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Studies on Nutritive Characteristics and Variability in Pawpaw (*Carica papaya L.*)

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Abstract: Fruits of fifteen morphotypes of *Carica papaya* of "sunrise solo" was evaluated to determine their nutritive characteristics, phenotypic and genotypic variability as well as the heritability and expected genetic advance of the nutritive traits. The result indicated that the moisture content was high among the morphotypes and differed significantly ($p<0.01$). Protein values were significantly different among the morphotypes and ranged from 0.293 to 0.82%. Crude fat was low in all the morphortypes and the morphotypes varied significantly ($p<0.01$) in carbohydrate, ash, moisture content and dry matter contents. The mineral and vitamin contents of the morphotypes also varied significantly from one another ($p<0.01$). High thiamine content was observed in Pear red fruits while vitamin C content was high in oblong yellow fruits. The variability observed in these traits were more of genetic nature than non-genetic and indicates that there is considerable scope for selections in the morphotypes. High heritability and genetic advance was observed in crude fibre, ash, calcium, sodium, protein and riboflavin indicating that selection for these traits can be effective for their improvement.

Key words: *Carica papaya*, fruits, morphortypes

INTRODUCTION

Carica papaya (family Caricaceae) is a tropical fruit crop widely grown in Nigeria for food, ornamental and traditional health care purposes (Sofoware, 1997).

Papaya is important for its fruit which ranks only second to banana in terms of daily consumption in South east Asia (OECD, 2005). The green unripe fruit is used as a remedy for ulcer, impotence and as an antiseptic (Elizabeth, 1994).

It also has a milky juice containing an active principle ingredient known as papain. Furthermore, it is used as a remedy in dyspepsia, kindred ailments and clarification of beer. The juice has been in use on meat to make it tender (Wilson, 1974; Bouanga-Kalou *et al.*, 2011) and is used in the treatment of gangerous wounds or bonus (Hewitt *et al.*, 2000) and also in the cosmetics products (Knight, 1980).

Tropical fruits have received a surge in interest due to their significance nutritionally, health wise and economically and in the general well being of individuals. Papaya is regarded as a good source of iron, calcium, vitamins A, B and C and the carotenoid content is low compared to mango and tomato (USDA, 2006).

Crop improvement is dependent not only on the magnitude of the phenotypic variability but also on the extent to which the desirable characters are heritable. Hence, it is essential to partition the observed variability into its heritable and non heritable components by appropriate genetic analysis (Okoye and Ene-Obong, 1992; Baye, 2000; Nwofia *et al.*, 2006; Hefny, 2011). This study was conducted using fifteen *Carica papaya* L. morphotypes of 'Sunrise Solo' pawpaw cultivar to determine their nutritive characteristics, phenotypic and genotypic variability, the broad sense heritability estimates and expected genetic advance.

MATERIALS AND METHODS

Collection of morphotypes: Fifteen pawpaw (*Carica papaya L.*) morphotypes were collected from farmers in Abia State, Nigeria in January, 2011. All the morphotypes were hand harvested directly from trees and their morphological and horticultural attributes determined.

Proximate analysis: Proximate analysis of *Carica papaya* fruit pulp such as moisture, crude protein, fat, fibre and dry matter contents were determined using the method described by James (1995). Ash content was determined by the method of AOAC (1984) furnace incineration gravimetric method while total carbohydrate was determined by difference as the nitrogen free extract. The nitrogen free extract was given as the difference between 100 and the sum of protein, fat, fibre and moisture.

Mineral analysis: The mineral analysis of the *Carica papaya* fruit pulp was determined by the dry ash extraction method described by James (1995) and Kirk and Sawyer (1998). 5.0 g of each morphotype was ashed and the resulting ash dissolved in 5 mls of dilute HCL solution and made up of 100 mls. This was then used in the analyses of each mineral. Calcium was determined using the versanade EDTA titrimetric method while phosphorous was determined by the

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molydovanadate colorimetric method and calcium and potassium was determined by photometry (James, 1995).

Vitamin analysis: The analysis for riboflavin, thiamine, niacin and vitamin C was done using the spectrophotometric method of Okwu (2004). All determinations for proximate, mineral and vitamins analysis were done in triplicates.

