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Research Article

Physicochemical Characterization of Selected Pomegranate (*Punica granatum* L.) Cultivars

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ABSTRACT

The physical and chemical characteristics of five pomegranate cultivars (Mridula, Ganesh, White muscut, G-137 and Jalor seedless) were examined in the present investigation. Physical properties of different cultivars were determined such as major diameter (85.05 to 91.62 mm), intermediate diameter (76.85 to 87.83 mm), minor diameter (79.86 to 90.01 mm), sphericity (0.903 to 0.937), fruit weight (294.4 to 404.14 g), fruit volume (289 to 387 mL), number of arils per fruit, weight of 100 arils were evaluated and analysed for the varietal difference. In addition, properties such as peel moisture content (68.72 to 74.15% w.b.), aril moisture content (78.25 to 81.82% w.b.), peel ash content (0.81 to 1.51%), aril ash content (0.29 to 0.53%), juice pH (3.47 to 3.96), total soluble solids (11.60 to 13.00 °Brix), titratable acidity (0.42 to 0.58%), total phenolic content, juice yield per fruit (104 to 186 mL) juice turbidity (142.20 to 364.50 NTU) and textural properties, like fruit compressive strength/firmness of arils (23.09 to 34.54 N), cutting strength of peel (84.33 to 111.35 N) and aril skin puncture force (0.28 to 0.38 N) were also investigated. Overall results suggested that the measured physico-chemical properties were quite different by the cultivar differences.

RESEARCH ARTICLE

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INTRODUCTION

Pomegranate (*Punica granatum* L.) is a fruit of Punicacea family and is one of the prominent and commercial fruits in the world. The fruits are mostly consumed either in fresh form or processed as juice, jellies and syrup for domestic as well as industrial market. Pomegranate is commercially grown for its sweet and acidic taste of the arils.

Arils are the edible part of the fruit which represents around 52-58% of the whole fruit weight comprised of 64-78% juice and 22-36% of seeds (Al-Maiman and Ahmad, 2002; Kandylis and Kokkinomagoulos, 2020). The remaining parts like flowers, leaves, and roots can be utilized for medicinal purpose (Lansky and Newman, 2007). Arils contain plentiful of vitamins, sugars, polysaccharides, polyphenols, and minerals making it nutritionally important for human health (Al-Said *et al*., 2009; Meena *et al*., 2020).

The estimation of physical and engineering properties of any agricultural commodity is important from the design and development aspect of machineries for harvest, handling and storage. For horticultural crops, especially fruits and vegetables, shape is very imperative factor in sorting, sizing and estimating the number of fruits that can be kept in shipping or storage containers.

Although, some research studies involving the quantification of physical properties of pomegranate are reported (Al-Maiman and Ahmad 2002; Fadavi *et al*., 2005; Kingsly *et al*., 2006).

It is very important to understand the variation in the physico-chemical properties of fruits like juice yield, number of arils per fruit, total phenol content and so on, due to the existing cultivar difference. Therefore, this study was envisaged to determine the various physico-chemical properties of selected pomegranate cultivars of the semi-arid region of Punjab (India).

MATERIALS AND METHODS

Fresh pomegranate fruits of all the cultivars were harvested from the farm orchard of ICAR-Central Institute of Post-Harvest Engineering and Technology (CIPHET), Abohar region (30.1489°N, 74.2253°E) of Punjab in India in 2018. Fruits were subjected to cleaning and washing to remove any foreign material present before using them for experimental purpose. A sample of 10 freshly harvested fruits of each variety was taken for the estimation of physical and chemical attributes.

Fruit dimensions such as the major diameter *(L)*, intermediate diameter *(W)*, minor diameter *(T)*, length of calyx (L_{calyx}) was determined using digital vernier callipers (M/s Mitutoyo, ±0.01mm). Individual fruit weight (g) was recorded using digital weighing balance (M/s Mettler Toledo, ±0.01 g) and volume was determined using water displacement method (Mohsenin 1970). Geometric mean diameter, *GMD* (D_p) and sphericity (Φ_s) was calculated using the following relationship as reported by (Mohsenin 1970; Mahawar *et al*., 2017; Mahawar *et al*., 2019; Altuntas and Mahawar, 2021).

$$Dp = (L \times W \times T)^{1/3} \tag{1}$$

$$\Phi s = \frac{(LWT)^{1/3}}{L} \tag{2}$$

Surface area (*S*) of the fruits was calculated by keeping the equivalence with a sphere having equivalent *GMD*, using the following formula as reported by Altuntas *et al.* (2005); Mahawar *et al.* (2017):

$$S = \pi Dp^2 \tag{3}$$

Where, *S* is the surface area (mm²); D_p is the geometric mean diameter (mm).

