Food Science and Quality Management
ISSN 2224-6088 (Paper) ISSN 2225-0557 (Online)
Vol.126, 2026

Consumer Preference and Acceptability of Processed and Stored Green Vegetable Pigeon Peas (*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. Consumer preference and acceptability of four medium duration pigeon pea genotypes pre-treatment and stored for 22, under different conditions was determined by a team of semi-trained panelists based on 7 – point hedonic scale. The five (5) pre-treatments, T1- Threshed fresh sample stored in a deep freezer at -180C; T2: Threshed fresh sample, dehydrated then stored under room conditions; T3: Threshed fresh sample, blanched then stored in a deep freezer at -180C; T4: Threshed fresh sample, blanched, dehydrated then stores under room condition; T5: Peas stored in pods, were assessed. There were significant differences among the panelists ($P<0.05$) on appearance, color, Odor/Smell, and seed tenderness, while they generally agreed on taste and overall preference ($P>0.05$). The average sensory score among the panelists on physical appearance of samples stored in pods was 6.3, indicating high acceptability, while blanched samples had an average of 6.0 rating. The podded, blanched + oven dried recorded an average of 5.6, 6.6, and 6.1 scores, respectively on seed tenderness. The highest moisture reduction of 43% was noted in samples stored in pods and kept under room condition while the lowest reduction of 6% was noted on blanched sample stored in a deep freeze at negative 18oC. A positive relationship ($P\leqslant 0.001$) between appearance and color ($r=0.71$) and tenderness ($r=0.42$) was noted, while the odor/Smell was positively related with taste ($r=0.463$) and overall acceptance ($r=0.532$). Peas stored in pods were the most preferred and acceptable pre-treatment and storage of green vegetable pigeon peas due to color, taste and physical appearance. Those blanched and dehydrated also rated highly on taste but not in tenderness.

Keywords: Pigeon pea, storage, sensory, acceptance

DOI: 10.7176/FSQM/126-04
Publication date: June 28th 2026

1. Introduction

Pigeon pea is a popular legume in the dryland regions of Kenya, produced by majority of the households and is ranked third in acreage after beans and cowpeas. The region is characterized by high levels of food insecurity and malnutrition (Salome, 2016), due to lack of and access to diversified diets. Due to its high nutritive value, green vegetable pigeon peas, when consumed, green, has potential in reducing malnutrition in the region. Households in the Eastern region of Kenya shell them when harvested as green peas, based on the household and marketing needs ((Shiferaw et al., 2008). When shelled, the peas are exposed to extreme temperature regimes, reducing their shelf life. Majority of the households store the peas in pods (without shelling), for about 3-5 days (Shiferaw et al., 2008) before consumption or delivery to the market. The pods protect the peas from harsh temperatures increasing their shelf life. There are several pre-treatment methods that have potential to increase the green vegetable pigeon peas apart from storing in pods.

There is scanty information on the effect of these pre-treatment and storage on consumer preference and acceptability of green vegetable pigeon peas. Czaikosk et al., (2012) observed that soyabeans quality changes when stored under cold storage, while Tosun and Yücecan (2008) observed reduction in vitamin C by 52% due to pre-treatment and freezing of Soya beans. Removal of water from food through dehydration has been recommended as one of the methods of increasing the shelf life, through reduction in moisture levels (Morris et al., 2004). Consumer preference and acceptability has been used to assess products for commercialization. Panelist involved in sensory evaluation have always rated highly cooked peas with great appearance and taste, while physical characteristics of the peas have always contributed to how panelists rate the appearance (Mkanda, 2007). Pea Testa color has been observed by Ojwang et al., (2016) to influence green vegetable pigeon pea

consumers' acceptance. They noted that dark colored green vegetable pigeon pea genotypes were not preferred and accepted by consumers as they are used to cream colored peas. Storage of peas in pods, blanching (Pervin et al 2017), dehydration and refrigeration methods are being applied in most households in effort to increase the shelf life in other related products. There is limited information on the effect of these pre-treatments on the consumer preference and acceptability in green vegetable pigeon pea product.

