

Variation in Pummelo Cultivars: A Review

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Abstract: *Pummelo (Citrus grandis (L) Osbeck) is referred to a type of giant citrus fruit native to southern Asia and Malaysia belongs to the family Rutaceae. It is thought to be the ancestor of the grape fruit. Pummelos are an excellent source of antioxidant flavonoids, a good source of potassium, phosphorus, folic acid, citric acid, etc. The peel is sometime used to make processed products viz., marmalade and candy or sometimes dipped in chocolate and the peel is also used in cooking specially in China. The fruit ranges from nearly round to oblate or pear-shaped specific with cultivars; 4 to 12 in (10-30 cm) wide and usually weighing 1-2 kg. The peel, clinging or more or less easily removed, may be green, greenish-yellow or pale-yellow 1.25-2 cm thick. Pulp varies from greenish-yellow or pale-yellow to pink or red having 11 to 18 segments, very juicy to fairly dry. The flavour varies from mildly sweet and bland to subacid or rather acid. Chemical compositions are also varying from cultivar to cultivar. Till date very little work has been done on pummelo fruit because of less availability of fruit and specificity of regions. Hence, there is immense scope of pummelo as it is a good source of health nutrition.*

Keywords: *Pummelo, Cultivars, Physical Properties, Bio-chemical Properties*

1. Introduction

Pummelo (*Citrus grandis* L. Osbeck) is referred to a type of giant citrus fruit and parent of many citrus fruits such as grapefruits and tangelos and belongs to the family Rutaceae [1]. It is native of southern Asia and Malaysia [2] although, Burana-osota [3] and Min [4] reported that pummelo is a native of Asia especially in China (primary centre of origin), southern Japan, Vietnam, Malaysia, Indonesia and Thailand (secondary centre). Pummelo has been regarded as one of the ancestral species as well as important commercial fruit tree under the genus *Citrus* [5].

The fruit is a good source of vitamins C [6, 7], B1, B2 and B12 and protein [8] as well as an excellent source of water, fat, carbohydrates,

vitamin A, and niacin [9]. It is also excellent source of antioxidant flavonoids [9], potassium, phosphorus, folic acid, citric acid, etc. [10].

Fruit is always round shape and big size with a very thick skin but soft and easy to peel away. Swingle and Reece [11] reported that the fruit of pummelo are large or very large, subglobose, oblate-spheroid or subpyriform; seeds large, thick, wrinkled, while, Scora [1] and Burana-osot [3] reported round to slightly pear shaped pummelo fruit. It may grow to a diameter of 12 inches or more and attain a weight of 9 to 10 kg. The easy-to-peel greenish yellow rind is thick and contains a dense layer of spongy pith [12]. The flesh, divided into about sixteen to eighteen segments, varies from a pale straw color to pink to deep rose. Some pummelo fruit contain an excess of seeds and others are nearly seedless.

Thus the objective of the present review was to study the different types of cultivars and their physico-chemical properties.

2. Physico-chemical variation in different pummelo cultivars

2.1. Aroma#1

Fruits of Aroma#1 were emerald green coloured with pyriform shape having average fruit weight 958g with polar diameter of 14.1 cm having 17.6% juice content with TSS of 9.6°B. Its edible portion consists of 41.30%. Seeds are deltoid to globous in shape. Flesh colour was chrome yellow to white [13].

2.2 Aonlan

It is a triploid pummelo cultivar originated from a cross between a diploid acid-less pummelo cultivar and a tetraploid white seedy grapefruit cultivar [14]. The fruits, which mature early (from late Aug. to early Sept.), are large (average weight 489.3g) with a regular flat or round shape and a polished green rind, usually seedless, and with a tender and juicy flesh with good flavour. The fruit

contains 11.5% TSS, 8.26% total sugar, 0.55% acid and 49.2 g/100 g vit. C (ascorbic acid).

2.3 Aiwanyou

It is a selection from the population of Wanbaiyou cultivar. Its outstanding characteristics are that it is precocious, productive and highly resistant to diseases and has late maturity. Fruits are large to very large, weighing 1425 g on average, but can also be reaching 2370g, having a smooth yellow rind. Flesh is white in colour, fine and tender, juicy, containing a soluble solids content of 10.7-11.5% and a titratable acidity of 1.46%. Just after harvest the flavour is quite sour but later fruits develop a pleasant acid sweet flavour and it is rated as having quite a good eating quality [15].

