the seeds removed by hand. The testae of the seeds were removed by squeezing the seeds between two fingers. The seeds were dried in an oven at 60°C and ground into fine seed powder with a National Kitchen Blender. The seed meal was stored at −10°C until required for analysis.

Proximate composition

Proximate chemical analysis of the ground papaya seeds was achieved using standard procedures as follows: moisture, ether extract (AOAC, 1980) and crude protein by the Kjeldahl procedure (AOAC, 1970), ash content by the dry ashing technique and crude fibre (AOAC, 1970).

Mineral content

The mineral content was determined by a wet ashing method (AOAC, 1970). Estimation of the minerals was by atomic absorption spectrophotometry using a Perkin-Elmer 290 instrument.

Characterization of lipids

The iodine value, refractive index, saponification value, non-saponifiable matter and free fatty acids were determined by standard methods (AOAC, 1970). Carotene in the oil was estimated as described by Brubacher (1968).

Fatty acids analysis

Analysis of fatty acids was carried out by methylation (Morrison & Smith, 1964) of the lipid extract (Folch *et al.*, 1957), followed by gas chromatography (FID) utilizing a 1·5 m × 1 mm 3% OV-17 on a Gas Chrom Q 60/80 column. Temperature was programmed from 140 to 250°C at 3°C/min. Carrier gas was helium at a flow rate of 0·75 ml/min. Fatty acids were quantified and identified by comparing their retention times with those of standard fatty acids.

Estimation of some toxicants

Total thioglucosinolate was estimated using the method of Gmelin & Kjaer (1970). Tannin was determined by the modified vanillin-hydrochloric acid method of Price *et al.* (1978). Phytic acid in the seed was determined by the method of Wheeler & Ferrel (1971). Isothiocyanate of the seed oil was determined as described by Chung-Shin Tang (1971).

Carbohydrate classification

Total available carbohydrate was determined by the method of Finley & Wheeler (1973). The method of Dubois *et al.* (1956) was used to classify the sugars, using paper chromatography and quantifying the eluted spots by colorimetry.

Statistical analysis

Analysis of variance of the data was done using a Hewlett Packard MATH/STAT PAC for HP 41CV.

RESULTS AND DISCUSSION

Proximate composition

Table 1 summarizes the proximate composition of the *Carica papaya* seeds, defatted and undefatted. The values obtained are generally higher than for most seeds (Oyenuga, 1968; Becker *et al.*, 1981; Afolabi *et al.*, 1985). The seed is a rich source of proteins (27·76% undefatted, 44·42% defatted), lipids (28·41% undefatted) and crude fibre (22·56% undefatted, 31·83% defatted) ($P < 0·01$). These high values for proximate composition make the papaya seeds a rich source of nutrients. In the defatted seed, the protein

TABLE 1
Proximate Composition of Papaya Seed

Proximate composition (%)	*Undefatted*	*Defatted (dry weight)*
Moisture	6·20 ± 0·05	0·25 ± 0·04
Ether extract (oil)	28·3 ± 1·04	0·17 ± 0·06
Crude protein	27·8 ± 0·04	44·4 ± 0·50
Crude fibre	22·6 ± 0·12	31·8 ± 1·74
Lignin	—	1·49 ± 0·03
Ash	3·50 ± 0·36	4·48 ± 0·01
Total carbohydrate (by difference)	11·67	—
Available carbohydrate	—	8·90 ± 0·10
Unavailable carbohydrate (by difference)	—	8·46

and the fibre appear enriched. Besides supplying protein and oil, the high fibre value is of particular interest because, when the seed is used at an adequate level, it could be a rich source of dietary fibre which has been shown to have beneficial effects. It also appears that a large percentage of the carbohydrate is available (Table 1).

Toxicants

In Table 2, the concentrations of some toxicants are presented. Glucosinolates appear to occur in the highest proportion when compared to other toxicants ($P < 0·01$). The presence of isothiocyanate in the oil of the papaya seed (0·03%) (Table 5, see below), suggests some degree of hydrolysis of thioglucosinolate present in the seed by the enzyme thioglycosidase (Gmelin & Kjaer, 1970). The occurrence of these toxicants may limit the use of the papaya seed and its oil for animal or human consumption.

