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RESEARCH PAPER

Physical, chemical and quality attributes of Alphonso mango (*Mangifera indica*) fruits of different orchards in Dharwad district, Karnataka

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Abstract: A survey was undertaken during summer 2021 in selected talukas of Dharwad district to ascertain the reasons for wide variation in quality of Alphonso mango fruits produced from different orchards. Totally 32 orchards spread over in Dharwad, Alnavar and Kalaghatagi talukas were selected. Soil, index leaf and fruit samples were collected and analysed for nutrients and quality parameters. In index leaf samples, nutrients followed the order N>Ca ≥ K>Mg>S>P while in fruit samples the order was N ≥ K≥Ca>Mg>P>S. In all fruit samples, pulp+juice contributed 50 to 60 per cent or even more (80 %) to total fruit weight, where as peel contributes 10 to 20 per cent. Ripened mango fruits weigh 10 to 15 grams lesser than unripened fruits. pH of pulp + juice of mango fruits ranged from 4.25 to 5.13. In all fruits, non-reducing sugars were more (5.56 to 10.76 %) than reducing sugars (3.15 to 4.44 %). Fruits of Kalaghatagi medium black soil orchards contained highest total sugars (13.34 %), Beta-carotene pigment (82.53 mg kg^{-1}) and fructose sugar (92.86 mg kg^{-1}), where as those from acid soils and red soils recorded lowest sugars (12.37 %), carotene (68.57 mg kg^{-1}) and fructose sugar (85.71 mg kg^{-1}). Fruit sugar content was significantly and positively correlated with leaf potassium content (r^2 =0.43*). To improve the fruit quality in shallow red and acid soils, application of lime, organic matter and critical nutrients particularly (N, K, Ca, Fe and Zn) are recommended.

Key words: Alphonso, Non reducing sugar, Pigments, Quality, Reducing

Introduction

Mango (*Mangifera indica* L.) the "King of Fruits" is the main fruit crop of Asia and possesses it's own importance all over the world. It belongs to the family Anacardiaceae. It is also called "Nectar of God" being most palatable and rich in sugars, organic acids and minerals. The Alphonso variety of mango is unique with regard to quality attributes. The fruit has very thin skin, high amount of pulp and juice. It has dark orange colour pulp with characteristic flavor, least fibres and good keeping quality. Because of its shape, size and colour of skin, it is highly preferred by consumers and food industry. The productivity and quality of mango is greatly influenced by fertilizers and agro-chemicals. Nutrient management is one of the important components of mango production technology. Application of balanced amount of nutrients at proper growth stage either by soil application or through foliar spray or both may improve quality and yield of mango. It is observed that imbalanced fertilization is considered to be one of the major contributing factors for the low productivity and quality of mango.

Major and micronutrients are taken up and assimilated by the tissues of the plants in varying quantities depending on the plant need. Potassium is a quality nutrient that needs to be provided in relatively large amounts particularly to fruit crops. There is a direct relationship between potassium accumulation in the plant tissues and fruits quality and carbohydrate content. Potassium has a well established role in maintaining nitrogen to carbon ratio in plants. It also plays a major role in sugar synthesis and translocation of sugars to storage organs. Das (2006) reported that micronutrients play a vital role in various enzymatic activities and synthesis of assimilates and hormones. Irregular fruit bearing in mango is a major problem in India and nutrients management may also be one of the reasons for this phenomenon. Mango malformation is also another problem which greatly reduces fruit bearing. Quality of mango fruits and their keeping quality is also influenced by nutrition (Raghupathi and Bhargava, 1999).

Material and methods

A preliminary survey was undertaken during the month of November 2020 in selected talukas of Dharwad district to identify the mango orchards, where Alphonso cultivar is being grown. Orchards of preferably same age and varying soil types were selected. Based on the uniformity of orchards with respect to age and vigour, a total of thirty two representative orchards spread over in Dharwad, Alnavar and Kalaghatagi talukas were selected. "Alphonso" variety of mango was selected for the study as most of the well established orchards in these areas are under this variety.

