As. J. Food Ag-Ind. **2011**, 4(03), 153-160

OPEN ACCESS

Asian Journal of Food and Agro-Industry

ISSN 1906-3040

Available online at www.ajofai.info

Research Article

Effect of location and storage time on physicochemical properties of pineapple fruit

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Abstract

Pineapples (*Ananas comosus* cv. Smooth Cayenne) in the mature green stage of maturity (160 days after full bloom) of rainy season crops in the year 2009 from 3 locations planted in Lampang province were studied. The fruit were stored to ripen from 1/4 to 4/4 stages at ambient temperature. The chemical compositions were statistically significant; differences existed for moisture content, protein, fibre, free sugar and organic acid content in relation to the planting location and ripenening stages. The content of total soluble solid and free sugar content were highest in pineapple planted in Ban-sadet village at 4/4 ripening stage. The dominant sugars were glucose, fructose and sucrose, which increased during ripening development in both locations planted. Organic acids content in pineapple juice samples also showed significant differences ($P \leq 0.05$) in citric, acetic, L-malic and total acids, while ascorbic, tartaric, oxalic and succinic acid content was tract observed and non-significant between treatments. In addition, the colour value of pineapple juice showed significant difference between locations planted and ripening stages. Yellow (b*) colour was increased from 8.76 to 14.35 after ripening from 1/4 to 4/4 stages.

Keywords: *Ananas comosus*, cv pattavia, free sugar, organic acid, colour value, ripening stage, post harvest, Thailand

Introduction

Thailand is blessed with large areas appropriate for pineapple growing. The leading thirteen provinces for pineapple production in Thailand are Prachuapkhirikhan, Chumphon, Phetchaburi, Chonburi, Rayong, Trat, Chacheongsao, Kanchanaburi, Ratchaburi, Uthai Thani, Nong Khai, Nakhon Phanom and Lampang [1]. Large-scale cultivation of pineapple for fresh fruit

consumption depends on a few varieties of the Cayenne group. The variety "Pattavia" of the Smooth Cayenne group is the most popular of all in view of the size of its fruit, the highest yield produced and acceptable eating quality. 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 [2]. 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 [3].

There are many changes of chemical substances in pineapple after harvesting; acid content, total soluble solid and phenol compounds. The titratable acidity usually declines during storage of harvested pineapple [4]. On the other hand, the sugar content of pineapple keeps increasing after harvest. As Paull and Chen [5] argue that fruit sugars continue to increase through to senescence, unless the fruit is harvested. These changes in the acid and sugar content make pineapples after harvest sweeter and less sour. However, research on the influence of the location planted and ripening stage during storage of pineapple fruit is limited. Thus, the purpose of this experiment was to study the influence of particular locations used for planting and the degree of ripening on physiochemical attributes (colour, L*, a*, b*, total soluble solids, acidity, pH, TSS, protein, fat, ash, fibre, moisture content, free sugars and organic acid content) of pineapple fruit.

Materials and Methods

Pattavia Pineapple (*Ananas comosus* cv. Smooth Cayenne), was obtained from a private plantation at Ban Lang, Ban Sadet village and the LARTC experimental field, Muang District, Lampang Province. The pineapple fruit was selected from mature green stage of maturity (160 days after full bloom) on rainy season crops planted during 2009, from June to July. The fruit was stored to 3 stages of pineapple maturation (1/4, 3/4 and 4/4) at ambient temperature. The fruit shell and core were removed using a stainless steel knife and the flesh was cut into small pieces for proximate analysis. The remaining fruit pieces were blended into pulp by using a kitchen blender and juice was extracted by being passed through No 0.1-filter paper for chemical attributes. The chemicals and standards used were HPLC grade.

Proximate analysis

The homogenized pineapple flesh from each treatment was analyzed for moisture content, protein, fat, ash, crude fibre and carbohydrate content following the method of AOAC [6].

Analysis of chemical attributes of pineapple fruit

Pineapple juice was used for chemical analysis. The juice was analyzed for total soluble solids (TSS) and pH. TSS was measured with a digital refractometer PR- 101 (ATAGO Company, Tokyo, Japan). The pH was measured at room temperature using Satorious Professional Meter PP– 50 Operation Manual pH Meter.

