ISSN: 0128-7680
Pertanika J. Sci. & Technol. **17 (1)**: 117 – 123 (2009)

Physico-Mechanical Properties of the Josapine Pineapple Fruits

Rosnah Shamsudin[1*],Wan Ramli Wan Daud[2],
Mohd Sobri Takrif[2] and Osman Hassan[3]

[1]Department of Process and Food Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia
[2]Department of Chemical and Process Engineering, Faculty of Engineering, Universiti Kebangsaan Malaysia, 43600 UKM, Bangi, Selangor, Malaysia
[3]School of Chemical Sciences & Food Technology, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 UKM, Bangi, Selangor, Malaysia
[*]E-mail: rosnahs@eng.upm.edu.my

ABSTRACT

The physico-mechanical properties data of fruits are important in the design of various handling, packing, and storage and transportation system. The physical-mechanical properties of pineapple fruit from the Josapine variety, namely the weight of the fruit (with and without peel), pulp to peel ratio, diameter of the whole fruit (with and without peel), at three different positions along the longitudinal axis of the fruit, length of the fruit (with and without peel) and the length of crown were studied using the standard method at seven stages of maturity during storage at 25°C and 52% (RH). The effect of fruit maturity on the firmness of each fruit at three different locations was measured using a cylindrical die of 6 mm in diameter with the Instron Universal Testing Machine. The results indicated that the average total weight of a single fruit is 886.86 ± 49.67 g. The average pulp to peel ratio is 1.91. The average diameter (with and without peel) was 86.83 ± 5.24 mm and 80.95 ± 4.15 mm (top section), 100.77 ± 3.84 mm and 90.19 ± 3.73 mm (middle section) and 97.17 ± 3.49 mm and 73.30 ± 5.11 mm (bottom section), respectively. The average length of the fruit (with and without peel) was 126.65 mm and 113.64 mm, respectively. The average length of crown was 89.13 mm. The firmness of the fruits was found to decrease with the stage of maturity. These data are important in determining the optimum stage of maturity for fruit processing.

Keywords: Diameter, firmness, Josapine, length, pineapple, stage of maturity

INTRODUCTION

Pineapple (*Ananas comosus* L.) is an important food crop which is planted extensively in the tropical and sub-tropical regions. It is one of the major commercial fruits in Malaysia, and is mainly used as fresh dessert fruits or for the preparation of canned pineapple in the form of slices or rings, juices and jams. There are five varieties of pineapples in Malaysia; these include Moris, Sarawak, Gandol, Josapine and N36. The Josapine is a hybrid, between 'Johor' ('Singapore Spanish' x 'Smooth Cayenne') and 'Sarawak' ('Smooth Cayenne') varieties, developed by the Malaysian Agriculture Research and Development Institute (MARDI) for the fresh fruit. It fruits very early. (120 days, after flower induction) allowing an annual plantation cycle in Malaysia. The vigorous plant produces two to three shoots and the leaves are spiny only at the tip. According to Abdullah and Rohaya (1997), the pineapple fruit can

Received: 2 July 2007
Accepted: 7 October 2008
[*]Corresponding Author

be divided into two major portions; namely, the fruit body and the crown. Each portion is different in terms of their morphological features, behaviour and characteristics.

Maturity at harvest is an important factor affecting the quality and the rate of change of quality during post harvest. The maturity indices can be determined in many ways, including the estimation of the duration of development; measurement of size, weight or density, physical attributes; (such as color, firmness and moisture content); as well as other chemical attributes such as starch, sugar or acid content or morphology evaluation (Shewfelt, 1993).

The common practice in the field for determine the ripeness fruit is by pressing with the thumb. For evaluating the mechanical properties of the fruits and vegetables, many investigators have used a rigid cylindrical die to study the load-deformation behavior of the fruit (Boussinesq, 1885; Timoshenko and Goodier, 1951; Finney, 1963). Today sophisticated devices have been developed for texture measurement in fruits and vegetables for example texture analyzers and pressure testers. The three commonly used pressure testers are the Magness-Taylor, UC Fruit Firmness testers and Instron Universal Testing Machine. Force deformation characteristics of agricultural products are important to simulate the destruction that occurs in bruising. A firmness of fruit is a useful indicator to estimate harvest maturity.

The objectives of the study were to determine (1) the physical properties, namely weight of fruit with and without peel, pulp to peel ratio, diameter of the whole fruit with and without peel at three different position along the longitudinal axis of the fruit, length of fruit with and without peel, length of crown; and (2) to determine the effect of fruit maturity on the firmness fruit, at three different locations of each fruit during storage at 25°C and 52%RH.

