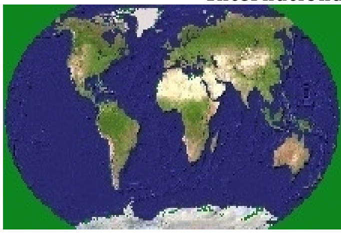
International Journal of Multidisciplinary Research and Development 2014; 1(6): 194-199



International Journal of Multidisciplinary Research and Development

IJMRD 2014; 1(6): 194-199
www.allsubjectjournal.com
Received: 08-10-2014
Accepted: 11-11-2014
e-ISSN: 2349-4182
p-ISSN: 2349-5979

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Application of MAP to extend freshcut mango shelf-life

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Abstract
Fresh-cut fruits and vegetables generally are packaged in film bags or containers overwrapped with film, which creates a modified atmosphere within the package (MAP). Low storage temperature and MAP are extensively used to extend the shelf life of many intact and fresh-cut fruit and vegetables products because they reduce rates of respiration and cut surface deterioration and browning. During our research, we notice the main factors influence
ng to fresh cut mango shelf-life. If fresh cut mango is packed in 5% O_2 and 10% CO_2 or preserved in 5 ^{0}C, its shelf-life is only 2-10 days. Moreover, its nutrient is also reduced dramatically together with water loss. If only preserving in 5% O_2 and 10% CO_2, its shelf-life is just 2 days. With a combination of cooling 5 ^{0}C with modified atmosphere packaging (5% O_2 and 10% CO_2), its shelf-life can be extended to 15 days with stable nutrient. One more advantage of preservation at low temperature 5 ^{0}C we don't see any chilling inrury on fresh cut mango. The most importance is to limit the water drip loss during preservation.

Keywords: MAP, fresh cut, mango, shelf-life

1. Introduction

Mango (*Mangifera indica* L.) is one of the most important tropical fruit worldwide in terms of production and consumer acceptance. Mango fruit is considered as a source of antioxidants including ascorbic acid (mango fruit provides about 50% of the recommended daily intake of vitamin C) and carotenoids. Carotenoids, which are lipophilic radical scavengers found in many fruits and vegetables are also responsible of the bright yellow color of mango (Vinci *et al.*, 1995; Shieber *et al.*, 2000).

Fresh-cut or minimally processed fruit (peeled, cored and sliced) are a growing segment among food products due to the convenience and fresh-like quality of the products (Pittia *et al.*, 1999; Charles *et al.*, 2003). Consumers judge the quality of fresh-cut fruit on the basis of appearance and freshness at the time of purchase (Kader, 2002). Rapid deterioration of fruit during handling, transportation and storage is a damaging problem. Moreover, fresh-cut processing increases metabolic activity, and decompartmentalization of enzymes and substrates which may cause browning, softening and decay (Varoquaux and Wiley, 1994; Charles *et al.*, 2005). Postharvest losses in nutritional quality can be substantial, for example with decreases in vitamin C and carotenoid contents (Mc Carthy and Mattews, 1994; Sudhakar and Maini, 1994). Freshcut tropical fruit, such as mangoes, are more perishable than those from temperate climates, such as apples and peaches. It is therefore important to control deterioration processes in order to maintain quality.

