International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2021; 9(1): 1841-1845

Received: 24-11-2020
Accepted: 30-12-2020

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Influence of sea proximity and soil variations on fruit quality and post - harvest behavior of Alphonso mango *Mangifera indica* L. under coastal belt of Konkan

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DOI: https://doi.org/10.22271/chemi.2021.v9.i1z.11493

Abstract
The investigation was carried out to study the effect of sea proximity and soil variations on fruit quality and post-harvest behaviour of Alphonso mango. The physical parameters like length, breadth, weight and volume of fruit, specific gravity, skin thickness, pulp: stone, per cent weight of pulp, per cent weight of stone and per cent weight of peel and chemical parameters of the fruit such as total soluble solids, reducing sugars, total sugars, pH, titratable acidity and abscorbic acid content in fruit were investigated. The fruits were examined for their sensory qualities when they were ripe for accessing the colour, flavour and texture. The maximum length, breadth, volume of fruit, weight of fruit, weight of stone, skin thickness, skin weight, weight (ripe) and per cent weight of stone, and per cent weight of peel was observed at location away from the proximity to sea i.e. 25kms proximity to sea and the fruits obtained from plain land with good soil depth; while the maximum pulp: stone ratio and per cent weight of pulp was observed at location nearest to the sea i.e.<1kms from sea (L1) and in the fruits harvested from hilly terrain with red lateritic rocks. The titratable acidity and ascorbic acid was found to be maximum in fruits harvested from location, 25kms away from the sea and plain land with good soil depth; while the maximum pH, TSS, reducing sugar and total sugar was recorded in fruits harvested from the location nearest to sea i.e. <1 km proximity to sea and hilly terrain with red lateritic rocks. The maximum percent physiological loss in weight was recorded at 25kms proximity to sea and at the site where trees are planted on plain land with deep soil than other sea proximities and soil types. The highest shelf life of fruits (13.33 days) was observed at location less than 1km proximity to sea and in the fruits collected from the site hilly terrain with rocky soils as compared to other locations and soil types. The score of colour, flavor, taste and overall acceptability (average) of Alphonso mango fruit was found to be higher in the fruits collected from the location nearest to the sea and hilly terrain with rocky soils.

Keywords: Alphonso mango, sea proximity, soil types, fruit quality

Introduction
Mango (*Mangifera indica* L.) is the most important fruit of the Anacardiaceae family and is believed to have originated in the Indo-Burma region (Mukheerjee, 1972) [6], Possessing the pride position among tropical and sub-tropical regions. In India, it is most popular and choicest of all indigenous fruits amongst the millions of people hence, it is considered as a “King of Fruit” and contributes about 41 per cent of the world production. India still dominates the world production and ranks first with a total production of 21822 thousand tons from about 2258 thousand with productivity of 9.7 MT/ha in 2017-18 (Annonymous, 2018) [2]. Maharashtra state is emerging as the leading mango growing states, currently occupying 166.76 thousand ha area with production of 791.36 thousand metric tons and productivity 4.75 tons/ha. The Konkan region of Maharashtra is emerging as one of the biggest mango growing belts in India which accounts only one per cent of total geographical area of country, occupies about 8 per cent of total area (1.83 lakh ha) under mango in the country. However, the production is only 4 lakh tons with a productivity of about 2.5 tons ha-1. This region comprises two agro-climatic zones (North and south coast zones) is a long strip of 720 kms, stretching from north of Goa to south of Gujarat along the west coast of India,

Topographically, a region is distinctly different from other parts of country, Hilly terrain, well drain, slightly acidic in nature, red lateritic soil with assured annual rainfall ranging from 3000-3500mm during June-September, followed by bright sunny days period of over seven months from October to May, mild winter (December-February) during flowering and mild summer (March-May) during fruit development, render this region is one of the best region in the world for commercial cultivation of Mango and known worldwide as homeland for commercial cultivation of world famous Indian mango Cv, Alphonso, locally known as hapus.

