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Variability in Proximate Analysis of Twelve Selected Elite Pigeonpea Genotypes Across Varied Agro-Ecological Zones in Kenya

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Abstract
Pigeonpea [*Cajanus cajan* (L.) Millsp.] is a legume crop majorly grown in semi-arid tropics as a warm-season perennial that is depended on by more than a billion people mainly in Asia and Africa as their main source of protein. The study was carried out to assess variation in nutritional quality and determine influence of environmental factors on nutritional composition among 12 elite pigeonpea genotypes through proximate analysis based on AOAC official methods. The field experiment was conducted in four varied agro-ecological zones (Kabete, Kerio Valley, UoE and Kiboko) in randomized complete block design (RCBD).The genotypes and environment varied significantly ($P \leq 0.05$) for all the parameters measured except for lipids. The mean proximate composition results of the 12 pigeonpea genotype seed samples across the four environments were; moisture (9.597), lipids (1.948), ash (3.89), protein (21.049) and Carbohydrates (63.51) g/100g. Kabete and Kerio Valley scored the highest level of proteins (22.02 & 21.99 g/100 g) respectively while university of Eldoret recorded the least (19.4 g/100 g). The identified potential genotypes with high protein and ash content can be utilized in breeding for better nutritional quality to enhance nutritional and food security.
Keywords: Pigeonpea, malnutrition, food security, proximate analysis, agro-ecological zones

1. Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is a legume crop majorly grown in semi-arid tropics. It is a warm-season perennial that is depended on by more than a billion people mainly in Asia and Africa as their main source of protein (Saxena et al., 2002). It is an important grain that ranks among the five edible legumes that is used in intercropping systems, for food, fodder and firewood. Pigeonpea has the ability to withstand severe drought better than many legumes due to presence of deep roots and osmotic adjustment (OA) in the leaves that assist in maintaining cell turgor through accumulation of solutes (Subbarao *et al*., 2000). Apart from being drought tolerant, pigeonpea can do well even on poor soils in arid and semi-arid lands (ASAL) regions (Cheboi et al., 2015) and able to fix 40kg/ha of nitrogen due to their symbiotic relationship with rhizobia in their root nodules which improves soil fertility making better for cultivation of other crops (Oke, 2014).

Pigeon pea is wonderfully abundant in protein, making it an ideal supplement to traditional cereal-, banana- or tuber-based diets of most Africans which are generally protein-deficient (Chitra *et al*., 1996, Odeny, 2007). This has been considered as one of the best solutions to protein-calorie malnutrition in the developing world. Protein is a key nutrient for growth and development of children especially those under five years of age (Kinyua et al., 2016). If the quality and quantity are not met then protein malnutrition occurs which has serious irreversible consequences on the victims. Globally, 2.3 million children are malnourished. This is attributed to overdependence on starchy staples that provide nutrient which do not meet requirements especially for protein and energy in terms of quality and quantity and un-affordability of animal sourced proteins (Fasoyiro et al., 2013).

Pigeonpea green pods and dry peas are the most used in culinary but the dry peas are still underutilized in Africa. They contain about 25.83% proteins (Okpala & Ekwe, 2013) 65% of these constitute globulins (Saxena et al., 2010) with high levels of essential amino acids; methionine, lysine and tryptophan (Oke, 2014). This makes a key protein source for vegetarians. Despite the many benefits of pigeonpea, the commonly cultivated varieties have poor yields due to attack by insect pests like pod borer, pod sucking bugs and pod fly (Cheboi et al., 2016).

Earlier study by Cheboi et al., 2016 reported three tolerant genotypes among 16 genotypes evaluated for insect pest complex resistance however, their nutrient composition is not known. Therefore, this study aims at finding out the proximate composition of the pod borer tolerant pigeonpea genotypes in comparison with the susceptible and the commercial checks and asses the influence of environmental factors on nutritional composition in different agro-ecological zones. This will enhance food and nutritional security through selection of suitable parents for improved nutritional quality hence improved livelihood.

