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To study the effect of different chemicals and packing materials on the physiological and organoleptic characteristics of Mosambi (*Citrus limetta*) fruit

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Abstract
The experiment was conducted "to study the effect of different chemicals and packing materials on the physiological and organoleptic characteristics of Mosambi (*Citrus limetta)* fruit" at the Agricultural laboratory of Sant Baba Bhag Singh University, Jalandhar, Punjab (India) and Punjab agro. Juice ltd. Hoshiarpur FSSC LIC NO.10014063000386 and at Lal path lab, Nandachor, Punjab (India) during the year 2020. The experiment was laid out in Completely Randomized Design (CRD) with three replications and 10 treatments. After washing and drying, fruits are pre-treated with chemicals *viz*. 2,4-dichlorophenoxyacetic acid (2,4-D) and gibberellic acid (GA3) and packed in various packaging materials *viz*. high-density polyethylene (HDPE) and other packaging materials, Low-density polyethylene (LDPE) with or without perforations) and sealed with an electronic sealing system after being dehumidified. Fruits samples were analysed for various physiological characteristics and organoleptic chaacteres after 7 days of interval of storage (0, 7th, 14th, and 21th). The result revealed that among the different treatments T4 (HDPE perforated) treatment was superior for characters like fruit appearance, individual fruit weight, rind thickness, fruit juice content %, colour and flavor as compared to other treatments in respect of maintaining morphological and organoleptic parameters. However, least values were recorded in T0 (Control) for most of the parameters analysed. Therefore, treatment of T4 (HDPE perforated) may be suggested as effective and economical treatment for improving shelf life.

Keywords: LDPE, HDPE and CRD

Introduction
Citrus limetta, is considered to be a variety of Sweet orange and citrus varieties, belongs to the Rutaceae family and is often referred to Mosambi and Sweet limetta. *Citrus limetta* can be grown locally in tropical or subtropical climates, and fruit production begins to appear on plants that are 5 to 7 years old. It starts to evolve and produces a good yield from 10 to 18 years. Global production of sweet oranges in 2014 was 70.9 million tons, 24% of the total global production was produced by Brazil followed by China and India [3]. During 2016-2017, overall area under cultivation of Mosambi was 209.19 / ha with fruit production of 3497.35 MT and productivity 16.7 MT / ha [4]. The role of packaging to increase the shelf life of fruit is very crucial in post-harvest operations of horticultural fruit crops. Each polymer-sealed fruit is better than a few fruits stored in a plastic bag because sealing each fruit allows for a more efficient environment against respiratory biomass and even each sealed packaging helps in preventing the fruit from decaying infections that are considered secondary agents [2]. In view of the above fact, the present study was carried out to investigate the effect of different chemicals and packing materials on physiological and organoleptic characteristics of Mosambi fruit.

Method and Material
The experiment was laid out in Completely Randomized Design in which 10 treatments were implemented with 3 replications after 7 days of interval (0, 7th, 14th, and 21th) for identification of better effect of different chemicals and packaging material on physiological and organoleptic traits of Mosambi in December, 2020.

Fruits are pre-treatmented with hot water (55 °C) and the fruits were air dried room temperature for one hour after pre-treatment. The mosambi fruits were wrapped in various packaging materials *viz*. high-density polyethylene (HDPE) and other packaging materials, Low-density polyethylene (LDPE) with or without perforations) and sealed with an electronic sealing system after being dehumidified. Chemically *viz*. 2,4-dichlorophenoxyacetic acid (2,4-D) and gibberellic acid (GA3), prepared fruits were also kept at (ambient) room temperature. Fruit samples were analysed for various physical characteristics *viz*. Fruit appearance, Fruit diameter, Individual fruit weight, Rind Thickness and Fruit juice % and organoleptic characteristics *viz*. Colour, Flavour and Overall acceptability. Therefore, present investigation was conducted with 10 different treatments *viz*., T_1 (LDPE), T_2 (LDPE perforated), T_3 (HDPE), T_4 (HDPE perforated), T_5 (Cold storage), T_6 (Treated with 2,4-D 50 ppm (without packaging)), T_7 (Treated with 2,4-D 100 ppm (without packaging)), T_8 (Treated with GA3 50 ppm (without packaging)), T_9 (Treated with GA3 100 ppm (without packaging)), T_0 (Control).