2. Materials and Methods

Medium duration genotypes were planted in a randomized block design at Kiboko research station, in Eastern Kenya. The genotypes included ICEAP 00557 and ICEAP 00554 were originally from Tanzania, flowering in 90 days and mature in 160 days, KAT 60/8, developed at Katumani in Kenya, flowers in 120 days, and final plant height is about 130cm, have a spreading growth habit and MZ 2/9, which originally was selected from Mozambique germplasm and is an early flowering genotype. With exception of MZ 2/9, which was speckled brown, the other genotypes peas were green to light green in seed color. The seeds of the respective genotypes were sourced from ICRISAT.

2.1 Sample harvest and pre-treatment

Fresh pigeon pea pods were harvested at thirty-two (32 days) days post flowering based on recommendation by Singh et al., (1984) who suggested that peas need to be harvested 26-32 days after flowering, to benefit from maximum nutrient composition. The peas in pods and shelled were immediately threshed and transported to the Department of Food Science Lab., University of Nairobi in a cool box, at 4oC, based on previous recommendation (Onyango and Silim, 2000).

The harvested vegetable Pigeon pea samples were subjected to five treatments and arranged in a completely randomized design with 3 replications. After treatments, samples were stored for 22 days prior to sensory assessment. The treatment descriptions were as follows:

T1: Fresh peas: Pods were shelled, and peas, placed in polythene bags (Zip Bags) and air was removed by pressing to remove air. The sample was stored under room temperature for 22 days at temperatures between 20-25oC.

T2: Fresh + Oven-dried pre-treatment: 500 grams of fresh shelled peas were oven dried at 65oC for 8 hours, then stored at room temperature for 22 days, thereafter, prepared for sensory analysis.

T3: Fresh peas blanching: Two Kilograms of shelled peas were steam blanched at 72oC for 2 min, immediately submerged in cold water then drained. Immediately after blanching, the sample were stored in a deep freezer at -180C for 22 days.

T4: Blanched + Oven-dried pre-treatment: The shelled peas were blanched, then oven dried at 65oC for 8 hours. Immediately after oven-drying, the sample were stored in the laboratory under room temperature for 22 days.

T5: Peas stored in pods (Un-threshed): This represented the traditional way household store peas. The peas in pods were spread on an aluminum tray and kept on the table inside the laboratory, for a period of 22 days.

Moisture content after 22 days of storage was determined based on AOAC method specifications, by using oven drying (AOAC, 2000).

2.2. Panelist selection and training

The sensory assessment was based on the 7-point hedonic scale. Panelists were made up of seven (7) final year students from the Department of Food Science and Nutrition, University of Nairobi. They were native of lower Eastern region of Kenya, who have been exposed to vegetable green pigeon pea and had consumed the product in the past 12 months. A questionnaire was used to evaluate individual reaction to quantify the sensory attributes as follows: 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 (Mkanda et al., 2007). The characteristics evaluated were based on appearance, color, taste, aroma (flavor), seed tenderness and overall acceptance. Preliminary screening was done based on knowledge of the desired sensory attributes of vegetable pigeon peas, with the selected panelists, in a focus group discussion a day before the actual testing. The panelists underwent a detailed training on the sensory attributes of vegetable Pigeon pea and the use of appropriate descriptive terms.

2.3. Sample preparation and evaluation

After storage for 22 days, post pre-treatment, a sample of 200 grams were taken from each of the 5 treatments. The deep-frozen storage samples were thawed for 20 minutes, before cooking. Those stored in pods were threshed and weighed (200g), then prepared for cooking. All the samples were fully cooked to a status of normal

softness, based on the household procedure and consumer expectation of what is regarded as a cooked product (Ojwang et al, 2016). Efforts to reduce potential biases were made by using the serving plates that were not transferring any aroma or flavor to the product, and efforts to get all samples served at the same temperature and in equal amounts of 50 grams each was done. The samples were codded using three randomly selected numbers, to avoid biasness.

2.4 Data analysis

The effect of pre-treatment and storage duration were evaluated by performing a two-way ANOVA analysis at 5% level of significance, based on statistical analysis procedure outlined in GENSTAT 16th edition. The mean values of treatment of each parameter were further compared by using the least significant difference (LSD) test at ($P<0.05$) level of probability, using Turkey's method.

