Physico-chemical and sensory quality of fresh cut papaya (*Carica papaya*) packaged in micro-perforated polyvinyl chloride containers

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Revised: 17 January 2013 / Accepted: 4 February 2013 / Published online: 19 February 2013
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Abstract Papaya cubes at maturity stages, 5–45 % yellow (more green than yellow) and 55–80 % yellow (more yellow than green) were washed with 5 % H₂O₂, drained and packaged in PVC trays having five, seven and ten micro-perforations and stored for 19 days. PVC trays with 3 mm diameter punch holes were used as the control. Based on physico-chemical properties, optimum maturity for papaya and micro-perforation level of PVC trays were determined. Effectiveness of citric acid in prevention of browning was also tested. Firmness and TSS changed significantly, on day 19. O₂, CO₂ and C₂H₄ concentration changed 2.4 to 4.2 %, 23.4 to 5.9 %, and 0 to 0.13 % respectively, from day 3 to 19. pH and titratable acidity did not change significantly throughout the storage. Pretreated papaya cubes, packaged

in PVC trays with ten micro-perforations, kept under 4 °C had storage lives of 19 days.

Keywords Maturity · PVC trays · Minimal processing · Papaya

Papaya (*Carica papaya*) is an important tropical fruit in the world (Ahamed and Choudhary 1995). In Sri Lanka, the annual production of papaya is around 30,000,000 kg (Anon 2006). Papaya is a popular fruit among people due to its excellent taste and high nutritional value. It is rich in vitamins especially vitamin C (Nuns et al. 2006). Papaya is also being widely used as a valuable raw material in processing industry. In the worldwide tropical fruit trade, papaya has a good export market for its high nutritional value (Nuns et al. 2006). Even though, papaya has such high importance as a fresh fruit and a raw material, marketing of fresh papaya is a great problem because of its short postharvest life, which leads to high postharvest losses. The postharvest losses reported for papaya are around 46 % (Anon 2006). Poor postharvest handling during storage, packaging and transportation, incidence of diseases and limited storage facilities are some of the major reasons for such high postharvest losses. Postharvest life of fresh papaya varies from 3 to 6 days under tropical climatic conditions prevailing of Sri Lanka, due to enhanced physiological activities such as respiration and other metabolic processors that are associated with deterioration of products.

Thermal processing techniques such as pasteurization and sterilization compromise many of the sensory attributes, nutrients and other fruit qualities as high temperatures are

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employed (Ahamed and Choudhary 1995). The consumer demand for high quality products with fresh like characteristics, simplicity in use, convenience and health benefits has been increasing since past decade (Pereira et al. 2004). The demand is from airlines, hotel industry, hospitals, military forces and many other sectors where fast foods are important. Therefore, an introduction of a suitable processing technique to keep papaya in its fresh form will have a good advantage to extend the postharvest life and secure the portion of papaya which, wastes.

Minimal processing of papaya will be an appropriate processing technique to meet many of the requirements mentioned above. This technique includes, careful cleaning prior to processing, gentle washing, peeling, cutting, slicing or / and shredding and use of low temperatures and mild chemical treatments to retard physiological activities during processing and packaging (Kaur and Kapoor 2000). Hence, minimal processing keeps the fruits in its fresh form, saving most of the nutrients with it. Moreover, during minimal processing, peels, seeds and other inedible portions are removed and only the edible portion goes to the consumer. It reduces the unwanted cargo load which is important in export trade to minimize the transport cost. Further, a considerable load of by-products accumulated at a single place, facilitates practicing a method of by-product utilization.

Minimally processed papaya will be a more convenient and healthy fast food for busy households. This can be developed as a cottage industry as it employs simple operations and equipments. This study focused on development of minimally processed fresh cut papaya product. The effect of micro-perforation level of PVC packages on fruit firmness and shelf-life of minimally processed papaya were tested. The effect of citric acid concentration on prevention of browning was also tested.

Materials and methods

Uniformly matured disease free “Ratne” papaya fruits (1 kg $\pm$ 200 g) were harvested from the farming fields at Saliyapura, Sri Lanka and transported to the laboratory at Institute of Post Harvest Technology, Anuradhapura. The fruit pulp was analyzed in triplicates for firmness, titratable acidity (TA), pH and total soluble solids (TSS) to find out biological variability.

