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Amino Acid and Functional Characteristics of Pawpaw (*Carica papaya*) Seeds under Normal Storage Ripening

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Authors' contributions

This work was carried out in collaboration between all authors. Author GOO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ROA and WKS managed the analyses of the study. Author AAA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The amino acid contents and the functional properties of matured unripe, ripe and overripe pawpaw (*Carica papaya*) seeds were carried out using standard methods as follow up to a previous paper where some aspects of the chemical composition of the seeds at different ripening stages were determined. Twenty amino acids comprising ten essential and non- essential amino acids were detected, out of which total essential amino acids (EAA) in % were 48, 47 and 24 while non-essential amino acids in % were 52, 53 and 76 in unripe, ripe and overripe pawpaw seeds respectively. Functional properties for bulk density (BD), water absorption capacity (WAC), oil absorption capacity (OAC), foaming capacity (FC), emulsion capacity (EC), gelation capacity (GC) and viscosity were also determined. Favourable functional properties and the amino acids makes the results from this study an important index to the use of the seeds from the various ripening stages a means of supplementing the existing source of nutrient in food formulation.

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1. INTRODUCTION

Healthful diets containing functional materials or neutraceutical are currently having impact on food industries. A number of efforts have been made to search for new sources with beneficial health effects. These efforts may be mainly due to the increase cost of health care [1], which can easily be achieved through the use of various plant sources that abounds around us. Storage life of a product varies with species, variety and pre-harvest conditions. The quality of stored materials depends majorly on temperature and relative humidity available during storage. Pawpaw (*Carica papaya*) belongs to a family of *Caricaceae*. It is a perennial plant with a rapid growth rate and can produce fruit for more than 20 years. It has a rather complicated means of reproduction. The plants are male, hermaphrodite or female. The male trees are uncommon but sometimes occur. Hermaphrodite trees (flowers with male and female parts) are the most common, producing a pear shaped fruit. The plant is self pollinated [2]. It is cultivated for its fruits and favoured by people of the tropics as ingredients in jellies, preserves or cooked in various ways. The juice makes a popular beverage while young leaves, shoots and fruits are cooked as vegetable. The plant is now grown for papain; A chemical that have many health benefits especially in digestion and softening of meat. The fruit is reported to be an excellent source of calcium, provitamin A, vitamin C and also widely used in diets [3].

Carica papaya leaf extract was found to provide a means for the treatment and prevention of selected human diseases such as cancer, various allergic disorders for vaccine therapy [4], denge fever [5] and anti-inflammatory [6].

Ripening of fruits is the final stage of the maturation when the fruit changes colour, softens and develop the flavour, texture and aroma that constitutes optimum eating quality [7]. Ripening of fruits or other materials involves breaking down polysaccharides such as starch into smaller monosaccharide (glucose) through hydrolysis by enzymatic actions. Ripening of papaya fruit is important for it to be much more nutritious, palatable and edible for consumption. The stage of ripening determines the sweetness of the fruit because of increase in sugar content. Unripe fruits are often green, sour, odourless and hard [8]. Recently, artificial method of ripening is used and this is of much concern because instead of allowing fruits to ripe naturally, most sellers and producers have resulted to the use of chemicals to hasten the ripening of fruits to achieve uniform ripening attributes. Consumption of these artificially ripened fruits has been linked to several hazardous effects such as cancer, food poisoning, gastric irritation, mouth ulcers and stomach upset among others [9,10]. The effect of heat treatments on amino acid compositions of food and plant materials has been investigated and reported [11-13]. Raimo et al. [13] reported that available lysine content of canned baby food decreased after heat treatments. Functional properties in terms of the structure and stability of protein play important roles in the processing and sensorial perception of food especially in emulsions and foams where the formation and stabilization are only possible by absorbing a surface active agent at the interphase between the dispersed and the continuous phases [14]. Djilas et al. [15] reported that by-products (wastes) from plant materials are important sources of sugar, minerals and organic acids among others which have wide range of pharmacological uses. The peels and seeds from pawpaw fruits are generally discarded after consuming the pulp but due to the popularity of herbal therapy, the use of papaya seeds and peels are now widely spread [3,16,17]. Pawpaw seed is used in elimination of intestinal worms when chewed [18].

The aim of this research work is to determine the functional properties as well as the amino acids present in *Carica papaya* seeds at various stages of ripening under normal storage conditions in order to expand the scope of its usage or otherwise.

