Active Packaging of Guava

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Abstract—*Shelf life of Guava (Psidiumguajava L.) under active packaging was studied based on different types of packaging materials (LDPE, HDPE, PP with thickness of 40 micron) and different scavengers incorporated into it. Sachets of different scavengers (5 g each) namely $KMNO_4$ (for absorption of ethylene), Charcoal (for absorption of CO_2) and Iron Powder (for absorption of oxygen) were prepared and were incorporated with guava samples packed in different packaging material films to form the desired samples which were stored at $8\pm2^{O}C$. Different parameters namely total soluble solids (TSS), titrable acidity (TA), pulp to peel ratio, % weight loss (PLW%), bacterial count and color (L,a,b) values were calculated for every samples on weekly basis and were compared with the control samples. The change in values of different parameters with those of the control samples showed the effectiveness of different combination of packaging material and scavenger used . On the basis of experiments conducted and data analysed, the samples packed with PP and incorporated with ethylene scavenger showed the best results of their properties within five weeks of analysis whereas samples packed with LDPE and incorporated with charcoal scavenger showed the worst results. Among the PP samples incorporated with different scavengers, ones packed with $KMnO_4$ showed the best results followed by iron powder and charcoal respectively. All the samples showed better results as compared to theirrespective control samples. Thus the shelf life of guava could be enhanced for five weeks using PP films as packaging material and incorporating them with ethylene scavenger.*

1. INTRODUCTION

Guava (Psidiumguajava) is a popular tropical fruit cultivated in many tropical and subtropical regions of the world probably originated in the central America. Its adaptability into ranging environments makes it a favourite commercial crop all over the world. India is the leading producer of guava with approximately 40% of guava production of the world and this is the fourth most important fruit in India which occupies approximately 6.5% of the area under fruit cultivation. The different storage techniques and postharvest treatments to increase shelf-life of guava have been studied and recommendations are available for different cultivators. Guava stored under ambient conditions can be kept firm for about 2-3 weeks, which is considered adequate for domestic marketing. However, for export to distant markets, the existing technology will need to be upgraded to improve the shelf-life. Recent advances in post harvest technology have been introduced which helps in minimising losses and increasing fruit availability with acceptable quality. Low temperature storage alone has been found to be insufficient in controlling postharvest losses. This may lead to physiological disorders like chilling injuries, fruit decay, postharvest peel pitting, change in fruit texture and unacceptability towards sensory attributes. Keeping all the points in view it was concluded that there is a need of enhancing the shelf-life of guava and reducing the post harvest losses. Thus, active packaging may be a suitable method for storing guava for longer periods. Active packaging refers to the incorporation of certain additives into packaging film or within packaging containers with the aim of maintaining and extending product shelf life while maintaining the quality of the packaged food. The principles behind active packaging are based either on the intrinsic properties of the polymer used as packaging material itself or on the introduction of specific substances inside the polymer. This technology continuously modify the gas environment (and may interact with the surface of the food) by absorbing gases from package. Some of the polymers currently used for packaging include PVC, BOPP, LDPE, HDPE, HM-HDPE laminates and PP.

Roody et al. (2003) carried out the active packaging (AP) treatments (ethylene, moisture, oxygen and carbon dioxide scavengers along with an antimicrobial chitosan coating) on whole banana fruits stored at room (30±2ºC) as well as refrigeration (5±1ºC) temperatures for 9 and 15 days respectively. The fruits were analyzed for physico chemical parameters such as weight loss (%), moisture content (%), titratable acidity (%citric acid), ascorbic acid (mg/100g), O2 (%) and CO2 (%), C2H4 (µ/h/kg).

Singh and K Giri(2006) conducted a study on shelf-life of Guava under active packaging based on produce, film and system parameters such as respiration rate of produce, film permeability and in-pack environmental conditions.Most of the physico-chemical and textural properties of guava fruits during storage were affected by incorporation of ethylene absorbent in a dependent manner.The reduced changes in fruit firmness, total soluble content (TSS), titratable acidity (TA) and color showed the effectiveness of use of absorbent sachets in extending shelf life of guava fruit.

Reddy (2008) conducted a research on studying the physiochemical characterstics of Guava in which the samples showed an increasing TSS content with time. An increasing trend in TSS of guava squash was observed during storage period of 180 days. Swamy et al. (2011) studied to produce a stable and organoleptically preferred guava squash with proper suspension of fruit pulp.