Selection of optimum maturity stage

The experiment was conducted to select the optimum maturity stage out of two maturity stages. The firmness of papaya at table ripe stage was taken as the reference in this study. The two stages namely, more green than yellow (5–45 % yellow) and more yellow than green (55–80 % yellow)

were harvested, transported to the lab, and washed with a 5 % hydrogen peroxide (50 ml /l of water) solution (Sapers et al. 2001). Then fruits were peeled, deseeded and cut into cubes (15 mm $\times$ 15 mm $\times$ 15 mm). Cubes were washed with a hydrogen peroxide (50 ml /l of water) solution, drained and wiped with clean tissue paper. Then fruit cubes were packaged (80 g per package) in PVC trays with three micro-perforation levels. Three micro-perforation levels were created by changing the number of pinholes with 0.05 mm diameter made at the vertical four sides of the PVC trays with five holes, seven holes and ten holes per tray. Perforated trays with 15 punch holes with 3 mm diameter were used as the control. Samples were stored in a refrigerator at 4 ± 1 °C for 21 days and withdrawn at 3 days interval in triplicates and analyzed for firmness. The optimum maturity stage of papaya was selected based on reference value. Firmness of the papaya fruit at table ripe stage was taken as the reference in this experiment.

Selection of anti-browning treatment

Papaya cubes, at maturity stage of more yellow than green and washed with 5 % H₂O₂ solution, were treated with citric acid of three concentrations (0.5 g l⁻¹, 1 g l⁻¹ and 1.5 g l⁻¹). Samples were stored at refrigerator at 4 ± 1 °C for 19 days and analyzed for browning index using seven point Hedonic scale by ten trained panelists.

Selection of best perforation level

Results obtained in previous experiments were used in performing this experiment. Papaya cubes, at maturity stage of more yellow than green and washed with 5 % H₂O₂ solution (Sapers et al. 2001), were treated with citric acid (1 g l⁻¹) and packaged in the PVC trays with 5, 7 and 10 micro perforations (size 0.05 mm diameter). Samples packaged in PVC containers with 15 punch holes were used as the control. Self-sealing septa were attached to facilitate gas measurement. The lids of the PVC trays were heat sealed using a sealing machine. Samples were stored at refrigerator at 4 ± 1 °C for 19 days, withdrawn in 3 days interval and analyzed for in-package concentration of oxygen (O₂), carbon dioxide (CO₂) and ethylene (C₂H₄), pH, total soluble solids and titratable acidity according to the methods described below.

Gaseous composition

In package concentration of O₂, CO₂ and C₂H₄ in triplicates was measured in 2 days intervals using Gas Chromatography (Varian CP 3800, Australia). Oxygen was measured by using thermal conductivity detector (TCD) while carbon dioxide and ethylene were measured using

flame-ionized detector (FID). Helium was used as the carrier gas at a flow rate of 60 ml/min. Column oven, TCD and FID temperatures were of 70, 140 and 300° C, respectively.

Physico-chemical analysis

Firmness

Pulp firmness (penetration force) was determined by measuring the force required for a 8 mm diameter probe to penetrate to a depth of 10 mm in to a cube at a rate of 6 mm/s. Samples were measured in triplicates by using a fruit firmness Tester (Model CS1-2, Italy). Samples were placed perpendicular to the probe and were penetrated in their geometric centre.

Color

The instrumental color measurements of flesh L* and b* values were measured using a colour difference meter (DP-400, Japan). White porcelain reference plate ($Y=93.9$, $X=3155$, $y=.3319$) was used to calibrate the equipment. Readings were made by directly applying the chromo meter head on to the surface of the fruit cube.

Measurement of TSS, pH and TA

Finely cut flesh tissue (5 g) was homogenized with 5 ml of ionized water using a mortar and a pestle. The mortar and pestle were washed twice with 5 ml each of distilled water. The pooled fractions were centrifuged (Himac CR 21 E, Hitachi) at $13000\times g$ for 20 min. The supernatant (20 ml) was used to analyze pH, and TA.

The supernatant was diluted up to 80 ml by distilled water, the diluted supernatant was titrated against 0.1 N NaOH until faint pink color was obtained at the end point and TA was expressed as percentage citric acid. The pH was measured by using a pH meter (Thermo Orion 230). A sample of fruit was chopped and juice was extracted using a clean piece of cloth and TSS was measured using a hand held Refractometer (HR-5 AO22-1, Japan).

