Possibility of sea-freighting bio-sugarloaf pineapples (Reference number MAT17GH01)S

Consumer acceptance of organic and conventional sugar-loaf pineapples stored at 1°C and 8°C

BY

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Summary

Pineapple (*Ananas sp*.) is a tropical and perennial plant belonging to the *Bromeliaceae* family. It is an herbaceous plant and is native to areas where wild species exist such as Costa Rica, Brazil and Philippines in Central and Southern America (Fernandes *et al*., 2008). Pineapple is the third most important fruit after banana contributing to over 20% of the World production of tropical fruits (Coveca, 2002, Hossain *et al.,* (2015). About 70% of pineapple is consumed in the fresh state globally. The total production of pineapples in Ghana for the year 2014 was 661500 tonnes (FAOSTAT, 2016).

The pineapple fruit has vitamins, minerals, fibre and enzymes that are beneficial to the digestive system and help in maintaining ideal weight and balanced nutrition. It is also a good source of vitamin C, minimal fat and sodium with no cholesterol, delicious, healthy and nutritious and can be eaten raw or used in cooking. The stage of maturity at harvest depends on the market that the pineapple is transported to. Pineapple for the domestic market is harvested at the fully ripe stage while unripe but mature fruit are for the export market. Maturity is important in eating quality of pineapple. The small difference in maturity of pineapple at harvest makes the large difference in eating quality and consequently consumer satisfaction. The objectives of this study was to determine the sensory acceptance of two varieties of pineapples of different translucencies with storage temperature of 1°C and 8°C.

Organic and conventional sugar loaf pineapples were both stored after harvest at 1°C and 8°C for 14 days. Based on the formation of rings after cutting the pineapple fruit cylindrically, the stored pineapples were divided into 25-50%, 50-75% translucency groups. Consumer acceptance study was conducted with 30 consumers using 9- point hedonic scale. Consumers evaluated the appearance, color, taste, aroma, taste, texture, mouth feel and overall acceptability of the stored pineapples.

Generally, conventional and organic sugar-loaf pineapples which were stored at 8°C and 1°C for 14 days, it was observed that majority of the stored pineapples recorded 25-50% translucencies. Pineapples with 50-75% translucencies was in the minority. The overall acceptability for pineapples with 50-75% translucencies varied from 6-8 which is interpreted as slightly liked and like very much. On the other hand, pineapples with 25-50% translucencies gave overall

acceptability scores ranging from 6-7 which implied consumers slightly liked and moderately liked the pineapples samples. Principal component analysis (PCA) biplot for the sensory attributes and organic sugar loaf pineapples for three batches accounted for 80.23-96.7% of the variation. Conventional pineapples PCA explained 78.22-96.54% of the variation in sensory data set.

Organic and conventional Sugar-loaf pineapples with translucencies of 25-50% and 50-75% stored at 8°C and 1°C were acceptable to the consumers. Pineapples fruits with 50-75% were highly accepted because the fruits are over-mature, since more than half of the cross-sectional area of the fruit is translucent and sweeter. The taste of 25-50% was moderately liked. It is recommended that organic fruits to be sea-freighted should have a translucencies of 25-50% to be able to withstand transportation without deterioration.

1.0 Introduction

Pineapple, *Ananas comosus*, belongs to the *Bromeliaceae* family, from which one of its most important health-promoting compounds, the enzyme bromelain, was named. The Spanish name for pineapple, *pina*, and the root of its English name, reflects the fruit's visual similarity to the pinecone (Cho *et al*., 2004).

Pineapples have a wide cylindrical shape, a scaly green, brown or yellow skin and a regal crown of spiny, blue-green leaves. The fibrous flesh of pineapple is yellow in color and has a vibrant tropical flavor that balances the tastes of sweet and tart. The area closer to the base of the fruit has more sugar content and therefore a sweeter taste and more tender texture. They are second only to bananas as America's favorite tropical fruit. Although the season for pineapple runs from March through June, they are available year-round in local markets (Cho *et al*., 2004).

Pineapples have a wide cylindrical shape, a scaly green, brown or yellow skin and a regal crown of spiny, blue-green leaves and fibrous yellow flesh. The area closer to the base of the fruit has more sugar content and therefore a sweeter taste and more tender texture. Pineapple is an excellent source of vitamin C and manganese. It is also a very good source of copper and a good source of vitamin B1, vitamin B6, dietary fiber, folate and pantothenic acid (Cho *et al*., 2004)..

Fresh pineapple is low in calories. Nonetheless, it is a store-house for several unique health promoting compounds, minerals, and vitamins that are essential for optimum health. It contains a proteolytic enzyme bromelain that digests food by breaking down protein. Bromelain also has anti-inflammatory, anti-clotting and anti-cancer properties. Studies have shown that consumption of pineapple regularly helps fight against arthritis, indigestion and worm infestation. Pineapple is an excellent source of antioxidant vitamin-C with 100 g fruit containing 47.8 or 80% of this vitamin. Vitamin-C is required for the collagen synthesis in the body. Collagen is the main structural protein in the body required for maintaining the integrity of blood vessels, skin, organs, and bones. Regular consumption of foods rich in vitamin-C helps the body protect from scurvy; develop resistance to combat infectious agents (boosts immunity) and scavenge harmful, pro-inflammatory free radicals from the body (USDA database).

Organic production can take the same time or longer than conventional production. This depends on the variety, water and fertilizing regime. Many organic small holders farmers in Ghana use no or very little organic fertilizer and no organic pesticides. Weeding is then mostly done by hand. For the local Sugar-loaf variety a field trial has shown that organic fertilizers such as cocoa husk or compost give better results in terms of ripeness after a certain number of months, levels of pH and acidity, crown size and fruit weight. This might not be true for other varieties, but shows that production is not necessarily faster and more efficient when using chemical inputs.

When the fruit is almost ripe, each fruit is inspected by the buyer for its brix value, shape, color, and size. If it satisfies the quality standard, the fruit is harvested. Conventional pineapple is degreened shortly before harvesting using a chemical to achieve uniform color of the fruit. De-greening is not allowed in organic production. Harvest takes places all year round (Kleemann, 2011).

Pineapples can be stored at (7-12°C) for 2-4 weeks under commercial handling conditions, depending on cultivar and fruit maturity. Two weeks is the practical limit for fruit stored at (12°C); longer storage is possible at (7°C). Therefore, it is critical that refrigerated storage of pineapples be uninterrupted. Prolonged display (4-7 days) at room temperature in a retail outlet can, and frequently does, negate all prior careful handling of the fresh product. The longer a fruit is kept out of refrigerated storage, the more likely the fruit will be of poor eating quality (WFLO Commodity Storage, 2008).

Achinewhu and Hart (1994), studied ascorbic acid contents of the juice of four different pineapples species grown in the Rivers State of Nigeria before and after storage of whole pineapple and processing and storage of the juice for two months. Ascorbic acid of the fresh juice ranged from 22.5 mg to 33.5 mg/100 g sample. After storage at room temperature (30-32°C) of whole pineapple for two weeks, ascorbic acid was reduced to between 59 and 65 percent of the fresh juice. The aim of the consumer acceptability test was to evaluate the acceptability of organic and conventional sugar-loaf pineapples of different translucencies stored at 1°C and 8°C.

2.0 Materials and Methods

2.1 Materials

Organic and conventional sugar-loaf pineapples were harvested three different times from Ali farms in Ekumfi area (Central Region of Ghana) and Albe farms in the Eastern Region of Ghana respectively and transported to the CSIR-Food Research Institute laboratory. One hundred fruits were delivered for each variety per harvesting times in three batches.

