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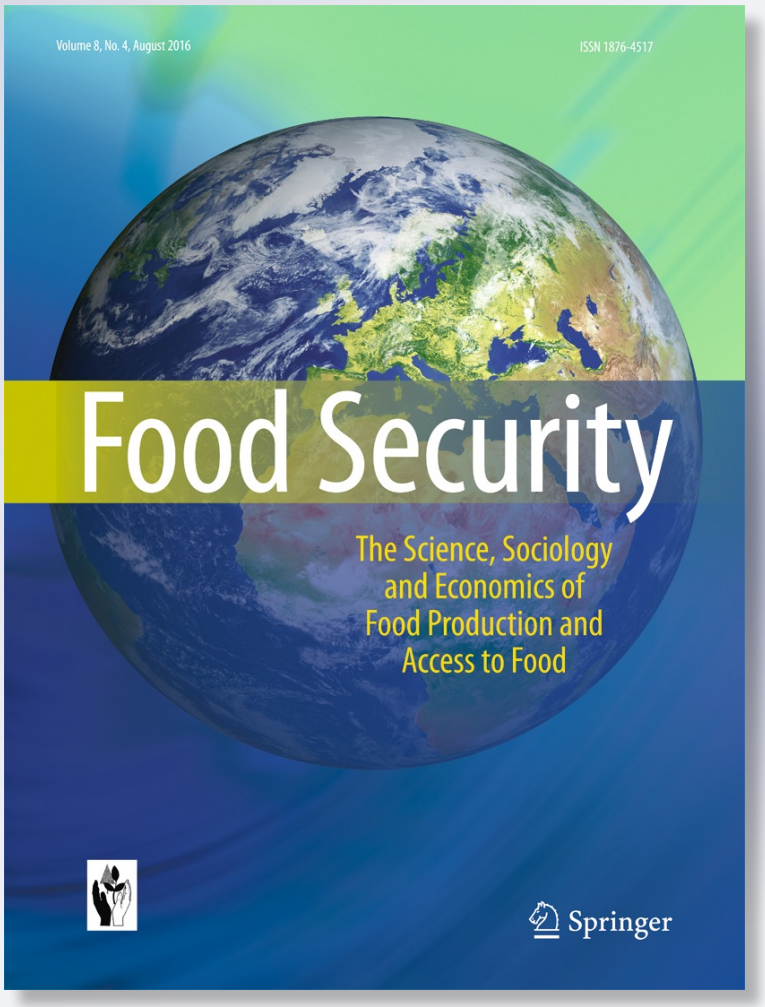

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ORIGINAL PAPER

Cultivar preference and sensory evaluation of vegetable pigeon pea (*Cajanus cajan*) in Eastern Kenya

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Abstract Pigeon pea is an important crop in the dry regions of Eastern Kenya because of its drought tolerance and high protein content. Preference and acceptability of 12 vegetable pigeon pea cultivars of medium duration to maturity were evaluated by consumers and farmers in Eastern Kenya on the basis of six seed parameters: color, appearance, taste, aroma, tenderness and overall acceptability. They were scored on a hedonic scale of 1–7, where 1 = highly unfavorable to 7 = highly favorable. Significant differences ($P < 0.05$) in the six parameters were recorded, the cultivars ICEAP 00068, ICEAP 00540, ICEAP 00554, ICEAP 00902, KAT 60/8 and MZ 2/9 being preferred. As production of pigeon pea and other grain legumes increases, incorporation in selection processes of cultivar preferences/acceptability, organoleptic properties, post-harvest processing and utilization to preserve nutritional qualities could greatly improve adoption and therefore food security and livelihoods of resource-constrained farmers and consumers. Such a development would increase the consumption of pigeon pea and therefore enhance the nutrition intake and food security in the dry regions of Eastern Kenya.

Keywords *Cajanus cajan* · Pigeon pea · Cultivar acceptability · Sensory · Preference

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Introduction

Pigeon pea is mainly cultivated by smallholder farmers in arid and semi-arid agricultural lands, where rainfall is marginal, and is used primarily as a source of food, nutrition and income generation (Mergeai et al. 2001a). It is consumed in many forms but mostly as a complement in cereal-based diets in many parts of Kenya particularly in the Eastern, Central, and Coastal regions (Kimani et al. 1994). Besides its nutritional value, pigeon pea also possesses various medicinal properties due to the presence of a number of polyphenols and flavonoids (Saxena et al. 2010). Cultivars developed for vegetable pigeon peas are grown using normal crop or agronomic practices, but pods are harvested at the appropriate stage of maturity for use as vegetable pigeon pea (Singh et al. 1984). When the crop is harvested at maturity, pigeon pea is either shelled manually prior to selling to consumers in small quantities in domestic markets or sold in-shell in certain target retail markets (Shiferaw et al. 2008). The quality requirements in the domestic vegetable pigeon pea markets are limited to physical attributes, which are assessed through physical inspection (Shiferaw et al. 2008).