Data analysis: The data obtained were subjected to analysis of variance as a randomized complete block design using the PROC mixed procedure (Littell *et al.*, 1996) of SAS (SAS institute, 2001) and the means separated using the least significant difference. The analysis of variance was used to partition the gross (phenotypic) variability into the components due to genetic and non-genetic environmental factors and to estimate their magnitude. Genotypic variance is the part of the phenotypic variance attributable to genotypic differences while phenotypic variances is the total variance among phenotypes from over a range of environments (Dudley and Moll, 1969). The phenotypic, genotypic and error variances were estimated using the formulae of Wricke and Weber (1986) and Prasad *et al.* (1981):

$$Vg = \frac{MSG-MSE}{r}$$

$$Vp = \frac{MSG}{r}$$

$$Ve = \frac{MSE}{r}$$

Where MSG, MSE and r are the mean square of genotypes, mean squares of error and number of replication respectively. The Phenotypic (PCV) and Genotypic (GCV) coefficients of variations were evaluated by the methods of Burton (1952); Johnson *et al.* (1955) and Kumar *et al.* (1985) as follow:

$$PCV = \frac{\sqrt{VP}}{\bar{X}} \times 100$$

$$GCV = \frac{\sqrt{VG}}{\bar{X}} \times 100$$

Where Vp, Vg and x are phenotypic and genotypic variances and grand mean respectively for attribute under consideration. Broad sense heritability (h^2B) expressed as the ratio of Vg to the Vp was estimated on genotypic mean basis as described by Allard (1999). Genetic advance was estimated by the method of Fehr (1987) as $Ga = K(Sp)h^2B$ where K is a constant (2.06 at 5% selection pressure), Sp is the phenotypic standard deviation $\sqrt{Vp}$, h^2B is the heritability in the broad sense. GA was calculated as a percentage of the mean.

RESULTS AND DISCUSSION

There are four main fruit shapes among the pawpaw morphotypes: Round, Pear, Oblong and Convex and these fruits had red, orange and yellow pulps (Table 1). The biggest fruits were observed among the round fruits which were also longer in length had more circumference, diameter and thickness. The 100 seed weight with and without mucilage were heavier in the pear shaped fruits while smaller seed sizes were observed among the convex shaped fruits (Table 1). This result agreed with the report of Baiyeri (2006) that showed that variability exists in fruit morphology in *Carica papaya* but differs from his report in that there were variability is seed size in this experiment. This indicates that there are differences in food reserves in the seeds of the morphotypes.

Table 1: Characterization of pawpaw (*Carica papaya L.*) fruit morphotypes

Morphotypes	Weight (cm)	Length (cm)	Cs (cm)	Cw (cm)	Diameter (cm)	Thickness (cm)	Seed w (g)	Seed w.o (g)
Round-shaped, yellow pulp	4.7	38.0	48.0	58.3	21.0	5.2	18.4	13.3
Round-shaped, yellow pulp	4.7	39.0	45.0	61.8	22.0	4.9	15.8	13.5
Round-shaped, orange pulp	4.8	36.0	48.5	62.2	23.0	5.3	23.2	13.1
Pear-shaped, red pulp	1.6	31.0	27.0	37.4	11.5	3.3	26.8	15.3
Pear-shaped, red pulp	1.5	31.4	27.0	36.0	10.5	3.3	35.7	17.8
Pear-shaped, red pulp	1.4	29.7	25.0	37.0	12.0	3.3	25.6	15.9
Pear-shaped, yellow pulp	1.5	30.0	27.0	39.5	10.7	3.4	27.8	17.5
Oblong-shaped, orange pulp	1.0	23.7	31.0	33.4	12.3	3.2	11.8	10.4
Oblong-shaped, yellow pulp	1.3	24.0	35.5	41.2	13.4	3.4	10.2	7.5
Oblong-shaped, yellow pulp	1.1	23.0	35.6	37.7	12.3	3.0	20.3	12.3
Oblong-shaped, yellow pulp	0.6	20.5	28.2	29.1	10.0	3.3	11.5	8.5
Convex-shaped orange pulp	0.8	24.2	24.0	30.0	9.3	3.0	16.3	10.2
Convex-shaped, orange pulp	0.9	23.0	26.1	32.0	9.8	3.1	14.7	11.3
Convex-shaped, orange pulp	1.3	26.1	28.5	35.1	12.2	4.0	8.2	4.5
Convex-shaped, orange pulp	1.4	24.4	28.2	34.6	11.5	4.0	10.3	6.2