2.2 Sample preparation

A total of 5 samples each of conventional and organic pineapples stored at 1°C and 8°C for 14 days were randomly selected and used for the consumer acceptance test. The pineapples were washed thoroughly and sliced cylindrically to check its translucency. The translucencies identified for conventional sugar-loaf pineapples were 25-50%, 50-75% translucencies at 1˚C and 25-50% translucency at 8˚C. For the organic pineapples, the following translucencies were observed 25-50% translucency at 1˚C, 25-50% and 50-75% translucencies at 8˚C. The pineapples were then peeled and sliced into 3g cylindrical slices and covered with cling film.

2.3 Consumer acceptability of sugar-loaf pineapples stored at different conditions

Consumer acceptance test was carried out using 30 consumers recruited from CSIR-Food Research Institute. All selected participants regularly consumed pineapples at least twice in a week. Each participant evaluated four (4) samples in a randomized order under white fluorescent light at the Sensory Laboratory of the CSIR-Food Research Institute. Three gram (3g) each of samples were served. The samples were coded with 3-digit random numbers. A glass of water and sliced cucumber were provided to cleanse their palate between samples. Consumers were asked to provide their liking responses on a 9-point hedonic scale (1 = dislike extremely, 5= neither like nor dislike, and 9 = like extremely) (Meilgaard *et al*., 2006; Stone and Sidel, 2004) for appearance, color, taste, aroma, taste, texture, mouth-feel and overall acceptability. The consumer test was conducted for three batches of the harvested pineapples.

2.4 Statistical Analyses

Ratings of acceptance of appearance, color, aroma, taste, texture, mouth-feel and overall acceptance of each sample were analyzed by analysis of variance (ANOVA) and then Fisher's least significant difference (LSD) procedure with Statistical Analysis Software (SAS, version 9.2,

SAS Inst. Inc., Cary, N.C., U.S.A.). Principal component analysis (PCA) was also performed in order to show relationships among pineapple type, batches and attributes (Variables). Mean value for each parameter was computed across complicated and replicated and used for PCA. All calculations were performed with the STATISTICA for Windows program (Release 7.0; StatSoft Inc., Tulsa, OK, USA).

3.0 Results and Discussion

The mean scores of 30 consumers' ratings of appearance, color, aroma, taste, texture, mouth-feel and overall acceptance for conventional sugar-loaf pineapples are shown in Table 2. For average overall acceptance, 25-50% translucency pineapples at 1˚C scored the highest (7.3), but was not significantly different from 50-75% translucency pineapples at 1˚C (6.4) and 25-50% translucency pineapples at 8˚C (5.9). Pineapples with 25-50% translucency at 1˚C was also rated highest for average acceptance of appearance (7.4), color (7.5), aroma (7.2) and taste (7.1), texture (7.2), mouth-feel (7.1). There was no significant differences ($p \geq 0.05$) in appearance, color, aroma, texture of all three samples. Pineapples with 50-75% translucency and stored at 1˚C was significantly different ($p \leq 0.05$) for taste, mouth-feel and over all acceptability. This is because the 50-75% translucency pineapple was nearing the ripening stage and tasted better. The dominant sugars increased during ripening development.

Table 1: Sensory attributes of conventional sugarloaf pineapples stored at 1°C and 8°C for 14 days

Translucency	Appearance	Color	Aroma	Taste	Texture	Mouth feel	Acceptability
25-50% at 1˚C	7.4±1.5^{a}	7.5±1.1^{a}	7.2±1.2^{a}	7.1±1.5^{a}	7.2±1.3^{a}	7.1±1.3^{a}	7.3±1.3^{a}
50-75% at 1˚C	7.3±1.3^{a}	7.3±1.0^{a}	6.6±1.5^{a}	6.1±2.0^{ab}	6.7±1.5^{a}	6.2±1.9^{b}	6.4±1.8^{ab}
25-50% at 8˚C	7.2±1.1^{a}	7.2±1.0^{a}	6.7±1.2^{a}	5.4±2.01^{a}	6.4±1.5^{a}	5.8±1.8^{a}	5.9±1.7^{a}

Mean of 30 determinations ± standard deviation, Means with the same letters in a row are not significantly different ($P \leq 0.05$).Overall acceptance and acceptance of appearance, aroma, texture, and taste were rated on a 9-point hedonic scale, "1 = extremely dislike"2= dislike very much, 3=dislike moderately, 4=dislike slightly, 5=Neither like nor dislike, 6= like slightly, 7= like moderately, 8= like very much to "9 = extremely like.

The organic sugar-loaf pineapples with 25-50% translucency stored at 1˚C were liked significantly more in terms of the appearance and color (Table 2). Based on mean overall acceptability scores, consumers liked the 50-75% translucency sugar-loaf pineapples stored at 8˚C very much. This

can be attributed to the ripening of the pineapples which was caused by the translucent characteristics and the storage conditions. Significant differences existed in overall acceptability ratings at $p \leq 0.05$ for the considered samples.

The consumers rated "like very much" for color, aroma, taste, texture and mouth-feel for pineapples with 50-75% translucency stored at 8˚C. This sample was significantly difference at $p \leq 0.05$ for color, aroma, taste, texture and mouth-feel attributes compared to the 25-50% translucency pineapples stored at 1˚C and 25-50% translucency pineapples stored at 1˚C. It was understandable for the consumers to accept the 50-75% translucency pineapples stored at 8˚C because of the ripening stage because the carbohydrates in the samples it being converted to sugars, making the pineapples very sweet and appreciated. On the other hand, the sugar content of pineapple keeps increasing after harvest. Paull and Chen (1993), concluded that fruit sugars continue to increase through to senescence, unless the fruit is harvested.

Table 2: Sensory attributes of organic sugarloaf pineapple stored at 1°C and 8°C for 14 days

Translucency	Appearance	Color	Aroma	Taste	Texture	Mouth feel	Overall Acceptability
25-50% at 1˚C	7.5±1.1^{a}	7.1±1.3^{a}	6.8±1.5^{b}	6.8±1.5^{b}	7.1±1.2^{b}	6.9±1.4^{a}	7.2±1.1^{b}
25-50% at 8˚C	7.0±1.2^{a}	7.1±1.3^{a}	6.1±1.2^{b}	5.6±1.6^{c}	6.6±1.2^{b}	6.1±1.6^{b}	6.1±1.4^{c}
50-75% at 8˚C	7.7±1.1^{a}	7.7±1.0^{a}	7.8±1.0^{a}	8.2±0.8^{a}	7.8±0.8^{a}	7.8±1.1^{a}	8.0±1.0^{a}

Mean of 30 determinations ± standard deviation, Means with the same letters in a row are not significantly different ($P \leq 0.05$).Overall acceptance and acceptance of appearance, aroma, texture, and taste were rated on a 9-point hedonic scale, "1 = extremely dislike"2= dislike very much, 3=dislike moderately, 4=dislike slightly, 5=Neither like nor dislike, 6= like slightly, 7= like moderately, 8= like very much to "9 = extremely like.

3.1 Consumer acceptability of second batch pineapples

Results from the consumer acceptance of organic grown sugar-loaf pineapples stored at 1°C and 8°C for 14 days is shown in Figure 1, including the significant difference between samples. Significant differences were seen for consumer ranking of aroma, taste, texture, mouth-feel and overall acceptability of sugar -loaf pineapples (Figure 1). Some of these differences may have occurred because consumers have their own acceptance standards.

