J. Hortl. Sci.
Vol. 11(1):67-71, 2016

Development of intermediate-moisture slices of papaya (*Carica papaya* L.) by hurdle technology

Akanksha Shrivastava and I.N. Doreappa Gowda*
Division of Post-harvest Technology
ICAR-Indian Institute of Horticultural Research
Hessaraghatta Lake Post, Bengaluru - 560 089, Karnataka, India
*E-mail: dore@iihr.res.in

ABSTRACT

Papaya fruits are highly perishable, with over 25% post-harvest losses which further rise during storage. To prevent these losses, we attempted to convert papaya slices into intermediate moisture (IM) slices using a novel combination-technology which included a combination of osmotic removal of water by sugar syrup (60°B) containing various preservatives/additives, and, added use of chemicals such as $CaCl_2$, citric acid, sodium metabisulphite or potassium metabisulphite (KMS), to reduce water activity. The osmosed slices were surface-dried and analyzed for physico-chemical characters and sensory attributes. Further, the product was stored upto six months at LT (Low Temperature) (4±1°C) and assessed for composition, stability and sensory attributes. Steam blanching of papaya slices, followed by osmosis in sugar solution of 60°B syrup containing a combination of preservatives, viz., citric acid 0.5%, $CaCl_2$ 0.5%, sodium metabisulphite 75ppm and KMS 350ppm, was superior as a treatment in terms of quality and stability of the product. These findings can help reduce post-harvest losses in papaya by providing a technology for preparing a ready-to-eat (RTE), nutrient rich intermediate-moisture product with good taste and flavour.

Key words: Papaya, preservation, Intermediate Moisture Food (IMF), quality, RTE

INTRODUCTION

Papaya ranks among the top five nutritionally beneficial fruits (alongside guava, watermelon, grapefruit and kiwifruit) among the common fruits, based on nutritional score and percentage Recommended Daily Allowance (RDA). The fruits have appreciable amounts of protein (0.42g), folate (102.12 μg), fibre (4.69g), copper (0.12mg), potassium (502.32mg), magnesium (57.96mg), pantothenic acid (0.53mg); are high in antioxidants (85.57), total carotene (2,740mg), beta carotene (888mg) and vitamin C (168.08mg) per 100g fruit (Krishna *et al*, 2008). During storage, in addition to physical loss in fruit weight, considerable losses also occur in essential nutrients notably, vitamins, minerals and compromised fruit quality. Papaya is highly perishable and is difficult to preserve in the fresh form for long periods at ambient temperature and humidity. To prevent these losses, and to better utilize the fruit, processing and value-addition is very essential.

Hurdle technology is a simple technology where a combination of preservation parameters are used at optimum levels to ensure maximum lethality of harmful microorganisms, so that damage to organoleptic properties of food is kept at a minimum. This technique was first introduced by Leistner (1992). The method is attractive, since, hurdles are used at low concentrations that do not adversely affect sensory quality of a product while maintaining stability and safety of the food item (Leistner and Gorris, 1995). The hurdle concept emphasizes complex interactions between temperature, water activity, pH, redox potential, etc. that are significant for microbial stability and safety of food (Leistner and Rodel, 1979). The present studies were made with an objective of preserving of ripe papaya slices using hurdle technology.

MATERIAL AND METHODS

Slice preparation and various hurdle treatments in papaya

Papaya fruits were procured from the orchards of ICAR-Indian Institute of Horticultural Research (IIHR), and from the neighbouring farm, Hesaraghatta, Bengaluru. Semi-ripe fruits collected of uniform-size, shape and ripeness were weighed, washed, peeled and cut into uniform sized slices, followed by steam blanching for 2 min at 60°C. The slices were then dipped in 60°Brix sugar syrup containing different preservatives or additives in the ratio of 1:2 (slices:sugar) in various treatments and placed for osmosis for 12 hours at ambient temperature (25-30°C). At the end of the osmotic process, papaya slices were separated from the osmotic solution and weighed to assess the extent of water removed by osmosis. Surface-moisture removal of the product was done with the help of a cabinet tray drier at 55-60°C for 4 hours for achieving the desired level of moisture. Moisture content in all the samples was maintained in the range of IMF (Intermediate Moisture Food) by controlled drying in the cabinet tray drier.