2. MATERIALS AND METHODS

2.1 Sample Collection

Freshly harvested matured unripe pawpaw (*Carica papaya*) fruits with absence of defects were collected from a farm at Iba town in Ifelodun Local Government area of Osun State, Nigeria. The fruit was authenticated at the Biology Laboratory of Science Laboratory Technology Department of Osun State Polytechnic, Iree, Nigeria as *Carica papaya* (Oblong yellow morphotype) based on fruit shape and pulp colour. A voucher specimen was deposited in the herbarium (No. 00105) of the institution.

2.2 Sample Preparation

The mature unripe fruits were separated into three parts; The first part is the mature unripe while the other two parts were subjected to normal storage ripening in the laboratory. The second part was separated when the fruit became ripe while the third part was allowed to overripe. The samples were washed with deionised distilled water, sliced open using sterilized stainless laboratory knife for the seeds to be separated. The seeds were sun dried, grinded with a laboratory blender (Phillip Harris model) and passed through a 2 mm sieve. The powdered samples were packed in a polyethylene bag kept in a refrigerator at 4℃ in preparation for further analysis.

2.3 Amino Acid and Functional Properties Determinations

Amino acid composition of the samples was determined using the ion exchange chromatography method as described by Adeyeye and Afolabi, [19] except tryptophan that was determined by the method reported by Ogunsua, [20]. Foaming capacity was determined according to the procedure of Sadeghi and Bhagya [21]. The gelation and viscosity were done by method reported by Mufumbo et al. [22]. Bulk density was determined using the methods highlighted by Wang and Kinsella, [23]. Water and oil absorption capacities were determined as described by Sosulski and McCurdy, [24] while emulsion capacity was done according to the method of Ockerman, [25].

3. RESULTS AND DISCUSSION

3.1 Results

The results of the analyses are presented on Tables 1 and 2. Table 1 shows the functional properties of the seed flour and Table 2 shows the amino acid profile of the seed flour.

3.2 Discussion

Functional properties of pawpaw seeds on Table 1 is an indication of their potentials for development of different food products. Water absorption capacity (WAC) increased from 59.12% in mature unripe to 61.48% in ripe seed which later reduced to 59.77% in the overripe seed. These seeds may not be considered critical in viscous food production because their values were not in the range of 149.1-471.5% [26,27]. Many factors including carbohydrates, conformation and environment can influence WAC content of food. The conformational changes in the protein molecules may expose previously enclosed amino acid side chains thereby making them available to interact with water [28]. The oil absorption capacity (OAC) value also got reduced from 32.08% in mature unripe seed to 26.98% in ripe seed and later increased a little bit to 30.44% in overripe seed sample. The values for WAC and OAC of the three samples were very low compared to the range of 223-265% WAC recorded for three varieties of *Carica papaya* seeds [17] and 245.6% for cowpea flour [29].

Bulk density (BD) content of mature unripe seed was found to be 0.98% which initially increased to 1.02% in ripe seed and later reduced to nearly the same value as the mature unripe seed; this may be due to microbial activities during ripening. The bulk densities of the three samples are higher than 0.77% reported for common maize sample [30]. Bulk density is greatly affected by particle size, solvents used for extracting the protein product [23] and method of drying [31]. The low bulk densities of the samples will make their packaging and transportation easy.

The foaming capacity reduced from 5.22% in mature unripe seed to 4.98% in ripe seed and later increased to 6.13% in overripe seed. The foaming capacities of the samples with the range of 4.98-6.13% was found to be comparable to 6% reported for *Sorghum bicolor L*. stem flour [32] but higher than 4.00% recorded by [30] for common maize. Low foaming capacity (LGC) has been attributed to inadequate electrostatic repulsions, lesser solubility and hence excessive protein-protein interactions. Viscosity of the seed samples in % were 49.11, 53.08 and 48.97 in mature unripe, ripe and overripe respectively. Viscosity is an important criterion that decides the applicability of starch in food and industries. The reduction in viscousity observed for the overriped pawpaw seed has been linked to the activities of amylase enzymes developed during ripening which degrades the starch to simple sugar [33]. Gelation capacities of the seed samples followed the same trend as observed on OAC and FC. The LGC of the samples are higher than the range of 8-10% reported for wheat flour and different composite flours from it [34].

