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DETERMINATION OF QUALITY TRAITS, AND THE NUTRIENT AND MINERAL CONTENTS OF COWPEA VARIETIES IN SOUTH AFRICA

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ABSTRACT

Eastern Cape, followed by Limpopo, have the highest numbers of citizens experiencing food insecurity. The Limpopo and Free State provinces share the highest prevalence rate of children affected by iron deficiency anaemia leading to severe stunting and underweight. Cowpea is an important grain legume that is rich in proteins (20-24%), minerals and vitamins for human and animal nutrition. Cowpea stands to enhance food security and nutrition in rural South African communities. Introduction of cowpea varieties that are rich in proteins, minerals and vitamins will improve the quality of the dietary intakes and nutritional status of the poor. To fast-track the development of improved cowpea varieties that meet the nutritional needs of consumers and farmers, thirty cowpea improved varieties were introduced and evaluated to determine their qualities and the nutrients they contain. This will assist breeders in ascertaining their usefulness and how to deploy the traits in breeding programmes. The seeds were harvested from seed multiplication plots during 2017 growing season, and were analysed in three replications to determine their nutrient and mineral contents (crude protein or CP, Ca, Na, Mg, Fe, Cu, Zn, P, K and moisture). The mineral contents were determined using an atomic absorption spectrophotometer while CP content was determined by the Kjeldahl method using Kjeltec™ Model 2300, as described in Foss Analytical AB manual. Results showed that the varieties exhibited significant ($P<0.05$) variations for the nutrients and minerals determined except for P and moisture. Eight varieties out-performed the two local control varieties (Glenda and Bechuana White with 24% and 20% respectively) in CP with a range of 25-31%. Many varieties also significantly out-performed the local checks in respect of minerals tested: 4, 12, 6, 5, 14, and 15 varieties exhibited higher concentrations of Ca, Mg, Na, Zn, Cu and Fe, respectively. Results also show that the quality of grains varied in terms of seed colour, texture, and eye colour. The results not only demonstrate that many of the improved varieties were better than the control varieties, but have also provided a database for utilising the promising varieties in breeding programme for the development of new cowpea germplasm with better quality traits and nutrient contents. Variation in seed qualities offers opportunities for farmers and consumers to make choice as these quality traits influence acceptability and marketability of cowpea in South Africa.

Key words: Bechuana White, bio-fortification, dietary intake, food security, marketability nutrition, protein content, *Vigna unguiculata*

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INTRODUCTION

In South Africa, there are approximately 14 million people who are vulnerable to food insecurity and 1.5 million children under the age of 6 years old are stunted by chronic malnutrition. Most poor households consume monotonous diets consistently and very often they are not concerned much about the nutritional component of the food as long as they get something to eat. Their diet often consists of foods with low levels of micro-nutrients but high contents of starch [1]. Eastern Cape, followed by Limpopo, have the highest numbers of citizens experiencing food insecurity. The Limpopo and Free State provinces share the highest prevalence rate for children aged 1 – 9 years, at 12%. Children living in formal urban areas (9%) were most affected by iron deficiency anaemia leading to severe stunting and underweight [2]. The food insecurity and nutrition in these provinces have led to undernutrition, which is characterised by protein energy malnutrition and micronutrient deficiencies [3-8]. Globally, the most important micronutrient deficiencies are iron, vitamin A, iodine, and zinc. A broad multifaceted comprehensive health intervention programme is needed to address childhood malnutrition. According to Chitiga-Mabugu *et al*. [8] strategies to address micronutrient malnutrition include high-dose vitamin A supplementation, food fortification, bio-fortification and dietary diversification. Other strategies include increasing the availability of diversity of nutritious foods at community and household levels through mixed cropping, the introduction of new crops, as well as the promotion of underexploited traditional food crops (legumes), and home-gardens. Cultivar development and deployment of cowpea with increased grain mineral content and protein composition rely on selection of genetically unique and complementary breeding lines [9-11]. Labadarios *et al*. [2] also reported that protein-energy malnutrition is a major concern in rural communities. Grain legumes are generally cheap sources of protein, micronutrients, vitamins and minerals, and are good complements to starchy diets. The protein in cowpea grain includes amino acids such as lysine and tryptophan [12, 13]. Cowpea can be prepared into various products such as *Akara, Moin Moin* and porridge [14] to enhance diversity and dietary intake in rural communities. Apart from its nutritional benefits, the cowpea plant fixes atmospheric nitrogen to meet its nitrogen demand and subsequent crops in rotation particularly the cereals [15, 16]. It is a resource-use efficient and drought tolerant crop with short growing period, thus making it a climate smart crop suitable as a choice crop for drought prone areas like Limpopo province in South Africa. It is also a source of regular income for farmers and all stakeholders in the value chain [16, 17].