Storage study

Storage study was conducted to test the acceptability of the product at the end of storage. Results obtained in previous experiments were used in performing this experiment. Papaya cubes at maturity stage of more yellow than green and washed with 5 % H_2O_2 solution, were treated with citric acid (1 g l^{-1}) and packaged in PVC trays with 10 micro perforations. The lids of the PVC trays were heat sealed using a sealing machine. Samples were stored at refrigerator at $4\pm 1^\circ\text{C}$ for 19 days, withdrawn in 3 days interval and

analyzed for microbiological properties. The proximate analysis and sensory evaluation was conducted at the end of the storage period.

Microbiological analysis

The total plate count and yeast and mould count were conducted throughout the storage period to evaluate the microbial content of the processed product as described in AOAC (1990).

Proximate analysis

Moisture, crude fat, crude protein, and vitamin C contents of the fresh and stored product, after 19 days, were determined in triplicates according to the standard methods of AOAC (1990).

Sensory evaluation

At the end of the storage period the minimally processed product was served for 30 panelists and color, taste, texture and overall acceptability of the product was evaluated over the control sample of freshly prepared fruit cubes using the seven point Hedonic Scale. (7-like extremely, 6-like very much, 5-like moderately, 4-neither like nor dislike, 3-dislike moderately, 2-dislike very much, 1-dislike extremely).

Statistical analysis

Data of gaseous concentration, firmness, TSS, TA, pH and proximate analysis were subjected to Variance analysis using SAS statistical package. Treatment means from 3 replicates were compared at $p<0.05$ according to LSD and Duncan mean separation procedures.

The results of the sensory evaluation test was analyzed by using Friedman test of Minitab statistical package and treatment means were compared at $p<0.05$ using multiple comparison procedure.

Results and discussion

Fruit firmness is a direct indicator for determining the fruit ripening. The initial firmness of papaya cubes at maturity stage more green than yellow was $8.00\pm 0.20\text{ kg cm}^{-2}$ and the firmness did not change towards table ripe level throughout the storage period regardless of micro perforation level and storage period. Where as firmness of papaya cubes at maturity stage more yellow than green having an initial firmness of $5.00\pm 0.20\text{ kg cm}^{-2}$ gradually reduced towards the firmness of table ripe stage which is $0.45\pm 0.05\text{ kg cm}^{-2}$ (Fig. 1). Papaya cubes in packages with ten micro-

perforations gradually reduced to a firmness of $0.45 \pm 0.05 \text{ kg cm}^{-2}$ at the end of 19th day of storage. Firmness reduction of minimally processed fruits is caused by dissolution of the middle lamella and subsequent cell separation and the activity of pectin esterase, which remains active even at low temperatures (Rodrigues et al. 2006). Papaya cubes in packages with five micro-perforations and seven micro-perforations, reached to firmness values of $1.17 \pm 0.05 \text{ kg cm}^{-2}$ and $0.41 \pm 0.05 \text{ kg cm}^{-2}$, respectively, and spoiled after 13 days of storage. Papaya cubes in the control reached to a firmness of $0.59 \pm 0.05 \text{ kg cm}^{-2}$ and spoiled after 9 days of storage.

Therefore papaya cubes at maturity stage more yellow than green is suitable for minimal processing. Paull and Chen (1997) has also reported that papaya with 55–80 % skin yellowing (more yellow than green) having 5 kg cm^{-2} flesh firmness is the best stage for minimal processing of papaya. Similarly, determination of optimum maturity stage for minimal processing, based on flesh firmness has been reported for avocado (Nikapitiya and Illeperuma 2003) and pears (Gorny et al. 1999).

Table 1 summaries the effect of different concentrations of citric acid on browning index of minimally processed papaya cubes packaged in PVC trays with ten micro-perforations. Acidification is widely used in controlling enzymatic browning particularly for fruits. As acid reduces pH below 4.5, it reduces the polyphenol oxidase activity by chelating the copper prosthetic group of the enzyme (Garcia and Barrett 2002). Citric acid is reported to be the most widely used acidulant in preventing enzymatic browning in fruits and vegetables (Shah and Nath 2006). In this research, different concentrations of citric acid were tested in controlling of browning. Browning index was significantly different ($p \leq 0.05$) among different concentrations of citric acid. Papaya cubes treated with 1 g l^{-1} citric acid having highest estimated median value indicating the color very closer to normal yellow, were better in terms of browning index. Similarly higher browning index value has been reported in controlling enzymatic browning of avocado slices treated with 1 g l^{-1} or 1.5 g l^{-1} citric acid solution (Nikapitiya and Illeperuma 2003). Moreover, Chauhan et al. (2006) have reported effectiveness of ascorbic acid (0.2 g/l) and citric acid (7 g/l) as anti-browning agents in minimal processing of papaya slices.

