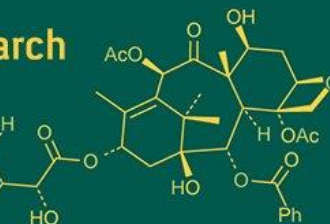
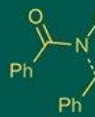
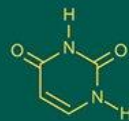
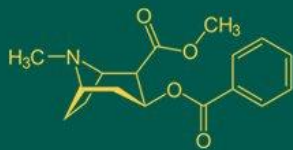


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Effect of pre cooling and storage conditions on physiological change of mango (*Mangifera Indica* L.) CV. Kesar

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Abstract

The present investigation entitled, "Effect of pre cooling and storage conditions on physiological change of mango (*Mangifera indica* L.) Cv. Kesar" was carried out at the Horticulture research farm, Department of Horticulture B.A. College of Agriculture- Anand Agricultural University, during the year 2017. The experiment was laid out on Factorial Completely Randomized Design, with three replications. The influence of precooling treatments viz., Control(P₀), ice cooling for 15 minutes(P₁), ice cooling for 30 minutes(P₂), hydrocooling at 10 °C temperature for 15 minutes(P₃) and hydrocooling at 12 °C temperature for 30 minutes(P₄) and Storage Conditions viz., Ambient Conditions(S₀), Zero energy cool chamber(S₁) and Cold storage 13±2 °C(S₂). After treatment, fruits were kept in CFB boxes at different storage condition. The fruits were analyzed periodically for various physiological changes. It can be conclude that The fruits treated with hydrocooling at 12 °C temperature for 30 minutes, proved to be most effective with respect to longest shelf life (25.04 days), lowest percentage of spoilage (10.65per cent at 9th day) and physiological loss in weight (5.82, 9.55, 13.41and 13.41 per cent, respectively) on 3th, 6th, 9th and 12th day of storage. In cold storage at 13±2 °C reduced physiological loss in weight (5.54, 10.16, 13.91, 12.08, 10.42 per cent and 16.09, 21.7 and 26.16 per cent treatment mean, respectively), enhanced shelf life of fruits (30.35 days), reduced spoilage (5.70, 15.10 and 4.16 per cent and 29.29, 40.40, 49.85 per cent treatment mean respectively) on 3th, 6th, 12th, pooled over periods and 17th, 22th, 27th day of storage.

Keywords: Mango, Kesar, pre-cooling, storage condition, shelf life, physiological change

Introduction

Mango (*Mangifera indica* L.) belongs to the family Anacardiaceae and the genus is believed to be originated in the Indo-Burma region. The fruit is having excellent adaptability and regarded as "King of Fruits." Moreover, Mango has been cultivated in Indian subcontinent for well over 4000 years and favorite of the kings and common people as well, Mango fruits have good nutritional value, every 100 g of mango pulp contain 81.7 g water, 16 g carbohydrate, 0.7 g protein, 0.4 g fat and 0.1 g fibers. It is rich in calcium, phosphorus, iron, magnesium, Vitamin A, B, C and also fair amount of anti-oxidants.

India is the largest producer of mango in the world with 18526.98 thousand MT productions on an area of 2163.47 thousand hectares and productivity of 8.56 MT per hectare (Anon., 2014 - 15a). The major mango growing states are Andhra Pradesh, Bihar, Gujarat, Uttar Pradesh Maharashtra, Karnataka, Kerala, Tamil Nadu, Orissa and West Bengal. The largest area of 315.42 thousand hectares is being covered by Andhra Pradesh, while Uttar Pradesh is largest producer of mango with 4347.50 thousand MT productions and productivity of 17.34 MT per hectare (Anon., 2014 - 15a).

Pre cooling is a rapidly remove of field heat and slower down the respiration of freshly harvested mango crop, which helps in minimizing the susceptibility to microbes and reduce water loss and thereby increase shelf life. Types of pre cooling are room cooling, hydro cooling, ice cooling, vacuum cooling etc. (Sonkar *et al.*, 2002) ^[114]. In Hydro cooling fruits are dipped in cold water or spray the cold water on the fruits to remove heat of fruits. (Kapse *et al.*, 1997) ^[38]. In Ice cooling method Packaging icing involves direct placement of slush, crushed ice surrounding the product for definite time.