Despite the benefits of cowpea and its cultivation, production in South Africa is limited by lack of improved varieties that exhibit high yield in combination with other quality traits preferred by farmers such as seed size, seed colour and micro- and macro-nutrients [18-20]. Previous reports have shown that nutrient contents in cowpea leaves, pods and grain is dependent on available soil nutrients for plant uptake. The quantity of minerals is least in the grains. This offers the opportunity for the evaluation of cowpea germplasm for mineral content in the grains in order to identify accessions with high nutrient and mineral contents for possible deployment in plant improvement programs and a release for cultivation and school feeding program in children [22, 23, 24, 25, 26].

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To be food and nutrition secured, the crops must produce good yields that support the growing population and contain all the necessary nutrients in adequate amounts for daily sustenance of its consumers to avoid malnutrition. One of the ways to improve food security and nutrition is to ensure that varieties developed are adapted, high yielding and contain essential nutrients [27]. These can be achieved through breeding programs and evaluation of germplasm available to determine the traits and nutrients in the germplasm collections. Evaluation of germplasm for agronomic traits and nutrient contents for breeding purpose is an important activity of developing cowpea to attain food security and nutrition [21, 28, 29].

The adoption of cowpea is dependent on the quality characteristics of the varieties. In Southern Africa, cowpea seed coat colour, seed size and the eye colour are important determinants for an easy acceptability, marketability and adoption of different varieties. Recent studies have shown that such quality traits are important for attaining food security and nutrition in rural families and should be considered as important factors for the improvement of cowpea in addition to other agronomic traits such as high yield, earliness to maturity and pest resistance [16, 21, 31-33]. Several studies have shown that cowpea is a good source of proteins, essential minerals including Ca, Cu, Fe, K, Mg, Mn, Na, P, Zn, carbohydrates and antioxidants that are essential for human nutrition and health [34,35]. The assessment of germplasm for nutrient contents and quality is critical to genetic enhancement of cowpea to meet the needs of farmers, consumers and food security and nutrition. Given the above background, cowpea stands to enhance food security and nutrition in ameliorating malnutrition in rural communities. Therefore, the present study was aimed at evaluating a set of germplasm lines for quality characteristics and nutrient contents in comparison with local control varieties. The promising varieties that exhibited good quality traits and nutrient contents will be tested in on-farm trials for adaptation and farmers' selection as well as being used as a breeding stock to further the development of new adapted germplasm and bio-fortification. According to Gondwe, *et al*. [33] such information and knowledge generated from the study would be used by researchers, processors, dietitians, and policymakers in planning hospital and school-feeding programs where they would need to match varieties to specific purposes for various needs based on their nutrient contents.

MATERIALS AND METHODS

Description of the study area

The seed increase trial was conducted at the University of Limpopo experimental farm (Syferkuil) located in Mankweng, Capricorn District, Limpopo Province, South Africa (23° 50' 42" S and 29° 42' 44" E). The study area is characterised by sandy loam texture belonging to Hutton form, and low erratic summer rainfall ranging from 400 to 650 mm.

Experimental materials

Thirty improved varieties and two local controls (Glenda and Bechuana White) were used for the nutrient determination. The varieties were germplasm lines introduced

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from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The control varieties are commonly grown by farmers in different cowpea production areas in South Africa.

Crop management

The experimental plot was prepared with tractor-mounted disc plough and harrow to enhance a good seedbed for good germination and seedling emergence. The cowpea varieties used for the study were planted in a single row of 4 m long and with intra-and inter- row spacing of 0.2 m x 1.00 m, respectively to generate fresh seeds for nutrient content analysis and seed quality trait determinations. The trial was planted on 10 January 2017. Round-up with an active ingredient of Glyphosate, N-(phosphonomethyl) glycine, in the form of its isopropylamine salt (240 ml/15 L water knapsack = 3 L/ha) and Dual gold with an active ingredient of S-Metolachlor (chloro-acetanilide) (30 ml/15 L water knapsack = 0.5 L/ha) were applied to control weeds at planting. Manual weeding was done subsequently on growing weeds in the field. Several sprays (3-4) of insecticide were applied on cowpea plants. Karate insecticide consisting of 2.5 EC with an active ingredient of lambda-cyhalothrin (pyrethroid) (60 ml/15 L water knapsack = 1 L/ha) was used to control insect pests (blister beetles and pod-sucking bugs) on cowpea from seedling stage until pod maturity while Aphox with an active ingredient of pirimicarb (carbamate) (4 g/15 L water knapsack = 500 g/ha) was used to control cowpea aphids at the seedling stage.