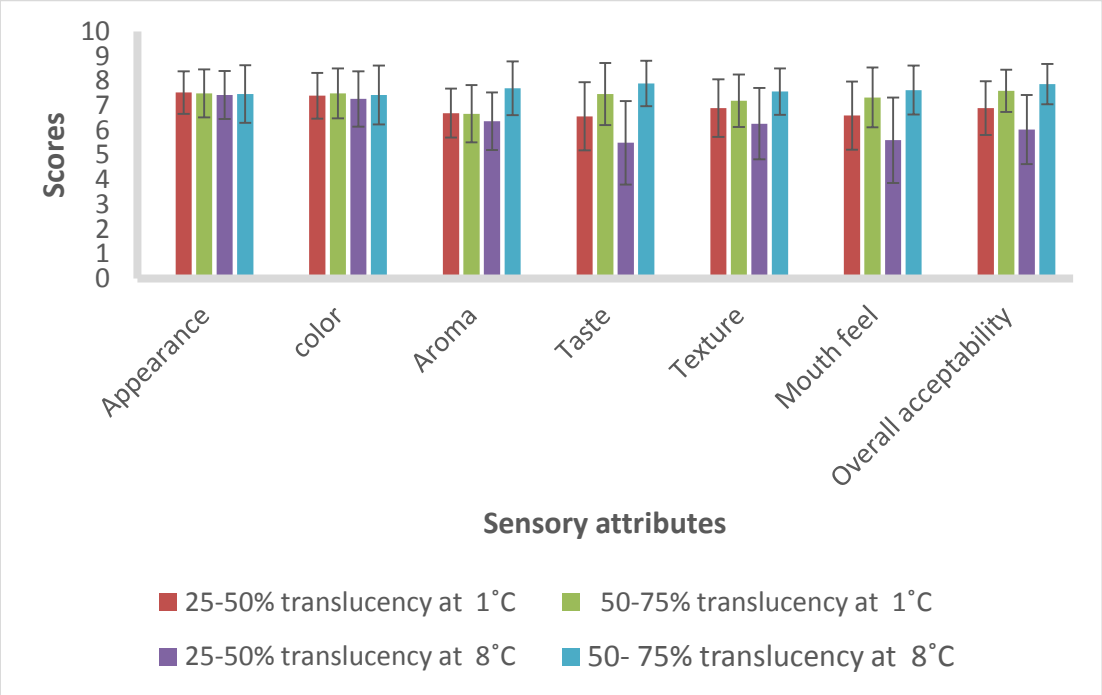

Figure 1: Showing mean scores of organic sugar-loaf pineapples stored at 1°C and 8°C for 14 days (Batch 2)

There was no difference in appearance acceptability between the organic sugar-loaf pineapples stored at 1°C and 8°C for both 25-50% and 50-75% translucencies. The 25-50% translucency pineapples stored at 8°C had lower mean scores for appearance, but there was no significant difference in consumer acceptance between all other samples. The score for color for pineapples samples was generally 7 which is interpreted as moderately liked. There was no significant differences in acceptance of organic sugar-loaf pineapples stored at 1°C and 8°C (Figure 1). The highest color score for organic stored pineapples at 1˚C with 50-75% translucency was 7.50 ± 1.01, thus it was moderately liked. No significant difference existed ($P>0.05$) between the color of all stored pineapples. The aroma rating for 25-50% translucency, 50-75% translucency pineapples stored at 1°C was moderately liked, however the 50- 75% translucency pineapples stored at 8°C was liked very much unlike the 25-50% translucency pineapples, which was slightly liked. There was no significant differences ($p\geq0.05$) in aroma scores for 25-50%, 50-75% translucency

pineapples stored at 1°C and 25-50%, stored at 8°C. The aroma scores of pineapples stored at 8°C with 50- 75% translucency was significantly different ($P \leq 0.05$).

Pineapples with 25-50% and 50-75% translucency was moderately liked for taste attribute with scores ranging from 6.57 -7.47 (Figure 1). The taste score for 25-50% translucency pineapples stored at 8˚C was 5.50, which is interpreted as like slightly. There was significant differences ($p \leq 0.05$) in the texture of organic pineapples stored at both temperatures (Figure 1). Interestingly, the 50-75% translucency organic pineapples stored at 1°C and 8°C for 14 days were not significantly different. The mouth-feel attribute was significantly differences ($p \leq 0.05$) for considered type of pineapples and storage treatments.

After 14 days of storage at 1°C and 8°C , the 50-75% translucency organic pineapples recorded an overall acceptability score of liked very much (Figure 1). This was because the pineapples were getting ripe and tasted sweeter compared to the others. The reason for the sweetness was because of the conversion of the carbohydrates into sugars. The results shows that if the organic pineapples are being transported there is a more likelihood of the high translucency pineapples getting spoilt than the low translucency ones. Organic pineapples with 25-50% translucency stored at 1°C gave an overall acceptability score of 6.90 compared to 6.03 for that stored at 8°C (Figure 1). This implies the former is well appreciated by the consumers. The scores for consumer acceptance of conventional sugar-loaf pineapples stored at 1°C and 8°C for 14 days is illustrated in (Figure 2).

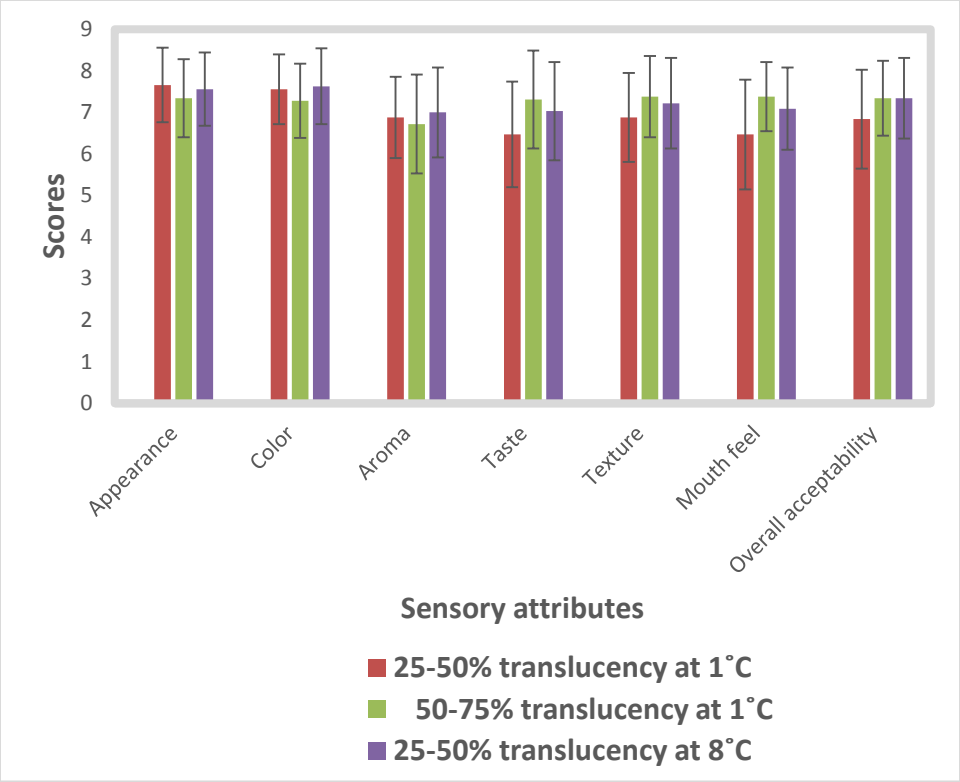

Figure 2: showing the mean scores for conventional sugar-loaf pineapples stored at 1°C and 8°C for 14 days (Batch 2)

The score for appearance of 25-50% and 50-75% translucency conventional pineapples stored at 1°C was moderately liked, the same applied to the 25-50% translucency conventional pineapples stored at 8°C. There was no significant difference between the scores at ($p \geq 0.05$). No significant differences were observed for the color and aroma for 25-50% and 50-75% translucency conventional pineapples stored at 1°C , they were slightly liked by consumers, however, 25-50% translucency conventional pineapples stored at 8°C was moderately liked although the score was not significantly different ($p \geq 0.05$).