The interaction effect of level of micro-perforation and in-package gaseous concentration was significant at $p < 0.05$. The concentration of O_2 in packages with five micro-perforations and seven micro-perforations changed from 6.37 to 2.84 % and from 7.46 to 1.98 %, respectively from the third day of storage to the 13th day of storage (Fig. 2). In-package concentration of O_2 and CO_2 in the control treatment changed from 6.66 % to 6.26 % and from 24.56 % to 4.40 %, respectively from the third day of storage to ninth day of storage. Table 2

Fig. 1 Effect of maturity stage (a - Growth stage more green than yellow b - Growth stage more yellow than green) on firmness of minimally processed fresh cut papaya cubes packaged in PVC packages with different levels of micro-perforation and stored at $4 \pm 1^\circ \text{C}$ for 19 days and $90 \pm 2\%$ RH. P5 – 5 micro perforations, P7 – 7 micro perforations, P10 – 10 micro perforations and ctrl – control with 15 punch holes. Vertical bars represents the standard error of the mean ($n = 3$). Each value represents the mean of three replicates

Table 1 Effect of citric acid on browning index of minimally processed fresh cut papaya cubes packaged in PVC packages with 10 micro-perforations and stored at $4 \pm 1^\circ \text{C}$ for 19 days and $90 \pm 2\%$ RH

Citric acid (g l^{-1})	Browning Index
0.5	5.33 ± 1.10 b
1	6.67 ± 0.98 a
1.5	4.11 ± 0.95 c
Control (Water)	3.12 ± 0.91 d

Each value represents the mean of triplicate $\pm$ SD judged by ten Panelists. BI: 1-brown, 2-moderate brown, 3-slight brown, 4-neither yellow nor brown, 5-slight yellow and 7-yellow normal. Different letters indicate that the values are significantly different at $p < 0.05$

Fig. 2 Effect of micro-perforation level on in-package gaseous concentration (a,b,c) and physico-chemical properties (d,e,f) of minimally processed fresh cut papaya cubes packaged in PVC packages with different levels of micro-perforation and stored at 4 ± 1 °C for 19 days

Concentration of in-package CO_2 reduced from 15.10 % to 10.09 % and from 9.98 % to 8.97 % in packages with five micro-perforations and seven micro-perforations respectively

Table 2 Proximate composition of fresh papaya cubes and minimally processed fresh cut papaya cubes packaged in PVC packages with 10 micro-perforations and stored at 4 ± 1 °C for 19 days and 90 ± 2 % RH.

Property	Fresh	Stored	LSD0.05
Moisture (%)	91.7 $\pm$ 1.05a	91.6 $\pm$ 1.03 a	1.12
Crude fat (%)	0.11 $\pm$ 0.01a	0.11 $\pm$ 0.01 a	0.014
Crude protein (%)	0.58 $\pm$ 0.09 a	0.56 $\pm$ 0.08 a	0.12
Vitamin C (mg/100 g)	57 $\pm$ 1.25 a	5 7 $\pm$ 1.5 a	6.25

Each value represents mean of three replications $\pm$ SD. Means in each row followed by the same letter are not significantly different (LSD critical value, $p<0.05$)

and 90 ± 2 % RH. P5 – 5 micro-perforations, P7 – 7 micro-perforations, P10 – 10 micro-perforations and ctrl – control with 15 punch holes. Vertical bars represents the standard error of the mean ($n=3$). Each value represents the mean of three replicates

from third day of storage to the 13th day of storage (Fig. 2). Concentration of O_2 and CO_2 in the packages with ten micro-perforations, changed from 2.37 % to 4.15 % and from 23.43 % to 5.9 %, respectively from third day of storage to the 19th day of storage. A concentration of 5–10 % CO_2 and 2–5 % O_2 has been suggested for modified atmospheric packaging (MAP) of minimally processed products (Kader et al. 1989). In the present study, in-package O_2 and CO_2 concentration in packages with 10 micro-perforations was within these limits after the ninth day of storage to the 19th day of storage (Fig. 2).