Arils (edible portion) were separated manually from the fruit and total aril weight per fruit was observed. In addition, the total number of arils in a fruit were also counted and presented. The ratio of peel weight and fruit weight signifies the average peel yield (%) and similarly, aril yield (%) was determined as the ratio between aril weight and fruit weight. After the determination of aril properties, juice of each variety was extracted using a juice extractor (M/s Kalsi, Machine No. 10) in the laboratory for evaluation of chemical properties.

Moisture content of both peel and arils was determined using hot air oven method (78±2°C) until constant values are not obtained (Riyahi *et al.*, 2011).

The juice samples were subjected to the estimation of total juice yield, pH, total soluble solids (TSS), turbidity, acidity and vitamin C content. TSS was determined using a digital refractometer (M/s Atago, 0-85% Brix) as reported by Mahawar *et al.* (2018). Titratable acidity (TA) was determined by adopting the method of AOAC (2009). Juice pH was measured using a digital pH meter (M/s Eutech, range 0-14) at 20ºC. Juice turbidity was determined using digital turbidity meter (M/s Systronics, range: 0-1000 NTU). Ash content of arils and peel samples was determined using muffle furnace keeping the samples at 650°C for 8 hours.

The total phenolic content (TPC) was determined by the Folin–Ciocalteu method following a described procedure as reported by Mena *et al.* (2012). Results were expressed as mg 100 mL^{-1} of gallic acid equivalents (GAE).

Colorimetric aluminium chloride method was used for the measurement of total flavonoid content as described by Huang *et al.* (2005). Catechin was used as a standard for preparation of calibration curve.

The anthocyanin content of pomegranate aril was determined by pH differential method (Wrolstad *et al.*, 2005).

All the samples were kept for centrifugation at 7500 rpm using refrigerated centrifuge (M/s. Remi, India) for 15 min at 4°C. The in vitro free radical scavenging activity of the samples was determined using the DPPH free radical (Gonzalez-Molina *et al.*, 2008).

Textural properties like firmness of fruit, skin puncture of aril and cutting strength of peel of respective cultivars were determined using Texture Analyser (M/s Stable Micro Systems Ltd). Aril firmness was determined using 25 mm diameter cylindrical probe (contact area 490.87 mm^2) with the settings as: pre-test speed (1.50 mm s^{-1}), test speed (1 mm s^{-1}), post- test speed (10 mm s^{-1}), target mode (strain 30%), trigger force (30 g). Cutting strength of peel was determined by blade probe with the settings as; pre-test speed (2 mm s^{-1}), test speed (2 mm s^{-1}), post- test speed (10 mm s^{-1}), target mode (strain 70%), trigger force (60 g).

Statistical analysis of the observed data was performed using SPSS version 16.0 software. Univariate analysis in general linear model was done for analysis of variance (ANOVA) at 5% level of significance.

RESULTS AND DISCUSSION

The difference among the measured physical properties of selected pomegranate cultivars was observed to be significant at 5% level of significance (Table 1). White Muscut cultivar had the highest major diameter of 91.62 mm, minor diameter of 90.01 mm and intermediate diameter of 87.83 mm, while the lowest values were observed in

Mridula cultivar that is major diameter of 85.43 mm, minor diameter of 76.85 mm and thickness of 79.86 mm. An individual fruit of White Muscut cultivar having highest weight of 404.14 g, while among all cultivars weight of Jalore seedless cultivar was lowest 293.18 g. The existing variation in fruit is dependent on climatic conditions and production practices (Radunic *et al.*, 2015). Tehranifar *et al.* (1997) observed the fruit weight in the range of 196.89–315.28 g.