TABLE 2
Some Toxicants of the Papaya Seed

Toxicant	*Per cent[a] dry weight of defatted seed meal*
Phytates	3·04 ± 0·41
Glucosinolates	10·0 ± 0·12
Tannins	6·35 ± 0·09

[a] Values are means of triplicate determinations ± standard deviation of means. Values are significant at $P < 0·01$.

TABLE 3
Sugar Composition of Papaya Seeds

Sugar	*Per cent[a] of seed dry weight*	*Per cent total sugar*
Sucrose	1·77 ± 0·01	75·0
Glucose	0·11 ± 0·00	4·66
Fructose	0·09 ± 0·01	3·81
Galactose	0·11 ± 0·00	4·66
Xylose	0·07 ± 0·04	2·97
Raffinose	0·06 ± 0·00	2·54
Cellobiose	0·05 ± 0·00	2·54
Sorbose	0·02 ± 0·00	0·85
Unidentified (by difference)	—	2·97

[a] Values are means of triplicate determinations ± standard deviation of means. Values are significant at $P < 0·001$.

Saccharide composition

The monosaccharides (Table 3) such as glucose, fructose, galactose etc., occur in trace amounts. In terms of percentage of total sugars, sucrose is predominant (75·0%). The low level of the free monosaccharide suggests that the seeds used were matured. Two sugars which together constitute 2·97% of the total sugars could not be identified.

TABLE 4
Mineral Content of Papaya Seeds

Mineral	*Concentration (μg/g)*
Cu	50 ± 2
Mg	220 ± 2
Fe	130 ± 3
Ca	17 340 ± 10
S	520 ± 10
Ni	10 ± 6
Co	4 ± 0
Mn	3 ± 0
K	340 ± 1
Na	110 ± 0
P	10 250 ± 20

Values are means of duplicate determinations ± standard deviation of means. Values are significant at $P < 0·001$.

Mineral composition

In general, the mineral composition (Table 4) of the papaya seed is low when compared to other plant seeds (Oyenuga, 1968; Afolabi *et al.*, 1985). However, the calcium (17 340 μg/g) and phosphorus (10 250 μg/g) levels are high. This high occurrence of Ca and P suggests that phytic acid would occur as the insoluble calcium salt in the seed.

Seed oil

The physico-chemical properties of the papaya seed oil are presented in Table 5. The seed oil is low in iodine value (74·8) and free fatty acids (0·94%) when compared to olive oil. The low free fatty acids content is

TABLE 5
Some Physico-Chemical Properties of Papaya Seed Oil

Ether extract (%)	28·3 ± 1·04
Iodine value	74·8 ± 1·20
Saponification value (%)	197 ± 3·03
Non-saponifiable matter (%)	0·72 ± 0·09
Free fatty acids (%)	0·94 ± 0·01
Carotene (μg/g)	0·02 ± 0·01
Isothiocyanate (%)	0·03 ± 0·02
Refractive index 25°C	1·467 8

indicative of low enzymatic hydrolysis. This could be an advantage as oil with high free fatty acids develops off flavour during storage (Bailey, 1954). The refractive index reflects the degree of unsaturation and chain length. The value obtained here (1·4678) is expected of an oil with low iodine value and the presence of C18:1 in the proportion observed (Table 5). The percentage saponifiable is 197 ± 3·03% while the non-saponifiables are only 0·72 ± 0·09%. This is an indication that the steroidal and related components are low in the oil. This is a good oil property sought after for both nutritional and industrial purposes. The oil is also low in carotene value (0·02 μg/g) when compared with palm oil, the traditional source of cooking oil in the rain forest of Nigeria.

