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Physico-chemical properties and mass modelling of Nagpur mandarin (*Citrus reticulata*) fruit

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Abstract
The study was conducted to determined physico-chemical properties and study of mass modelling of Nagpur mandarin fruit. Fruit size in terms of length, width thickness, sphericity and shape of fruit were determined. The average surface area, projected surface area, actual volume, elliptical volume and oblate spheroid volume of fruit were found to be 147.35 cm^2, 94.83 cm2, 155.70 cm^3, 168.55 cm^3 and 171.36 cm^3, respectively. In first and second classifications, the Nagpur Mandarin mass and volume modeling based on the larger dimension are the most appropriate. The chemical properties i.e. Ph, TSS, acidity, ascorbic acid, total sugar, reducing and non reducing sugar of Nagpur mandarin fruit juice has been reported to be 2.52, 10.82 ^oB, 0.62%, 42.59 $mg100g^{-1}$, 7.53%, 3.03% and 4.50%, respectively.

Keywords: Chemical composition, Mass modelling, Nagpur mandarin, Physical properties, Segment dimension

Introduction
Mandarin orange (Citrus reticulata) is easily peelable and commonly grown citrus fruit in India. Mandarin is a name of cluster for a group of oranges with thin and slack peel.
Mandarin (*Citrus reticulata*), sweet orange (*Citrus sinensis*) and acid lime (*Citrus aurantifolia*) are Indian most common commercial citrus species, sharing 41, 25 and 23 per cent of the country 's total citrus fruits. China stands first in citrus production (29.56 million tonnes) followed by Brazil (18.96 million tonnes) and India stands third in citrus production (12.74 million tonnes) with an area of 10.55 million hectares (14.9% of total fruit area) with a productivity of 10.4 MTha-1. Citrus is grown in 26 states but only nine states contribute more than 89% of the total production. Maharashtra is the country's leading producer of mandarins, with a high area of 0.135 million hectares (40.9%), a total production of 7.42 million tons (21.61%) and productivity of 5.5 million MTha1. Because of its good quality fruit, Nagpur *Santra* (nagpur mandarin) is the finest variety, popular both in India and the world. It is generally consumed as raw form and fruit salads as well as juice. The fruit contains three layers are 1. The external yellow/orange peel is full of oil glands which gives essential oils for producing the distinguishing orange odour. 2. The monocarp is whitish thread. 3. The endocarp which consisting of 8 to 10 segments filled with juicy sacs (vesicles) (Jhade *et al.* 2018) [7].
Physical properties of agricultural commodities are very important factors in the design of various processing machineries like grading, conveying, cleaning etc. Among all physical properties the mass, volume, sphericity etc. are very important over the design of sorter of fruits and vegetables (Mirzaee *et al.* 2008) [13]. The identical size fruits get higher market value as compared to other fruits. Therefore, cleaning and grading of fruit on the weight basis is important which reduces the cost of packing and handling (Khoshnam *et al.* 2007) [10]. The most common method used for identify the shape of fruits and segments are to determined sphericity. To establish relations between mass and measurement (major, medium, small) and areas that would be useful and applicable to designing a variety of equipment (Marvin *et al.* 1987) [11]. Some researchers have also described various physical properties of the different fruits and vegetables, namely caper (Sessitz *et al.* 2007) [18], potato (Singh *et al*. 2006; Sadowska *et al.* 2004) [20, 17], gumbo-fruit (Akar and Aydin, 2005) [3], orange (Tabatabaeefar, 2000) [23], pear (Wang, 2004) [24], onion (Abhayawick *et al.* 2002) [2], apple (Meisami-asl *et al.* 2009) [12], and date (Keramat Jahromi *et al.* 2004). Tabatabaeefar and Rajabipour (2005) [22] will find out in mass and volume modeling the models for predicting apple mass based on its

volume, sizes and projected area. The mass modeling of the apricot is performed by Mirzaee *et al.*, (2008) [13].
The model investigated many kind of model for predication mass of oranges, lemon on dimensions and project areas. The mass model based on minor dimension as nonlinear relations for grading system of oranges was recommended (Khoshnam *et al.* 2007) [10]. Also, some physical properties of oranges has investigated and reported by several researchers. Some studies were performed on physical property of oranges but not specified for Nagpur mandarin fruit. Therefore the study was conducted to find out the physical, chemical properties and mass modelling of Nagpur mandarin fruit and segments.

Materials and Methods

For characterizing Nagpur mandarin the physical properties viz. dimensions, size, sphericity, fruit volume, fruit weight and pH of Nagpur mandarin fruit, segment and juice were determined. For measuring physical properties 30 Nagpur mandarin fruit were randomly selected.
For size measurement the tri-axial dimensions length (a), width (b) and thickness (c) of Nagpur mandarin fruit were measured using a vernier caliper (Mitutoyo, Japan) having a least count of 0.2 mm. Geometric mean diameter (Dg), surface area (As) and sphericity were determined using the following equations (1) to (3) (Mohsenin, 1986) [14]. PA was measured with graphical methods, the estimated area of three mutually perpendicular areas.

$$S \text{ or } D_g = (a \times b \times c)^{1/3} \quad \text{..... (1)}$$

$$A_s = \pi (D_g)^2 \quad \text{..... (2)}$$

$$\text{Sphericity} = \frac{\text{Geometric mean diameter,mm}}{\text{Length,mm}} \quad \text{..... (3)}$$