Data Collection

At maturity, cowpea pods were manually harvested in late May of 2017 after the pods have dried under the sun to a low moisture level. The pods were threshed manually and the seeds were cleaned to remove any mixture or inert substances such as stones and pod walls. The grain yield varied from 1300 kg/ha (Glenda), 1700 kg/ha (Bechuana White) to 2500 kg/ha (IT98K-491-4). A 200 g seed weight in three replications were composed and prepared from each variety for nutrient analysis. The quality characteristics (seed coat colour, seed coat texture and eye colour) of the varieties were assessed visually by the breeder according the descriptor list of Biodiversity International for Genetic Resources [36].

Determination of proximate composition

All the nutrient determinations were conducted in three replications to enable experimental error estimation and validation of results. Moisture and crude protein (CP) contents were determined using the methods described by Alamu et al. [35] and the Association of Official and Analytical Chemist [37]. CP content was determined by the Kjeldahl method using Kjeltec™ Model 2300, as described in Foss Analytical AB manual [38]. A factor of 6.25 was used to convert from total nitrogen to CP (%).

Determination of mineral content

Calcium, iron, and zinc. Iron (Fe) and zinc (Zn) contents were determined using the method described by AOAC, 2005 [37]. Five grams (5 g) of each flour sample were gently heated over a Bunsen burner flame until most of the organic matter was destroyed. The remaining material was further exposed to high temperatures in a muffle furnace for several hours until white-grey ash was obtained and then cooled. About 20 ml of distilled water and 10 ml of dilute hydrochloric acid were added to the ash material. This mixture was boiled, filtered into a 250 ml volumetric flask, washed thoroughly with hot water, cooled, and made up to volume. Contents of Fe, Mg, Mn, P, Cu, Na, K and Zn in each sample were analysed using atomic absorption spectrophotometer (PYE Unicon, UK, and Model SP9). All nutrient analyses were conducted in South African accredited analytical laboratory at Döhne Agricultural Development Institute, Stutterheim, Department of Rural Development and Agrarian Reform, Eastern Cape, South Africa.

Statistical Analysis

The nutrient data generated were subjected to analysis of variance (ANOVA) procedure using a one-way ANOVA to determine variation among the treatment means using GenStat 20.1 version. Duncan's multiple range test was used to separate the means at $P \leq 0.05$. The quality traits were analysed using descriptive statistics where the frequency distributions of the variables were tabulated and bar graphs were plotted from the distributions.

RESULTS AND DISCUSSION

The results on the quality traits (seed coat colour, texture and eye colour) of the thirty cowpea varieties are presented in Figures 1-3.

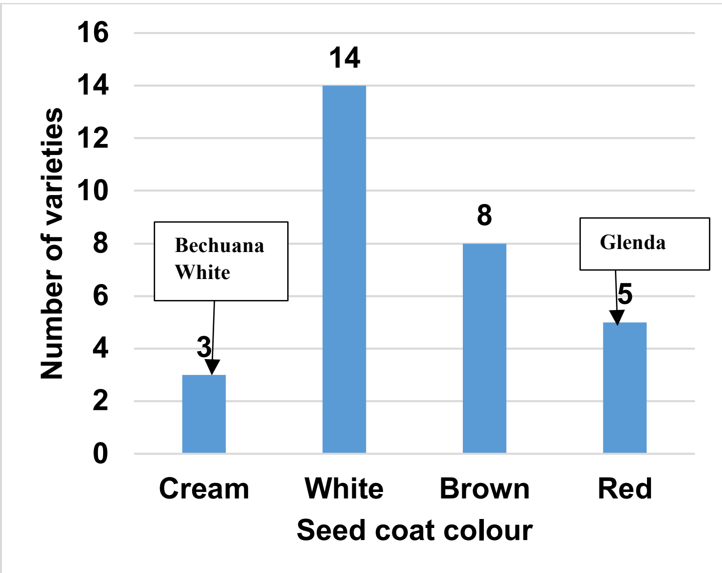

Figure 1: Frequency distribution of seed coat colour among thirty varieties of cowpea