Alphonso possesses many significant attributes such as attractive colour and flavour, ample sweetness, low fibre-containing pulp and long shelf life. Despite having so many virtues, cultivation of Alphonso in different localities in India does not result in same quality of fruits. Even within Konkan region, the fruits show conspicuous variation in their taste and flavour. The altitude and topographical variation can bring about changes which significantly affect plant growth and quality of mango, thus there is very considerable climatic variability in both macro and micro scale. The growth, yield and quality of Alphonso mango seems to be varying according to the coastal low land and upland. It is believed that the fruit quality is highly influenced by proximity to sea and soil type. Therefore, an experiment was conducted with an objective to study the effect of sea proximity and soil variations on fruit quality and post-harvest behaviour of Alphonso mango.

Material and Methods

The present investigation was conducted at three locations *viz*. Karde/Murud (<1 km proximity to sea), Dapoli (10 kms proximity to sea) and Wakavali (25 kms proximity to sea) Tal. Dapoli, Dist. Ratnagiri (Maharashtra), during the year 2017-2018 and 2018-19.The experiment was laid down in factorial randomized block design. The experimental details were as follows,

A. Main treatments: Proximity to sea (km) (3)

1. L1-<1 km proximity to sea
2. L2- 10 kms proximity to sea
3. L3- 25 kms proximity to sea

B. Sub -treatments: Soil types (3)

1. S1 –Plain land with good soil depth (more than one meter)
2. S2 - Hilly terrain with good soil depth (more than one meter)
3. S3 – Hilly terrain with red lateritic rocks

Table 1: Treatment Combinations

Sr. No.	Treatment combinations	Treatment details
1	L1S1	<1km proximity to sea (N17o45.728‟, E073o07.198‟, Altitude-25 M MSL) with Alphonso mango plantation on plain land with good soil depth (more than 1 meter).
2	L1S2	<1km proximity to sea (N17o46.712‟, E073o07.557‟, Altitude-55 M MSL) with Alphonso mango plantation on hilly terrain with good soil depth (more than 1 meter).
3	L1S3	<1km proximity to sea (N17o44.375‟, E073o08.206‟, Altitude-177 M MSL) with Alphonso mango plantation on hilly terrain with red lateritic rocks.
4	L2S1	10 kms proximity to sea (N17o44.922‟, E073o11.112‟, Altitude-171 M MSL) with Alphonso mango plantation on plain land with good soil depth (more than 1 meter).
5	L2S2	10 kms proximity to sea (N17o46.054‟, E073o10.531‟, Altitude-196 M MSL) with Alphonso mango plantation on hilly terrain with good soil depth (more than 1 meter).
6	L2S3	10 kms proximity to sea (N 17o44.134‟, E073o09.908‟, Altitude-233 M MSL) with Alphonso mango plantation on hilly terrain with lateritic rocks.
7	L3S1	25 kms proximity to sea (N 17o44.064‟, E073o16.991‟, Altitude-179 M MSL) with Alphonso mango plantation on plain land with good soil depth (more than 1 meter).
8	L3S2	25 kms proximity to sea (N 17o43.933‟, E073o16.892‟, Altitude-209 M MSL) with Alphonso mango plantation on hilly terrain with good soil depth (more than 1 meter).
9	L3S3	25 kms proximity to sea (N 17o43.445‟, E073o16.700‟, Altitude-214 M MSL) with Alphonso mango plantation on hilly terrain with lateritic rocks.

The Alphonso mango trees of 20 to 30 years old having uniform size and canopy were selected for this experiment. Recommended cultural practices and plant protection measures were followed as per schedule formulated by Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli in order to protect blossom and fruit set from major pest (Mango hopper), diseases (Powdery mildew) and parasite like Loranthus. The recommended dose of FYM and N, P, K were applied in month of June as per recommended schedule.

The fruits were randomly harvested from the selected branches and following observations were recorded

Physical Parameters

The length of the fruit was recorded at harvest by measuring the linear distance from the point of attachment of stalk to the stylar end (apex of the fruit) and the breadth of the fruit was measured as the maximum linear distance between two shoulders of the fruit with the help of vernier calipers and expressed in centimeters. Weight of raw fruits immediately after harvest was recorded in grams and expressed as average fruits weight (g). The volume of fruits was determined by water displacement method and expressed in ml. The specific gravity of mango fruit was calculated by dividing the weight of fruit by volume of fruit. Percent weight of pulp, stone and peel was recorded for five fruits and averaged. The pulp to stone ratio was computed by dividing the average weight of pulp by weight of stone of same fruit. The fruits were examined for their sensory qualities when they were ripe for accessing the colour, flavour and texture. It was carried out by panel of 5 judges with score on 9 point Hedonic scale (Amerine *et al*., 1965) [1].