The actual volume of the Nagpur mandarin fruit was determined by displacement method describe under platform scale method. The volume of fruit was calculated by taking into consideration the geometry of the fruit similar to the geometrical shape knowing the length, width and thickness. The structure as Oblate spheroid and ellipsoid was defined by the use (4) and (5) (Mohsenin, 1986) [14].

$$\text{Volume of oblate spheroid, (Vosp)} = \frac{2}{3}\pi\left(\frac{a}{2}\right)\left(\frac{b}{2}\right)^2 \quad \text{..... (4)}$$

$$\text{Volume of ellipsoid, (Vellip)} = \frac{2}{3}\pi\left(\frac{a}{2}\right)\left(\frac{b}{2}\right)\left(\frac{c}{2}\right) \quad \text{..... (5)}$$

For determination weight of fruit, weight of segment, peel weight (excluding pomace), seed weight and pomace weight was measured individually using electronic weighing balance with an accuracy of 0.005 g. Number of seeds extracted from each fruit was calculated the mean seed number and segments per fruit was counted and recorded as number of segments per fruit. The fruit juice was extracted by using juicer and the juice percentage was measured.
The juice content calculated juice weight and total weight of fruit. The juice to pomace ratio, specific gravity of fruit, sp. Gravity of juice was determined using method describe in (Mohsenin, 1968).

Mass and surface area modeling

To estimate the mass, the projected area and the surface area models of Nagpur mandarin fruit, the following models were considered:

1. Single or multiple variable regressions of Nagpur mandarin fruit mass, based on dimensional characteristics: length (L), width (W), thickness (T) and geometric mean diameter (Dg).
2. Single regression of Nagpur mandarin fruit mass, based on the surface area and projected area.
3. Single regression of Nagpur mandarin fruit mass, projected area and surface area, based on the volumes of the assumed shape.
4. Single regression of Nagpur mandarin fruit projected area and surface area based on mass (Khanali *et al.* 2007 and Soltani *et al.* 2011) [21].

From the above, all four classifications were measured for mass modeling whereas the third classification was neglected in volume modeling. In other words, volume modeling based on mass was not done because the results of mass modeling based on volume and volume modeling based on mass are the same. In the case of the first classification, mass/volume modeling was taken with respect to major, intermediate and minor diameters. The model obtained with three variables for predicting fruit mass/volume was:

$$M = k_1a+k_2b+k_3c+k_4, \quad \text{.....(6)}$$

$$V = k_1a+k_2b+k_3c+k_4. \quad \text{..... (7)}$$

In this classification, the mass/volume can be determined as a function of first, second and third dimensions. In the second classification models, mass/volume of fruit was determined based on mutually perpendicular projected areas as follows:

$$M= k_1PA_1+k_2PA_2+k_3PA_3+k_4, \quad \text{.....(8)}$$

$$V= k_1PA_1+k_2PA_2+k_3PA_3+k_4. \quad \text{.... (9)}$$

In this classification, the mass/volume can be determined as a function of projected area. In the case of the third classification, to achieve models which can predict the fruit mass on the basis of volume, three volume values were either measured or calculated. At first, actual volume V_m as stated earlier was determined, then the fruit shape was assumed as a regular geometric shape viz. oblate spheroid (V_{osp}) and ellipsoid (V_{ellip}) shapes,
In this classification (applied for mass modeling), the mass can be estimated as either a function of volume of supposed shape or the measured volume as given in following equations:

$$M = k_1V_{osp}+ k_2 \quad \text{..... (10)}$$
$$M = k_1V_{ellip}+ k_2 \quad \text{..... (11)}$$
$$M = k_1V_m+ k_2 \quad \text{..... (12)}$$

In the fourth classification, the projected and surface areas of Nagpur mandarin fruit were estimated based on mass as follows:

$$SP = k_1M + k_2 \quad \text{..... (13)}$$
$$V = k_1M + k_2 \quad \text{..... (14)}$$

where k_1 and k_2 are constants.
Statistica software was used to analyze data and determine the regression models between the studied attributes. The best

fitted models were selected based on a higher coefficient of determination (R^2, $p< 0.05$) and a lower regression standard error (RSE). The lower regression standard error was determined using equation (3.16).

$$RSE = \frac{(M_a - M_p)^2}{N} \quad \text{..... (15)}$$

Where, M_a is Actual mass of fruit, g, M_p is Predicated mass of fruit, g and N is number of sample The lower regression standard error (RSE) value calculated using difference between predicted and actual value. The formula for calculation is as follows.

Moisture content and chemical properties

The moisture content of Nagpur Mandarin juice was determined by using hot air oven at 105 ± 2 °C for 24 h (AOAC, 2000) [1]. The pH of mandarin juice was measured by using digital pH meter. The total soluble solids of ripen mandarin fruit juice was measured in Brix by using refractometers of various ranges (0 - 53, and 45 - 90 ºB) (Ranganna, 2000). The viscosity of mandarin juice was determined by Brookfield viscometer RVDV II + pro (Brookfield engineering lab, USA) and spindle no. 62 with speed 50 rpm. The acidity of sample was calculated by standard A.O.A.C. method (2000) [1] and ascorbic acid determined by using method describe in Ranganna (2000). Total sugar was determined by using Phenol Sulphuric Acid Method. Reducing sugars was estimated using Nelson Somogyi method and non reducing sugars value of non reducing sugars was obtained by subtracting the reducing sugars from total sugars.