3. Results and Discussion

3.1 Effect of pre-treatment and storage on moisture content (%)

The moisture content on dry weight basis was determined at day 0, after 22 days and 60 days of storage. The base moisture levels for the fresh peas (T1) and blanched then stored in a deep freezer was 57%, compared to 56% after 22 days of storage (Table 1).

Table 1. Moisture content (MC) % of pre-treated green vegetable pigeon peas after 22 days of storage

Treatment	0 Day (% MC)	22 Days (% MC)
T1: Fresh and deep frozen[R]	57c	56a
T2: Fresh and dehydrated[T]	13a	14b
T3: Fresh Blanched and deep frozen[S]	57a	56a
T4: Fresh, Blanched and dehydrated[U]	13a	14b
T5: Fresh stored in pods at Room[V]	54a	13b

[R]Samples (wet mass) were non-blanched then deep-frozen storage at -18°C (T1). [S]Samples steam blanched at 72°C for 4 mins, then deep-frozen storage at -18°C. (T3) [T]Oven-dried samples at 65°C for 8 hours, then stored under room condition (T2). [U]Samples (wet mass) were blanched then oven-dried at 65°C for 8 hours and stored room condition (T4). [V]Un-threshed pods (podded, wet mass) stored at room temperature of 20-25°C (T5). Means followed by the same letter in a column are not significantly different

The fresh dehydrated and those that were blanched then dehydrated recorded a base moisture content of 13%, increasing to 14% after 22 days of storage. Peas stored in pods recorded a higher moisture content of 54%, which reduced to 13% after 22 days of storage. Moisture loss from samples stored under frozen conditions (-18C) may have been due to formation of ice crystals on the surface of peas, which may sublime into gaseous state leading to water loss when freezer is open, as explained by Araujo et al (2017), who observed that when dried galega kale which were not packed in water vapour and oxygen proof materials, like in this situation, moisture was lost as a consequent of increases in storage temperature during freezer door opening. The 1% gain in moisture level for products stored in room condition after dehydration could be due to absorption of moisture from the atmosphere during storage.

3.2 Effect of pre-treatment and storage on green vegetable pigeon pea physical appearance

Sensory evaluation for physical appearance was done on un-cooked vegetable pigeon peas, which were pre-treated and stored for 22 days. There was significant difference ($P<0.01$) in appearance among pre-treatments based on the panellist score (Table 2). The panellists scores ranged from 6.3 (high likeability) for peas stored in pods to 4.4 (neither liked nor disliked) for fresh peas that were dehydrated and stored under room condition (Table 53). While blanched + dehydrated and fresh dehydrated recorded a sensory score of 4.4 and 4.6, respectively; those stored in pods, blanched then stored in a deep freezer and those that were fresh and deep frozen recorded a higher sensory value for physical appearance. The score for appearance was mainly influenced by pea colour, as the sample with higher score for colour, such as fresh, podded (6.6), also scored highly for appearance (6.3). Dehydration of the green vegetable pigeon peas reduced the green coloration and seed size, resulting in lower sensory score. The seed size defines the consumer preference, and the most preferred seed size in Indian market is 10–14 g/100 seeds (Varshney et al., 2017). Physical observation of the dehydrated products reduced the pea size, because of moisture loss, producing wrinkled peas, leading to lower scores on physical appearance. This study therefore has noted that the visual appearance based on colour and size, influences the selection, preference, and choices among the green vegetable pigeon peas consumers. Storage of peas in pods

and in deep freezer maintained the physical appearance, leading to consumer preferences.

Table 2: Analysis of variance on the sensory characteristics of post-harvest vegetable Pigeon pea at 22 days post-treatment.