Imbalanced gas concentration in packages with five micro-perforations and seven micro-perforations may be due to low permeability of packages. High CO_2 concentration and low O_2 concentration in MAP system promotes growth of lactic acid bacteria (Barry-ryan et al. 2000; Babic

Table 3 Effect of micro-perforation level on instrumental color (L and b) measurements of minimally processed fresh cut papaya cubes packaged in PVC packages with different levels of micro-perforation and stored at 4 ± 1 °C for 19 days and 90 ± 2 % RH. P5 – 5 micro-perforations, P7 – 7 micro-perforations, P10 – 10 micro-perforations and ctrl – control with 15 punch holes

Property	Days after storage	Treatment			
		P5	P7	P10	Control
L value	0	59.1 $\pm$ 0.56a	59.1 $\pm$ 0.56a	59.1 $\pm$ 0.56a	59.1 $\pm$ 0.56a
	3	57.1 $\pm$ 1.15abc	58.3 $\pm$ 1.47abc	59.0 $\pm$ 1.00ab	52.3 $\pm$ 2.46de
	6	56.3 $\pm$ 1.47abc	55.8 $\pm$ 1.30c	58.2 $\pm$ 0.72abc	50.1 $\pm$ 2.15ef
	9	52.5 $\pm$ 1.32de	53.1 $\pm$ 0.85d	58.9 $\pm$ 1.15ab	49.3 $\pm$ 1.47f
	13	50.7 $\pm$ 1.53def	50.8 $\pm$ 3.30def	57.1 $\pm$ 2.81abc	-
	16	-	-	56.0 $\pm$ 2.64bc	-
	19	-	-	56.3 $\pm$ 3.15abc	-
b value	0	15.7 $\pm$ 0.99abcd	15.7 $\pm$ 0.99abcd	15.7 $\pm$ 0.99abcd	15.7 $\pm$ 0.99abcd
	3	16.5 $\pm$ 0.47ab	17.0 $\pm$ 0.89ab	17.71 $\pm$ 1.54a	12.9 $\pm$ 0.34e
	6	14.9 $\pm$ 2.14bcde	16.0 $\pm$ 2.56abc	16.0 $\pm$ 1.97abc	12.6 $\pm$ 0.96e
	9	15.6 $\pm$ 1.56abcd	14.4 $\pm$ 1.14bcde	15.0 $\pm$ 1.25bcde	9.9 $\pm$ 1.33f
	13	13.5 $\pm$ 1.32cde	13.2 $\pm$ 0.95de	14.9 $\pm$ 1.13bcde	-
	16	-	-	14.5 $\pm$ 1.86bcde	-
	19	-	-	13.2 $\pm$ 1.05de	-

Each value represents mean of three replications $\pm$ SD. Means in each treatment followed by the same letter are not significantly different (Duncan critical value for L- 3.13 and b-2.72 at $p<0.05$)

et al. 1993). This may be the reason for early spoilage of those two treatments. If modified atmosphere packaging conditions are not properly established and maintained, fermentative metabolites are produced due to low O_2 and / or elevated CO_2 concentration causing unfavorable odors and flavors (Gorny et al. 1999; Toivonen and Deell 2002). Singh and Goswami (2006) have also reported that careful monitoring of in-package gas levels are very important as; accumulation or depletion of gases may cause adverse effects on the quality as well as shelf-life of commodities.

C_2H_4 induces increase rate of respiration, promotion of biochemical reactions and physiological metabolism (Paull and Chen 1997). Packages with five and seven micro-perforations had relatively high in-package ethylene. The concentration of C_2H_4 in the packages with five micro-perforations and seven micro-perforations increased from 0.08 % to 7.24 % and 0.19 % to 7.78 % respectively from third day of storage to the end of 13th day of storage (Fig. 2) and that of control increased from 0.13 % to 1.37 %. In-package C_2H_4 concentration in packages with ten micro-perforations was comparatively low. It was not detectable from third day of storage and 0.13 % at the end of 19th day of storage. This may be due to low O_2 and high CO_2 concentration in those packages. Previous studies (Singh and Goswami 2006; Gorny 1997; Day 1996) have reported that, low O_2 and high CO_2 concentrations reduce the C_2H_4 biosynthesis. Therefore, minimizing the level of C_2H_4 in packages with ten micro-perforations was effective in extending shelf-life of minimally processed papaya. Paull and Chen (1997) have also reported the effectiveness of minimizing the level of ethylene in extending the shelf-life of minimally processed papaya.

