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Effect of precooling and storage temperatures on ripening pattern of mango cv. Alphonso

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Abstract
The study was conducted the effect of different precooling and storage temperatures on quality of mango cv. Alphonso. The experiment was carried out during the season May 2016 at R.F.R.S., Vengurle, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli with five precooling temperatures (P_1 – Control, P_2 – 21 ± 2˚C, P_3 - 18 ± 2 ^{0}C, P_4 – 15 ± 2 ^{0}C and P_5 - 12 ± 2 ^{0}C.) and four storage temperatures (S_1 – Ambient temperature (27-30 ^{0}C), S_2 - 18 ± 2 ^{0}C, S_3 – 15 ± 2 ^{0}C and S_4 - 12 ± 2 ^{0}C.). After precooling fruits were stored for 21 days at different storage temperatures and again brought to above precooling temperature by air cooling after 21 days. Then the cooled fruits were kept for ripening for seven days at room temperature. It was found that the peak ripening was noticed after 14 days at ambient temperature (S_1) and after 21 days at 18 ^{0}C (S_2), 15 ^{0}C (S_3) and 12 ^{0}C (S_4) temperature. Interaction P_5S_4 showed maximum green fruits (36%) followed by P_5S_3 (28%) at 21 days storage. Maximum ripening was noticed in P_5S_3 (68%) at 28 days storage. The interaction P_5S_4 was significantly superior to others.

Keywords: Precooling, storage, temperature and ripening pattern

Introduction
Mango (*Mangifera indica* L.) is a delicious fruit. Besides its fine taste, high palatability, sweet fragrance, attractive colour and nutritional value, it is called as 'the king of fruits' and is also a national fruit of India. It is good source of vitamin A, and C. India is the largest producer of mango in the world and ranks first in area and production. Post-harvest handling is the problem of mango as due to climacteric nature of the fruit. So, post-harvest handling can play a major role to reduce the losses. The post-harvest losses in mango are about 25 to 30 per cent post-harvest losses. This is mainly due to the non-availability of commercial low temperature store houses, lack of cool chain during transport and storage (Krishnamurthy and Rao, 2001) [4]. Ripening is the process by which fruits attain their desirable flavour, quality, colour, palatable nature and other textural properties. Ripening is associated with change in composition i.e. conversion of starch to sugar. On the basis of ripening behavior, fruits are classified as climacteric and non-climacteric fruits. Mango is a climacteric in nature. One of the most important factors affecting post-harvest life and quality of horticultural crops is temperature. Similarly, low-temperature storage has been one of the most effective methods for maintaining the quality of most of the fruits and vegetables. This method reduces the rate of respiration, ethylene production, ripening, senescence, undesirable metabolic changes and further decay (Niranjana *et al.,* 2009) [5]. Kapse (1993) [3] reported that the pre-cooling of mango cv. Kesar at 12 and 16 ºC temperature resulted in improving the quality of ripened fruits and delayed ripening. Nair and Singh (2009) [7] observed that mango is highly sensitive to lower temperature storage below 10–13 °C due to chilling injury. Thus, optimum temperature required for ripening of mango varied from cultivar type and agro-climatic conditions during growth and development of the fruit. Alphonso is premium export cultivar and the export by air is very costly. Hence, if shelf life of fruits increased without affecting the quality up to about 30 days, it can be exported through sea route. This will reduce the freight cost and will boost the export of fresh fruits. However, harvested mango fruits, are kept in cold storage with or without precooling. After storage they are directly brought to ambient temperature for ripening. This affects the quality of fruits and cause losses. In order to reduce these losses, it is necessary to standardize precooling and storage methods at different temperatures. In view of this, the effect of precooling and storage temperatures on ripening pattern of mango cv. Alphonso during storage was investigated.

