Variation in contents of crude protein and mineral elements in 32 cowpea (*Vigna unguiculata* (L.) Walp) accessions in Ghana

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ABSTRACT

Thirty-two cowpea accessions were studied for variation in contents of protein and mineral nutrients (calcium, magnesium, potassium and sodium). Cowpea flour from 40 wholesome dried seeds of each accession was used for the analysis. The wet oxidation method was used to determine the content of mineral nutrients. Nitrogen content was determined by the Kjeldahl procedure. Protein content ranged from 16.35 to 27.27 per cent. Sodium content ranged from 90.53 to 91.30 ppm, and potassium content from 30.33 to 71.30 ppm. Similarly, values for magnesium and calcium ranged from 146.73 to 968.20 ppm and from 43.33 to 171.20 ppm, respectively. Percent crude protein correlated significantly positively with sodium and negatively with calcium. Magnesium was correlated significantly with potassium. Black seeds generally recorded the highest percent crude protein on the average, while cream seeds had the highest magnesium and calcium contents, respectively.

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RÉSUMÉ

ASANTE, I. K., ADU-DAPAAH, H. & ADDISON, P.: *Variation dans la teneur en protéines brute et les éléments minérales en 32 accessions de dolique* (Vigna unguiculata *(L.) Walp) au Ghana*. Trente-deux accessions de dolique étaient étudiées pour la variation en teneurs de protéines et de nutriments minérales (le calcium). La farine de dolique de quarante graines saines séchés de chaque accession était utilisée pour l'analyse. La détermination de nutriments minérales était par la méthode d'oxydation humide. La teneur d'azote était déterminée par la procédure de Kjeldahl. Teneur de protéine variait entre 16.35 et 27.27 %. La teneur de sodium variait entre 90.53 et 91.30 ppm, la teneur de potassium variait entre 30.33 et 71.30 ppm. De la même façon les valeurs pour le magnésium et le calcium variaient respectivement entre 146.73 et 98.20 ppm et entre 43.33 et 171.20 ppm. Le pourcentage de protéine brute corrélait considérablement positivement avec sodium en négativement avec calcium. Le magnésium était corrélé considérablement avec le potassium. Les graines colorées noires enregistraient en général le plus élevé du pourcentage de protéine brute en moyenne, alors que les graines colorées crèmes avaient les teneurs de magnésium et de calcium les plus élevées respectivement.

Introduction

Cowpea is an important food legume, which is cultivated between 35° N and 30° S of the equator, covering Asia and Oceania, the Middle East, southern Europe, Africa, southern USA, and Central and South America (Perinno *et al.*, 1992). It is a drought-tolerant crop with better growth in warm climates. Therefore, the crop is most popular in the semi-arid region of the tropics, where other food legumes do not perform better. Cowpea has the unique ability to fix nitrogen even in very poor soils (Singh, Chambliss & Sharma, 1997) and serves as a cheap source of plant protein. Its protein content ranges from 23 to 25 per cent (1997); the chemical score for cowpea protein is 40 (Linnemann &Azam-Ali, 1993).

Cowpea is used as a pulse crop and also cultivated as a fodder (Pasquet, 2000). Nutritional improvement of cowpea as a legume has focused on its protein and amino acid contents, with minimal attention on mineral elements. Sodium, potassium, magnesium and calcium are among the inorganic elements considered to be essential to human life. These major elements are required

in several hundred milligrams per day (Danso *et al*., 2001).

This study aims at screening for cowpea accessions high in these elemental minerals and other nutritional components, and later incorporating them into cowpea breeding programmes.

The study is a component of a nutritional improvement programme of cowpea as a food legume by the Department of Botany, University of Ghana and the Legume Unit of the CSIR-Crops Research Institute under the Agricultural Services Sub-sector Investment Programme (AgSSIP).

Materials and methods

The 32 cowpea accessions were grown at the University Farm in August 2002. Twenty accessions were collected from the Plant Genetic Resources Centre of the Council for Scientific and Industrial Research at Bunso; six accessions from the Department of Crop Science, University of Ghana, Legon; and the remaining six varieties were collected from the CSIR-Crops Research Institute in Kumasi. The seeds were grown in a randomized complete block design with three replications. Seeds of each accession were sown at a spacing of 90 cm × 90 cm. Two seeds per hill were planted and thinned to one, 7 days after emergence. Harvested pods were sun-dried and shelled. The seeds were also sun-dried to 10-13 per cent moisture. One hundred and fifty seeds selected randomly from each accession were used for the study.

Forty wholesome seeds of each accession were ground, using a mortar and a pestle, into fine flour and used to determine the contents of calcium, potassium, magnesium and sodium. Half a gram (0.5 g) of the flour sample of each accession was weighed into 125-ml Erlenmeyer flasks, and to each individual flask was added 5 ml of conc. H_2SO_4. The flasks were placed on pre-heated sand bath in a fumed chamber and heated for about 5 min until they fumed. Hydrogen peroxide was added dropwise until the solutions turned colourless. Samples were then removed from the sand bath and allowed to cool. They were diluted with distilled water and filtered into 100-ml volumetric flasks and topped up. The samples were then read on flame photometer for potassium and sodium, and on the Atomic Absorption Spectrophotometer for magnesium and calcium. The readings were used in the following calculations to determine the actual values of the elements.

Potassium and sodium

The milliequivalent (meq) of exchangeable potassium and sodium was calculated as follows: mineral element in meq/100 g sample = flame photometer reading (a – b) / Atomic mass; where a = flame photometer reading value for sample, and b = flame photometer reading value for blank. To convert calculated potassium and sodium from meq/100 g sample to ppm, the values determined were multiplied by 390 and 230, respectively.