Three mango fruits collected from each orchard which were of uniform size and ripened properly. Fruits were collected during second week of May. These fruits were kept for ripening in laboratory for 10 days under dry paddy straw. After ripening, these fruits were utilized for physical, chemical and nutrients analysis. Three fruits collected from each orchard were analysed individually for physical and chemical properties. The pulp + juice of all the three fruits was composited and analysed for various physical, chemical and quality parameters like fruit weight determined by measuring the fruits on a weighing balance, fruit density calculated by water displacement method, volume of the fruit calculated by water displacement method,

juice content, pulp content, peel content were determined by employing gravimetric method as given by Singh *et.al* (2020), refractive index was estimated using a hand refracatometer (Chatwal and Anand, 1979), juice pH determined by potentiometric method as given by Gupta (2007), titratable acidity estimated by using the method employed by Gupta (2007), total soluble salts estimated by conductometric method given by Gupta (2007), fructose sugars content estimated by employing Roe's colorimetric method as given by Gupta (2007) and pigment content estimated by employing the methods given by Sadasivam and Manickam (1996).

Results and discussion

It was observed that, on an average unripened fruits of Dharwad taluka orchards recorded highest weight (range 149.50 to 303.49 g) with a mean of 248.91 g, closely followed by fruits of Alnavar taluka with an average of 240.66 g (Table 1). Lastly fruits of Kalaghatagi taluka recorded lowest fruit weight of

Table 1. Physical properties of mango fruit samples*

Sample number	Weight of unripened fruit (g)	Weight of ripened fruit (g)	Per cent reduction in fruit weight	Volume of unripened fruit (cc)	Density of unripened fruit (g cm^{-3})
		Dharwad taluka			
1	149.50	114.30	23.54	122.50	1.22
2	226.50	208.90	7.70	195.50	1.16
3	277.60	268.30	3.35	244.60	1.13
4	236.50	216.50	8.45	192.00	1.23
5	274.80	252.30	8.18	228.00	1.21
6	246.80	223.10	9.60	213.80	1.15
7	280.20	261.30	6.75	221.00	1.27
8	182.80	159.40	12.50	118.00	1.55
9	217.30	202.30	6.90	163.00	1.33
10	292.90	269.80	7.88	239.00	1.23
11	292.80	239.70	18.13	259.80	1.13
12	205.50	173.40	15.62	121.00	1.70
13	252.10	210.00	16.69	197.00	1.28
14	244.70	205.30	16.10	187.00	1.31
15	303.40	284.90	6.09	243.00	1.25
16	271.90	239.50	11.91	218.00	1.25
17	270.70	242.80	10.30	208.00	1.30
18	298.60	254.40	14.80	254.40	1.28
Range	149.50-303.40	114.30-284.90	3.35-23.54	118.00-259.00	1.13-1.70
Mean	248.91	212.13	11.36	212.13	1.28
		Alnavar taluka			
19	318.10	283.40	10.90	223.00	1.43
20	308.00	276.90	10.09	221.00	1.39
21	217.20	193.40	10.95	165.00	1.32
22	140.30	107.60	23.30	107.30	1.31
23	322.10	288.50	10.43	258.00	1.25
24	235.00	206.10	12.29	183.00	1.28
25	143.90	112.50	21.82	105.00	1.37
Range	140.30-322.10	107.60-288.50	10.09-23.30	105.00-258.00	1.25-1.43
Mean	240.66	209.77	14.25	180.32	1.34
		Kalaghatagi taluka			
26	250.40	223.50	10.75	201	1.25
27	227.40	193.50	14.90	163	1.40
28	218.40	187.50	14.14	162	1.35
29	223.50	196.50	12.08	175	1.28
30	206.50	185.30	10.26	152	1.36
31	252.50	213.80	15.32	203	1.24
32	245.90	202.90	17.48	198	1.24
Range	206.50-252.50	185.30-223.50	10.26-17.48	152.00-203.00	1.24-1.40
Mean	232.09	200.43	13.55	179.14	1.30
		Overall			
Range	140.30-322.10	107.60-288.50	3.35-23.54	105.00-259.80	1.13-1.70
Mean	247.12	210.62	12.27	192.28	1.30
S.ED	45.18	46.09	4.56	42.65	0.12
C.V. (%)	18.28	21.88	37.16	22.18	9.23

*values are mean of three fruits

(Av. 232.09 g) . This variation in weight of unripened fruits might be due to accumulation of nutrients, moisture content and other organic constituents leading to alteration in the size of the fruits**.** Masroor *et al*. (2016) reported that, for Summer Bahisht Chaunsa mango cultivar the weight of the unripened fruits ranged from 270.19 to 430.12 gm. Hence the present values of weight of unripened fruits closely agree with the values reported by Masroor *et al*. (2016).