Result and Discussions

Fruit size

The data obtained on length, width and thickness of fruit have been summarised in Table 1 was found to vary in the ranges from 64.58 to 75.69, 61.24 to 72.54 and 60.25 to 72.57 mm, respectively. Data on geometric median diameter, surface, and planned area ranges between 60.31 mm to 70.36 mm, between 0.85 and 0.95, between 124.09 cm and 169.40 cm^2 and 89.35 to 99.38 cm^2, respectively. Mean fruit size values in terms of length, width and thickness were noticed to be 70.56, 68.05 and 67.11 mm respectively. The calculated geometrical average fruit diameter and sphericity were 65.72 mm and 0.932.

Table 1: Variation in physical parameters of Nagpur mandarin fruit.

Sr. No.	Particular	Average	Range	SD	CV
1	Length, mm	70.56	64.58 to 75.69	2.84	4.02
2	Width, mm	68.05	61.24 to 72.54	2.98	4.38
3	Thickness, mm	67.11	60.25 to 72.57	3.15	4.70
4	Geometric mean dia., mm	65.72	60.31 to 70.36	2.70	4.11
5	Sphericity	0.932	0.85 to 0.95	0.018	1.88
6	Surface area, cm^2	147.35	124.09 to 169.40	10.64	7.22
7	Average projected area, cm^2	94.832	89.35 to 99.38	2.785	2.936
8	Shape	Oblate Spheroid Ellipsoid			

The average surface area and projected surface area was measured to be 147.35 cm^2 and 94.83 cm^2. The classification of shape according Mohsenin (1980) was oblate spheroid and elliptical. Similar results were found by Biswas and Teotia (2012) [5] for small garden fruit of length 68.00 mm; Varane *et al.* (2015) for average length 71.70 mm, 70.30 mm and 71.70 mm with breadth 68.00, 66.00 mm and 66.70 mm for Kondonaran, Mudkhed and Nagpur Mandarin cultivar of mandarin, respectively. Garavand and Nassiri (2010) for sweet lemon with average length 68.89 mm, width 66.83 mm, thickness 63.41 mm, geometric mean diameter 66.32 mm, sphericity 0.924, surface area 138.81 cm2 was reported.

The maximum weight of the Nagpur mandarin fruit was determined to be 174.35 g and the minimum weight was 143.54 g with standard deviation 7.57. The average weight of the Nagpur mandarin was found to be 162.24 g (Table 2). Similar results were found by Varane *et al.* (2015) for average weight 173.57 g for coorg mandarin cultivar, Garavand and Nassiri (2010) [6] with average weight 154.96 g for sweet lemon. Bhatnagar *et al.* (2015) [4] reported the fruit weight ranged from 86.33 to 137.88 g and Patil *et al.* (2011) [16] was reported 152.13 g for Nagpur mandarin.

The fruit actual volume, elliptical volume and oblate spheroid volume were found to vary from 144.36 to 167.96, 130.01 to 207.37 and 131.89 to 206.14 cm^3, respectively. The average actual volume, elliptical volume and oblate spheroid volume of fruit was observed to be 155.70, 168.55 and 171.36 cm^3, respectively (Table 2). A similar result was reported by Garavand and Nassiri (2010) [6] with 171.84, 154.81 and 163.43 cm^3 for actual volume, ellipsoid volume and oblate spheroid volume for sweet lemon. Patil *et al.* (2011) [16] was reported 161.26 cm3 for Nagpur mandarin.

Table 2: Variation in volume, density and viscosity of Nagpur mandarin fruit and juice

Sr. no.	Particular	Average	Range	SD	CV
1	Fruit weight, g	162.24	143.54 to 174.35	7.57	4.66
2	Actual Volume, cm^3	155.70	144.36 to 167.98	6.59	4.23
3	Elliptical Volume, cm^3	168.55	130.01 to 207.37	18.19	10.79
4	Oblate Spheroid Volume, cm^3	171.36	131.89 to 206.14	18.10	10.57
5	Specific gravity of fruit, kgcm$^{3-1}$	1.04	0.99 to 1.067	0.015	1.411
6	Specific gravity of juice, kgcm$^{3-1}$	0.953	0.94 to 0.96	0.006	0.634
7	Viscosity, mPa.s	496.64	493.65 to 499.35	0.006	2.86

The specific gravity of fruit and juice were found to vary from 0.99 to 1.067 kgcm^{-3} and 0.94 to 0.96 kgcm^{-3}. The average specific gravity of fruit and juice was calculated to be 1.04 and 0.95 kgcm^{-3}. The viscosity of juice was found to vary from 493.65 to 499.35 mPa.s. The average viscosity of juice was noted to be 496.64 mPa.s (Table 2).

Mass and surface area modeling classifications

First classification models

In the first mass grouping (numbers 1-8 displayed in Table 3) models were included. The model 1, 4, 5 and 7 was considered to have the highest value of R^2 (0.978) but the lowest RSE value was found in model 7 (0.200) as compared to model 1 (0.239), model 4 (0.226) and 5 (0.239). However, for model 7, all three diameters have to be calculated in which this process was more complicated and time consuming, therefore model 1 which is having higher R^2 (0.969) and lower RSE (0.239) of the single-dimensional mass model was selected. The predicted mass model for Nagpur mandarin is shown in Fig. 1.

