**Packaging and storage techniques to enhance the shelf life of sweet lovi-lovi (*Flacourtia* spp.) fruits**

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**Abstract**: Sweet lovi-lovi (*Flacourtia* spp.), which is a less utilized plant species in Kerala belonging to *Flacourtiaceae* family bears sweet, red fruits but with a very short shelf life of few hours. In this study an attempt is being made to enhance the storability of sweet lovi-lovi fruits by packaging in different containers and storage at ambient, refrigerated and cold storage conditions. Sweet lovi-lovi accession maintained at College of Horticulture, KAU was utilized for the study. The packaging of fruits in polythene cover of 200 gauge without ventilation and shrink wrapped areca plates placed in cold storage condition at 12 ± 2°C temperature found to increase the shelf life by three days. Browning of fruits due to phenolic oxidation was also reduced significantly under refrigerated storage of fruits in polythene cover of 200 gauge without ventilationat a temperature of 5 ± 2°C.

**INTRODUCTION**

Lovi-lovi (*Flacourtia* spp.), is an underexploited crop seen in Kerala homesteads, bearing red fruits with high nutritional potential. Lovi-lovi belonging to *Flacourtiaceae*family is of sweet and sour types. Sour type *Flacourtiainermis*is ofcommon occurrence and sweet types belonging to different species like *Flacourtiacataphracta*, *Flacourtiamontana* and *Flacourtiajangomas*are rarely seen*.* Thetrees of sweet lovi-lovi are of spreading nature with sharp spines all over the trunk and it limits the cultivation of the crop to a certain extent. Fruits of sweet lovi-loviare non - climacteric in nature with very short post harvest life.Fruits deteriorate rapidly within hours of harvest by means of browning, loss of firmness followed by microbial infestation. The shorter shelf life is also related to the pedicel length which is less or practically nil. Hence an attempt is made to enhance the shelf life, consumer acceptance and marketability of sweet lovi-lovi fruits by packaging in convenient containers and storing under suitable conditions.

**MATERIALS AND METHODS**

The present investigation was conducted in the year 2016-2017at the Department of Processing Technology,College of Horticulture, Kerala Agriculture University. Thesweet lovi-lovifruits were collected from trees of Accession 2(*Flacourtiacataphracta*) at College orchard maintained by Department of Fruit Sciences(Plate 1). The collected fruits (Plate 2)weresanitised with 100 ppm sodium hypochlorite solution and packed in polythene cover of 200 gauge with ventilation, polythene cover of 200 gauge without ventilation, polypropylene punnets, polystyrene box covered with cling film, shrink wrapping in areca plate and unwrapped fruitswere kept as control.They were stored under ambient, refrigerated condition at 5± 2°C and in cold storage at 12 ± 2°C. The experiment was laid out in a completely randomized block design with six treatments and three replications.



 **Plate 2.Sweet lovi-lovi fruits**

**Plate 1. Sweet lovi-lovi tree**

The shelf life was calculated as number of days from harvest till the fruits became unmarketable. When more than 25 per cent of the fruits in a sample showed browning, symptomsof spoilage and microbial growth they are designated as unmarketable fruits. Weight loss occurs in fruits after harvest due toloss of substratesduring physiological processes like transpiration and respiration and it will affect the quality of produce. Physiological loss in weight of sweet lovi-lovi fruits was estimated as per the method suggested by Srivastava and Tandon (1968) and browning of the fruits was observed visually as black or brown spots and lesions and fruits were scored unmarketable, when half of the surface gets discoloured. Total Soluble Solids and total sugars of stored fruits were also analysedduring storage as per AOAC (1980) and Ranganna (1997) respectively.

