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Physiological weight loss of mango cv. alphonso as influenced by the different types of edible coatings viz. single layer, composite and bilayer

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Abstract
This study was designed to optimize the suitable type and concentration of edible coating formulations viz. polysaccharide based, protein based and lipid based coatings coated as single layer, composite and bilayer on the mango cv. Alphonso for the purpose of preservation and shelf life extension. The experiment were divide into three phases as single layer coating composite coating and bilayer coating. In bilayer experiment the fruits were stored under two different storage conditions of cold and ambient. The results for physiological weight loss was measured after an interval of 3 days throughout the storage period. The best and optimized results obtained from each phase was used for the latter. The results showed that from the phase I treatment E2, E3, E5, E7, E9, E11 were found to have lower values for PLW as compared to the treatments of higher concentration from the respective groups except group of chitosan where higher concentration of chitosan showed good results. From the phase II i.e. composite coating formulations the best optimized results were found for the treatment T5, T11 and T14 which were selected for the phase III i.e bilayer coating experiment.

Keywords: Alphonso, edible coating, composite, bilayer, physiological weight loss, shelf life

Introduction
In India, Konkan region of Maharashtra state is mainly known for its richness and versatility in fruits availability. But most of the fruits are seasonal and are highly perishable. The preservation of these fruits is very important aspect which can be overcome by proper packaging methods and storage practices. Mango (*Mangifera indica* L.) undoubtedly is one of the oldest and choicest fruits in the tropics and is acclaimed as "King" of fruits due to its wide adaptability, high nutritive value, richness in variety, delicious taste, pleasant flavour and attractive appearance (Morton, 1987). Mango (*Mangifera indica* L.) cv. "Alphonso", locally called as "Hapus" is highly perishable cash crop with limited shelf life, which leads to huge post-harvest loss every year. During the post- harvest, there are considerable losses due to microbes, insects, respiration and transpiration. The important quality factors considered for its marketability is physiological weight loss. Edible coatings have also a high potential to reduce the physiological weight loss for various fruits. Several studies have demonstrated that the postharvest life of fruits can be extended by use of edible coating technology and needs more study the effect of single layer, composite and bilayer edible coating on physiological weight loss. Thus the present investigation was made to study the effect of different edible coatings as single layer, composite and bilayer coatings on the physiological weight loss of mango cv. Alphonso.

Material and Methods
The present research work was undertaken at Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The aim of the present investigation was to develop the single layer coating formulations, composite edible coating formulations by incorporation of active ingredients and bilayer coating formulations using polysaccharides, lipids and proteins as base material and to study the effect of all the formulations on physiological weight loss of Alphonso mango throughout the storage period. Experiments were formulated for single coating with six different basic coating material and adding functional ingredients to form composite coatings.

The best optimized concentration of single layer coating was used as base for the composite coating formulation which were incorporated with active ingredients such as antioxidant (alpha tocopherol), texture enhancer (calcium gluconate) and antimicrobial (*Aloe vera* gel). The best optimized solutions were then used for bilayer coating treatments. Basic components used to prepare edible coating solutions were polysaccharide based - 1) Chitosan 2) Cassava starch; Protein based – 1) Whey protein isolate 2) Gluten; Lipid based – 1) Beeswax white 2) Olive oil and the active components were as antioxidant (α- tochopherol); texture enhancer (calcium gluconate) and antimicrobial (*Aloe vera* gel). Plasticizers, emulsifiers and surfactants such as glycerol; glycerol monostearate; tween 80 respectively were used to add to the textural properties of coating formulations.

The evaluation of physiological weight loss were carried out to monitor quality changes in test samples coated with the single layer, composite and bilayer edible coatings at an interval of every 3 days until fruits showed signs of spoilage. The physiological weight loss (%) of mango samples were calculated using method as described. Three mango samples from each treatment were weighed at the start of experiment and at the end of each 3 days storage interval using a digital weighing balance. Fruit weight loss is expressed as a percentage of the initial weight of each fruit. The difference between the initial & final weight of the fruit were considered as a total weight loss. The results were expressed as the percentage loss of the initial weight as per the standard method of AOAC. The PLW was expressed in percentage and calculated using formula

$$PLW\% = \frac{W1-W2}{W1} * 100$$

where, W_1 is the initial weight and W_2 is the final weight

The data obtained in the present study was then subjected to Factorial Completely Randomized Design with twelve treatment combinations for single layer coating and eighteen treatment combinations for the composite edible coating formulations. The data for bilayer coating treatments were the fruits were stored under two different storage conditions i.e. ambient and cold was analysed by Completely Randomized Design as suggested by Panse and Sukhatme (1995) [8].

