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Varietal Differences in Physical Characteristics and Proximate Composition of Cowpea (*Vigna unguiculata*)

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Abstract: Twenty-eight varieties of cowpea seeds from Nigeria and USA origins showed significant variation in physical characteristics and proximate composition. Seed size dimensions namely; seed length, width and thickness had range values of 6-10mm, 4-7mm and 3-5mm, respectively. Seed hydration index had values between 95-137; 100- seed weight ranged between 11-26g and seed hardness recorded values between 6-8 kgf. Discriminant analysis of results showed that seed weight was the most important variable accounting for 93% of the variance in the physical properties. Ash content ranged between 3-4%, crude protein, crude fat, moisture and total carbohydrate contents had range values of 20-27, 0.6-1, 9-12 and 57 –62%,respectively. The total mineral content as represented by the ash values had the highest contribution of 71%, to differences in proximate composition. While protein and carbohydrate content accounted for 25% of variance in proximate composition. The results showed wide variation in the physical and chemical properties of the cowpea seeds, suggesting possible variation in suitability of seeds for various end-use products. The physical and chemical variables identified as the most discriminating may find application as indices for selection of cowpea varieties for processing into different products.

Key words: Physical Characteristics · Proximate Composition · Cowpea · Variety

INTRODUCTION

Cowpea (*Vigna unguiculata*) is an important source of plant protein in West-Africa. Unlike other legumes such as soybeans and groundnuts, which are oil-protein seeds, cowpea is starch-protein seeds offering a wider pattern of utilization than any other legume in West Africa [1]. In many parts of West Africa including Nigeria, cowpea seeds are consumed as boiled seeds alone or in combination with other foods such as rice, maize and plantain. Cowpeas are also processed into paste for the preparation of various traditional foods, such as Akara (fried cowpea paste and Moinmoin (steamed cowpea paste) [2]. Attempts to expand utilization of cowpea include investigation on processing into flour [3-6] and investigation into fungal fermentation of cowpeas [7].

Although Nigeria is one of the world largest producers of cowpea [8], most of the production get into domestic utilization for various food preparations while little or non get into industrial processing [1]. Thus, there is a need to expand utilization of cowpea through industrial processing. The potential of cowpea seeds to be processed into value-added products, would be influenced by their physical and chemical properties. Physical properties such as seed coat texture affect hydration characteristics while chemical composition affects cooking properties of seeds [9,10]. The proportions of chemical components such as carbohydrate and protein influence seed cooking time [1,11,12]. The objective of this study was to investigate the effect of variety on the physical and chemical properties of cowpea seeds with a view to provide baseline information towards their end use quality.

MATERIALS AND METHODS

Materials: Cowpea varieties used in the study were obtained from various sources in Nigeria and the USA as reported by Henshaw *et al*. [13].

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Methods: Determination of physical properties, seed size dimensions, namely seed length, width and thickness were determined following the procedure described by Demooy and Demooy [14]. Ten randomly selected seeds were used for the measurement of each dimension in triplicates. Dimensions were measured with Vernier callipers and micrometer screw gauge. Seed weight was determined as 100-seed weight by weighing 100 randomly selected seeds in triplicate. The horticultural properties of the cowpea seeds namely, seed shape, seed coat colour and hilum colour were described after visual examination. Seed shapes were classified using descriptors for cowpea seeds as described by Ogle *et al.* [15]. Seed hardness was determined as the maximum force required to break or fracture seed. The Instron Universal Testing Machine (Model 1122. Instron Inc; Carton, MA, USA) was used. The Warner-Bratzler cell (Warmer blade) with a triangular cut-out was operated at a cross head speed of 50 mm/min. and chart speed of 100 mm/min. The full-scale load was 20 kg. Whole seeds were measured with the side down and cut across the narrow axis of the cotyledon. Thirty seeds were individually measured for each of the 28 varieties. Seed hardness was reported as the average of 30 measurement of peak force required to break seed. Hydration index of seed was determined as described by Onayemi *et al.* [16].

Determination of proximate components, moisture, crude fat, crude protein and ash were determined by standard methods of AOAC [17]. The total carbohydrate was obtained by difference.

Statistical Analysis: Analysis of variance (ANOVA) was used to determine varietals effect on physical and chemical properties of seed. Post-hoc multiple comparison was by Tukey test. Canonical discriminant analysis (Proc. Candisc; SAS Version 0.03, 1988) was performed to identify the physical and chemical variable, which contribute most to varietal differences.