Chemical Parameters

Total soluble solids was measured by direct readings of mango using a digital Erma make hand refractometer (0° to 32° Brix range) and the value was expressed as 0Brix. The pH of mango fruit was determined by using pH meter at room temperature. Titratable acidity and ascorbic acid were

determined as per the procedure of Ranganna (1997) [11]. The titrimetric method of Lane and Eynon described by Ranganna (1997) [11] was adopted for estimation of reducing sugar. The physiological loss in weight (%) and shelf life of fruits (In days) of Alphonso mango fruits during storage at ambient temperature recorded by using appropriate methods.

Result and Discussion

The quality of Alphonso mango fruits in terms of physico-chemical properties was analyzed during course of study. Fruit quality was considerably influenced by pre-harvest management and post-harvest conditions to which fruits are exposed. However, the geographic location also persuades the physical and chemical of fruits as prevailing edaphic and environmental factors impinge on quality aspects. The effect of these factors on quality of mango is judged by determining various physical and chemical properties of fruits.

Physical parameters of fruit: The values of various physical parameters of fruit of alphonso mango significantly differed due to sea proximities and soil variations and their interactions. In the present investigation, with respect to sea proximity irrespective of soil variations, the maximum length, breadth, volume of fruit, weight of fruit, weight of stone, skin thickness, skin weight, weight (ripe) and per cent weight of stone, and per cent weight of peel was observed at location away from the proximity to sea i.e. 25 kms proximity to sea (L3); while maximum pulp: stone ratio and per cent weight of pulp was observed at location nearest to the sea i.e.<1kms from sea (L1). The specific gravity was found maximum at 10kms proximity to sea (L2) and minimum at 25kms proximity to sea (L1). With regards to the soil variations, the maximum specific gravity, pulp: stone ratio and % weight of pulp was observed in the fruits harvested from hilly terrain with red lateritic rocks (S3); while maximum length, breadth, weight and volume of fruit, weight of peel, weight of pulp, weight of stone, weight of skin and weight of ripe fruit, skin thickness, per cent weight of stone and per cent weight of peel was observed in the fruits obtained from plain land with good soil depth (S1).

Among the interactions, L3S1 recorded maximum length and breadth of fruit, weight of fruit, volume of fruit, weight of peel, weight of pulp and weight of stone, skin thickness, skin weight, ripe fruit weight, per cent weight of stone and per cent weight peel and maximum pulp: stone ratio and per cent weight of pulp was recorded in L1S3 interaction.

The colour, flavour, taste of mango pulp was significantly varied among the various sea proximities, soil variations and their interactions. The Higher score of colour (8.33), flavour (8.39) and taste (8.39) of pulp was found at location nearest to the sea (L1) than location 25kms proximity to sea. The score of colour flavour and taste of pulp was noted maximum in hilly terrain with rocky soil than plain with good soil depths. Among the interactions, L1S3 showed highest score of colour (8.92), flavour (9.00) and taste (8.33) of pulp; while the minimum score of colour (6.67), flavour (7.00) and taste (6.75) of pulp was registered in L3S1. The variation in the physical properties of mango fruits were also reported by Madigu *et al.* (2009) [4], Rajan *et al.* (2013) [10], Chovatiya *et al.* (2015) [3] and Wei *et al*. (2017) [12].

Chemical parameters of fruit

In the present investigation, with respect to sea proximity irrespective of soil variations, the increasing trend in titratable acidity and ascorbic acid and decreasing trend in pH, total soluble solids, reducing sugar and total sugar content in fruit was observed from<1 km from sea (L1), to 25 kms proximity to sea (L3). These trends indicated that the titratable acidity and ascorbic acid was maximum at location, 25 kms away from the sea (L3) than the location nearest to the sea i.e. <1 km from sea (L1); while the maximum pH, TSS, reducing sugar and total sugar was recorded at the location nearest to sea i.e.<1 km proximity to sea (L1) location and minimum at 25 kms proximity to sea (L3) location.