Much research has focused on the use of postharvest treatments to extend fresh cut mango shelf-life. G. A. Gonzalez-Aguilar *et al.* (2000) investigated treatments to inhibit browning and decay and prolong shelf life of fresh-cut mangoes. Combinations of antibrowning agents and modified atmosphere packaging (MAP) resulted in a reduction of browning and deterioration of fresh-cut mangoes stored at 10 °C. Combinations of several browning inhibitors were more effective than those applied individually. Murillo Freire Jr *et al.* (2009) improved the storage of minimally processed mangoes (Mangifera indica L.) by hot water treatments. Whole mangoes were subjected to hot water dipping (HWD) at 46 or 50 ◦C for 30 or 75 min, cooled for 15 min, minimally processed and stored at 6 ◦C for 9 d. Sensory analysis, firmness, color, acidity, pH, total soluble solids (TSS), ascorbic acid, total carotenoids, malondialdehyde (MDA) and respiration rate (RR) were investigated. A global beneficial effect of HWD 50 ◦C/30 min was observed. This treatment was the only one to maintain the acceptability of fresh-cut mangoes for 6 d, the yellow color, expressed by b* value, for 9 d and the firmness for 3 d compared to the control. Moreover, HWD 50 ◦C/30 min increased the total carotenoids content after 3 d compared to the control. Although the ascorbic acid content decreased during storage, HWD 50 ◦C/30 min is the less degrading condition of the heat treatments. Lipid peroxidation, estimated by MDA content, was less important for HWD 50 ◦C/30 min. Finally, the RR of whole mangoes treated by HWD 50 ◦C/30 min was lower than in the other treatments and could be used as an indicator of product shelf-life. This study selected the HWD 50 ◦C/30 min as the optimal heat treatment to improve the quality of fresh-cut 'Keitt'mangoes. Rungsinee Sothornvit* and Patratip Rodsamran (2010) examined mango film coated for fresh-cut mango in modified atmosphere packaging. In this study, fresh-cut mango was wrapped with mango film and packed in modified atmosphere packaging (MAP). Each package was stored at 30 °C or 5 °C and sensory evaluation was performed to determine its quality and shelf life. The shelf life of uncoated and coated fresh-cut mango pieces was 6 days for each at 5 °C and was 3 and 4 days, respectively, at 30 °C. The sensory evaluation indicated that coated fresh-cut mango was slower to produce an off-flavour and maintained better visual quality than uncoated mango at 30 °C. Nonetheless, coated fresh-cut mango was softer than uncoated mango because of the hydrophilic nature of the mango film. No significant difference in the oxygen and carbon dioxide concentrations was observed between coated and uncoated fresh-cut mango. Coating fresh-cut mango with mango film showed a similar effect to MAP in prolonging the shelf life of the fresh produce. The use of the coating will enhance fruit quality and lead to better acceptance by consumers. In our research, we focus on examine changes of fresh cut mango about some key characteristics such as physiology, nutrient and sensory.

2. Material & Method

2.1 Material

Mango fruits are collected in Mekong river delta, Vietnam

Fig 1: Mango fruit

2.2 Research method

2.2.1 Experimental arrangement

We examine 4 experiments:

- CT1: fresh cut mango is preserved in normal air room temperature
- CT2: fresh cut mango is preserved in normal air at 5°C.
- CT3: fresh cut mango is preserved in MAP (5% O_2 and 10% CO_2) at normal room temperature.
- CT4: fresh cut mango is preserved in MAP (5% O_2 and 10% CO_2) at 5 ^{0}C.

Testing frequency: Samples of CT1 and CT3 are daily examined. Samples CT2 and CT4 are examined 5 days per once. Testing parameters include respiration rate, water drip loss, physiochemical and sensory characteristics.

2.2.2 Sample preparation

Samples are preserved in MAP at condition 5% O_2, 10% CO_2. Before testing, samples are stored in cooling and transferred to normal room temperature 3-4 hours ready for analysis.

2.3 Testing method

Fresh cut mango quality is determined through firmness, color, vitamin C, soluble dry matter (°Brix), total acidity, total sugar, water drip loss, air composition, sensory value.

2.4 Statistical analysis

All data are processed by Excel 2003.

3. Result & Discussion

3.1 Physiological change of fresh cut mango

3.1.1 Color change

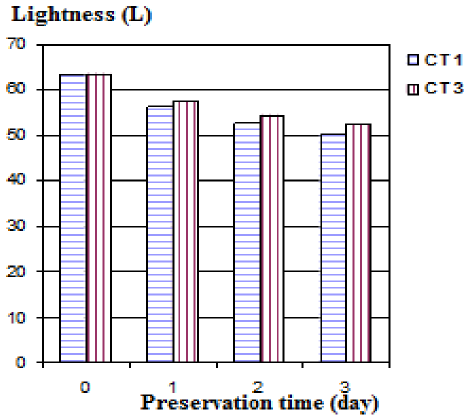

Fig 2: Lightness (L) of fresh cut mango under normal room temperature by different packing styles

