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Research Application Summary

The effect of some pre- and postharvest factors of organic sugarloaf on pineapple juice quality and microbial safety

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Abstract

The study was conducted to assess the impact of maturity stage, storage temperature and time of harvest of pineapple fruits on pineapple juice quality and microbial safety of organic sugarloaf using completely randomized design (CRD) with 18 treatment combinations and three replications. The physicochemical, microbial and sensory properties were evaluated on the pineapple juice. The results showed significant differences in the parameters analyzed for the various juice obtained. The pineapples also had high Total Soluble Solids (TSS) values since they were organic fruits. From the study, over mature pineapples, harvested in the afternoon and stored in a refrigerator before juicing had the highest TSS value (20.2 oB), titratable acidity content (1.10 % citric acid), vitamin C (20.93 mg/100ml) and total phenol content (82.84 mg/100ml) but had the least total flavonoid content (6.10 mg/100ml). Yeast and mould counts ranged from 2.342 log CFU/ml to 4.227 log CFU/ml, which were below the limit of microbial shelf life for juice. Results from the sensory evaluation showed that juice from over mature sugarloaf harvested in the morning and stored in ambient condition before processing was preferred by consumers in terms of taste, aftertaste and overall acceptability. This information will help pineapple fruit producers and processors to have a fair idea of the juice quality to expect based on the stage of maturity, time of harvest and temperature of storage before processing.

Key words: Flavonoid content, harvest time, juice quality, pineapples

Résumé

L'étude a été menée pour évaluer l'impact du stade de maturité, de la température de stockage et de la période de récolte des fruits d'ananas Pain de Sucre bio sur la qualité et la sureté microbienne du jus d'ananas en utilisant un dispositif complètement randomisée (CRD) avec 18 combinaisons de traitement et trois répétitions. Les propriétés physicochimiques, microbiennes et sensorielles ont été évaluées sur le jus d'ananas. Les résultats ont montré des différences significatives au sein de paramètres analysés pour les différents jus obtenus. Les ananas avaient également des valeurs élevées de solides solubles totaux (TSS) puisqu'il s'agissait de fruits bios. D'après l'étude, les ananas plus mûrs, récoltés dans l'après-midi et conservés au réfrigérateur avant d'être pressés, présentaient la valeur TSS la plus élevée (20,2 oB) ainsi qu'une teneur élevée en acidité titrable (1,10 % d'acide citrique), en vitamine C (20,93 mg/100ml) et en phénol total (82,84 mg/100ml) mais avaient la teneur en flavonoïdes totaux la plus faible (6,10 mg/100ml). Le nombre de levures et de moisissures variait de 2,342 log CFU/ml à 4,227 log CFU/ml, ce qui était inférieur à la limite microbienne pour la conservation du jus. Les résultats de l'évaluation sensorielle ont montré que le jus d'ananas Pain de Sucre plus mûrs, récolté le matin et stocké à température ambiante avant le traitement était préféré par les consommateurs en termes de goût, d'arrière-goût et d'acceptabilité globale. Cette information aidera les producteurs et les transformateurs d'ananas à avoir une idée juste de la qualité du jus à espérer en fonction du stade de maturité, de l'heure de la récolte et de la température de stockage avant la transformation.

Mots clés : Teneur en flavonoïdes, période de récolte, qualité du jus, ananas

Introduction

Pineapple is a popular fruit in Ghana as well as in other countries of the world. It contains substantial vitamins, carbohydrates, crude fibre, water and different minerals that promote good health (Hossain *et al*., 2015). The consumption of pineapple fruit and juice has the potential to reduce the risk of certain chronic human health issues such as constipation and irregular bowel movement, urinary tract infection during pregnancy (Debnath *et al*., 2012), bacterial and viral infection (Loon *et al*., 2018). It contains malic acid, which is responsible for boosting immunity, and the enzyme bromelain which assists in the digestion of proteins by helping to breakdown proteins into amino acids (Debnath *et al*., 2012).