Weight of ripened fruits in the study area ranged from 107.60 to 288.50 g with a mean value of 210.62 g. Data clearly indicated that, ripened fruits recorded lesser weight than fresh fruits. The extent of reduction in fruit weight ranged from 3 to 23 per cent (Table 1). The reduction in weight of the ripened fruits was attributed to loss of moisture and changes in biochemical constituents like conversion of acids to sugar and synthesis of pigments. However majority of the ripened fruits recorded 10 to 15 per cent less weight than fresh fruits. The weight of ripened Alphonso mango fruits obtained in the present study closely agree with the values reported by Singh *et al*. (2020).

The volume of the unripened mango fruits ranged from 105.00 to 259.80 cc with a mean value of 192.28 cc. In general fruits of Dharwad taluka recorded highest volume (118.00 to

Table 2. Pulp weight, peel weight, pulp:peel ratio and refractive index of ripened mango fruits*

Weight of pulp+juice (g)	Weight of peel (g)	Pulp:Peel ratio	Refractive Index (RI)
	Dharwad taluka		
78.50 (68.67)	14.80 (12.94)	5.30:1	1.362
124.80 (59.74)	35.00 (16.75)	3.50:1	1.360
140.20 (52.25)	27.00 (10.06)	5.10:1	1.363
132.10 (61.01)	28.00 (12.93)	4.70:1	1.365
149.30 (59.17)	34.30 (13.59)	4.30:1	1.358
135.40 (60.69)	28.10 (12.59)	4.80:1	1.362
152.80 (58.47)	33.90 (12.97)	4.50:1	1.355
94.60 (59.34)	37.00 (23.20)	2.50:1	1.362
124.70 (61.64)	26.30 (13.00)	4.70:1	1.363
166.90 (61.86)	33.80 (12.52)	4.90:1	1.358
192.60 (80.35)	34.90 (14.55)	5.50:1	1.362
92.50 (53.34)	24.20 (13.95)	3.80:1	1.365
126.10 (60.04)	27.30 (13.00)	4.60:1	1.360
132.50 (64.53)	26.60 (12.95)	4.90:1	1.355
198.60 (69.70)	28.10 (09.86)	7.10:1	1.357
152.10 (63.50)	28.00 (11.69)	5.41:1	1.363
154.80 (63.25)	31.40 (12.93)	4.90:1	1.362
131.40 (44.00)	28.30 (9.47)	4.60:1	1.360
Range78.50-198.60	14.80-37.00	2.50:1 to 7.10:1	1.355-1.365
Mean	137.77	29.28	1.361
	Alnavar taluka		
195.20 (68.87)	36.70 (12.94)	5.30:1	1.357
187.20 (67.60)	35.80 (12.92)	5.20:1	1.355
119.60 (61.84)	26.20 (13.54)	4.50:1	1.362
64.20 (59.66)	20.50 (19.05)	3.10:1	1.357
215.30 (74.62)	27.10 (9.39)	7.97:1	1.358
123.60 (59.97)	23.50 (11.40)	5.20:1	1.360
67.20 (59.73)	14.50 (12.88)	4.60:1	1.362
Range64.20-215.30	14.50-36.70	3.10:1 to 7.97:1	1.355-1.362
Mean	138.90	26.32	1.359
	Kalaghatagi taluka		
139.00 (62.19)	30.80 (13.75)	4.50:1	1.360
123.60 (63.87)	26.10 (13.45)	4.70:1	1.366
127.10 (67.78)	24.30 (12.96)	5.20:1	1.365
121.50 (61.83)	27.40 (13.94)	4.40:1	1.365
118.40 (63.89)	25.90 (13.97)	4.50:1	1.362
134.00 (62.67)	28.50 (13.33)	4.70:1	1.357
125.30 (61.75)	26.20 (12.91)	4.70:1	1.358
Range118.40-139.00	24.30-30.80	4.40:1 to 5.20:1	1.357-1.366
Mean	126.99	27.02	1.362
Overall			
Range64.20-215.30	14.50-37.00		1.360-1.366
Mean	137.93	28.36	1.36
S.ED	35.50	4.91	
C.V. (%)	25.74	17.31	

*Figures in paranthesis indicate per cent values of pulp+juice and peel

259.00 cc) with an average of 198.34 cc closely followed by fruits of Alnavar taluka with an average of 180.32 cc, further followed by fruits of Kalaghatagi taluka (Av. 179.14 cc) variation in fruit volume was attributed to the size and shape of the fruit.