Various hurdle treatments imposed were: T_1 (Control - Steeping in 60°B sugar syrup + Citric acid 0.5%); T_2 (Steeping in 60°B + KMS 700ppm + Citric acid 0.5%); T_3 (Steeping in 60°B + KMS 700ppm + $CaCl_2$ 0.5% + Citric acid 0.5%); T_4 (Steeping in 60°B + $CaCl_2$ 0.5% + NaMS 150ppm + Citric acid 0.5%); T_5 (Steam blanching + Steeping in 60°B + $CaCl_2$ 0.5% + NaMS 75ppm + KMS 350ppm + Citric acid 0.5%); T_6 (Steam blanching + Steeping in 60°B + $CaCl_2$ 0.5% + Sodium benzoate 150ppm + Citric Acid 0.5%) and T_7 (Steam blanching + Steeping in 60°B + $CaCl_2$ 0.5% + Sodium benzoate 150ppm + NaMS 150ppm + Citric acid 0.5%).

Physical and biochemical analysis

Papaya pulp (10g) was placed in a hot air oven overnight and subsequently weighed at hourly intervals until no further decrease in weight occurred. For calculating the moisture content, the formula mentioned below was applied:

Moisture content (%) = $(W_1 - W_2 / W_1) \times 100$

Where,

W_1 = Initial weight, W_2 = Final weight

Water activity was measured using a water activity meter (Model: Hygrolab, Rotronic). Total ascorbic acid content in papaya samples was estimated by the volumetric method (Ranganna, 1991), carotenoid content by spectrophotometer (Model: SP-3000 Plus) at 452nm, using β-carotene as the standard (Ranganna, 1991). Total antioxidant activity was measured by the FRAP method (Benzie and Strain, 1996) .

Organoleptic evaluation

Organoleptic evaluation was done initially (after drying the sample) and, subsequently, at three and six months of storage, by a panel of eight semi-skilled judges using a hedonic rating system of 100 points (with a maximum score of 30 each for colour and texture, and 40 for flavour) (Stone and Sidel, 1985).

Statistical analysis was performed for Factorial Completely Randomized Design (FCRD). Analysis of variance (ANOVA) was conducted to arrive at significant differences between various factors.

RESULTS AND DISCUSSION

Chemical composition of the fresh papaya fruits used in the study is presented in Table 1. Ripe fruits had TSS 11.25°B, acidity 0.36% and ascorbic acid 40.2mg/100g, with total antioxidant content at 45.27mg/100g. These are in conformity with values obtained by Zaman *et al* (2006). Variation in physico-chemical and processing parameters can be attributed to varietal characteristic, seasonal conditions and level of fruit maturity. Similar observations were made by Goukh *et al* (2010), Othman (2009) and Campostrini & Glenn (2007) in papaya fruit.

Moisture content in fresh papaya samples was fairly high (86.49%) and this can support microbial growth. Therefore, various combinations of different preservatives, osmotic removal of water and blanching treatment were used for reducing moisture content. Similar conclusion was drawn by Mishra *et al* (2015).

Hurdle-processed papaya slices were analyzed for physico-chemical properties and sensory attributes at the initial stage prior to storage, and at six months of storage at (i) ambient and (ii) low temperature conditions. The best hurdle treatments were identified on the basis of retention of nutritional quality along with high organoleptic scores, apart from the product storage stability.

At the initial stage (Table 2a), moisture content

Table 1. Composition of fresh papaya fruits used in product preparation

Composition	Value
Moisture (%)	86.49
Total Solids (TS) (%)	13.51
Total Soluble Solids (TSS) (°B)	11.25
Total Titratable Acidity (%)	0.36
Ascorbic acid (mg/100g)	40.2
Reducing sugars (%)	2.21
Non-reducing sugars (%)	1.26
Total sugars (%)	3.47
Total carotenoids (mg/100g)	0.842
Total antioxidants (mg equivalent of ascorbic acid /100g)	45.27

among different treatments was in the range of 35.19 to 45.96%, with a maximum in T_6 (Steam blanching + Steeping in 60°B + $CaCl_2$ 0.5% + Sodium benzoate 150ppm + Citric acid 0.5%) and the minimum was recorded in T_1 (Control - Steeping in 60°B sugar syrup + Citric acid 0.5%) (Table 2b). In treatment T_1 (Control), 17.2% decrease was observed in moisture content, while the other treatments showed a range from 34.6 to 42.8% during the entire storage period.