Sources of variation	D.f. [a]	Appearance[b]	Colour[r]	Odour/ smell[b]	Flavour/ taste[e]	Tenderness[c]	Overall acceptance[c]
Treatment	4	4.83**	7.04**	4.81*	4.53ns	5.54*	1.24ns
Tester	6	4.11ns	5.19ns	2.65ns	4.46ns	2.96ns	2.96ns
Residual	24	0.99	0.98	1.73	2.78	1.68	1.92
LSD $_{(0.05)}$	-	1.10**	1.09**	1.45*	1.84ns	1.43*	1.53ns
CV (%)	-	18.7	19.4	25	34.1	24.8	27.6

[a]Degrees of freedom for the Anova tests.
*[b]Visual appeal for seed appearance, colour and aroma of vegetable pigeon pea seed as evaluated by randomly selected and trained sensory evaluation panels. Assessment was conducted using hedonic scale of 1-7 where 1= highly unfavourable [dislike] and 7=highly favourable [likable] for a particular attribute. [c]Evaluation of taste and tenderness after normal cooking of vegetable pigeon pea and its overall acceptability by a trained panel based on hedonic scale of 1-7 where 1= highly unfavourable [dislike] and 7=highly favourable scale (likable). * = significant at P<0.05; ** = significant at P<0.01; ns = non-significant at P<0.05 based on Turkey's Test. Means followed by the same letter in a column are not significantly different*

3.3 Effect of pre-treatment and storage on green vegetable pigeon pea colour

Sensory evaluation for pea colour was done on un-cooked vegetable pigeon peas, which were pre-treated and stored for 22 days. The study noted a significant difference (P<0.001) in pea colour among the pre-treatments (Table 2) of vegetable pigeon peas. The average sensory score rated by the panellists for seed colour ranged from 4.0, for dehydrated fresh products, to 6.6 for peas stored in pods. Panellist awarded samples that were freshly blanched (4.7), freshly blanched then dehydrated (4.6); and fresh dehydrated (4.0), which were below the average of 5.09 (Table 3). The samples stored in pods had a high sensory score (6.6), followed by fresh deep-frozen (5.6) for seed colour. Deep-frozen samples maintained their initial greenness colour, while dehydration affected the green coloration, leading to lower sensory scores, probably due to adversely effect on the pea chlorophyll content resulting into brownish colour, which are not popular with the consumers. Lower sensory scores of 4.7 scores were recorded for fresh blanched samples. This could be due to destruction of chlorophyll content of vegetable pigeon peas by high temperature (720C) due to steam blanching treatment. Nguyen et al. (2012) reported that chlorophyll content in peas was reduced gradually as the blanching temperature and time increased.

Table 3: Average sensory characteristic scores of pre-treated vegetables pigeon pea after 22 days of storage

Sample Treatment[a]	Appearance[b]	Colour[b]	Aroma[b]	Taste[c]	Tenderness[c]	Overall Acceptance[c]
Fresh and deep frozen	5.4abc	5.6bc	4.0a	3.7a	5.6ab	4.6a
Fresh and dehydrated	4.4a	4.0a	5.1ab	5.6a	4.1a	4.9a
Fresh Blanched and deep frozen	6.0bc	4.7ab	5.1ab	4.7a	5.9a	5.0a
Fresh, Blanched, and dehydrated + Room	4.6ab	4.6ab	6.1b	4.7a	4.4a	5.0a
Fresh stored in pods at Room	6.3c	6.6c	5.9ab	5.7a	6.1a	5.7a
Mean	5.34	5.09	5.26	4.89	5.23	5.03
SEM	0.38	0.37	0.49	0.53	0.49	0.53
SED	0.53	0.53	0.7	0.89	0.69	0.74
LSD$_{>0.05}$	1.10**	1.09***	1.45*	1.84^{NS}	1.43*	1.53^{NS}
CV	18.7	19.4	25	34.1	24.8	27.6

** =significant at P≤0.05; ** = significant at P≤0.01. *** = significant at P≤0.001*
[a]Post-harvest treatment of pigeon pea.
[b]Visual appeal for seed appearance, color and aroma of vegetable pigeon pea seed as evaluated by a randomly selected and trained sensory evaluation panels. Assessment was conducted using hedonic scale of 1-7 where 1= highly unfavorable [dislike] and 7=highly favorable scale.
[c]Evaluation of taste and tenderness after normal cooking of vegetable pigeon pea and its overall acceptability by a trained panel based on hedonic scale of 1-7 where 1= highly unfavorable [dislike] and 7=highly favorable scale (likable). Means followed by the same letter in a column are not significantly different