**RESULTS AND DISCUSSION**

Maximum shelf life of 3 days was recorded in fruits packed with polythene cover (200 gauge) without ventilation and shrink wrapped areca plates stored under cold storage condition (12 ± 2°C) (Fig 1). Whereas, all the packages stored under ambient condition and fruits stored in refrigerated condition without any package were found to have shortest shelf life (1 day). Fruits packed in polythene cover created a modified atmosphere with more carbondioxide and less oxygen which could extend the storage life (Dalal and Subramanyam, 1970).Rai*et al*. (2001) reported that the respiration of fruits decreases with the progress of storage under low temperature due to the accumulation of carbondioxidein packages. The low rate of respiration reduces physiological, pathological and physical deterioration during the storage. This help to retain freshness of fruits in their marketing channel.

Fig 1. Effect of packaging and storage condition on shelf life (days) of sweet lovi-lovi fruits

Physiological loss in weight (PLW %) increased in all the treatments during storage under ambient, refrigerated and cold storage condition. An increase in PLW of fruits in all the treatments with increasing period of storage was due to the loss of moisture by evapo-transpiration and loss of reserved food material by respiration. On comparing the three storage conditions, fruits packed in polythene cover (200 gauge) without ventilation in cold storage at 10°C to 14°C have least PLW (0.02 %) and maximum PLW was recorded for ambient stored fruits with no package (10.64 %) (Table 1). Pahel (2013) reported that different types of wrapping materials have significant effect on PLW of sapota fruits during storage.

Fruits are highlysensitive to minor bruises that cause enzymatic browning adversely affecting the eating quality of the fruit, thus making it unfit for consumption and it aggravates the problem of marketing. Evaluation of three storage conditions showed that fruits packed in polythene cover (200 gauge) without ventilation stored under refrigerated condition (3°C to 7°C) developed least browning (15.68 %), followed by fruits stored in polypropylene punnets in cold storage condition (10°C to 14°C) (Table 2). Prasad (1998) observed that the reduction in quality of sweet and sour lovi-lovi fruits was gradual in refrigerated storage as compared to room conditions.

Table 1. Effect of packaging and storage condition on physiological loss (%) in weight of sweet lovi-lovi fruits

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| --- |
| Physiological loss in weight (%) |
| Treatments | Ambient | Refrigerated storage | Cold Storage |
| 1 DAS | 1 DAS | 2 DAS | 1 DAS | 2 DAS | 3 DAS |
| T1 | 10.64 (3.26) | 4.54 (2.13) | - | 1.78 (1.33) | - | - |
| T2 | 4.82 (2.19) | 0.41 (0.61) | 0.83 | 0.73 (0.85) | - | - |
| T3 | 1.70 (1.30) | 0.45 (0.67) | 0.72 | 0.02 (0.15) | 0.16 | 0.29 |
| T4 | 0.84 (0.92) | 0.54 (0.73) | - | 0.13 (0.36) | 0.17 | - |
| T5 | 2.66 (1.63) | 0.85 (0.92) | - | 0.18(0.42) | 0.48 | - |
| T6 | 0.25 (0.50) | 0.04 (0.18) | 0.23 | 0.04 (0.19) | 0.07 | 0.26 |
| SE | 0.21 (0.04) | 0.09 (0.06) | - | 0.03 (0.02) | - | - |
| CD (0.05) | 0.64 (0.12) | 0.29 (0.18) | - | 0.09 (0.05) | - | - |
| CD for interaction  | 0.13 |

Table 2. Effect of packaging and storage condition on browning (%) of sweet lovi-lovi fruits

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| --- |
| Browning (%) |
| Treatments | Ambient | Refrigerated storage | Cold Storage |
| 1 DAS | 1 DAS | 2 DAS | 1 DAS | 2 DAS | 3 DAS |
| T1 | 45.83 (42.61) | 75.00 (60.12) | - | 33.33 (35.13) | - | - |
| T2 | 46.29 (42.86) | 24.08 (29.24) | 53.7 | 83.33 (66.82) | - | - |
| T3 | 39.21 (38.73) | 15.68 (23.04) | 45.1 | 35.29(36.40) | 39.21 | 49.02 |
| T4 | 66.67 (54.79) | 46.67 (43.09) | - | 22.67 (28.29) | 29.33 | - |
| T5 | 73.81 (59.27) | 68.89(56.13) | - | 26.19 (30.73) | 38.09 | - |
| T6 | 68.62 (55.95) | 53.33 (46.92) | 71.11 | 39.22 (38.7) | 49.02 | 68.63 |
| SE | 3.31 (1.96) | 3.26 (2.19) | - | 4.18 (2.97) | - | - |
| CD (0.05) | 10.19 (6.05) | 10.04 (6.74) | - | 0.31 (9.16) | - | - |
| CD for interaction  | 5.97 |