2. Materials and Methods

2.1 Sampling sites

The twelve genotypes were grown at four different agro-ecological zones (**Fig. 1**). The seed samples were collected from the four varied sites after harvesting for proximate analysis in the laboratory. Kerio valley (Elgeiyo/Marakwet County) is situated at 1°35″ S and 36°66″E. It has an altitude of 1890 m above sea level (A.S.L) with an average annual rainfall mean of 600mm. The average temperature of the area range 16-30^{0}C. Their soils are Vitric andosols. Kabete (Kiambu county) receives a temperature ranging 16 -23 ^{o}C, with friable clay with acid humic top soils with an elevation of 900-1500 m. a. s. l and receiving mean rainfall of 1000 mm per annum. University of Eldoret (UoE) field is located in Uasin Gishu County. It is located 0° 30′ 0″ N, 35º 15′ 0″ E at an elevation of 2180 meters A.S.L. Average annual rainfall is 850mm and mean temperature of 16.6°C. UoE Soils are Ferrassols with low level of Nitrogen, Phosphorus and Potassium. Kiboko (Makueni) is situated 37^{o}40′E, 2^{o}10′ 2^{o}S at an elevation of 975 m A.S.L. It receives an average rainfall of 545-629 mm and mean temperature of 22.6. Their soil is classified as Acri-Rhodic Ferrassols (Jaetzold and Schmidt, 1983).

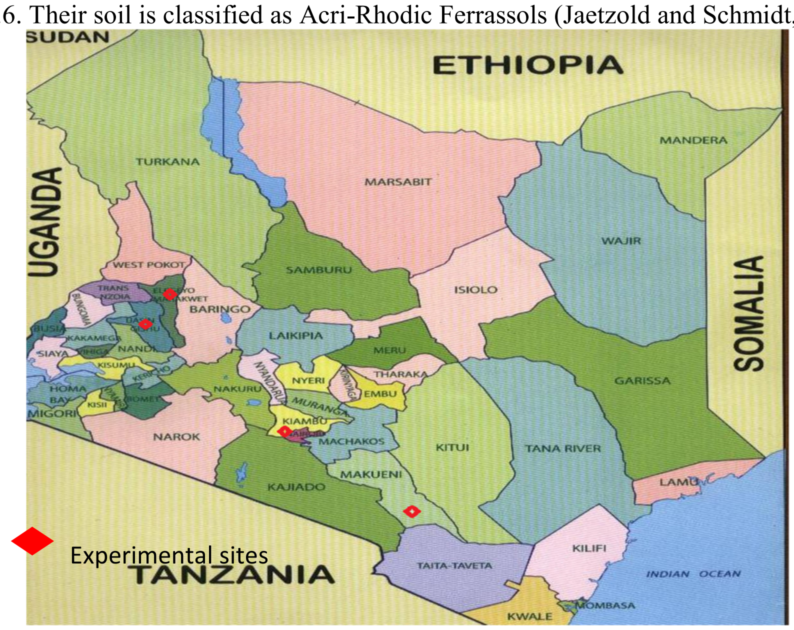

Figure 1. Map of Kenya showing four varied experimental sites for sample collection

2.2 Sample Preparation for proximate analysis

Dried peas were milled using a laboratory miller (Powerline®, BM-35- Kirloskar, India) fitted with a 2.0 mm opening screen to make fine flour. Samples and their controls were analyzed in triplicates for moisture content, crude fat, crude protein, ash and carbohydrates.

2.2.1 Moisture content

Moisture content of the pigeon peas flours was determined using the oven-drying procedure (AOAC, 2000: AOAC, 1995) Method 934.01. About 2 g of the samples was dried in the oven at 105^{0}C for 3.5 hrs. then, cooled in a desiccator and weighed. Moisture content was obtained by calculating loss in weight as a percentage of the initial weight.