Materials and Methods

Physiologically mature, hard green fruits at optimum maturity of mango Cv. Alphonso were harvested with the help of Nutan Zela with keeping 2.5 to 3.5 cm stalk during morning hours from the Regional Fruit Research Station, Vengurle Dist. Sindhudurg (Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli) during May 2016**.** After harvesting, the fruits were treated with 0.1% carbendazine and kept under shade for 1-2 hours in order to dry them. The experiment was laid out in Factorial Completely Randomized Design (FCRD) with two replications. Initial observation was recorded and fruits were kept in forced air cooling chamber for the pre-cooling at P_1 – Control, P_2 – 21 ± 2 ^{0}C, P_3 - 18 ± 2 ^{0}C, P_4 – 15 ± 2 ^{0}C and P_5 - 12 ± 2 ^{0}C. The precool temperature was checked by using thermometer which was inserted in the pulp of the fruit and the constant temperature maintained. Precooled fruits were stored for 21 days at different storage temperature like S_1-Ambient temperature (27-30 ^{0}C), S_2-18 ± 2 ^{0}C, S_3-15 ± 2 ^{0}C and S_4 -12 ±2 ^{0}C. After 21 days storage, fruits were again brought to above precooling temperature by forced air cooling and kept for ripening for 7 days at room temperature. To record the ripening pattern, the fruits were categorized into seven groups *viz*; green, turning, half ripe, ripe, overripe, shrivelled and diseased. This ripening pattern under each treatment was studied at 7 days interval.

Results and Discussion

Ripening pattern: Mango being a climacteric fruit, its ripening is characterised by a sharp increase in ethylene production and respiratory climacteric, followed by series of biochemical changes. Treatments which render a favourable conditions for these changes during the course of normal ripening that ultimately decide the final quality and shelf life of fruit.

Data regarding the effect of different precooling and storage temperature on ripening pattern of Alphonso mango fruit exhibited during subsequent stages of ripening are given in Table.

It is revealed from the data that the ripening was fastest at ambient temperature (S_1), followed by 18 ^{0}C (S_2), 15 ^{0}C (S_3) and 12 ^{0}C (S_4) temperature. The peak ripening was noticed after 14 days at ambient temperature (S_1) and after 21 days at 18 ^{0}C (S_2), 15 ^{0}C (S_3) and 12 ^{0}C (S_4) temperature, this could be due to low temperature and high humidity which hindered or slowed down the ripening process.

Interaction P_1S_1 (control) recorded maximum ripe shrivelled (52%) and diseased fruits (16%) at 21 days storage and it showed poor ripening trend. In interactions P_5S_2, P_5S_3 and P_5S_4 observed that up to 14 days fruits remained green. Interaction P_5S_4 showed maximum green fruits (36%) followed by P_5S_3 (28%) at 21 days storage. Maximum ripening was noticed in P_5S_3 (68%) at 28 days storage. The interaction P_5S_4 was significantly superior to others. This findings are in conformity to the observations reported by Gole (1986) [1], Badar (1990) [2] and Padhye (1997) [6].

Table 1: Effect of precooling and storage temperatures on ripening pattern of mango fruits during storage

Days	Green	Green Shrivel	Turning	Half Ripe	Ripe	Ripe Shrivel	Diseased	Total
P1S1								
0	25 (100)	0	0	0		0	0	25
7	7 (28)	0	12 (48)	5 (20)	1 (4)	0	0	25
14	3 (12)	2 (8)	12 (48)	4 (16)	3 (12)	0	1 (4)	25
21	0	3 (12)	0	2 (8)	8 (32)	13 (52)	4 (16)	25
28	-	-	-	-	-	-	-	-
P2S1								
0	25 (100)	0	0	0	0	0	0	25
7	18 (72)	0	6 (24)	1 (4)	0	0	0	25
14	14 (56)	2 (8)	6 (24)	2 (8)	1 (4)	0	0	25
21	0	5 (20)	0	1 (4)	2 (8)	9 (36)	3 (12)	25
28	-	-	-	-	-	-	-	-
P3S1								
0	25 (100)	0	0	0	0	0	0	25
7	19 (76)	0	5 (20)	1 (4)	0	0	0	25
14	11 (44)	1 (4)	9 (36)	3 (12)	1 (4)	0	0	25
21	0	4 (16)	0	2 (8)	4 (16)	12 (48)	3 (12)	25
28	-	-	-	-	-	-	-	-
P4S1								
0	25 (100)	0	0	0	0	0	0	25
7	21 (84)	0	3 (12)	1 (4)	0	0	0	25
14	8 (32)	2 (8)	11 (44)	2 (8)	1 (4)	0	1 (4)	25
21	0	6 (24)	0	1 (4)	7 (24)	9 (36)	2 (8)	25
28	-	-	-	-	-	-	-	-
P5S1								
0	25 (100)	0	0	0	0	0	0	25
7	21 (84)	0	3 (12)	1 (4)	0	0	0	25
14	12 (48)	1 (4)	8 (32)	3 (12)	1 (4)	0	0	25
21	0	3 (12)	3 (12)	1 (4)	8 (32)	8 (32)	2(8)	25