The average volume of a single fruit of White Muscut was higher 387 mL and the lowest value 289 mL was recorded for *cv.* Mridula. Total arils weight was highest and lowest for White Muscut 255.09 g and G-137 139.44 g, respectively. Similarly, peel weight was highest 160 g and lowest 99.45 g for G-137 and Jalore seedless, respectively. Being larger as well as heavier, the total number of arils per individual fruit was higher 974 in White Muscut variety and the number was lowest 606 in Mridula cultivar. Fruit size may fluctuate depending on climatic conditions and production practices (Radunic *et al.*, 2015). Calyx length varied between 16.38 (G-137) to 21.79 (White Muscut) cultivar. These results are consistent with previous studies, where calyx length ranged between 13.45 to 24.0 mm (Tehranifar *et al.*, 1997) and Radunic *et al.* (2015) observed 14.3-19.2 mm of calyx length in their study. Moisture values were higher for arils as compared to peels irrespective of the varieties.

The aril moisture content of G-137 (81.82%) cultivar found higher as compared to other accessions, whereas peel moisture content was higher in Jalore seedless (74.15 ± 0.01). It was also observed that, peel moisture contents of all cultivars had significant inter- varietal differences. The juice yield and total soluble solids was higher in White Muscat (186.00±2.00 ml and 13°Brix) followed by G-137 cultivar (152.00 ± 0.15 ml and 12.50°Brix). It was lowest in Jalore seedless (104±0.05 ml and 11.60°Brix). Mir *et al.* (2012) reported higher TSS in Ganesh (14.46°Brix), Mridula (15.60°Brix) and G-137 (15.57°Brix) cultivars. Similarly, some Spanish cultivars reported to have TSS in the range 12.36 to 16.32% (Martinez *et al.*, 2006).

Table 1. Physical properties of selected pomegranate cultivars.

Cultivar	*L* (mm)	*W* (mm)	*T* (mm)	L_{calyx} (mm)	*GMD* (mm)	*S* (mm^2)	Φ_s	Volume (ml)	Weight (g)	No. of arils	Weight of 100 arils (g)	Total arils weight (g)	Total peel weight (g)
Mridula	85.43± 1.57^{c}	79.86± 1.09^{e}	76.85± 1.83^{e}	17.26± 1.80^{cb}	80.63± 1.42^{ed}	20424.11± 654.28^{ed}	0.90± 0. 01^{e}	289± 17.13^{d}	294.4± 16.83^{d}	795± 5.00^{d}	26.65± 0.23^{c}	188.21± 6.80^{c}	106.55± 10.06^{d}
Ganesh	87.11± 0.96^{ba}	84.78± 0.98^{c}	82.12± 1.33^{ca}	18.31± 1. 09^{b}	84.64± 0.92^{cb}	22506.15± 442.91^{cb}	0.93± 0. 01^{ba}	317.4±11 .15^{cb}	324.58± 7.89^{c}	1000± 20.00^{cb}	30.02± 0.11^{b}	207.07± 2.44^{b}	122.05± 15.70^{c}
White Muscut	91.62± 1.54^{a}	90.01± 1.63^{a}	87.83± 1.28^{a}	21.79± 0.70^{a}	89.80± 1.26^{a}	25333.93± 644.52^{a}	0.94± 0. 01^{a}	387± 23.58^{a}	404.14± 18.26^{a}	1141± 9.00^{a}	36.67± 0.21^{a}	255.09± 7.98^{a}	143.45± 7.71^{a}
Jalore seedless	85.05± 2.73^{c}	81.08± 1.24^{d}	77.12± 2.85^{d}	18.78± 0.75^{b}	81.30± 2.19^{d}	20764.95± 1012.70^{d}	0.91± 0. 01^{dc}	290± 25.59^{d}	293.18± 22.46^{d}	734± 6.00e^{d}	23.14± 0.58^{d}	186.34± 3.28^{dc}	99.45± 3.56^{d}
G-137	89.86± 2.75^{a}	87.44± 2.73^{ba}	84.16± 3.12^{ba}	16.38± 2.46^{d}	87.12± 2.72^{ba}	23844.35± 1371.70^{b}	0.92± 0. 01^{cb}	329± 19.21^{b}	348.44± 32.78^{b}	1045± 5.00^{b}	21.53± 0.21^{e}	139.44± 1.98^{e}	160± 20.14^{b}
							ANOVA						
F value	1.70^{NS}	6.88^{S}	3.98^{S}	6.24^{S}	4.25^{S}	4.20^{S}	3.66^{S}	3.72^{S}	4.24^{S}	210.75^{S}	61.99^{S}	109.16^{S}	
Significance	0.198	0.002	0.020	0.003	0.016	0.016	0.027	0.025	0.016	0.000	0.000	0.000	
LSD	6.55	4.85	7.05	7.22	5.43	2.78	0.00	6.25	6.93	4.53	0.91	19.53	

