Effect of Hurdle Technology on the Quality and Stability of Minimally Processed Papaya

Ankita
M.Tech Food Tech.(Food Safety& Standards), Sam Higginbottom Institute of Agricultural Engineering and Technology

Singh Rongen
Assistant Professor, Department of Food Process Engineering, Vaugh School of Agricultural Engineering and Technology, Sam Higginbottom Institute of Agricultural Engineering and Technology, Allahabad-211007

Nayansi
M.Tech Food Tech. (Food Quality Management), Sam Higginbottom Institute of Agricultural Engineering and Technology

ABSTRACT
The present investigation aimed to study the combined effect of blanching, osmotic dehydration and preservatives on the quality and stability of minimally processed papaya. Osmotic dehydration of Papaya using sucrose solution at mild temperature (25°C) was investigated. Different sucrose solution (50%, 55%, 60%, 65% and 70% w/v) were employed for osmotic dehydration process. Physico-chemical analysis (TSS, water activity and ascorbic acid) and microbial quality along with a sensory analysis were measured at regular intervals throughout the storage period. During storage for 30 days, a decrease in water activity, ascorbic acid (g/kg), firmness (N), color (L* value) and sensory characteristics was observed. From the results it were revealed that the papaya slices obtained showed a good overall acceptability upto 30 days of storage at refrigerated temperature.

1. INTRODUCTION
Papaya (Carica papaya L.), one of the most important fruit crops of the world (Ali et al., 2011), is a climacteric tropical fruit and is known to have a very short postharvest life due to the loss of weight, rapid pulp softening and the presence of microbial growth (Fabi et al., 2007; Gonzalez-Aguilar et al., 2009). It is a good source of vitamin A, lycopene, polysaccharides and proteins. Preparation of fresh-cut fruit and vegetable causes increase in respiration rates and ethylene production rates. It also induces synthesis of secondary metabolites, membrane disruption and activation of defence mechanisms (Brecht et al., 2004). Hence, fresh-cut produce is extremely perishable and even more susceptible to spoilage than intact fresh produce. Minimally processed fresh-cut papaya provides convenience, uniqueness and nutritional quality which could create marketing opportunities (Wall et al., 2010).

Osmotic dehydration, a technique used to produce high moisture products, involves immersing pieces of food in a hypertonic solution allowing the adjustment of the physico-chemical properties of food by reducing water content and incorporating simultaneously ingredients or additives with antioxidant or other preservative properties into the food. This process promotes stabilization of colour parameters, reducing non-enzymatic browning reactions and often improves fruit product colour (Krokida, Karathanos, & Maroulis, 2000).

Three basic problems confront the extension of shelf life of fresh cut fruits and vegetable products. First is the intermixing of polyphenol oxidase with phenolics due to peeling and cutting which undergo enzymatic browning to produce an undesirable brown color and second tissue wounding induces a high respiration rate which triggers faster tissue deterioration and third is the faster growth of microorganisms.

The shelf life of peeled, sliced and polyethylene packed papaya slices when stored at room when kept at 8-10°C, do not stay more than 8-10 days. Therefore, many alternate approaches were followed for papaya preservation. The blanching treatment for microbial reduction and browning inhibition affects freshness and taste. Cut papaya undergoes enzymatic browning which can be inhibited by dipping in sodium bisulphite solution. Citric acid is used to reduced the pH content. Restaino et al. (1982) reported that citric acid increases the inhibitory properties of potassium sorbate at pH 5.5 against several common deteriorative microorganisms. Huhtanen et al. (1983) reported an increase of inhibitory properties of potassium sorbate against Clostridium botulinum in the presence of this acid.

The objective of this work was to develop a shelf stable high moisture papaya by hurdle technology and to increases the shelf-life of the product. This process is based on mild heat treatment (blanching), osmotic dehydration and the use of preservatives which helps in slight reduction of aw, a decrease in pH.