A taste score of 7.31 was recorded by 50-75% translucency conventional pineapples stored at 1°C, whereas 25-50% translucency pineapples gave a score of 6.47 (Figure 2). Conventional pineapples with 25-50% translucency stored at 8°C recorded taste score of 7.03. Texture scores was not significantly different among the samples in both storage conditions. Moderately liked score was obtained for 50-75% translucency conventional pineapples stored at 1°C. It also recorded a high

score for mouth-feel (7.38), a score of 6.47 was observed for 25-50% translucency conventional pineapples stored at 1°C. The overall acceptability scores for both 50-75% translucency conventional pineapples stored at 1°C and 25-50% translucency conventional pineapples stored at 8°C was 7.34 (moderately liked). No significant difference ($p \geq 0.05$) existed in the overall acceptability of conventional sugar-loaf pineapples stored at 1°C and 8°C (Figure 2).

3.2 Consumer acceptability of third batch of conventional and organic sugarloaf pineapples

The mean scores for the conventional sugar-loaf pineapples is presented in Table 3. There were no significant ($P > 0.05$) differences in hedonic scores between the 25-50% translucency conventional pineapples stored at 1˚C and 8˚C for appearance, aroma, taste, texture, flavor, mouth-feel and overall acceptability, with average scores ranging from 5.79 to 7.34 for these attributes. Consumers liked the 25-50% translucency conventional pineapples stored at 1˚C and 8˚C slightly and moderately (Table 3). However, 25-50% translucency pineapples stored at 1˚C gave a higher score of 6.83±1.26 (Like moderately) compared to 6.42±1.53 (Like slightly) for 25-50% translucency pineapples stored at 1˚C. The samples were not however different from each other. The higher acceptability ratings for the 25-50% translucency pineapples stored at 1˚C could be attributed to the storage condition.

Table 3: Mean scores of conventional sugar-loaf pineapples stored at 1°C and 8°C for 14 days

Translucency	Appearance	Color	Aroma	Taste	Texture	Mouth feel	Overall Acceptability
25-50% at 1˚C	7.3±0.9[a]	7.3±0.7[a]	7.0±1.21[a]	6.4±1.6[a]	7.0±1.1[a]	6.8±1.3[a]	6.8±1.3[a]
25-50% at 8˚C	6.8±1.2[a]	6.9±1.2[a]	6.3±1.39[a]	5.8±1.6[a]	6.6±1.3[a]	6.2±1.4[a]	6.4±1.5[a]

Mean of 30 determinations ± standard deviation, Means with the same letters in a row are not significantly different ($P \leq 0.05$).Overall acceptance and acceptance of appearance, aroma, texture, and taste were rated on a 9-point hedonic scale, "1 = extremely dislike"2= dislike very much, 3=dislike moderately, 4=dislike slightly, 5=Neither like nor dislike, 6= like slightly, 7= like moderately, 8= like very much to "9 = extremely like.

The sensory attributes scores for organic sugar-loaf pineapples stored at 1°C and 8°C for 14 days is given in Table 4. Consumers scored 7.21 (like moderately) for the appearance of 50-75% translucency sugar-loaf pineapples stored at 1˚C. The reason for this score was because 50-75% translucency sugar-loaf looked almost fully ripe. A low score of 6.83±1.17 (like slightly) for appearance was recorded for 25-50% translucency pineapples stored at 1˚C. The same trend was observed for the color attribute of the samples (Table 4).

Table 4: Mean scores of organic sugar-loaf pineapples stored at 1°C and 8°C for 14 days

Translucency	Appearance	Color	Aroma	Taste	Texture	Mouth feel	Overall Acceptability
25-50% at 1˚C	6.8±1.2[a]	6.8±1.3[a]	6.5±0.9[b]	6.5±1.5[b]	6.8±1.2[a]	6.5±1.2[a]	6.5±1.4[b]
25-50% at 8˚C	7.1±1.2[a]	7.0±1.3[a]	7.3±0. 9[a]	6.9±1.4[ab]	7.1±1.4[a]	6.9±1.5[ab]	7.0±1.4[ab]
50-75% at 1˚C	7.2±1.1[a]	7.3±1.0[a]	7.3±1.0[a]	7.6±1.4[a]	7.3±1.2[a]	7.5±1.4[b]	7.5±1.3[a]

Mean of 30 determinations ± standard deviation, Means with the same letters in a row are not significantly different ($P \leq 0.05$).Overall acceptance and acceptance of appearance, aroma, texture, and taste were rated on a 9-point hedonic scale, "1 = extremely dislike"2= dislike very much, 3=dislike moderately, 4=dislike slightly, 5=Neither like nor dislike, 6= like slightly, 7= like moderately, 8= like very much to "9 = extremely like.

The scores for aroma for 25-50% translucency pineapples stored at 8˚C and 50-75% translucency pineapples stored at 1˚C was the same (7.31) compared to 6.83 for 25-50% translucency at 1˚C. Significant differences existed in the samples at $p \leq 0.05$ (Table 4).

Sugar-loaf pineapples with 50-75% translucency stored at 1˚C gave a score of 7.55 (like very much) for taste. The reason for this score was because 50-75% translucency sugar-loaf tasted almost fully riped and sweet. A least score of 6.48 was scored for 25-50% translucency pineapples stored at 1˚C. This result indicate that 25-50% translucency pineapples stored at 1˚C will store for a longer days during transportation by sea freight. Significant differences were observed at ($p \leq 0.05$) for the taste scores. Texture scores for all samples were not significantly different at ($p \geq 0.05$). The mouth-feel attribute ranged from 6.52- 7.52, with 50-75% translucency pineapples stored at 1˚C recording a score of like very much. The mouth-feel scores were significantly different for all samples at ($p \leq 0.05$) (Table 4).

As expected, the 50-75% translucency pineapples stored at 1˚C recorded a high overall acceptability of 7.52 (like very much) compared to a score of 6.52 for 25-50% translucency pineapples stored at 1˚C. Overall acceptability scores were significantly different at ($p \leq 0.05$) (Table 4). Generally, the 50-75% translucency pineapples are almost ripened and will taste better than the 25-50% translucency pineapples. However the low translucency pineapples will store for long during transportation by sea compared to the high translucency pineapples where almost all the carbohydrates have been converted to sugars. According to Ikegwu and Ekwu (2009), the solid contents of food products are related to their food values and the decrease in total solids may be

as a result of microbial activities. Their activities by way of utilizing the food also decrease the content of non-structural carbohydrates, protein and food energy.