With regards to the soil variations, the maximum pH, TSS, reducing sugar and Total sugar was recorded at hilly terrain with red lateritic rocks (S3) than plain land with good soil depth (S1) while the maximum titratable acidity and ascorbic acid was recorded at plain land with good soil depth (S1)than hilly terrain with red lateritic rocks (S3).

Among the interactions, L1S3 recorded maximum pH, total soluble solids, reducing sugar and total sugar; while maximum titratable acidity and ascorbic acid was recorded in L3S1 and L2S1 interactions respectively. The high pH, TSS, reducing sugar and total sugar content in the fruits of Alphonso mango grown at location nearest to sea and on hilly terrain with lateritic rocks may attributed to presence of low moisture in the soil and low leaf water potential. Manchekar (2011) also observed the significant difference in the chemical parameters in Alphonso mango fruits at different locations. Madigu *et al.* (2009) [4] studied the quality characteristics of mango (*Mangifera indica* L. cv. „Tommy Atkins") fruit from trees subjected to water stress which also supports the present findings. The quality aspects of Alphonso mango pulp in the mango orchards of Konkan region of Maharashtra are in line with the reports of Patil *et al*. (1990) [8] and Puranik (2015) [9]. Irrigation water amount also affected fruit quality parameters like fruit total soluble solids, soluble sugar, starch, titratable acid and vitamin C content. (Wei *et al*., 2017 and Nagle *et al*. 2010) [12, 7].

Correlation co-efficient value among different physical parameters of Alphonso mango indicated that per cent weight of pulp exhibited significantly negative correlation with length, breadth, fruit weight and volume of fruit, skin thickness, percent weight of stone and per cent weight of peel whereas per cent weight of pulp exhibited significantly positive correlation with specific gravity of fruit and pulp to stone ratio. Correlation co-efficient value among different chemical parameters of Alphonso mango indicated that total soluble solids (TSS) exhibited significantly negative correlation with titratable acidity and ascorbic acid content in fruit while had significantly positive correlation with reducing sugar, total sugar content in fruit and pH of fruit. Overall acceptability of the fruit exhibited significantly positive correlation with reducing sugar, total sugar content, pH, colour, flavor, taste and shelf life of fruit while it showed significantly negative correlation with titratable acidity, ascorbic acid content in fruit and physiologically loss in fruit.

Table 2: Influence of sea proximity, soil variations and their interactions on physical parameters of fruits of Alphonso mango

	Length of Fruit(cm)	Breadth of Fruit(cm)	Fruit Weight (g)	Volume of Fruit (ml)	Specific gravity	Skin Thickness (mm)	Skin Weight (g)	% Wt. of pulp	% Wt. of Stone	% Wt. of peel	Pulp: Stone
Location											
L1	8.05	7.15	238.57	222.79	0.99	1.84	0.31	67.1	14.99	17.92	4.49