Free sugars analysis

Free sugars concentration was analyzed with high performance liquid chromatography (HPLC) model Agilent 1200-series (Agillent Technology, Germany) with a modified method from Agilent Technologies [7]. The HPLC was operated under the following conditions; ZORBAX Carbohydrate column (4.6mm×150 mm, 5 μm). Mobile phase: Acetronitrile: Deionized water

(3:1), Detector: reflective index detector (RID); Flow rate: 1 mL min-10 and column temperature and detector temperature are 30 and 35ºC, respectively. The diluted samples and sugar standards, glucose, fructose and sucrose (0.1%) were dissolved in ACN: DI (1:1) at a concentration of 1:10. All the diluted samples and the sugar standard (10 µl) were Syringe filtered (Nylon 0.45µm) and directly injected to the reverse phase chromatography column. The presence and abundance of fructose, glucose and sucrose were automatically calculated by comparing sample peak area to standards (0.2–1 %) using Chemstation software with correlation between 0.9000-1.0000.

Organic acid analysis

Organic acids (Malic, Tartaric, Oxalic, Citric, Lactic, Acetic, Succinic and Ascorbic acids) content in pineapple juice were determined using High Performance Liquid Chromatography (HPLC) by following the method of Agilent Technologies [7]. HPLC (Agilent 1200-series, Agillent Technology, Germany) equipped with a Diode Array Detector and ZORBAX SB-Aq (4.6mm×150mm, 5µm column) was used for organic acid determination. The following conditions were used: mobile phase, 99% 20Mm NaH_2PO_4 at pH 2 and 1% Acetonitrile; flow rate, 1 ml/ min for 10 min; 35°C of column temperature. For the stock solution of the organic acid standards (Malic, Tartaric, Oxalic, Citric, Lactic, Acetic, Succinic and Ascorbic acids at 0.2%, 0.4%, 0.6%, 0.8% and 1.0% concentration were dissolved in ACN at a concentration of 1:10 and Syringe filter (Nylon 0.45 µm). The samples were Syringe filtered (Nylon 0.45 µm) and 0.5 – 1 ml placed into the HPLC vial for further analysis. 10 µl of standard and samples were directly injected to the reverse phase chromatography column. The presence and abundance of fructose, glucose and sucrose were automatically calculated by comparing sample peak area to standards (0.2–1 %) using Chemstation software with correlation between 0.9000-1.0000.

Colour value

The colour values of pineapple juice samples were measured with Juki 555 colorimeter. Each measure was performed and calculated to hue angles as per the formula described by McGuire [9]. Each value represents a mean of a triplicate determination. Results were reported as average of individual values as L* (lightness), a* (+ a = red, - a = green) and b* (+ b = yellow, - b = blue).

Data analysis

The results were statistically evaluated by two-way analysis of variance (ANOVA). Statistical differences with *p*-values under 0.05 were considered significant and means were compared by DMRT using SPSS program version 14.01.

Results and Discussion

The photographs in Figure 1 show the external appearance of pineapple fruit from the three locations planted which were stored at ambient temperature to 3 stages (1/4, 3/4 and 4/4) of ripening. The changes to the external colour upon storage time of the fruit from green, green-yellow to a mixture of yellow and purple without green can be seen. External colour of pineapple is an important trait in consumer preference. During maturation chlorophyll fades out and total and pulp carotenes increase, while peel carotenes decrease. The pineapple fruit from Ban Lang village field was the first for 4/4 yellow colour, followed by the fruit from LARTC experiment field and Ban Sadet village field, respectively. As the fruit ripens, the ‘eyes’ change from pointed to flat, slightly hollow at the centre, the fruit becomes enlarged, less firm and more aromatic. The range of chemical constituents of ripe pineapple, depending upon stage of fruit ripeness and environmental factors, has been reported by Dull [9] and Kermasha *et al*. [10].