Sahoo and Panda (2014) assessed the effect of active packaging techniques and storage environment for maintaining quality and shelf life of guava. Changes in headspace gases, PLW, ascorbic acid, texture, colour and subjective quality were evaluated.Active packaging in PP with pin holes was found to be the best followed by vacuum pack with PP in cold condition and could be used to store for 28 and 24 days with desirable texture, color, ascorbic acid and marketability. It is also inferred that under ambient conditions guava could be stored for 4 days using LDPE and PP with pin holes.

2. MATERIALS AND METHODS:

2.1 Raw Materials: Freshly harvested guavas of unknown variety were procured from the local market of Rudrapur, Uttarakhand, India. Fruits were washed thoroughly in water and were packed in different packaging materials along with different scavengers for storage.

2.2 Experimental Plan: Various dependent parameters were calculated for different independent parameters(scavangers and packaging material).Three packaging material namely Low Density Poly-ethylene(LDPE), High Density Poly-ethylene(HDPE) and Poly-Propylene(PP) were used. The three scavengers used were $KMnO_4$, Charcoal and Iron Powder for absorption of ethylene, carbon-di-oxide and oxygen respectively.

Weekly analysis of 27 samples (stored at 10^0C) was done comprising of following combinations:NineHDPE samples (with three charcoal scavenger, three KMnO4 scavenger and three iron powder scavenger).Nine LDPE samples (with three charcoal scavenger, three KMnO4 scavenger and three iron powder scavenger).Nine PP samples (with three charcoal scavenger, three KMnO4 scavenger and three iron powder scavenger).The control samples were stored with and without the packaging materials seperately at10^0C and with and without the packaging materials separately at ambient condition.

The dependent parameters calculated were percentage weight loss[PLW(%)], total soluble solids (TSS in obrix), titrable acidity (%citric acid), pulp to peel ratio, bacterial count and color (L, a, b values).

2.3 Experimental Procedure: During the storage studies, all the samples of guava were evaluated for their quality. Methodology used for calculating the quality parameters are:

2.3.1 Physiological loss in weight: It was measured by Electronic weighing machine. Sample of guava was taken out from the package and weighted one by one. PLW(%) was calculated as:

$$PLW(\%) = \frac{initial\ weight - final\ weight}{initial\ weight} \times 100$$

2.3.2 Bacterial count: One ml of guava juice sample was withdrawn from each flask of sample juice and diluted with nine ml of distilled water, which was 10^{-1} dilution. In the same way, dilution series up to 10^{-5} dilution level were prepared. One ml sample from 10^{-1} to 10^{-5} dilution level was inoculated into five different Petri-plates and Nutrient agar media was poured over the samples and mixed thoroughly by rotating clockwise and anticlockwise several times. The plates were later incubated at 30°C. After 48- 72 hours, number of colonies on each plate were observed, counted and expressed as cfu/ml of fermenting liquor. Each petri plate was divided into four equal parts and then the colonies were counted in a single part and then multiplied by four, this gives the total number of colonies in a single petri plate. The formula applied for calculating the total plate count is as follows:

$$\text{Colony forming unit (cfu/ml)} = \frac{no.of\ colonies \times dilution\ factor}{aliquot\ sample}$$

2.3.3 Pulp to peel ratio: Guava is peeled properly with knife and weight of the peel measured through electronic balance. Weight of the pulp is calculated by subtracting the total peel weight from the total guava weight. Ratio is taken out from calculated values of pulp and peel weight.

2.3.4 Total soluble solids (TSS):TSS content of a guava pulp is measured using a refractometer and is expressed in °brix. First of all, the refractometer surface was cleaned and dried properly. A drop of fresh fruit pulp was put on the prism of the refractometer and while pointing the direction of the prism in good light and looking through the eye piece the readings were recorded in obrix where the base of the blue color sat on the scale.

2.3.5 Total color change: Color of the sample was determined by combination of digital camera, computer and graphics software. The pixel value tool present in Adobe Photoshop software was positioned to 100 pixel for determining respective L, a, b values. The L*, a* and b* values are calculated for determination of the color of guava, where,

L* is the luminance of lightness component (0-100), a* from green to red (-120 to +120), b* from blue to yellow (-120 to + 120). Adobe photoshop 7.0 is used to obtain colour parameters L*, a*, b*. To convert lightness L, a, and b values obtained from Histogram window to L*, a*, b* following formula were used.

$L^* = L/250 \times 100$,$a^* = (240a/255)-120$, $b^* = (240b/255)-120$

Finally, the total color change is calculated as follows:

$$\text{Total color change } (\Delta t) = \sqrt{(L^*)^2 + (a^*)^2 + (b^*)^2}$$

2.3.6 Titrable acidity: The method for calculating the titrable acidity (%citric acid) is determined as follows

(a)10ml of fresh juice was drawn out using a clean and dry 10 ml pipette and was discharged into a 250ml beaker (Appendix

A). Using another clean and dry pipette, distilled water was added to the juice in the beaker to make the volume 100 ml.