MATERIALS AND METHODS

Pineapple (*Ananas comosus* L.), from the Josapine variety, was obtained from a plantation in Johor, a southern state in Malaysia. The pineapples were harvested at stage of maturity 1. The stage of maturity was determined based on the standard specification and grade by Federal Agricultural Marketing Authority (FAMA, 2004). After harvesting, the fruits were stored at room temperature of 25°C, relative humidity (RH) of 52% until they reached the desired maturity stage required for the experiment. They were selected at seven different stages of maturity and the description for the various stages is given in Table 1. Each measurement was repeated three times, and the average values are reported.

Shape, Size and Weight of Fruit

The length and width of the whole Josapine pineapple fruit with and without peel were measured by keeping the fruit resting horizontal on its most stable position. The sample fruit was peeled manually using a knife. The diameter and length of the fruit with and without peel were determined by digital vernier calipers. The diameter of pineapple was recorded at three different locations of the whole fruit, i.e. top, middle and bottom section (*Fig. 1*). The top is defined as the end of the fruit where the crown is. The weight of the whole fruit with and without peel was recorded using the electronic balance. To determine the pulp to peel ratio, every individual pineapple is peel and pulp were weighed separately. The average values of three replications were reported.

Mechanical Properties of Fruit

Fruit firmness was determined by using an Instron universal testing machine (Model 5566, US) with a cylindrical die of 6 mm in diameter at 25°C. The load cell of Instron was 5000N

TABLE 1
Description on maturity stage

Maturity Stage	Description
1	immature fruit all eyes are glossy bluish dark green with reddish bractea (first day storage)
2	all eyes are glossy dark green with traces of yellow between eyes at base (4 days in storage)
3	eyes are dark green with 1-2 eyes yellowish green at base (5 days in storage)
4	about 25% of eyes, from the base, are yellow (6 days in storage)
5	about 50% of eyes are orangey yellow, half ripe fruit (7 days in storage)
6	more than 75% of the eyes are orangey yellow, three-quarter ripe fruit (8 days in storage)
7	full orangey yellow, fully ripe fruit (11 days in storage).

Source: Standard specification and Grade by FAMA

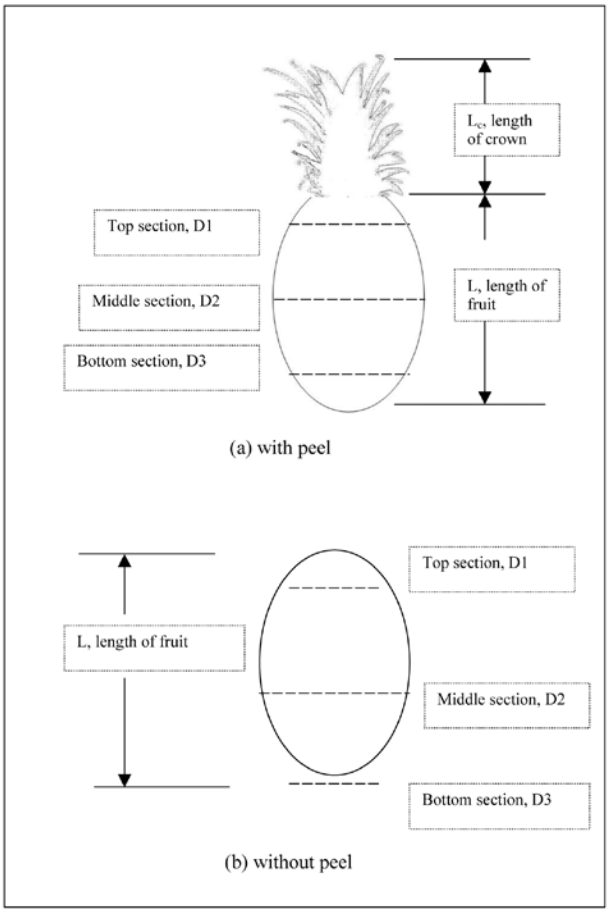

Fig. 1: Longitudinal section of pineapple fruit (a) with peel (b) without peel

with the crosshead speed fixed at 10 mm/min until rupture. The pineapple fruit was loaded in a horizontal position. Clamps were employed to hold a section of the pineapple fruit to determine the firmness of fruit. The individual pineapple fruit was compressed at three different location of each fruit namely (a) top section, (b) middle section and (c) bottom section as shown in *Fig. 2.* The three pineapple fruits were randomly taken from each stage of maturity for mechanical properties. The compression was started at the preset condition until rupture, occurred in the force-deformation curve. The rupture force was taken as the maximum peak force which required rupturing the peel of the fruit.