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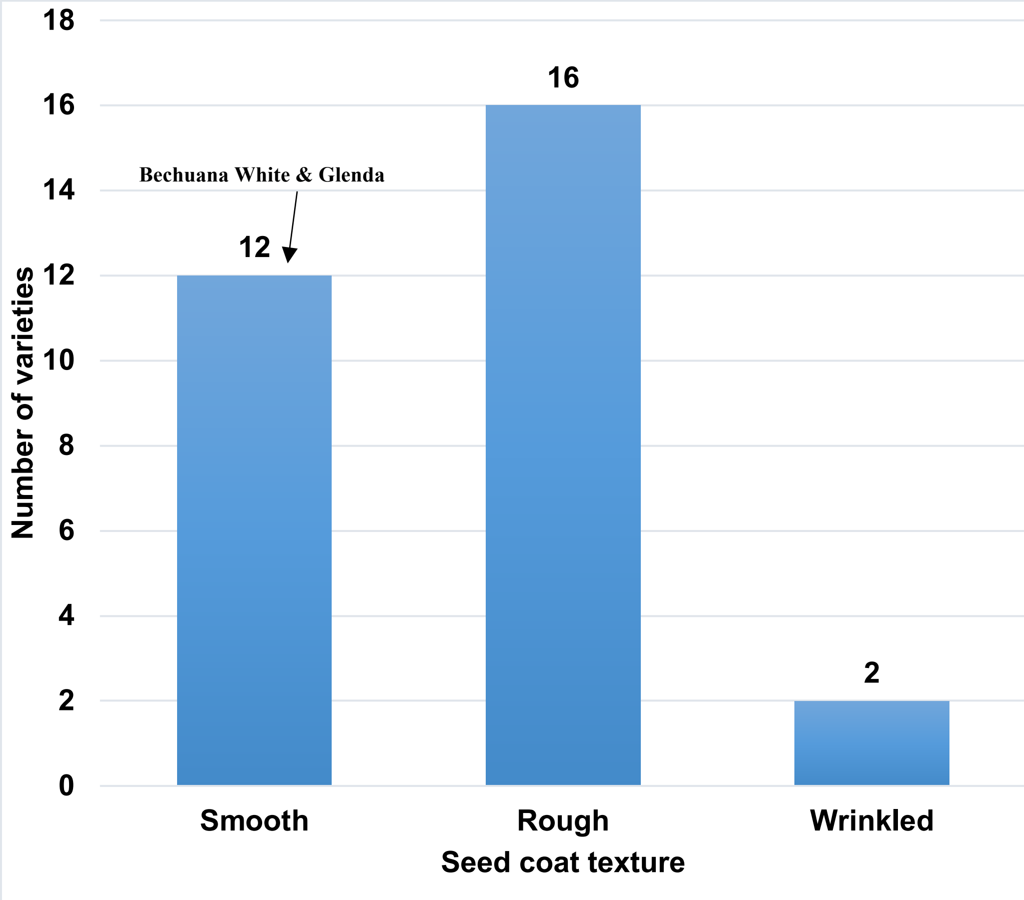

Figure 2: Frequency distribution of seed coat texture among thirty varieties of cowpea

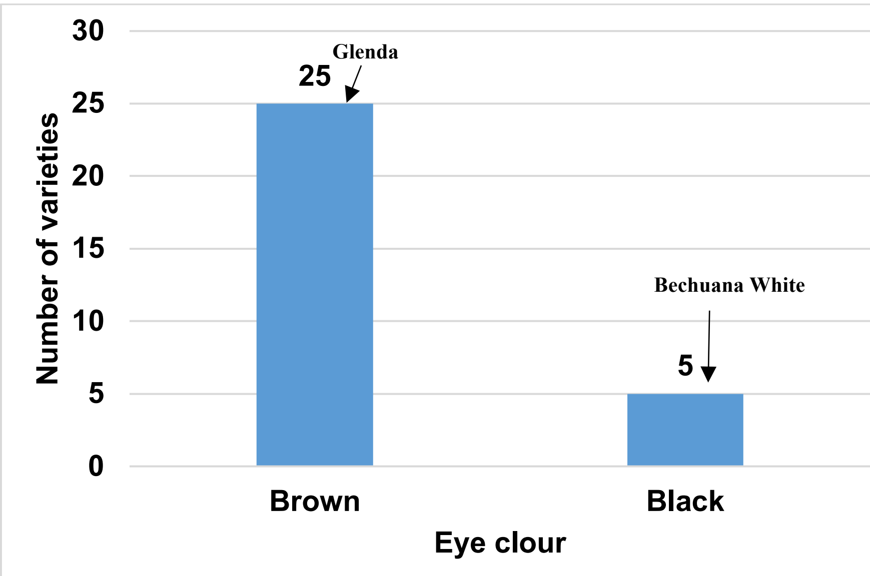

Figure 3: Frequency distribution of seed eye colour among thirty varieties of cowpea

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Seed coat colour

The results on cowpea coat colour show that the major colours exhibited by the varieties include cream, white, brown and red (Figure 1) [36]. Seed colour is one of the important determinants for acceptability and marketability of cowpea varieties that drives demand-led breeding in cowpea production [21,33]. Availability of different seed colours offers opportunity for consumers to make choice and increase their satisfaction on dietary intake and nutrition.