Pineapples are produced conventionally or organically in Ghana. Unlike conventional farming, there is a restriction on the use of pesticides in organic farming. More so since the consumption of conventional fruits and juice is an issue of high concern since studies have shown that eating conventional fruits exposes humans to pesticide residues. Organic fruits are found to be healthier and tastier and help in the reduction of allergic diseases, overweight and obesity (Ekelund and Tjärnemo, 2004; Mie *et al*., 2017). Quality is defined as the degree of excellence of a product or its suitability for a particular use (Abbott, 1999). Pre- and postharvest management enable us to achieve the expected quality of pineapple fruits and juice (Joas *et al*., 2009).

Studies have been carried out on the effect of maturity stage on quality of pineapple fruits and juice. For example Joomwong and Joomwong, (2014) reported that pineapples harvested at an immature stage had the highest pH as compared to those harvested at the mature and over mature stage. The authors concluded that harvesting pineapples at over matured stage increased the consumer acceptability of pineapples. Studies by Dhar *et al*. (2008) and Kamol *et al*. (2014) indicated that fruits harvested at premature stage had higher moisture content, total titratable acidity, ascorbic acids and stored longer than fruits harvested at an optimum mature stage which on the other hand had higher Total Soluble Solids and more edible portion.

Different preharvest factors influence juice yield, including variety, fruit ripeness and conditions during fruit growth. Also, processing factors such as the extent of cell disruption, the rate of increase in pressure during extraction and duration of the pressing operation can alter juice yield (de Carvalho *et al*., 2017).

However, storage temperature and relative humidity are the two main factors that affect a pineapple's quality after harvest (Quyen *et al.,* 2013).

Research conducted by Hong *et al*. (2013) indicated that pineapple fruits stored from 6 to 24 days at a temperature of 25 °C had a decrease in TSS while those stored at 10°C and 6°C relatively maintained their TSS. Likewise, there was an effective slowing down of vitamin C and TA rate of decreases when the fruits were stored at 6 °C followed by 10 and 25 oC. Alhassan *et al.* (2014) stored oranges at ambient temperature (25°C to 30°C) for 5 and 10 days and the results revealed an increased in vitamin C content during these days of storage. They recommended that processors, therefore, need to monitor that the maturity stage and the temperature at which fruits are stored before purchasing since the quality of a product can be compromised or enhanced by these factors.

In a recent survey by Kereth *et al.* (2013), 95% of farmers harvest their fruits in the morning while the rest harvest theirs in the afternoon. It was seen to be a good practice since humidity is high in the morning and fruits are healthy, turgid and have a high weight. Harvesting fruits in the afternoon will lead to fruit shrinkage and rejection by consumers as a result of high temperature and evaporation during these periods. However, recent research by (Amin *et al*., 2008), indicated that mango fruits harvested in the afternoon had a significant increase in TSS as compared to those harvested in the morning and evening.

At the time of this research, most of the available literature (Selvarajah and Herath, 1997; Asare, 2012; Hong *et al*., 2013; Nadzirah *et al*., 2013) on factors affecting changes in physicochemical properties were limited to factors such as variety, maturity stage, storage temperature, and postharvest treatment with edible coatings. No empirical study appeared to have been performed on the effect of maturity stage and storage temperature and time of harvest of pineapple fruits on pineapple juice quality especially in Ghana where this research was undertaken. The objective of this research was therefore to assess the impact of maturity stage, storage temperature and time of harvest of pineapple fruits on pineapple juice quality and microbial safety of organic sugarloaf. The information generated is expected to help pineapple fruit producers and processors to have a fair idea of the juice quality to expect based on the stage of maturity, time of harvest and temperature of storage before processing.