Wt - Fruit weight; L - Fruit length, Cs - Fruit circumference at smallest point; Cw - Fruit circumference at widest point; D - Fruit diameter; T - Fruit thickness; Sw - 100 fresh seed weight with mucilage; Swo - 100 fresh seed weight without mucilage

Table 2: Proximate composition of 15 pawpaw (*Carica papaya L.)* morphotypes

Morphotypes	Protein	Fat	Fibre	Ash	MC	CHO	DM
Round-shaped, yellow pulp	0.470	0.473	0.387	0.340	88.213	10.117	11.787
Round-shaped, yellow pulp	0.643	0.440	0.440	0.333	88.200	9.743	11.800
Round-shaped, orange pulp	0.410	0.527	0.367	0.347	86.273	12.077	13.727
Pear-shaped, red pulp	0.587	0.653	0.507	0.207	85.727	12.420	14.173
Pear-shaped, red pulp	0.470	0.630	0.520	0.400	85.007	12.973	14.993
Pear-shaped, red pulp	0.763	0.560	0.540	0.333	85.587	12.217	14.413
Pear-shaped, yellow pulp	0.760	0.480	0.473	0.660	86.607	11.020	13.395
Oblong-shaped, orange pulp	0.410	0.453	0.333	0.333	82.227	16.243	13.773
Oblong-shaped, yellow pulp	0.410	0.447	0.333	0.673	87.407	10.623	12.600
Oblong-shaped, yellow pulp	0.470	0.507	0.340	0.340	85.060	13.283	14.720
Oblong-shaped, yellow pulp	0.293	0.437	0.373	0.273	83.900	14.560	14.100
Convex-shaped, orange pulp	0.643	0.540	0.533	1.027	87.600	9.657	12.413
Convex-shaped, orange pulp	0.587	0.473	0.520	0.673	87.800	9.947	12.200
Convex-shaped, orange pulp	0.537	0.413	0.533	0.660	90.417	7.444	9.567
Convex-shaped, orange pulp	0.820	0.433	0.527	0.860	85.000	12.360	15.000
$LSD_{0.05}$	0.196	0.031	0.039	0.219	2.159	2.077	0.337

MC - Moisture Content, CHO - Carbohydrate, DM - Dry Matter

Table 3: Mineral composition of 15 pawpaw (*Carica papaya L.*) morphotypes

Morphotypes	Calcium (mg/100 g)	Phosphorus (mg/100 g)	Sodium (mg/100 g)	Potassium (mg/100 g)
Round-shaped, yellow pulp	18.70	24.87	6.43	229.60
Round-shaped, yellow pulp	21.38	26.67	5.69	226.73
Round-shaped, orange pulp	26.72	29.11	6.26	230.13
Pear-shaped, red pulp	17.37	42.04	3.76	216.27
Pear-shaped, red pulp	16.03	44.08	3.57	216.27
Pear-shaped, red pulp	14.69	38.10	6.44	209.07
Pear-shaped, yellow pulp	21.38	41.36	4.35	218.67
Oblong-shaped, orange pulp	30.73	31.29	5.09	194.93
Oblong-shaped, yellow pulp	37.41	33.06	4.67	174.93
Oblong-shaped, yellow pulp	29.39	40.95	6.27	195.20
Oblong-shaped, yellow pulp	41.42	31.84	5.65	182.11
Convex-shaped, orange pulp	21.38	45.44	3.99	237.60
Convex-shaped, orange pulp	25.38	44.63	4.27	243.93
Convex-shaped, orange pulp	22.71	39.80	4.37	243.93
Convex-shaped, orange pulp	33.40	42.13	5.87	244.93
$LSD_{0.05}$	5.12	1.15	0.08	1.24