Decrease in titrable acidity during storage is attributable to acid hydrolysis of polysaccharides, and non-reducing sugars to similar components, where the acid is utilized for converting these sugars to hexose sugars or complexes in presence of metal ions (Sagar and Kumar, 2006). Reduced in acidity in the segments during storage was observed in osmo-dehydrated ripe pineapple slices preserved using hurdle process (Michael, 2012). At three months of storage, T_6 (Steam blanching + Steeping in 60°B + $CaCl_2$ 0.5% + Sodium benzoate 150ppm + Citric acid 0.5%) showed maximum moisture content (47.94%) and lowest acidity (0.206%), which could be the reason of spoilage, as, effectiveness of the preservative (i.e., sodium benzoate) used in this treatment depends on the level of acidity. At the initial stage (i.e., at the onset of storage), ascorbic acid content among the different treatments imposed was in the range of 33.63 - 36.49mg/100g; But, at six months of storage, T_1 showed a 21.27% decrease in ascorbic acid content compared to that at the initial stage. The reason for this could be thermal degradation of ascorbic acid during processing, and subsequent oxidation and light reaction (Brockmann *et al*, 1998).

In comparison to other blanching treatments, T_1 (Control) with no blanching treatment showed a drastic change (from 2.88mg/100g in the initial period, to 1.48 mg/100g at six months after storage) in carotenoid content. Storage for six months resulted in a gradual decline in total antioxidant content. However, decrease was higher in Control compared to that in the hurdle-processed papaya samples. Treatments involving preservatives (KMS, NaMS, *etc.*), registered more stability in total carotenoids and antioxidant content in comparison to Control, as, these preservatives prevent oxidation reaction that leads to deterioration of the respective constituents.

Table 2. Chemical composition of hurdle-processed papaya samples

Treatment	Titratable acidity (%)	Moisture content (%)	Ascorbic acid (mg/100g)	Total carotenoids (mg/100g)	Total antioxidants (mg equivalent of ascorbic acid /100g)
(a) At the onset of storage					
T_1	0.321	35.19	36.49	2.88	41.21
T_2	0.315	36.46	35.7	2.19	38.63
T_3	0.311	37.85	34.97	2.12	32.63
T_4	0.315	36.82	35.07	2.13	37.18
T_5	0.270	41.48	34.97	2.60	40.22
T_6	0.315	45.96	33.63	2.12	33.86
T_7	0.308	44.19	33.66	2.30	34.39
F-test	*	*	*	*	*
S.E±m	0.015	0.386	0.282	0.029	0.061
CD *(P=0.05)*	0.0403	1.094	0.810	0.078	0.175

*Significant at 5%

Treatment	Titratable acidity (%)	Moisture content (%)	Ascorbic acid (mg/100g)	Total carotenoids (mg/100g)	Total antioxidants (mg /100g)
(b) At six months of storage					
T_1	0.121	17.2	15.22	1.48	12.26
T_2	0.262	34.6	34.51	3.06	26.96
T_3	0.257	36.6	32.24	1.83	26.61
T_4	0.259	34.9	30.44	1.90	27.05
T_5	0.254	41.3	32.66	2.41	34.71
T_6	-	-	-	-	-
T_7	0.260	42.8	31.13	2.23	27.87
F-test	*	*	*	*	*
S.E±m	0.008	0.421	0.264	0.032	0.052
CD *(P=0.05)*	0.022	1.194	0.749	0.091	0.146

*Significant at 5%; - : Product get spoiled before the end of 6 months

Organoleptic evaluation

Results of organoleptic evaluation are presented in Tables 3(a) & (b).

Table 3. Sensory evaluation of hurdle-processed papaya slice product

Treatment	Colour (30 marks)	Texture (30 marks)	Flavour (40 marks)	Overall acceptability (100 marks)
(a) At the initial stage (on set of storage)				
T_1	23.35	22.54	31.36	76.47
T_2	23.18	22.56	30.25	75.96
T_3	23.13	23.04	30.79	77.35
T_4	23.16	23.31	28.60	75.08
T_5	24.61	25.39	32.30	82.29
T_6	23.69	24.27	28.57	76.56
T_7	24.54	25.08	32.32	82.08
(b) At six months of storage				
T_1	9.52	7.84	11.43	28.79
T_2	19.38	17.02	22.47	58.86
T_3	20.29	18.05	23.06	61.39
T_4	20.68	20.02	23.56	64.62
T_5	21.65	21.41	25.06	68.14
T_6	-	-	-	-
T_7	21.40	21.31	24.82	67.70

