Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(1): 1414-1417
Received: 07-11-2018
Accepted: 09-12-2018

**Narendra Kumar Yadav**
College of Agricultural Engineering and Technology, SKUAST-Kashmir, Shalimar, Jammu and Kashmir, India

**Ahmad Ali**
College of Agricultural Engineering and Technology, SKUAST-Kashmir, Shalimar, Jammu and Kashmir, India

**Rishabh Dev**
College of Agricultural Engineering and Technology, SKUAST-Kashmir, Shalimar, Jammu and Kashmir, India

**Mahesh Pandurang Asabe**
College of Technology and Engineering (CTAE), Udaipur, Rajasthan, India

**Mohd Abass**
Department of Horticulture, SKUAST-Kashmir, Shalimar, Jammu and Kashmir, India

**\Correspondence**
**Narendra Kumar Yadav**
College of Agricultural Engineering and Technology, SKUAST-Kashmir, Shalimar, Jammu and Kashmir, India

# Evaluation of physical properties of different grades of kinnow mandarin

**Narendra Kumar Yadav, Ahmad Ali, Rishabh Dev, Mahesh Pandurang Asabe and Mohd Abass**

## Abstract
The present study shows that the post-harvest physical properties data of fruits and vegetables are important in adoption and design of various handling, packaging, storage and transportation systems. Physical properties namely, length, width, thickness, sphericity, volume, projected area, weight loss, bio yield point and firmness were determined with respect to storage period. At the end of 11 days storage, the fruit cumulative weight loss in ambient conditions was 19.4%. Bio yield point, firmness of kinnow fruits decreased with respect to number of days of storage. The firmness of kinnow fruit was significantly higher in stem-calyx axis in vertical position than that in horizontal position.

**Keywords:** Physical properties, moisture content, kinnow, storage

## Introduction
The mechanical harvesting of fruits causes damage from branches and other fruits as fruit falls from the tree and drops on the ground. These damages are in the form of splits, punctures and bruises. Further damage is caused when it is raked, picked up, loaded and transported to distant places by trucks [6]. Generally, it takes several days in transportation from one place to another that causes various changes in physico-mechanical properties of fruits [5]. The post-harvest mechanical properties data of fruits and vegetables are important in adoption and design of various handling, packaging, storage and transportation systems. The fruit compression test simulates the condition of static loading that fruit can withstand in mechanical handling and storage. The most common practice to determine the fruit ripeness in field situation is pressing with ball of the thumb. Force deformation characteristics of fruits beyond the elastic limit may be important to simulate the destruction that occurs in bruising. Elastic modulus or Young's modulus is often used by engineers as an index of product firmness[7]. Puncture tests are also measures of firmness of fruits and vegetables to estimate harvest maturity or post-harvest evaluation of firmness[3]. Research has been carried out for several years to determine the resistance of fruits and vegetables to compression force [4].
There is a dearth of information on post-harvest physico-mechanical properties changes of kinnow peel and fruit under ambient storage conditions which are helpful to decide handling, packaging, storage, and transportation systems to be adopted and their designs. The objective of this paper is to report changes in basic physical and textural properties of kinnow fruit under ambient storage conditions. During storage the loss of moisture from the peel is continuously replenished by the movement of the moisture from the pulp. If this loss due to combined effect of respiration and transpiration goes on unchecked, the fruit shrivels up and becomes unmarketable [1].

## Materials and Methods
Kinnow fruits were procured from experimental orchard of ICAR- CIPHET ABOHAR (Punjab), India. Random samples were drawn from a freshly harvested lot of citrus at the time of harvest, and were washed by water, drained by tissue paper to remove droplets of water present on the surface. The purpose of washing was not only to remove field soil and surface microorganisms but also to remove fungicides, insecticides and other pesticides from the kinnow. Fruits were divided into three lots each consisting of 20 fruits. One lot of fruits was taken into ventilated corrugated fiberboard box and kept in ambient conditions (16.8±2°C, 50±8 % RH). Post-harvest physical properties of kinnow fruits were determined with respect to the storage period in ambient conditions.

### Sample preparation

To acquire a better comparison of the physical properties with the moisture content, the fresh kinnow were kept for at room temperature (16±3°C) Performing this practice, 3 different grade samples with variation in their moisture content and physical attributes were obtained (Fig. 1). These samples were further used for the estimation of physical properties.