Table 4: Vitamin composition of 15 pawpaw (*Carica papaya L.*) morphotypes

Morphotypes	Thiamine (mg/100 g)	Vitamin C (mg/100 g)	Niacin (mg/100 g)	Riboflavin (mg/100 g)
Round-shaped, yellow pulp	0.017	41.07	0.330	0.054
Round-shaped, yellow pulp	0.018	44.59	0.325	0.045
Round-shaped, orange pulp	0.021	45.17	0.357	0.051
Pear-shaped, red pulp	0.026	36.37	0.305	0.041
Pear-shaped, red pulp	0.027	37.55	0.322	0.045
Pear-shaped, red pulp	0.029	39.31	0.335	0.029
Pear-shaped, yellow pulp	0.027	38.13	0.332	0.041
Oblong-shaped, orange pulp	0.021	49.87	0.285	0.060
Oblong-shaped, yellow pulp	0.022	52.80	0.304	0.054
Oblong-shaped, yellow pulp	0.027	53.97	0.271	0.060
Oblong-shaped, yellow pulp	0.024	48.69	0.319	0.064
Convex-shaped, orange pulp	0.017	47.09	0.380	0.041
Convex-shaped, orange pulp	0.013	46.93	0.354	0.048
Convex-shaped, orange pulp	0.018	50.45	0.371	0.032
Convex-shaped, orange pulp	0.023	48.11	0.389	0.041
$LSD_{0.05}$	0.006	2.23	0.015	0.012

Highly significant differences ($p<0.01$) were observed in all the proximate attributes studied in the pawpaw morphotypes. Protein content was highest in the convex shaped fruits and it differs significantly from the other morphotypes except the pear shaped fruits.

Pear shaped fruits had the highest fibre content while the ash was observed to be highest in the convex shaped fruit type. Moisture content was high among the morphotypes and it ranged from 82% to 90% among them. The carbohydrate content ranged from 7.444% to 16.243% among the morphotype while the convex shaped orange fruit had the highest dry matter (Table 2). Similar results have been obtained in other fruits and vegetables such as benniseed (Dashak and Fali, 1993), bambara groundnut (Akubuo and Uguru, 1999) and plum (Druzic *et al.*, 2007; Voca *et al.*, 2009). The variation observed in this morphotypes can be attributed to the genetic make up of the fruit.

The mineral composition of the pawpaw morphotypes are shown in Table 3 while the vitamin contents are shown in Table 4. Highly significant ($p<0.01$) effect was observed among the morphotypes for mineral contents and vitamins. Calcium was higher (41.42 mg/100 g) in oblong shaped yellow fruits while the convex, orange fruits had the highest phosphorus and potassium (45.41 mg/100 g and 244.93 mg/100 g) while sodium content was high in the pear shaped fruits (Table 3). High thiamine content was observed in pear shaped, red fruit while vitamin C content was high in oblong, yellow fruits, Niacin content was highest in convex fruits regardless of the pulp colour while riboflavin was observed more in oblong yellow fruits (Table 4). These values of minerals and vitamins makes pawpaw fruit pulp a rich source of nutrients and underline its significance nutritionally in the diet of the third world countries where its use is on the increase. Interestingly, the different morphotypes were characterized with different proximate, mineral and vitamin contents, so selecting a morphotype could lead to an increase in a specific mineral or vitamin.

The mean squares and variance ratios obtained from the analysis of variance of the proximate, mineral and vitamin contents in the pawpaw morphotypes are shown in Table 5. The estimates of the variance components for the fifteen attributes showed that the phenotypic and genotypic variances were close to each other for most attributes (Table 6). The magnitude of the error variance was relatively lower than the genotypic variance for most characters. These lower error variances is an indicator that the genotypic component was the major contributor to the total variance for these characters and therefore most of the variability observed in proximate, mineral and vitamin contents of these *Carica papaya* morphotypes has more of a genetic than non genetic basis. The variability due to genotypic variance indicates considerable scope for selection. Similar results have been reported by Nayakar (1976) for niger, Singh and Yadava (1986) for sunflower, Baye (2000) for *Vernonia galamensis*, Nwofia *et al.* (2006) for cowpea.