Table 3: Regression mass models for Nagpur mandarin fruits

SN	Models	Parameter		Equation
		R^2	RSE	
1	$M = k_1a + k_2$	0.969	0.239	M = 2.999a - 48.687
2	$M = k_1b + k_2$	0.896	0.439	M = 2.88b - 34.206
3	$M = k_1c + k_2$	0.785	0.630	M = 2.548c - 8.406
4	$M = k_1a + k_2b + k_3$	0.972	0.226	M = 2.507a + 0.522b - 49.679
5	$M = k_1a + k_2c + k_3$	0.969	0.239	M = 2.959a + 0.041c - 48.691
6	$M = k_1b + k_2c + k_3$	0.912	0.403	M = 4.426b - 1.500c - 38.731
7	$M = k_1a + k_2b + k_3c + k_4$	0.978	0.200	M =2.373a +1.593b –0.919c –51.622
8	$M = k_1D_g + k_2$	0.917	0.392	$M = 2.921d_g - 37.727$
9	$M = k_1A_p + k_2$	0.835	0.552	$M=2.484A_p-73.29$
10	$M = k_1A_s + k_2$	0.911	0.405	$M = 0.679A_s + 62.155$
11	$M = k_1V + k_2$	0.920	0.384	M = 1.101V - 9.224
12	$M = k_1V_{osp} + k_2$	0.934	0.350	$M = 0.404V_{osp} + 93.024$
13	$M = k_1V_{ellip} + k_2$	0.905	0.419	$M = 0.396V_{ellip} + 95.533$

From Table 3, it shows that the model 3 had the lowest mass prediction power. Similar results were reported by Tabatabaefar and Rajabipour (2005) [22] for apples, Khoshnam*et al.* (2007) [10] for pomegranate and Soltani*et al.* (2011) [21] for bananas.

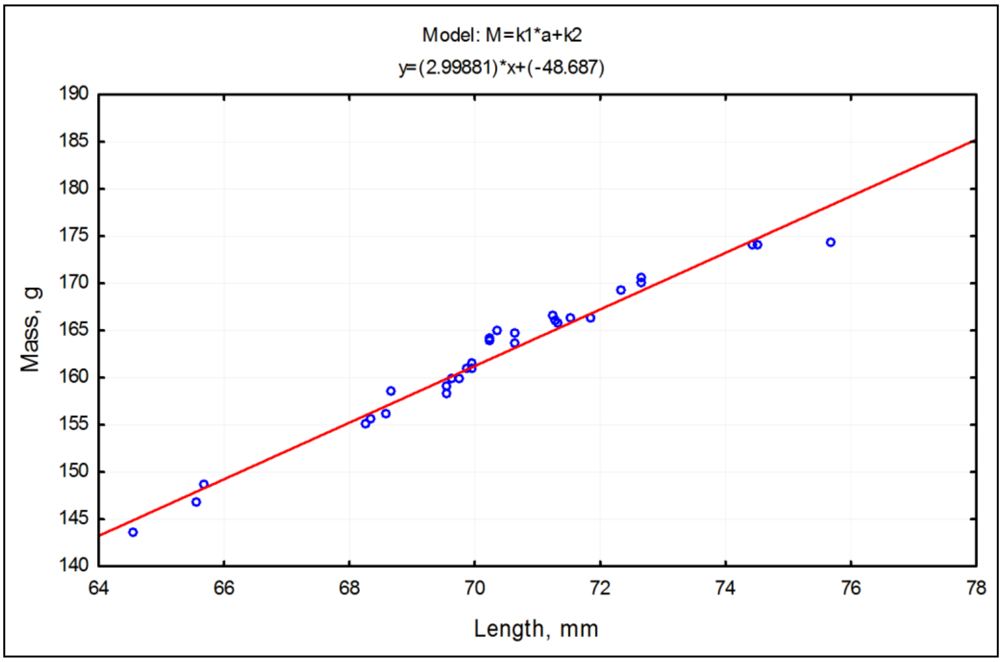


Fig 1: Mass model based on length of Nagpur mandarin fruit

Second classification models

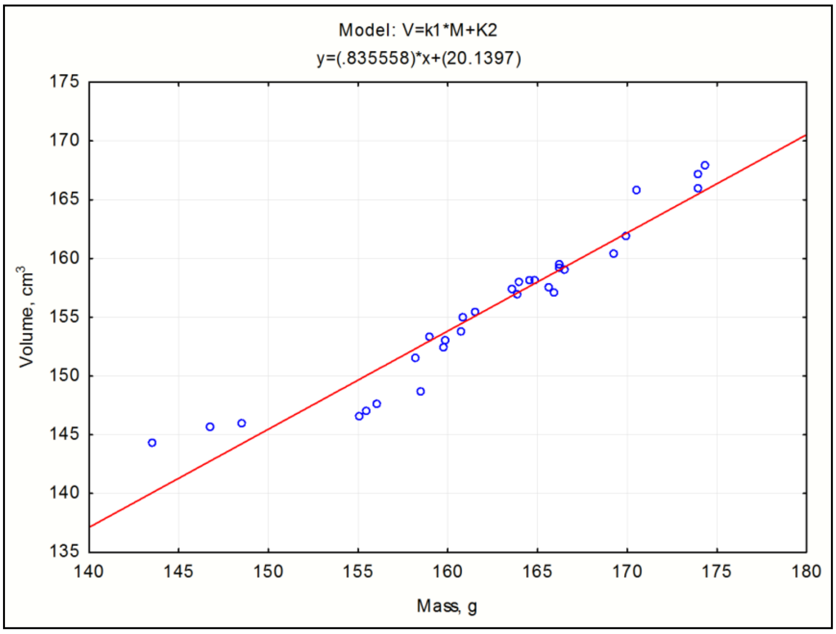
As seen in Table 3, the Nagpur mandarin fruit mass model based on surface area (R^2=0.911) and projected area (R^2 = 0.835) was found less acceptable. In the second group, the Nagpur mandarin fruit mass model based on surface area also had higher R^2(0.911) and lower RSE (0.405) value than the model based on the projected area, but the fruit must be peeled for calculation of surface area, which destruct the fruit. Therefore this model is an impractical method. The better suited line for mass model based on the projected area had a linear pattern, while Khoshnam*et al.* (2007) [10] considered a power modeling feature for pomegranate based on its projected area.