Previous analysis of consumer demand for pigeon pea focused primarily on morphological characteristics of raw seeds (Mkanda et al. 2007). Visible characteristics of uncooked seeds, however, are not a reliable measure of cooking quality. It has been hypothesized that the location of pigeon pea cultivation (soil types, agronomic practices and environment) may affect the cooking quality of legumes by changing their structure (Yeung 2007). Also climate, soil type, moisture, and other factors may interact with genetic factors to produce cowpeas of varying cooking quality (Yeung 2007). Lentil cultivars differed significantly ($P < 0.05$) in their cooking times when grown in different soil types (Illadis 2003) but genotype affected variation in cooking time more than environmental

conditions. Human sensory data provide a good model and estimate of how consumers will react to food as these can account for both the product properties and the interpretation of these properties by consumers (Lawless and Heymann 2010). As improved pigeon pea cultivars are developed to overcome the challenges of biotic constraints and yield improvement, consumer preferences of pigeon pea products must be considered at an early stage in the breeding process in order to enhance cultivar adoption.

There is limited published data on the description of sensory properties of vegetable pigeon pea cultivars or cultivars that are currently grown by farmers in the Eastern region of Kenya. Consumer and farmer preferences or lack of preferences, morphological or physical attributes, cooking characteristics, flavor and texture have not been appropriately documented. Therefore, the objective of this study was to determine the acceptability and preference for vegetable pigeon pea cultivars of medium duration among the farmers and consumers of the Eastern region of Kenya, using sensory characteristics.

Materials and methods: study sites and cultivars

The study was conducted at the Kenya Agriculture and Livestock Research Organization's Kiboko station and Kambi ya Mawe sub-station between October 2012 and August 2013. Color and weight of seeds of 12 pigeon pea cultivars (ICP 7035B, ICEAP 00068, MTHAWAJUNI, MZ 2/9, KAT 60/8, ICEAP 00540, ICEAP 00557, ICEAP 00911, ICEAP 00902, ICEAP 00554, ICEAP 00850 and Kionza), which were of medium duration to maturity, were evaluated for sensory and organoleptic (taste) characteristics in this study (Table 1). Kionza, a local genotype, grown by many farmers in the region for both grain and green vegetable pea due to its early maturation was used as a control.

Agronomic practices and management

The cultivars were grown under rain-fed and supplementary irrigation at Kambi ya Mawe and Kiboko locations, respectively. Normal agronomic practices recommended for the two locations were followed. The seed was drilled in the furrow and thinned to one seedling per hill, 2 weeks after germination at a spacing of 30 cm. Field plots were maintained weed-free by hand hoeing as needed. No fertilizers were applied to the crop as was the practice reported previously (Silim et al. 2006; Nganyi 2009). The crop was protected from pests, such as termites, pod borers, pod suckers, and pod flies by applying pesticides during the cropping cycle. Termites (*Odontotermes spp.* and *Microtermes. spp*) were prevalent during the months of January and February of 2013 when ambient temperatures were high, mainly at Kambi ya Mawe. They were controlled using imidacloprid (Bayer Crop Sciences AG, Monheim, Germany) and chlorpyrifos (Dow AgroSciences, Hertfordshire, U.K.), a broad-spectrum, non-systemic pyrethroid at the rate of 30 ml/20 l of water and applied to cover the foliage of the crop twice a month for the 2 months of the growing season. Pod suckers (*Riptortus dentipes* F. and *Clavigralla* spp.) and pod flies (*Melanogromyza obtusa* (Malloch)), the major pigeon pea pests in the region (Minja et al. 1999), were controlled by application of broad-spectrum non-systemic, pyrethroid alpha-cypermethrine and dimethoate, a systemic organophosphate. Cypermethrine was applied at the rate of 1.25 l ha^{-1} equivalent to 25 ml /20 l of water, while 35 ml of dimethoate (Cheminova A/S, Lemvig, Denmark) was applied at the rate of 1.50 l ha^{-1}, equivalent to 35 ml in 20 l of water. The pesticides were applied uniformly using a 20 l knapsack sprayer, when appropriate. The need for spraying was determined by assessing insect presence and damage, through field scouting on a weekly basis.

Panelist selection and training

Women farmer panelists, drawn from Kwagathoga village located near the Kambi ya Mawe Research Station, were mobilized a week prior to the actual testing of the crop samples in February 2013. On the evaluation day, a group of women ($n = 50$) aged 25 to 56 years, responded. Preliminary screening of regular consumers of fresh pigeon peas was conducted, based on the presence or absence of allergy to any type of food. The consumers that met the initial screening test and did not possess any allergy to pigeon pea food were then trained on the physical and sensory assessments of vegetable pigeon peas, before the organoleptic and sensory testing began under the supervision of a panel leader. This was conducted during the crop season, lasting from emergence to maturity. Mock sensory assessments involving three cultivars with different colors, seed size and taste were presented to the panelists. Finally, panelists ($n = 25$) were selected. The selection was based on how well they understood the assessment process, and how accurately they filled in the questionnaire. The same participants were called upon to participate in the subsequent evaluation during the ratoon season i.e. the crop that emerged from re-growth of the previous crop without replanting in July, 2013.