**Grade 1** **Grade 2** **Grade 3**

**Fig 1:** Pictorial view of different grades of kinnow fruits.

### Peel moisture content

About 5 g of peel sample was taken in to a glass container at the time of experimentation. The samples were dried in hot air oven at 80°C for 24 h. Peel moisture content was calculated on weight basis. The average values of three replications are reported. Moisture content of the fruit was determined by using the standard method[15]

Moisture content (% w.b.) = $\left(\frac{Initial\ weight - Final\ weight}{Initial\ weight}\right)$

### Axial dimensions

Kinnow peel was removed manually and the dimensions of randomly selected one fruit were taken using digital vernier caliper (M/S Mitutoyo, Japan) with an accuracy of 0.01mm. Length, width and height of fruit were measured which helped in estimation of arithmetic and geometric mean diameter of the three lots. Arithmetic mean diameter (AMD) and geometric mean diameter (GMD) of the seed were calculated by using the following relationships[9]:

$$AMD = \left(\frac{L + W + H}{3}\right)$$

$$GMD = \left(L \times W \times H\right)^{1/3})$$

Where,

L= length, W= width, H= height, all in mm.

### Sphericity

Sphericity (Φ) of kinnow fruit was calculated by using the following relationship[9].

$$\Phi = \frac{(LWT)^{\frac{1}{3}}}{L}$$

Where, L is the length, W the width and H is the height, all in mm.

### Surface area

Surface area (S) of kinnow fruit was found by analogy with a sphere of the same geometric mean diameter, using the following relationship[2].

$S = \pi Dp^2$, Where, $D_P$ =geometric mean diameter.

### Bulk density

It was measured using a volumetric flask of 1000 ml and fruits were poured into that flask. Weight of the poured flask was taken and the procedure was repeated five times and average bulk density ($\rho_b$) of the fruit was calculated by dividing the weight of fruits with the volume of flask.

### True density

True density defined as the ratio between the mass of kinnow fruit and the true volume of the fruit, was determined using the toluene ($C_7H_8$) displacement method. Toluene was used in place of water because it is absorbed by fruit to a lesser extent. The volume of toluene displaced was found by immersing a weighted quantity of litchi seed in the toluene[12].

True density ($\rho_t$) = $\left(\frac{weight\ of\ fruit}{Toluene\ displaced}\right)$

### Coefficient of friction

Static coefficients of friction of kinnow fruit against four different surfaces namely plywood, stainless steel, galvanized iron sheet and mild steel were determined using a single fruit. With single fruit resting on the surface, the surface was raised gradually until the fruit just started to slide down [16]. The coefficient of friction was calculated from the following relationship:

$\mu = \tan \alpha$, Where, 'μ' is the coefficient of friction and 'α' is the angle of tilt in degrees.

### Weight loss

For determining weight loss in fruit during storage, 20 fruits in each experimental lot were numbered and kept in ambient conditions (16.8±2°C, 50±8 % RH). Weight of the fruit was measured with respect to storage period with Digital balance (M/S Metler Toledo, JL1503C) having least count of 0.001 g. The loss in weight was expressed as percentage of the original fresh weight of the fruit. The average weight of 10 fruits for 11 days storage period in ambient conditions was used.

### Fruit compression test

Kinnow fruit was set upon a flat base plate of Texture Analyzer. Probe carrier was fixed with a 75 mm diameter flat plate and brought in contact with the fruit. A 50 N load cell was used. Compression force was applied at pre-test speed of 1 mm/s, test speed of 1 mm/s, post speed of 5 mm/s, strain of 40%, trigger force of 5g to compress the fruit for 5 mm from the contact point. The bio yield point was considered as the force under the prescribed conditions, required to cause permanent deformation indicated by the peak force before a sudden drop as shown in a force–deformation curve (Fig. 2). The firmness was expressed as the force in kN required to compress the fruit to 10 mm distance. Fruit compression tests were performed in two orientations *viz.*, stem-calyx axis in horizontal and vertical directions. The average values of 10 replications for 11 days storage in ambient conditions is reported.

## Results and Discussion

### Peel moisture content

Initial moisture content of kinnow peel was observed to be 75-77.79% w.b.

### Axial dimensions

Average values of the three principal dimensions of kinnow, namely, length, width and height determined in this study of different grades. The average length, width and height of three grades varied from 78.19-68.12 mm, 77.43-66.23 mm, 63.41-56.88 mm, respectively. Arithmetic and geometric mean diameter ranged from 73.01-63.74 mm and 72.67-63.54 mm, respectively (Table 1, 2 & 3).