L2	8.49	7.38	243.95	219.81	1.06	1.82	0.31	65.43	15.8	18.76	4.16
L3	9.13	7.7	252.34	233.72	0.9	1.87	0.33	65.21	16.18	18.6	4.04
S.E.	0.04	0.03	1.22	1.2	0.01	0.01	0	0.12	0.09	0.08	0.05
C.D.	0.12	0.1	3.66	3.61	0.02	0.03	0.01	0.35	0.28	0.24	0.14
Soil Variation											
S1	8.82	7.65	250.85	233.46	0.93	1.94	0.34	64.69	16.24	19.07	4
S2	8.66	7.49	247.03	229.15	0.97	1.85	0.32	65.96	15.72	18.33	4.22
S3	8.19	7.08	236.99	213.71	1.05	1.75	0.29	67.09	15.02	17.89	4.48
S.E.	0.04	0.03	1.22	1.2	0.01	0.01	0	0.12	0.09	0.08	0.05
C.D.	0.12	0.1	3.66	3.61	0.02	0.03	0.01	0.35	0.28	0.24	0.14
Interaction											
L1S1	8.51	7.33	241.71	229.15	0.93	1.91	0.33	65.83	15.35	18.82	4.3
L1S2	8.28	7.2	240.39	222.33	0.98	1.85	0.31	67.51	14.93	17.57	4.54
L1S3	7.36	6.91	233.61	216.9	1.05	1.77	0.3	67.95	14.68	17.37	4.63
L2S1	8.69	7.58	249.78	229.17	1	1.92	0.34	63.68	16.71	19.61	3.82
L2S2	8.59	7.41	248	227.26	1.05	1.83	0.32	65.47	15.85	18.68	4.14
L2S3	8.18	7.16	234.08	202.99	1.12	1.72	0.27	67.15	14.85	18	4.53
L3S1	9.27	8.05	261.07	242.05	0.86	2	0.36	64.57	16.65	18.79	3.89
L3S2	9.1	7.88	252.7	237.88	0.87	1.86	0.33	64.89	16.38	18.73	3.97
L3S3	9.03	7.18	243.27	221.25	0.98	1.75	0.3	66.18	15.52	18.3	4.27
S.E.	0.07	0.06	2.11	2.08	0.01	0.01	0.01	0.2	0.16	0.14	0.08
C.D.	0.2	0.17	NS	6.25	NS	0.04	0.02	NS	NS	0.42	NS

Table 3: Influence of sea proximity, soil variations and their interactions on chemical parameters of fruits of Alphonso mango

	Total Soluble salts (0Brix)	**pH**	**Titratable Acidity (%)**	**Ascorbic Acid (mg/100g)**	**Reducing Sugar (%)**	**Total Sugar (%)**	**PLW (%)**	**Shelf life of fruit (days)**
Location								
L1	21.42	4.62	0.27	45.35	4.39	18.21	11.88	13.33
L2	20.64	4.29	0.34	42.65	3.7	15.38	12.37	13.33
L3	19.56	4.24	0.37	53.51	3.35	12.43	13.25	12.89
S.E.	0.13	0.03	0.04	0.57	0.06	0.14	0.6	0.12
C.D.	0.4	0.11	0.11	1.72	0.19	0.42	0.18	0.37
Soil Variation								
S1	19.44	4.12	0.35	55.63	3.43	13.75	13.79	11.44
S2	20.33	4.37	0.33	49.76	3.64	14.82	12.64	13
S3	21.83	4.66	0.3	47.17	4.37	17.45	11.07	15.11
S.E.	0.13	0.03	0.04	0.57	0.06	0.14	0.6	0.12
C.D.	0.4	0.11	0.11	1.72	0.19	0.42	0.18	0.37
Interaction								
L1S1	20.67	4.5	0.26	50.16	3.86	16.92	12.94	12
L1S2	21.08	4.58	0.29	39.48	4.04	17.88	11.94	12.83
L1S3	22.5	4.78	0.27	45.35	5.26	19.81	10.78	15.17
L2S1	19.58	3.82	0.38	58.58	3.23	13.64	13.82	11.5
L2S2	20.17	4.32	0.33	52.31	3.55	13.93	12.44	13.17
L2S3	22.17	4.73	0.31	42.65	4.31	18.56	10.85	15.33
L3S1	18.08	4.05	0.4	58.16	3.19	10.69	14.63	10.83
L3S2	19.75	4.22	0.36	57.5	3.31	12.64	13.56	13
L3S3	20.83	4.45	0.33	53.51	3.54	13.97	11.58	14.83
S.E.	0.23	0.06	0.07	0.99	0.11	0.24	0.1	0.2
C.D.	NS	0.19	0.2	2.97	0.33	0.73	0.31	NS

Table 4: Influence of sea proximity, soil variations and their interactions on colour of pulp, flavour and taste of fruit of Alphonso mango