Result and Discussion

The analysis of variance revealed significant differences among the treatments for all the traits attributes under study. Data recorded on the effect of different chemicals and packing materials on physiological and organoleptic perameters of Mosambi (*Citrus limetta*) fruit.

Physiological parameter

Fruit Appearance

This study shows that chemicals and packaging materials have a significant impact on Mosambi at the end or end of the 21st storage period. Maximum value of appearance (6.78) was obtained in HDPE perforated (T4) whereas minimum (5.23) was recorded in control (T0) shown in Table 1. These findings are supported by Tatl and Ozguven (1999) [10], as well as Tugwell and Chvyl (1996) [11].

Individual fruit weight

Chemicals and packaging materials were found to have significant impact on individual fruit weights as shown in Table 2. The minimum reduction in weight from 0 day to 21 day (153.49 gm) was obtained in HDPE perforated treatment (T4) whereas, minimum value (124.50 gm) in control (T0) on 21th day of the storage due to maturation and decrease during respiration and respiration. The current results are supported by Bhullar [1], who investigated that chemically treated fruits with 2, 4-D and high-density polyethylene can be stored.

Fruit diameter

The results of this study showed that the packaging material had a significant effect on fruit diameter, but the minimal reduction in fruit diameter found during cold storage (T5) showed better results than other packaging materials on the other hand in chemical treatment of fruit treated with 2, 4 -D 100 ppm (T7) showed minimal diameter reduction compared to other pretreatment chemicals. The maximum diameter reduction was found in the control (T0) (Table 3).

Rind thickness

In the present study, it was found that chemically treated fruits, cold handling, and packaging materials were of very different sizes, as shown in Table 4. Minimal reduction in skin thickness was noted in T4. The maximum shrinkage of bark thickness was recorded in the treatment or control (T0). The reduction in skin thickness of unprocessed fruit is maximal under ambient or ambient temperature conditions, resulting in greater moisture loss and skin thickness shrinkage, a term used by Wills *et al.* [12].

Fruit juice %

This study showed that juice weight decreased with increasing storage time and showed a significant effect of different treatments on fruit juices as shown in Table 5. The maximum juice content (51.31%) was determined in perforated high density polyethylene (T4) and the minimum juice content (46.21%) in the control (T0) was recorded. This may be due the property of high-density polyethylene, supplying barrier in opposition to the water vapor and continues relative humidity which decrease the transpiration rate. The current findings are supported through Kaur [5] and Singh [7] in kinnow mandarin.

Organoleptic parameter

Colour

The records presented in the Table 6 is indicating that the packaging material used to be appropriate for preserving the fruit colour; fruits sealed in excessive density polyethylene with perforation (T4) confirmed less color modifications with slower rate. Whereas, the maximum rapid and quick colour changes regarded in control (T0). The current findings are supported through the end result obtained by means of the Siddiqui [8] and Mandhyan [6].

Flavor

The different packaging treatments affected the flavor at the last of storage, large value recorded in packaging material was in high density polyethylene with perforation (T4) (5.48) and minimum value was recorded in control (T0) shown in Table 7. The present findings are supported by Sonkar and Ladaniya [9].

Overallaccept ability

In this experiment, various treatments of packaging, cold treatments and chemical treatments significantly affects the fruits overall acceptability shown in Table 8. The maximum value (5.41) of acceptability recorded in cold treatment (T7) and this may be due to the low temperature, which limits the biochemical activity, reduces the respiration rate of the fruit, causing delays in ripening and the fruit can be stored for days. Whereas, minimum value (2.12) was recorded in control (T0).