3.3 Principal Component analysis of consumer acceptability on pineapple samples

3.3.1 Organic Sugar-loaf pineapples Batch 1

The Principal Component Analysis (PCA) of sensory data of Batch 1 organic pineapples of different translucencies is shown in figure 3. Principal Components (PC)1 which explained 96.7% of variation within the equation showed a higher positive correlation (> 0.93) with descriptors colour, taste, aroma, appearance, texture, mouth-feel and overall acceptably (Table 1). Using PC 1, organic pineapples samples with 50-75% translucent at 1 °C exhibited higher positive correlation with colour (0.933), aroma (0.998), texture (0.999) and taste (0.999). Considering the PCI, there was a good relationship between aroma, texture, color and taste with organic pineapples with translucency of 50-75% (050751C). This can be attributed to the sweetness of the pineapple because it is matured. The reason for the sweetness is because of the conversion of the carbohydrates into sugars.

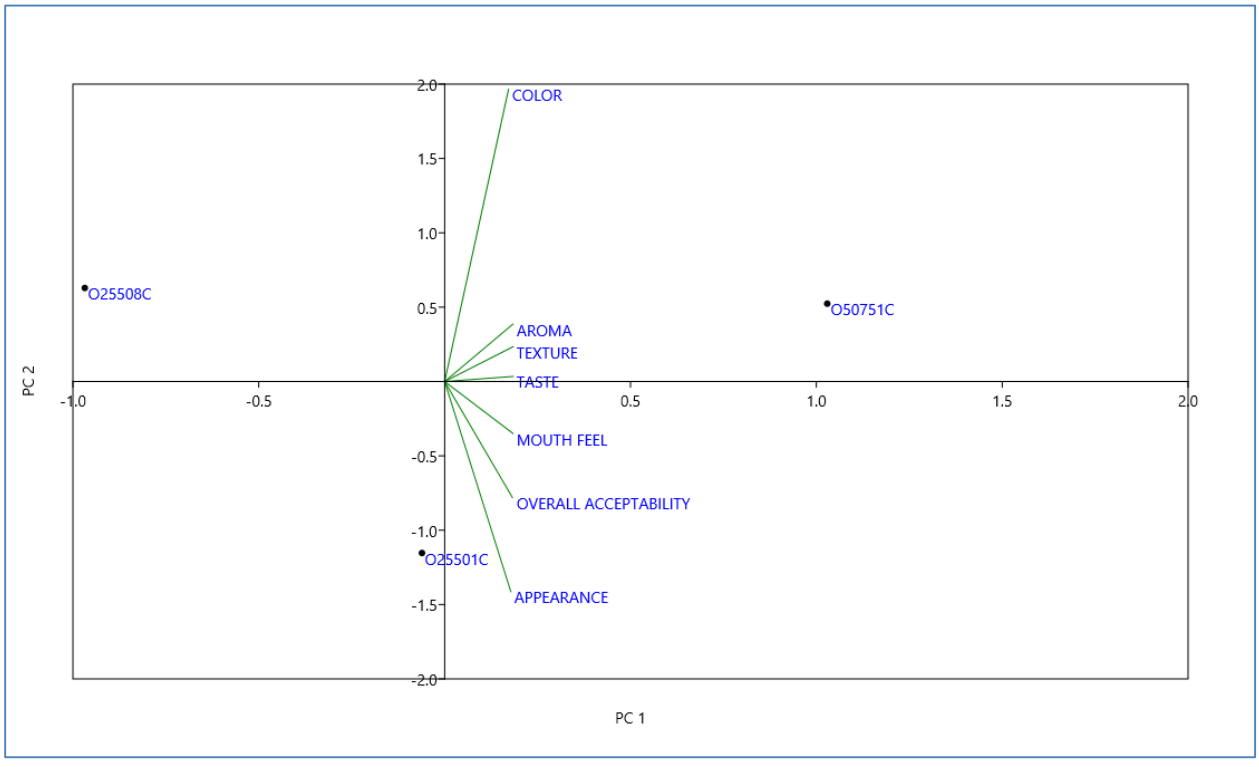

Figure 3: Principal Component Analysis (PCA) of sensory data of organic pineapple samples (O2550T1C[1], O5075T8C[2] & O5075T1C[3]) O2550%1C = Organic 25-50% translucent @ 1˚C, O25508C= Organic 25-50% translucent @ 8˚C, O50751C = Organic 50-75% translucent @ 1˚C

Table 5: Principal component factor loadings for organic pineapple attributes

Attributes	PC 1	PC 2
Appearance	0.96575	-0.25948
Color	0.93263	0.36083
Aroma	0.99748	0.070925
Taste	0.99998	0.006242
Texture	0.99907	0.043012
Mouth feel	0.99794	-0.06418
Overall acceptability	0.98968	-0.14332

3.3.2 Organic Sugar-loaf pineapples –Batch 2

Figure 4 presents the Principal Component Analysis (PCA) biplots of sensory data of organic pineapple samples with different translucencies. Principal Components (PC) 1 explained 80.23 % of variation within the equation. It showed a higher positive correlation (0.991 - 0.997) with descriptors taste, texture, mouth-feel, aroma and overall acceptably (Table 6). Using PC 1, organic pineapples samples with 25-50% translucent at 1°C exhibited higher positive correlation with colour (0.90). Organic pineapple sample with 50-75% translucency at 8°C showed a higher positive correlation with mouth-feel (0.99), taste (0.991), texture (0.991) and overall acceptability (0.995).

[1] O2550%1C = Organic 25-50% translucent @ 1˚C
[2] O25508C= Organic 25-50% translucent @ 8˚C
[3] O50751C = Organic 50-75% translucent @ 1˚C

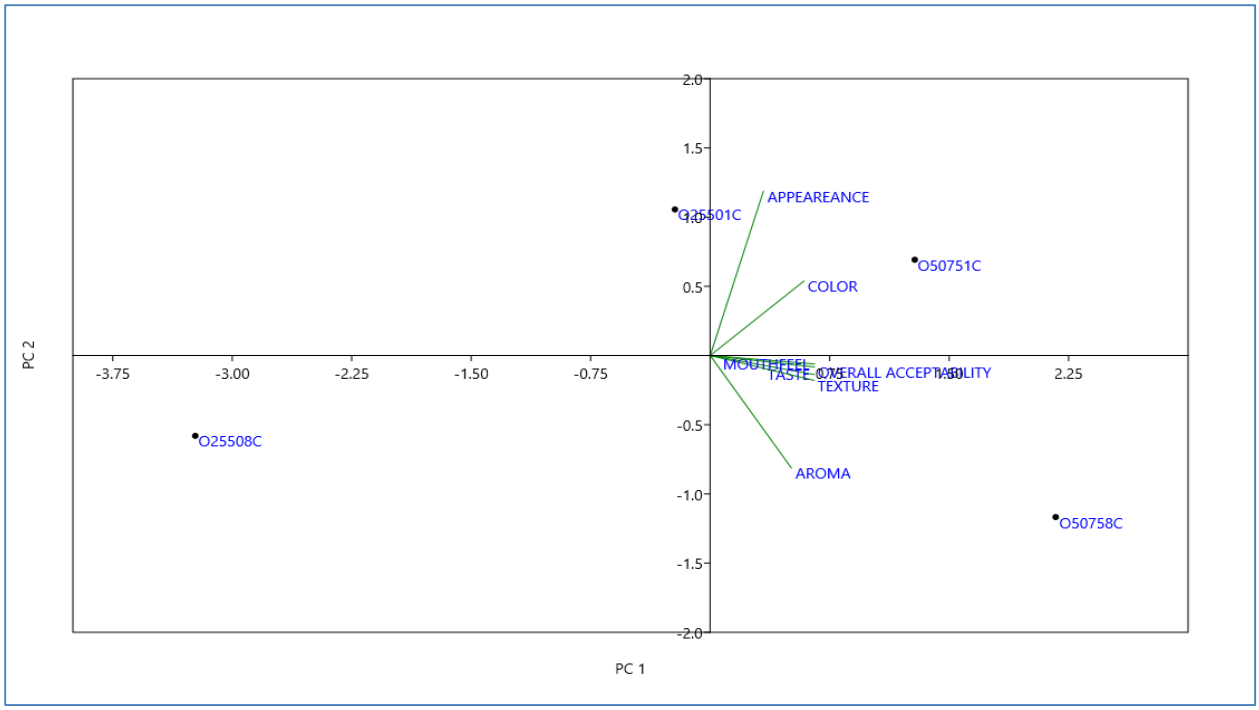

Figure 4: Principal Component Analysis (PCA) of sensory data of organic pineapple samples (O2550T1C[4], O2550T8C[5], O5075T8C[6] & O5075T1C[7])