2.2.2 Lipids

Lipids were determined based on the Sox let extraction method (AOAC, 2000: AOAC, 1995) Method 920.29. Samples of 2 g of pigeon peas flour samples was weighed into an extraction thimble and fitted into an extracting column. Fat was extracted for about 8 hours using petroleum ether (40-60^{0}C). The extract was then dried in an oven at 105^{0}C for 30 minutes, cooled in a desiccator and weighed. Total fat was obtained by calculating the change in weight of the flask then expressing as a percentage of the initial weight.

2.2.3 Crude Protein

Crude protein content (N× 6.25) was determined by the Kjedahl digestion method of the AOAC International (1995) Method 992.23. The sample (0.3 g) was weighed into a digestion flask, 0.5 g of selenium catalyst and 25 ml of concentrated H_2SO_4 added and shaken to mix and placed in the heating block at 370-400^{0}C for about 60-90 minutes or until the contents turned clear. Then in 0.2 ml of the digested sample, 5ml of a previously prepared N1 mixture was added and allowed to stand for about 15 minutes before 5ml of N2 is added. The mixture was further, allowed to stand for one hour for colour development (blue) then read using spectrophotometer at 650 nm absorbance. The absorbance value was used to read off the % N from a graph plotted using standards (Okalebo et al., 2002) and calculated using the formula below and calculated total protein by multiplying with a factor of 6.25.

$$\% \text{ Nitrogen} = \frac{(a-b) x \, v \, x \, 100}{1000 \, x \, w \, x \, al \, x \, 1000} \quad (1)$$

Where
a = Concentration of N in the solution
b = Concentration of N in the blank
v = Total volume at the end of analysis procedure
w = Weight of the dried sample and
al = Aliquot of the solution taken.

2.2.4 Ash content

Ash content of the samples was determined by (AOAC International, 1995) Method 923.03. Two (2.0) g of each sample was weighed into a previously dried and weighed porcelain crucible and burnt in a Muffle furnace at 600^0C for 6 hours. The ash content was obtained as weight of the residue expressed as a percentage of the initial weight of the sample.

2.2.5 Carbohydrate content

Carbohydrate content was determined by subtracting the sum of weights of protein, lipid and ash from the total dry matter.

$$(\mathbf{CH_2O})_\mathbf{n} = \mathbf{Organic\ matter}\ (\%) - \{\mathbf{Protein}\ (\%) + \mathbf{Lipid}\ (\%) + \mathbf{Ash}\ (\%)\} \quad \mathbf{(2)}$$

2.3 Statistical analyses

The proximate values for the pigeonpea genotypes were done in triplicates and subjected into analysis of variance (ANOVA) and means separated using Fisher's least significant difference (LSD) test using SAS version 9.1 Software (SAS, 2008).

Results and discussion

3.1 Variation in proximate composition of 12 pigeonpea genotypes in four varied environments

The 12 genotypes varied significantly in different environments in nutritional composition. However there was no significant difference in lipids composition among the genotypes across the four varied environments. This explains that lipid composition is not influenced by environmental factors. The variation within and between genotypes can be explained by their variances in genetic makeup and environmental effect.

In University of Eldoret field, all genotypes recorded significant results in moisture content at 116% difference between ICEAP00557 a susceptible genotype recording low value (4.2 g/100g) and ICEAP01541 tolerant genotype recording high value (9.1 g/100 g) and a mean of 7.09 g/100g (**Table 1)**. Bamidele & Akanbi (2013) reported similar findings at 7.99 g/ 100 g. This variation among genotypes could be due to the differences in time taken from harvesting to analysis and quality of drying. Moisture content is a determinant of storage stability of foods as foods with very high moisture contents spoil faster and compromise seed viability.

Lipid contents varied significantly among the genotypes. ICEAP 01150 a moderately susceptible genotype recorded low levels (1.23 g/100 g) and KAT 60/8 a susceptible check recorded the highest value (3.05 g/100 g) about three times higher. Differences in lipid contents could be because of different characteristics of each genotype. Fasoyiro et al. (2013) in their study found the pigeonpea to contain 3.06 g/100g while Adebayo et al., (2012) found a range of between 1.67 g- 2.28 g/100 g. Findings from these two studies were similar to the current study however these are very low values based on the fact that legumes store more of their energy in form of fat/lipids.