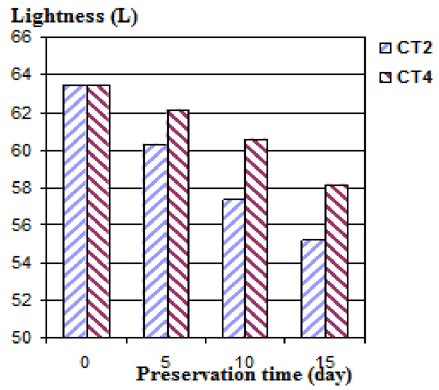

Fig 3: Lightness of fresh cut mango (L) under the same temperature (5 ^{0}C) by different packing styles

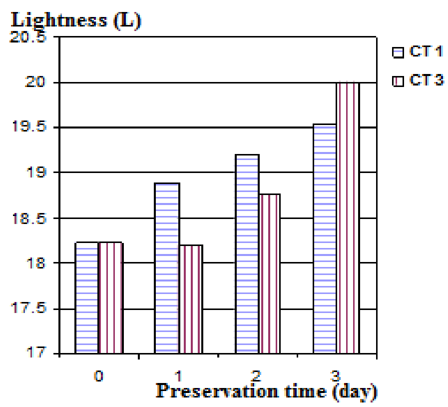

Fig 4: Lightness (L) of fresh cut mango under the same normal room temperature with different packing styles

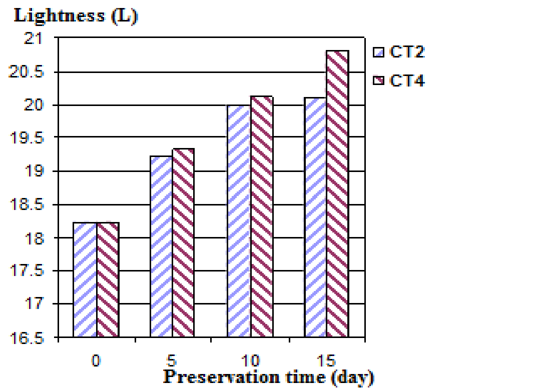

Fig 5: Lightness (L) of fresh cut mango under the same temperature (5 ^{0}C) with different packing styles

From figure 1-5, we decide to choose 5 ^{0}C in modified packaging 5% O_2 and 10% CO_2

3.1.2 Firmness change

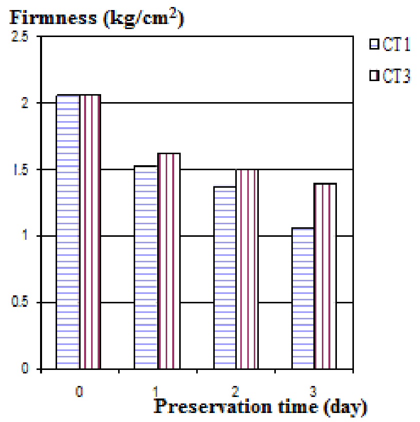

Fig 6: Firmness (kg/cm^2) of fresh cut mango under the same normal room temperature with different packing styles

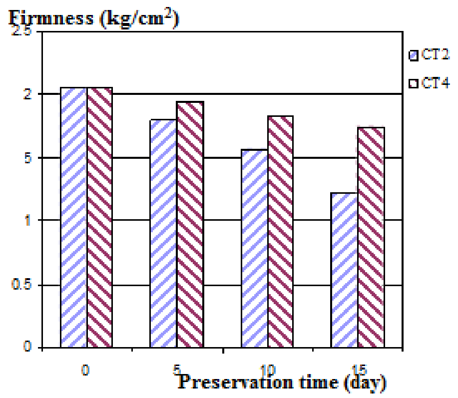

Fig 7: Firmness (kg/cm^2) of fresh cut mango under the same temperature (5 °C) with different packing styles

From figure 6 & 7, we see the firmness of fresh cut mango has decreased during preservation.