Contd…….

Days	Green	Green Shrivel	Turning	Half Ripe	Ripe	Ripe Shrivel	Diseased	Total
P1S2								
0	25 (100)	0	0	0	0	0	0	25
7	19 (76)	0	6 (24)	0	0	0	0	25
14	19 (76)	0	6 (24)	0	0	0	0	25

21	0	0	2 (8)	2 (80)	20 (80)	0	1 (4)	25
28	0	0	2 (8)	1 (40)	15 (60)	5 (20)	2 (8)	25
P2S2								
0	25 (100)	0	0	0	0	0	0	25
7	19 (76)	0	4 (16)	2 (8)	0	0	0	25
14	18 (72)	0	5 (20)	1 (4)	1 (4)	0	0	25
21	1 (4)	0	2 (8)	12 (48)	9 (36)	0	1 (4)	25
28	1 (40	0	3 (12)	2 (8)	14 (56)	2 (8)	3 (12)	25
P3S2								
0	25 (100)	0	0	0	0	0	0	25
7	20 (80)	0	4 (16)	1 (4)	0	0	0	25
14	20 (80)	0	2 (8)	2 (8)	1 (4)	0	0	25
21	7 (28)	0	1 (4)	5 (20)	10 (40)	0	2 (8)	25
28	2 (8)	0	5 (20)	3 (12)	13 (52)	1 (4)	1 (4)	25
P4S2								
0	25 (100)	0	0	0	0	0	0	25
7	23 (92)	0	2 (8)	0	0	0	0	25
14	19 (76)	0	4 (16)	1 (4)	1 (4)	0	0	25
21	1 (4)	0	4 (16)	5 (20)	14 (56)	0	1 (4)	25
28	0	0	3 (12)	3 (12)	16 (64)	1 (4)	2 (8)	25
P5S2								
0	25 (100)	0	0	0	0	0	0	25
7	25 (100)	0	0	0	0	0	0	25
14	25 100)	0	0	0	0	0	0	25
21	3 (12)	0	6 (24)	4 (16)	11 (44)	0	1 (4)	25
28	3 (12)	0	5 (20)	8 (32)	8 (32)	0	1 (4)	25

Contd…….

P1S3								
Days	**Green**	**Green Shrivel**	**Turning**	**Half Ripe**	**Ripe**	**Ripe Shrivel**	**Diseased**	**Total**
0	25 (100)	0	0	0	0	0	0	25
7	23 (92)	0	2 (8)	0	0	0	0	25
14	20 (80)	0	3 (12)	1 (4)	1 (4)	0	0	25
21	6 (24)	1 (4)	6 (24)	7 (28)	5 (20)	0	0	25
28	0	0	6 (24)	2 (8)	15 (60)	1 (4)	1 (4)	25
P2S3								
0	25 (100)	0	0	0	0	0	0	25
7	21 (84)	0	3 (12_	1 (4)	0	0	0	25
14	20 (80)	0	4 (16)	0	1 (4)	0	0	25
21	1 (4)	0	5 (20)	3 (12)	16 (64)	0	0	25
28	1 (4)	0	3 (12)	3 (12)	16 (64)	1 (4)	1 (4)	25
P3S3								
0	25 (100)	0	0	0	0	0	0	25
7	25 (100)	0	0	0	0	0	0	25
14	25 (100)	0	0	0	0	0	0	25
21	6 (24)	0	3 (12)	5 (20)	9 (36)	0	2 (8)	25
28	2 (8)	1 (4)	4 (16)	1 (4)	14 (56)	1 (4)	2 (8)	25
P4S3								
0	25 (100)	0	0	0	0	0	0	25
7	24 (96)	0	1 (4)	0	0	0	0	25
14	23 (92)	0	2 (8)	0	0	0	0	25
21	2 (8)	0	3 (12)	6 (24)	13 (52)	0	1 (4)	25
28	3 (12)	0	5 (20)	1 (4)	13 (52)	0	3 (12)	25
P5S3								
0	25 (100)	0	0	0	0	0	0	25
7	25 (100)	0	0	0	0	0	0	25
14	25 (100)	0	0	0	0	0	0	25
21	7 (28)	0	2 (8)	4 (16)	12 (48)	0	0	25
28	1 (4)	0	4 (16)	2 (8)	17 (68)	0	1 (4)	25