In addition to the above sensory evaluation test, panelists drawn from the Department of Food Science and Nutrition at the University of Nairobi participated in the evaluation of July, 2013. On the day of evaluation, 13 staff (5 males and 8 females) were trained in the physical and sensory characteristics of vegetable pigeon peas, before the assessments began under the supervision of the panel leader. Sensory testing, as previously described, was presented to the team as a mock test for

Table 1 Genotype characteristics of pigeon pea accessions based on seed color and seed weight at two locations in Eastern Kenya

Cultivars	Seed color	Seed weight (g/100 seeds)[a]	
		Kambi ya Mawe[b]	Kiboko[b]
ICP 7035B	Brown /Bronze and speckled	25.2	25.8
ICEAP 00068	Green	24.9	26.2
ICEAP 00850	Light green	21.5	24.6
ICEAP 00554	Green	21.0	25.5
ICEAP 00557	Green	23.1	25.9
ICEAP 00540	Green	22.9	24.9
KAT 60/8	Pale green	22.9	23.9
MTHAWJUNI	Dark purple and speckled	28.8	30.4
MZ 2/9	Dark brown/Bronze	35.9	35.6
ICEAP 00911	Pale green	21.8	24.8
ICEAP 00902	Pale green	23.8	23.9
Kionza	Green, brown ringed helium	24.6	26.5
Mean seed weight		24.6	26.5
$LSD_{(0.05)}$		2.47	2.35

[a] Seed weight was quantified on 100 seeds randomly sampled, counted and weighed

[b] Locations in which the agronomic experiments and sensory evaluations were conducted during the crop season (main cropping cycle - October 2012 to March 2013) during which pigeon peas are seeded and cultivated and the ratoon season (crop that emerges from re-growth of previous plant stubbles without replanting – April to August, 2013)

selection of the final team. Seven panelists (2 male and 5 female), were ultimately selected, based on how well they understood the process and how accurately they filled in the questionnaire. They were aged 25–47 years and were not allergic to any food.

Sample preparation

Fresh pods from each plot were harvested and shelled early in the morning of evaluation with women farmer panelists from Makueni, and in the afternoon for evaluation with panelists drawn from the Department of Food Science and Nutrition. Fresh pods were harvested separately from both locations and threshed. After mixing thoroughly, triplicate samples of 200 g were packed in cool boxes containing ice (4 ± 1 °C) in order to minimize degradation before testing (Onyango and Silim 2000). In Makueni, three women experienced in cooking vegetable pigeon peas, were engaged in cooking the samples until softness was attained, based on normal practices. Samples were tested for being fully cooked by chewing seeds and evaluating particle size, based on previous methods (Fasoyira et al. 2005).

Sensory evaluation

Sensory evaluation was carried out three times. The first evaluation was conducted by panelists consisting of 10 women farmers during the cropping season in Makueni. In this case, they evaluated 11 pigeon pea cultivars with the exception of Kionza, a local genotype which was not mature at the time of evaluation. The second evaluation was done again with a group of panelists comprising 25 women farmers in Makueni during the ratoon season. Additionally, 7 panelists, drawn from the Department of Food Science and Nutrition Laboratory at the University of Nairobi, conducted another evaluation. Cooked samples were served in duplicates following established procedures and presented to panelists (MellGaard et al. 1991; Bainbridge et al. 1996). Panelists rinsed their mouths after testing each genotype to reduce the lingering taste of the previous genotype. The farmer sensory panels were comprised of the same panel members for both the cropping cycle and ratoon seasons, thus enabling comparison of all cultivars for both seasons. A preset questionnaire (Watta et al. 1989) was used to measure the intensity of individual reactions to the traits of the genotypes on a hedonic scale of 1–7 where 1 = very highly unfavorable, 2 = highly unfavorable, 3 = moderately unfavorable, 4 = neither favorable nor unfavorable, 5 = moderately favorable, 6 = highly favorable and 7 = very highly favorable: the traits were color, appearance, taste, aroma, tenderness (chewing and hand feel) and overall acceptability.

Data analysis

The descriptive sensory determination was conducted in duplicates in three evaluations. Genotype, location of cultivar growth, panelists and their interactions were evaluated by

analysis of variance (ANOVA), based on a 5 % level of significance using GENSTAT 14th edition (Payne et al. 2011). The mean values of the cultivars for each parameter were compared by Tukey's test at ($P < 0.05$).

Results

Seed appearance of pigeon peas

The appearances of cooked vegetable pigeon peas were evaluated by farmers and consumers during the crop and ratoon seasons. There were significant differences ($P < 0.05$) among the cultivars with respect to seed appearance, based on farmers' evaluation during the crop and ratoon seasons, and by consumers at the ratoon cycle at both locations (Table 2). The sensory evaluation by consumers varied significantly ($P < 0.01$) between locations during the crop and ratoon cycles at both locations. Interaction between locations and genotype (L x G) was significant ($P < 0.01$) during crop and ratoon seasons and consumer evaluation. The interactions of cropping seasons and cultivars (G x S) was significant ($P < 0.01$) at both locations. Combined analysis indicated that interaction between G x L and G x S were significant (Table 2). This suggests that seed appearance of pigeon pea cultivars may not be determined by the genetic factors only, but by also environment.