2. MATERIAL AND METHOD
2.1 Sample preparation
Fresh quality papaya were chosen from the local market of Allahabad for the preparation of minimally processed papaya. Fruit was washed to remove dirt and surface microflora to prevent contamination during preparation of minimally processed papaya. Washed papaya was peeled, cut into slices of equal sizes using a knife. The papaya slices were blanched with hot water for 1-2 min. Osmotic solution was prepared using commercial grade sucrose and distilled water. Syrup were prepared at concentrations (50%, 55%, 60%, 65%, and 70% w/v). Three different preservatives were added in the syrup: Citric acid added at different level of (3%, 4%, 5%, 6%, 7%), Potassium sorbate added at concentration of (900, 950, 1000, 1050, 1100 ppm) and sodium bisulphite added at different concentration of (50,100,150,200,250 ppm). TSS was measured by using hand refractometer. The blanched fruit pieces was immersed in sucrrose solution in the ratio of 1:10 at different concentration. Osmotic dehydration was carried up to 10 days at ambient temperature (25°C). Then the samples removed from the syrup and rinsed quickly with distilled water to eliminate the solution from the surface and carefully blotted with tissue paper to remove the excess surface water. Finally prepared papaya slices were packed in polyethylene (HDPE) and stored at refrigerated temperature.

2.2 Physico-chemical analysis
The weight and moisture content of samples before and after the osmotic process were determined and used to calculate the variables water loss (WL), weight reduction (WR) and solid gain (SG) of minimally processed papaya. Water Activity
can be measured by using a water activity meter. Total soluble solids (TSS), and ascorbic acid content were determined by (Ranganna, 1986) The surface color of the Papaya was measured by using a colorimeter (XY COLOUR LAB) Color was expressed as the CIE: L*: a*: b*: uniform color space, where L* indicates lightness, a* corresponds to chromaticity on a green (-) to red (+) axis and b* the coloration on a blue (-) to yellow (+) axis (Francis 1980). Firmness of Papaya was measured by using a texture analyzer.

For microbiological assessments, samples were examined for total plate count (TPC), Yeast and Mold count (Y&M), and total coliforms and Salmonella as as per the procedure described by Vanderzant and Splitstoesser (1992). All the counts were done in triplicate and the results were reported as log cfu/g.

2.3 Sensory analysis
A panel of semi-trained panelists assessed sensory attributes according to general appearance, color, flavor, texture and overall acceptability on a 9-point hedonic scale

2.4 Statistical analysis
Statistical analysis was done on the data by analysis of variance (ANOVA) on Surface Response Methodology. RSM were used for multivariative variance analysis test at (p<0.05). Whenever ANOVA indicated a significant, a pair-wise comparison of means by least significance difference (LSD) was carried out.

3. RESULT AND DISCUSSION
3.1 Effect of sucrose concentration on weight reduction, solid gain and water loss.
In minimally processed papaya the percentage of weight reduction and water loss increases with increase in sucrose concentration. The maximum weight reduction and water loss percentage was found to be 34.10% and 45.97% in treatment T5 (70 ° brix) and minimum percentage found to be 18.11% and 28.37% in treatment T1 (50 brix). The water loss was favored by higher solution concentrations, due to the increase of the osmotic gradient between the food material and the osmotic solution. The presence of a large amount of solute causes a higher osmotic pressure that makes the WL easier. These results corroborate those obtained by Ito et al. (2007) in the PVOD of cantaloupe cylinders and mango slices.

But in sugar gain the maximum percentage found to be 9.26% in T1 (50 brix) and minimum percentage found to be 6.56% in treatment T5 (70 ° brix). The concentrated solutions may have promoted the formation of a dense layer of solutes at the surface of the osmohydrated papaya. This layer acts as a barrier against penetration of the solutes into the food and makes solutes mass transfer more difficult, which results in a lower solids uptake in fruits tissue. Diluted solutions penetrate better into the fruit tissue than concentrated solution. With increased sugar concentration, the osmotic solution becomes more viscous, that makes the solutes penetration more difficult. Similar behavior was also observed by Mastrantonio et al. (2005).

3.2 Water activity
The water activity of control sample (fresh fruit) was found to be 0.996 which is higher than treated sample. Water activity of treated sample reduced due to osmotic dehydration of papaya at different sucrose concentration. It can be concluded that the value of water activity (aw) decreases with increase in sugar concentration. Since the sucrose hydrolysis reduced the water activity aw more than the desired, which was an additional safety factor for the preservation of minimally processed papaya. Reducing the water activity of samples also decreases the non-enzymatic browning reaction (Krokida et al., 2000). But during storage there is slight increase in the value of water activity.

3.3 Ascorbic Acid
In fresh fruit Ascorbic Acid content (mg/100g) is 56.4 which is reduced to 34.2. From the result it can be concluded that the major ascorbic loss in minimally processed papaya occur during processing and first month of storage. It can be observed that the vitamin losses was not only due to degradation reaction but also diffusion in syrup. These findings were similar to Alzamora et al., (1989). During storage ascorbic acid content decreases in large amount. There is no effect of ascorbic acid loss at different sugar concentration.