Materials and Methods

Juice preparation. The experiment was conducted at the school of Agriculture laboratory, University of Cape Coast. Organic sugarloaf fruits were obtained from an accredited farm of the Department of Agriculture, Ataabadzi, in the central region of Ghana. The fruits were harvested at three different times of the day: morning (7 a.m.), afternoon (12 p.m.) and evening (5 p.m.) (Amin *et al*., 2008) at three different maturity stages, namely unmatured, matured and over matured. Fruits were selected based on size and color uniformity, and blemished and diseased fruit were discarded (Hong *et al*., 2013). Fruits were stored at both room temperature (25 °C) and in a refrigerator (5 °C) for three days before juicing. A completely randomized design was deployed using a factorial design with three replications to study the effect of the factors on pineapple juice quality and safety. The treatment combinations are shown in Table 1.

Table 1. Experimental design of variable combination

Sample ID condition	Maturity stage	Time of harvest	Storage
UMA	Unmatured	Morning	Ambient
MMA	Matured	Morning	Ambient
OMA	Overmatured	Morning	Ambient
UAA	Unmatured	Afternoon	Ambient
MAA	Matured	Afternoon	Ambient
OAA	Overmatured	Afternoon	Ambient
UEA	Unmatured	Evening	Ambient
MEA	Matured	Evening	Ambient
OEA	Overmatured	Evening	Ambient
UMR	Unmatured	Morning	Refrigerated
MMR	Matured	Morning	Refrigerated
OMR	Overmatured	Morning	Refrigerated
UAR	Unmatured	Afternoon	Refrigerated
MAR	Matured	Afternoon	Refrigerated
OAR	Overmatured	Afternoon	Refrigerated
UER	Unmatured	Evening	Refrigerated
MER	Matured	Evening	Refrigerated
OER	Overmatured	Evening	Refrigerated

Determination of physicochemical properties. Physicochemical analysis such as for pH, Total soluble solids, Titratable acidity, Ascorbic acid, Total phenolic content, total antioxidant activity, Total flavonoid, Moisture content, Ash content, Protein content, Carbohydrate, Mineral content as well microbial load and sensory quality of the juice were analyzed. The procedures used to carry out these quality determinations are described as follows:

pH. The pH of juice samples was recorded at ambient temperature condition using a digital pH meter (PHT- 01 ATC).

TSS. Total soluble solids of the pineapple juice, a digital refractometer (Palm Abbe Digital Refractometer) was used. The obtained values were expressed in % Brix.

Titratable Acidity. Titratable acidity (TA) of the pineapple juice was obtained using a modified method of Crisosto and Garner (2001). This was done by pipetting 10 ml of the juice into a conical flask. 200 ml of 0.1N NaOH was poured into a burette and was titrated against the sample in the flask with three drops of phenolphthalein as an indicator. The obtained TA values were expressed as a percentage of citric acid (mole equivalent = 0.064). The formula used to calculate the titratable acidity is as follows: % Titratable acidity = (0.1 x 0.064 ml of 0.1 N NaOH) x100/ g

of sample (1)

Vitamin C. Vitamin C analyses were determined according to Helmenstine (2019) with slight modification where 10 ml of pineapple juice was pipetted and diluted to 100 ml. 25 ml of the homogenized solution was pipetted into a 250 ml Erlenmeyer flask. 10 ml of 0.5M H_2SO_4 and 0.5g $NaHCO_3$ was added. The solution was then titrated against the standard, KIO_3 until a deep blue Iodine starch complex was obtained. Moles of iodine reacting were calculated using the equation below:

Ascorbic acid + I2 $\rightarrow$ 2 I- + dehydroascorbic acid.

The concentration in mol/L of ascorbic acid in the solution obtained was calculated and then the concentration in mg/100ml also calculated.