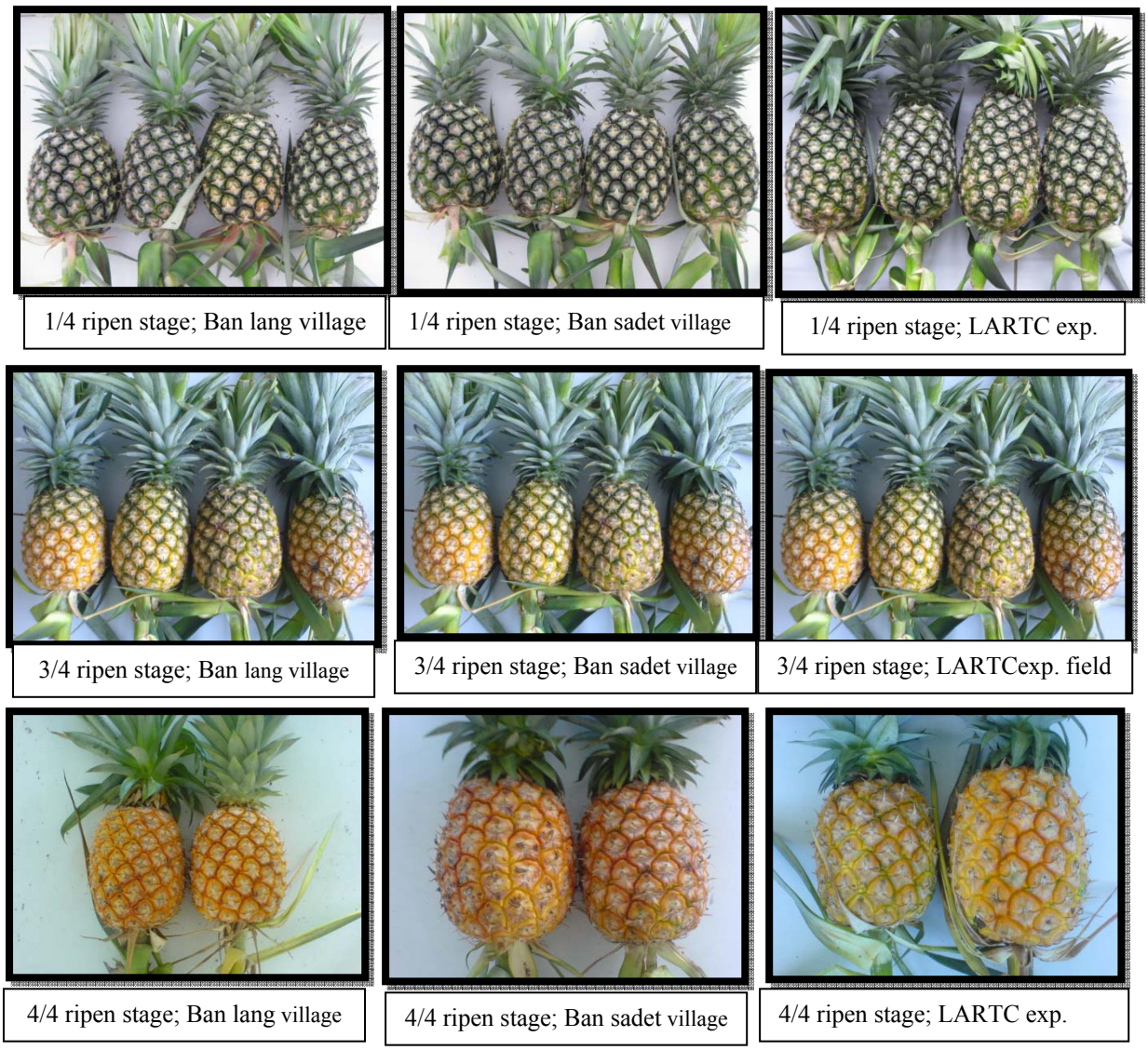

Figure 1. External appearance of pineapple fruit from three locations and stored at ambient temperature to 3 stages in pineapple maturation.