RESULTS AND DISCUSSION

Physical Properties: Seeds varied in all horticultural properties (Table 1). Seed coat texture which was either smooth or wrinkled have been shown to affect cooking properties and moisture absorption properties. According to Sefa-Dedeh *et al.* [9] and Sefa-Dedeh and Stanley [10], cowpea seeds with smooth seed coat texture tend to absorb less water than seeds with wrinkled seed coat. Seed coat texture could be an important selection index when processing cowpea seeds into flour, ease of soaking and dehulling characteristics are important to give a lightly coloured flour. Seed shape varied from the typical kidney shape for beans to globose, ovoid and rhomboid shapes. The seed coat colour is an important property which influence consumer acceptance of cowpea varieties in Nigeria. The brown coloured seeds are preferred to cream/white for cooking by boiling because they provide a sensory appeal by their colour. While the cream/white coloured varieties are mainly used in products requiring dehulling (removal of the seed coat) such as cowpea paste and flour.

Table 1: Horticultural characteristics of cowpea varieties

No.	Variety	SeedCoat Texture	Seed Shape	Hilum Colour	Seed Coat Colour
1.	Vita 5	Wrinkled	Kidney	Black	White
2.	TVX 3236	Wrinkled	Rhomboid	Brown	Cream/brown
3.	California Blackeye 5	Wrinkled	Kidney	Black	White
4.	White Acre	Smooth	Globose	Cream	Creamywhite
5.	Mississippi Silver	Smooth	Crowder	Brown	Brown
6.	Better Green Cream	Smooth	Globose	Light green	Cream
7.	Pinkeye Purple hull	Wrinkled	Ovoid	Dark red	Cream
8.	Texas Cream 40	Wrinkled	Rhomboid	Light yellow	Cream
9.	White California Blackeye A	Wrinkled	Kidney	Light yellow	White
10.	White California Blackeye B	Wrinkled	Kidney	Brown	White
11.	IAR –339 –1	Wrinkled	Kidney	Brown	White
12.	Ife Brown	Wrinkled	Rhomboid	Brown	Brown
13.	TVX 1984 –012F	Smooth	Ovoid	Brown	Brown
14.	IT81D –994	Wrinkled	Kidney	Black	White
15.	Whippoorwull	Smooth	Rhomboid	Brown	Brown
16.	IFE BPC	Wrinkled	Rhomboid	Brown	Brown
17.	IT86D – 719	Wrinkled	Kidney	Black	White
18.	IT850-3850-2	Smooth	Ovoid	Cream	Red brown
19.	Kanannado	Wrinkled	Kidney	Black	White
20.	IT88DM – 363	Wrinkled	Kidney	White	Brown
21.	Moola	Wrinkled	Kidney	Black	White
22.	IT82D – 889	Smooth	Kidney	Black	Maroon
23.	L – 25	Wrinkled	Rhomboid	Brown	Brown
24.	IT82E – 9	Smooth	Ovoid	Black	Black
25.	L – 80	Wrinkled	Rhomboid	Brown	Brown
26.	IT84S – 2246-4	Wrinkled	Kidney	Brown	Brown
27.	IT86D – 1010	Wrinkled	Ovoid	Black	White
28.	Coronet	Wrinkled	Ovoid	Dark red	Cream white

There were significant varietal differences in all the physical properties are shown in Table 2. Discriminant analysis showed that three (3) dimensions were sufficient to explain 98% of total variance in physical properties

