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NUTRITIONAL AND ANTIOXIDANT COMPOSITION OF EGGPLANT ACCESSIONS IN GHANA

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ABSTRACT

Eggplants (*Solanum* spp.) are important vegetable crops, well known for nutritional and medicinal values of their fruits and leaves. In order to select more nutritious varieties in Ghana, 33 eggplant accessions were investigated for nutritional, mineral and antioxidant content of their fruits. Proximate and antioxidant analysis were determined by AOAC and DPPH methods. The results showed significant differences (P<0.05) among nutritional, mineral and antioxidant traits. Most accessions contained high moisture content (above 70%). Nutrient concentrations ranged from 0.10 fat to 6.10 g 100 g^{-1} carbohydrate; and 0.107 magnesium to 11.271 mg 100 g^{-1} iron. Total phenolic content was highest in accession ST004-03 (210 mg GAE g^{-1} (gallic acid equivalent), and lowest in SA002-02 (171.10 mg GAE g^{-1}). Accessions ST004-02 and ST004-03 displayed the highest DPPH (2, 2-diphenyl-1-picrylhydrazyl) radical scavenging activity (0.017 mg ml^{-1}); while San 005-01 (1474 mg ml^{-1}) showed the highest antioxidant content. Principal component analysis indicated that the first 3 components with Eigen value >1.5 contributed 68.68% of total variability. Dry matter, protein, moisture and carbohydrate contents showed maximum contributions to the total variability**.** Biplot analysis displayed strong and positive associations among ash, protein and moisture with dry matter; moisture and carbohydrate and; protein and ash. Accessions San 005-01, San 005-02, SA 002-07, SA 002-08 and ST004-03 were identified as good sources of nutrients, minerals and antioxidant properties among the others; and could be used as potential donors for hybridisation programme to develop varieties with higher concentration of these traits.

Key Words: Carbohydrates, mineral, nutritional, *Solanum*

RÉSUMÉ

Les aubergines (*Solanum* spp.) Sont des cultures légumières importantes, bien connues pour les valeurs nutritionnelles et médicinales de leurs fruits et de leurs feuilles. Pour sélectionner des variétés plus nutritives au Ghana, 33 accessions d'aubergines ont été étudiées pour déterminer la teneur nutritionnelle, minérale et antioxydante de leurs fruits. Les analyses proximale et antioxydante ont été déterminées par les méthodes AOAC et DPPH. Les résultats ont montré des différences significatives (P <0,05) entre les caractéristiques nutritionnelles, minérales et antioxydantes. La plupart des accessions avaient une teneur en eau élevée (supérieure à 70%). Les concentrations de nutriments allaient de 0,10 à 6,10 g de glucides à 100 g^{-1}; et 0,107 magnésium à 11,271 mg 100 g^{-1} de fer. La teneur totale en composés phénoliques était la plus élevée lors de l'accession ST004-03 (210 mg GAE g^{-1} (équivalent d'acide gallique) et la plus faible dans le SA002-02 (171,10 mg GAE g^{-1}). Les accessions ST004-02 et ST004-03 ont présenté l'activité de piégeage de radicaux DPPH (2,2-diphényl-1-picrylhydrazyle) la plus élevée (0,017 mg ml^{-1}); tandis que San 005-01 (1474 mg ml^{-1}) présentait la plus forte teneur en antioxydants. L'analyse des composantes principales a montré que les 3 premières composantes avec une valeur propre supérieure à 1,5 ont contribué à 68,68% de la variabilité totale. Les teneurs en matière sèche, en protéines, en humidité et en glucides ont contribué au maximum à la variabilité totale. L'analyse bi-parcelle a montré des associations fortes et positives entre les cendres, les protéines et l'humidité avec la matière sèche, l'humidité et les glucides; protéines et cendres. Les accessions San 005-01, San 005-02, SA 002-07, SA 002-08 et ST004-03 ont été identifiées comme étant de bonnes sources d'éléments nutritifs, de minéraux et de propriétés antioxydantes; et pourrait être utilisé comme donneur potentiel pour le programme d'hybridation visant à développer développer des variétés avec une concentration plus élevée de ces caractères.

Mots Clés: glucides, minéraux, nutritionnels, *solanum*

INTRODUCTION

Vegetables and fruits constitute an important alternative source of nutrients, in developing countries, mainly in sub-Saharan Africa (SSA) where animal and dairy sources of nutrients are often insufficient (Afari-Sefa *et al*., 2012). The SSA region is characterised by high consumption of carbohydrate-rich staple foods, deficient in micronutrients resulting in malnutrition (Saka *et al*., 2010). In a survey by WHO (2002), Ghana had the lowest proportion of fruit and vegetable intake among the surveyed countries in Africa, Eastern Mediterranean, Europe, America, South-east Asia and Western pacific regions. There is, therefore, an urgent need to identify fruit and vegetables for potential nutrients in order to improve diets and fight malnutrition in the country.

Eggplants represent one of such vegetables rich in essential nutrients needed for the normal growth of humans (Chinedu *et al*., 2011). They contain antioxidants, especially phenols that retard the process of oxidation to keep the optimum level of reactive oxygen and nitrogen species, and prevent a large number of chronic diseases (Seifried *et al*., 2007). Eggplants belong to the family of *Solanaceae* and the plant genus *Solanum*. In Africa, there are more than 200 *Solanum* species, with some 30 indigenous species to West Africa (Singh, 2009). Both cultivated and wild types of this vegetable are consumed in Ghana. They include *S. aethiopicum*, *S. melongena*, and *S. macrocarpon*, with *S. torvum* and *S. anguivi* representing the wild forms. Moreover, various parts of these plants are used in indigenous medicine by virtue of their high levels of phytochemical components (Chinedu *et al*., 2011; Nwodo *et al*., 2011).

The diversity of this vegetable crop is large, with wide variations observed within vegetative, fruit and nutritional characteristics of different cultivars ((Picha, 2006; Solaimana *et al*., 2015), allowing the consumers to have a wide range of use. Thus, it is necessary for the plant breeder to balance traits such as taste, appearance and compounds contributing to the nutritional value in his/her breeding programme, to achieve optimum results (Daunay, 2008). In this regard, wild relatives of cultivated eggplant varieties, such as Turkey berry and African eggplant ('nsusua') have been identified as rich sources of essential nutrients, antioxidants as well as disease resistance traits; which may be ideal for introgression breeding into cultivated ones (Gousset *et al.*, 2005; Denton and Nwangburuka, 2011; Meyer *et al.*, 2015).

While literature provides several reports on nutritional, mineral and antioxidant constituents of eggplants, such as antioxidant activity (Jung *et al.*, 2011), dry matter and protein (Raigon *et al.* 2008) and ascorbic acid (Prohens *et al.* 2007); a comprehensive report on nutritional and antioxidant composition of eggplant accessions and their wild relatives in Ghana is not readily available. Lack of this information hampers development of nutritious, multi-purpose varieties. The objective of this study was to evaluate the nutritional, mineral and antioxidant composition of germplasm accessions of eggplant sourced from different parts of Ghana and to study the variability in these traits.