Seed coat texture

A summary of the seed coat texture variations is presented in Figure 2. The varieties varied among their coat textures and these are smooth, rough and wrinkled. Seed coat texture also influences consumers' preference in terms of acceptability and marketability [21, 33]. Many consumers prefer the rough textured seed because the roughness enables the seed coat to imbibe water and cooking ingredients (such as salt and other seasoning agents) that makes such variety to cook faster and taste better as compared to the smooth coated texture. The wrinkled textured varieties are not often preferred by consumers even though they cook faster than the rough textured varieties because their appearance is considered ugly. The variations obtained in the seed coat texture and colour offer great opportunity for further improvement of cowpea for these traits through breeding.

Eye colour

Figure 3 shows the information on cowpea eye or helium colour. Result shows that the frequency distribution of the eye colours of the thirty cowpea varieties fell into two categories, brown and black [36]. Cowpea eye colours also have implication on the consumers' preference and marketability of the varieties particularly in South Africa where many consumers prefer white coat with black eye while some prefer white or brown coat with brown eye. The eye colour is genetically driven, thus making it possible to breed for these traits to meet the needs of the consumers.

Proximate analysis of cowpea varieties for moisture content and crude protein

The analysis of variance on moisture content (MC) of the thirty varieties shows that there was no significant ($P \leq 0.05$) difference among the varieties (Table 1). MC of the thirty varieties varied from 11.25 to 13.10%. These values fall within the range of global recommendation for MC (10-14%) to ensure good storability and increased shelf life of cowpea seeds during storage. The higher the MC, the faster the deterioration of seed viability during storage [31]. The low MC of these varieties is an indication of good sun-drying of the pods in the field before harvesting and threshing, which will enhance good storage life.

Significant ($P \leq 0.05$) differences were obtained among the cowpea varieties for the CP contents. In this study, CP ranged from 17.31% to 31.50% and eight improved varieties performed better than the two control varieties (Table 2, Figure 4). The global range varied from 20% to 26% [12]. In this study CP of 31.50% was achieved well above the range reported by Bresani [12]. This implies that the eight promising varieties are suitable for use as breeding stocks for the improvement of cowpea protein content. In addition, these varieties can be recommended for feeding programs in schools and communities where malnutrition or protein deficiency incidence is prevalent [6]. Cowpea can be used to supplement carbohydrate meals and diversify the nutrition and dietary intakes of rural communities. These findings also corroborate previous reports [27, 33, 35] that suggested significant variations exist in CP of different cowpea varieties evaluated.