The green colour of vegetable pigeon peas is widely considered as an appropriate marker for monitoring physical appearance changes during processing and storage (Goncalves et al., 2011). The thermal processing led to loss of the vivid green chlorophyll colour, resulting in olive brown colour, characteristic of pheophytin. This is ultimately perceived by consumers as a loss of quality. Some of the colour changes in food products results from enzymatic reactions and the release of organic acids from disrupted tissue (Martins and Silva, 2002). In the sensory evaluation of broccoli, it was noted that the vegetable colour was the most important characteristic influencing consumer choice (Goncalves et al. 2011). This study therefore observes that the green coloration of the vegetable pigeon peas plays a significant role in consumer selection and preference. Change in colour due to dehydration and high temperature blanching are detrimental on the coloration of the peas, leading to reduced preference and potential rejection.

3.4 Effect of pre-treatment and storage on green vegetable pigeon pea taste

No significant difference ($P>0.05$) in pea taste among the pre-treatments (Table 52) of vegetable pigeon peas, indicating that pre-treatment of the product and storage for 22 days, do not affect the taste of the final product, and therefore does not impact on palatability of green vegetable pigeon peas. The panellist score on taste ranged from 3.7 for fresh peas stored in a deep freezer to 5.7 for peas stored in pods (Table 3). The leaching of nutrients during thawing and preparation could have had a change in taste of the products. Though not significant, these results show that dehydration of the peas changes the taste of peas leading to increased consumer preference and acceptance. Discussion with the panellists indicated that fresh dehydrated and fresh blanched + dehydrated peas, which scored 4.7 respectively, produced taste that is different from the normal taste they are used to. This study therefore noted that even though different pre-treatment of peas does not change the taste, those stored in pods were more preferred and accepted by consumers.

3.5 Effect of pre-treatment and storage on green vegetable pigeon pea tenderness

There was a significant difference ($P<0.05$) in pea tenderness among the pre-treatments (Table 2) of vegetable pigeon peas. The panellists gave a score ranging from 4.1 for fresh dehydrated products to 6.1 for peas stored in pods after 22 days of storage. Comparatively, the samples that were dehydrated scored very low on tenderness of 4.1 compared to those stored pods (6.1), fresh blanched and deep frozen (5.9), Fresh and deep-frozen (5.6) and fresh blanched and dehydrated (4.4) (Table 53). The low tenderness score observed in this study among the dehydrated samples, could be due to poor textural quality resulting from dehydration. This has been mainly due to product exposure to high temperatures in the presence of air during the drying process (Eze and Akubor, 2012). This has been shown to interfere with the cooking quality of vegetable seeds (Sharma et al., 2006). Similar observations have been made in a study reported by Shams and Shouk, (1999), who noted that when green peas are dehydrated at 60 watts in a microwave, panellists gave them a lower score, due to the hard texture.

3.6 Effect of pre-treatment and storage on green vegetable pigeon pea aroma

The study noted a significant difference ($P<0.05$) in pea aroma among the pre-treatments (Table 2) of vegetable pigeon peas, indicating the importance of aroma as a selection criterion for pre-treated green vegetable pigeon peas for consumer preferences and acceptance. The sensory scores for aroma ranged from 4.0, for fresh deep-frozen sample to 6.1, for blanched and dehydrated products, with an overall mean value of 5.3 (Table 3). While the scores for fresh peas stored in a deep freezer had significantly ($P<0.05$) lower scores, 4.0 than the average, peas stored in pods and fresh dehydrated sample were slightly above the average score value of 5.3. Fresh peas that were blanched and dehydrated improved the aroma of the product, followed by those stored in pods and finally fresh peas which were blanched and stored in a deep freezer, in that order. Aroma is an integral part of taste and general indicator of food preference and is an important parameter for acceptability of formulated foods (Mkanda, 2007). Blanching and dehydration of green vegetable pigeon peas improved the aroma of cooked vegetable pigeon pea. Foods of various constituents when subjected to heat treatment (blanched, oven-dried) may produce a wide spectrum of aroma, resulting from degradation of sugar and amino acids and their interactions (Amaefule and Onwudike, 2000; Morris et al., 2004). Dehydration therefore produced a characteristic sweet smell aroma that is preferred and acceptable to consumers.