3.4 Colour Analysis
Color is an attribute of food quality which initially being judged by a consumer at the point of purchasing food products. Loss of color during osmotic dehydration process is one of the most significant changes (Osorio et al., 2007). Initially the value Lightness(L*), redness (a*), yellowness (b*) of fresh cut papaya were 44.20, 14.47, and 26.6 respectively. The maximum value of lightness (L*) for papaya was found to be 57.70 in treatment T1 (50 brix) and minimum value were found to be 47.21 in T5 (70 brix) and during storage lightness decreases upto 30 days of storage. The a* value also decrease as the sucrose concentration increases. The b* value of papaya increases from T1 to T5 ranged from 27.12 to 30.43. So it was concluded that an increase in yellowness (b*) coordinate and a decrease in lightness (L*) and redness (a*) was achieved as the sucrose concentration increased. Higher decreases in L* values of non-treated sample (control sample) compared to treated sample showed that blanching, osmotic dehydration, chemical treatments the combined effect preserved the natural color of the minimally processed papaya during storage. The a* value, which indicates redness when positive or greenness when negative, also showed a decreasing trend during storage. A significant reduction of the b* value, yellowness when positive or blueness when negative, was also observed during storage. During storage chroma value decreases and hue angle increases. Findings of present investigation were in close conformity with values described by (Waghmare and Annapure 2013). The decrease in L value for Papaya may be attributed to brown pigment formation during processing due to high levels of reducing sugars and air loss of osmohydrated papaya (Moreno et al., 2000). Generally, “L*” and “a*” parameters are well correlated to browning reaction. Enzymatic and non-enzymatic reactions are the most important reason of browning development in fruits and vegetables during dehydration. This reduction of lightness values could also be attributed to the shrinkage of plant tissue which leads to increase in samples opacity. The changes of redness and yellowness are clear and seem to be relevant to alteration of fruit pigments and solids uptake (Falade and Igbela, 2007).

Fig.3 Graph of Lightness for minimally processed papaya packed in HDPE stored at 4°C. To (control sample-fresh fruit), T1 (Treatment consists of 50° brix solution)
Initial microbial load of fresh papaya was found to be 5.6 cfu/gm. Microbial load increases up to 30 days of storage. Yeast and mould count were found in T1 which contain 2.44 cfu/gm and minimum were found in T5 which contain 1.90 cfu/gm. From the table it can be observed that total plate count and yeast and mould count was found to be less than 10 cfu/gm in papaya slices. The results obtained were comparable with the results of reported by Lopez-Malo et al. (1994). No coliforms and salmonella were detected in any of the samples during the whole storage period. It was concluded that the combined effect of blanching, osmotic dehydration and the use of chemical preservatives decreased the microbial load up to 30 days of storage at refrigerated temperature. It indicating that the selected condition were capable of assuring the microbial stability of the product.

3.7 Sensory Analysis
Changes in sensory attributes such as color, flavor, texture and overall acceptability of minimally processed papaya influenced by various treatments were evaluated during storage for 30 days. Color scores for papaya decreased during storage. The loss of color scores was due to the development of browning in minimally processed papaya. This can be confirmed by decrease in L* value of the papaya. Appearance and texture scores were also found to decrease during 30 days of storage. It could be observed that overall acceptability of sample is found to be acceptable. But overall acceptability are goes decreasing with no. of days increasing during the storage. In conclusion, the shelf-life was based on the score of overall acceptability and the combined application of blanching, osmotic dehydration and preservatives result in successful storage of minimally processed papaya for 30 days with little loss of sensory quality.

CONCLUSION
In current research Papaya can be minimally processed by hurdle technology and their shelf life can be extended by the combined effect of blanching, osmotic dehydration and the use of preservatives which can be packed in polyethylene (HDPE). From the results it was revealed that the higher values of solution concentration resulted in higher flow of water and solids and loss of weight through the Papaya slices. Microbiological study showed the acceptable level for TPC, yeast & mold, growth to all dilutions. Coliform and Salmonella were not detected in any of the sample during storage. From color measurement it was showed that an increase in yellowness (b*) coordinate and a decrease in lightness (L*) and redness (a*) was achieved as the sucrose concentration increased. Finally, from texture analysis it was found that osmo-sed samples were considerably softer than untreated samples and force increases as sugar concentration increases. A shelf life of 30 days is observed, which was microbiologically and organoleptically stable at refrigerated temperature.

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