Third classification models

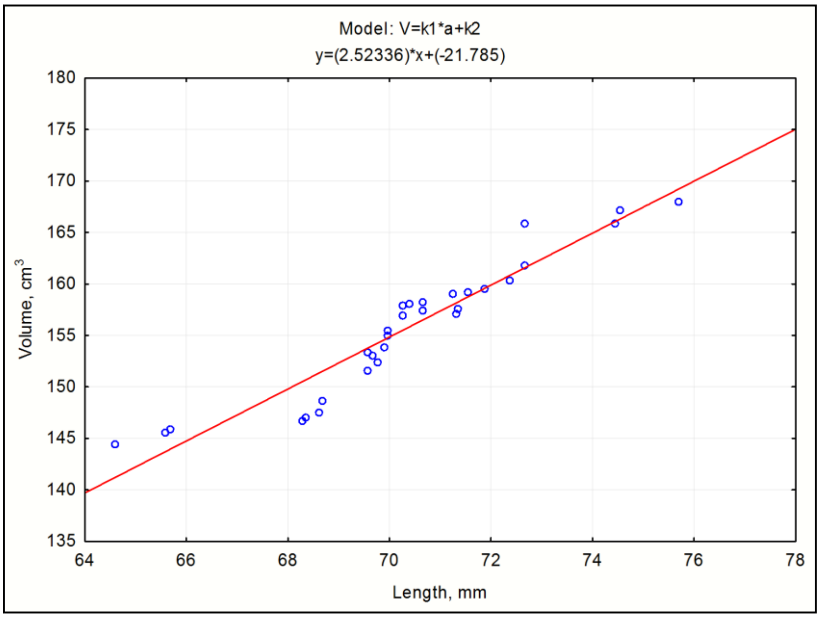
From Table 4, a strong association between the mass and the expected oblate spheroid volume of Nagpur mandarin fruit was assumed (R^2 =0.82). The R^2 value for projected area and surface area were 0.85 and 0.875.

Fourth classification models

Calculating the surface area and projected area in mandarin fruit is a troublesome method. The mass was calculated easily and reliably with only a digital balance. Therefore, these parameters were determined roughly by having a relationship between the surface / projected area of fruit to mass. There was a clear relation between the surface area and fruit mass with highest R^2 (0.911).



a) Volume verses weight



b) Volume verses length

Fig 2: Volume model based on length and weight of Nagpur mandarin fruit

The linear model was the best fit for the results. There was little gap between linear and polynomial pattern with respect to R^2. As shown in Fig. 2, the fruit mass was not ideally predicted the projected area, however the outcome was found satisfactory. The volume model also predicted highest R^2 (0.920) with correlation to mass with lower RSE value (0.334) shown in Table 4.4 and Fig. 2a. Similarly the relation between volume and length is also described in Fig. 2b. with higher R^2 values (0.904). This implies that the volume of the supposed ellipsoid may well predict the surface and area. The configuration of the saffron crocus corm mass dependent on the approximate volume of the present and presumed spheres, Oblate spheroid and ellipsoid types has also been proposed by Hassan-Beygi *et al.* (2010).

Table 4: Regression volume models for Nagpur mandarin fruits

SN.	Models	Parameter		Equation
		R^2	RSE	
1	$V = k_1a + k_2$	0.904	0.366	V = 2.523a - 21.785
2	$V = k_1b + k_2$	0.825	0.495	V = 2.411b - 8.501
3	$V = k_1c + k_2$	0.721	0.625	V = 2.127c + 13.240
4	$V = k_1a + k_2b + k_3$	0.906	0.363	V = 2.244a + 0.297b - 22.349
5	$V = k_1a + k_2c + k_3$	0.904	0.366	V = 2.573a - 0.052c -21.78

6	$V = k_1b + k_2c + k_3$	0.841	0.472	V = 3.745b - 1.298c - 12.415
7	$V = k_1a + k_2b + k_3c + k_4$	0.911	0.353	V = 2.130a + 1.201b - 0.776c -23.98
8	$V = k_1D_g + k_2$	0.847	0.462	$V = 2.446D_g - 11.742$
9	$V = k_1A_p + k_2$	0.850	0.458	$V = 0.572A_p + 71.491$
10	$V = k_1A_s + k_2$	0.875	0.419	$V = 2.214A_s - 54.272$
11	$V = k_1M + k_2$	0.920	0.334	V = 0.836M + 20.140

Fractional classification of Nagpur mandarin fruit

The pulp weight, peel thickness and peel weight of fruit was found to vary from 101.25 to 149.25 g, 2.31 to 4.24 mm and 22.98 to 39.57 g with an average value of 128.54 g 3.02 mm and 31.04 g with a standard deviation of 7.77, 0.52 and 3.74, respectively (Table 5). It was observed that the Nagpur mandarin fruit having higher weight had a better pulp recovery. Similar result reported by Bhatnagar *et al.* (2015) [4] for Nagpur mandarin.