There were significant differences in ash contents among the twelve genotypes (**Table 1**). This depicted a 53.1% difference between ICEAP 00850 resistant check which recorded the lowest value (3.5 g/ 100g) and Mthawajuni tolerant genotype (landrace) which recorded the highest value (5.36 g/100 g). Bamidele and Akanbi (2013) reported a value of 3.62 g/100 g, Kaushal et al., 2012 also reported similar results to this study, a mean of 3.05 g/100g. This explains the high amount of minerals found in pigeonpea.

Proteins contained in the 12 varieties were significantly different with a range of 17.69 – 21.25 g/100 g for ICEAP01154/2 (tolerant) and ICEAP01150 (moderately susceptible) respectively showing a 20 % difference. Fasoyiro et al (2013) and Saxena et al., 2010 found similar protein contents of pigeonpea at 21.41 g/100 g and 18.8 g/100g, however finding by Onweluzo & Nwabugwa (2009) were significantly lower (9. 43) g/100 g. These differences could be attributed to genotype as well as environmental factors that influence nitrogen availability which includes soil PH, temperature and rainfall that determine maturity period of the plant. The low variation (20%) between the genotypes explains that pigeonpea are rich in protein and the trait is controlled by the genes.

Carbohydrate contents among the 12 genotypes differed significantly. The variations showed a 13.8% differences among the 12 genotypes in their carbohydrate contents, MZ 2/9 (landrace) had the least content (63.33 g/ 100 g) while ICEAP0068 (moderately susceptible) recorded the highest (72.1 g/ 100 g). Mula & Saxena (2010) found 70.8 g /100 g while Okpala & Okoli (2011) reported 69.43 g/100 g which was similar to findings of the current study. The variation between the genotypes is also low (13.8%) making pigeonpea a good source of energy and can be utilized by both humans and animals as animal fodder

Table 1: Means for proximate composition of 12 elite pigeonpea genotypes from University of Eldoret field

	Genotype	Moisture	Lipids	Ash	Proteins	CHO
1	ICEAP 01541	9.1a	2.2bc	3.90b	21.01a	63.79g
2	ICEAP 01154/2	8.65ab	2.45ab	3.78b	**17.69c**	67.44de
3	ICEAP 00902	8.0bc	1.23d	3.88b	17.83c	60.08b-d
4	ICEAP 00850	7.7cd	1.25d	3.5b	17.85c	69.68bc
5	ICEAP 00554	4.8fg	1.93b-d	4.05b	19.34b	69.90b
6	ICEAP 00068	5.1ef	1.23d	3.6b	17.98c	72.10a
7	ICEAP 00557	4.2g	1.55cd	3.88b	19.59b	70.79ab
8	KAT 60/8	5.9e	3.05a	3.58b	19.64b	67.84c-e
9	ICEAP 01150	7d	1.23d	3.75b	21.25a	66.78ef
10	Mthawajuni	8.38a-c	2.35ab	5.36a	20.10ab	63.82g
11	MZ 2/9	8.38a-c	2.08bc	5.23a	20.99a	63.33g
12	UGACC 22	7.9bc	2.4ab	5.15a	19.62b	64.94fg
	Grand Mean	**7.09**	**1.91**	**4.13**	**19.4**	**67.45**
	Genotype	***	*	**	***	***
	CV%	**5.34**	**16.77**	**6.46**	**2.81**	**1.3**
	Lsd	**0.83**	**0.71**	**0.59**	**1.2**	**1.93**
	Std. Dev.	**1.65**	**0.63**	**0.69**	**1.34**	**2.96**

Values are means of three replicates. Values in the same column not followed by the same letter are significantly different at 5% level of significance. *** Significantly different at (P≤ 0.001),* (P≤ 0.05) and ** (P≤ 0.01)

Kerio Valley pigeonpea seeds showed significant different results among the 12 genotypes. Moisture content recorded a range of 9.1 -11.4 g/100g, lipids 1.63 -2.95 g/100 g, ash 3.03 -4.88 g/100 g, proteins 19.83 g-23.62 g/100g while carbohydrates 58.84 g-64.99 g/100 g **Table 2**.