MATERIALS AND METHODS

Plant materials. Thirty three freshly harvested eggplant (immature fruits with shiny and firm peels) accessions from five species made up of *S. macrocarpon* (8), *S. melongena* (8), *S. aethiopicum* (12), *S. torvum* (4) and *S. anguivi* (2) were obtained from research fields of the Faculty of Agriculture, Kwame Nkrumah University of Science and Technology in Ghana (located on longitude 01° 33W and latitude 06° 41 N). These accessions were initially collected from Central, Western, Greater Accra, Ashanti and Northern regions of the country, and cultivated in the field (Table 1), following the standard agronomic practices for eggplant.

Sample preparation. Four samples (replicates) of each accession, each weighing 5 g, were processed independently. Prior to analysis, fruits were hand-rinsed under tap water to remove dirt from the surface; cut into pieces (1 cm long) using a knife, and then dried in an oven at 105 °C using an oven (Gllenkamp, England). The oven-dried fruit samples were cooled in a desiccator and ground using a porcelain mortar and a pestle before proximate analysis.

Analytical methods. Proximate analysis was carried out using the AOAC (1990) standard methods. Moisture was determined by drying a representative 5 g chopped fruits (sample) in an oven (Gllenkamp, England), at 105 °C until constant weight. Ash content was determined by the incineration of each fruit sample (2 g), in a muffle furnace (Lenton, England), at 550 °C for 4 hr until the ash turned white. Crude protein was assessed by the Kjeldahl method using the value of 6.25 as conversion factor of nitrogen to protein (Jagat and Basanta, 2007).

Lipid content was evaluated by hexane extraction for 7 hr in a Soxhlet apparatus. For crude fibre, 2 g of dried sample were digested with 0.25 M sulphuric acid and 0.3 M sodium hydroxide solution. The insoluble residue obtained was washed with hot distilled water and oven dried (Gllenkamp, England) at 100 °C until constant weight. The concentration of carbohydrate was calculated using the formula of FAO (2002). The dried residue was then incinerated and weighed for the determination of crude fibre content.

For mineral composition, 1 g of fine powdered sample from each accession was digested following wet digestion procedures, using concentrated HNO3 and 30% H_2O_2. The digested samples were used for elemental Fe, Cu, Mn and Zn analysis using Atomic Absorption Spectrophotometer. Phosphorus was determined using vanadomolybdate (Yellow method). Transmittance was determined at 430 nm using Jenway 6051 colorimeter. Sodium, K and Ca were evaluated using Flame photometer.

Antioxidant analysis. The total concentration of phenols was determined using the Folin–Ciocalteu assay (Macdonald *et al.* (2001), with

TABLE 1. Eggplant accessions used for nutritional analyses in Ghana

Accession	Collection site	Region	Taxon	Accession	Collection site	Region	Taxon
San005-01	Atonsu	Ashanti	San	ST004-04	Juaboso	Western	ST
San005-02	Atonsu	Ashanti	San	SM001-01	Abura	Central	SM
SA002-01	Bunso/ PG	Eastern	SA (Gp)	SM001-02	Juaboso	Western	SM
SA002-02	Bunso/ PG	Eastern	SA (Gp)	SM001-03	Abura	Central	SM
SA002-03	Bunso/ PG	Eastern	SA (Gp)	SM001-04	Mankesim	Central	SM
SA002-04	Kejetia	Ashanti	SA (Gp)	SM001-05	Mankesim	Central	SM
SA002-05	Kejetia	Ashanti	SA (Gp)	SM001-06	Dome	Gr. Accra	SM
SA002-06	Kejetia	Ashanti	SA (Gp)	SM001-07	Abura	Central	SM
SA002-07	Bunso/ PG	Eastern	SA (Sp)	SM001-08	Mankesim	Central	SM
SA002-08	Bunso/ PG	Eastern	SA (Sp)	SMA003-01	Abura	Central	SM
SA002-09	Bole	Northern	SA (Kp)	SMA003-02	Keta	Volta	SMA
SA002-10	Bawku	Northern	SA (Kp)	SMA003-03	Ajumako	Central	SMA
SA002-11SA002-12	BawkuYedi	NorthernNorthern	SA (Kp)SA (Kp)	SMA003-05SMA003-06	JuabosoDenu	WesternVolta	SMASMA
ST004-01	Adenta	Gr. Accra	ST	SMA003-07	Denu	Volta	SMA
ST004-02	Abura	Central	ST	SMA003-08	Denu	Volta	SMA
ST004-03	Atonsu	Ashanti	ST				

San = *S. anguivi*, SM = S. *melongena*, SMA = *S. macrocarpon*, ST = *S. torvum* and SA = *S. aethiopicum,* PG = PGRRI, Gp = Gilo group, Kp = Kumba group, Sp = Shum group gallic acid as standard. The total antioxidant capacity of the methanol extract was evaluated by the phosphomolybdenum method, according to the procedure described by Prieto *et al.* (1999). The DPPH (1, 1-diphenyl-2 picrylhydrazyl) method was used to determine the free radical scavenging activity (Mensor *et al.*, 2001).

Data analyses. Data collected on nutritional, mineral and antioxidant components were processed using Analysis of Variance (ANOVA), and significant means were separated by the Tukey's test (P<0.05). Furthermore, principal component analysis was employed to assess percent contribution of each trait to total genetic variability among the eggplant accessions. The use of bi-plot analysis described the multivariate relationships among accessions and traits. GenStat Statistical Software Programme (11th edition) was used in all data analyses.

RESULTS

Non-minerals composition. Data for nutritional traits among the 33 accessions are presented in Table 2. Significant differences (P<0.05) were found among all the accessions for the measured parameters. Percent moisture ranged from 50.01 (SA002-07) to 91.38% (SMA003-03). Cultivated accessions SMA003-01, SMA003-03, SMA003-05, SA002-02, SA002-11, SA002-01, SM001-06, SM001-07 and SM001-03 showed high moisture values; while lower values were observed in wild accessions SA002-07 (50.10%), SA002-08 (60.10%) and San005-01 (62.01%) (Table 2).

Significant (P<0.05) differences characterised the amount of dry matter observed among the accessions, and ranged from 0.86 to 4.99 g 100 g^{-1} (Table 2). The highest dry matter was obtained in wild accession SA002-08 (49.99 g^{-1}100 g^{-1}). Accessions SA002-07, San 005-01 and San 005-02 also showed appreciable levels of dry matter and were significantly different (P<0.05) from the others. However, low values were recorded in accessions SMA003-01, SMA003-03, SMA003-05, SM001-03, SM001-06, SM001-07, SA002-01, SA002-02 and SA002-11 (Table 2).

Total available carbohydrate portions among eggplant accessions varied between 1.23 g^{-1}100 g^{-1} in SA002-08 to 6.10 g^{-1}100 g^{-1} in SM001-06 (Table 2). Carbohydrate was found to be abundant in SM001-06, followed by SM001-08 (6.04 g^{-1}100 g^{-1}), and was significantly different (P<0.05) from other accessions. The lowest carbohydrate value was noted in accessions SA002-08 (1.23 g^{-1}100 g^{-1}) (Table 2). At species level, available carbohydrate was comparatively higher in *S. melongena* accessions, followed by *S. macrocarpon*, *S. aethiopicum* and *S. torvum* and *S. anguivi* (Table 2).