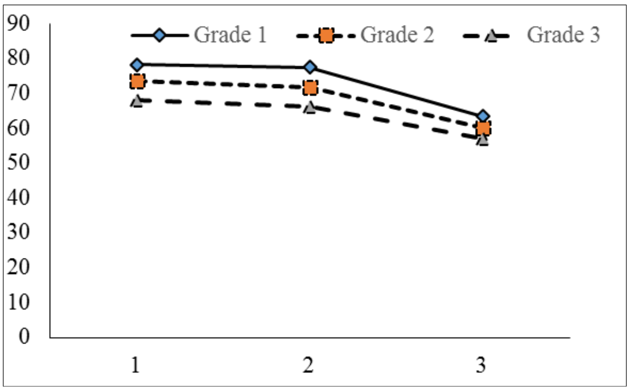



**Fig 2:** Axial dimensions of kinnow fruits of different grades

The regression equations are as follows:

$L = -5.03x+83.34$ ($R^2 = 0.99$)

$W = -5.60x+83.03$ ($R^2 = 0.99$)

$H = -3.27x+66.66$ ($R^2 = 0.99$)

**Table 1:** Geometric dimensions of grade 1 fruits

| AMD | GMD | Surface area($mm^2$) | Volume (ml) | $Pa_l$($cm^2$) | $Pa_w$($cm^2$) | $Pa_h$ ($cm^2$) | Weight (g) |
|---|---|---|---|---|---|---|---|
| 73.01±2.33 | 72.67±2.30 | 16597.38±1070.07 | 227.55±19.68 | 56.44±3.71 | 43.48±2.55 | 43.70±1.61 | 198.97±16.93 |

**Table 3:** Geometric dimension of grade 3 fruits

| AMD | GMD | Surface area($mm^2$) | Volume (ml) | $Pa_l$($cm^2$) | $Pa_w$($cm^2$) | $Pa_h$ ($cm^2$) | Weight(g) |
|---|---|---|---|---|---|---|---|
| 63.74±2.02 | 63.54±2.00 | 12689.06±783.09 | 147.25±12.99 | 41.72±0.93 | 34.90±1.83 | 35.84±2.31 | 135.04±12.03 |

AMD = Arithmetic mean diameter (mm), GMD = Geometric mean diameter (mm), $Pa_l$ =Projected area on the basis of length ($cm^2$), $Pa_w$ = Projected area on the basis of width ($cm^2$), $Pa_h$ = Projected area on the basis of height ($cm^2$)

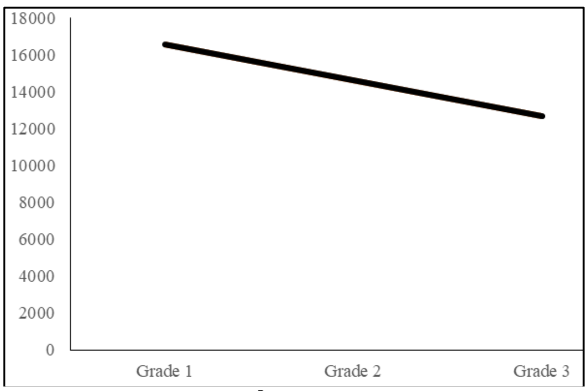
### Sphericity

Sphericity of the kinnow fruit increased from 0.93-0.94 % as the moisture content increased from 75-77.79% w.b. The relationship between sphericity (Φ) and moisture content appears linear and can be represented by the following equation:

$$\Phi = \frac{(LWT)\ 1/3}{L}$$

### Surface area

Surface area of kinnow fruit increases linearly from 16.61-12.71 cm², when the moisture content increased from 75-77.79 % w.b. The variation of moisture content ($M_c$) and surface area (S) can be expressed mathematically as follows:




$S = -1954.2x+18540$ ($R^2 = 0.99$)

### Weight loss

The percentage cumulative weight loss of kinnow during storage under ambient conditions for 11 days of storage is presented in Table 4. The weight loss increased with increase in storage period under ambient conditions and these followed second-order polynomial regression equations. Use of various substances in respiration can result in loss of food reserves in the tissue. At the end of 11 days storage, the cumulative loss of weight in ambient storage conditions was 19.4% and 7.3%, respectively. The fruit stored under ambient condition lost the weight almost three times more than that stored in refrigerated condition. The higher weight loss in fruit stored under ambient condition may be attributed to the high rate of change in soluble sugar concentration due to the monosaccharides being used in the respiration process during storage at higher temperatures (Fig. 3). The trend in weight loss of kinnow fruits with storage period is in agreement with previous studies [8, 10, 13, 14], Cuquerella, Del Ris, & Matoes, 1989).