Table 1: Effect of different treatments on appearance of mosambi fruits

Treatments	7 Days	14 days	21 days
T1	7.58±0.34	6.94±0.36	6.12±0.65
T2	7.49±0.54	6.82±0.54	6.33±0.51
T3	7.67±0.23	6.86±0.50	6.48±0.50
T4	7.89±0.67	7.10±0.98	6.78±0.65
T5	7.41±0.54	6.42±0.56	6.02±0.65
T6	7.30±0.23	6.52±0.87	6.24±0.54
T7	7.50±0.54	6.98±0.12	6.39±0.31
T8	7.42±0.87	6.61±0.37	6.04±0.87
T9	7.39±0.76	6.56±0.41	6.12±0.56
T0	7.10±0.98	6.18±0.23	5.23±0.98

Table 2: Effect of different treatments on the individual fruit weight (gm)

Treatments	0 Days	7 Days	14 days	21 days
T1	172.67±3.23	166.45±2.56	158.29±2.58	151.92±2.55
T2	171.36±2.98	165.26±3.65	156.66±1.59	151.03±3.79
T3	169.22±4.33	161.45±2.98	153.87±3.19	147.65±4.11
T4	168.56±3.87	163.67±2.31	158.67±2.54	153.49±2.81
T5	171.98±5.23	163.22±4.98	156.65±2.78	150.23±3.99
T6	167.43±3.54	159.69±1.56	151.39±3.34	145.45±2.32
T7	173.45±2.41	166.32±4.67	157.67±3.89	152.06±4.16
T8	170.56±3.57	163.23±3.16	154.89±4.78	148.76±2.45
T9	168.34±4.45	159.34±4.99	152.45±3.87	144.93±3.94
T0	167.45±3.45	158.45±3.74	144.5±2.56	124.50±3.11

Table 3: Effect of different treatments on the fruit diameter (cm)

Treatments	0 Days	7 Days	14 days	21 days
T1	7.14±0.93	6.94±1.01	6.65±0.98	6.35±0.12
T2	7.10±0.75	6.91±1.21	6.71±0.75	6.44±1.02
T3	7.11±0.81	6.84±0.64	6.65±0.61	6.41±0.46
T4	7.54±0.83	7.33±0.76	7.10±1.45	6.86±0.76
T5	7.21±1.21	6.95±0.49	6.75±0.74	6.55±0.32
T6	7.19±0.92	6.87±0.40	6.57±0.98	6.25±0.15
T7	7.50±0.33	7.21±0.39	7.01±1.03	6.83±0.54
T8	7.01±0.41	6.74±0.86	6.45±0.21	6.20±0.33
T9	7.17±0.74	6.90±0.79	6.64±0.54	6.35±0.29
T0	7.24±0.75	6.74±1.22	6.21±0.66	5.65±1.11

Table 4: Effect of different treatments on the rind thickness of fruit

Treatments	0 Days	7 Days	14 days	21 days
T1	0.43±0.09	0.40±0.09	0.37±0.07	0.34±0.04
T2	0.39±0.03	0.36±0.04	0.32±0.04	0.29±0.03
T3	0.31±0.02	0.28±0.04	0.25±0.06	0.21±0.04
T4	0.42±0.08	0.41±0.09	0.39±0.04	0.35±0.06
T5	0.39±0.09	0.36±0.08	0.33±0.06	0.30±0.04
T6	0.43±0.02	0.40±0.07	0.35±0.04	0.31±0.05
T7	0.39±0.03	0.37±0.05	0.34±0.06	0.32±0.06
T8	0.43±0.04	0.41±0.07	0.34±0.06	0.30±0.05
T9	0.39±0.05	0.36±0.04	0.32±0.04	0.28±0.07
T0	0.41±0.06	0.35±0.06	0.31±0.05	0.25±0.06

Table 5: Effect of different treatments on juice content (%)