The average protein concentration ranged between 1.14 to 2.68 g^{-1}100 g^{-1} (Table 2). In general, wild accessions showed higher values of crude protein concentration compared to the rest, in spite of their relatively smaller fruit sizes (Plate 1). Accessions SA002-07, showed the highest concentration of crude protein and was significantly different (P<0.05) from the rest; while SMA003-07 recorded the lowest.

Variation in crude fibre concentrations among the eggplant accessions were significant (P<0.05) (Table 2). Eggplants from cultivated SMA003-05 recorded the highest amount of fibre (1.776 g 100 g^{-1}) and were significantly different from the others. Accessions SA002-07 and SA002-08 recorded the lowest values of 0.514 and 0.551 g^{-1}100 g^{-1} and there was no significant (P>0.05) difference between the two.

Crude fat of eggplant accessions was the most variable (CV= 6%) among the traits under study (Table 2). The level ranged from 0.10 to 1.04 g^{-1}100 g,$^{-1}$; with the cultivated accession SMA003-01 recording the highest value for this trait (1.04 g^{-1}100 g^{-1}) and was significantly different (P<0.05) from the rest. The lowest values were observed in accessions

TABLE 2. Nutritional composition of eggplant accessions (on dry weight basis) from a study in Ghana

Accession code	Moisture (%)	Dry matter ($g^{-1}100\ g^{-1}$)	Carbohydrate ($g^{-1}100\ g^{-1}$)	Protein ($g^{-1}100\ g^{-1}$)	Fibre ($g^{-1}100\ g^{-1}$)	Fat ($g^{-1}100\ g^{-1}$)	Ash ($g^{-1}100\ g^{-1}$)
San005-01	62.01 b	3.80 l	2.44 c	1.983 q	0.94 g	0.11 ab	0.87 l
San005-02	75.79 bc	2.42 kl	3.10 d	1.872 nop	1.60 n	0.46 mno	0.43 f-j
SA002-01	90.05 j-m	1.09 a-d	5.23 l	1.72 fgh	1.21 jk	0.51 nop	0.34 b-e
SA002-02	90.90klm	0.91 abc	5.72 mn	1.43 b	1.18 j	0.46 mn	0.32 ab
SA002-03	89.07 h-l	1.09 b-f	5.51 m	1.50 bc	1.13 ij	0.42 lm	0.34 b-e
SA002-04	86.87 efg	1.31 ghi	4.47 e	1.92 pq	1.40 l	0.56 p	0.34 b-e
SA002-05	85.79 e	1.42 i	4.70 efg	1.74 f-k	1.23 k	0.56 p	0.35 b-e
SA002-06	86.18 e	1.38 i	5.02 i-l	1.720 f-i	1.02 hi	0.54 p	0.32 ab
SA002-07	**50.01 a**	3.99 l	1.70 b	**2.68 s**	**0.51 a**	0.57 p	**0.56 k**
SA002-08	60.10 b	**4.99 m**	**1.23 a**	2.35 r	0.55 ab	0.41 klm	0.46 ij
SA002-09	83.01 d	1.70 j	5.14 jkl	1.71 fg	0.56 b	0.21 d-h	0.35 b-e
SA002-10	80.24 c	1.98 k	4.70 efg	1.72 f-i	0.75 d	0.52 op	0.33 a-d
SA002-11	90.22 j-m	0.98 a-d	4.95 h-k	1.68 ef	1.52 m	0.52 nop	0.35 b-e
SA002-12	81.63 cd	1.84 jk	5.18 kl	1.80 j-n	0.62 c	0.22 e-i	0.34 b-e
ST004-01	81.06 cd	1.89 jk	4.91 g-j	1.79 i-n	0.81 e	0.13 abc	0.45 hij
ST004-02	80.40 c	1.96 k	4.94 g-j	1.62 de	1.00 hi	**0.10 a**	0.38 b-g
ST004-03	81.52 cd	1.85 jk	4.84 ghi	1.82 k-n	0.92 fg	0.18 c-g	0.39 d-i
ST004-04	82.74 d	1.73 j	5.12 jkl	1.75 f-l	0.83 e	0.23 f-i	0.34 b-e
SM001-01	88.99 g-l	1.10 b-g	5.53 m	1.97 q	0.93 g	0.27 hi	0.38 c-h
SM001-02	89.13 i-l	1.09 b-e	5.85 no	1.54 cd	0.98 h	0.17 a-f	0.37 b-f
SM001-03	89.49 j-m	1.05 a-d	5.60 m	1.78 g-m	1.02 hi	0.15 a-d	0.40 e-i
SM001-04	88.85 f-k	1.12 c-h	4.88 ghi	1.86 m-p	1.41 l	0.26 hi	0.48 j
SM001-05	88.82 f-k	1.12 c-h	5.13 jkl	1.76 f-l	1.27 kl	0.29 ij	0.45 g-j
SM001-06	90.20 j-m	0.08 a-d	**6.10 p**	1.48 bc	0.78 d	0.27 hi	0.39 d-i
SM001-07	90.04 j-m	1.09 a-d	4.96 h-k	1.78 g-m	1.53 m	0.19 c-g	0.36 b-e
SM001-08	88.55 f-j	1.15 d-h	6.04 op	1.59 d	0.59 bc	0.28 ij	0.37 b-f
SMA003-01	91.04 lm	0.90 ab	5.05 i-l	1.83 l-o	0.89 f	**1.04 q**	**0.27 a**

TABLE 2. Contd.

Accession code	Moisture (%)	Dry matter (g^{-1}100 g^{-1})	Carbohydrate (g^{-1}100 g^{-1})	Protein (g^{-1}100 g^{-1})	Fibre (g^{-1}100 g^{-1})	Fat (g^{-1}100 g^{-1})	Ash (g^{-1}100 g^{-1})
SMA003-02	85.91 e	1.41 i	4.57 af	1.79 h-m	1.73 o	0.16 a-e	0.34 b-e
SMA003-03	**91.38 m**	**0.86 a**	5.251	1.81 j-n	1.55 m	0.148 a-d	0.37 b-f
SMA003-05	90.98 lm	0.90 ab	4.77 fgh	1.91 opq	**1.78 p**	0.24 ghi	0.39 d-i
SMA003-06	87.19 e-i	1.28 e-i	4.82 ghi	1.75 f-l	1.61 n	0.17 b-f	0.36 b-e
SMA003-07	86.82 ef	1.32 hi	5.64 mn	**1.14 a**	1.20 jk	0.37 kl	0.33 abc
SMA003-08	86.98 e-h	1.30 f-i	5.18 kl	1.74 f-j	1.04 i	0.35 jk	0.39 c-h
CV (%)	0.8	4.1	1.5	1.4	1.1	6.0	5.2

Mean values followed by the same letter within a column do not differ significantly ($P<0.05$) according to according to the Tukey's test

ST004-02 (wild type), SM001-02, SM001-03, SMA003-02 and SMA003-03 (cultivated types).