Sensory evaluation for seed appearance by farmers during crop season ranged from 2.2 on genotype ICP 7035B to 5.6 on cultivar ICEAP 00554, indicating a range of reactions with respect to seed appearance of cultivars (Table 3). At both locations, brown, speckled seed were not preferred and was mainly associated with the seed color in the cropping season. Sensory evaluation of seed characteristics during the ratoon season had values which ranged from 1.8 (KIONZA) to 5.6 (ICEAP 00068). (Table 3). Sensory evaluation of seed appearance by consumers gave a range of values from 3.5 to 6.2 at Kambi ya Mawe while at Kiboko, the scores ranged from 3.9 to 6.1.

Seed color of cooked vegetable pigeon peas

The colors of cooked seeds of vegetable pigeon pea cultivars were evaluated by farmers at the crop and ratoon season, as well as by consumers at the ratoon season. Variation in the sensory scores for seed color of cooked vegetable pigeon peas were recorded among cultivars (Table 3). Preference for seed coat color of the cultivars varied and the interactions of locations by cultivars (L x G) was significant ($P < 0.05$) in both cropping seasons (Table 2). Similarly, the interactions of cultivars by seasons (G x S) was also significant ($P < 0.01$) for the above traits (Table 2).

Table 2 Analysis of variance of the visual and sensory characteristics of vegetable pigeon pea cultivars at Kambi ya Mawe and Kiboko locations during 2012/2013

		Seed appearance[a]			Seed color[a]			Seed odor[a]		
Source	df	Crop	Ratoon	Consumers	Crop	Ratoon	Consumers	Crop	Ratoon	Consumers
Tester	11	17.44 ns	9.4 ns	8.47 ns	15.98 ns	19.02 ns	5.02 ns	16.25 ns	15.46 ns	5.99 ns
Cultivars (G)	11	22.67**	30.3**	9.16**	32.88**	32.36**	16.61**	15.19**	7.19**	1.42 ns
Locations (L)	1	13.46**	68.3*	5.76*	3.84 ns	155.3**	11.81*	80.01**	2.41 ns	0.19 ns
G x L	11	8.69**	20.5*	9.65*	7.87**	14.89**	4.55**	7.34**	3.34 ns	6.26 ns
CV (%)		29.4	29.9	24.3	29.7	30.5	22.6	26.8**	33.7 ns	22.4 ns
		Taste[b]			Seed tenderness[b]			Overall acceptance[b]		
Tester	11	7.35 ns	21.55 ns	8.07 ns	8.23 ns	16.63 ns	2.52 ns	7.61 ns	7.29 ns	4.57 ns
Cultivars (G)	11	11.16**	6.80**	1.13 ns	12.6**	8.59**	4.56**	15.6**	17.89**	5.97 ns
Locations (L)	1	31.49**	0.17 ns	3.24*	19.56 ns	18.41**	1.71 ns	34.57**	27.55**	7.44**
G x L	11	5.17**	6.15**	6.07*	5.97**	7.27**	11.97**	12.45**	4.31**	6.85**
CV (%)		30.0	33.7	28.6	28.9	30.7	22.8	21.9**	28.2 ns	18.2 ns

[a] Visual appeal for seed appearance, color and odor of vegetable pigeon pea seed as evaluated by a randomly selected and trained sensory evaluation panels consisting of farmers (crop and ratoon season) and consumers. Assessment was conducted using a hedonic scale of 1–7 where 1 = highly unfavorable (dislike) and 7 = highly favorable scale (like)

[b] Evaluation of seed taste and tenderness subsequent to normal cooking and its overall acceptability by a trained panel of farmers and consumers based on hedonic scale of 1–7 (highly unfavorable-highly favorable). The heading df refers to degree of freedom for the sources of variation in analysis of variance (ANOVA). The numbers in the table refer to mean square errors of the visual and sensory scores (derived from ANOVA by dividing the degrees of freedom by the sum of squares). ANOVA was conducted on 3 replicates per treatment and each replicate represented scores from 10, 25, and 7 random panel members

ns non-significant, * = significant at $P < 0.05$; ** = significant at $P < 0.01$

Table 3 Mean sensory scores for seed appearance of vegetable pigeon pea cultivars and seed color subsequent to cooking at Kambi ya Mawe and Kiboko locations in 2013