It was observed that, all the mango fruits recorded R.I. (Refractive index) values in the range of 1.355 to 1.366 with a mean value of 1.36. Chatwal and Anand (1979) reported that, for most of the liquids R.I. is in the range of 1.30 to 2.50 (Table 2). The values of R.I. obtained in the present study are similar to the findings of Dhopavkar (2001). Similar ranges of R.I. which indicate total soluble sugars content in mango fruits of (Cv. Alphonso) at ripening stage were also found by Alwala (2014) and Puranik (2015).

Data indicated that, pulp weight of Alphonso mango fruits collected from different orchards in the study area ranged from 64.20 to 215.30 g with a mean value of 137.93 g (Table 2). Wide variation was noticed with respect to pulp content. Majority of the fruit samples recorded pulp weight in the range of 125.00 to 150.00 g. With respect to pulp percentage which ranged from 61.22 to 83.84 per cent with a mean value of 66.65 per cent. Singh *et al.* (2020) reported maximum pulp percentage of 79.94 per cent for Dushehari variety of mango grown in Madhya Pradesh. Sarker *et al*. (2016) reported similar values of pulp content for Amrapali mango cultivar in Bangladesh. Krishnamoorthy and Hanif (2015) reported that, the pulp percentage in mango fruits Cv. Imampasand ranged from 72 to 74 per cent.

Peel weight of Alphonso mango fruits in the study area ranged from 14.50 to 37.00 g with a mean value of 28.36 g (Table 2). Not much variation existed between fruit samples of different talukas for peel content. Critical examination of the data indicated that, majority of the fruit samples recorded peel weight in the range of 25.00 to 35.00 g. With respect to peel per cent which ranged from 9.39 to 23.20 per cent with a mean value of 12.91 per cent. Majority of the fruit samples recorded peel content in the range of 12 to 14 per cent. The values of peel per cent obtained for Alphonso mango fruits closely agree with the values of Singh *et al*. (2020) as well as Krishnamoorthy and Hanif (2015).

The values of pulp:peel ratio for Alphonso mango fruits of Dharwad taluka ranged from 2.50:1 to 7.10:1(Table 2). Similarly for fruits of Alnavar and Kalaghatagi talukas the values ranged from 3.10:1 to 7.97:1 and 4.40:1 to 5.20:1 respectively. Wide ratio indicates the maximum quantity of pulp with minimum peel weight. Majority of the samples recorded pulp:peel ratio in the range of 4.50 to 5.00:1. The values of pulp:peel ratio obtained in the present investigation closely agree with the values reported earlier by Sarker *et al*. (2016) and Krishnamoorthy and Hanif (2015).

Data indicated that, pulp + juice samples of all the mango fruits recorded acidic pH which ranged from 4.23 to 5.13 with a mean value of 4.65 (Table 3). Narrow variation existed between fruit samples of different orchards for pH (range 4.62 to 4.69). Acidic pH of the fruit samples was due to the predominance of organic acids over sugars. Among the organic acids, malic acid was the dominant one (Gupta, 2007). Sarker *et al*. (2016) reported similar acidic pH values for fruit samples of Amrapali variety of mango.

Total soluble salts content in pulp + juice samples of Alphonso mango fruits ranged from 2.40 to 4.63 dS m^{-1} with a mean value of 3.33 dS m^{-1}(Table 3). Narrow variation existed between fruit samples for total soluble salts content (3.09 to 3.50 dS m^{-1}). Total soluble salts are contributed by chlorides and sulphates of calcium, magnesium, sodium and potassium. Among them potassium and calcium salts are dominant over sodium and magnesium.