Table 2: Physical properties of selected cowpea varieties

S/N	Variety	Length (mm)	Width (mm)	Thickness (mm)	100-seed weight (g)	Hydration	Seed ???
1.	Vita 5	7.4gh	4.9cd	3.8d	15.7c	114.3cd	7.1cd
2.	TVX 3236	6.5cd	4.5ab	4.1ef	11.7b	94.7a	6.5ab
3.	California Blackeye 5	9.2J	5.8h	4.5gh	24.5g	122.7g	7.5fg
4.	White Acre	5.7b	4.2a	3.4ab	10.6a	114.9d	6.6bc
5.	Mississippi Silver	7.4gh	5.5fg	5.2i	18.9f	116.9e	7.8gh
6.	Better Green Cream	5.0a	4.3a	3.7cd	10.1a	107.8bc	7.1cd
7.	Pinkeye purple hull	7.6hii	5.6gh	4.1ef	13.6c	114.6cd	7.4ef
8.	Texas Cream 40	6.5cd	4.4a	4.1cf	13.6c	137.5i	6.7bc
9.	White CB A	9.0j	5.5fg	4.4gh	20.5f	130.9h	7.2cd
10.	White CB B	10.0j	6.2i	4.7h	25.5g	130.9h	7.2cd
11.	IAR – 339 – 1	7.4gh	5.4fg	3.7cd	16.5c	115.2d	7.9gh
12.	Ife Brown	6.8de	5.5fg	3.7cd	17.3f	110.5bc	7.6gh
13.	TVX 1948 – 012F	5.4ab	5.2def	3.8d	11.9b	126.2gh	7.1cd
14.	IT81D – 994	9.0j	6.1	4.6h	23.4	117.8e	6.8bc
15.	Whippoorwill	7.5h	5.4fg	3.3a	12.1b	122.7g	6.6bc
16.	IFE BPC	7.9i	5.5fg	3.8d	16.4e	122.6g	7.2cd
17.	IT86D –719	7.2fgh	5.0cde	3.5ab	14.5d	134.4i	6.7bc
18.	IT850-3850-2	7.1efg	5.3	4.0e	13.5e	95.6a	7.5fg
19.	Kanannado	9.2j	6.9	5.9i	25.8g	115.7d	7.9gh
20.	IT88DM – 363	7.4gh	5.0cde	4.3fg	14.6d	139.3j	7.5da
21.	Moola	8.4ij	6.2	4.6h	21.6f	123.5g	7.6gh
22.	IT82D – 889	7.1efg	4.4ab	3.3a	12.6b	114.0cd	6.4bc
23.	L – 25	6.5cd	4.3a	3.3a	10.9a	105.9b	6.5bc
24.	IT82E – 9	6.2c	5.6gh	4.9i	15.3d	108.0bc	5.9a
25.	L – 80	7.4gh	4.7bc	3.5bc	13.5c	129.6h	7.4ef
26.	IT84S – 2246-4	7.9i	5.4fg	3.7cd	16.5e	116.6e	6.3ab
27.	IT86D – 1010	6.9def	5.3fg	4.1e	17.8f	120.5f	6.3ab
28.	Coronet	7.4gh	3.8h	3.9e	18.9f	119.7f	8.1i

Values in a column bearing different superscript are significantly different a 0.05

Table 3: Canonical discriminant analysis of physical properties

Function	Eigenvalue	% variance	Cumulative % variance
1	2567.2	92.96	92.96
2	120.8	4.37	97.33
3	32.3	1.17	98.50
4	23.9	0.87	99.36
5	11.8	0.43	99.79
6	5.8	0.21	100.00

(Table 3). The first discriminant function had the largest weight in contribution, accounting for 93% of total variance. In Table 4, correlations between discriminant functions and the physical variables are shown. Seed weight has the highest correlation of 0.85, with the first discriminant function indicating that this variable is the most important variable which underlie varietal differences in physical properties, accounting for 93% of total variance in the data set. Seed weight is largely a function of seed components, mostly contained in the cotyledons. The cotyledons, which make up more than 87% of the seed weight contain most of the seed proteins (93%); fat, (95%); ash (87%) and nitrogen free extract (88%) [18]. Ogle *et al.* [15] classified cowpea varieties into size categories based on their 100-seed weight. Varieties with seed weight between 10-15 g are described as small; 15.1-20 g are medium size-seed while large seed have 20.1-25 g. Seed weight over 25 g are described as very large seeds. The seed weight of cowpea variety could be a useful criterion for determining suitability for a particular end-use application. For example, varieties with large seeds would be preferred for canning, since this would mean less quantity of beans would be required to attain a high cooked bean weight.

Furthermore, classification based on seed weight may be used to determine conformity to standards during quality control of raw materials. Apart from seed weight, the other five physical variables (Table 4) together contributed an insignificant 7% of total variance in physical characteristics of the cowpea varieties.

Table 4: Correlations between discriminating physical variables and cononical discriminant functions

	Discriminant Functions					
Variable	1	2	3	4	5	6
100-seed weight	0.85	0.25	0.20	-0.20	-0.35	0.02
Seed Thickness	0.17	0.17	0.83	0.25	0.17	0.2
Seed Hydration index (Hi)	0.03	-0.19	0.92	0.22	0.24	-0.02
Seed Length	0.19	-0.18	-0.11	0.96	-0.04	-0.00
Seed Width	0.13	0.19	-0.13	-0.07	0.91	-0.3
Seed Hardness	0.02	0.01	0.00	-0.05	-0.31	0.95