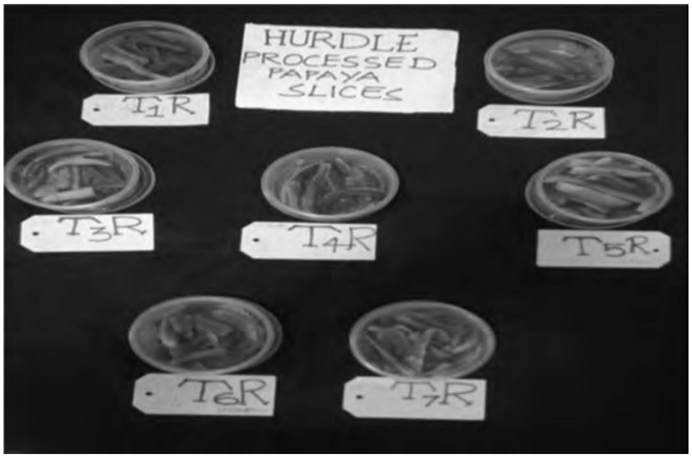

Fig 1. Hurdle-processed papaya slices at the initial stage, just prior to storage

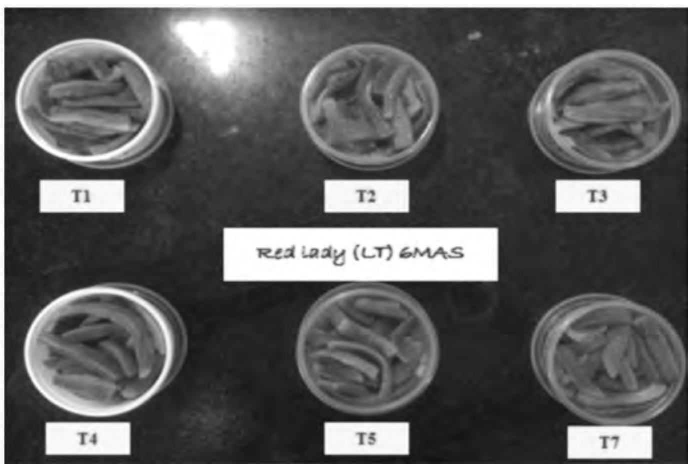

Fig 2. Hurdle-processed papaya slices at six months after storage under low temperature (4°C)

Higher score for overall acceptability was recorded in low-temperature storage in treatment T5 (82.65) upto six months of storage (68.14). These results are in conformity with findings in osmo-dehydrated ripe pineapple slices using hurdle processes (Michel, 2012), in mango powder (Hymavathi and Vijaya 2005), in mango slices (Jose *et al*, 2008), in osmo-air dehydrated pineapple fruits (Rashmi *et al*, 2005), in sun-dried sapota (Vaghani and Chundawat, 1997), in minimally processed papaya by a combination of methods (Lopez *et al*, 1994), in high hydrostatic pressure-processed mango puree (Guerrero, 2006), in minimally processed Chinese cabbage (Ahn *et al*, 2005), and, in minimally processed fruits by combined methods (Alzamora *et al*, 1995).

In conclusion, it is stated that for preparation of good quality hurdle-processed papaya slices with stability and higher organoleptic scores, a treatment combination consisting of steam blanching + steeping in 60°B sugar syrup + $CaCl_2$ 0.5% + NaMS 75ppm + KMS 350ppm + citric acid 0.5%), followed by a combination of steam blanching + steeping in 60°B sugar syrup + $CaCl_2$ 0.5% + sodium benzoate 150ppm + NaMs 150ppm + citric acid 0.5%) produced good results. In these hurdle combinations, even though a lower concentration of preservatives was used, inclusion of blanching in the methodology retained good colour, quality and stability in the product. Apart from preservation of slices, these combinations helped obtain fresh fruit like quality in the product as, moisture could be maintained in the range prescribed for IMF (Intermediate Moisture Foods).

ACKNOWLEDGEMENT

The authors are grateful to the erstwhile and present Directors, and Heads of PHT Division, ICAR-Indian Institute of Horticulture for providing facilities to carry out this work.