L: Major intercept, *W*: intermediate intercept, *T*: minor intercept of fruit, *GMD*: Geometric mean diameter (excluding calyx), L_{calyx}: Length of calyx, $W_{100\ aril}$: Weight of 100 arils, W_{aril}: total weight of arils per fruit, W_{peel}: Total weight of peel per fruit. *S*: Surface area,

^{S}: Significant ($P \leq 0.05$), ^{NS}: Non- significant, All the values presented as mean ± SD

Table 2. Chemical properties of juice obtained from selected pomegranate cultivars.

Cultivar	Moisture (% w.b.)		Ash (%)		pH	TSS	TA (%)	Juice yield/ fruit (ml)	Turbidity (NTU)
	Aril	Peel	Aril	Peel					
Mridula	80.82±0.39^{ba}	68.72±0.01^{e}	0.38±0.03^{cb}	1.51±0.01^{a}	3.96±0.02^{a}	12.50±0.50^{ba}	0.56±0.02^{d}	108±0.02^{d}	142.20±0.20^{ed}
Ganesh	79.69±0.01^{cb}	69.06±0.01^{d}	0.53±0.02^{a}	0.86±0.00^{dc}	3.47±0.01^{edc}	11.75±0.25^{cba}	0.58±0.01^{b}	142±0.10^{c}	145±2.00^{d}
White muscut	79.59±0.01^{dcb}	70.35±0.02^{c}	0.29±0.01^{ed}	0.81±0.01^{e}	3.50±0.00^{c}	13.00±0.00^{a}	0.50±0.04^{ed}	186±2.00^{a}	364.50±3.50^{a}
Jalore seedless	78.25±0.01^{edcb}	74.15±0.01^{a}	0.44±0.00^{b}	1.02±0.00^{b}	3.49±0.01^{cd}	11.60±0.60^{dcba}	0.42±0.02^{a}	104±0.05^{ed}	157.25±3.15^{c}
G-137	81.82±0.11^{a}	72.62±0.02^{b}	0.30±0.00^{d}	0.89±0.01^{c}	3.66±0.01^{b}	12.50±0.50^{ba}	0.48±0.02^{c}	152±0.15^{b}	195.50±0.70^{b}
					ANOVA				
F value	64.16^{S}	2.94×10^{4S}	40.65^{S}	1.31×10^{3S}	458.95^{S}	1.75^{NS}	2.00^{S}	3.57^{S}	1.41×10^{3}
Significance	0.001	0.00	0.002	0.00	0.00	0.301	0.00	0.00	0.00
LSD	0.66	0.00	0.00	0.00	0.00	1.73	0.12	7.02	9.83

All the values presented as mean ± SD
^{S}: Significant (P≤0.05), ^{NS}: Non- significant

Table 3. Bio-chemical properties of juice obtained from selected pomegranate cultivars.