Table 2: Means for proximate composition of 12 elite pigeonpea genotypes from Kerio valley

	Genotype	Moisture	Lipids	Ash	Proteins	CHO
1	ICEAP 01541	10.10b	2.95a	3.38de	22.51ab	61.06b-d
2	ICEAP 01154/2	10.85ab	1.68b	3.03e	22.63ab	61.83bc
3	ICEAP 00902	10.12b	1.83b	3.5d	22.16a-c	62.40a-c
4	ICEAP 00850	10.17b	1.73b	3.7cd	20.66b-d	63.75ab
5	ICEAP 00554	10.75ab	2.25ab	3.53cd	22.19a-c	61.28b-d
6	ICEAP 00068	10.15b	1.63b	3.43d	23.62a	61.18b-d
7	ICEAP 00557	11.40a	1.78b	3.9c	23.36a	59.57cd
8	KAT 60/8	9.10c	2.4ab	3.68cd	19.83d	64.99a
9	ICEAP 01150	10.05bc	2.95a	4.68ab	23.48a	58.84d
10	Mthawajuni	10.37b	2.35ab	4.88a	20.52cd	61.88bc
11	MZ 2/9	10.37b	2.08ab	4.72a	22.67a	60.16cd
12	UGACC 22	9.90bc	2.4ab	4.32b	20.24cd	63.14ab
	Grand Mean	**10.28**	**2.17**	**3.89**	**21.99**	**61.67**
	CV%	**4.27**	**8.66**	**4.43**	**4.05**	**2.08**
	Genotype	*	**NS**	***	**	*
	Lsd	**0.97**	0.9	**0.38**	**1.99**	**2.85**
	Std. Dev.					

Values are means of three replicates. Values in the same column not followed by the same letter are significantly different at 5% level of significance. *** Significantly different at (P≤ 0.001), ** (P≤ 0.01), *(P≤ 0.05) and NS (not significantly different)

Similarly, significant variation was observed among the twelve pigeonpea genotypes grown at Kabete except for lipids where there was no significant variation observed. Individual proximate values were as follows; moisture 9.43 -11.35g/100 g, lipids 1.6 – 2.5 g/100g, ash 3.2 -4.38 g/100g, protein 19.69 - 24.53g/100g and carbohydrates 59.99 -64.03 g/100 g **Table 3**.

Table 3: Proximate composition means of 12 elite pigeonpea genotypes from Kabete experimental site

	Genotype	Moisture	Lipids	Ash	Proteins	CHO
1	ICEAP 01541	9.525d	1.975ab	3.2e	24.58a	60.72d-e
2	ICEAP 01154/2	11.28a	2.5a	3.25de	19.69f	63.22ab
3	ICEAP 00902	10.7b	1.75ab	3.4c-e	21.87c-e	62.28a-d
4	ICEAP 00850	11.35a	1.33b	3.3e	20.35ef	63.68a
5	ICEAP 00554	10.33bc	2.13ab	3.125e	21.17d-f	63.26ab
6	ICEAP 00068	10.8ab	1.6ab	3.5c-e	21.14d-f	62.96a-c
7	ICEAP 00557	9.43d	1.7ab	3.88a-c	24.53a	60.28e
8	KAT 60/8	9.88cd	2.13ab	3.33de	20.97d-f	63.71a
9	ICEAP 01150	9.55d	2.45a	4.18ab	23.84ab	59.99e
10	Mthawajuni	9.88cd	1.85ab	4.38a	22.24b-d	61.66b-e
11	MZ 2/9	9.88d	1.57ab	4.23ab	23.15a-c	61.18c-e
12	UGACC 22	9.4d	1.9a	3.83b-d	20.84d-f	64.03a
	Grand Mean	**10.16**	**1.92**	**3.64**	**22.02**	**62.25**
	Genotype	***	**NS**	***	***	***
	CV%	**2.56**	**22.04**	**6.54**	**3.85**	**1.33**
	L.S.D	**0.572**	**0.933**	**0.524**	**1.87**	**1.829**
	Std. Dev.	**0.716**	**0.4476**	**0.46**	**1.714**	**1.517**

Values are means of three replicates. Values in the same column not followed by the same letter are significantly different at 5% level of significance. *** Significantly different at (P≤ 0.001), and NS (not significantly different).