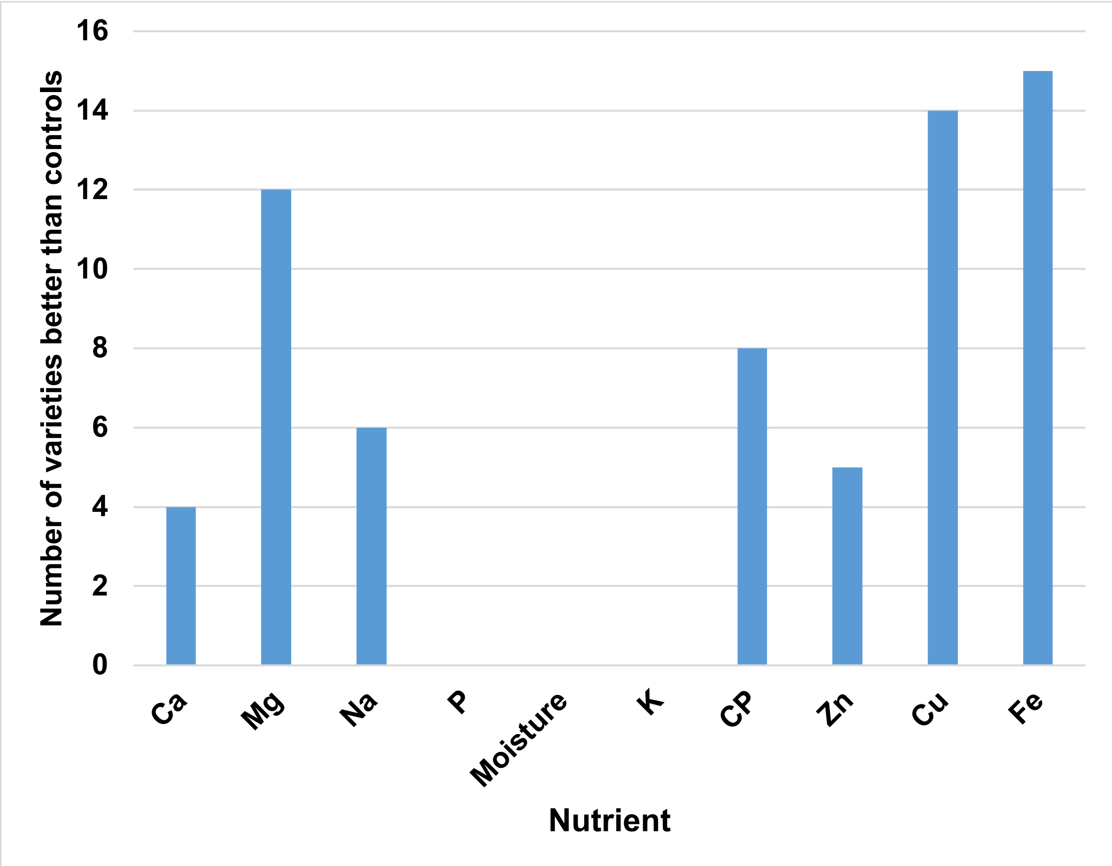

Figure 4: Frequency distribution of nutrient contents of twenty-eight improved cowpea varieties as compared with two local cowpea controls

Calcium, magnesium, iron, zinc and phosphorus contents of cowpea varieties

Results on calcium, magnesium, and phosphorus concentrations are shown in Table 1. The variance analysis shows that significant (P≤0.05) differences were obtained among the varieties for the four minerals (Table 1). Four varieties performed above the control varieties in calcium concentration (Figure 4). The variations could be due to genetic capability of the four varieties to absorb more calcium from the soil, which were partitioned in the seeds better than other varieties [29, 39]. The varieties with calcium concentrations above the local controls can be recommended for bio-fortification program for variety improvement and for children school feeding programs. Calcium is also known to play an important role in the formation of strong bones, muscle functions and body hormones. Feeding on cowpea seeds that have inherently sufficient amounts of calcium will ensure healthy sustenance of bones and other body functions in which calcium is involved.

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Significant (P≤0.05) differences were obtained among the varieties with respect to the concentration of magnesium (Mg) in the seed (Table 1). Twelve varieties exhibited higher concentrations of Mg than the local control (Bechuana White), which had 0.30% (Figure 4). Mg concentration ranged from 0.9-2.25%. The results signify inherent capabilities of the 10 varieties to absorb more Mg from the soil, which are then partitioned into the seed [40]. This inherent ability can be exploited through breeding and bio-fortification to improve cowpea varieties for this trait. Mg is the central core of the chlorophyll molecule in plant tissues. Thus, if Mg is deficient, the shortage of chlorophyll results in poor and stunted plant growth. Mg also helps to activate specific enzyme systems. If Mg is deficient, production of photosynthates and grain yield will be reduced. This also implies that the promising varieties will be able to translate the high Mg concentrations into economic yield better than varieties with lower concentrations of Mg. With regards to human nutrition, Mg plays a critical role in energy-requiring metabolic processes, in protein synthesis, membrane integrity, nervous tissue conduction, neuromuscular excitability, muscle contraction, hormone secretion, and intermediary metabolism [39]. Consumption of cowpea grains with adequate concentration of Mg will enhance and sustain body functions of the consumers.

Results show that significant (P≤0.05) differences were observed for iron and zinc concentrations among the varieties. Fifteen and four cowpea varieties performed exceedingly above the local controls (Figure 4), which signifies the inherent capabilities of the test lines to absorb more Fe and Zn, respectively from the soil and then partitioned into the seed [39]. The concentration of Fe varied from 20.00 ppm to 160.50 ppm while Zn varied from 6.80 ppm to 66.60 ppm. Iron is needed for the transfer of oxygen to body tissues and other organs while zinc plays an essential role in the body in terms of metabolism, and prevents illnesses by supporting the immune system. Consumption of cowpea varieties enriched with these minerals will sustain the good health of the consumers in rural families. In addition, these promising varieties that performed better in Fe and Zn contents than the local controls can be hybridized with varieties that possess other important economic traits to develop new varieties for food security and better nutrition.

Results show that there were significant (P≤0.05) differences among the varieties for the concentration of phosphorus contained in the seeds (Table 1). However, none of the test varieties excelled better than the two local controls (Figure 4). This implies that the no significant difference between the local and the test varieties in terms of phosphorus concentration is an indication that the improved varieties are nutritionally as good as the local controls [27].