	Phenols (GAE mg 100 g^{-1})	Flavanoids (CE mg 100 g^{-1})	Anthocyanins (mg 100 g^{-1})	DPPH (TE mg 100 g^{-1})
Mridula	104.33^{a}±0.80	18.62^{b}±0.05	1.33^{a}±0.04	16.01^{a}±0.01
Ganesh	70.56^{c}±0.76	17.3^{c}±0.07	1.18^{b}±0.01	12.17^{c}±0.03
G 137	64.12^{d}±0.60	15.72^{e}±0.15	0.74^{c}±0.00	7.47^{e}±0.03
Muscat	53.63^{e}±0.31	17.06^{d}±0.02	0.26^{e}±0.00	8.86^{d}±0.03
Jallore	87.12^{b}±0.23	20.3^{a}±0.05	0.44^{d}±0.00	13.35^{b}±0.07
		ANOVA		
F value	1.52×10^{3S}	576.10^{S}	5.52×10^{5S}	7.04×10^{3S}
Significance	0.00	0.00	0.00	0.00
LSD	1.67	0.24	0.06	0.13

All the values presented as mean ± SD
^{S}: Significant (P≤0.05), ^{NS}: Non- significant

The juice pH depicted the acidic taste of the juice was higher in Mridula cultivar (3.96) which was in confirmation with the results obtained by Cemeroglu *et al.* (1992). The juice pH of G137, White Muscut and Jalore seedless was significantly acidic than other cultivars. Titratable acidity of the different cultivars taken in this study was in the range of 0.42 to 0.58. The acidity of pomegranate varieties grown in Iran were found in the range of 0.35 to 3.36% (Akbarpour *et al.*, 2009). The turbidity of juice was highest for the White Muscut cultivar (364.50 NTU), whereas it was below 200 NTU in all other cultivars and lowest for Ganesh cultivar (145 NTU). The information is presented in Table 2.

Total phenolics and flavonoid content of fresh arils of the five pomegranate varieties are presented in Table 3. The phenol content of juice extracted from five different cultivar varied from 53.63 to 104.33 (GAE mg 100 g^{-1}), whereas the flavonoid content varied from 15.72 to 20.3 (CE mg 100 g^{-1}). Mridula cultivar had highest TPC whereas Jallore has the highest content of flavonoids. The quantifiable amounts of flavonoids range from 15.72 to 20.3 mg CE 100 g^{-1}. The reported values in this study were considerably lower than those reported by Tehranifar *et al.* (1997); Cam *et al.* (2009); Pande and Akoh (2009) in their respective studies. The anthocyanin content of juice extracted from different cultivars varied from 0.26 (Muscat) to 33.33 (Mridula) (C3G mg 100 g^{-1}). Mridula cultivar had the highest amount of total anthocyanins compared with other cultivars and the range (5.56 and 30.11 mg 100 g^{-1}) was in accordance with previously published reports for different pomegranate cultivars (Tehranifar *et al.*, 2010).

The presence of anthocyanin and phenolic acids, and other biomolecules determines the antioxidant activity of pomegranate arils and juice color (Shahkoomahally *et al.*, 2021).

The free radical scavenging capacity of juice extracted from five different cultivar varied from 7.47 to 16.01 (TE mg 100 g^{-1}). The antioxidant capacity in reference with DPPH radical inhibition values were found in the sequence Mridula> Jallore> Ganesh >White Muscat> G-137. The results were found in corroboration with the findings of high antioxidant activity in pomegranate cultivars as reported by Zaouay and Mars (2011). This existing variation was attributed to the inherent differences in cultivars and extraction methodologies. The information about the evaluated bio-chemical properties of fruit juice is depicted in Table 3.

Table 4. Textural properties of selected pomegranate cultivars.

Cultivar	Peel cutting force (N)	Fruit compressive strength (N)	Aril skin puncture (N)
Mridula	111.35±4.52^{a}	29.34±1.18^{cb}	0.29±0.01^{b}
Ganesh	101.67±8.51^{b}	27.64±1.11^{d}	0.26±0.01^{c}
White muscut	89.68±6.48^{d}	31.73±1.66^{ba}	0.29±0.01^{b}
Jalore seedless	84.33±11.60^{ed}	34.54±2.09^{a}	0.38±0.01^{a}
G-137	99.99±5.49^{cb}	23.09±1.47^{ed}	0.25±0.02^{dc}
		ANOVA	
F value	1.70^{NS}	6.95^{S}	19.91^{S}
Significance	0.178	0.000	0.000
LSD	23.57	4.66	0.00

All the values presented as mean ± SD
^{S}: Significant (P≤0.05), ^{NS}: Non- significant

It was observed that, firmness of whole fruit (34.54 N) and arils (0.38 N) of Jalore seedless cultivar was higher. Owing of the higher peel thickness of Mridula cultivar, the peel cutting force was highest as 112.62 N. Aril skin puncture force of Ganesh and G137 cultivars were at par and was significantly different for all other cultivars (Table 4). The variation in the physical as well as chemical properties among the cultivars is attributed to the genotype of the cultivars. The agro-climatic conditions, postharvest practices, processing techniques, type of cultivar have influenced the quality and quantity of pomegranates juice (Martinez *et al.*, 2012).