Table 3. pH, total soluble salts and titratable acidity of ripened mango fruits

Sample Number	pH (pulp+juice)	Total soluble salts (dS m^{-1})	Titratable acidity (%)
	Dharwad taluka		
1	5.10	3.56	0.20
2	5.02	4.17	0.13
3	4.52	3.42	0.13
4	4.47	3.12	0.20
5	4.60	4.28	0.06
6	4.86	2.93	0.26
7	4.70	3.32	0.20
8	4.60	3.12	0.13
9	4.50	3.62	0.06
10	4.80	2.84	0.13
11	4.70	3.33	0.26
12	4.60	2.87	0.20
13	4.40	2.95	0.33
14	4.30	3.09	0.26
15	5.10	4.13	0.20
16	4.40	2.85	0.21
17	4.50	3.36	0.13
18	5.02	3.61	0.13
Range	4.30-5.10	2.84-4.28	0.06-0.33
Mean	4.68	3.37	0.18
	Alnavar taluka		
19	4.42	3.33	0.20
20	5.13	2.88	0.26
21	5.01	3.37	0.33
22	4.80	4.11	0.26
23	4.70	4.63	0.20
24	4.39	3.26	0.13
25	4.41	2.95	0.40
Range	4.39-5.13	2.88-4.63	0.13-0.40
Mean	4.69	3.50	0.25
	Kalaghatagi taluka		
26	4.23	2.78	0.13
27	4.60	3.13	0.13
28	4.86	3.26	0.26
29	4.50	2.85	0.20
30	4.73	4.03	0.06
31	4.80	2.40	0.20
32	4.60	3.19	0.20
Range	4.23-4.86	2.40-4.03	0.06-0.26
Mean	4.62	3.09	0.17
	Overall		
Range	4.23-5.13	2.40-4.63	0.06-0.40
Mean	4.65	3.33	0.19
S.ED	0.24	0.52	0.08
C.V. (%)	5.16	15.62	42.11

The titratable acidity of mango pulp samples ranged from 0.06 to 0.4 per cent with a mean value of 0.19 per cent (Table-3). It appears that all the fruit samples recorded low titratable acidity. This might be due to the fact that, as the fruits ripen there is conversion of acids to sugar and their derivatives by the reactions involving reversal of glycolytic pathway. Thakare (2016) reported that the values of titratable acidity of mango fruits of different orchards in Konkan ranged from 0.13 to 0.35 per cent. Similarly Anees *et al.* (2011) reported the values of Titratable acidity for Dashehari mango fruits ranging from 0.18 to 0.29 per cent.

Perusal of data presented in Table-4 showed that, reducing sugar content in mango fruit samples ranged from 3.15 to 4.44 per cent with a mean value of 3.77 per cent. It was observed that, fruit samples of Alnavar taluka recorded numerically higher reducing sugar content (range 3.65 to 4.37 %, Av. 4.07 %) closely followed by fruit samples of Kalaghatagi (range 3.37 to

Table 4. Reducing sugar, non reducing sugar, total sugars, fructose sugar and pigment content in ripened mango fruits

Sample number	Reducing sugars (%)	Non reducing sugars (%)	Total sugars (%)	Fructose sugar (mg kg^{-1})	Pigment content (mg kg^{-1})
			Dharwad taluka		
1	4.58	9.12	13.70	60.00	67.11
2	3.30	9.91	13.21	110.00	59.02
3	3.15	5.56	8.71	110.00	57.21
4	3.66	5.97	9.63	100.00	60.64
5	4.37	8.12	12.49	110.00	71.48
6	3.20	7.87	11.07	90.00	69.09
7	3.73	9.26	12.96	60.00	66.52
8	4.30	8.39	12.69	100.00	59.39
9	3.62	6.58	10.20	90.00	82.78
10	3.65	7.92	11.59	100.00	58.57
11	3.66	7.12	10.78	70.00	55.96
12	3.34	10.37	13.71	90.00	82.28
13	3.67	8.82	12.49	100.00	74.79
14	4.33	9.02	13.35	80.00	72.42
15	3.52	10.26	13.78	100.00	52.54
16	3.27	9.72	12.99	110.00	58.50
17	3.73	6.40	10.13	120.00	82.29
18	3.47	8.17	11.64	90.00	94.70
Range	3.15-4.58	5.56-10.37	8.71-13.78	60.00-120.00	52.54-94.70
Mean	3.70	8.25	11.95	93.89	68.07
			Alnavar taluka		
19	4.37	8.90	13.27	60.00	68.68
20	4.24	6.61	10.85	90.00	70.35
21	3.95	8.40	12.35	100.00	78.30
22	4.14	7.42	11.56	90.00	70.61
23	3.80	9.26	13.06	100.00	52.52
24	3.65	7.99	11.64	70.00	70.35
25	4.37	9.47	13.84	90.00	75.99
Range	3.65-4.37	6.61-9.47	10.85-13.84	60.00-100.00	52.52-78.30
Mean	4.07	8.30	12.37	85.71	69.54
			Kalaghatagi taluka		
26	3.37	10.76	14.13	60.00	68.68
27	3.70	10.00	13.70	90.00	70.35
28	3.73	9.69	13.42	100.00	78.30
29	3.86	9.77	13.63	90.00	70.61
30	3.67	8.39	12.06	100.00	52.52
31	4.44	8.27	12.71	70.00	70.35
32	3.42	10.29	13.71	90.00	75.99
Range	3.37-4.44	8.27-10.76	12.06-14.13	60.00-110.00	52.52-78.30
Mean	3.74	9.60	13.34	92.86	69.54
			Overall		
Range	3.15-4.44	5.56-10.76	8.71-14.13	60.00-120.00	50.44-143.67
Mean	3.77	8.48	12.27	92.33	72.41
SED	0.38	1.36	1.41	15.69	17.2
CV (%)	10.08	16.04	11.49	16.99	23.75