Sodium, potassium, and copper contents of cowpea varieties

Table 1 shows that the concentrations of Na, K and Cu varied significantly (P≤0.05) among the varieties. This implies that the varieties have different capability to absorb the nutrients from the soil and partition the nutrients into the grain. Six and fourteen varieties respectively for Na and Cu performed above the local controls (Figure 4). The range of Na and Cu concentrations varied from 0.12% to 3.20% for Na and 1.30% to 17.0% for Cu. Cu is vital for the normal function of respiratory enzymes, which are

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involved in biochemical reactions in the body cells. Copper plays a vital role in the absorption, translocation, storage, and metabolism of iron as well as the maintenance of haematologic and neurologic systems. Sodium on the other hand, is an essential electrolyte that helps maintain the balance of water in and around the body cells. It is important for proper muscle and nerve functions. It also helps to maintain stable blood pressure levels. Insufficient sodium in the blood is known as hyponatremia and occurs when water and sodium are out of balance. In other words, there is either too much water or not enough sodium in the blood. To maintain the body functions, which is supplemented with Na and Cu minerals, adequate consumption of cowpea varieties enriched with these minerals is necessary. In addition, cowpea varieties with inherent uptake of Na and Cu above the local controls could be recommended to dietitians for feeding program of people who lack these minerals. Furthermore, the promising varieties will be deployed for trait improvement and bio-fortification through breeding.

Results show that there were significant ($P \leq 0.05$) differences among the varieties for the concentration of potassium in the seeds (Table 1). However, none of the test varieties did better than the two local controls (Figure 4). This implies that the improved varieties are nutritionally as good as the local controls. The findings also corroborate the report of Mamiro *et al*. [27]. Potassium helps in maintaining normal nerve functions and muscle contractions in addition to sustaining regular heartbeat. A diet rich in potassium helps to offset some of sodium's harmful effects on blood pressure.

In general, recent reports have shown that cultivation of resource-use efficient grain legumes such as cowpea, and supplementing legume diets with cereal-based diets is the only way to ensure crop diversity, food & nutrition security to enhance balanced dietary intake in the rural communities.

CONCLUSION

This study has shown that the improved cowpea varieties exhibited different quality traits that are important determinants for acceptability and marketability of cowpea varieties. The quality traits identified in the study are also important for consideration in hybridization program to enhance the development of new varieties. In terms of nutritional contents, the studied test varieties have exhibited high protein contents, and would be suitable for addressing protein-energy malnutrition in rural communities as well as in formulating blends for baby foods and feeding-school programs. The study also revealed variations among the 28 improved cowpea test varieties that performed exceedingly above the check varieties (Bechuana white and Glenda) in the concentrations of Ca, Mg, Na, Fe, Cu and Zn. These findings offer opportunity for cowpea menus to be recommended as regular meals for alleviating malnutrition problems where these minerals are implicated in human nutrition and diets. Furthermore, the study revealed that the varieties that expressed concentration of the minerals above the local control varieties are promising candidates to be recommended for cultivation by farmers. The varieties are also available for crop improvement and germplasm enhancement programme in the development of better agronomic traits and farmers' preferred varieties to promote food security and nutrition.

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Table 1: Concentrations of Ca, Mg, Na, P and moisture content in thirty varieties of cowpea

Variety	Ca (%)	Mg (%)	Na (%)	P (%)	Moisture (%)
Bechuana W. (check)	0.10b	0.30d	0.30c	0.40a	12.60a
Glenda (check)	0.30c	0.17e	1.03b	0.47a	12.13a
IT00K-1217	0.30c	**2.2a**	**2.40a**	0.47a	11.53a
IT84S-2246-4	0.30c	**2.15a**	**2.85a**	0.50a	11.35a
IT86D-1010	0.33c	**1.43b**	1.37b	0.37b	12.40a
IT86D-719	0.35b	**2.25a**	**3.20a**	0.40a	11.60a
IT95K-1156-3	0.35b	**1.10c**	1.10b	0.50a	11.75a
IT95K-1491	**0.4b**	**1.20c**	1.15b	0.50a	11.55a
IT97K 390-2	0.30c	0.10e	0.30c	0.40a	12.10a
IT97K-499-35	0.15e	0.30d	0.30c	0.35a	12.10a
IT98K-1105	0.35b	0.10e	0.30c	0.45a	11.40a
IT98K-463-6	0.25c	0.20d	0.15d	0.50a	11.90a
IT98K-530-1	**0.6a**	0.10e	0.20c	0.10c	11.70a
IT98K-690	0.30c	**2.13a**	**2.13a**	0.50a	11.33a
IT99K-316-2	**0.4b**	**2.15a**	**2.65a**	0.40a	11.25a
IT99K-494-6	**0.4b**	0.10e	0.35c	0.50a	12.00a
IT99K-529-1	0.27c	0.27d	0.13d	0.47a	12.06a
Jana Fod	0.20d	0.30d	0.30c	0.50a	12.80a
Pan-311	0.30c	**1.47b**	1.33b	0.37b	11.90a
TVu 13464	0.30c	**1.40b**	**2.00a**	0.35b	11.70a
IT00K-1060	0.32c	0.09e	0.27c	0.52a	11.60a
IT00K-1263	0.31c	**2.22a**	**2.04a**	0.45a	11.50a
IT90K-284-2	0.27c	0.09e	0.33c	0.47a	11.40a
IT95K-627-34	0.17e	0.28d	0.42c	0.43a	11.90a
IT97K-1068-7	0.17e	0.282d	0.17d	0.12c	12.00a
IT98K-128-3	0.11e	0.27d	0.23c	0.32b	12.40a
IT97K-568-18	0.32c	**2.21a**	1.81b	0.57a	13.10a
IT98K-491-4	0.11e	0.28d	0.12d	0.08c	12.20a
IT98K-628	0.17e	0.28d	0.24c	0.4a	12.00a
IT98K-962	0.33c	0.10e	0.24c	0.47a	11.50a
IT98K-692	0.22d	0.09e	0.17d	0.51a	12.00a
Mean	0.28	0.83	0.95	0.41	11.90
P-Level (P≤0.05)	0.05	0.04	0.05	0.04	0.68