$Y = -2.71x+194.83$ ($R^2 = 0.82$)

$Y = -2.47x+156.42$ ($R^2 = 0.81$)

$Y = -2.92x+132.6$ ($R^2 = 0.91$

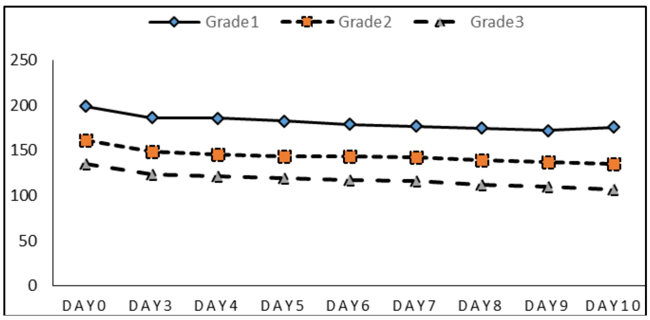



**Fig 3:** Reduction in the fruit weight over storage of 10 days

**Table 4:** Reduction in the fruit weight (g) over storage of 10 days

| | Day 0 | Day 3 | Day4 | Day5 | Day6 | Day7 | Day8 | Day9 | Day10 | % reduction |
|---|---|---|---|---|---|---|---|---|---|---|
| Grade1 | 198.97 | 186.14 | 185.59 | 182.76 | 178.93 | 176.77 | 174.81 | 172.34 | 175.72 | 11.68 |
| Grade2 | 161.04 | 148.55 | 145.50 | 143.00 | 144.00 | 142.06 | 139.62 | 137.43 | 135.57 | 15.81 |
| Grade3 | 135.03 | 123.91 | 121.42 | 119.14 | 117.59 | 115.84 | 112.04 | 110.00 | 107.26 | 20.56 |

### Fruit compression test

The firmness values of kinnow slowly decreased during the post-harvest storage under ambient conditions and followed second degree polynomial relationship (Table 5, 6 & 7). The decrease in firmness of kinnow fruit has strong relationship with storage period and the trend is in agreement with the results reported by[11] for Lane-late and Valencia oranges. The decrease in firmness was more pronounced under ambient condition than that Bio yield point (BYP) and firmness (F) ratio of orange fruit in horizontal and vertical orientations under compression in ambient and refrigerated storage conditions with respect to the storage period (75 mm diameter flat probe, probe speed: 1 mm/s).

**Table 5:** Textural properties of Grade 1 fruits over the storage

| | Bio yield point (kgf) | Rupture (kgf) | Firmness(kgf) |
|---|---|---|---|
| Day0 | 13.637±1.856 | 13.432±1.295 | 6.069±0 |
| Day3 | 13.902±1.028 | 13.006±.238 | 5.454±0.660 |
| Day5 | 16.146±1.809 | 16.520±0.577 | 5.444±0.452 |
| Day7 | 15.653±4.124 | 13.823±3.748 | 5.053±1.406 |
| Day9 | 6.464±0.494 | 13.462±2.503 | 5.456±0.237 |
| Day11 | 12.056±4.361 | 9.985±0 | 5.764±0.741 |

**Table 6:** Textural properties of Grade 2 fruits over the storage

| | Bio yield point (kgf) | Rupture (kgf) | Firmness (kgf) |
|---|---|---|---|
| Day0 | 14.690±1.643 | 14.023±1.168 | 5.654±0.426 |
| Day3 | 15.720±1.682 | 16.949±1.520 | 5.902±0.502 |
| Day5 | 14.236±0 | 10.698±0 | 5.545±1.049 |
| Day7 | 10.552±1.762 | 16.591±0 | 6.008±0.357 |
| Day9 | 9.131±2.105 | 15.880±1.928 | 6.023±0.756 |
| Day11 | 13.341±0.687 | 12.481±0.037 | 5.003±0.194 |