Results from Kiboko differed significantly with a range of; moisture (9.1 - 10.1 g/100 g), lipids (0.95 - 2.28 g/100g), ash (3.02 - 4.72 g/100 g), proteins (18.27 - 23.23 g/100g) and carbohydrates (59.2 - 64.95 g/100g) as shown in **Table 4.**

Table 4: Proximate composition means of 12 pigeonpea genotypes from Kiboko experimental site

	Genotype	Moisture	Lipids	Ash	Proteins	CHO
1	ICEAP 01541	11.37bc	0.95b	3.38de	23a	61.31b-d
2	ICEAP 01154/2	12.35a	1.68ab	3.02e	18.27c	64.67a
3	ICEAP 00902	10.1d	1.83ab	3.5d	19.60bc	64.95a
4	ICEAP 00850	10.81cd	1.73ab	3.7cd	20.12bc	63.55a-c
5	ICEAP 00554	10.75cd	2.25a	3.52d	18.72c	64.76a
6	ICEAP 00068	10.15d	2.12a	3.43d	21.28ab	63.0a-c
7	ICEAP 00557	11.4bc	2.28a	3.9c	23.23a	59.20d
8	KAT 60/8	9.1e	1.40ab	3.67cd	21.71ab	64.12ab
9	ICEAP 01150	11.73ab	1.45ab	4.68ab	21.59ab	60.56cd
10	Mthawajuni	10.38d	1.85ab	4.88a	19.91bc	62.99a-c
11	MZ 2/9	10.38d	2.12a	4.72a	21.57ab	61.20b-d
12	UGACC 22	11.73ab	1.9ab	4.33b	20.19bc	61.86a-d
	Grand Mean	**10.86**	**1.79**	**3.89**	**20.77**	**62.68**
	Genotype	***	**ns**	***	**	*
	CV%	**3.46**	**5.38**	**4.27**	**4.68**	**2.28**
	LSD	**0.83**	**1**	**0.36**	**2.14**	**3.14**
	Std. Dev.	**0.91**	**0.49**	**0.6**	**1.66**	**2.06**

Values are means of three replicates. Values in the same column not followed by the same letter are significantly different at 5% level of significance. *** Significantly different at (P≤ 0.001), ** (P≤ 0.01), *(P≤ 0.05) and NS (not significantly different).

3.2 Influence of environmental factors on proximate composition among 12 pigeonpea genotypes in varied agro-ecological zones

Combined means for the twelve pigeonpea genotypes cultivated at four different agro-ecological zones show that environmental factors significantly affect nutritional composition. The variation percentage for the results were as follows; moisture 26% (8.49 g-10.78 g), lipids 48% (1.51g-2.24 g), ash 48% (3.29 - .4.87 g), proteins 16% (19.56g-22.78 g), carbohydrates 6% (61.49g-65.17 g) **Table 5**. Environment effect was significantly high (P≤0.001) for most of the parameters analyzed except for lipids where the effect was low (P≤0.05). Similarly, Genotype environment interaction (G*E) significantly influenced proximate composition except for lipids.

The variations among the genotypes in varied environments might have been contributed by the varied environmental factors; altitude, latitude, rainfall, soil type and temperature that affect growth and development of the plant. Pigeonpea is sensitive to photoperiods which may influence flowering, seed filling and crop maturity as explained by Silim et al., 2007.