	Colour of pulp	**Flavour of Pulp**	**Taste of pulp**	**Average (Overall acceptability)**
Location				
L1	8.33	8.39	8.39	8.38
L2	7.94	7.94	8.06	7.97
L3	7.5	7.67	7.67	7.6
S.E.	0.07	0.07	0.06	0.05
C.D.	0.22	0.2	0.19	0.16
Soil Variation				
S1	7.17	7.33	7.39	7.32
S2	7.97	7.97	8.06	7.96
S3	8.64	8.69	8.67	8.67
S.E.	0.07	0.07	0.06	0.05
C.D.	0.22	0.2	0.19	0.16
Interaction				
L1S1	7.83	7.92	8.08	7.97
L1S2	8.25	8.25	8.25	8.25
L1S3	8.92	9	8.83	8.92

L2S1	7	7.08	7.33	7.14
L2S2	7.92	7.92	8	7.92
L2S3	8.92	8.83	8.83	8.86
L3S1	6.67	7	6.75	6.86
L3S2	7.75	7.75	7.92	7.72
L3S3	8.08	8.25	8.33	8.22
S.E.	0.13	0.11	0.11	0.09
C.D.	0.38	0.33	0.33	0.27

Table 5: Correlation co-efficient value among different physical parameters of Alphonso mango

	Length of fruits	Breadth of fruits	Fruit weight	Volume of fruit	Specific gravity	Pulp: stone	Skin: thickness	% wt. Of pulp	% wt. Of stone	% wt. Of peel
Length of fruits	1.000									
Breadth of fruits	0.802**	1.000								
Fruit weight	0.826**	0.902**	1.000							
Volume of fruit	0.662**	0.806**	0.845**	1.000						
Specific gravity	-0.630**	-0.701**	-0.639**	-0.867**	1.000					
Pulp: stone	-0.683**	-0.771**	-0.679**	-0.693**	0.583**	1.000				
Skin: thickness	0.483*	0.701**	0.698**	0.801**	-0.709**	-0.649**	1.000			
% wt. Of pulp	-0.651**	-0.721**	-0.633**	-0.639**	0.521*	0.978**	-0.635**	1.000		
% wt. Of stone	0.685**	0.794**	0.708**	0.710**	-0.597**	-0.994**	0.662**	-0.956**	1.000	
% wt. Of peel	0.546*	0.565*	0.484*	0.494*	-0.383	-0.858**	0.539*	-0.945**	0.807**	1.000

Table 6: Correlation co-efficient value among different physical parameters, storage and sensory parameters of Alphonso mango

	TA	AA	Red Sugar	Total sugar	TSS	pH	Colour	Flavour	Taste	Overall acceptability	PLW	Shelf life of fruit
TA	1.000											
AA	0.619**	1.000										
Red Sugar	-0.667**	-0.696**	1.000									
Total sugar	-0.790**	-0.802**	0.860**	1.000								
TSS	-0.723**	-0.730**	0.841**	0.892**	1.000							
pH	-0.747**	-0.754**	0.785**	0.811**	0.833**	1.000						
Colour	-0.659**	-0.716**	0.688**	0.764**	0.871**	0.824**	1.000					
Flavour	-0.644**	-0.648**	0.687**	0.726**	0.738**	0.758**	0.639**	1.000				
Taste	-0.605**	-0.560*	0.669**	0.707**	0.840**	0.695**	0.754**	0.545*	1.000			
Overall acceptability	-0.713**	-0.767**	0.797**	0.840**	0.944**	0.867**	0.892**	0.788**	0.841**	1.000		
PLW	0.452	0.573**	-0.759**	-0.710**	-0.844**	-0.753**	-0.745**	-0.693**	-0.725**	-0.848**	1.000	
Shelf life of fruit	-0.443	-0.532*	0.661**	0.607**	0.835**	0.755**	0.801**	0.707**	0.740**	0.869**	-0.909**	1.000

(TA-Titratable acidity, AA-Ascorbic acid, TSS-Total soluble solids, PLW-Physiological loss in weight)

Conclusion

The fruits of Alphonso mango harvested from the orchards close to sea proximity and red lateritic rocks exhibited better post-harvest fruit quality in terms pulp: stone ratio, reducing sugar, total sugar, total soluble solids, pH, colour, flavor and taste.

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