Treatments	0 Days	7 Days	14 days	21 days
T1	47.87±0.98	46.64±0.87	46.32±0.76	46.29±0.35
T2	48.18±0.87	47.76±0.86	47.43±0.87	47.15±0.87
T3	49.78±0.86	49.23±1.26	48.89±0.89	48.56±0.73
T4	52.67±0.67	51.98±1.56	51.54±0.83	51.31±0.81
T5	50.45±1.03	49.67±0.84	49.27±0.78	48.84±0.93
T6	51.65±0.45	50.34±0.67	49.75±-.67	49.24±0.79
T7	49.56±0.93	48.76±0.87	48.43±0.66	48.29±0.88
T8	48.98±0.82	47.78±0.78	47.35±0.59	46.99±0.76
T9	49.54±0.87	48.96±0.97	48.54±1.38	48.12±0.45
T0	49.59±0.76	48.21±0.57	47.14±0.38	46.21±0.54

Table 6: Effect of different treatments on the colour of fruit

Treatments	0 Days	7 Days	14 days	21 days
T1	9.57±0.45	8.59±0.37	6.24±0.67	5.44±0.32
T2	9.63±0.54	8.61±0.29	6.45±0.37	5.34±0.43
T3	9.55±0.49	8.63±0.43	6.52±0.43	5.67±0.43
T4	9.58±0.59	8.89±0.51	7.01±0.37	5.99±0.60
T5	9.70±0.23	8.78±0.87	6.92±0.58	5.81±0.46
T6	9.60±0.43	8.48±0.48	6.35±0.28	5.13±0.65
T7	9.50±0.66	8.54±0.32	6.49±0.79	5.38±0.77
T8	9.62±0.76	8.27±0.61	6.32±0.29	5.03±0.15
T9	9.71±0.49	8.10±0.58	6.01±0.88	4.98±0.25
T0	9.69±0.78	7.51±0.43	5.83±0.35	4.31±0.45

Table 7: Effect of different treatments on the flavor of fruit

Treatments	0 Days	7 Days	14 days	21 days
T1	9.40±0.35	8.59±0.57	6.39±0.86	5.02±0.64
T2	9.50±0.86	8.61±0.65	6.42±0.64	5.17±0.67
T3	9.60±0.87	8.63±0.88	6.82±0.68	5.26±0.79
T4	9.50±0.37	8.89±0.65	7.21±0.57	5.48±0.24
T5	9.70±0.74	8.78±0.43	7.92±0.32	5.41±0.63
T6	9.60±0.36	8.48±0.13	6.35±0.35	5.03±0.45
T7	9.50±0.83	8.94±0.15	6.49±0.46	5.19±0.87
T8	9.60±0.37	8.57±0.35	6.32±0.76	4.81±0.26
T9	9.70±0.64	8.30±0.65	6.01±0.64	4.98±0.65
T0	9.60±0.75	7.41±0.37	5.83±0.65	4.32±0.44

Table 8: Effect of different treatments on the overall acceptability of fruit

Treatments	0 Days	7 Days	14 days	21 days
T1	9.40±0.35	7.39±0.77	5.89±0.36	4.32±0.64
T2	9.50±0.86	7.51±0.65	5.82±0.94	4.57±0.67
T3	9.61±0.87	7.62±0.88	5.92±0.68	4.86±0.79
T4	9.50±0.47	7.89±0.65	5.97±0.57	5.18±0.24
T5	9.70±0.64	8.18±0.43	5.99±0.32	5.41±0.63
T6	9.60±0.56	6.41±0.73	4.36±0.35	3.23±0.95
T7	9.50±0.88	6.84±0.85	4.41±0.46	3.59±0.97
T8	9.60±0.39	5.97±0.35	4.22±0.76	3.11±0.96
T9	9.70±0.66	6.10±0.65	4.29±0.64	3.18±0.65
T0	9.60±0.67	5.41±0.37	3.73±0.67	2.12±0.94

Conclusion

Findings from the experiment showed that the perforated HDPE packaging content performed better than all of the other treatments. Further, it can be concluded that among the different treatments, T4 treatment proved superior as compare to other treatments in respect of maintaining physical and organoleptic traits. However, the minimum value was recorded for T0 (Control) for most of the traits the traits studied. Therefore, treatment of T4 (HDPE perforated) may be suggested as effective and economical treatment for improving shelf-life of mosambi fruits.

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