Table 5: Mean proximate composition of the twelve genotypes across four varied sites

	Genotype	Moisture	Lipids	Ash	Protein	CHO
1	ICEAP 01541	10.02b	2.02ab	3.46de	**22.78a**	61.72de
2	ICEAP 01154/2	**10.78a**	**2.15a**	3.29e	19.56d	**69.29a**
3	ICEAP 00902	9.74bc	1.66bc	3.57d	20.36b-d	64.68a
4	ICEAP 00850	10.01b	1.51c	3.56d	19.77dc	65.16a
5	ICEAP 00554	9.16d	2.14a	3.56d	20.35b-d	64.8a
6	ICEAP 00068	9.05d	1.64bc	3.49de	21b	64.82a
7	ICEAP 00557	9.11d	1.88a-c	3.88c	22.68a	62.46c-e
8	KAT 60/8	**8.49e**	**2.24a**	3.56d	20.54bc	65.17a
9	ICEAP 01150	9.58c	2.02ab	4.32b	22.54a	61.54de
10	Mthawajuni	9.75bc	2.1a	**4.87a**	20.69b	62.59cd
11	MZ 2/9	9.75bc	1.96ab	4.73a	22.09a	61.47e
12	UGACC 22	9.73bc	2.15a	4.4b	20.22bd	63.49bc
	Mean	**9.597**	**1.948**	**3.89**	**21.049**	**63.51**
	CV	**3.71**	**6.52**	**5.49**	**3.96**	**1.73**
	Genotype	***	***	***	***	***
	Environment	***	*	***	***	***
	G*E	***	*	***	***	***
	LSD	**0.35**	**0.402**	**0.214**	**0.839**	**1.1**

Values are means of three replicates. Values in the same column not followed by the same letter are significantly different at 5% level of significance. *** Significantly different at (P≤ 0.001), ** (P≤ 0.01), *(P≤ 0.05) and NS not significantly different.

Generally, Kabete and Kerio Valley scored the highest level of proteins (22.02 & 21.99 g/100 g) respectively while university of Eldoret recorded the least (19.4 g/100 g). University of Eldoret is characterized with acidic soil which limits nitrogen availability which is a building block for proteins while Kabete and Kerio Valley are potential areas for medium duration pigeonpea characterized with good soil and warm environment. However, highest ash content was recorded at university of Eldoret (4.13 g/100 g) while Kabete recorded the least (3.64 g/100 g) **Table 6**. Witten et al. (2016) also reported variation in nutrient content due to cultivation in different environments. This could be due to the environmental and soil factors which were varied from site to site. According to Honrick (1992), a number of factors affect nutritional quality of crops for instance, soil PH, available nutrients, organic matter content and soil water relationship, weather and climate factors including temperature , rainfall, light intensity in addition to the crop variety and post- harvest handling. These factors affect growth and development of pigeonpea hence influences the nutritional quality.

Table 6: Variation in proximate composition means in the four varied experimental sites

Sites	Moisture	Lipids	Ash	Proteins	CHO
UoE	7.09a	1.91a	4.13a	19.4c	67.45a
Kerio Valley	10.28c	2.17a	3.89b	21.99a	61.67b
Kabete	10.16d	1.92a	3.64c	22.02a	62.25b
Kiboko	10.86b	1.79a	3.89b	20.79b	62.68b
Mean	**9.597**	**1.94**	**3.89**	**21.04**	**63.51**
CV%	**3.71**	**6.52**	**5.49**	**3.96**	**1.73**
Lsd	**0.35**	**0.402**	**0.214**	**0.839**	**1.1**

Values are means of three replicates. Values in the same column not followed by the same letter are significantly different at 5% level of significance.

4. Conclusion

This study shows that pigeonpea seeds have high protein and ash content which may be useful in addressing protein energy malnutrition. In addition, the findings also demonstrate that genotypes perform differently in different environments and there is much influence from environmental factors on nutritional quality. These environmental factors directly or indirectly influence the nutrient content of crops by affecting nitrogen availability in the soil. The increase in ash content among the genotypes is also essential in mineral composition which is good to human health. Therefore, potential genotypes with high protein and ash content can be selected for utilization in breeding for improved nutritional and food security. The high carbohydrate content, crude protein makes it not only important to the human diet, but also suitable as high protein feed and fodder ingredient to livestock.

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