Among these formulas, CT1 is decreased dramatically; following CT3, CT2 and finally CT4. After 3 days of preservation, firmness of fresh cut mango is CT1 = 1.025 kg/cm^2; CT3 = 1.4 kg/cm^2. After 15 days, firmness of fresh cut mango CT4 = 1.75 kg/cm^2, CT2 = 1.23 kg/cm^2. At the same normal room temperature: in the first two days of preservation, there is not significant difference between CT1 and CT3 about firmness. At the 3rd days of preservation, there is significant difference; CT1 reduced 50% (from 2.05 kg/cm^2 to 1.025 kg/cm^2); CT3 reduced 31.7% (from 2.05 kg/cm^2 to 1.4 kg/cm^2). At the same temperature 5 ^{0}C: In the first 5 days of preservation, there is not significant difference between CT1 and CT3 about the firmness. After 10 days of preservation, there is significant difference (α = 0.05). After 15 days, firmness of CT2 reduced 40% (from 2.05 kg/cm^2 to 1.23 kg/cm^2); CT4 reduced 14.63% (from 2.05 kg/cm^2 to 1.75 kg/cm^2). A comparison among packing formulas, CT1 and CT2, CT3 and CT4, we see that at normal room temperature CT1 and CT3 is softer at 5ºC to packing for CT2 and CT4. During preservation, CT4 has firmness reduced 14.6% (from 2.05 to 1.75). Application of MAP (5% O_2 and 10% CO_2) with cooling temperature 5 ºC can maintain firmness to 15 days.

3.1.3 Respiration change

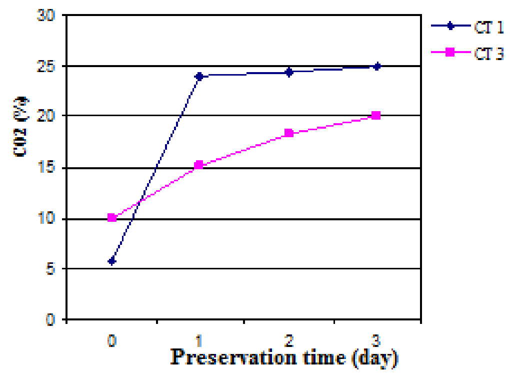

Fig 8: Change of CO_2 (%) of fresh cut mango under the same room temperature with different packing styles

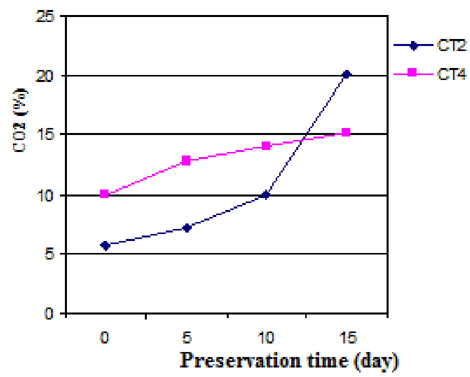

Fig 9: Change of CO_2 (%) of fresh cut mango under the same temperature (5 ºC) with different packing styles

From figure 8 & 9, we see the concentration of CO_2 increases during preservation. In the same normal room temperature, concentration of CO_2 increases dramatically to 5 ^{0}C. CT1 and CT3 after 3 days have CO_2 concentration 24.9% and 20.1%. Meanwhile CT4 after 15 days of preservation concentration, CO_2 is 15.2%, CT2 is 20.1%. By MAP preservation, CO_2 increases slowly at the same temperature. After 3 days of preservation, concentration of CO_2 regarding to CT1 increases 5.7% (0 day) to 24.9%. Meanwhile CT3 has CO_2 concentration from 10% (0 days) to 20.1%. At 5 ºC, after 15 days of preservation, CO_2 concentration of CT2 increases 5.7% (0 day) to 20.1%. CT2 has CO_2 concentration 10% (0 day) to 15.2%. So a combination of cooling temperature and MAP can limit respiration to extend fresh cut mango shelf-life to 15 days (CO_2 increased 16%).

3.1.4 Change of water drip loss

Table 1: Water drip loss (ml/kg) of fresh cut mango under the same normal room temperature with different packing styles

CT	Preservation time (days)			
	0	**1**	**2**	**3**
CT1	0	5	9	15
CT3	0	0	0	0

Table 2: Water drip loss (ml/kg) of fresh cut mango under the same temperature (5 °C) with different packing styles

CT	Preservation time (days)			
	0	**5**	**10**	**15**
CT2	0	10	21	40
CT4	0	0	0	0

From table 1 & 2, application of MAP will not release water. At normal room temperature in 3 preservation days, samples release 15 ml/kg; meanwhile at 5 °C after 5 preservation times water drip loss is 10 ml/kg. So we can see the positive effect of MAP.