Calcium and magnesium

The milliequivalent (meq) of exchangeable calcium and magnesium was calculated as follows: mineral element in meq/100 g sample = spectrophotometer reading (a – b) × 2 / Atomic mass; where a = flame photometer reading value for sample, and b = flame photometer reading value for blank. To convert calculated calcium and magnesium from meq/100 g sample to ppm, the values determined were multiplied by 400 and 243.2, respectively.

Nitrogen content was determined by the Kjeldahl procedure (AOAC, 1975), and protein content was taken as N × 5.71 (WHO, 1973).

Results and discussion

Table 1 presents summary variability of the variables studied. Protein content ranged from 16.35 to 27.27 per cent, with a mean value of 22.53 per cent. Mean values for sodium ranged from 90.53 to 91.30 ppm, with a mean of 90.18 + 0.09 ppm. Mean values for potassium ranged from 30.33 to 71.30 ppm, with a mean of 60.37 + 0.95 ppm. Similarly, values for magnesium ranged from

TABLE 1

Summary Variability in Crude Protein Content, Mineral Nutrient Concentration, and Seed Coat Colour in 32 Cowpea Accessions

Accession	*Sodium (ppm)*	*Potassium (ppm)*	*Magnesium (ppm)*	*Calcium (ppm)*	*Crude protein (%)*	*Seed coat colour*
87/30	91.30	64.80	275.13	72.47	26.90	Brown-mottled
4557	91.27	54.27	184.07	61.40	23.88	Cream
Gbeho	91.30	65.80	441.33	97.53	22.05	Brown-mottled
Adom	90.53	49.37	590.40	171.20	20.44	Red
87/153	90.60	67.53	426.27	83.80	22.82	Red
87/83	90.83	71.43	444.93	83.13	26.45	Black
Soronko (CRI)	90.60	67.47	707.20	112.60	21.41	Flesh
BTB 96/091	90.53	71.30	153.93	96.80	21.62	Dark-mottled
87/1	90.50	70.33	387.87	74.20	22.28	Dark-mottled
BTB 96/054	90.53	53.73	146.73	56.87	22.90	Brown
87/7	90.83	56.70	188.00	57.40	23.12	Red
Bengpla	90.90	55.23	233.67	43.33	27.27	Cream
Soronko	90.60	65.03	428.27	69.20	24.40	Flesh
87/137	90.90	51.87	194.27	45.20	22.98	Red
Asetenapa	90.67	68.90	393.00	133.40	22.34	Cream
87/49	90.63	52.87	175.60	54.00	23.46	Red
87/27	90.70	51.03	151.80	45.40	22.00	Dark-mottled
1239	90.57	54.17	189.07	50.47	23.61	Brown-mottled
Caroni	90.63	55.23	196.87	70.27	24.42	Red
96/129	90.70	30.33	596.80	133.60	24.21	Red
Ayiyi	90.90	54.13	190.20	111.40	20.72	Cream
Asontem (CRI)	90.57	57.73	213.67	137.60	19.63	Brown
87/157	90.73	58.03	231.67	53.47	22.53	Red
Bengpla (CRI)	90.57	71.00	949.73	163.60	16.35	Cream
87/142	90.87	68.03	527.60	89.40	22.30	Flesh
96/046	90.87	70.40	564.07	71.80	22.77	Red
87/34	90.67	63.67	197.27	46.80	19.71	Red
87/147	90.67	51.97	484.27	102.47	20.40	Red
1977	90.67	58.77	288.10	93.33	20.93	Cream
Asontem	90.67	62.60	303.40	92.60	22.40	Brown
IT820-077-2	90.67	70.43	829.73	143.47	21.92	Brown
Kaase Market	90.60	68.40	968.2	117.87	22.82	White
Mean	85.41	57.42	363.40	84.69	22.53	
SED	0.06	2.39	44.12	6.47	0.41	
CV (%)	0.28	17.51	58.28	36.93	7.61	

146.73 to 968.20 ppm, with a mean of 383.95 + 24.49 ppm; and values for calcium from 43.33 to 171.20 ppm, with a mean of 88.63 + 3.62 ppm. Percent coefficient of variation values for protein, sodium, potassium, magnesium and calcium were 7.61, 0.28, 17.51, 58.28 and 36.93 per cent, respectively. Differences among the 32 cowpea accessions for all the variables were significant as judged by their SED values.

The 32 accessions could be grouped into eight different seed coat colours: black, brown, brown-mottled, cream, dark-mottled, flesh, red, and white (Table 1). On the average, black accessions had the highest percent crude protein (26.4 %) and potassium content of 71.43 ppm. The white seeds had the highest magnesium content of 575.14 ppm. The cream accessions had the highest calcium content of 108.04 ppm, followed by the brown seeds with 107.72 ppm.

Percent crude protein correlated with sodium ($r = 0.358$, $P = 0.02$) and negatively with calcium ($r = -0.535$, $P = 0.001$). Magnesium was correlated with potassium ($r = 0.440$, $P = 0.006$) and calcium ($r = 0.652$, $P = 0.001$).

Most consumers have high preference for the white cowpea because it boils faster. This practice indicates an indirect way of selecting for high magnesium contents. Though black cowpeas are less preferred (Asante, Adu-Dapaah & Addison, 2004), they have relatively high percentage protein content on the average. Sodium, calcium, magnesium and potassium are among the six major minerals which are now considered as being essential to human life (Danso *et al*., 2001); therefore, information on their composition in cowpea breeding is vital. For breeding, the following accessions could be incorporated into cowpea breeeding programmes aimed at improving food quality: 87/30 (for high protein content), 87/30 and Gbeho (for high sodium content), 87/83 (for high potassium content), and Bengpla CRI (for high magnesium and calcium contents).

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