CONCLUSION

In this study, various physico-chemical and textural properties of five different pomegranate cultivars were determined. The results authenticated that there was significant variation in the determined properties among the selected cultivars. The variations could be originated from genotype of cultivar or due to agro-climatic and environmental conditions. This information about variation of physico-chemical attributes is pertinent for easy identification of pomegranate cultivars, particularly for juice extraction and preparation of suitable value-added products. It will also be helpful for pomegranate producers and processors from cultivation and processing point of view and to the breeders for improvement in desirable traits.

DECLARATION OF COMPETING INTEREST

The authors declares that they have no conflict of interest.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Vijay Singh Meena: Conceptualization, data curation, formal analysis, resources, software, validation, writing-original draft, writing-review & editing.
Bhushan Bibwe: Conceptualization, methodology, resources, writing-review & editing.
Bharat Bhushan: Conceptualization, formal analysis, validation, writing-original draft.
Kirti Jalgaonkar: Formal analysis, methodology, supervision, writing-original draft.
Manoj Kumar Mahawar: Supervision, validation, visualization, writing-review & editing.

REFERENCES

Akbarpour V, Hemmati K and Sharifani M (2009). Physical and chemical properties of Pomegranate (*Punica granatum* L.) fruit in maturation stage. *American Eurasian Journal of Agriculture Environment and Science, 6(4): 411-416.*

Al-Maiman S, and Ahmad D (2002). Changes in physical and chemical properties during pomegranate *(Punica granatum* L.) fruit maturation. *Journal of Food Chemistry, 76(4): 437-441.*

Al-Said FA, Opara LU and Al-Yahyai RA (2009). Physico-chemical and textural quality attributes of pomegranate cultivars (*Punica granatum* L.) grown in the Sultanate of Oman. *Journal of Food Engineering, 90(1): 129-134.*

Altuntas E, Özgöz E, and Taşer, ÖF (2005). Some physical properties of fenugreek (*Trigonella foenum-graceum* L.) seeds. *Journal of Food Engineering, 71(1): 37-43.*

Altuntas E, and Mahawar MK (2021). Mass prediction of cherry laurel genotypes based on physical attributes using linear regression models. *Journal of Agricultural Faculty of Gaziosmanpasa University. 38(2): 87-94.*

AOAC (2009). Association of official analytical chemistry. Official methods of analysis. 16th ed. *Washington.* 1141.

Cam M, Hisil Y and Durmaz G (2009). Classification of eight pomegranate juices based on antioxidant capacity measured by four methods. *Food Chemistry, 112: 721-726.*

Cemeroglu B, Artik N and Erbas S (1992). Extraction and composition of pomegranate juice. *Fluessiges Obst, 59(6): 335-340.*

Fadavi A, Barzegar M, Azizi MH and Bayat M (2005). Physicochemical composition of ten pomegranate cultivars (*Punica granatum* L.) grown in Iran. *Food Science Technology International, 11: 113-119.*

Gonzalez-Molina E, Moreno DA and Garcia-Viguera C (2008). Genotype and harvest time influence the phytochemical quality of fino lemon juice (*Citrus lemon* L. Burm. f.) for industrial use. *Journal of Agricultural and Food Chemistry, 56(5): 1669-1675.*

Huang D, Ou B, and Prior RL (2005). The Chemistry behind antioxidant capacity assays. *Journal of Agricultuiral and Food Chemistry, 53(6): 1841-1856.*

Kandylis P and Kokkinomagoulos E (2020). Food applications and potential health benefits of pomegranate and its derivatives. *Foods, 9(2): 122.*