Zero energy cool chamber known as on farm storage chamber, for fresh fruits to reducing of transpiration, respiration and ripening even after harvest. The spoilage of fruits reducing the storage temperature 10-15 °C cooler than the outside temperature Cold storage, in which the mango fruits are storage at low temperature, for shelf life of fruits. Mango fruits cv. Kesar by applying various precooling treatments and different Storage conditions for tide over glut period and to prevent the pests and diseases infection.

Materials and Methods

The experiment was conducted in at the Horticultural Research Farm, Fruit processing centre Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during the year 2017. The mango mature fruits of uniform size and shape having specific gravity between 1.0 and 1.04 were selected from Farm, AAU, Anand. Fruits were harvested at tapkaa stage. That fruits were labeled according to treatments and replication. The statistical analysis was done by using method of analysis of variance (ANOVA) for Completely Randomized Desing with Factorial concept by Gomez and Gomez (1976) [115] Hydro-cooling at 10 °C temperature for 15 min, Hydro- cooling at 12 °C temperature for 30 min. For

hydro-cooling treatment, cool water sprayed on fruits. The constant temperature was maintained by continuous adding of ice in cool water for precooling. For ice cooling treatment, fruits placed uniform plastics carats and fruits were covered with ice crystal for 15 and 30 min, treated fruits were kept in CFB boxes and stored at ambient condition, cold storage (13±2 °C) and zero energy cool chamber. Analysis was done before application of treatment, and at 3 days interval for fruits stored in all conditions till the end of room temperature storage and then after at 5 days interval for ZECC and in cold storage. Physiological evaluation observations were recorded at fruits ripening stage. During the storage period, the following data observations were recorded at initial, 3th and 6th, 9th, 12th, 17th, 22th, 27th days of storage.

Results and Discussion

The result revealed that among different pre cooling and storage conditions on physiological change of mango.

Physiological loss in weight (%)

Data pertaining to the Physiological loss in weight (%) as significant by different treatment of precooling and storage conditions are presented in Table 1

Table 1: Effect of precooling and storage conditions on physiological loss in weight of mango cv. Kesar

Treatments	Treatment details	Physiological loss in weight (%)								
		Storage period (days)								
		0	3	6	9	12	Pooled	17	22	27
A. Precooling										
P ₀	Control	7.13	12.08	16.43	17.07	13.18	-	-	-	
P ₁	Ice cooling for 15 minutes	6.82	11.41	15.68	16.38	12.57	26.87	-	-	
P ₂	Ice cooling for 30 minutes	6.20	10.37	14.41	14.83	11.45	18.55	23.91	-	
P ₃	Hydro-cooling at 10°C temperature for 15 minutes	6.50	10.38	14.92	15.56	11.84	21.11	26.02	-	
P ₄	Hydro- cooling at 12°C temperature for 30 minutes	5.82	9.55	13.41	13.89	10.67	17.43	22.43	-	
S.Em. ±		0.18	0.18	0.33	0.44	0.28	-	-	-	
C.D. at 5%		0.53	0.53	0.94	1.27	0.83	-	-	-	
B. Storage Conditions										
S ₀	Ambient condition	7.44	11.35	16.02	18.12	13.23	-	-	-	
S ₁	Zero energy cool chamber	6.50	10.77	14.97	16.44	12.17	24.07	-	-	
S ₂	Cold storage 13±2°C	5.54	10.16	13.91	12.08	10.42	16.09	21.7	26.16	
S.Em. ±		0.14	0.14	0.25	0.34	0.22	-	-	-	
C.D. at 5%		0.41	0.41	0.74	0.98	0.66	-	-	-	
C.V. %		8.48	5.11	6.53	8.47	7.15	-	-	-	
Interaction		NS	NS	NS	NS	NS	-	-	-	