The fatty acids composition of the seed oil is presented in Table 6. The fatty acids present in measurable quantities are C12:0 (lauric acid), C14:0 (myristic acid), C16:0 (palmitic acid), C18:0 (stearic acid), C18:1 (oleic acid) and C18:2 (linoleic acid). Values obtained are in agreement with previous work (Subramaniam & Achaya, 1957) on the Indian and Mexican

TABLE 6
Fatty Acids Composition of Papaya Seed Oil

Fatty acid	*%*[a]
Lauric acid (C12:0)	0·01 ± 0·01
Myristic acid (C14:0)	0·04 ± 0·02
Palmitic acid (C16:0)	16·6 ± 0·06
Stearic acid (C18:0)	1·90 ± 0·03
Oleic acid (C18:1)	79·1 ± 0·12
Linoleic acid (C18:2)	2·57 ± 0·04

[a] Values are means of triplicate determinations ± standard deviation of means. Values are significant at $P < 0·001$.

varieties. The major fatty acid is C18:1 and this may be of nutritional advantage (Friedman & Reid, 1973).

In conclusion, it appears the papaya seed is a rich source of nutrients. However, it has a considerable drawback which is the presence of toxicants in both the seed and the oil. In order to utilize this rich source of food, research efforts should be directed at making the seed and its products toxin free.

REFERENCES

Afolabi, O. A., Oshuntogun, B. A., Adewusi, S. R. A., Fapojuwo, O. O., Ayorinde, F. O., Grissom, F. E. & Oke, O. L. (1985). Preliminary nutritional and chemical evaluation of raw seeds from *Mucuna solanei*: An underutilized food source. *J. Agric. Fd. Chem.* **33**, 122–4.

AOAC (1970). *Official methods of analysis.* (11th edn), Association of Official Analytical Chemists, Washington, DC.

AOAC (1980). *Official methods of analysis.* (13th edn), (Williams Horwitz (Ed)), Association of Official Analytical Chemists, Washington, DC.

Bailey, E. A. (1954). *Industrial oil and fat products.* (3rd edn), Interscience Publishers, London.

Becker, R., Wheeler, E. L., Lorenz, K., Stafford, A. E., Grosjeani, O. K., Betschart, A. A. & Saunders, R. M. (1981). A composition study of amaranth grain. *J. Fd. Sc.* **46**, 1175–80.

Brubacher, G. (1968). The determination of vitamins and carotenoids in fats. In: *Analysis and characterization of oils, fats and fat products.* (Boekenoygen, H. A. (Ed.)), Interscience Publishers, London.

Chung-Shin Tang (1971). Benzyl isothiocyanate of papaya fruit. *Phytochemistry*, **10**, 117–22.

Dubois, M., Gilles, K. A., Hamilton, J. K., Rebers, P. A. & Smith, F. (1956). Colorimetric method for determination of sugars and related substances. *Anal. Chem.* **28**, 350–5.

Finley, J. W, & Wheeler, E. L. (1973). Sucrose determination by a modified Anthrone method. Application with sweetened wheat–soyblend and corn–soy–milk. *Cereal Chem.* **50**, 210–16.

Folch, J., Lees, M. & Staley, G. H. S. (1957). A simple method for the isolation and purification of total lipids from animal tissues. *J. Biol. Chem.* **226**, 497–509.

Friedman, Z. & Reid, B. (1973). Essential fatty acids, prostaglandins and human milk. In: *Human milk, its biological and social value.* (Freic, S. & Eidelman, A. I. (Eds)). Excerpta Medica, Amsterdam, Oxford, Princeton.

Gmelin, R. & Kjaer, A. (1970). Glucosinolates in the caricaceae. *Phytochemistry*, **9**, 591–601.

Morrison, W. R. & Smith, L. (1964). Preparation of fatty acid methyl esters and dimethyl acetals from lipids and boronfluoride methanol. *J. Lipid Res.* **5**, 600–8.

Oyenuga, V. A. (1968). *Nigeria foods and feedingstuffs.* (3rd edn), Ibadan University Press, Ibadan.

Price, M. L., Vanscoyoc, S. & Butler, L. G. (1978). A critical evaluation of the vanillin reactions as an assay for tannins in sorghum grain. *J. Agric Fd. Chem.* **26**, 1214–15.

Subramaniam, V. V. R. & Achaya, K. T. (1957). Lesser known Indian vegetable fats. I—Oleic rich fats. In: *The chemical constitution of natural fats.* (4th edn). (Hilditch, T. P. & Williams, P. N. (Eds)), 272.

Wheeler, E. L. & Ferrel, R. E. (1971). A method of phytic acid determination in wheat and wheat fractions. *Cereal Chem.* **48**, 312–16.