The highest amount of ash was recorded in wild accession San005-01(0.87 g 100 g^{-1}) and was significantly different ($P<0.05$) from the others; while four cultivated types (SMA003-01, SMA003-08, SA002-02 and SA002-06) recorded the lowest (Table 2). Except for accessions SA002-07 and SA002-08), the amount of mineral ash in San005-01 was more than twice higher than the that observed in *S. melongena* (SM001-01, SM001-02, SM001-03, SM001-06, SM001-07 and SM001-08), *S. macrocarpon* (SMA003-01-SMA003-08) and *S. aethiopicum* accessions (SA002-01 - SA002-12).

Mineral composition. The 33 eggplant accessions revealed significant differences ($P<0.05$) among them, with respect to concentrations of phosphorus, potassium, magnesium, calcium, iron, zinc, copper and manganese. No significant ($P>0.05$) variation was observed in sodium (Table 3).

Differences among eggplant accessions for the amount phosphorus were significant ($P<0.05$) and ranged between 0.150 mg $^{-1}$100 g^{-1} (SA002-03) and 0.378 mg $^{-1}$100 g^{-1} (SM001-08), with a CV of 9.9% (Table 3). Nine cultivated accessions (SM001-03, SM001-06, SM001-08, SA002-01, SA002-02, SA002-04, SA002-09, SA002-10, and SA002-12) and five wild types (San005-01, San005-02, SA002-07, SA002-08, and ST004-02) recorded relatively high concentration of phosphorus.

Significant differences ($P<0.05$) were observed among eggplant accessions for mean potassium concentration, which ranged from 2.200 to 3.573 mg $^{-1}$100 g^{-1}. Two wild accessions (SA002-07, SA002-08, (SM001-05 and SMA003-05) recorded high values with mean potassium concentrations of 3.573, 3.453, 3.390 and 3.317 mg $^{-1}$100 g^{-1}, respectively (Table 3).

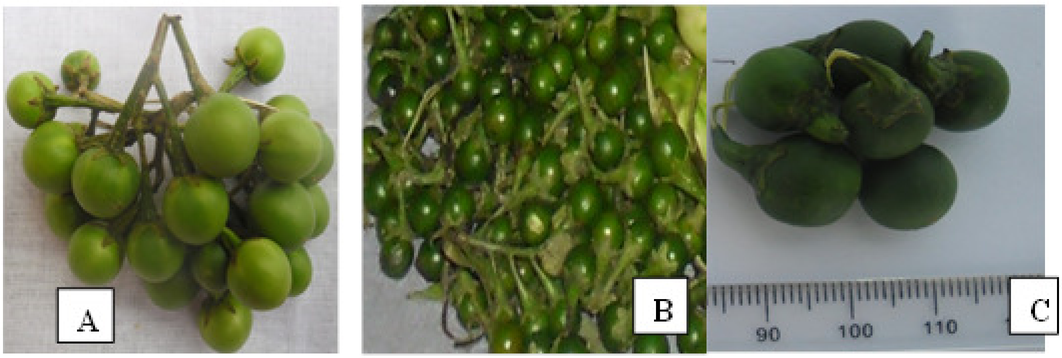

Plate 1. Eggplant fruits of wild accessions (A) *S. torvum* (B) *S. anguivi* (C) *S. aethiopicum* (shum group) used in a nutritional study in Ghana.

The concentration of magnesium varied significantly ($P<0.05$) among the accessions, ranging from 0.107 to 0.257 mg $^{-1}$100 g^{-1} (Table 3). The highest levels were observed in four cultivated accessions SA002-09 (0.257 mg $^{-1}$100 g^{-1}), SM001-08 (0.210 mg $^{-1}$100 g^{-1}), SA002-12 (0.210 mg $^{-1}$100 g^{-1}) and SM001-06 (0.197 mg $^{-1}$100 g^{-1}) (Table 3).

The amount of calcium observed among the eggplant accessions was significant ($P<0.05$) and ranged from 0.110 mg $^{-1}$100 g^{-1} in SA002-11 to 0.196 mg $^{-1}$100 g^{-1} in SA002-07 (Table 3). The top 8 accessions comprised of eight cultivated (SA002-10, SM001-06, SA002-09, SA002-11, SA002-12 and SA002-10) and two wild ones (SA002-08 and SA002-07).

No significant ($P>0.05$) variation was noted among the different accessions of eggplants with respect to concentration of sodium, which ranged from 0.203 mg $^{-1}$100 g^{-1} in SA002-08 to 0.237 mg $^{-1}$100 g^{-1} in SA002-06 (Table 3).

The highest amount of iron was observed in two wild accessions San005-01 and San005-02 (11.217 mg -1100 g-1) and was significantly different ($P>0.05$) from the others (Table 3). This value decreased more than eight folds in accession SA002-03, a cultivated accession which recorded the least (Table 3).

The concentration of zinc among accessions showed significant differences ($P<0.05$) and ranged from 0.467 mg $^{-1}$100 g^{-1} (SM001-07) to 3.600 mg $^{-1}$100 g^{-1} (San005-01) (Table 3). In general, wild accessions recorded high zinc levels compared to cultivated types. In the case of Cu, however, there were significant differences which ranged from 0.467 to 6.833 mg $^{-1}$100 g^{-1} (Table 3). The highest amount of copper was observed in accession SA002-09 (6.833 mg $^{-1}$100 g^{-1}) and was significantly different ($P<0.05$) from all accessions.

Manganese concentrations among eggplant accessions ranged between 1.030 and 9.567 mg $^{-1}$100 g^{-1} and varied significantly ($P<0.05$) (Table 3). The highest amount was recorded in accession SA002-02 (9.567 mg $^{-1}$100 g^{-1}); with wild accessions generally showing higher concentrations than the cultivated types (Table 3).

Total phenols. The eggplant accessions presented significant differences ($P<0.05$) for total phenols, which ranged from 171.10 to 210 mg GAE g^{-1} on dry weight basis (Table 4). Six cultivated accessions SM001-04 (193.20), SM001-03 (191.50), SM001-08 (196.00), SA002-06 (191.40), SMA003-05 (193.20), SMA003-06 (198.40) and one wild one (ST004-03, 210.00) showed high amount of phenols (mg GAE g^{-1}). The amount of phenols in the wild accession ST004-03 was comparatively higher than the quantities in all cultivated accessions (Table 4).