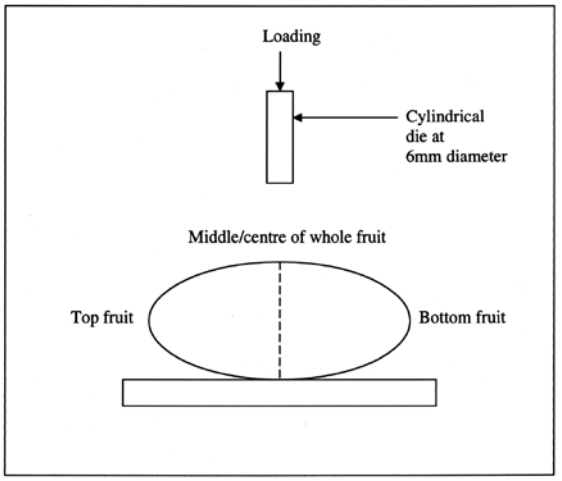

Fig. 2: Orientations of pineapple under compressive loading

RESULTS AND DISCUSSION

Table 2 shows the physical constituents of pineapple fruit from Josapine variety, as percentage of weight of the whole fruit and the pulp-peel-ratio. The total weight of a single whole fruit for pineapple varies between 800.38 g and 940.13 g with an average value of 886.86 g. The pulp to peel ratio of Josapine variety varies between 1.48 and 2.54 with an average of 1.91. According to Chan (1993), the average weight of other varieties like Gandul, Moris and Maspine are 1.6kg, 1.0kg and 1.76kg respectively. Thus, the weight of Josapine fruit was less than other varieties. The advantage of Josapine variety had improved acid content (0.63%), total soluble solid or TSS (16.8%) the plants are not spinney, ripen to full colour, yet remained firm and retained their flavours, resisted blemish and excellent in keeping quality (Chan, 1993).

Tables 3(a) and (b) shows the range of average diameter at three different locations of a whole Josapine pineapple fruit both with and without peel. The diameter of the Josapine pineapple fruit is at a maximum, in the middle portion and less at both the ends. The maximum and minimum observed diameters for this variety with peel were 106.93 mm and 77.07 mm, respectively. These values were 98.17 mm and 65.57 mm, respectively.

Tables 3(a) and (b) shows the length of fruit with and without peel. The maximum and minimum observed length of fruit with peel was 136.51 mm and 119.26 mm, respectively. These values for the fruit without peel were 124.59 mm and 103.49 mm respectively. The

TABLE 2
Constituents of pineapple fruit (Josapine variety)

	Total weight of a single fruit (g)	pulp (%)	peel (%)	Pulp/peel ratio
Maximum	940.13	67.50	37.50	2.54
Minimum	800.38	62.78	31.16	1.48
Average	886.86	65.29	34.71	1.91
Standard deviation	49.67	1.09	0.70	0.36

TABLE 3(a)
Diameter and length of Josapine pineapple fruit (with peel)

	With peel			
	Maximum	Minimum	Average	Standard deviation
D1 (mm)	94.60	77.07	86.83	5.24
D2 (mm)	106.93	93.85	100.77	3.84
D3 (mm)	101.26	90.38	97.17	3.49
L, Length of fruit (mm)	136.51	119.26	126.65	5.48
L_c, Length of crown (mm)	113.48	65.78	89.13	14.36

TABLE 3(b)
Diameter and length of Josapine pineapple fruit (without peel)

	Without peel			
	Maximum	Minimum	Average	Standard deviation
D1 (mm)	88.06	73.11	80.95	4.15
D2 (mm)	98.17	82.93	90.19	3.73
D3 (mm)	83.73	65.57	73.30	5.11
L, Length of fruit (mm)	124.59	103.49	113.64	5.39

average length for Josapine variety with and without peel was 126.65 mm and 113.64 mm respectively.

The pineapple crown is made up of a bunch of crown leaves, which physiologically behaves like leafy vegetable. The maximum and minimum length of the crown for Josapine pineapple fruit was 113.48 mm and 65.78 mm, with an the average was 89.13 mm.

Fig. 3 shows the force (N) required to rupture the peel of Josapine pineapple fruit at different stages of maturity under ambient storage. The force decreased with the stage of maturity from 74.79 N to 42.93 N (top position), 62.56 N to 37.20 N (middle position) and

57.14 N to 36.04 N (bottom position). The decrease in force is strongly influenced by the ripening process and storage period. This trend is in agreement with the results reported by Jha *et al.* (2005) for mango (32.96 N to 22.39 N, 288 hours in storage) and Krishna and Reddy (2005) for orange (15.6 N to 10.8 N, 10 days in storage). These phenomena could be due to changes in structure of the pectin polymers, during ripening in the cell wall (Jha *et al.*, 2005). Biochemical changes studies of the wall during fruit ripening indicated that there are structural changes in pectin, hemicellulose and cellulose. Fruit firmness was closely associated with the maturity stage. Mature green fruit had the highest penetration values and the yellow fruit had the lowest values (Edmundo Mercado-Silva *et. al.*, 1998; Jha, Kingsly and Sangeeta Chopra, 2005).