Total Phenols. Total phenols of the pineapple juice were determined using a modified spectrophotometric method as described by Lu *et al*. (2011) where 10 ml fruits juice was diluted to 100 ml with distilled water and filtered. Subsquently 250 µl of the filtrate was pipetted into a colorimetric tube in triplicate and 750 µl of distilled water was added followed by 1 ml of 10 fold diluted Folin Ciocalteau phenol reagent. After five minutes, 1.5 ml of 10% Na_2CO_3 was added to the mixture. The content was allowed to react for about 30 min in the dark after which the absorbance of the solution was read at 765 nm using UV mini 1240 (Shimazu Cooperation). A graph of standard calibration and unstandard calibration curve was plotted using Gallic acid equivalents in mg/100ml juice.

Total flavonoids. The total flavonoid content was estimated using the colorimetric assay developed by Zhishen *et al.* (1999).

Total antioxidant capacity. The total antioxidant capacity was determined following Aguilar-Urbano *et al*. (2013).

Juice yield. Juice yield was determined by using the method described by Asare (2012) and the results recorded in percentage.

Microbial load analysis. Microbiological analysis was conducted with slight modifications as described by other researchers (Chia *et al*., 2012). Total plate counts (TPC) were determined using the plate count agar (PCA) (Merck, Germany) and the DRBC agar (Condalab, Spain) was used for yeast and mould counts. A sample of 0.1 ml of each serial dilution (10 − 1 to 10 − 5) was spread across the solidified agar for both tests. The PCA plate was incubated at 37 °C for two days and at 5 °C for seven days, while the yeast and mould plate was incubated at 25 °C for five days. The results are expressed as log CFU/ml.

Sensory evaluation. Sensory evaluation of the fresh pineapple juice was performed by 30 semi-trained panelists. The panelists assessed the juice based on colour, aroma, taste, aftertaste and overall acceptability using a nine-point hedonic scale ranging from 1 (extremely dislike) to 9 (extremely like) (Stone *et al*., 2008).

Statistical analysis. In this study, General Linear Model (GLM) in Analysis of Variance (ANOVA) was performed in Minitab (Version 18.0) to determine the effects of maturity stage, time of harvest, and storage condition on physicochemical, nutritional, microbial and sensory characteristics of the three pineapple varieties. Tukey's test at p< 0.05 level was used to determine the significance between the treatment means.

Results and Discussions

Physicochemical properties. The quality attributes of the pineapple juice are presented in Tables 2 and 3. Significant differences ($p < 0.05$) were detected in all measured parameters except titratable acids and juice yield. No significant difference was found between the juice yields of the various treatment combination. Juice yield ranged from 46.05 to 80.75%. Apart from UMA (46.05%), OMA (46.16%) and OEA (55.89%) which had their juice yield within the normal juice yield of between 49.1 to 56.0% (de Carvalho *et al*., 2017), the rest had higher juice yields. The juice pH ranged from 4.90 to 5.43, which are less acidic than the pH values obtained by other researchers (Sairi *et al*., 2004; LU, 2014) but agreed with pH values of pineapples harvested at different maturity stage by Kermasha *et al*. (1987). Further pH was observed to be higher in juice made from immature fruits as previously Joomwong and Joomwong (2014). Juice yield ranged from 54.45 to 67.84%.No significant differences were found between the treatment combinations. This is in agreement with Asare (2012) who reported no significant difference between the juice yield of sugarloaf pineapples harvested at a full-ripe stage and half-ripe stage. However, juice yield was found to be high when the pineapples are harvested at the over mature stage.