Contd……

P1S4								
Days	**Green**	**Green Shrivel**	**Turning**	**Half Ripe**	**Ripe**	**Ripe Shrivel**	**Diseased**	**Total**
0	25 (100)	0	0	0	0	0	0	25
7	24 (96)	0	1 (4)	0	0	0	0	25
14	22 (88)	0	3 (12)	0	0	0	0	25
21	11 (44)	0	4 (16)	5 (20)	4 (16)	0	1 (4)	25
28	5 (20)	1 (4)	3 (12)	1 (4)	12 (48)	2 (8)	1 (4)	25
P2S4								

0	25 (100)	0	0	0	0	0	0	25
7	25 (100)	0	0	0	0	0	0	25
14	24 (96)	0	1 (4)	0	0	0	0	25
21	9 (36)	0	9 (36)	4 (16)	2 (8)	0	1 (4)	25
28	1 (4)	1 (4)	3 (12)	6 (24)	9 (36)	4 (16)	1 (4)	25
P3S4								
0	25 (100)	0	0	0	0	0	0	25
7	24 (96)	0	1 (4)	0	0	0	0	25
14	21 (84)	0	4 (16)	0	0	0	0	25
21	8 (32)	0	5 (20)	3 (12)	7 (28)	0	2 (8)	25
28	2 (8)	2 (8)	2 (8)	2 (8)	10 (40)	5 (20)	2 (8)	25
P4S4								
0	25 (100)	0	0	0	0	0	0	25
7	24 (96)	0	1 (4)	0	0	0	0	25
14	20 (80)	0	4 (16)	1 (4)	0	0	0	25
21	3 (12)	0	10 (40)	3 (12)	8 (32)	0	1 (4)	25
28	0	0	4 (16)	4 (16)	14 (56)	2 (8)	1 (4)	25
P5S4								
0	25 (100)	0	0	0	0	0	0	25
7	25 (100)	0	0	0	0	0	0	25
14	25 (100)	0	0	0	0	0	0	25
21	9 (36)	0	9 (36)	5 (20)	1 (4)	0	1 (4)	25
28	1 (4)	0	2 (8)	8 (32)	12 (48)	1 (4)	1 (4)	25

Figures in parenthesis indicates percent value
Precooling temperature: - 1) P_1 – Control, 2) P_2 – 21 ± 2˚C, 3) P_3 - 18 ± 2˚C, 4) P_4 – 15 ± 2˚C, 5) P_5 - 12 ± 2˚ C
Storage temperature: - 1) S_1 – Ambient temperature, 2) S_2 - 18 ± 2˚C, 3) S_3–15 ± 2˚C, 4) S_4 - 12 ± 2˚ C

Conclusion

In the present investigation we conclude that in the ripening pattern, the peak ripening of Alphonso mango fruits was noticed after 14 days at ambient temperature (S_1) and after 21 days peak ripening was observed in S_2 (18 ^{0}C), S_3 (15 ^{0}C) and S_4 (12 ^{0}C) temperature. Interaction P_5S_4 showed maximum green fruits (36%) followed by P_5S_3 (28%) at 21 days storage. The interaction P_5S_4 was significantly superior to others.

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