2.4 Benimadoka

It is a cross of Mato buntan X Hirado buntan. It is called as a superior pummelo cultivar because of early to mid-season maturity. While study on physico-chemical attributes, Yamada [16] reported that the fruit is large, weighs 700-1000 g, is oblate to broadly globose in shape, has a thick, pale yellow rind and contains many seeds. The pale red flesh is tender and juicy. Citric acid and soluble solids are lower than in Hirado buntan, but its flavour is superior.

2.5 Banpeiyu

Morton [17] reported that the fruits of 'Banpeiyu' are nearly rounded and very large. Peel and pulp are pale-yellow in colour, smooth, thick, tightly clinging, having 15-18 segments with thin but tough walls; firm but tender, juicy, of excellent quality, sweet-acid flavor; medium-late in season; keeps well for several months.

2.6 Chandler

Chen and Wu [18] reported that the pummelo cultivar Chandler fruits were uniform, weighing 1046.7 g on average. The rind thickness was 2.1 cm; the flesh was tender and juicy, with few seeds, and had a pleasant sweet flavour. Fruits were of very good eating quality.

While, Chen [19] found that the fruits of Chandler (red-fleshed) were medium in size, weighing 1000g on average and nearly round in shape; rind is yellow and glossy, with red, tender and moderately juicy flesh, with a soluble solids content of 11%, vitamin C (ascorbic acid) content of 30 mg/100 ml, a pleasant acid-sweet flavour, and good eating quality. Morton [17] proposed that the Chandler cultivar is a hybrid of 'Siamese Sweet' (white) and 'Siamese Pink' (acid) oblate to globose; of medium size; peel smooth, at times minutely hairy, medium-thick; core small; pulp pink, fine-grained, tender, fairly juicy; segment walls thin;

flavor superior to that of either parent; subacid, about 12% sugar.

2.7 Chuhongyou

The fruit of cv. Chuhongyou selected from the seed cultivated pomelo, ripens in late September, has a crimson sarcocarp, few seeds, and excellent eating quality (soft and crisp pulp, abundant juice, and sweet-sour flavour). It is also easy-to-peel and it bears high-quality fruits [20]. In another study, Xu [21] reported that the fruits of cv. Chuhongyou are oval round in shape with a shape index of 0.96, having an average weight around 750 g. The fruit appearance looks quite pretty and is easy to peel. Flesh of the ripe fruits is deep red color without a few seeds or seedless, juicy with a pleasant acid sweet flavor, of good eating quality.

2.8 Chinese evergreen

The fruit is pyriform in shape, weighs 1586 g having 13 fruit segments with 19% juice content. It also has 9.1°B TSS with 58.8% edible portion. The flesh is rhodonite red in colour [13].

2.9 DES#1

The fruit weighs 1008 g with spheroid in shape. The fruit has 12 segments with 16.3% juice content. The fruit contains 9.0°B TSS with 48.3% edible portion having neyron rose (red group) colour [13].

2.10. Double

Fruit is round, oblate or faintly pear-shaped; 6 to 8 in (15-20 cm) wide; peel smooth, up to 1 in (2.5 cm) thick; shows no evidence of deformity. The main fruit has 19 segments, the lesser fruit 4; pulp may be red, pink-and-white, or white; is sweet and juicy; mostly seedless, rarely with one or a few more seeds. Occasionally, under adverse conditions, there are many seeds. Fruits are borne in clusters of 5 or 6; not all on a tree will be double [17].

2.10 Eyou 1

Wong *et al.*, [22] discovered the pummelo (*Citrus maxima*) cv. Eyou 1 as a chance seedling. They reported that the fruits mature in late November, weigh 1500 g on average, and have an ovate shape. The rind is light yellow, with a good aroma. The flesh is yellowish, tender and juicy, with a very good flavour and very good eating quality.

2.11 Feicuiyou

Ding *et al.*, [23] reported that the 'Feicuiyou' another selection cultivar has outstanding characteristics of juicy green sacs with a pleasant flavour and long storage life. Fruits are medium size, weighing 700-1000 g with a light green rind.

The ascorbic acid level is very high, reaching 108.04 mg/100 ml (2-3 times more than other pummelo varieties).

2.12 Guifeihongyou

It is a hybrid between grapefruit and pummelo cultivar Wentan, has medium to large fruits, weighing around 1000 g, oblate to nearly round in shape, with a smooth bright yellow rind. Flesh is light purple red in colour with juicy, with a soluble solids content of 10.5%, titratable acidity of 0.72%, ascorbic acid of 402.0 g/ml and edible rate of 53.9%, with less than 30 seeds (much lower than the standard cultivar Shatianyou) [24].