Fig. 3 shows the force required to rupture the peel of pineapple fruit is higher at the top position than at the bottom position. This might be due to the ripening process of pineapple fruit, which started at the bottom position and slowly propagated to the top position. Fruitlets in the lower portion of a fruit are more mature or ripe than the upper portion (Ramlah, 1981). Therefore, the force required to rupture the fruit was minimum at the bottom position.

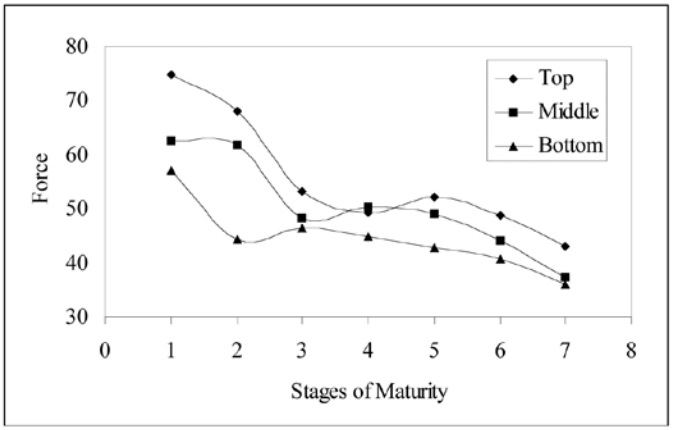

Fig. 3: Maximum load of the peel of the Josapine pineapple fruit

Fig. 3 shows the force increases after maturity 2 at bottom position maturity 3 at middle position, and maturity 4 at top position before decreasing further. According to Jha and Matsuoka (2002), during storage the fruit had started to rot and the epidermis probably loss its firmness and the inner surface provided a greater resistance to the compression and caused an increased temporarily. During storage period, the rotting process continued further and probably made the fruit softer which in turn to decrease the firmness continuously. The second phase of decreased in force was observed after stage of maturity 3, at bottom position, stage 4 at middle position and stage 5 at top position. This indicates that fruits firmness at bottom position start probably rotting 1 stage of maturity ahead of the fruits firmness at middle position. Similar trend was also observed for middle and top position. This may be attributed to the effect of ripening process.

CONCLUSIONS

As a conclusion, the average total weight of a single fruit of Josapine pineapple is 886.86 ± 49.67g. The average force observed that decreased with the stage of maturity during storage at 25°C and 52% (RH). The force required to rupture the peel of pineapple fruit is higher at the top position than at the bottom position when compressed using cylindrical die of 6 mm in diameter.

REFERENCES

Abdullah, H. and Rohaya, MA. (1997). Influence of maturity stage on quality of stored pineapple (*Ananas comosus* CV. Mauritius). *Journal of Bioscience 8*(2), 119 – 126.

Boussineq, J. (1885). Contact stresses between bodies in compression. In N.N. Mohsenin (Ed.), *Physical properties of plant and animal materials* (pp. 278-308). New York: Gordon and Breach Science Publishers.

Chan, Y. K. (1993). Recent advancements in hybridization and selection of pineapple in Malaysia. *Acta Horticulture 334 First International Pineapple Sysposium*, 33-44.

Mercado-Silva, Erdmundo, Benito-Bautista, Pedro and Ma Delus angeles Garcia-Velasco. (1998). Fruit development, harvest index and ripening changes of guavas produced in central Mexico. *Biology and Technology Post harvest, 13*, 143-150.

FAMA. (2004). *Analisis Industri Buah Nanas*. Kuala Lumpur.

Finney. (1963). Contact stresses between bodies in compression. In N.N. Mohsenin (Ed.), *Physical properties of plant and animal materials* (p. 278-308). New York: Gordon and Breach Science Publishers.

Jha S.N., Kingsly A.R.P. and Sageeta Chopra. (2005). Physical and mechanical properties of mango during growth and storage for determination of maturity. *Journal of Food Engineering, 72*, 73–76.

Jha, S.N. and Matsuoka. (2002). Surface stiffness and density of eggplant during storage. *Journal of Food Engineering, 54*, 23-26.

Ramlah, M. (1981). In H. Abdullah and M.A. Rohaya. Influence of maturity stage on quality of stored pineapple (*Ananas comosus* CV. Mauritius). *Journal of Bioscience, 8*(2), 119 – 126.

Shewfelt, R. L. (1993). Measuring quality and maturity. In *Handling Post harvest*. US: Academic Press Inc.

Timoshenko and Goodier. (1951). Contact stresses between bodies in compression. In N.N. Mohsenin (Ed.), *Physical properties of plant and animal materials* (p. 278-308). New York: Gordon and Breach Science Publishers.