REFERENCES

Ahn, H.J., Kim, J.H., Kim, J.K., Kim, D.H., Yook, H.S. and Byun, M.W. 2005. Combined effects of irradiation and modified atmosphere packaging on minimally processed Chinese cabbage (*Brassica rapa* L.). *Food Chem.*, **89**(4):589-597

Alzamora, S.M., Cerrutti, P., Guerrero, S. and Lopez-malo, A. 1995. Minimally processed fruits by combined methods. In: Food Preservation by Moisture Control, Barbosa-Canovas, G.V. and Welti-Chanes (eds), Technomic Publishing Inc., Lancaster, USA, pp. 463-492

Benzie, I.F.F. and strain, J.J. 1996. Ferric reducing ability of plasma (FRAP) as a measure of anti-oxidant power: The FRAPP assay. *Analytical Biochem.*, **239**:70-76

Brockmann, M.C. 1998. Food dehydration. Van arsdel W.B., Copley, M.J., Morgan, A.I. Jr. (eds.). The AVI Publishing Co. Inc., Westpot, Connecticut, USA, **2**:489

Campostrini, E. and Glenn, D.M. 2007. Ecophysiology of papaya: a review. *Braz. J. Pl. Physiol.*, **19**(4):413-424

Goukh, A.A.A., Shattir, A.E.T. and Mahdi, E.F.M. 2010. Physico-chemical changes during growth and development of papaya fruit. II: Chemical changes. *Agri. Biol. J. N. Am.*, **1**(5):871-877

Guerrero, B.J.A., Barbosa, C.G.V., Moraga, B.G. and Moraga, B.M.J. 2006. Effect of pH and ascorbic acid on high hydrostatic pressure-processed mango puree.

J. Food Proc. Pres., **30**:582-596

Hymavathi, T.V. and Vijaya, K.V. 2005. Carotene, ascorbic acid and sugar content of vacuum dehydrated ripe mango powders stored in flexible packaging material. *J. Food Composition & Analysis*, **18**(1-2):51-59

Jose, A.U., Hector, E. and Lourdes, D. 2008. Colour behaviour in mango (*Mangifera indica*) slices self-stabilized in glass jars by hurdle technology during storage. *African J. Biotechnol.*, **7**(4):487-494

Krishna, K.L., Paridhavi, M. and Patel, J.A. 2008. Review on nutritional, medicinal and pharmacological properties of papaya (*Carica papaya* Linn.). *Nat. Product Radiance*, **7**(4):364-373

Leistner, L. 1992. Food preservation by combined methods. *Food Res. Int'l.*,**25**:151

Leistner, L. and Gorris, L.G.M. 1995. Food preservation by hurdle technology. *Trends in Food Sci. Technol.,* **6**:41-46

Leistner, L. and Rodel, W. 1979. Microbiology of intermediate moisture foods. In: Procs. Int'l. Meeting on food Microbiology and Technology. Jarvis, B., Christian, J.H.B. and H.D. Michener. (eds.). Medicina Viva Servizio Congress, Prama, Itlay, p. 35

Lopez, M.A.E., Palou, E., Welti, J., Corte, P. and Argaiz, A. 1994. Shelf-stable high moisture papaya minimally processed by combined methods. *Food Res. Int'l.,* **27**:545-553

Michael, J. 2012. Standardization of preservation of osmo-dehydrated ripe pineapple slices by using hurdle processes. M.Sc. (Hort.) thesis, University of Agricultural Sciences, Bengaluru, India.

Mishra, B.B., Gautam, S., Chander, R. and Sharma, A. 2015. Characterization of nutritional, organoleptic and functional properties of intermediate-moisture shelf stable ready-to-eat *Carica papaya* cubes. *Food Biosci.*, **10:**69-79

Ranganna, S. 1991. Manual of analysis of fruit and vegetable products. (2nd edn.), Tata McGraw Hill Publication. Co. Ltd., New Delhi, India, p. 1112

Sagar, V.R. and Kumar, R. 2006. Preparation and storage of ready-to-eat dehydrated gooseberry (*aonla*) shreds. *J. Food Sci. Technol.*, **43**(4):349-352

(MS Received 07 October 2015, Revised 05 May 2016, Accepted 19 May 2016)