3.7 Effect of pre-treatment and storage on green vegetable pigeon pea overall acceptance

There was no significant difference among the pre-treatments ($P>0.05$) for overall acceptance (Table 52), indicating that pre-treatment of the green vegetable and storage for 22 days, does not affect the overall acceptance by the consumers. The trained panellists score on overall acceptance ranged from 4.6 for deep-frozen to 5.7 for peas stored in pods (Table 53). The overall acceptability score, 5.7, was higher (though not significant) among the peas stored in pods for 22 days, indicating high overall preference. These results indicate that though colour, tenderness, appearance, and aroma are the main factors influencing acceptance and preference among the consumers for pre-treated and stored green vegetable pigeon peas, consumers don't mind cooking them for consumption.

3.8 Relationships between different sensory characteristics in green vegetable pigeon peas.

A positive correlation between appearance, colour, and tenderness (P<0.001) (Table 4) was observed. Consumers are used to see the greenness in green vegetable pigeon peas based on its physical appearance. Green vegetable Pigeon pea coloration is green and therefore, any change in colour confuses the consumers.

Table 4: Pairwise correlation coefficient for mean sensory characteristics of pre-treated and store green vegetable pigeon peas.

Parameters	Appearance	Color	Odor/ Smell	Overall Acceptance	Taste
Appearance	-				
Product Color	0.706***	-			
Odor-Smell	-0.0109^{NS}	0.0694^{NS}	-		
Overall Acceptance	0.3556^{NS}	0.579***	0.532***	-	
Product Taste	0.3096^{NS}	0.3634^{NS}	0.463***	0.734***	-
Tenderness/Softness	0.422***	0.429***	0.3356^{NS}	0.458***	0.3663^{NS}

** =significant at P≤0.05; ** = significant at P≤0.01. *** = significant at P≤0.001*

Any pre-treatment that interferes with the colour of the product may not be acceptable. On tenderness, oven dried products were found to be hard and gritty, and sometimes changed the physical appearance of the product, leading to reduced preference and acceptance. Colour was also positively and significantly related to overall acceptance and tenderness, indicating that selection of genotypes that meet consumer expectation need to consider the colour of the pigeon pea testa. Dehydration contributes to poor textural quality in dried samples, which reduces tenderness leading to gritty feel during chewing. The practice also affects the greenness of the peas because of chlorophyll breakdown at high temperature. Positive and significant (P<0.05) association was also noted between odour/smell and taste (r=0.734) and tenderness (r=0.458). Consumers do consider taste as an important parameter when evaluating sensory characteristics of food for acceptance (Muhimbula et al., 2011) and therefore forms an important parameter in selecting genotypes for production among the household utilization.

4. Conclusion

The sensory evaluation of green vegetable pigeon pea, which were pre-treated and stored for 22 days revealed that appearance, colour, smell/odour, and tenderness were the main sensory parameters that influenced consumer's preference and acceptance. Dehydration of green vegetable pigeon peas at 65oC for 8 hours improved the aroma of the peas, while it reduced the tenderness and therefore the general appearance of the product. When green vegetable pigeon peas were blanched and subsequently stored in a deep freezer, the green coloration of the testa is maintained, which is preferred by most consumers. Peas stored in pods and those freshly blanched and subsequently stored in a deep freezer, scored poorly on taste due to leaching of the mineral during thawing for cooking and storage in a deep freezer. Blanching of fresh peas and storing in a deep freezer recoded a higher sensory score on appearance, tenderness, and the seed colour, due to low temperature storage that didn't affect the testa. Fresh peas which have been blanched and oven dried scored higher than those which were fresh and directly dehydrated on the smell/odour, tenderness, colour, and appearance, indicating that blanching helps retain the colour and freshness of the product before dehydration is done. Peas stored in pods for 22 days was the most preferred and accepted by the consumers, confirming that this practice is still relevant.

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