Table 6: Principal component factor loadings for organic pineapple attributes.

Attributes	PC 1	PC 2	PC 3
Appeareance	0.50882	0.7993	0.31974
Color	0.89666	0.36246	-0.25423
Aroma	0.77599	-0.5471	0.31389
Taste	0.99261	-0.092326	-0.07878
Texture	0.99122	-0.12076	0.053831
Mouthfeel	0.9968	-0.041013	-0.068546
Overall acceptability	0.9948	-0.055213	-0.085588

3.3.3 Organic Sugar-loaf pineapples –Batch 3

Principal Component Analysis (PCA) of sensory data of organic pineapple samples of different translucencies is shown in figure 5. Principal Components (PC) 1 accounted for 94.25 % of variation within the equation showing a higher positive correlation (0.903 – 0.998) with descriptors

[4] Brown = Organic 25-50% translucent @ 1˚C
[5] Violet = Organic 25-50% translucent @ 8˚C
[6] Blue = Organic 25-50% translucent @ 8˚C
[7] Lime = Organic 50-75% translucent @ 1˚C

taste, aroma, appearance, texture, mouth-feel, aroma and overall acceptably (Table 7). Using PC 1, organic pineapples samples with 25-50% translucency at 8 C (O702) exhibited higher positive correlation with aroma (0.90), appearance (0.960) and texture (0.998). Organic pineapple sample with 50-75% translucence at 1°C (O568) indicated a higher positive correlation with mouth-feel (0.980), taste (0.970), colour (0.979) and overall acceptability (0.998).

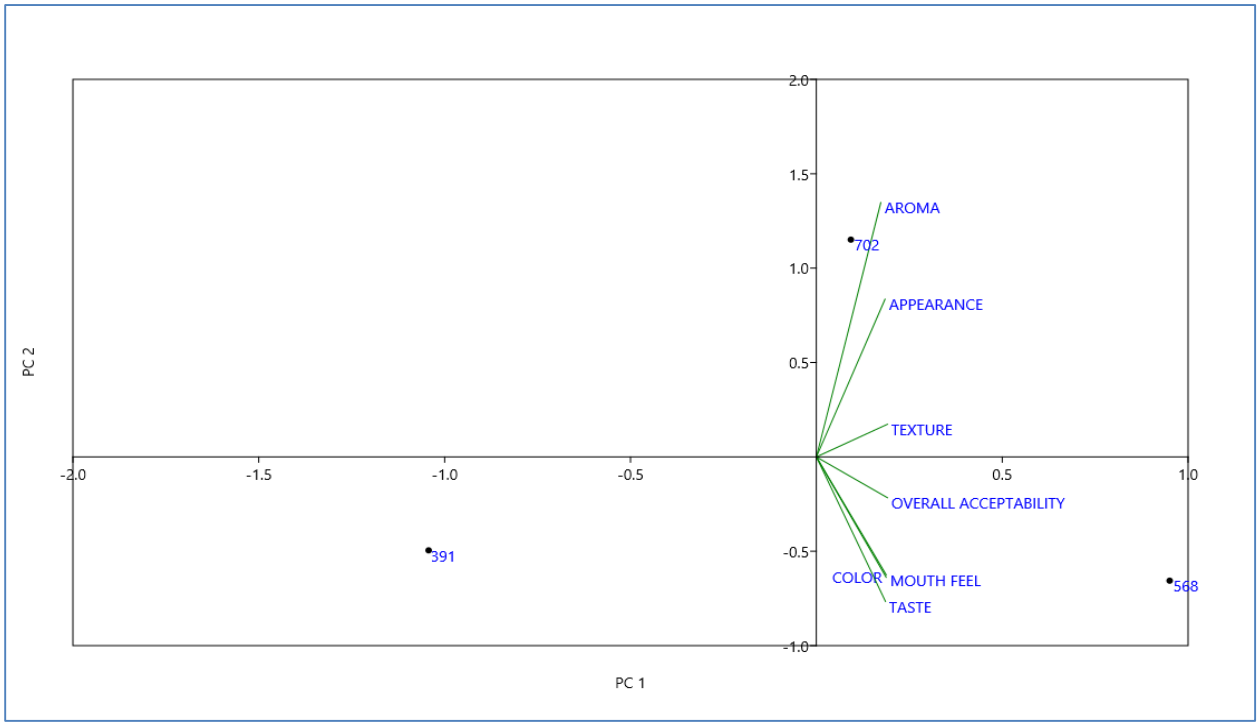

Figure 5: Principal Component Analysis (PCA) of sensory data of organic pineapple samples (O702[8], O568[9] & O391[10])

Table 7: Principal component factor loadings for organic pineapple attributes.

Attributes	PC 1	PC 2
Appearance	0.96399	0.26593
Color	0.97919	-0.20296
Aroma	0.90342	0.42875
Taste	0.96984	-0.24374
Texture	0.99848	0.055112
Mouth feel	0.98003	-0.19886
Overall acceptability	0.99762	-0.068886

[8] O702 = Organic 25-50% translucent @ 8˚C
[9] O568 = Organic 50-75% translucent @ 1˚C
[10] O391= Organic 25-50% translucent @ 1˚C

3.3.4 Conventional Sugar-loaf pineapples –Batch 1

The principal component plot is shown in figure 6. Principal Components (PC) 1 explained 96.5% of variation within the equation and showed a higher positive correlation (0.91 – 1.00) with descriptors taste, texture, mouth-feel, aroma, appearance, colour and overall acceptably (Table 8). Using PC 1, conventional pineapples samples with 25-50% translucency stored at 1 °C showed a higher positive correlation (0.906 and 0.998) with appearance and aroma respectively. Considering the first quadrant for the PC1, 25 -50% translucency (C2550T1C) pineapples stored at 1 °C had consumers appreciating the aroma and appearance. Consumers however preferred the colour, mouthfeel, texture and taste of the C5075T1C pineapples as shown in the second quadrant of PC1.