Effect of precooling on Physiological loss in weight (%)

Data found in Table 1 showed that differences among precooling treatments on PLW (%) was found significant during storage periods at 3rd, 6th, 9th, 12th days of storage. Among the different treatment P₄ (hydrocooling at 12 °C temperature for 30 minutes) recorded significantly minimum PLW (%) i.e. 5.82, 9.55, 13.41, 13.71 and 10.67 percent at 3rd, 6th, 9th, 12th and pooled over period days of storage respectively. Where, significantly maximum PLW (%) was recorded with the control (7.13, 12.08, 16.43, 17.07 and 13.18 percent respectively) which was at par with treatment P₁ (ice cooling for 15 minutes) at 3rd, 9th and 12th days of storage. Based on mean data, treatment P₄ (hydrocooling at 12°C temperature for 30 minutes) also recorded minimum PLW (%) i.e. 17.43 and 22.43 percent at 17th and 22nd days of storage respectively. The lowest loss of fruit weight treated with hydrocooling at 12 °C temperature for 30 minutes. In treated fruits reduction rate of transpiration and respiration and delaying in ripening due to restrict ethylene

accumulation. The Similar result were also recorded by Mann and Singh (1976) [56], Chauhan *et al.* (1987) [17] and Puttaraju and Reddy (1997) [77]. Who reported that, precooling in easy possible time after harvest had the lowest PLW in mango. While Unde *et al.* (2004) [112] observed that precooling of grapes reduced PLW. The physiological loss in weight could be decreased by pre-cooling treatment and Patel (2006) [74] in mango cvs. Amrapali and Neelphanso mango fruits.

Effect of storage conditions on Physiological loss in weight (%)

Data found in Table 1 showed the differences storage conditions on PLW (%) was found significant during storage periods at 3rd, 6th, 9th, 12th and pooled over periods days of storage. Among the different storage conditions, treatment S₂ (cold storage at 13±2 °C) recorded minimum PLW (%) i.e. 5.54, 10.16, 13.91, 12.08 and 10.42 percent at 3rd, 6th, 9th, 12th and pooled over period days of storage

respectively. Whereas, significantly maximum PLW (%) was recorded with the control (7.13, 12.08, 16.43, 17.07 and 13.18 percent at 3rd, 6th, 9th, 12th and pooled over days period of storage respectively.) That was at par with treatment S₀ (ambient condition) at pooled over periods. Based on mean data, treatment S₂ (cold storage at 13±2 °C) was recorded minimum PLW (%) i.e. 16.09, 21.70 and 26.16 percent at 17th, 22nd and 27th days of storage respectively) and treatment S₁ (zero energy cool chamber) recorded 24.07 percent of PLW at 17th days of storage conditions whereas were ambient conditions fruits rottener and not suitable for marketing. Cold storage at 13±2 °C was also effective in minimizing PLW compared to control. That due high rate of transpiration in ambient condition as compare to cold storage. Similar findings were obtained by Dhemre and Waskar (2004) [24] and Mann and singh (1976) [56] and

Galathia (2004) [28] in Dashehar mango and Unde *et al.* (2004) [112] in grapes cv. Thompson seedless.

Interaction effect

The interaction between precooling and storage methods on PLW of mango fruits remained non-significant. It can be concluded that physiological loss in weight was significantly reduced with the treatment hydro cooling at 12 °C temperature for 30 minutes. Whereas, cold storage at 13±2 °C has also profound effect in minimizing loss in weight.

Spoilage fruit (%)

According to data percent spoilage as effect by precooling treatments and storage conditions are presented in Table 2

Table 2: Effect of precooling and storage conditions on spoilage of mango cv. Kesar