4.44 %) and Dharwad talukas (range 3.15 to 4.58 %). Das (2006) reported that, potassium plays role in sugar synthesis as it is a constituent of glycolytic pathway. High potassium content of both soils and leaves might have to high reducing sugar content in mango fruits of Alnavar taluka. The values of reducing sugar content obtained in the present study are similar with the findings of Alwala (2014) and Puranik (2015).

Total sugars content in Alphonso mango fruit samples ranged from 8.71 to 14.13 per cent with a mean of 12.27 per cent. Some variation existed between fruit samples of different talukas for sugar content, where in fruit samples of Kalaghatagi taluka recorded numerically higher values (range 12.06 to 14.13 per cent, Av. 13.34 %) than those of Alnavar (range 10.85 to 13.84 %) and Dharwad talukas (8.70 to 13.78 %). Similar to the relationship between reducing sugars and leaf/soil potassium, the same relationship persists for total sugars also. Masroor *et al.* (2016) reported that, the values of total soluble sugars content in mango mango cultivar Summer Bahisht Chaunsa ranged from 15.96 to 17.38 per cent (Table 4).

Non reducing sugars were computed by deducting reducing sugars from total sugars. Data indicated that, non reducing sugars content in mango fruits ranged from 5.56 to 10.76 per cent with a mean of 8.48 per cent (Table 4). Similar to the trend as observed for total sugars, fruits of Kalaghatagi taluka recorded highest non reducing sugar content (8.27 to 10.76 %, mean 9.6 %) closely followed by fruits of Alnavar (6.61 to 9.47 %) and Dharwad talukas (Av. 8.25 %).

Fructose sugar content ranged from 60.00 to 120.00 mg kg^{-1} with an average of 92.33 mg kg^{-1} (Table 4). It was observed that fruit samples in all the talukas (Table 4) differ widely with respect to fructose sugar content and the variation was 60.00 to 120.00 mg kg^{-1}. This wide variation in fructose sugar content in fruits might be attributed to variation in nutrients content in both index leaves as well as soils and particularly for potassium and boron contents.

Among the carotenes present in mango fruits â-carotene is the dominant one. These pigments are the precaursors of Vitamin-A. Perusal of data presented Table-4 showed that pigment content in Alphonso mango fruits of different orchards ranged from 50.44 to 143.67 mg $kg^{-1}$with an average of 72.41 mg kg^{-1} (Table 4). Babu (2014) reported that in Kesar variety of mango cultivated in Gujarath state, the carotenoid content ranged from 27.00 to 34.00 mg $kg^{-1}$and they impart colour to the fruits and is a genetic character.

Conclusion

Due to nutritional values with a nice aroma, taste, flavor and health, mango is recognized as “king of fruits” in South Asia. A better understanding of the quality of mango fruit can be obtained by analysis of mango pulp. Fruit bearing and quality of fruits was very good in medium black soils of Kalaghatagi taluka and few black soils of Dharwad taluka which produced best quality fruits along with good size. Potassium, calcium, zinc and boron are the critical nutrients in improving the quality of mango fruits (Cv. Alphonso).

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