The seed weight and seeds per fruit was found to varying from 0.61 to 3.26 g and 3 to 9 with an average seed weight and seeds per fruits was determined to be 1.34 g and 5.87 with standard deviation of 0.62 and 1.59. The pomace weight has neen found in between 41.51 to 57.64 g with an average weight of 50.19 g and a standard deviation of 3.83 (Table 5).

Table 5: Variation in fruit fractions and pulp recovery of Nagpur mandarin fruit

Sr. no.	Particular	Average	Range	SD	CV
1	Pulp weight, g	128.54	104.25 to 149.25	10.00	7.77
2	Peel thickness, mm	3.02	2.31 to 4.24	0.52	17.03
3	Peel weight, g	31.04	22.98 to 38.57	3.74	12.40
4	Number of seeds	5.87	3 to 9	1.59	27.13
5	Seed weight, g	1.34	0.61 to 3.26	0.62	46.66
6	Pomace weight, g	50.19	41.51 to 57.64	3.83	7.63
7	Juice content, g	49.35	41.81 to 57.64	4.90	7.63
8	Juice content,%	29.73	24.42 to 37.04	3.23	10.87
9	Juice to pomace ratio	0.60	0.43 to 0.85	0.08	13.42
10	Peel to pomace ratio	0.62	0.48 to 0.83	0.10	14.77

Juice content and recovery

The juice content of fruit was found to vary in the range of 41.89 g to 57.64 g with average juice content was found in between 49.35 g with standard deviation of 4.90 (Table 5). Similar result reported by Bhatnagar *et al.* (2015) [4] for Nagpur mandarin. The maximum juice recovery of the fruit was recorded to be 37.04% whereas, minimum was 24.42% & with the standard deviation of 3.23 (Table 5). The average juice recovery from the fruit was 29.73%. It was observed that the fruit having higher fruit weight recorded higher pulp weight and better pulp recovery.

During the experimentation it was also observed that, fruit weight and its juice recovery had some relationship. Hence, fruit weight could be taken as a parameter for the estimation of juice recovery. The relationship obtained between the fruit weight and juice recovery is shown in Fig. 3 and relationship in fruit volume and juice recovery is shown in Fig. 4. Taking juice recovery as a function of the fruit weight, following second degree polynomial equation was developed.

$$y = 0.007x^2 – 1.743x + 129.0 \quad R^2 = 0.921 \qquad \ldots (4.1)$$

Where, y = Juice recovery,% and x = Fruit weight, g.

$$y = 0.563x – 57.29 \quad R^2 = 0.894 \qquad \ldots (4.2)$$

where, y = juice recovery,% and x = Fruit volume, cc.