Treatments	Treatment details	Spoilage (%)								
		Storage period (days)								
		0	3	6	9	12	Pooled	17	22	27
A. Precooling										
P ₀	Control	0	0	0	22.01	50.21	14.44	-	-	-
P ₁	Ice cooling for 15 minutes	0	0	0	17.11	34.48	10.32	51.73	-	-
P ₂	Ice cooling for 30 minutes	0	0	0	12.72	27.52	8.05	46.67	53.39	-
P ₃	Hydro-cooling at 10°C temperature for 15 minutes	0	0	0	14.49	31.04	9.11	45.36	50.38	-
P ₄	Hydro- cooling at 12°C temperature for 30 minutes	0	0	0	10.65	23.89	6.91	41.25	49.45	-
S.Em. ±		-	-	-	0.57	1.44	0.40	-	-	-
C.D. at 5%		-	-	-	1.66	4.25	1.16	-	-	-
B. Storage Conditions										
S ₀	Ambient condition	0	0	0	23.19	51.09	14.86	-	-	-
S ₁	Zero energy cool chamber	0	0	0	17.30	34.09	10.28	48.95	-	-
S ₂	Cold storage 13±2°C	0	0	0	5.70	15.10	4.16	29.29	40.40	49.85
S.Em. ±		-	-	-	0.44	1.11	0.31	-	-	-
C.D. at 5%		-	-	-	1.28	3.22	0.92	-	-	-
C.V. %		-	-	-	11.17	12.88	4.81	-	-	-
Interaction		-	-	-	NS	NS	NS	-	-	-

Effect of precooling on Spoilage fruits (%)

Data found in Table 2 showed that differences among precooling treatments on Spoilage (%) was found significant during storage periods at 9th, 12th and pooled over period days of storage. Among the different treatment P₄ (hydrocooling at 12 °C temperature for 30 minutes) recorded significantly minimum spoilage fruits (%) i.e. 10.65, 23.89 and 6.91 percent at 9th, 12th and pooled over period days of storage respectively. Where, significantly maximum spoilage fruits (%) was recorded with the control (22.01, 50.21 and 14.44 respectively) at par with treatment P₁ (ice cooling for 15 minutes) at 9th and 12th days of storage.

Based on mean data, treatment P₄ (hydrocooling at 12 °C temperature for 30 minutes) also recorded minimum spoilage fruits (%) i.e. 41.25 and 49.45 percent at 17th and 22nd days of storage respectively and due to rotting of fruit in treatment P₀ (control) marketable fruits (%) was not recorded at 17th days of storage. Hydrocooling at 12 °C temperature for 30 minutes treated fruits have comparatively less spoilage than control, and it proved storage longer period of time with better fruit qualities, because these treatments significantly control of pest and disease infection to fruits, and so reduce decay losses. The similar results were reported by Mann and Singh (1976) [56], Roy and Pal (1991) [87], Oosthugse *et al.* (1995) [67], Kapse and Katrodia

(1997) [38] and Vala (2002) [109] in mango fruit, and Trivedi and Desai (2006) in guava fruit.

Effect of storage conditions on Spoilage fruits (%)

Data found in Table 2 showed that differences storage conditions on Spoilage fruits (%) was found significant during storage periods at 9th, 12th and pooled over period days of storage. Among the different storage conditions, treatment S₂ (cold storage at 13±2 °C) recorded minimum spoilage fruits (%) i.e. 5.70, 15.10 and 4.16 percent at 9th, 12th and pooled over period days of storage respectively. Whereas, significantly maximum spoilage fruits (%) was recorded with the control (23.19, 51.09 and 14.86 percent at 9th, 12th and pooled over period days of storage respectively.) Based on mean data, treatment S₂ (cold storage at 13±2 °C) was recorded minimum spoilage fruits (%) i.e. 29.29, 51.09 and 14.86 percent at 17th, 22nd and 27th days of storage respectively) and treatment S₁ (zero energy cool chamber) recorded 48.95 percent of spoilage fruits (%) at 17th days of storage conditions whereas were ambient conditions fruits rottener and not suitable for marketing. Among storage conditions in the present experiment, the cold storage has proved effective in minimizing the spoilage than the ambient condition. The results were reported by Kapse and Katrodia (1997) [38], Padhye (1997) [68] and Puttaraju and Reddy (1997) [77] in mango fruit.