Cultivars	Kambi ya Mawe[a]	Kiboko[a]	Kambi ya Mawe[b]	Kiboko[b]	Kambi ya Mawe[c]	Kiboko[c]
Seed appearance						
ICEAP 00068	5.1	3.6	3.8	5.6	6.1	4.6
ICEAP 00540	5.3	4.1	5.0	5.5	5.9	3.9
ICEAP 00554	5.6	5.6	5.3	3.3	5.6	5.7
ICEAP 00557	4.6	4.6	5.6	4.8	4.3	6.1
ICEAP 00850	4.8	4.4	4.5	5.5	3.9	4.6
ICEAP 00902	4.9	4.9	5.0	5.1	5.1	4.9
ICEAP 00911	3.7	4.6	5.6	4.3	6.2	4.1
ICP 7035 B	2.2	3.3	5.4	2.4	4.0	3.9
KAT 60/8	5.2	4.7	5.5	4.9	5.6	5.3
MTHAWAJUNI	3.9	3.5	5.6	4.6	3.5	4.4
MZ 2/9	4.6	2.4	3.4	2.0	4.9	4.3
Kionza[d]	0	0	4.3	1.8	4.4	4.6
Mean	4.5	4.2	4.9	4.1	4.9	4.7
$LSD_{(0.05)}$	0.7	0.9	0.82	0.86	0.78	0.89
CV(%)	24.8	31.1	26.8	33.3	21.0	26.4
Seed color (cooked)						
ICEAP 00068	5.1	4.2	5.1	5.0	6.1	5.3
ICEAP 00540	5.7	4.8	5.6	5.8	6.3	5.1
ICEAP 00554	5.3	5.6	5.8	3.2	5.6	5.5
ICEAP 00557	4.8	4.9	6.1	5.1	5.4	6.1
ICEAP 00850	4.9	4.6	5.3	5.8	5.0	5.1
ICEAP 00902	5.3	5.3	5.8	4.1	5.9	5.1
ICEAP 00911	3.9	4.6	6.1	4.5	6.3	4.3
ICP 7035 B	2.1	3.8	5.4	2.5	3.6	3.6
KAT 60/8	5.7	5.2	5.5	5.2	5.7	5.6
MTHAWAJUNI	3.5	2.9	5.2	5.0	3.4	4.1
MZ 2/9	4.1	2.2	3.5	2.5	4.5	4.1
Kionza[d]	–	–	4.8	1.9	5.6	4.8
Mean	4.6	4.4	5.3	4.2	5.3	4.9
LSD(0.05)	0.7	0.9	0.82	0.94	0.81	0.87
CV(%)	24.0	32.6	24.6	36.0	20.7	23.8

[a] Sensory assessment made by farmers during the crop season

[b] Assessment made by farmers at ratoon crop, and

[c] Evaluation by consumers during the crop season

[d] Local check genotype

The scores for sensory evaluation by farmers of cooked seed color of vegetable pigeon peas (hedonic scale) ranged from 2.1 to 5.7 at Kambi ya Mawe, while at Kiboko location, the average scores ranged from 2.2 to 5.6 (Table 3). Across locations, the cultivars ICEAP 00554 (5.4), ICEAP 00902 (5.3) and ICEAP 00557 (4.9) were the most preferred, while ICP 7035B, ICEAP 00911 and MZ 2/9 had scores of 2.9, 4.2 and 3.2, respectively. Evaluation of seed color subsequent to cooking from plants harvested by farmers during the ratoon season recorded mean scores of 3.5 to 6.1. At Kiboko location, the scores for sensory evaluation of cooked seed ranged from 1.9 to 5.8. Across the two locations, cultivars ICEAP 00850 (5.6), ICEAP 00557 (5.6) and ICEAP 00540 (5.7) were highly preferred cultivars, while MZ 2/9 (3.0), KIONZA (3.3) and ICP 7035B (4.0) were the least preferred. Sensory evaluation for seed color of cooked vegetable peas conducted by panelists from the Department of Food Science and Technology at the University of Nairobi had scores ranging from 3.4 to 6.3 at Kambi ya Mawe and 3.6 to 5.8 at Kiboko. Across locations, ICP 7035B, MTHAWAJUNI and MZ 2/9 had scores of 3.6, 3.8, and 4.3, respectively, while ICEAP 00068 (5.7), KAT 60/8

(5.7) and ICEAP 00557 (5.8) had the best scores for cooked pigeon pea seed color.

Pigeon pea seed odor (aroma)

The cultivars differed significantly ($P < 0.01$) in odor during the cropping season ($P < 0.01$. The odor of vegetable seed evaluated during the cropping seasons also varied with location. Interaction between locations and cultivars (G x L) was significant ($P < 0.01$) during the ratoon season (Table 2). Similarly, the interactions of seasons by cultivars (G x S) were also significant ($P < 0.05$) at both locations (Table 2). The scores for evaluation of odor of vegetable pigeon pea seed varied at both locations and for both cropping seasons (Table 4). The evaluation scores by panelists from the Department of Food Science and Nutrition indicated variable responses for seed aroma.

Seed taste of cooked pigeon pea

Based on consumer evaluation of cooked pigeon peas, significant differences ($P < 0.05$) among cultivars were recorded. Sensory evaluation of palatability of cooked vegetable pigeon peas varied significantly ($P < 0.05$) between locations and seasons and the interactions of cultivars by locations (G x L) were also significant ($P < 0.01$) for this characteristic (Table 2). Palatability evaluation of cooked seeds of vegetable pigeon pea cultivars had scores of 2.9 for ICP 7035B to 5.6 on genotype ICEAP 00554 at Kambi ya Mawe while values ranged from 2.6 on MZ 2/9 to 5.6 on ICEAP 00554 cultivars at Kiboko (Table 5). Across locations, the cultivars ICEAP 00554 (5.6), ICEAP 00902 (5.0) and KAT 60/8 (4.7) had the best scores for taste and flavor, while ICP 7035B (3.4), MTHAWAJUNI (3.4) and MZ 2/9 (3.6) had the least scores among the cultivars evaluated.