The internal quality of fruit can be described by the content of total soluble solids (TSS) and titratable acidity (TA) (Lu *et al*., 2014). No significant difference existed between the TA of the treatment combinations. The TA values ranged from 0.70 to 1.10 % citric acid. To increase the amount of TA in pineapple juice, farmers and processors should harvest their over mature pineapples in the afternoon and store in a refrigerator. Wide variations in TSS and TA (6.2 and 19.1% C.V. values, respectively) were found among the studied treatment combination the results were similar to those stated by Lu *et al*. (2014). The TSS values ranged from 14.90 to 20.20 oB which corresponds with TSS of various pineapple varieties reported by Lu *et al*. (2014). Generally TSS tend to increase as fruit mature (Dhar *et al.,* 2008; Kamol e*t al.,* 2014). From the present study, it apparent that harvesting unmature fruits in the morning and storing in water ambient condition will result in increased TSS as compared to harvesting them in the afternoon and evening. Even though fruits harvested at the over mature stage resulted in high TSS, harvesting them in the afternoon will result in high TSS since during that time, more heat influx with reduced water inside will be observed (Maqbool and Malik, 2008). A similar finding was published for mango (Morais and Assis, 2002; Amin *et al.,* 2008). Pineapple is known to be a good source of ascorbic acid which ranges from 5.08 to 33.57 mg/100g (Lu *et al.,* 2014). Results from this research also showed a range of ascorbic acid content. OAR variety had the highest content (20.93 mg/100ml) while UMA had the least (9.98 mg/100ml). Similar results were found for MD 2 pineapples harvested at different maturity stage and stored at different temperature (Syazwani *et al.,* 2012).

Phenolics such as flavonoids, phenolic acids, and tannins are considered major contributors to the antioxidant activity of vegetables and fruits (Vladimir-Kne evi *et al*., 2011). From the present study, significant differences were observed among the treatment combinations on total antioxidant capacity (TAC). The results showed that TAC increased when pineapples are harvested in the afternoon at all three stages of maturity and stored in ambient condition before juicing. However, to produce juice with the highest TAC, the results from this study shows that over mature pineapples should be harvested in the afternoon. Total flavonoids were found to range from 6.10 to 10.37 mg/l, with OAR having the lowest and MMR the highest. Similar results were observed in different pineapple varieties in research conducted by (Lu *et al*., 2014). Comparing to flavonoids of processed citrus juices which had TFC content of 0.77 to 8.32 mg/g (Del Caro *et al*., 2004), organic sugarloaf juice has higher TFC.

Total phenol content was observed to range from 52.08 to 82.84 (82.84mg GAE/l FW). which is in agreement with TPC of other pineapple varieties (Lu *et al*., 2014) except for OAR which had a higher TPC value (82.84mg gallic acid equivalent (GAE)/l fresh weight (FW). Comparing the TPC of the pineapple juice to the TPC of juice from Topaz, an actual pineapple variety, TPC of apple was found to have higher TPC (Begi-Akagi *et al*., 2011). To select a particular treatment combination to produce quality juice, a processor, farmer or consumer needs to define his/her quality attributes (Abbott, 1999) since results from this research show that treatment OAR produced the highest TAC, TPC, vitamin C, TSS and TA, which are all desirable quality parameters, but it resulted in rather a lowest TF content. Hence when a processor wants to produce juice with a higher TF content he/she should choose treatment MMR. Furthermore, C.V. values indicated that the TA content was the most variable property (19.4%) while the least variable was pH (1.1%).

Microbial load. Figure 1 shows the mean differences between yeast and mould count (YMC) and Total Plate Count (TPC) of sugarloaf pineapple juice. The mean yeast and mould count (CFU/ml) among the treatments for the organic sugarloaf pineapple juice were observed to range from 2.342 log CFU/ml (UMA) to 4.227 log CFU/ml (OMR), which means they were produced from healthy fruits (Vasavada and Heperkan, 2002). The mean Total Plate Count (TPC) ranged from 0.00 log CFU/ml (MMR) to 4.164 log CFU/ml (MAR). Yeast and moulds were found in all treatment combination and this may have been due to the processing technique (Kaddumukasa *et al.,* 2017). Organic fruits are also prone to microbes than inorganic fruits due to the frequent usage of organic fertilizers (Bordeleau *et al*., 2002), however, the microbial load was below the limit of microbial shelf life for juice, which is 6 log CFU/ml (Chia *et al*., 2012).