Values with the same letter within the same column are not significantly ((P≤0.05)* different from each other. Values within each column, which are highlighted in bold indicate varieties that significantly performed over the better check variety (Bechuana white or Glenda) in the nutrient concentrations

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Table 2: Concentrations of K, CP, Zn, Cu and Fe in thirty varieties of cowpea

Varieties	K(%)	CP(%)	Zn(ppm)	Cu(%)	Fe(ppm)
Bechuana W. (check)	6.20a	20.30d	16.55e	4.5c	49.95f
Glenda (check)	3.00b	24.70c	36.73c	4.0c	79.43e
IT00K-1217	0.1d	24.20c	35.33c	1.30d	**119.80c**
IT84S-2246-4	0.10d	24.35c	18.05e	**5.0b**	**123.30c**
IT86D-1010	0.65d	19.03d	**59.57b**	3.8c	**145.77a**
IT86D-719	0.10d	24.05c	**59.75b**	4.3c	**150.55a**
IT95K-1156-3	0.70d	25.00c	38.80c	**5.0b**	**113.70d**
IT95K-1491	1.05c	**27.05b**	42.35c	4.0c	**108.60d**
IT97K 390-2	1.75c	25.45c	**60.45a**	3.5c	**121.55c**
IT97K-499-35	6.20a	18.75d	10.75f	**7.0b**	27.90g
IT98K-1105	1.60c	25.30c	15.75e	**8.5b**	47.35f
IT98K-463-6	6.10a	**29.85a**	17.13e	4.5c	55.67f
IT98K-530-1	1.30c	23.23c	34.00d	3.0c	**133.80b**
IT98K-690	1,31c	26.63c	30.97d	3.3c	**130.03b**
IT99K-316-2	1.42c	22.25d	44.20c	3.5c	**110.65d**
IT99K-494-6	1.35c	26.60c	46.30c	3.5c	94.33e
IT99K-529-1	5.67a	**27.90b**	18.60e	**5.5b**	47.20f
Jana Fod	6.20a	**26.40b**	39.40c	4.0c	20.00g
Pan-311	0.40d	21.43d	23.60e	3.0c	**108.97d**
TVu 13464	1.05c	21.25d	38.55c	4.0c	**108.45d**
IT00K-1060	1.6c	22.50d	**66.60a**	**17.0a**	**155.40a**
IT00K-1263	1.6c	**31.13a**	6.80f	**5.0b**	47.60f
IT90K-284-2	1.7c	**2810a**	15.50e	**9.0b**	41.40f
IT95K-627-34	6.2a	23.19c	12.40f	**15.0a**	43.90f
IT97K-1068-7	6.1a	19.69e	18.40e	**6.0b**	43.50f
IT98K-128-3	6.1a	18.56d	15.60e	**10.0b**	34.40g
IT97K-568-18	5.53a	**31.50a**	19.60e	4.0c	**119.50c**
IT98K-491-4	6.2a	17.31e	18.90e	**9.0b**	50.70e
IT98K-628	6.1a	20.88d	19.10e	**6.0b**	53.20e
IT98K-962	1.5c	25.56c	**58.90b**	4.0c	**160.50a**
IT98K-692	1.4c	**26.38b**	8.20f	**6.0b**	45.20f
Mean	*2.98*	*23.50*	*30.54*	*5.68*	*88.81*
P-Level (P≤0.05)	*0.4*	*0.04*	*0.04*	*0.02*	*0.03*

Values with the same letter within the same column are not significantly ((P≤0.05)* different from each other. Values within each column, which are highlighted in bold indicate varieties that significantly performed over the better check variety (Bechuana white or Glenda) in the nutrient concentrations.

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