Table 5: Proximate Composition

S/N	Variety	Ash	Crude fat	Moisture	Crude Protein	Total Carbohydrate
1.	Vita 5	4.0e	0.61ab	12.4b	24.7	58.4
2.	TVX 3236	3.6bc	1.1c	11.5b	23.8	60.0
3.	California Blackeye 5	3.6bc	0.66abc	10.5b	22.7	62.6
4.	White Acre	4.1c	0.90bc	11.0b	25.2	59.5
5.	Mississippi Silver	3.9d	0.71abc	11.9b	20.4a	63.1
6.	Better Green Cream	3.6bc	1.1c	11.4b	25.4a	58.5
7.	Pinkeye purple hull	3.8cd	1.1c	10.0a	27.4	57.7
8.	Texas Cream 40	3.8cd	0.73abc	10.8b	23.6	60.9
9.	White CB A	3.8cd	0.79abc	10.9b	26.2	58.2
10.	White CB B	3.6bc	0.94bc	11.2b	23.5	60.7
11.	IAR – 339 – 1	3.8cd	0.59ab	11.3b	24.3	59.9
12.	Ife Brown	3.6bc	0.58ab	11.6b	23.1	61.1
13.	TVX 1948 – 012F	4.2e	0.40a	12.3b	24.3	58.7
14.	IT81D – 994	3.7c	1.1c	11.7b	26.1	57.4
15.	Whippoorwill	3.8cd	0.74abc	10.0a	24.4	61.1
16.	IFE BPC	3.8cd	0.62ab	11.1b	24.6	60.0
17.	IT86D –719	3.7c	1.2c	12.2b	23.5	59.4
18.	IT850-3850-2	3.7c	1.4d	11.9b	25.5	57.6
19.	Kanannado	3.3a	1.0c	11.1b	23.9	60.7
20.	IT88DM – 363	4.1e	0.86bc	11.6b	24.2	59.1
21.	Moola	3.6bc	1.2c	9.4a	24.2	61.3
22.	IT82D – 889	3.7c	0.87bc	11.3b	26.9	57.2
23.	L – 25	3.8	1.1c	10.7b	22.3	62.1
24.	IT82E – 9	3.5b	0.67abc	11.2b	23.3	61.3
25.	L – 80	3.5b	1.4d	12.0b	24.2	58.5
26.	IT84S – 2246-4	3.7c	0.60ab	12.4	23.9	59.3
27.	IT86D – 1010	3.8cd	0.97bc	12.2	22.8	60.3
28.	Coronet	3.6bc	0.97bc	10.1a	20.8ab	64.6
	Mean	3.7c	0.89	11.2	24.12	59.9
	Standard Deviation	0.20	0.29	1.4	1.6	1.8

Table 6: Canonical discriminant analysis of proximate components of cowpea seed

Function	Eigenvalue	% Variance	Cummulative % Variance
1	66.80	71.30	71.30
2	16.10	17.13	88.43
3	7.20	7.70	96.13
4	3.60	3.87	100.00

Table 7: Correlations between discriminating proximate variables and discriminant functions

	Discriminant functions			
Variable	1	2	3	4
Ash	0.95	0.04	0.16	0.25
Protein	0.07	0.95	0.14	-0.28
Total carbohydrate	-0.14	-0.82	0.48	0.27
Fat	-0.13	-0.23	0.25	0.93

Proximate Composition: Results of analysis of proximate composition are given in Table 5. All proximate components were significantly different ($P \leq 0.05$). Ranges obtained for each component were within values reported for cowpea Duke [19], Longe [20]. Protein content ranged between 20-27%, fat, 0.40-1.2%, Ash, 3-4% and total carbohydrate 57 – 61%. Results of discriminant analysis in Table (6) show that 3 canonical discriminant functions (CDFs) were sufficient to explain 96% of data variation. Although the Ash content is small (3-4%) it was shown to be a major (71%) contributor to variation in proximate components. Results in Table 7 show that the ash content had the highest correlation (0.95) with the first CDF. The significance of the result would be better interpreted to mean that varieties cultivated under wide cultural conditions such as soil composition. Climatic and agronomic practices vary widely in mineral content as represented by the ash value. The protein and carbohydrate contents contributed 25% of total variance in proximate components having the highest correlations with the 2nd and 3rd CDFs (Table 7). These components are important in determining nutritive quality and processing quality of cowpea seeds. The content of fat was the least discriminating variable. The low fat content in cowpea is an advantage during processing to flour, since unlike other legumes such as soyabean there is no need for a defatting stage in flour production.

CONCLUSION

The results of the study have shown that seed weight is the most discriminating physical property among the cowpea varieties studied. This property may become an important criterion for selecting cowpea variety for processing into different end products.

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