Results and Discussion

Data pertaining to effect of various coatings i.e. single layer, composite and bilayer on the physiological weight loss and the changes occurring during storage period for mangoes stored in ambient and cold storage from day 0 to day the mangoes were spoiled are presented in the form of tables and figures. The experimental results for physiological weight loss statistically analysed are explained briefly.

Effect of Single layer coating various different concentrations of edible coatings on physiological weight loss

Physiological weight loss is a very important parameter to be considered during the storage study of fruits like alphonso mango. In this study the data pertaining to PLW as significantly affected by the concentrations of coating material are depicted in Table 1 and figure 1. The final results showed that the PLW increased gradually from day 0 to day 15. The minimum weight loss was observed in treatment E3 (6.41%) where fruits were coated with 4% cassava starch. The maximum weight loss was observed in E8 (17.58%) on day 15 where fruits were coated with 10% gluten. After comparing the two concentrations from each group of basic coating solution, it was observed that E2, E3, E5, E7, E9, E11 were relatively lower than E1, E4, E6, E8, E10 and E12 respectively. Thus the lower concentrations from each group except the first group of chitosan was selected for the development of composite layer coating in phase II of the experiment.

Also from the data presented in table 1, it was observed that a linear increase occurred in all the treatments. The interaction of storage days and coating concentration showed significant results with respect to physiological weight loss upto 15 DAT. There was a drastic increase in PLW in interaction treatment E8 (17.589%) and a slightly lower values were recorded for treatment E10 which was at par with E1, E6, E7, E11 and E12. Similar results were observed by Mane *et al*. (2021) [7], Patil *et al*. (2016) [10], Apiradee (2016), Kaur (2017) [6], Patel (2006) [9] in mango cv. Amrapali and Preethi *et al*. (2017) [12] in mango cv. Alphonso.

Table 1: Effect of single layer coating of different concentrations of edible coating on Physiological weight loss

Treatment	3	6	9	12	15
E1	0.5493	1.6033	3.2114	6.9948	10.1667
E2	0.3859	1.1283	1.8554	2.8821	7.3402
E3	0.7152	1.6346	3.102	4.5574	6.41
E4	0.8548	1.4952	2.4245	3.718	8.2468
E5	1.5167	2.4998	3.8438	6.223	7.9514
E6	1.3865	2.9263	4.7582	6.6648	10.1313
E7	2.0401	3.5041	5.7197	7.9857	10.3535
E8	2.1992	5.3371	8.6647	12.5004	17.589
E9	2.581	4.8606	8.7517	11.7168	14.4357
E10	2.3973	5.2778	8.4286	12.1026	15.8919
E11	1.4674	4.0369	6.6331	8.2546	10.3269
E12	1.4604	3.0856	5.2557	7.3881	10.1931
SE±	0.270899	0.439065	0.628512	0.797593	1.054662
CD (1%)	0.760172	1.232062	1.763672	2.238131	2.959495