**Table 7:** Textural properties of Grade 3 fruits over the storage

| | Firmness (kgf) | Bio yield point (kgf) | Rupture (kgf) |
|---|---|---|---|
| Day 0 | 7.357±1.089 | 15.781±0 | 13.266±0.412 |
| Day 3 | 6.151±0.470 | 14.567±0.633 | 14.154±1.384 |
| Day 5 | 5.945±1.413 | 12.998±1.796 | 9.644±0 |
| Day 7 | 5.654±0.772 | 10.397±0.233 | 15.005±1.078 |
| Day 9 | 5.615±1.832 | 10.297±1.108 | |
| Day 11 | 4.992±0.785 | 8.876±1.007 | 13.638±4.623 |

All Values are represented as Average ±SD

### Conclusion

An investigation of some physical properties of kinnow fruit was conducted and results show that there exists significant difference in the determined properties with respect to geometrical attributes. The observed data can be used for determining the mathematical relationship between the geometric properties with weight of the fruit. The fresh fruit contains about 76.40 % (wb) moisture content while length, width, height, and geometric mean diameters of the fresh fruits were recorded 78.19-68.12 mm, 77.43-66.23 mm, 63.41-56.88 mm and 72.67-63.54 mm respectively. The average values of sphericity, was found 0.93-0.94 %. Coefficient of static friction values were noted to be 1.294, 1.140 and 1.018 for mild steel, rubber and plywood surfaces respectively.

### References

1. Ahmed EM, Martin FG, Fluck RC. Damaging stresses to fresh and irradiated citrus fruit. Journal of Food Science. 1973: 38:230-233.
2. Altuntas E, Ozgoz E, Taser OF. Some physical properties of fenugreek (*Trigonella foenum-graceum* L.) seeds. Journal of food Engineering. 2005; 71(1):37-43.
3. Blankenship SM, Parker M, Unrath CR. Use of maturity indices for predicting post-storage firmness of Fuji apples. Horticulture Science. 1997; 32(5):909-910.
4. Churchill DB, Sumner HR, Whitney JD. Peel Strength properties of three orange varieties. Transactions of the ASAE. 1980; 23(1):173-176.
5. Fidelibus MW, Teixeira AA, Davies FS. Mechanical properties of orange peel and fruit treated pre-harvest with Gibberellic acid. Transactions of the ASAE. 2002; 45(4):1057-1062.
6. Guzel E, Alizade HHA, Sinn H. Optical properties of W. Navel and Hamlin oranges regarding mechanical harvesting and sorting. AMA. 1994; 25(1):57-63.
7. Gyasi SR, Friedly B, Chen P. Elastic and viscoelastic Poisson s ratio determination for selected citrus fruits. Transactions of the ASAE. 1981; 24(3):747-750.
8. Martinez-Javega JM, Cuquerella J, Del Ris MA, Matoes M. Coating treatments in postharvest behavior of oranges. IIR Commisions C2/D1, D2/3. Technical innovations in freezing and refrigeration of fruits and vegetables. University of California Publication. 1989, 51-55.
9. Mohsenin, Nuri N. Physical properties of plant and animal materials. Vol. 1. Structure, physical characterisitics and mechanical properties. Physical properties of plant and animal materials. Structure, physical characteristics and mechanical properties, 1970.
10. Muramatsu, N, Kiyohide K, Tatsushi O. Relationship between texture and cell wall polysaccharides of fruit flesh in various species of citrus. Horticulture Science 1996; 31(1):114-116.
11. Olmo M, Nadas A, Garcia JM. Nondestructive methods to evaluate maturity level of oranges. Journal of Food Science. 2000; 65(2):365-369.
12. Sacilik K, Ozturk R, Keskin R. Some physical properties of hemp seed. Biosys. Eng. 2003; 86:191-198.
13. Sarig Y, Nahir D. Deformation characteristics of Valencia oranges as an indicator of firmness. Horticultural Science. 1973; 8(5):391-392.
14. Singh K. Storage behaviour of sweet oranges and mandarins. Indian Council of Agriculture Research. *Technical Bulletin* (Agri-culture Series) 1971, 35.
15. Suthar SH, SK Das. Some physical properties of karingda (*Citrullus lanatus*) seeds. Journal of Agricultural Engineering Research. 1996; 65(1):15-22.
16. Varnamkhasti MG, Mobli H, Jafari A, Rafiee S, Heidarysoltanabadi M, Kheiralipour K. Some engineering properties of fruits. International Journal of Agriculture and Biology. 2008; 4(2):23-31.