Sensory evaluation. Table 4 shows the mean scores for the sensory attributes of pineapple juice from organic sugarloaf. The sensory qualities color, aroma, taste, after taste and overall acceptability, were analyzed using 30 semi-trained panelists. The sensory attributes differed significantly ($p<0.05$) between the treatments for taste, after taste and overall acceptability of the pineapple juice. According to Tukey's Studentized Range Test, the treatment OMA recorded high mean scores of 8.0 for taste; which means the panel liked treatment OMA very much. Similar results were obtained by other researchers such as Joomwong and Joomwong (2014). The mean values of after taste (7.8) and overall acceptability (8.1) of OMA was highest compared to for other treatments. The aftertaste of treatment OMA was preferred very much by the consumers as compared to the other treatments. No significant difference was observed between the means of the colour and aroma of the juice prepared from the various treatments, however, consumers liked moderately (7.2) the colour of OER. Juice from over mature fruits was scored higher overall acceptability values as compared to those from the mature and unmature pineapples. This could be due to the improvement of the aroma of fruits during maturation (Bender *et al*., 2000).

Table 2. Interaction effect of maturity stage, time of harvest and storage on physicochemical properties of organic pineapple juice

Sample ID %citric acid	TAC (mg/kg)	TF (mg/l00)	TPC (mg/l00)	Vit. C (mg/100m)	pH	TSS (oB)	TA	Juice yield (%)
UMA	140.99 ^{gh}	7.54 ^{i}	56.38 ^{bcd}	9.98 ^{j}	5.07^{efgh}	18.97^{ab}	0.93^{a}	46.05^{a}
MMA	133.45^{h}	9.35 ^{cde}	52.08 ^{d}	15.37^{h}	5.17^{cdef}	18.27^{abc}	1.02^{a}	66.29^{a}
OMA	169.84 b^{cdef}	8.90 ^{def}	62.84 ^{bcd}	14.07^{i}	5.30^{abc}	19.23^{ab}	0.83^{a}	46.16^{a}
UAA	179.64 ^{bc}	9.64 ^{c}	67.13 ^{bc}	17.31^{c}	5.30^{abc}	1^{bc}	0.79^{a}	61.43^{a}
MAA	179.52 ^{bc}	7.94 ^{hi}	60.14 ^{bcd}	16.55 ^{def}	4.90^{i}	17.20^{abc}	0.91^{a}	71.61^{a}
OAA	175.16 ^{bcd}	8.65 ^{fg}	66.14 ^{bc}	19.77 ^{b}	5.43^{a}	19.83^{a}	0.70^{a}	71.10^{a}
UEA	155.48 ^{cdefgh}	9.39 ^{cd}	60.14 ^{bcd}	16.00 ^{gh}	4.97 ^{ghi}	16.13^{bc}	0.77^{a}	79.45^{a}
MEA	150.28 ^{defgh}	7.88 ^{hi}	59.41 ^{bcd}	16.40 ^{ef}	5.27^{bcd}	19.13^{ab}	0.78^{a}	74.87^{a}
OEA	144.96 ^{fgh}	9.28 ^{cde}	55.37 ^{bcd}	15.10 ^{h}	5.37^{ab}	18.93^{ab}	0.81^{a}	55.89^{a}
UMR	173.45 ^{bcd}	9.38 ^{cde}	67.34 ^{bc}	19.43^{b}	4.97^{ghi}	16.37^{bc}	0.92^{a}	65.48^{a}
MMR	186.43 ^{b}	10.37 ^{a}	66.14 ^{bc}	17.10^{cd}	5.20 ^{cde}	17.87^{abc}	0.89^{a}	80.75^{a}
OMR	147.50 ^{efgh}	9.74 ^{bc}	54.19 ^{cd}	16.81^{cde}	5.03^{fghi}	18.60^{ab}	0.91^{a}	67.60^{a}
UAR	153.85 ^{cdefgh}	8.32 ^{fgh}	59.81 ^{bcd}	16.33^{fg}	4.93^{hi}	16.27^{bc}	0.95^{a}	64.30^{a}
MAR	172.10 ^{bcde}	8.07 ^{ghi}	67.24 ^{bc}	15.16^{h}	5.13^{def}	16.00^{bc}	0.76^{a}	70.88^{a}
OAR	223.65^{a}	6.10 ^{j}	82.84 ^{a}	20.93^{a}	5.30^{abc}	20.20^{a}	1.10^{a}	63.20^{a}
UER	155.91 ^{cdefgh}	10.31 ^{ab}	59.96 ^{bcd}	14.01^{i}	5.10^{efg}	14.90^{c}	0.88^{a}	69.80^{a}
MER	164.01 ^{bcdefg}	7.50 ^{i}	62.21 ^{bcd}	15.10^{h}	5.30^{abc}	17.63^{abc}	0.88^{a}	65.90^{a}
OER	174.56 ^{bcd}	8.80 ^{ef}	67.79 ^{bc}	15.57^{h}	5.20^{cde}	19.80^{a}	0.97^{a}	71.60^{a}
MEAN	160.04	8.73	62.62	16.16	5.16	17.87	0.88	66.24
CV %	5.0	2.3	6.7	5.0	1.1	6.2	19.4	23.8