TABLE 3. Mineral element concentration (mg $^{-1}$100 g^{-1}) of eggplant accessions recorded on dry weight basis in an experiment in Ghana

Accession code	P	K	Mg	Ca	Na	Fe	Zn	Cu	Mn
San005-01	0.330 f-j	**2.200 a**	0.157 a-d	**0.110 a**	0.217 a	**11.217 r**	**3.600 k**	3.100 g	5.367 ef
San005-02	0.310 e-j	**2.200 a**	0.130 ab	0.117 ab	0.223 a	**11.217 r**	**3.267 jk**	4.600 lm	5.767 f
SA002-01	0.330 f-j	2.667 b-e	0.117 ab	0.127 ab	0.227 a	2.67 bc	1.667 d-g	2.000 cd	8.667 m
SA002-02	0.333 f-j	2.823 d-h	**0.107 a**	0.123 ab	0.230 a	2.200 b	1.600 d-g	3.100 g	**9.567 n**
SA002-03	**0.150 a**	**2.433 ab**	0.120 ab	0.127 ab	0.227 a	**1.133 a**	1.600 d-g	5.200 o-r	6.467 gh
SA002-04	0.297 d-j	2.527 bc	0.120 ab	0.113 ab	0.227 a	3.000 b-e	1.933 gh	5.167 opq	1.510 bc
SA002-05	0.177 ab	2.867 e-i	0.120 ab	0.113 ab	0.227 a	3.200 cde	2.267 hi	2.000 cd	**1.233 ab**
SA002-06	0.210 a-d	3.207 k-o	0.127 ab	0.113 ab	0.237 a	4.533 ghi	1.867 fgh	4.867 mno	**1.030 a**
SA002-07	0.357 hij	**3.390 n-q**	0.143 abc	**0.196 f**	0.213 a	10.200 q	**3.267 jk**	0.867 b	6.800 hi
SA002-08	0.330 f-j	**3.583 q**	0.130 ab	**0.193 f**	0.203 a	8.600 p	2.800 ij	2.100 cd	1.610 bc
SA002-09	0.307 e-j	**2.257 a**	**0.257 e**	**0.183 ef**	0.210 a	3.697 efg	**0.500 a**	**6.833 u**	7.967 k
SA002-10	0.357 hij	2.697 c-f	0.130 ab	**0.193 f**	0.217 a	6.33 lmn	**0.800 abc**	6.167 t	8.567 m
SA002-11	**0.220 a-e**	2.910e-j	0.150 a-d	**0.157 b-f**	0.207 a	5.400 ijk	2.000 gh	5.867 st	7.367 j
SA002-12	0.367 ij	2.867 e-i	0.210 de	**0.173 c-f**	0.207 a	3.600 def	**0.600 ab**	3.767 hi	8.767 m
ST004-01	**0.227 a-e**	2.797 d-h	0.140 abc	**0.110 a**	0.207 a	3.800 e-h	1.733 e-h	2.767 fg	1.243 ab
ST004-02	0.287 c-j	2.807 d-h	0.147 abc	0.113 ab	0.207 a	5.133 ij	1.800 fgh	3.500 h	2.523 d
ST004-03	**0.230a-e**	3.007 g-l	0.140 abc	0.123 ab	0.230 a	5.467 jkl	1.867 fgh	2.067 cd	5.300 e
ST004-04	0.277 c-i	3.027 g-l	0.140 abc	0.143 a-e	0.227 a	4.600 hij	2.067 gh	2.167 de	1.723 c
SM001-01	0.273 c-h	2.963 g-k	0.147 abc	0.113 ab	0.233 a	5.367 ij	**1.000 abc**	4.767 lmn	1.373 abc
SM001-02	0.250 b-f	2.590 bcd	0.113 ab	0.137 a-d	0.207 a	2.800 bcd	1.133 bcd	1.003 b	2.377 d
SM001-03	**0.287 c-j**	2.993 g-l	0.110ab	0.137 a-d	0.217 a	6.733 mno	**0.967 abc**	6.100 t	2.367 d
SM001-04	0.250 b-f	3.227 l-o	0.120 ab	0.133 abc	0.213 a	7.000 mno	1.667 d-g	5.567 rs	2.467 d
SM001-05	0.263 b-g	**3.453 opq**	0.170 bcd	0.117 ab	0.210 a	4.667 hij	**1.000 abc**	5.100 nop	8.500 lm
SM001-06	**0.353 g-j**	2.977 g-l	0.197 cde	**0.180 def**	0.207 a	6.267 klm	1.600 d-g	4.467 kl	7.067 ij
SM001-07	0.277 c-i	2.770 c-g	0.137 abc	0.123 ab	0.217 a	4.600 hij	**0.467 a**	2.067 cd	2.513 d
SM001-08	**0.377 j**	2.807 d-h	0.210 de	**0.177 c-f**	0.210 a	7.400 o	1.133 bcd	4.167 jk	7.150 ij
SMA003-01	0.330 f-j	3.040 h-l	0.157 a-d	**0.157 b-f**	0.217 a	6.333 lmn	1.333 c-f	5.533 qrs	6.367 g

TABLE 3. Contd.

Accession code	P	K	Mg	Ca	Na	Fe	Zn	Cu	Mn
SMA003-02	0.273 c-h	3.150 j-n	0.170 bcd	0.120 ab	0.210 a	4.200 fgh	**0.867 abc**	5.467 pqr	1.310 abc
SMA003-03	0.277 c-l	3.083 i-m	0.150 a-d	0.133 abc	0.220 a	5.200 ij	1.133 bcd	1.767 c	5.167 e
SMA003-05	**0.200 abc**	3.317 m-p	0.117 ab	0.137 abcd	0.220 a	7.200 no	1.200 cde	**0.467 a**	6.500 gh
SMA003-06	**0.287 c-j**	2.927 f-j	0.170 bcd	0.117 ab	0.223 a	7.600 o	1.733 e-h	2.533 ef	8.533 m
SMA003-07	0.277 c-i	**3.573 pq**	0.167 a-d	0.120 ab	0.223 a	5.333 ij	2.267 hi	4.033 ij	8.100 kl
SMA003-08	0.263 b-g	2.937 f-j	0.170 bcd	0.117 ab	0.227 a	7.600 o	1.333 c-f	2.767 fg	7.867 k
CV (%)	9.9	2.7	12.9	9.8	10.5	4.8	10.0	3.1	2.5

Mean values followed by the same letter within a column do not differ significantly ($P < 0.05$) according to according to the Tukey's test

Total antioxidant. Differences among accessions for total antioxidant concentrations were significant ($P<0.05$) and ranged from 529.80 to 1474 mg g^{-1}. Total antioxidant was highest in two wild accessions San005-01 (1474 mg g^{-1}) and ST004-03 (1400 mg g^{-1}). However, this was significantly reduced ($P<0.05$) in cultivated accession SMA003-02 (529.80) (Table 4).

DPPH radical scavenging activity. The DPPH radical scavenging activities for all 33 eggplant accessions are presented in Table 4. There were significant differences ($P<0.05$) among the accessions with respect to DPPH radical scavenging activity which ranged from 0.017 to 0.028mg ml^{-1} (Table 4).