There was no significant difference in total soluble solid (TSS) content in papaya cubes, packaged in different micro-perforation levels throughout the storage period at $p<0.05$. However, TSS has significantly increased from initial value

Fig. 3 Sensory attributes of fresh papaya cubes and minimally processed fresh cut papaya cubes packaged in PVC packages with 10 micro-perforations and stored at 4 ± 1 °C for 19 days and 90 ± 2 % RH. Hedonic scale: 7- like very much; 6-like moderately; 5-like slightly; 4- neither like nor dislike; 3-dislike slightly; 2-dislike moderately; 1-dislike very much, $n=30$. Values with different letters (a, b) differ significantly $p<0.05$ for each sensory quality attribute

of 9.50 ± 0.02 % to 12.00 ± 0.20 % throughout the storage period in all the treatments (Fig. 2). This increase in TSS may be due to breakdown of pectin and conversion of carbohydrates into simple sugars during storage caused by metabolic activities of the tissues (Rodrigues et al. 2006). A similar increase in TSS has been reported in modified atmosphere packaged 'Kolikutu' banana (Illeperuma and Galappatti 2000). Kathiyani et al. (2006) have also reported such increase in TSS of banana. Shrink packaged fresh mango has also shown similar pattern of increment in TSS during the storage (Shah and Nath 2006). There was no significant change ($p < 0.05$) in pH of papaya cubes throughout the storage period and it ranged from 5.50 ± 0.20 to 5.70 ± 0.20 (Fig. 2). Titratable acidity ranged from 0.89 ± 0.02 % to 0.54 ± 0.02 % and change was not significant ($p < 0.05$) throughout the storage period. Changes in TA among the packages with different micro-perforation levels was also not significant ($p < 0.05$). Similarly, Illeperuma and Galappatti (2000) have reported that there was no significant difference in changes of pH and TA in modified atmosphere packaged 'Kolikutu' banana. This may be due to decrease in rate of respiration and other biochemical processes under high carbon dioxide atmosphere (Illeperuma and Galappatti 2000). All papaya cubes, irrespective of the treatment, showed reduction in both lightness (L value) and yellow colour (b value). Samples packaged in PVC containers with 10 micro perforations showed the highest lightness value throughout the storage and papaya cubes in controlled sample showed the lowest lightness (Table 3) values during 9 days of storage at 4 °C (Table 3). However the present colour evaluation of all treatments during the storage did not show severe browning except the control sample.

Hydrogen peroxide (H_2O_2) has identified as a safe disinfectant for minimally processed commodities (Kaur and Kapoor 2000). Dipping fresh-cut cantaloupe melon in 5 % H_2O_2 has been effective in improving the microbial quality and shelf-life. (Sapers et al. 2001). The total plate count and yeast and mould count of minimally processed papaya cubes did not show any difference throughout the storage and remained as less than 25 and 10, at the 0 and 19th day of storage (Data not shown). This reveals the effectiveness of 5 % H_2O_2 in keeping the microbial count of minimally processed papaya cubes below critical level of 10^5 as reported by Hairigan (1998) and Lopez-Rubira et al. (2005). The moisture content of the product has changed from the initial value of 91.7 % to 91.6 %, however the change was not significant at $p < 0.05$ level. Moreover, minimal processing has not significantly changed ($p < 0.05$) the crude fat, crude protein and vitamin c contents during the storage (Table 2).

Even though, a product is physico-chemically and microbiologically acceptable, good sensory quality is more important for a minimally processed product when it is marketed. Therefore, a sensory evaluation was conducted

to check the consumer acceptance on the newly introduced product. The fresh sample showed higher estimated median values for all sensory attributes except for color (Fig. 3). However, all sensory parameters namely, odour, texture, taste, color and overall acceptability were above the scale of 5 indicating that they are in acceptable range. There was no significant difference in sensory parameters of fresh papaya cubes and the new product. Illeperuma and Nikapitiya (2006) have also reported that there were no adverse changes in sensory qualities of minimally processed avocado when compared with freshly prepared ones.

Conclusions

The optimum maturity stage for minimal processing of papaya was more yellow than green with firmness of 5.00 ± 0.20 kg cm⁻². Dipping papaya cubes in a 5 % H_2O_2 solution maintained at 4 ± 1 °C for 1 min followed by dipping in a solution containing citric acid (1 g l⁻¹) at 4 ± 1 °C for 1 min allowing to drain and packaging 80 ± 2 g in a 0.05 mm thick PVC containers of $12.3 \times 9 \times 3$ cm with ten micro-perforations can result in a shelf-life of 19 days at 4 ± 1 °C.

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