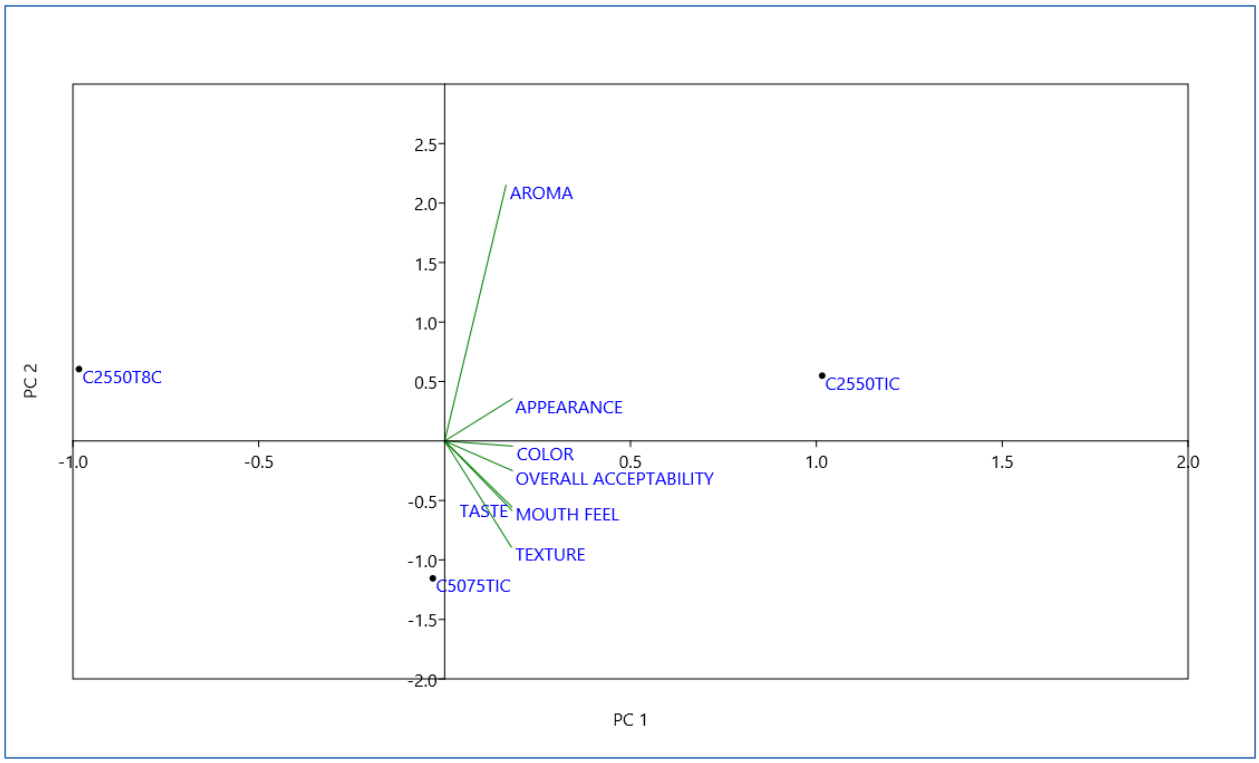

Figure 6: Principal Component Analysis (PCA) of sensory data of convention pineapple samples (C2550T1C[11], C2550T8C[12] & C5075T1C[13])

[11] C25501C = Conventional 25-50% translucent @ 1˚C
[12] C25508C= Conventional 25-50% translucent @ 8˚C
[13] C50751C = Conventional 50-75% translucent @ 1˚C

Table 8: Principal component factor loadings for conventional pineapple attributes.

Attributes	PC 1	PC 2
Appearance	0.99756	0.069814
Color	0.99996	-0.0084944
Aroma	0.90599	0.42331
Taste	0.99337	-0.11492
Texture	0.98445	-0.17565
Mouth feel	0.99402	-0.10922
Overall acceptability	0.9988	-0.049074

3.3.5 Conventional Sugar-loaf pineapples –Batch 2

Figure 7 illustrates Principal Component Analysis (PCA) of sensory data of conventional pineapple samples. The Principal Components (PC)1 which explained 78.22 % of variation within the equation showed a higher positive correlation (0.85 – 0.97) with descriptors taste, texture, mouth-feel and overall acceptably (Table 9). However, PC 1 exhibited a negative correlation with aroma (0.98), colour (0.79 and appearance (0.58). Using PC 1, conventional pineapples samples with 25-50% translucent stored at 8°C exhibited higher negative correlation (0.98) with aroma coupled with a moderate negative correlation (0.58 and 0.79) with appearance and colour respectively.

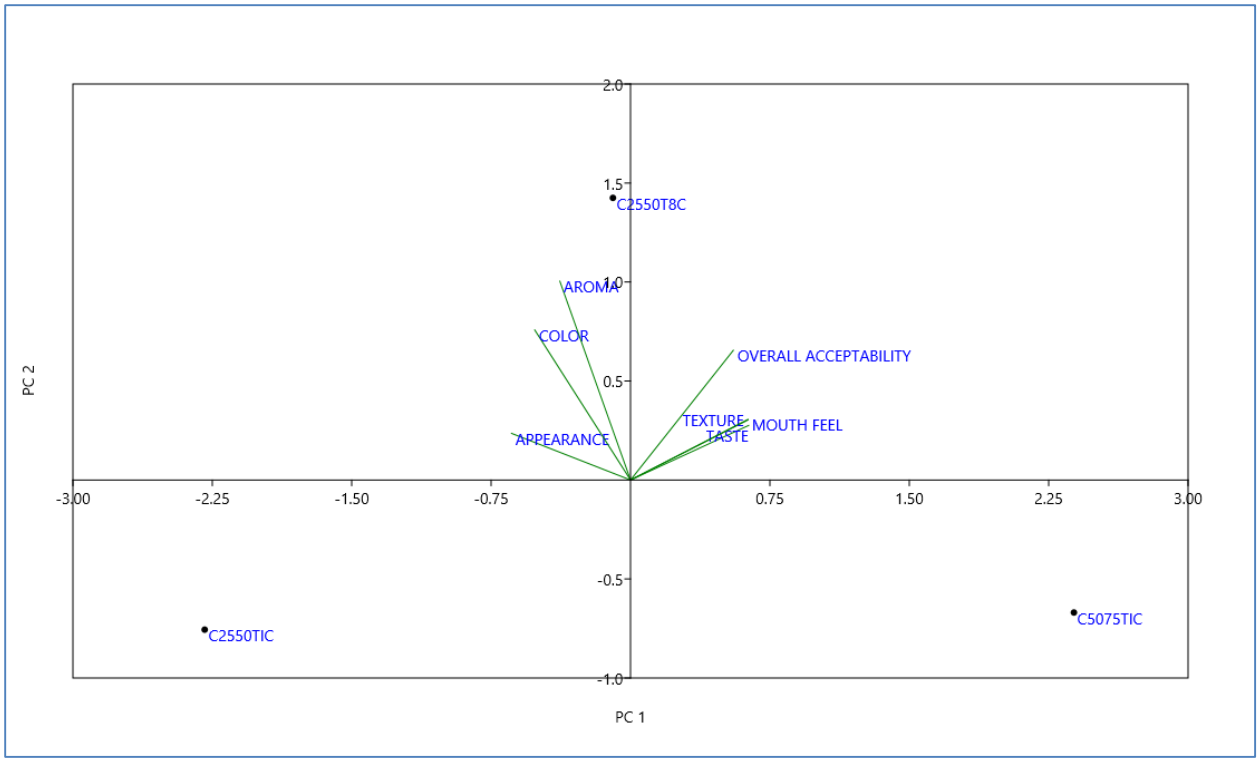

Figure 7: Principal Component Analysis (PCA) of sensory data of conventional pineapple samples (C2550T1C[14], C2550T8C[15] & C5075T1C[16])

Table 9: Principal component factor loadings for conventional pineapple attributes.