Principal component analysis. The first principal component (PC1) accounted for 33.15% of total variation, and was characterised by moisture (-0.418), dry matter (0.409), carbohydrate (0.41), protein (0.339), iron (0.313), ash (0.312) and zinc (0.309) (Table 5). All other traits contributed minimal to the total variation in PC1 (Table 5). The second principal component contributed 17.44% of the total variation, and was positively correlated with phosphorus (r=0.425), magnesium (r=0.465), calcium (r=0.452), copper (r=0.244) and manganese (r=0.311. Fibre (r=-0.330) and zinc (r=-0.275) also showed significant, but negative contribution to the second component (Table 5). The third principal component accounted for 10.09% of the total variation in the population, and was identified by fat (r=-0.645), sodium (r=-0.492), ash (r=0.299), magnesium (r=0.240) and calcium (r=-0.243). Carbohydrate, protein, iron, zinc and copper contributed minimally towards divergence in the third component; while there was no association for moisture and dry matter (Table 5).

Principal component biplot analysis. Figure 1 shows the biplot analysis of eggplant accessions with proximate and mineral

TABLE 4. Phenolic concentration and antioxidant content and activity of eggplant accessions in a study in Ghana

Accession code	Total phenol (mg GAE g^{-1})	Antioxidant content (mg g^{-1})	DPPH reduction EC50 (mg ml^{-1})
San005-01	176.30 a-e	1474.00 k	0.018 abc
San005-02	171.10 a	534.60 ab	0.019 abc
SA002-01	190.10 b-g	673.90 fg	0.026 ef
SA002-02	171.10 a	625.00 c-g	0.020 a-d
SA002-03	179.80 a-g	560.60 a-d	0.020 abc
SA002-04	176.70 a-e	538.70 abc	0.020 abc
SA002-05	181.20 a-g	565.30 a-d	0.019 abc
SA002-06	191.40 d-h	779.80 h	0.021 a-d
SA002-07	183.20 a-g	618.50 b-g	0.021 bcd
SA002-08	186.80 a-g	659.70 efg	0.028 f
SA002-09	182.30 a-g	581.40 a-e	0.019 abc
SA002-10	190.30 b-g	607.00 a-f	0.020 abc
SA002-11	184.60 a-g	588.80 a-f	0.019 abc
SA002-12	171.90 ab	548.30 abc	0.019 abc
ST004-01	172.20 ab	605.60 a-f	0.020 abc
ST004-02	177.20 a-e	589.00 a-f	0.017 a
ST004-03	210.00 h	1400.00 k	0.017 a
ST004-04	178.60 a-f	1050.00 j	0.019 abc
SM001-01	186.00 a-g	1309.00 l	0.018 abc
SM001-02	182.60 a-g	589.00 a-f	0.019 abc
SM001-03	193.50 e-h	643.50 d-g	0.017 ab
SM001-04	193.20 e-h	625.30 c-g	0.020 a-d
SM001-05	189.00 a-g	606.00 a-f	0.018 abc
SM001-06	191.00 c-g	611.00 a-g	0.019 abc
SM001-07	188.20 a-g	908.30 i	0.024 de
SM001-08	196.00 fgh	1054.00 j	0.019 abc
SMA003-01	189.70 a-g	768.10 h	0.021 cd
SMA003-02	172.80 a-d	529.80 a	0.020 a-d
SMA003-03	189.20 a-g	934.20 i	0.019 abc
SMA003-05	193.20 e-h	698.00 gh	0.021 a-d
SMA003-06	198.40 gh	899.20 i	0.021 bcd
SMA003-07	172.30 abc	534.10 ab	0.020 abc
SMA003-08	176.60 a-e	570.10 a-d	0.019 abc
CV (%)	7.3	8.6	5.6

Mean values followed by the same letter within a column do not differ significantly ($P<0.05$) according to the Tukey's test

TABLE 5. Principal component analysis of nutritional and mineral composition of eggplants in a study in Ghana

Parameter	PC1	PC2	PC3
Moisture	-0.41889	-0.04423	0.00655
Dry matter	0.40885	0.00382	0.00001
Carbohydrate	-0.41116	0.07126	0.02989
Protein	0.33948	-0.03630	-0.09028
Fibre	-0.14952	-0.33023	0.20121
Fat	0.01851	0.04759	-0.64652
Ash	0.31224	-0.09106	0.29897
P	0.13888	0.42497	0.11788
K	0.03661	-0.02239	-0.12800
Mg	-0.02173	0.46504	0.23983
Ca	0.13789	0.45215	-0.24326
Na	-0.02942	-0.19057	-0.49253
Fe	0.31284	0.04457	0.08234
Zn	0.30899	-0.27510	-0.07459
Cu	-0.12873	0.24409	0.03617
Mn	-0.04458	0.31090	-0.19961
Eigen value	5.30	2.79	1.61
Percentage	33.15	17.44	10.09
Cumulative	33.15	50.59	60.68

composition explained by the first two components. Most of the accessions were clustered around the centre, with few scattered in the four quadrants showing genetic variability in the measured traits (Fig. 1). The biplot analysis grouped the accessions into clusters over the four quadrants based on the amount of protein, fat, ash, dry matter, carbohydrate, moisture, potassium, phosphorus, magnesium, calcium, sodium, iron, zinc, copper and manganese. Three wild accessions in the top left quadrant were closely related to ash, protein, dry matter, zinc and iron. The top right quadrant consisted of a mixture of wild and cultivated accessions associated with fibre and sodium. The bottom left quadrant consisted of two cultivated accessions SA002-10 and SA002-12 linked with phosphorus, calcium, magnesium and fat. The bottom right quadrant comprised eight cultivated accessions related to manganese, copper, carbohydrate and moisture. SA002-07, SA002-08, San005-01 were the most divergent among the eggplant accessions when the principal component axes were concentrated on zero (Fig. 1).

DISCUSSION

The significant differences recorded among the eggplant accessions in relation to proximate, mineral and antioxidant components (Tables 2, 3 and 4) indicate wide variation among the accessions in relation to these traits. This provides opportunity to select eggplant species with high nutrient and antioxidant composition. The result is in consonance with an earlier report by Arivalagan *et al.* (2013), who detected significant differences in the mineral contents among 32 germplasm accessions of *S. melongena*. Oppong *et al.* (2015) also reported the distinct concentrations of iron and zinc in *S. torvum* and *S. aethiopicum* accessions. Also, Jose *et al.* (2013) reported a wide diversity of *S. melongena* accessions for protein, carbohydrate, starch, total soluble sugars and fibre. However, no variation was observed for moisture content in their study which is contrary to the results obtained in this study. This difference may be due to the larger number of accessions (33) used in the present study, compared to seven in the case of the previous workers. In addition, higher values recorded for total phenol (210.0 mg GAE g^{-1}), antioxidant (1474 mg g^{-1}) and activity (0.017 mg ml^{-1}) in accessions ST 004-03, San 005-01 and ST 004-02, respectively indicates that these accessions could play a significant role in the breeding of eggplant with improved medicinal properties (antioxidant traits). Similar results have been reported for total antioxidant activity and phenolic content among *S. melongena and also in C. chinense* accessions (Castro-Concha *et al.*, 2014; Somawathies *et al.*, 2014)

Proximate composition among accessions. High levels of moisture in the samples of most