Kingsly ARP, Singh DB, Manikantan MR and Jain RK (2006). Moisture dependent physical properties of dried pomegranate seed (*Anaradana*). *Journal of Food Engineering, 75: 492-496.*

Lansky EP and Newman RA (2007). Punica granatum (pomegranate) and its potential for prevention and treatment of inflammation and cancer. *Journal of Ethnopharmacology*, *109: 177-206.*

Mahawar MK, Jalgaonkar K, Kumar M, Meena VS and Bhushan B (2017). Determination of some physical properties of date *palm fruits* (*cv.* Khadrawy and Medjool). *Acta Agrophysica, 24(2): 217-223.*

Mahawar MK, Jalgaonkar K, Bibwe B, Kulkarni T, Bhushan B and Meena VS (2018). Optimization of blended Aonla-Guava fruit bar through Response surface methodology. *Nutrition and Food Science. 48(4): 621-630.*

Mahawar MK, Bibwe B, Jalgaonkar K and Ghodki BM (2019). Mass modeling of kinnow mandarin based on some physical attributes. *Journal of Food Process Engineering, 42(5).*

Martinez JJ, Melarejo P, Hernandez F, Salazar DM and Martinez R (2006). Arils characterization of five new pomegranate (*Punica granatum* L.) varieties. *Scientia Horticulturae, 110: 241-246.*

Martinez JJ, Hernández F, Abdelmajid H, Legua, P, Martínez R, El Amine, A and Melgarejo P (2012). Physico-chemical characterization of six pomegranate cultivars from Morocco: processing and fresh market aptitudes. *Scientia Horticulturae, 140: 100-106.*

Meena VS, Jalgaonkar K, Mahawar MK, Bhushan B, Bhushan B, Kashyup P (2020). Optimization of process variables for preparation of Pomegranate juice fortified aonla candy. *Current Science, 118(1): 114-118.*

Mena P, Gironés-Vilaplana A, Marti N and García-Viguera C (2012). Pomegranate varietal wines: Phytochemical composition and quality parameters. *Food Chemistry, 133: 108-115.*

Mir MM, Umar I, Mir SA, Rehman MU, Rather GH and Banday SA (2012). Quality evaluation of pomegranate crop – a review. *International Journal of Agriculture Biology, 14: 658-667.*

Mohsenin NN (1970). Physical properties of plant and animal materials. *Gordon and Breach Science Publishers,* New York.

Pande G and Akoh CC (2009). Antioxidant capacity and lipid characterization of six Georgia-grown pomegranate cultivars. *Journal of Agricultural and Food Chemistry, 57: 9427-9436.*

Radunic M, Špika MJ, Ban SG, Gadze J, Diáz-Pérez JC and MacLean D (2015). Physical and chemical properties of pomegranate fruit accessions from Croatia. *Food Chemistry, 177: 53-60.*

Rice-Evans CA, Miller NJ and Paganga G (1997). Antioxidant properties of phenolic compounds. *Trends in Plant Sciences, 2: 152-159.*

Riyahi R, Rafiee S, Dalvand MJ and Keyhani A (2011). Some physical characteristics of pomegranate seeds and arios. *Journal of Agricultural Technology, 7(6): 1523-1537.*

Shahkoomahally S, Khadivi A, Brecht JK and Sarkhosh A (2021). Chemical and physical attributes of fruit juice and peel of pomegranate genotypes grown in Florida, USA. *Food Chemistry, 342:* 128302.

Tehranifar A, Zarei M, Nemati Z, Esfandiyari B and Vazifeshenas MR (1997). Investigation of physic-chemical properties and antioxidant activity of twenty Iranian pomegranate (*Punica granatum* L.). *Scientia Horticulturae, 126: 180-185.*

Wrolstad RE, Durst RW and Lee J (2005). Tracking color and pigment changes in anthocyanin products. *Trends in Food Science and Technology, 16: 423-428.*

Zaouay F and Mars M (2011). Diversity among Tunisian pomegranate (*Punica granatum* L.) cultivars as assessed by pomological and chemical traits. *International Journal of Fruit Science, 11(2):151-166.*