Proximate composition

The proximate analyses of Pattavia pineapple fruit from different locations and stages of maturation are summarized in Table 1. When compared with the location planted, moisture, protein and fat content, fruit from the LARTC experimental field was the highest which was also lowest in ash, fibre and nitrogen free extract. In addition, protein, fat, ash and fibre in the flesh of pineapple fruit were not significantly different between stages of ripening. However, the moisture content and nitrogen free extract slightly increased with an increase in storage time.

The range of chemical constituents of ripe pineapple depends on the stage of fruit ripeness and on agronomic and environmental factors. Freshly harvested pineapple fruit contains 86% water, 8 g sugars, 0.5 - 1.6 g acids, 1 g proteins, 0.5 g ash, 0.1 g fats, some fibre and vitamins (mainly A and C). The vitamin C content varies from 10 to 25 mg/100 g [11].

Table 1. Proximate analyses of Pattavia pineapple fruit from different locations and storage time to difference stages of ripening at ambient temperature.

Treatments		Chemical composition (%)*					
Location planted:		Moisture	Protein	Fat	Ash	Fibre	NFE
Ban lang village		86.26^{b}	0.68^{b}	0.55^{ns}	0.46^{a}	1.18^{a}	11.19^{b}
Ban Sadet village		82.61^{c}	0.72^{b}	0.47	0.40^{a}	1.09^{a}	14.54^{a}
LARTC exp. field		88.13^{a}	0.95^{a}	0.48	0.29^{b}	0.94^{b}	9.28^{c}
Stage of ripening	1/4	85.34^{ns}	0.74^{ns}	0.44^{ns}	0.35^{ns}	1.10^{ns}	11.73^{c}
	3/4	85.72	0.79	0.51	0.37	1.05	12.49^{b}
	4/4	86.94	0.81	0.56	0.39	1.06	14.79^{a}

*Means followed by different letters in a column are significantly different at $P \leq 0.05$.
ns is not significant difference ($P > 0.05$)

Chemical attributes of pineapple fruit during storage

There are many changes in chemical substances in pineapple after harvesting; total soluble solid, free sugar and organic acid content (Tables 2 and 3). The differences between planting locations were prominent in total soluble solids (TSS) and total sugars. The pineapple fruit from Ban Sadet and Ban Lang village were significantly higher in these attributes than the fruit from LARTC experimental field. The total soluble solid of pineapple keeps increasing after harvest and storage from stage 1/4 to 4/4 of ripening.

Analysis of free sugar indicates that the pineapple juice contains mainly sucrose, fructose and glucose, respectively. As with other fruit species, total sugar increased with ripeness, showing steady changes, with the lowest values in stage1/4 of ripening and increasing from stage 3/4 to 4/4 of ripening, which was 8.76 to 14.35% of total sugar (Table 2). In addition, the proportion of fructose and glucose increased 1 - 3 times from 1/4 to 4/4 stages of ripening, which also indicated more sweetness than the first day of storage, while sucrose showed only slight decline during storage.

A analysis was made of the individual organic acids in the Pattavia pineapple fruit from different locations and during ripening at three stages from mature green to full yellow (Table 3). The major acid components were citric, acetic and L-malic acids. Significant differences ($P \leq 0{\cdot}05$) were found in total acid content in Pattavia pineapple fruit planted, with Ban Lang village being the highest, followed by LARTC experimental field and Ban Sadet village. The content of most organic acids decreased during ripening from 1.25 to 1.12%**.**

Table 2. TSS and free sugar content of Pattavia pineapple fruit from different locations and storage to different stages of ripening at ambient temperature.

Pineapple samples		TSS (°Brix)	Free sugar content (%)*			
			Fructose	Glucose	Sucrose	Total sugar
Location: Ban Lang village		13.63[a]	2.30[c]	2.19[b]	8.35[a]	11.63[b]
Ban Sadet village		13.77[a]	2.78[b]	2.62[ab]	8.83[a]	12.83[a]
LARTC exp. field		12.17[b]	3.18[a]	2.87[a]	7.14[b]	11.98[ab]
Stage of ripening:	1/4	12.62[b]	1.90[b]	2.30[b]	8.34[ns]	8.76[c]
	3/4	13.06[b]	2.54[a]	2.35[b]	8.42	13.34[b]
	4/4	14.04[a]	3.81[a]	3.00[a]	7.55	14.35[a]

*Means followed by different letters in a column are significantly different at $P \leq 0.05$.
ns is not significant difference ($P>0.05$)

Table 3. Organic acid content of Pattavia pineapple fruit from different locations and storage to different stages of ripening at ambient temperature.