The TSS and total sugar content of sweet lovi-lovi fruits in different packages decreased during storage in three different storage conditions. On comparing the three storage conditions, fruits in areca plates wrapped with polyolefin film of 15μ thickness stored under cold storage (10°C to 14°C) were found to be best in retaining TSS and total sugars (17.26°Brix and (12.74 %)(Table 3 and 4).Pelayo*et al*. (2003) reported a reduction in TSS of three per cent on storage at 5°C for strawberry cultivar Aromas, whereas the reduction was 10 % in cultivar Selvaafter nine days. Mishra and Kar (2014) reported a significant decrease in total sugar of 9 % in Chandler and 10 % in Camarosa cultivars of strawberry on storage at 5°C for 9 days.

Table 3. Effect of packaging and storage condition on TSS (°Brix) content of sweet lovi-lovi fruits

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| --- |
| TSS (°Brix) |
| Treatments | Ambient  | Refrigerated storage | Cold Storage |
| 1 DAS | 1 DAS | 2 DAS | 1 DAS | 2 DAS | 3 DAS |
| T1 | 16.03 | 16.23 | - | 16.33 | - | - |
| T2 | 16.27 | 16.53 | 13.43 | 16.60 | - | - |
| T3 | 16.67 | 16.87 | 13.37 | 17.20 | 13.60 | 10.17 |
| T4 | 16.73 | 16.77 | - | 16.63 | 13.13 | - |
| T5 | 16.43 | 16.77 | - | 16.67 | 13.37 | - |
| T6 | 16.63 | 16.93 | 13.87 | 17.27 | 13.57 | 10.87 |
| SE | 0.08 | 0.06 | - | 0.10 | - | - |
| CD (0.05) | 0.24 | 0.18 | - | 0.31 | - | - |
| CD for interaction  | 0.23 |

Table 4. Effect of packaging and storage condition on total sugar (%) content of sweet lovi-lovi fruits

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| --- |
| Total sugars (%) |
| Treatments | Ambient  | Refrigerated storage | Cold Storage |
| 1 DAS | 1 DAS | 2 DAS | 1 DAS | 2 DAS | 3 DAS |
| T1 | 12.22 | 12.65 | - | 12.58 | - | - |
| T2 | 12.39 | 12.54 | 10.98 | 12.61 | - | - |
| T3 | 12.51 | 12.61 | 11.37 | 12.69 | 11.32 | 10.91 |
| T4 | 12.25 | 12.42 | - | 12.63 | 11.12 | - |
| T5 | 12.24 | 12.56 | - | 12.67 | 11.26 | - |
| T6 | 12.49 | 12.47 | 10.84 | 12.74 | 11.66 | 10.65 |
| SE | 0.05 | 0.06 | - | 0.02 | - | - |
| CD (0.05) | 0.17 | NS | - | 0.06 | - | - |
| CD for interaction  | 0.14 |

Storageat low temperature is found good for maintenance of acceptable appearance, texture and nutritive value ofstrawberriesNunes*et al*.(1995).

Hence by packaging the sweet lovi-lovi fruits in polythene cover (200 gauge) without ventilation and shrink wrapped areca plates placed in cold storage condition (12 ± 2°C) can increase the shelf life.The method can be suitably adopted in cold chain,making the nutritionally rich fruits available to consumers at places other than its area of production.

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