Note: Results expressed as means. Means in the same line with different letter are significantly different (p<0.05)
* See Table 1 for sample IDS

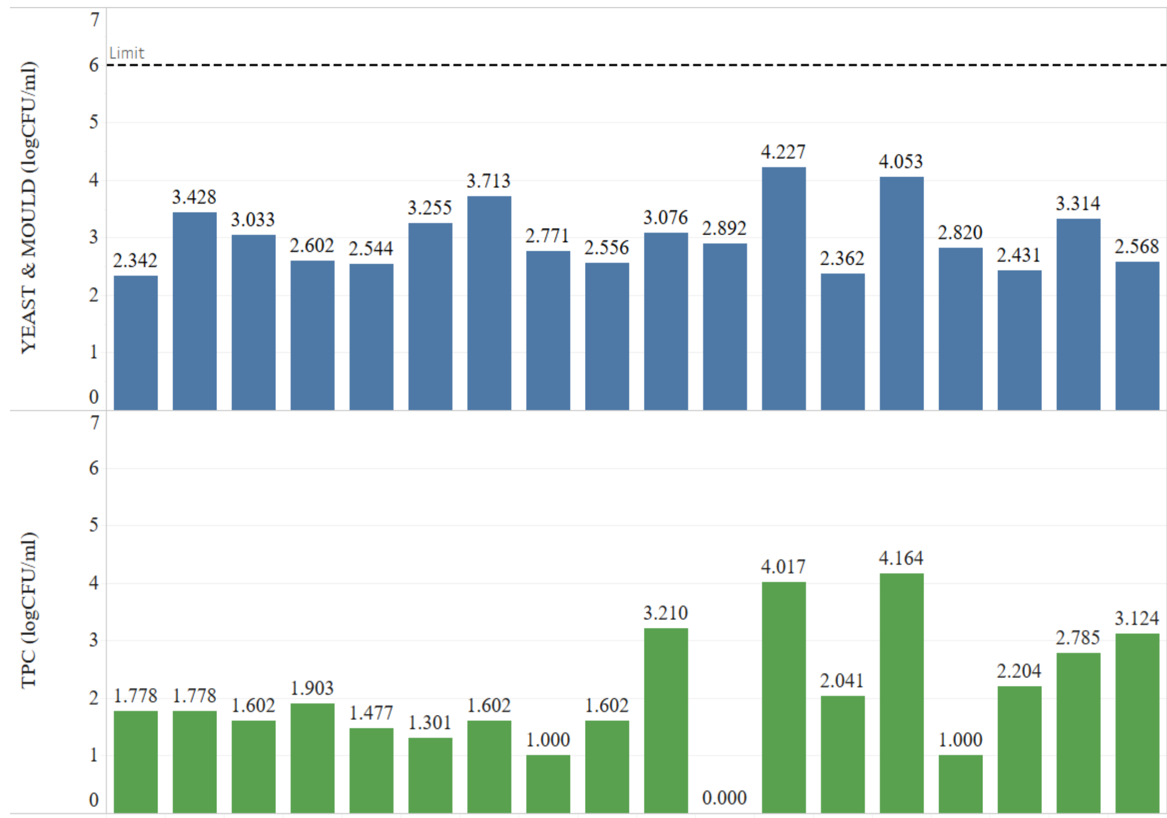

Figure 1. YMC and TPC of Sugarloaf pineapple juice. The dashed-line shows microbial shelf life limit

Table 3. Interaction effect of maturity stage, time of harvest and storage on Sensory Attributes of organic pineapple juice Interaction

Sample ID	Colour	Aroma	Taste	After taste	OA
UMA	6.5^{a}	6.4^{a}	7.3^{ab}	7.1^{ab}	7.4^{ab}
MMA	6.1^{a}	6.2^{a}	7.4^{ab}	6.7^{abc}	7.2^{ab}
OMA	6.5^{a}	6.3^{a}	8.0^{a}	7.8^{a}	8.1^{a}
UAA	5.9^{a}	5.4^{a}	5.9^{abc}	6.4^{abc}	7.0^{abc}
MAA	6.7^{a}	6.8^{a}	6.4^{abc}	6.4^{abc}	7.4^{ab}
OAA	6.8^{a}	6.1^{a}	6.7^{abc}	7.2^{ab}	7.6^{ab}
UEA	6.2^{a}	5.2^{a}	5.4^{bc}	5.6^{abc}	6.1^{bc}
MEA	6.9^{a}	5.9^{a}	6.9^{abc}	6.6^{abc}	7.3^{ab}
OEA	6.2^{a}	6.2^{a}	6.2^{abc}	6.6^{abc}	7.0^{abc}
UMR	6.5^{a}	6.1^{a}	5.6^{bc}	5.5^{bc}	6.2^{bc}
MMR	5.9^{a}	6.5^{a}	5.8^{bc}	6.0^{abc}	6.6^{abc}
OMR	6.1^{a}	5.8^{a}	5.9^{abc}	6.1^{abc}	6.7^{abc}
UAR	6.6^{a}	6.6^{a}	6.4^{abc}	6.7^{abc}	6.8^{abc}