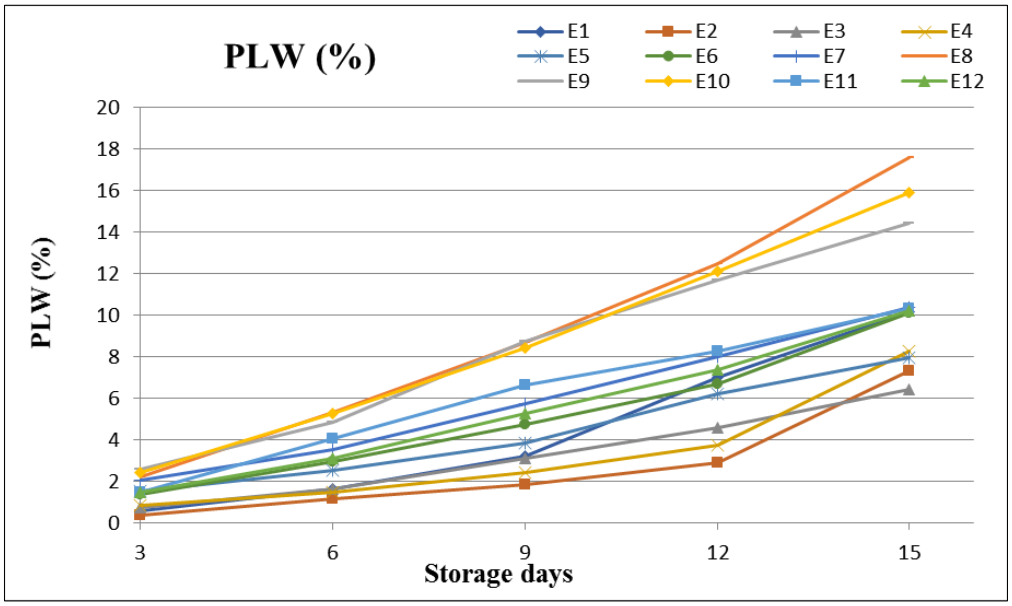

Fig 1: Effect of single layer coating of different concentrations of edible coating on Physiological weight loss

Effect of composite edible coating and various functional active ingredients on Physiological Weight loss

The pooled data on changes in physiological weight loss of mango fruit cv. Alphonso during the storage days after treatment for two trails conducted are presented in Table 2 and graphically represented in Figure 2. The treatments and storage interaction exhibited significant impact on weight loss. It was noticed from the results that the ripening trend in physiological weight loss was observed with the advancement of ripening and storage period at ambient temperature. It was observed that the treatment T5, T11, T14 recorded the least values followed by T16. The lowest value recorded was 4.95 % for T5 after 21 days of storage. The maximum PLW was observed in T18 where the fruits were spoiled and fermentation occurred in fruits. In the interaction effects between the treatments showed that the maximum increase in weight loss was observed in control treatment 20.98% and 22.08% in trial 1 and 2 respectively. The continuous increase could be the result of loss of moisture from the fruit peel through respiration and transpiration. Similar trends of increase was observed by Mansute (2016).

The reason for reduction in weight loss may be the blockage of lenticels and or stomata (Dhalla and Handson, 1988) this idea is supported by reduction in respiration (Hangmaier and aker, 1993). Physiological weight loss (%) was observed for both control sample and coated samples, but coated samples were observed with lesser rate of weight loss between from day to day at room temperature stored mangoes. But a significant change was not observed in the overall storage period. Along with PLW, managing temperature is the most critical factor in the process of ripening for mature-green mangoes. For mangoes when held at 27–30 °C during ripening, the skin of the fruit becomes better coloured and the fruit acquire a good flavor. Ripening retards when mangoes are held above 30 °C and or subject to chilling injury if held below 14 °C. Sometimes, coatings may help in withstanding sudden changes in temperatures during storage at room temperatures, but still lot of scientific proofs are to be given to prove this phenomenon. Half-matured fruit and fruits from early season harvests underwent limited ripening and were less acceptable. For maximizing storage potential, suggestions were made by controlling maturity of fruit at harvest and storage temperature for progressive harvests throughout the season. From the table 2 it was found that the increase in physiological weight loss was statically significant. The interaction of storage days and composite edible coating showed linear increase in the PLW. The minimum values recorded for PLW for the interaction T5 was at par with T11, T14 and T16. The highest value recorded for PLW was for the interaction T18 which was at par with T7. From the phase II the best optimized formulations were recorded as T5, T11 and T14 which were further used for the bilayer coating in phase III.