The Phenotypic Coefficient of Variation (PCV) were higher than the corresponding genetic coefficient of variation (GCV, Table 7) indicating that all the attributes had to some degree interacted with the environment. The PCV ranged from 2.34 to 48.46 while GCV ranged from 2.8 to 46.06. The broad sense heritability ranged from 79.57% to 99.93%. These high heritability estimates indicates that environmental factors did not greatly affect phenotypic variation of such attributes and therefore selection for these characters is likely to be dependable and effective. Similar findings were reported by Sao (2006); Nwofia *et al.* (2006); Ambade (2008). Mishra *et al.* (2008); Golani *et al.* (2007); and Hefny (2011). Genetic advance as percentage of the mean ranged from 4.17% to 90.87%. High genetic advance and high heritability were observed in fibre, ash, calcium, sodium, protein and riboflavin, while moisture content had high heritability but low genetic advance. Heritability in conjunction with genetic advance is more effective and reliable in predicting the results and effectiveness of selection (Johnson *et al.*, 1955). High genetic and high

Table 5: Mean squares and variance ratios obtained from analysis of variance in the pawpaw morphotypes

	Mean square		
Attributes	Genotype	Error	Variance ratio
Protein	0.0690	0.0140	5.10
Fat	0.0156	0.0003	44.59
Fibre	0.0209	0.0005	38.19
Ash	0.1760	0.0170	10.29
Moisture content	12.3320	1.6670	7.40
Carbohydrate	14.5020	1.5420	9.41
Dry matter	6.8030	0.0410	167.71
Calcium	188.0800	9.3800	20.04
Phosphorus	142.6600	0.4700	301.53
Sodium	3.1844	0.0021	1534.23
Potassium	1434.4700	0.5500	2613.25
Thiamine	0.00007	0.00001	5.82
Vitamin C	96.36000	1.78000	58.02
Niacin	0.00342	0.00008	45.63
Riboflavin	0.00031	0.00005	5.93

Table 6: Phenotypic (Vp), genotypic (Vg) and error (Vg) variances for the pawpaw morphotypes

Character	Vp	Vg	Ve
Protein	0.0230	0.0183	0.0047
Fat	0.0052	0.0051	0.0001
Fibre	0.0070	0.0068	0.0002
Ash	0.0587	0.0530	0.0057
Moisture content	4.1107	3.5550	0.5557
Carbohydrate	4.8340	4.3200	0.5140
Dry matter	2.2677	2.2540	0.0137
Calcium	62.6900	59.5700	3.1000
Phosphorus	47.4000	47.4000	0.1600
Sodium	1.0615	1.0608	0.0007
Potassium	479.1600	477.9700	0.1800
Thiamine	0.000023	0.000020	0.000003
Vitamin C	32.12	31.530000	0.59000
Niacin	0.00114	0.00111	0.00003
Riboflavin	0.00010	0.00009	0.00002

Table 7: Phenotypic Coefficient of Variability (PCV), Genotypic Coefficient (GCV), Broad sense heritability (h^2B) and Genetic Advance (GA) in the pawpaw morphotypes

Attributes	Range	Mean	PCV	GCV	PCV-GCV	h^2B	GA%
Protein	0.18-0.88	0.55	27.57	24.60	2.97	79.57	44.90
Fat	0.40-0.66	0.50	14.42	14.28	0.14	98.08	28.84
Fibre	0.30-0.56	0.45	18.59	18.32	0.27	97.14	90.48
Ash	0.10-1.12	0.50	48.46	46.06	2.40	90.29	71.23
MC	80.04-90.82	86.60	2.34	2.18	0.16	86.48	4.17
CHO	7.23-18.27	11.65	18.87	17.84	1.03	89.37	34.73
DM	9.18-15.08	13.24	11.37	11.34	0.03	99.74	23.29
Ca	12.02-44.09	25.21	31.42	30.62	1.20	95.02	61.35
P	24.00-46.12	37.02	18.63	18.60	0.03	99.68	38.24
Na	3.48- 6.48	5.11	20.16	20.15	0.01	99.93	41.45
K	173.20-245.60	217.14	10.08	10.07	0.01	99.75	19.42
Thiamine	0.01-0.03	0.02	21.80	20.33	1.47	86.96	38.56
Vit C	35.20-54.56	45.34	12.50	12.38	0.12	98.16	25.31
Niacin	0.27-0.39	0.33	10.17	10.04	0.13	97.37	19.88
Ribloflavin	0.01-0.07	0.05	21.28	20.18	1.10	90.00	39.50

heritability for some of the nutritive attributes suggested that selection for these traits can be effective for their improvement.

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