Seed tenderness (texture)

Preference and acceptability of seed tenderness of vegetable pigeon pea cultivars subsequent to cooking were evaluated (Table 5). Significant differences ($P < 0.01$) among cultivars were recorded based on panel assessments by farmers at crop and ratoon seasons. Difference in evaluation scores and preference for seed tenderness as an organoleptic characteristic was recorded between cropping seasons at Kambi ya Mawe but not at Kiboko location (Table 5). There were significant ($P < 0.01$) interactions of cultivars by seasons (G x S) at Kambi ya Mawe and Kiboko locations (Table 6). The mean scores for seed tenderness ranged from 2.8 on ICEAP 7035B to 5.3 on ICEAP 00554, indicating variation at both locations. The cultivars with the highest scores were ICEAP 00554 (5.3), ICEAP 00068 (5.1) and MTHAWAJUNI (4.7) at Kambi ya Mawe while ICP 7035B (2.8), ICEAP 00557 (3.6) and ICEAP 00911 (3.8) had the least. Similar findings were

Table 4 Mean sensory scores for seed odor of vegetable pigeon pea cultivars at Kambi ya Mawe and Kiboko locations in 2013 cropping years

Cultivars	KYM[a]	Kiboko[a]	KYM[b]	Kiboko[b]	KYM[c]	Kiboko[c]
ICEAP 00068	5.2	3.3	4.7	4.6	5.7	4.9
ICEAP 00540	4.3	3.2	4.2	4.5	5.7	4.3
ICEAP 00554	5.5	5.3	4.1	4.2	4.8	5.5
ICEAP 00557	4.7	4.6	4.7	5.0	4.8	5.4
ICEAP 00850	4.7	3.8	5.0	4.5	3.9	5.5
ICEAP 00902	5.1	5.2	3.9	4.4	4.7	5.4
ICEAP 00911	3.7	3.6	3.7	4.1	6.1	4.7
ICP 7035 B	3.5	3.1	4.3	3.6	4.5	5.3
KAT 60/8	5.2	3.6	4.1	4.2	5.1	4.2
M(THAWAJUNI	4.3	3.6	4.1	4.0	4.9	4.6
MZ 2/9	5.1	2.3	3.5	3.1	5.2	5.1
Kionza	0	0	4.8	3.3	4.9	4.9
Mean	4.7	3.8	4.2	4.1	5.0	5.0
$LSD_{(0.05)}$	0.7	0.70	0.89	0.86	0.82	0.79
CV(%)	24.1	28.2	33.9	33.8	21.9	21.1

[a] Sensory assessment made by farmers during the crop season (main cropping cycle - October 2012 to March 2013) during which pigeon peas are seeded and cultivated to maturity)

[b] Sensory assessment made by farmers during the ratoon season (crop that emerges from re-growth of previous plant stubbles without replanting – April to August, 2013)

[c] Sensory evaluation done by consumers during the crop season

Table 5 Mean sensory scores for seed taste and seed tenderness subsequent to cooking of vegetable pigeon pea cultivars evaluated by farmers and consumers at Kambi ya Mawe and Kiboko locations in 2012/13 cropping year

Cultivars	Kambi ya Mawe[a]	Kiboko[a]	Kambi ya Mawe[b]	Kiboko[b]	Kambi ya Mawe[c]	Kiboko[c]
Seed taste						
ICEAP 00068	5.4	3.4	3.6	4.8	5.1	4.9
ICEAP 00540	4.6	4.1	4.6	3.9	5.2	3.7
ICEAP 00554	5.6	5.6	4.3	4.4	4.0	4.9
ICEAP 00557	4.3	4.1	4.6	4.7	4.4	5.4
ICEAP 00850	4.9	3.2	3.9	4.6	4.1	5.1
ICEAP 00902	4.9	5.1	4.3	4.8	4.6	4.9
ICEAP 00911	3.4	4.1	4.7	4.2	5.1	4.2
ICP 7035 B	2.9	3.6	4.5	3.3	4.1	5.2
KAT 60/8	5.2	4.2	4.1	5.0	4.9	4.0
MTHAWAJUNI	4.3	2.7	3.3	4.1	4.6	4.5
MZ 2/9	4.7	2.6	3.7	3.2	4.3	5.7
Kionza[d]	–	–	3.9	3.1	4.7	4.9
Mean	4.6	3.9	4.1	4.1	4.6	4.8
$LSD_{(0.05)}$	0.8	0.80	0.78	0.84	0.95	0.99
CV(%)	27.3	31.8	34.5	32.7	27.6	27.7
Seed tenderness						
ICEAP 00068	5.1	3.7	4.0	5.1	6.1	5.0
ICEAP 00540	4.3	3.9	4.8	4.9	6.1	4.6
ICEAP 00554	5.3	5.3	4.3	4.4	4.2	4.8
ICEAP 00557	3.6	3.6	4.0	4.5	4.1	6.0
ICEAP 00850	4.4	4.1	5.2	4.8	3.5	5.2
ICEAP 00902	4.9	4.7	4.3	4.6	4.4	5.2
ICEAP 00911	3.8	4.3	4.8	4.7	6.4	4.9
ICP 7035 B	2.8	3.3	4.6	3.3	4.4	5.4
KAT 60/8	4.4	4.1	5.5	4.8	6.0	4.2
MTHAWAJUNI	4.7	3.1	5.6	4.4	4.9	5.9
MZ 2/9	4.6	2.8	3.6	3.5	5.0	5.6
Kionza[d]	–	–	5.8	3.6	5.3	5.3
Mean	4.3	3.9	4.8	4.4	5.0	5.2
$LSD_{(0.05)}$	0.8	0.80	0.85	0.89	0.87	0.88
CV(%)	27.0	29.5	28.8	32.8	23.1	22.9