3.2 Change of nutritional values on fresh cut mango
3.2.1 Change of total soluble solid (TSS)

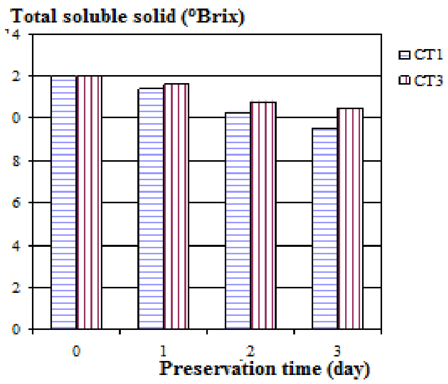

Fig 10: Change of total soluble solid (°Bx) of fresh cut mango under the same normal room temperature with different packing styles

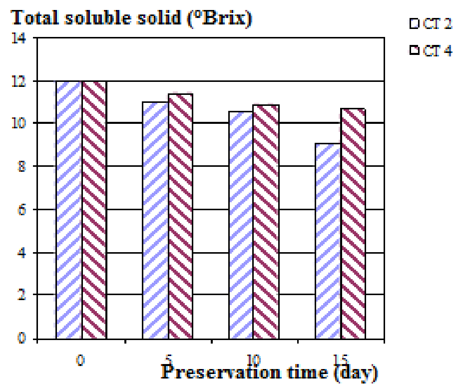

Fig 11: Change of total soluble solid (°Bx) of fresh cut mango under the same temperature (5 °C) with different packing styles

From figure 10 & 11, we see that the total soluble solid decreases during preservation. Among them, CT1 reduces dramatically and following CT3, CT2 and CT4. After 3 days of preservation TSS of fresh cut mango CT1 is 9.5 °Bx, TSS of fresh cut mangi CT3= 10.5 °Bx. After 15 days of preservation, TSS of CT4 is 10.7 °Bx; TSS of CT2 is 9.03°Brix. At the same normal room temperature, in the first two days of preservation, there is not significant difference between CT1 and CT3 about the total soluble solid. However, on the 3rd day of preservation we observe the significant difference ($\alpha = 0.05$). At the same temperature 5 °C, there is not significant difference beteen CT1 and CT3 about the total soluble solid. However, after 15 days of preservation we notice the significant difference ($\alpha = 0.05$). From above result, we see that MAP has affected to respiration rate of fresh cut mango in order to prevent loss of total soluble solid. Environmental temperature has positive effect to the total soluble solid. Preservation formula CT4 has reduction of total soluble solid from 12 °Brix to 10.7 °Brix (10.8% reduction).

3.2.2 Change of total sugar

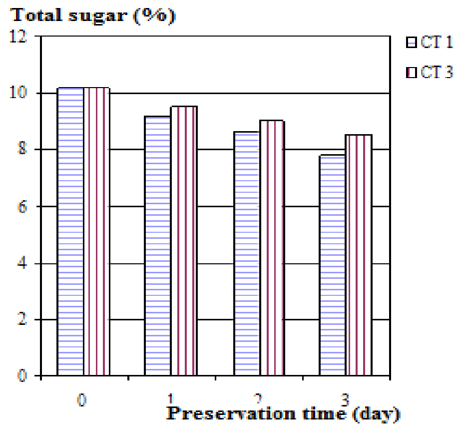

Fig 12: Change of total sugar (%) of fresh cut mango under the same normal room temperature with different packing styles

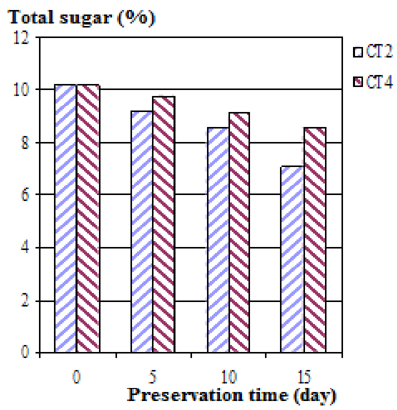

Fig 13: Change of total sugar (%) of fresh cut mango under the temperature (5 °C) with different packing styles