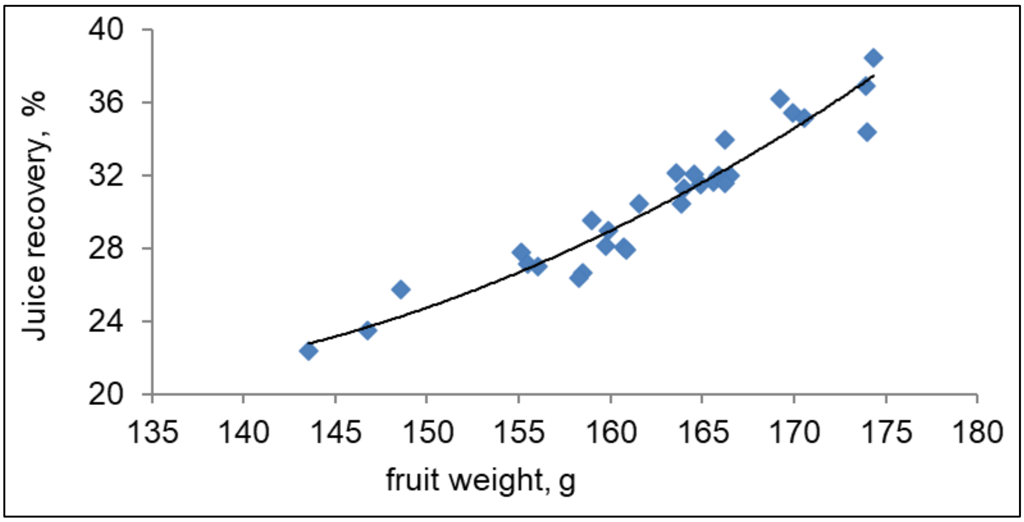


Fig 3: Relationship between Nagpur mandarin fruit weight and juice recovery

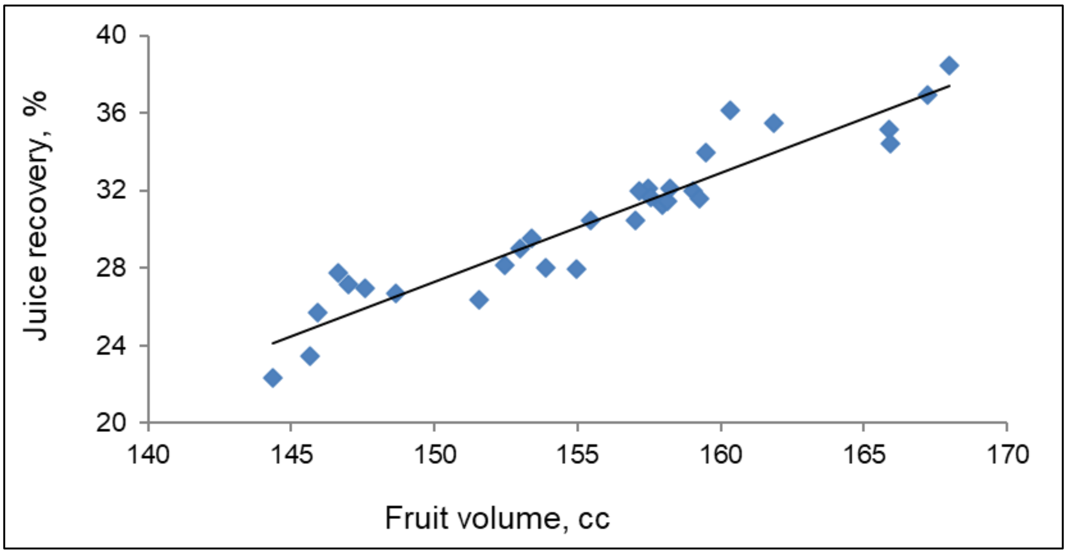


Fig 4: Relationship between Nagpur mandarin fruit volume and juice recovery

The juice to pomace ratio and peel to pomace ratio of fruit was found to vary in between 0.43 to 0.85 and 0.48 to 0.83 with an average juice to pomace ratio and peel to pomace ratio was observed to be 0.60 and 0.62 with standard deviation of 0.08 and 0.10 (Table 5).

Physical Parameters of Nagpur Mandarin Fruit Segment

From Table 6 the physical parameters of segment *viz*. Length, width and thickness were found to vary in the ranges from 42.08 to 50.14, 15.24 to 25.05 and 9.00 to 16.19 mm, respectively. The data for Dg and sphericity was observed in between 18.10 to 26.48 and 0.42 to 0.54. The values of the size of segment in terms of length, width and thickness were found to be 45.05, 19.37 and 11.44 mm, respectively. The average Dg and sphericity of fruit were measured in between 21.48 mm and 0.476.

Table 6: Variation in fraction of segment of Nagpur mandarin

Sr. no.	Particular	Average	Range	SD	CV
1	Length of segment, mm	45.05	42.08 to 50.14	2.21	50.14
2	Width of segment, mm	19.37	15.24 to 25.05	2.32	11.96
3	Thickness of segment, mm	11.44	9.00 to 16.19	1.90	16.63
4	geometric mean of segment, mm	21.48	18.10 to 26.48	2.09	9.75
5	Sphericity of segment	0.476	0.42 to 0.54	0.031	6.43
6	No. of segments	10.87	7 to 14	2.00	18.36
7	Weight of segments, g	11.53	9.24 to 14.25	1.42	12.36
8	Projected area of segment	21.43	18.16 to 26.29	2.18	10.17

The number of segments, weight of each segment and projected area of segment was found to be 7 to 14, 9.24 to 14.25 g and 18.16 to 26.29 mm2, respectively. The mean values are found to be 10.87, 11.53 g and 21.43 mm2 for number of segment, weight of segment and projected area of segment, respectively.

Moisture content

The average initial moisture content of Nagpur mandarin juice was measured 90.46% (wb).

Chemical parameters of Nagpur mandarin

The chemical parameters i.e. Ph, TSS, acidity, ascorbic acid, total sugar, reducing and non reducing sugar of Nagpur mandarin fruit juice was determined and summarized in Table 7. Also TSS to acid ratio and sugar to acid ratio was determined. The chemical properties viz. Ph, TSS, acidity and ascorbic acid of fruit juice was found to vary in the ranges from 2.21 to 2.70, 10.59 to 11.25 °B, 0.54 to 0.69% and 41.45 to 43.92 mg100g^{-1}, respectively. The data for total, reducing and non reducing sugar was found in between 7.21 to 7.72%, 2.29 to 3.44% and 4.21 to 4.92%, respectively. The range of sugar to acid ratio and TSS to acid ratio was measured to be 10.45 to 14.30 and 16.30 to 19.61. The mean values of the chemical properties size i.e. Ph, TSS, acidity, ascorbic acid, total sugar, reducing and non reducing sugar of Nagpur mandarin fruit juice was determined to be 2.52, 10.82 °B, 0.62%, 42.59 mg100g^{-1}, 7.53%, 3.03%, 4.50%, 12.30 and 17.60, respectively. Similar result for ascorbic acid (41.83 mg100g^{-1}), total sugar (5.75 to 8.87%) and reducing sugar (3.73 to 5.76%) were reported by Bhatnagar *et al.* (2015) [4] for Nagpur mandarin. Patil *et al.* (2011) [16] was reported 9.68 oB TSS for Nagpur mandarin. Shravan *et al.* (2018) [19] reported the 11 ^{0}B TSS and 46.5 mg100g-1 for sweet orange fruit.