Table 2: Effect of composite coating and various functional active ingredients on Physiological Weight loss

Treatment	3 DAT	6 DAT	9 DAT	12 DAT	15 DAT	18 DAT	21 DAT
T1	1.70	4.34	7.30	9.25	10.99	11.70	12.37
T2	1.90	5.59	8.44	9.12	10.57	11.63	12.62
T3	3.86	6.60	9.79	11.86	12.59	13.55	15.46
T4	2.39	6.00	8.35	9.90	11.08	12.36	13.60
T5	0.77	1.53	2.35	2.91	3.79	4.59	4.95
T6	3.10	5.55	7.75	9.27	11.82	12.65	14.44
T7	2.24	4.43	11.12	12.78	14.35	16.41	17.48
T8	2.75	6.28	10.10	12.12	14.74	15.64	16.49
T9	2.41	5.00	9.03	10.90	12.15	13.30	15.03
T10	1.64	4.37	7.78	8.80	11.16	11.98	12.75
T11	1.27	2.59	3.46	4.15	5.24	5.75	6.30
T12	1.63	4.15	7.58	9.24	11.80	12.34	13.58
T13	7.17	9.51	11.57	12.22	16.37	18.19	18.87
T14	1.38	2.30	3.13	3.91	4.77	5.67	6.36
T15	1.06	1.97	3.78	5.27	8.13	10.12	11.96
T16	1.02	2.27	4.08	5.10	7.31	8.13	9.93
T17	1.08	2.82	5.34	9.00	12.17	13.66	16.16
T18	1.09	3.28	9.92	12.02	14.87	17.61	18.38
SE±	0.92	1.41	1.95	1.91	1.82	1.87	1.90
CD (1%)	2.57	3.96	5.46	5.37	5.11	5.25	5.34

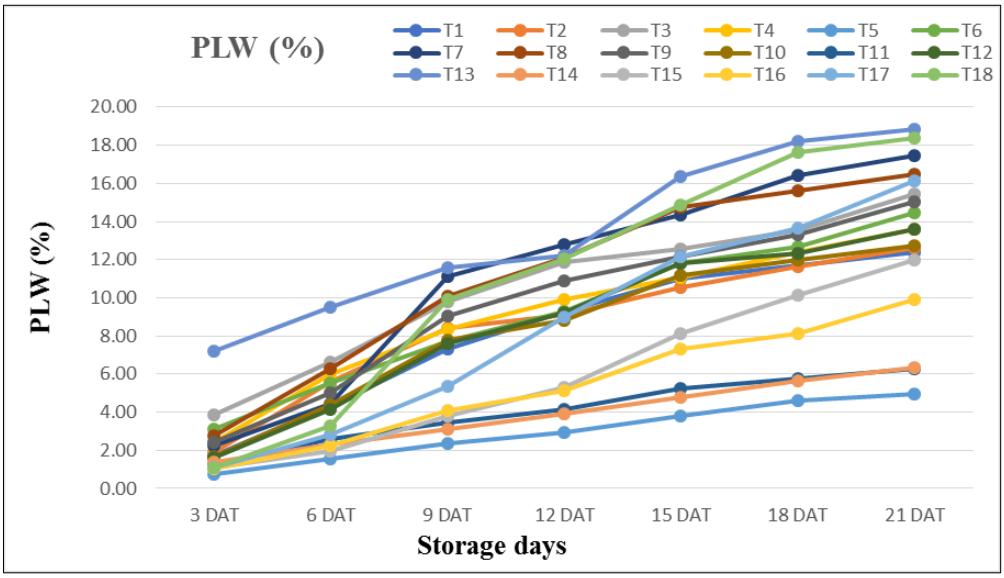

Fig 2: Effect of composite coating and functional active ingredients on Physiological Weight loss

Effect of bilayer layer coating using best optimized formulations of composite edible coatings on physiological weight loss

In this study the data pertaining to PLW as significantly affected by the bilayer coating under ambient and cold storage conditions are depicted in Table 3 and Figure 3. The final results showed that the PLW increased gradually from day 0 to day 30 in both ambient and cold storage conditions. The minimum weight loss was observed in cold storage treatments where the treatment T5 (13.1%) was observed to have lowest physiological weight loss. The maximum weight loss was observed in T4 (44.282%) on day 24 DAT where the fruits were stored in ambient conditions. No fruits were available for analysis stored in ambient conditions on 27 DAT and 30 DAT as all fruits were decayed.

The maximum PLW recorded for the treatment T5 may be the impact of ambient storage conditions of temperature and humidity which caused higher rate of respiration in fruits and greater utilization of stored energy and leads to degradation of fruits. The lower values of PLW recorded for the treatment T5 was the effect of coating material and the storage temperature together. Also in treatment T1 the value for PLW was recorded to be lower as compared to other treatments in ambient condition on 24 DAT which shows that the coating formulation helped in withstanding the sudden changes in temperature during storage at room temperature. The drastic loss in PLW was observed in treatment T8 though it was subjected to cold conditions. The reason may be the fermentation occurred in the fruits due to the higher thickness of coating solutions.