[a] Sensory evaluation of pigeon cultivars for seed taste and seed tenderness made by trained panel of farmers during the cropping season (main cropping cycle, October 2012 to March 2013, during which pigeon peas are seeded and cultivated to maturity)

[b] Assessment made by farmers at the ratoon season (crop that emerges from re-growth of previous plant stubbles without replanting – April to August, 2013)

[c] Sensory evaluation by consumers during the cropping season;

[d] Local check cultivar

recorded at Kiboko. During the ratoon season, seed tenderness scores generally ranged from 3.6 (MZ 2/9) to 5.8 (Kionza) at Kambi ya Mawe and at Kiboko from 3.3 (ICP 7035B) to 5.1 (ICEAP 00068).

Overall preference of vegetable pigeon pea cultivars

The overall preference of pigeon pea cultivars differed depending on the season (crop or ratoon) at which the evaluation was conducted (Table 6). The interaction of season by cultivars (G x S) was significant ($P < 0.01$) at both Kiboko and KYM. Similarly, the interaction of cultivars and locations (G x L) was also significant ($P < 0.01$) during both seasons. The overall preference scores ranged from 3.1 (ICP 7035B) to 5.9 (ICEAP 00554) at Kambi ya Mawe. At Kiboko, the overall preference and acceptability scores ranged from 2.3 (MZ 2/9) to 5.9 (ICEAP 00554).

Table 6 Mean sensory scores for overall acceptability of vegetable pigeon pea cultivars evaluated by farmers and consumers at Kambi ya Mawe and Kiboko locations in 2012/13 cropping year

Cultivars	Kambi ya Mawe[a]	Kiboko[a]	Kambi ya Mawe[b]	Kiboko[b]	Kambi ya Mawe[c]	Kiboko[c]
ICEAP 00068	5.4	3.5	5.0	5.1	6.1	5.9
ICEAP 00540	5.3	4.4	5.1	5.5	5.9	5.1
ICEAP 00554	5.9	5.9	5.6	4.3	5.0	5.7
ICEAP 00557	4.8	4.8	5.5	5.2	4.2	6.1
ICEAP 00850	4.8	4.2	5.3	5.4	3.8	5.5
ICEAP 00902	5.2	5.2	5.1	5.0	5.0	5.6
ICEAP 00911	4.0	5.1	5.0	4.9	6.1	5.0
ICP 7035 B	3.1	3.8	5.3	3.4	4.1	4.8
KAT 60/8	5.1	4.6	6.0	5.2	5.4	4.7
MTHAWAJUNI	4.9	3.6	4.6	4.3	4.1	5.1
MZ 2/9	5.4	2.3	3.8	3.2	5.1	4.4
Kionza	0	0	4.2	3.1	4.6	5.1
Mean	4.9	4.3	5.0	4.5	5.0	5.3
$LSD_{(0.05)}$	0.7	0.80	0.75	0.87	0.62	0.69
CV(%)	20.3	22.8	24.1	30.9	16.8	17.7

[a] Sensory assessment made by farmers during the cropping season (The main cropping cycle, October 2012 to March 2013, during which pigeon peas are seeded and cultivated to maturity)

[b] Evaluation by farmers during the ratoon season (crop that emerges from re-growth of previous plant stubbles without replanting – April to August, 2013)

[c] Assessment made by consumers during the cropping season

Discussion

One of the main determinants for farmer and consumer selection of pigeon pea cultivars is seed color. The cultivar ICEAP 00554 (green seed-coat color) was one of the most preferred cultivars in this research. Cultivars with brown, speckled or bronze colored seed such as MZ 2/9, MTHAWAJUNI, and ICP 7035B had poor scores. Green seed coat color is often perceived by farmers and consumers as an ideal characteristic of pigeon pea. Our results are supported by other findings in which it was reported that the color of cowpea seed greatly influenced choice and marketability in Nigeria (Latunde-Dada 1993). Similarly, it was reported that although seed color is a simply inherited genetic trait (Saxena et al. 2010), farmer and consumer preferences may be highly based on the visual appeal of the seed coat. Therefore, cultivar development and selections often based on yield attributes and various agronomic traits (Ojwang et al. 2016a, b, c) should prioritize seed coat color as a major selection criterion in this geographic location. Participatory selection / breeding with greater inputs from farmers and consumers during the early stages of cultivar development and multi-location testing would be highly desirable as this would enhance crop utilization with considerable implications for food security. We hypothesize that the selection of pigeon pea cultivars with desirable seed color may improve their marketability, sale, consumption, and food security in this region.