Table 7: Variation in chemical parameters of Nagpur mandarin juice

Sr. no.	Particular	Average	Range	SD	CV
1	Ph	2.52	2.21 to 2.70	0.270	0.107
2	TSS, °B	10.82	10.59 to 11.25	0.370	0.034
3	Acidity%	0.62	0.54 to 0.69	0.0755	0.122

4	Ascorbic acid, mg100g^{-1}	42.59	41.45 to 43.92	1.245	0.029
5	Total sugar%	7.53	7.21 to 7.72	0.276	0.037
6	Reducing sugar%	3.03	2.29 to 3.44	0.642	0.212
7	Non reducing sugar%	4.50	4.21 to 4.92	0.374	0.083
8	Sugar to acid ratio	12.30	10.45 to 14.30	1.928	0.157
9	TSS to acid ratio	17.60	16.30 to 19.61	1.768	0.100

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References

1. AOAC. Official Method of Analysis, Association of Official Analytical Chemists, Wishington, D C. U.S.A. 2000.
2. Abhayawick L, Laguerre JC, Tauzin V, Duquenoy A. Physical properties of three onion varieties as affected by the moisture content. J. Food Eng 2002;55:253-262.
3. Akar R, Aydin C. Some physical properties of Gumbo fruit varieties. J. Food Eng 2005;66:387-393.
4. Bhatnagar P, Singh J, Jain SK. Physico-chemical variations in fresh ‘Nagpur’ Mandarin fruits of Jhalawar district. Hortflora Research Spectrum 2015;4(4):293-300.
5. Biswas Pijush Kanti, Teotia NS. Study on the fruit characters and yield potential of different types of mandarin (*Citrus reticulata* L Blanco) orange gardens in Lower Dibang Valley district of Arunachal Pradesh. International Journal of Farm Sciences 2012;2(2):7-10. Print ISSN : 2229-3744. Online ISSN : 2250-0499.
6. Garavand Amin Taheri, Amin Nassiri. Study on some morphological and physical Characteristics of sweet lemon used in mass models. International Journal of Environmental Sciences 2010;1(4):2010
7. Jhade RK, Huchche AD, Dwivedi SK. Phenology of flowering in citrus: Nagpur mandarin (*Citrus reticulata* Blanco) perspective. International Journal of Chemical Studies 2018;6(2):1511-1517.
8. Keramat Jahromi M, Rafiee S, Jafari A, Ghasemi Bousejin MR, Mirasheh R, Mohtasebi SS. Some physical properties of date fruit (cv. Dairi). Int. Agrophysics, 2008;22:221-224.
9. Khanali M, Ghasemi Varnamkhasti M, Tabatabaeefar A, Mobli H. Mass and volume modelling of tangerine (Citrus reticulate) fruit with some physical attributes. Int. Agrophysics 2007;21:329-334.
10. Khoshnam F, Tabatabaeefar A, Ghasemi Varnamkhasti M, Borghei A. Mass modeling of pomegranate (*Punica granatum* L.) fruit with some physical characteristics. J. Scientia Horticulturae 2007;114:21-26.
11. Marvin JP, Hyde GM, Cavalieri RP. Modeling potato tuber mass with tuber dimensions. Trans. ASAE 1987;30:1154-1159.
12. Meisami-asl E, Rafiee S, Keyhani A, Tabatabaeefar A. Some Physical Properties of Apple cv. ‘Golab’. Agricultural Engineering International: the CIGR Ejournal 2009, XI.
13. Mirzaee E, Rafiee S, Keyhani AR, Emam Jomeh Z, Kheiralipour K. Mass modeling of two varieties of apricot (prunus armenaica L.) with some physical Characteristics. J. Plant Omics 2008;1:37-43.
14. Mohsenin NN. Physical properties of plant and animal materials. Gorden and Breach Science Publishers, New York, USA 1986.
15. NHB Annual report of National Horticulture Board, Pune 2014.
16. Patil NB, Shedame, Bhagyashree M, Ingle SH. Effect of plant growth regulators and fungicides on quality of Nagpur Mandarin. Internat. J. Pl. Protec 2011;4(1):112-115.
17. Sadowska J, Fornal J, Vacek J, Jelinski T, Flis B. Characteristics of physical properties of genetically modified potatoes I. Mass and geometric properties of tubers. Int. Agrophys 2004;18:269-276.
18. Sessiz A, Esgici R, Kizil S. Moisture-dependent physical properties of caper (Capparis ssp.) fruit. J. Food Eng 2007;79:1426-1431.
19. Shravan R, Shere DM, Joshi Monali M. Study of physico-chemical characteristics of sweet orange (Citrus sinensis) fruit. Journal of Pharmacognosy and Phytochemistry 2018;7(6):1687-1689
20. Singh DK, Goswami TK, Chourasia MK. Physical properties of two popular Indian potato varieties. J. Food Process Eng 2006;21:301-316.
21. Soltani Mahmoud, Reza Alimardani, Mahmoud Omid. Modeling the Main Physical Properties of Banana. Fruit Based on Geometrical Attributes International Journal of Multideiciplinary Sciences and Engineering 2011;2(2) www.ijmse.org
22. Tabatabaeefar A, Rajabipour A. Modeling the mass of apples by geometrical attributes. Scientia Horticulturae 2005;105:373-382.
23. Tabatabaeefar A, Efagh-Nematolahee A, Rajabipour A. Modeling of orange mass based on dimensions. Agr. Sci. Tech 2000;2:299-305.
24. Wang J. Mechanical properties of pear as a function of location and orientation. Int. Food Properties 2004;7:155-164.