(b) Few drops of 1% phenolphthalein indicator were added to the juice/water solution in the beaker using a dropping pipette.

(c) 0.1N solution of NaOH was poured into the burette using a funnel until it reaches the zero mark.

(d) Slowly the NaOH solution was titrated into the juice/water solution (with a 25ml burette or an automatic burette).

(e) When the juice in the beaker turned light pink in color, burette was shut down and reading was noted down. Total amount of NaOH used up was calculated.

Titrable acidity was calculated as

$$\text{Titrable acidity} = \frac{normality\ of\ alkali \times titre \times equivalent\ weight\ of\ citric\ acid \times volume\ made\ up \times 100}{volume\ of\ sample\ taken \times weight\ of\ volume\ of\ sample \times 1000}$$

3. RESULTS AND DISCUSSION

The present investigation deals with the enhancement of shelf-life of guava using the concept of active packaging. Designed experiments were done for enhancing the shelf-life of guava. The effect of scavenger and packaging material on different parameters, i.e., PLW(%), pulp to peel ratio, titrable acidity(%citric acid), bacterial count, TSS, color change were studied. Weight loss was measured in percentage, TSS in °brix and microbial count in cfu/ml.

3.1 Variation of pulp to peel ratio with storage period: During the ripening process, the peel layer becomes relatively thinner and hence the ratio shows an increasing trend with storage period[13]**.** During the analysis period the guava sample packed in PP packets showed the minimum value for pulp to peel ratio whereas, LDPE packets showed the maximum value. The pulp to peel ratio continuously increased with storage time in all the samples. After the study of four weeks PP samples incorporated with iron powder showed the best results with the mean pulp to peel ratio of 9.8 whereas, sample packed with LDPE incorporated with $KMnO_4$ showed the worst result with the mean of 12.63.

3.2 Variation of TSS with storage period: It was observed that the total soluble solids (TSS) showed an increasing trend for all the samples. The increase in the TSS value is generally attributed to the fact that during the ripening process, water is removed and the conversion of polysaccharides into reducing sugars enhances the sugar content of the fruit. Hydrolysis of polysaccharides like starch, cellulose and pectin substance into simpler substances results in increase of total soluble solids [9]. TSS in all the samples was found to be maximum in LDPE samples and minimum in PP samples. The TSS continuously increased with storage time in all the samples. After the study of four weeks PP samples incorporated with $KMnO_4$ showed the best results with the mean value of 8.15 whereas, the sample packed with LDPE incorporated with charcoal showed the worst result with the mean of 8.66.

3.3 Variation of titrableacidity(percentage citric acid) with storage period: In our experiment, a declining trend of titrable acidity(% citric acid) was observed during the storage period in all the combinations of packaging material and scavenger. This generally happens because during the ripening process, the acid is utilised for the conversion of polysaccharides present in the fruit into reducing sugar. Thus, all the acid is used up for the conversion process and acidity decreases.Acidity of guava squash witnessed a decreasing trend during storage period. This might be attributed to utilization of acid for hydrolysis of polysaccharides and non-reducing sugars to convert them to hexose sugars (reducing sugars) or complexing in the presence of metal ions. The declining trend might also be due to chemical interaction among the chemical constituents of juice induced by temperature influencing enzymatic action [3]**.** Degree of reduction in acidity is dependent on concentration of sugar and is a general phenomenon during storage of beverages in the presence of sugars [7].During the analysis period, the guava samples packed in PP and incorporated with iron powder scavenger showed the maximum value for titrable acidity (% citric acid) wheras, the sample packed in LDPE and incorporated with iron powder scavenger showed the minimum value. For the charcoal scavenger as well as $KMnO_4$ scavengerthe guava samples packed in PP showed the minimum titrable acidity (% citric acid) whereas, LDPE samples showed the maximum value. For control samples, the samples packed in PP showed the minimum value throughout the period whereas the samples packed in HM-HDPE and LDPE showed non-uniform behavior.The titrable acidity continuously decreased with storage time in all the samples. After the study of four weeks PP samples incorporated with Iron powder showed the best results with the mean value of 0.67 whereas, the sample packed with LDPE incorporated with $KMnO_4$ showed the worst result with the mean of 0.51.