In the eastern region of Kenya, high preference for vegetable pigeon pea may be partially attributed to the availability of seed, regardless of seed-coat color. Farmers have often utilized cultivars which had readily available seed especially from markets. Therefore, the availability of pigeon pea with green seed coat in Eastern Kenya (Kimani et al. 1994; Mergeai et al. 2001) may have influenced their selection as recorded in this study. In addition, the utilization of a cultivar such as Kionza (local cultivar), may be attributed to its earliness and yield potential such as numerous seeds per pod (seven-seeded pods) and large seed size and weight (31 g/100 seeds). This is especially true during critical months of food insecurity prior to harvest when food reserves are extremely low and scarce in this dry semi-arid region. Therefore, besides seed coat color, cultivar earliness (minimum maturity duration) may be an important preference attribute as it enhances food security of farmers and consumers by ensuring availability of high-protein food during critical months of the year when resources are meager.

Organoleptic characteristics including palatability (taste) are important parameters for evaluating sensory attributes of food stuffs and their overall acceptability (Muhimbula et al. 2011). Many food products may be visually appealing but if devoid of good taste and aroma, may be unacceptable to consumers. In our research, cultivars with a bitter taste and brown/speckled or bronze seed color scored poorly in the sensory evaluation tests. Our results are similar to those of Mkanda et al. (2007) who found that dark striped beans with

bitter taste compared to light colored ones were unpalatable and contributed to consumers' rejection or low preference. Similarly, Bressani and Ellis (1980) and Guzman-Mandondo et al. (1996) reported that dark colored legume seeds had high content of phenolic compounds (condensed tannins) which contributed to their bitter taste subsequent to cooking. The lack of preference and acceptability of some bean cultivars with colored seed coats was attributed to the flavor, also prevalent in the seed coat of many leguminous crops, and contributes greatly to the dislike of those cultivar types (Enwere 1998). The incorporation of organoleptic properties (e.g. palatability) early in the preliminary stages of cultivar selection and development is an important criterion that may increase their consumption and and promote food security.

The assessments of pigeon pea cultivars by a panel of consumers, farmers and University of Nairobi panelists subsequent to cooking showed significant differences ($P < 0.05$) among cultivars in their overall acceptability. These differences imply that many cultivars with diverse characteristics of maturity duration (early, moderate, late yield, seed size), sensory qualities (appearance, color, palatability, tenderness, aroma), and nutritional qualities should be incorporated in the selection process in order to maximize production, marketing and consumption of pigeon pea and should also be applied to other legumes. The status quo in many breeding programs and variety selection of pigeon pea /legumes often tend to have evaluation of post-harvest characteristics and nutritional qualities at the end of the selection procedure. This is in contrast to other crops such as potato (Olanya et al. 2010). Similarly, cultivar and post-harvest evaluation should be done in diverse environments in order to maximize production, cultivar stability, and acceptability. Pigeon pea and other grain legumes are an important source of food security and livelihoods for resource-constrained farmers in Kenya and other parts of the world due to their drought-resilience. Additionally, they are utilized to enhance soil fertility owing to their symbiotic nitrogen fixation, thus promoting sustainable cropping systems in Kenya and elsewhere.

As production of pigeon peas and other grain legumes (chickpea, lentils, dry beans, faba beans) have steadily increased in Kenya and Sub-Saharan Africa to more than 20 million tons, it is hoped that increased production would facilitate consumption and enhance food security (FAOSTAT 2011). The per capita availability of grain legumes (pulses) for consumption in sub-Saharan Africa has increased by 22 % between1994 and 2008 at a growth rate of 1.7 % per year (FAOSTAT 2011). In Kenya, the per capita production of pulses was estimated at 15 Kg/yr. in 2008, while per capita consumption during the same period was approximated at 16 Kg/yr. (FAOSTAT 2011), which may indicate that the difference was made up by imports. This consumption pattern is lower than neighboring countries such as Uganda, which has a per capita consumption of 19 Kg/yr. For optimum food and nutritional security in this region, consumption of approximately 19 Kg/yr. may be reasonable even though this would be considerably less than that of Burundi with a per capita consumption of pulses of 34 Kg/yr.

Incorporation of cultivar preferences, organoleptic properties and post-harvest consumer demand, processing and utilization to preserve nutritional qualities in cultivar selection /breeding processes could greatly improve food security and livelihoods of resource-constrained farmers in Eastern Kenya and other parts of the world. Pigeon pea and other grain legumes /pulses are ideally suited as a nutritious crop to supplement protein intake in the dry, semi-arid region of Eastern Kenya.

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Compliance with ethical standards

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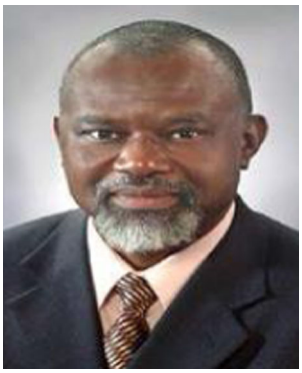

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