From figure 12 & 13, we realise thotal sugar decreases during preservation. After 3 days of preservation, total sugar in CT1 = 7.8%, CT3 = 8.53%. Meanwhile after 15 days of preservation, total sigar in CT4 = 8.6%, CT2 = 7.13%. This is the result of respiration during fresh cut mango preservation. At the same normal room temperature, in the first two days of preservation there is not significant difference between CT1 and CT3 about total sugar. However, after 3 days of preservation, there is significant difference ($\alpha = 0.05$). At the same temperature 5 ^{0}C, after 5 days of preservation there is significant difference about total sugar ($\alpha = 0.05$). From above result, we see that preservation in 5 °C is superior to normal room temperature. Cooling temperature decreases respiration rate of fresh cut mango.

3.2.3 Change of organic acidity

From figure 14 & 15, we realise that total acidity decreases during preservation. After 3 days of preservation, total acidity in CT1 is 0.55%; CT3 is 0.65%. Meanwhile after 15 days of preservation, total acidity in CT4 is 0.73%; CT2 is 0.57%. This is the result of respiration. At the same normal room temperature, in the first day of preservation there is not significant difference between CT1 and CT3 about total acidity. However on the 2nd day of preservation there is significant difference $\alpha = 0.05$). At the same temperature 5 °C, after 5 days of preservation, total acidity of fresh cut mango is significant difference ($\alpha = 0.05$). From above results, total acidity of fresh cut mango preserved at 5 °C is higher sample preserved at normal room temperature. This phenomenon is also elaborated as respiration.

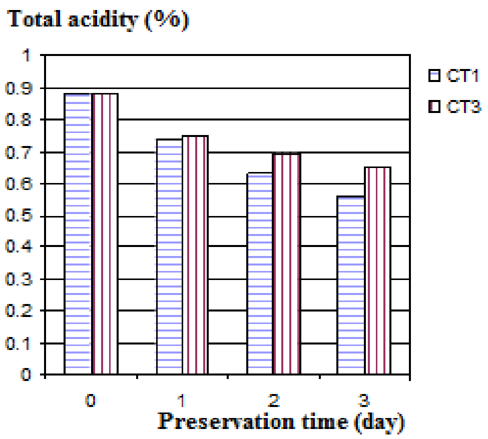

Fig 14: Total acidity (%) of fresh cut mango under the same normal room temperature with different packing styles

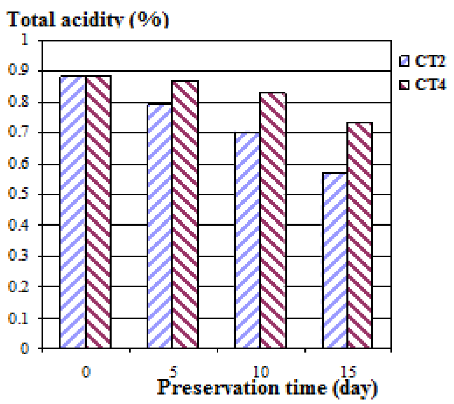

Fig 15: Total acidity (%) of fresh cut mango under the same temperature (5 °C) with different packing styles

3.2.4 Change of vitamin C (mg%)

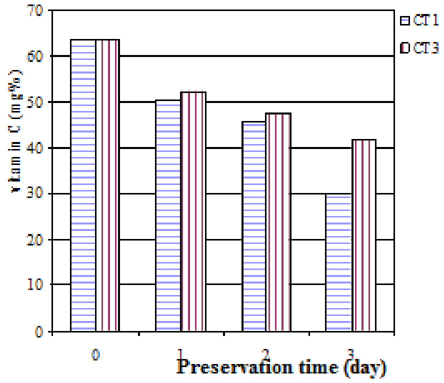

Fig 16: Change of vitamin C (mg %) of fresh cut mango under the same normal room temperature with different packing styles