Pineapple samples		Organic Acids							
		Citric	Acetic	Ascorbic	Malic	Tartaric	Oxalic	Sacinic	Total acids
Location: Ban Lang		0.79[a]	0.32[a]	0.007[ns]	0.24[b]	0.001[ns]	0.0024[ns]	0.001[ns]	1.51[a]
Ban Sadet		0.68[a]	0.28[a]	0.001	0.30[a]	0.003	0.0077	0.0177	1.16[b]
LARTC		0.58[b]	0.09[b]	0.003	0.12[c]	0.0008	0.0010	0.0023	1.19[b]
Stage of ripening:	1/4	0.50[ns]	0.20[ns]	0.001	0.23[ns]	0.001[ns]	0.0068[ns]	0.0002	1.25[a]
	3/4	0.52	0.22	0.003	0.18	0.0014	0.0029	0.0002	1.23[a]
	4/4	0.54	0.19	0.006	0.15	0.0039	0.0074	0.0197	1.12[b]

*Means followed by different letters in a column are significantly different at $P \leq 0.05$.
Ns is not significant difference ($P>0.05$)

Physical attributes of pineapple fruit during storage

The yield of pineapple juice was calculated as kilograms of juice per kilogram of fruit. The results are presented in Table 4. The pineapple fruit planted from Ban Lang village provided the highest juice yield extracted (30.96%), followed by Ban Sadet village and LARTC experiment field which was 27.88 and 24.17%, respectively. As the storage time results in an increase in ripening, there is an incremental increase in yield of juice as the ripening stage increases. The yield increased from 27.33 to 28.93 as the ripening stage increased from 1/4 to 4/4, respectively.

The colour values (L*, a*, and b*) of pineapple juice extracted from different locations and storage time from 1/4 to 4/4 ripening stages are shown in Table 4. As can be seen from the table, pineapple from LARTC experiment field was higher in L* value and lower a* b* values than the other locations. This indicated that the pineapple juice colour was a rich yellow. In addition, the L* colour parameters slightly decreased from 30.71 to 27.82 as the ripening stage increased from1/4 to 4/4, respectively. After that a* and b*-values increased, while a value still increased, causing a colour shift towards the red yellow region during the final period of storage.

Table 4. The juice yield and colour values for Pattavia pineapple fruit from different locations and storage to different stages of ripening at ambient temperature.

Treatments		pH	Juice yield (%)	Colour value		
				L*	a*	b*
Location: Ban Lang village		4.56ns	30.96[a]	27.44[b]	8.35[a]	11.63[b]
Ban Sadet village		4.93	27.88[b]	27.93[b]	8.83[a]	12.83[a]
LARTC exp. field		4.53	24.17[b]	32.17[a]	7.14[b]	11.48[b]
Stage of ripening:	1/4	4.65	27.33[b]	30.71[a]	8.34[ns]	8.76[c]
	3/4	4.53	27.69[b]	29.02[ab]	8.42	13.34[b]
	4/4	4.33	28.93[a]	27.82[b]	7.55	14.35[a]

*Means followed by different letters in a column are significantly different at $P \leq 0.05$
Ns is not significant difference ($P > 0.05$)

Conclusions

Moisture, protein, fat, ash, fibre and nitrogen free extract of flesh from Pattavia pineapple fruit from different locations were not significantly different during storing to 3 stages of ripening from 1/4 to 4/4. Total soluble solids, fructose, glucose and total sugars were the highest at 3/4 and 4/4 ripening stages for all locations. At 4/4 stage of ripening, total acids in the fruit from Ban Lang village was higher than other locations and decreased during storage time.

Acknowledgements

The authors are grateful to the National Research Council of Thailand for providing financial support for this study through the Rajamangala University of Technology Lanna.

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