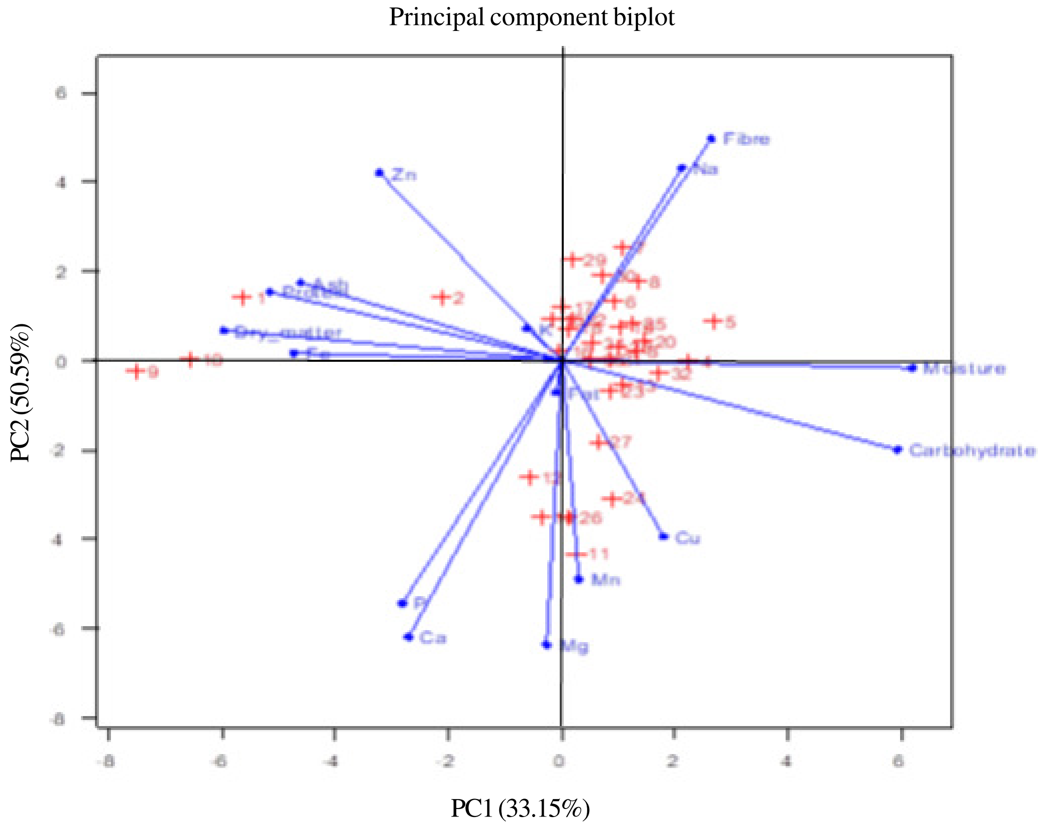

Figure 1. Sample score plot for the principal-component biplot analysis of the proximate and mineral characteristics of eggplant accessions for a study in Ghana.

1 = San005-01, 2 = San005-02, 3 = SA002-01, 4 = SA002-02, 5 = SA002-03, 6 = SA002-04, 7 = SA002-05, 8 = SA002-06, 9 = SA002-07, 10= SA002-08, 11 = SA002-09, 12 = SA002-10, 13 = SA002-11, 14 = SA002-12, 15 = ST004-01, 16 = ST004-02, 17= ST004-03, 18 = ST004-04, 19 = SM001-01, 20 = SM001-02, 21 = SM001-03, 22 = SM001-04, 23 = SM001-05, 24 = SM001-06, 25 = SM001-07, 26 = SM001-08, 27 = SMA003-01, 28 = SMA003-02, 29 = SMA003-03, 30 = SMA003-05, 31 = SMA003-06, 32 = SMA003-07 and 33 = SMA003-08.

accessions, suggest that these accessions would not be stored for long, since high water activity is associated with microbial action, which bring about food spoilage (Emmanuel-Ikpeme *et al*., 2014). However, the relatively low water content of accessions San 005-01, San 005-02, SA 002-07 and SA 002-08 indicates that they may have a longer shelf life compared to the others. A similar observation was reported by Oyeyemi *et al*. (2015) and Jose *et al*. (2013) in *S. melongena* and *S. anguivi* in Nigeria and Spain, respectively.

The mean carbohydrate concentration of cultivated accessions, SM001-06 and SM001-08, was significantly higher than the others; which suggests that these accessions could be considered as potential source of energy. Values recorded for these accessions are consistent with findings of several other researchers (Auta and Ali, 2011; Jose *et al*., 2013; Oyeyemi *et al*., 2015), who studied the nutritional composition of *Solanum anguivi*, *Solanum melongena* and *Solanum incanum*.

The results also show that eggplant accessions varied for crude protein composition (Table 2). The wild accessions (SA002-07, SA002-08, San005-01, San005-02, ST004-01, ST004-02, ST004-03 and ST004-04) contained comparatively higher amount of protein compared to the others, and thus, can be used as potential source of plant protein. According to WHO *et al.* (2007), the RDI (Recommended Dietary Intake) of crude protein for normal adult humans is 0.66 g protein kg^{-1} per day. Therefore, the consumption of 6 g wild accession such as SA 002-07 (on dry weight basis) should be enough to meet the daily requirement. Values obtained in wild accessions were found to be lower than 3.635g 100 g^{-1} for *Solanum anguivi* (Oyeyemi *et al.*, 2015). However, they were higher than the value range of 0.43 to 0.60 g 100 g^{-1} for *S. melongena* (Jose *et al.*, 2013).

The amount of fibre, an essential component of the digestive process, was highest in accessions SMA003-02 and SMA003-05 (Table 2). This may be exploited in improving food quality of the crop. Dietary fibre is an important part of the digestive process; it traps carbohydrates during digestion, and thus keeps blood sugar levels in check. It reduces the risk of heart disease, by reducing cholesterol and regulates blood sugar and help against diabetes (Jenkins *et al.*, 2003).

Generally, the low amounts of crude fat observed in the different eggplant accessions (Table 2) indicates that eggplants constitute a poor source of fat, as similarly observed by Ossamulu *et al.* (2014), and may be useful in the formulation of diet for obese and individuals with cardiovascular challenges.

The wild accessions San 005-01, SA 002-07 and SA 002-08 contained high amount of ash (mineral elements) (Table 2) and can be selected as potential donors of this trait in future hybridisation programmes.

Mineral composition among accessions. The study revealed significant differences in mineral composition among the eggplant accessions (Table 3), similar to reports of several earlier workers in accessions of *S. anguivi*, *S. aethiopicum S. torvum* and *S. melongena* (Arivalagan *et al.*, 2013; Oppong *et al.*, 2015; Oyeyemi *et al.*, 2015). The extent of diversity determines the limit to selection for improvement of this trait.

In general, the wild accessions contained relatively higher amount of iron, zinc and copper compared to the cultivated accessions (Table 3), which values are considerably higher than those reported by Arivalagan *et al.* (2013) in *S. melongena*, and Kamga *et al.* (2013) in *S. aethiopicum* and *S. scabrum*. The wild accessions may thus, serve as parental materials for the introgression of these traits into cultivated ones.