3.4 Variation of physiological loss in weight percentage with storage period: In our experiment, samples generally showed an increasing trend in PLW(%). This happens because the fruit loses its moisture content and hence the weight of the fruit decreases.The PLW(%) was found to inhibit maximum value for guava samples packed in LDPE whereas, minimum value of PLW(%) was found in PP samples throughout the analysis period for all the scavengers. The same trend of PLW(%) was found in control samples also.The PLW(%) continuously increased with storage time in all the samples. After the study of four weeks PP samples incorporated with $KMnO_4$ showed the best results with the mean value of 2.855 whereas, the sample packed with LDPE incorporated with charcoal showed the worst result with the mean of 5.13.

3.5 Variation of total color change with storage period: At the time of packing of guava, they were green in color but with storage there was a significant color change in each sample. The L*, a* and b* values were calculated for determination of the color of guava and hence the total color change was calculated.During the experimentation work, for iron powder and $KMnO_4$ scavenger, the guava samples packed in LDPE showed a greater value of total color change in comparisionto that of samples packed in HDPE and PP. A similar behavior of total color change was found in control samples as well. The samples incorporated with charcoal scavengers and packed in HDPE as well as LDPE showed almost similar value of total color change which was found to be greater than that of PP. The total color change continuously increased with storage time in all the samples. After the study of four weeks PP samples incorporated with $KMnO_4$ showed the best results with the mean value of 58.815 whereas, the sample packed with LDPE incorporated with $KMnO_4$ showed the worst result with the mean of 69.85.

3.6 Variation of bacterial count with storage period: Bacterial count calculated for each sample showed an increasing trend with storage time. It is because as soon as fruits are cut from their natural supply of nutrients, their quality begins to diminish due to a natural decomposition that starts as soon as biological cycle is interrupted by harvesting.For all the scavengers, the guava samples packed in LDPE showed the maximum value of bacterial count throughout the analysis period. The control samples showed the similar behavior as well throughout the analysis period. The guava samples packed in HDPE showed a greater value of bacterial count as compared to that of PP samples for all the scavengers during the entire analysis period.The bacterial count continuously increased with storage time in all the samples. After the study of four weeks PP samples incorporated with $KMnO_4$ showed the best results with the mean value of 110 whereas, the sample packed with LDPE incorporated with charcoal showed the worst result with the mean of 203.

3.7 Sensory evaluation: At the end of four weeks, a panel of ten members carried out the sensory evaluation test for all the guava samples left with us. We altogether did the evaluation using the most reliable **Hedonic scaletest** which is the most efficient method to score the samples on the basis of taste, texture, appearance, and smell. Of all scales and tests methods, the nine-point hedonic scale occupies a unique niche in terms of its general applicability to the measurement of product acceptance– preference. Each panelist was served the samples and provided with the **hedonic scale scoring sheet** for each sample. The panelist's task is to circle the term that best represents their attitude about the product. The responses are converted to numerical values for computational purposes: like extremely, 9; dislike extremely, 1.

3.7.1 Sensory evaluation test results: The score for sensory evaluation varied from 27 to 60. Polypropylene samples were found to score the highest points on **Hedonic scale.** The control samples scored the least rating with LDPE scoring the lowest points. Polypropylene samples incorporated with $KMnO_4$ scavenger scored the highest 60 points with a rating of 6.00 (like slightly) which indicates its effectiveness with respect to taste, smell, color, texture, etc. Also, the LDPE samples put under 10°C showed the lowest rating when compared with polypropylene and HDPE. Thus, through sensory analysis of samples, it can be inferred easily that polypropylene is the best packaging material with $KMnO_4$ as a scavenger used for enhancing the shelf-life of guava and retaining its physio-chemical properties.

4. CONCLUSION

On the basis of experiment conducted and data analysed, it can be concluded that when the three scavenger and packaging material are compared by viewing their affect on various parameters of guava, PP samples (incorporated with ethylene scavenger) showed the best results of their properties within five weeks of analysis whereas LDPE samples (incorporated with charcoal scavenger) showed the worst affect. Among the PP samples incorporated with three scavengers, ones packed with $KMnO_4$ showed the best results followed by iron powder and charcoal respectively.The control samples kept without any scavenger at 10°C were analyzed for four weeks as compared with the five weeks analysis of the other samples. These samples showed comparatively better results of dependent variables when compared with the control samples at ambient conditions. Thus, the importance of scavenger was clearly specified by the analysis of guava samples.Thus, the shelf- life of guava could be enhanced for five weeks using polypropylene as the packaging material. Ethylene scavenger is the best means for maintaining the quality and enhancing the shelf-life of guava.

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