Attributes	**PC 1**	**PC 2**
Appearance	-0.98163	0.19078
Color	-0.78993	0.6132
Aroma	-0.5832	0.81233
Taste	0.97477	0.22323
Texture	0.96935	0.24568
Mouth feel	0.96877	0.24798
Overall acceptability	0.848	0.53

3.3.6 Conventional Sugar-loaf pineapples –Batch 3

Principal Component Analysis (PCA) of sensory data of conventional pineapple samples of different translucencies is shown in Figure 8. Principal Components (PC)1 accounted for 100 % of variation within the equation showed a higher positive correlation (1.00) with descriptors taste, aroma, appearance, colour texture, mouth-feel and overall acceptably (Table 10). Using PC 1, conventional pineapples samples with 25-50% translucency stored at 1° C (C480) exhibited higher positive correlation of 1.00 with all the descriptors.

[14] C25501C = Conventional 25-50% translucent @ 1˚C
[15] C25508C = Conventional 25-50% translucent @ 8˚C
[16] C50751C = Conventional 50-75% translucent @ 1˚C

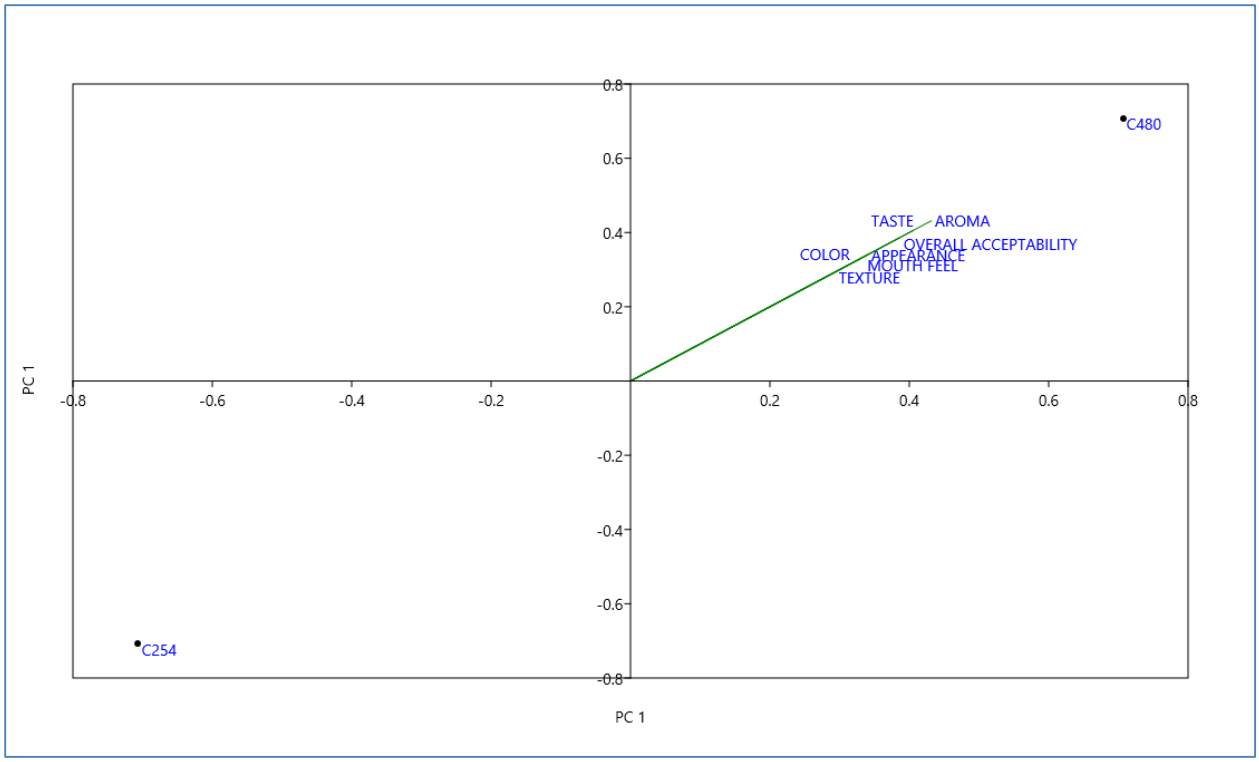

Figure 8: Principal Component Analysis (PCA) of sensory data of convention pineapple samples (C480[17] & C254[18])

Table 10: Principal component factor loadings for conventional pineapple attributes.

Attributes	PC 1
Appearance	1
Color	1
Aroma	1
Taste	1
Texture	1
Mouth feel	1
Overall acceptability	1

4.0 Conclusion

Organic and conventional pineapples with 25-50% and 50-75% translucencies stored at the 8°C and 1°C were preferred by consumers. The more translucent pineapples were highly accepted because it was more matured and sweet because the carbohydrates had broken down to sugars.

[17] C480 = Conventional 25-50% translucent @ 1˚C
[18] C254= Conventional 25-50% translucent @ 8˚C

High translucent pineapples will not store for long during sea-freighting for both organic and conventional sugar-loaf pineapples. The storage stability for 25-50% translucent pineapples will be high for sea-freighting of organic sugar-loaf pineapples. The results shows that if the organic pineapples are being transported there is a more likelihood of the high translucency pineapples getting spoilt than the low translucency ones. The organic pineapples stored at 1°C and 8°C will be able to be transported by sea for 14 days, if the translucency is >25% and 25-50%.

References

Achinewhu, S.C and Hart, A.D (1994). Effect of processing and storage on the ascorbic acid (vitamin C) content of some pineapple varieties grown in the Rivers State of Nigeria.Plant Foods Hum Nutr. 1994 Dec; 46(4):335-7

Cho E, Seddon JM, Rosner B, Willett WC, Hankinson SE. (2004). Prospective study of intake of fruits, vegetables, vitamins, and carotenoids and risk of age-related maculopathy. *Arch Ophthalmol*. 2004 Jun;122(6):883-92.. PMID:15197064.

Coveca, (2002). Comision veracruzana de comercializacion agropecuaria. Gobierno del Estado de Veracruz, México.

Fernandes, F. A. N. Jr., Linhares F. E. and Rodrigues, S., (2008). Ultrasound as Pre-Treatment for Drying of Pineapple, Ultrasonic Sonochemistry, Vol. 15, No. 6, pp. 1049- 1054

Hossain, F. M., Akhtar, S., and Anwar, M. (2015). Nutritional Value and Medicinal Benefits of Pineapple. *International Journal of Nutrition and Food Sciences*. Vol. 4, No. 1, pp. 84-88.

Ikegwu, O. J. and Ekwu, F.C. (2009). Thermal and Physical Properties of Some Tropical Fruits and their Juices in Nigeria. *Journal of Food Technology 7(2):38-42.*

Kleemann, L. (2011).Organic Pineapple Farming in Ghana - A Good Choice for Smallholders? No. 1671 | January 2011. Kiel Institute for the World Economy, Hindenburgufer 66, 24105 Kiel, Germany.

Meilgaard, M. C., Civille, G. V. and Carr, B. T. (2006). Sensory Evaluation Techniques (fourth ed.). Boca Raton: CRC Press.

Stone, H., and Sidel, J.L. (2004). Sensory Evaluation Practices (third ed.). New York; Elsevier Academic Press.

United Nations Commission on Trade and Development (UNCTAD) (2006). Trade and Environment Review. *UNCTAD/DITC/TED/2005/12*, United Nations, Geneva.

USDA National Nutrient Database.