Table 1. Functional properties of *Carica papaya* seeds (%)

Functional Properties	Sample A	Sample B	Sample C
BD	0.98 ± 0.01	1.02±0.01	0.99±0.02
WAC	59.21±0.10	61.48±0.03	59.77±0.05
OAC	32.08± 0.10	26.98±0.20	30.44±0.01
FC	5.66±0.01	4.98±0.03	6.13±0.05
EC	7.08± 0.02	9.21±0.30	7.58±0.01
Viscosity	49.11± 0.01	53.08±0.03	48.97±0.20
GC	78.00± 0.01	67.00±0.05	78.00±0.30

Table 2. Amino acid profile of *Carica papaya* seeds (%)

Amino Acid	Sample A	Sample B	Sample C
Cystein	0.018±0.001	0.025±0.010	0.019±0.005
Methionine	0.037±0.002	0.078±0.100	0.062±0.003
Lysine	0.042±0.001	0.071±0.030	0.058±0.001
Proline	0.061±0.004	0.058±0.003	0.063±0.010
Valine	0.088±0.001	0.074±0.005	0.092±0.001
Trypsin	0.091±0.200	0.074±0.005	0.113±0.002
Isoleucine	0.102±0.010	0.098±0.001	0.013±0.003
Phenylalanine	0.105±0.002	0.121±0.004	0.156±0.005
Threonine	0.128±0.030	0.114±0.002	0.098±0.002
Leucine	0.378±0.001	0.285±0.010	0.037±0.003
Aspartic acid	0.010±0.001	0.008±0.001	0.011±0.002
Glutamic	0.028±0.001	0.037±0.002	0.028±0.001
Glutamine	0.047±0.003	0.053±0.001	0.076±0.004
Tryptophan	0.060±0.003	0.070±0.003	0.060±0.003
Histidine	0.080±0.002	0.102±0.005	0.087±0.002
Asparagine	0.106±0.001	0.097±0.004	0.112±0.001
Alanine	0.121±0.010	0.118±0.002	0.142±0.002
Serine	0.120±0.005	0.118±0.001	1.156±0.030
Arginine	0.122±0.002	0.207±0.001	0.156±0.004
Glycine	0.432±0.004	0.386±0.003	0.413±0.002
EAA	1.050	1.050	0.711
NEAA	1.126	1.196	2.241
TAA	2.176	2.246	2.952
%EAA	48	47	24
%NEAA	52	53	76
Leucine: Isoleucine	1:4	1:3	1:3

Note: A- Mature unripe; B- Ripe; C- Overripe; n = 3

Amino acids perform several functions in the body of individual and they are the basic components of protein. The amino acid composition of pawpaw seeds on Table 2 showed the trend of twenty amino acids comprising ten essential and non-essential amino acids each. These values were very low compared to the various values obtained for *Senna siamea* and *Mangifera indica* seeds [35,36]. The decrease in the levels of the amino acid contents (especially the essential amino acids) after sun drying could be attributed to possible structural modifications of the protein as a result of the heat [12]. The results showed that glycine is the predominant amino acid. The values for essential amino acids of mature unripe, ripe and overripe samples were 48.5%, 47.5% and 24.9% while non essential amino acids were 52.5%, 53.3% and 76.1% respectively. These values were higher than 41-51% reported for the various components in bottle gourd seeds [37]. Essential amino acids cannot be produced by the body and so need to be replenished regularly. Leucine plays important roles in regulating body sugar, wound healing and repair of muscle tissue as well as absorption of calcium while isoleucine helps in developing hemoglobin and regulation of body energy.

Generally from these results, normal storage ripening increased the concentrations of phenylalanine, leucine and glutamine while the values obtained for isoleucine and threonine got decreased in the various stages of ripening. It is pertinent to note that high quality proteins must contain the essential amino acids in proportion capable of promoting growth when they are the sole source of protein in diet and they should contain 33% or more essential acids [38]. From the average values of essential amino acids obtained for mature unripe and ripe seeds of 48.25% and 46.75%, their proteins are expected to be of high quality. The low EAA of the overripe seed compared to the other two samples may be as a result of microbial activities that took place during the ripening process.

Leucine: Isoleucine ratio was 1:4 in mature unripe while it was 1:3 in each of the ripe and overripe seeds. Lower concentration of leucine in the seeds is desirable because excess of it in foods would interfere with the utilization of isoleucine and lysine.

4. CONCLUSIONS

The research work has been able to show the extent to which pawpaw seeds which are normally discarded after consuming the pulp could be put into. The favourable functional properties and the profile of amino acids present in the seeds at the various ripening stages are pointers to this fact. The seeds could therefore be a major source of raw material and supplement in industrial formulations.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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