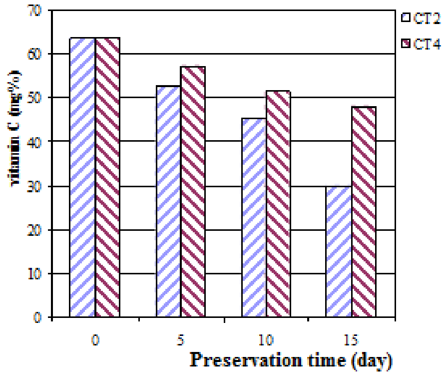

Fig 17: Change of vitamin C (mg%) of fresh cut mango under the same room temperature (5 °C) with different packing styles

From figure 16 & 17, we notice vitamin C decreases during preservation. After 3 days of preservation vitamin C of CT1 = 30.1 mg%, CT3 = 41.7 mg%. After 15 days of preservation, vitamin C of CT4 = 47.97 mg%, CT2 = 30.057 mg%. A combination of low temperature and MAP can maintain nutritional value of fresh cut mango to 15 days.

3.3 Sensory value of fresh cut mango during preservation

Table 3: Sensory value of fresh cut mango during preservation regarding to CT1 and CT3

CT	Preservation time (day)	CT1	CT3
Color	0	8.0[a]	8.0[a]
	1	6.8[a]	7.6[a]
	2	5.6[a]	6.6[a]
	3	3.4[a]	5.6[b]
Appearance	0	8.4	8.4
	1	6.8[a]	7.6[a]
	2	5.2[a]	6.2[b]
	3	3.2[a]	4.8[b]
Aroma	0	8.0[a]	8.0[a]
	1	6.8[a]	7.6[a]
	2	4.4[a]	6.4[b]
	3	3.4[a]	4.6[b]

From table 3, sensory values of CT1 and CT3 reduce by preservation time. However, CT1 is preferred to CT3. After 2 days of preservation, there is significant difference about preference (color, appearance, aroma) regarding to CT1 and CT3.

Table 4: Sensory value of fresh cut mango during preservation regarding to CT2 and CT4

CT	Preservation time (day)	CT2	CT4
Color	0	8.0[a]	8.0[a]
	5	7.2[a]	7.4[a]
	10	6.4[a]	7.2[a]
	15	4.8[a]	6.8[b]
Appearance	0	8.4[a]	8.4[a]
	5	7.4[a]	8.0[b]
	10	6.4[a]	7.6[b]
	15	4.4[a]	7.0[b]
Aroma	0	8.0[a]	8.0[a]
	5	7.2[a]	7.4[a]
	10	6.4[a]	7.2[b]
	15	4.8[a]	6.8[b]

From table 4, sensory values of fesh cut mango of both formula CT2 and CT4 reduce by preservation time. After 5 days of preservation, there is significant difference between CT2 & CT4 (α = 0.05). Meanwhile, CT2 has color, appearance and aroma reduced from the 10th date.

From above results, temperatures and packing styles have changed the sensory values of fresh cut mango. At 5^{o}C with MAP, sensory value of fresh cut mango can extend 10-15 days.

4. Conclusion

Mangoes are tropical fruit with a highly significant economic importance. The fruit is rich in antioxidants and recommended to be included in the daily diet due to its health benefits such as reduced risk of cardiac disease, anticancer, and anti-viral activities. Therefore, mango exporting countries must enforce adequate quality assurance systems and postharvest management practices to maintain fruit quality during the export chain. Fresh cut processors are facing challenges with the type of mango cultivars, quality at harvest, incorrect ripening stages, and inconsistent supply of fruit, incorrect fruit sizes, treatments, packaging and marketing. Preharvest factors such as cultural practices, time of harvest and maturity at harvest, handling operation, the time between harvest and cutting operation also can affect the quality of the end fresh cut product. Operational factors such as sharpness of the cutting tool, surface area of the cut tissue or cubes, efficiency of removal of excess surface water present from the cut tissues, proper sanitation methods, application of suitable MAP, and maintenance of cold chain management determine the shelf life and the consumer acceptance of the fresh cut product.

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