By contrast, values obtained for potassium (3.583 mg 100 g^{-1}), calcium (0.196 mg 100 g^{-1}), phosphorus (0.78 mg 100 g^{-1}) and magnesium (0.257 mg 100 g^{-1}) were lower than those obtained by Arivalagan *et al.*, (2013); Auta and Ali, (2011) and Oyeyemi *et al.* (2015) in *S. melongena, S. incanum and S. anguivi*. Accessions SA 002-08 (wild), SA 002-11, SM 001-08 and SA 002-09 recorded the highest amount of potassium, calcium, phosphorus and magnesium, respectively.

No one particular eggplant accession was rich in all minerals studied (Table 3). Some accessions recorded high concentrations of specific minerals, but low concentrations of others and *vice versa*. This finding is similar to a report by Ayaz *et al.* (2015), who studied the nutritional and mineral composition of seven cultivars of eggplant. To improve these traits, a correlation between the two traits can be ascertained to give an idea of what breeding schemes to be used in the improvement of traits in the eggplant population. Such information can be obtained by the biplot analysis (Fig. 1). In a biplot analysis, the correlation coefficient between any two traits is the angle between the biplot axes from the origin to the related trait. Lines in opposite directions indicate negative correlation. The angle observed between iron, protein, ash, zinc and dry matter and; fibre, moisture and carbohydrate and; copper, manganese, carbohydrate and moisture were acute with positive associations (Fig. 1). However, angles between zinc and copper; iron and copper; carbohydrate and protein, ash and dry matter was obtuse with negative correlations. The angle between iron and protein and; dry matter and ash (10^o) indicate high correlations, with potential high response to selection of one trait by the other.

Antioxidant composition. Sources of variation in relation to phenolic concentration were identified among eggplant accessions (Table 4). The highest amount of phenols (210.0 mg GAE g^{-1}) was recorded by ST004-03; while SA002-02 had the lowest (171.10 mg GAE g^{-1}). These values are outside the range of 48.67 to 61.11 mg GAE g^{-1} reported by Somawathi *et al.* (2014) for *S. melongena* accessions; and those obtained by Jung *et al.* (2011) for calyx, leaf, peel, pulp and stem of *S. melongena*. However, Prohens *et al.* (2007) recorded a range of 122 to 134 mg kg^{-1} in *S. macrocarpon* and *S. aethiopicum,* respectively. The differences observed may be attributed to pre-harvest conditions such as, temperature, light intensity, soil type and fertilisation. High light intensity usually results in the accumulation of ascorbic acid. Lopez-Andreau *et al.* (1986) reported on lower ascorbic acid levels in green house grown tomatoes compared to those grown outdoor. Similarly, Rosales *et al.* (2006) showed that under greenhouse condition, the concentration of total ascorbate increased significantly with higher temperature.

Apart from wild accession (ST004-03), cultivated accessions (SMA003-06, SM001-08, SM001-03, SMA005-05, SM001-04), and SA002-06 showed high levels of total phenol. Plant phenols have received much attention as potential natural antioxidants due to their ability to act as both efficient radical scavengers and metal chelators. They are very important for plant-based foods (Upadhyay and Mohan, 2013). Phenolic compounds such as N-caffeoylputrescine, 5-caffeoylquinic acid, and 3-acetyl-5-caffeoylquinic acid have been identified in *S. melongena* pulp (Singh *et al.* 2009); while delphinidin-3-(*p*-coumaroyl-rutinoside) -5-glucoside was found in the peels (Noda *et al*., 2000). Other antioxidants such as quercetin, apigenin, kaempferol, and isorhamnetin have also been reported to be present in the leaves of *S. melongena* (Xiang-Min *et al*., 2014).

Accessions ST004-02 and ST004-03 had the lowest EC50 value (0.017 mg ml^{-1}) with antioxidant activity of 589 to 1400 mg g^{-1}; while the highest was observed in SA 002-08 (659.7 mg g^{-1}) and SA 002-01 (673.9 mg g^{-1}). The antioxidant activity was found to be relatively higher among wild accessions ST004-04, ST004-03 and San 005-01, suggesting that these accessions could play a significant role in the breeding of eggplant with improved medicinal properties (antioxidant traits). Similar findings were reported by Prohens *et al.* (2007), who observed that the related accessions of *S. macrocarpon* had the highest concentration of phenols compared to *S. melongena*. Further, the differences in scavenging activity observed among the 33 accessions may be due to the presence of different phenolic compounds and other antioxidants present in the extracts of the accessions. Somawathi *et al.* (2014) reported that scavenging activities are due to presence of phenolic compounds and other antioxidants in plants.

Principal components analysis of nutritional and antioxidant traits. The significant contribution of the characters moisture, dry matter, carbohydrate, protein, iron, ash and zinc and; phosphorus, magnesium, calcium, manganese and fibre and; fat and sodium to variations observed in the three principal components, respectively (Table 5), indicates the importance of these 14 traits to total genetic variability among eggplant accessions for the studied traits.

These characters could be employed in differentiating eggplant accessions for further breeding programmes to create more variability. A similar observation was reported by Saha *et al.* (2010), who studied the variability among 52 tomato genotypes using textual, nutritional and functional attributes.

The principal component analysis (Table 5) indicated that the first three principal components cumulatively accounted for 60.68% of the total variation among the 16 characters describing 33 eggplant accessions; which suggest that a larger portion of the observed variation is attributable to phenotypic effect. This result is in close conformity with the findings of Cericola *et al*. (2013) and Nwangburuka *et al*. (2014), who reported that the first three axes accounted 55.7 for eggplant and 64.32% for okra, of the total variation among the selected characters. However, Jose *et al*. (2013) and Sunseri *et al*. (2010) recorded a much higher value (74.7 and 74%) for the first two axes in case of *S. melongena* and; first three axes in case of *S. aethiopicum.*

Biplot analysis of nutritional and mineral composition. With regard to trait associations of proximate and mineral composition, different accessions exhibited variable responses to different traits (Fig. 1). For example, the wild accessions San 005-01, San 005-02 and SA 002-08; showed the best response for ash, dry matter and zinc. However, their responses were poor for carbohydrate and moisture. The high ash and dry matter contents observed suggest the availability of minerals and nutrients in these accessions, which is confirmed by the significantly high amount of iron (Table 3). Similarly, cultivated accessions, SM001-01, SM001-02, SM001-03, SM001-04 and SM001-07; showed good attributes of crude fibre and sodium (Fig. 1). But these accessions were negatively associated with phosphorus and calcium. The varied responses among the eggplant accessions and their association with various nutrient traits indicate that one trait could be used to predict the other. Traits that showed positive correlation could be improved concurrently. On the other hand, traits that exhibited negative association could be improved independently (Shegro *et al*., 2013). Wild accessions San 005-01, SA 002-07 and SA 002-08 were most divergent among the eggplant accession, and therefore, can be utilised as parent materials to introgress traits of interest into a desired cultivar and may also serve as a source of variation for future breeding work.

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