Table 3: Effect of bilayer coating under two different storage conditions i.e ambient and cold storage on physiological weight loss

Treatment	3 DAT	6 DAT	9 DAT	12 DAT	15 DAT	18 DAT	21 DAT	24 DAT	27 DAT	30 DAT
T1 (amb)	3.65	4.256	6.534	9.054	11.073	13.014	14.07	14.37	-	-
T2 (amb)	4.74	4.7	7.487	13.042	20.078	28.409	35.235	38.49	-	-
T3 (amb)	0.6	5.914	11.214	19.745	28.029	34.378	39.065	42.157	-	-
T4 (amb)	2.81	7.022	13.371	19.824	27.732	37.283	41.551	44.282	-	-
T5 (cold)	1.29	3.268	4.942	6.953	8.353	9.591	10.988	11.929	12.4	13.1
T6 (cold)	2.39	3.168	4.525	6.165	8.206	10.724	13.5	17.302	22.9	27.4
T7 (cold)	2.54	3.136	5.471	6.657	8.161	9.78	11.74	13.898	15.7	24.6
T8 (cold)	1	5.609	7.301	10.349	12.629	14.972	17.1	19.894	28.717	31.568
SE±	0.389701	0.623884	0.803549	1.026874	1.561489	1.980485	2.337145	2.481673	0	0
CD (1%)	1.093542	1.750684	2.254845	2.881519	4.381703	5.557452	6.558278	6.963838	0	0

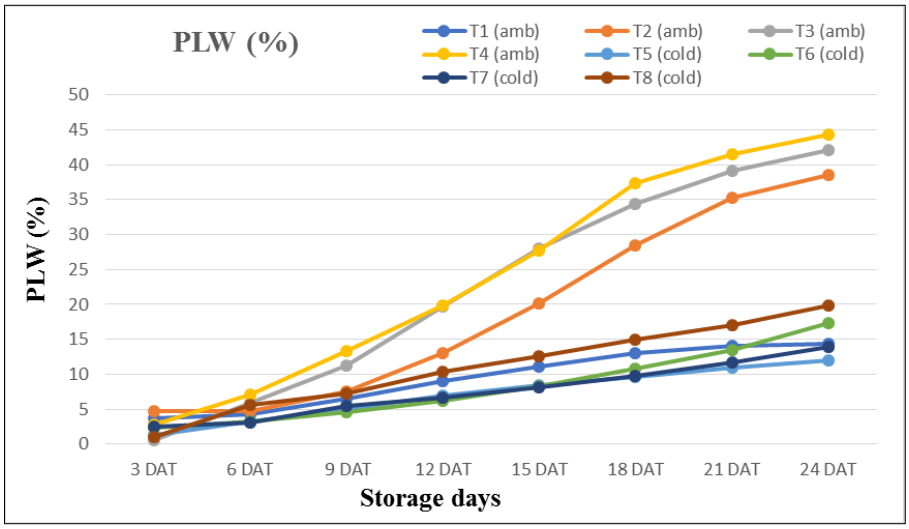

Fig 3: Effect of bilayer coating under two different storage conditions i.e ambient and cold storage on physiological weight loss

Conclusions

Shelf life studies of alphonso mango by applying different coating formulation in single layer, composite and bilayer treatments revealed that for the coated mangoes the physiological weight loss showed a slow and gradual increase. From the phase I of single layer coating experiment the lower concentrations showed lower values as compared to the higher concentration of coating for the respective groups. From the phase II i.e. composite coating formulations the best optimized results were found for the treatment T5, T11 and T14 which were selected for the phase III i.e bilayer coating experiment. The lower values of PLW were the results of effect of coating formulation and storage conditions. The higher values of weight loss were the results of fermentation and degradation of fruits which got spoiled at faster rate during storage. The active components incorporated in composite coating as antimicrobial (*Aloe vera* gel) showed significant results to reduce the spoilage in fruits. Thus the combination of coating material may be promising for the shelf life extension. It can optimize the coating performance by counter balancing the benefits and deficiencies of individual coatings.

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