Interaction Effect

The interaction effect of precooling and storage was shows non-significant at various intervals of storage. The results, spoilage in mango fruit increase continuously during storage

time. However, the rate of increase was comparatively slower in fruits treated than control. Among storage Condition fruit stored in cold storage at $13\pm 2^{\circ}\text{C}$ was promising for slower increase in spoilage.

Shelf life in days

The data on days of fruits shelf life as affected by various precooling treatments and storage methods are presented in Table 3

Table 3: Effect of precooling and storage conditions on shelf life of fruits of mango cv. Kesar

Treatment	Treatment Detail	Shelf life (days)
A. Precooling		
P ₀	Control	14.30
P ₁	Ice cooling for 15 minutes	21.57
P ₂	Ice cooling for 30 minutes	23.79
P ₃	Hydro-cooling at 10°C temperature for 15 minutes	23.02
P ₄	Hydro- cooling at 12°C temperature for 30 minutes	25.04
	S.Em. \pm	0.61
	C.D. at 5%	1.77
B. Storage Conditions		
S ₀	Ambient condition	14.26
S ₁	Zero energy cool chamber	20.03
S ₂	Cold storage $13\pm 2^{\circ}\text{C}$	30.35
	S.Em. \pm	0.48
	C.D. at 5%	1.37
	C.V. %	8.54
	Interaction	NS

Effect of precooling on shelf life in days

The date from the table 3. The different precooling treatments significantly extend the shelf life of fruit over control. Significantly, maximum (25.04 days) shelf life was recorded in P₄ (hydrocooling at 12°C temperature for 30 minutes) which was at par with treatment P₂ (ice cooling for 30 minutes), Where as minimum shelf life of fruit was recorded (14.30 days) in treatment P₀ (control).

The shelf life of fruits determines their keeping quality. Maximum shelf life observed in hydrocooling at 12°C temperature for 30 minutes. The pre-cooling extended shelf-life of mango fruits over to control. The extension of shelf-life of mango fruits might be due to the reduction in field heat in shortest possible time, lower moisture loss, restricted metabolic and respiratory activities and inhibition in water loss and low in ethylene production in fruits. These results are in agreement with the results of Singh (1990) [96], Joshi *et al.*, (1993) [33], Kapse and Katrodia (1997) [38], Dhemre (2001) [23], Sondkar and Nikam (2002) [101], Galathia (2004) [28], as well as Raut and Pillai (2002) [86] was also seen similar trend in sapota, respectively.

Effect of storage conditions

The methods of storage of fruits for increasing more shelf life were found significant. The treatment S₂ (cold storage at $13\pm 2^{\circ}\text{C}$) achieved significantly maximum (30.35 days) shelf life of fruit, which was followed by treatment S₂ (zero energy cool chamber as 20.03 days). While, S₀ (ambient condition) fruits resulted significantly minimum (14.26 days) shelf life. Among storage conditions, the cold storage $13\pm 2^{\circ}\text{C}$ results in to maximum shelf life. The low temperature coupled with high humidity in cold storage and cool chamber, which was more effective in improving the shelf life of mango fruit as compared to ambient temperature storage. Similar results were reported by Dhemre (2001) [23], Joshi (1993) [33], Kapse (1985), Padhye (1997) [68], Dhemre and Waskar (2004) [24] in mango, and Ransing and Desai (2004) [82] in guava.

Interaction effect

The interaction effect between precooling and storage for extending shelf life of fruit had non-significant effect. From the above results, it can be observed that, fruits treated with hydrocooling at 12°C temperature for 30 minutes had maximum days of shelf life of fruits. Whereas, among storage method maximum days of shelf life of fruit was achieved in cold storage at $13\pm 2^{\circ}\text{C}$.

Conclusion

From Experiment, it is concluded that, mango fruits treated with precooling treatment of hydrocooling at 12°C temperature for 30 minutes up to 24.05 days of the storage, found to be the best with respect to extension of shelf life of fruits. It reduced physiological loss in weight and decreased spoilage percentage of fruits, the fruits stored in cold storage at $13\pm 2^{\circ}\text{C}$, exhibited more shelf life, minimum physiological loss in weight and spoilage.

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