MAR	6.8^{a}	6.9^{a}	6.9^{abc}	6.5^{abc}	7.2^{ab}
OAR	7.0^{a}	6.0^{a}	5.0^{c}	6.4^{abc}	6.9^{abc}
UER	5.9^{a}	5.9^{a}	5.7^{bc}	6.3^{abc}	5.4^{c}
MER	6.3^{a}	6.4^{a}	6.4^{abc}	4.9^{c}	6.3^{bc}
OER	7.2^{a}	6.3^{a}	5.9^{abc}	5.8^{abc}	6.8^{abc}
MEAN	6.43	6.20	6.32	6.33	6.88
CV %	23.1	24.5	28.0	26.4	21.1

Note: Results expressed as means. Means in the same line with different letter are significantly different (p<0.05)

Conclusion

In this study, we determined the physicochemical, nutritional, microbial and sensory quality of juice produced from organic sugarloaf harvested at different maturity stages and times of the day and stored at different storage conditions. Our work showed that juice from pineapple fruit from an organic source had higher TSS. The findings showed that over mature sugarloaf should be harvested in the afternoon and kept in the refrigerator before juicing to obtain juice of higher quality. However, a small scale processor can harvest over mature fruits in the morning and keep them in the ambient before processing if storage in a refrigerator is to be a problem.

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