2.13 Gusangyou

Chen and Rao [25] reported that, Gusangyou, an old pummelo, variety with good characteristics, has been grown in Cangnan country for more than 150 years. Its fruit are oblate-round in shape with a light yellow rind colour, and weigh 1.0-1.5 kg; they mature in mid-October. Juice sacs are bright red in colour, crisp and juicy with a very good flavour.

2.14 Guiyou 1

The fruits of cv. Guiyou 1 were pyriform with big and apparent oil glands, slight concave apex and with areole ring, good in appearance and quality. The pericarp color of fruits was orange-yellow. The single fruit weight was 1028.4-1060.5 g with 12-15 petals and 99.5-110.5 seeds in each fruit. The contents of total sugars, invert sugar, reducing sugar, citric acid, soluble solids, vitamin C in pomelo juice were found to be 9.44-11.05 g/100 mL, 9.82-11.53 g/100 mL, 2.00-2.15 g/100 mL, 0.25-0.32 g/100 mL, 12.3-14.0% and 82.74-97.97 g/100 mL, respectively [26].

2.15 Gong Shui Bai You

A selection from Li Jia He Bai You pummelo (*Citrus maxima*) having the fruits are from seedless to almost seedless. The fruit flesh is crisp and juicy. It tastes moderately sweet and acid but with a strong fragrant flavour. It had a unique character i.e. the fruits can be stored for 150 to 200 days at room temperature [27].

2.16 Gusangyou

Chen and Rao, [25] reported that the fruits of cv. 'Gusangyou' were oblate-round in shape with a light yellow rind colour, and weigh 1.0-1.5 kg; they mature in mid-October. Juice sacs are bright red in colour, crisp and juicy with a very good flavour.

2.17 Hongrou Miyou

A mutation of the Guanxi Miyou pummelo cultivar mature in late September, 20-25 days earlier than that of the maternal cultivar having large fruits, weighing 1200-2350 g, with an

inclined shoulder. Fruit rind is moderately rough and thin with a thickness of 0.7-0.9 cm and yellow green in colour. The juice sac is light pink in colour, very juicy, having a soluble solids content of 11.55%, titratable acidity of 0.74%, ascorbic acid of 378.5 micro g/ g and juice rate of 59.0%. The eating quality is excellent [28].

2.18 Hubin Miyou

The pummelo cv. Hubin Miyou, derived from the cross between Pingshanyou x Wanbaiyou, is early bearing, high yielding and produces high quality fruits which mature in early November, weigh around 1500 g, have yellow skin and wax-yellow, crisp, acid-sweet, aromatic flesh and store well [29].

2.19 Hongzai Tianyou

Selected among seedlings of cv. Tianyou, produces nearly round fruits weighing 800-1200 g, with a thin, orange-yellow rind. It has creamy white, fine textured, very juicy flesh. The soluble solids content is 12.8% and ascorbic acid content 86.31 mg/100 g. Fruits mature in early to mid November [30].

2.20 Hongxinyou

The fruits of cv. 'Hongxinyou' weighing about 2-3 kg, and reaching up to 5 kg. The rind is orange-yellow, and the flesh is pinkish, soft and juicy with a pleasant acid-sweet flavour, of very good eating quality. Every 100 g juice contains 120 mg ascorbic acid. The citric acid content is 0.94% and 12% soluble solids [31].

2.21 Hirado

A chance seedling oblate in shape and large fruit. It's having bright-yellow colour of peel and pale greenish-yellow pulp. Fruits are smooth with glossy, medium-thick, clings tightly. It has numerous segments with thin, tough walls, tender, medium-juicy; of good, subacid flavor, faintly bitter [17].

2.22 Jingmenjuyou

A natural hybrid of mandarin and pummelo has outstanding characteristics like dwarf growing habit, high and stable production, late maturity, increased hardness, large fruit size, high eating quality and longer storage life. Fruits weigh 300 g on the average, reaching 420 g; the rind is golden yellow to orange red, glossy, attractive and is easily peeled. The flavour is pleasant, acid-sweet and without bitterness [32].

2.23 Jishou Shatianyou

The quality and cause of seedlessness of pummelo cv. Jishou Shatianyou was reported by [33]. After investigation they concluded that the

embryo abortion was considered to cause the seedlessness. They also reported that the average seed number per fruit ranged from 2 to 32. As the coat of the fruit became lighter, the edible section increased.

2.24 Kao Lang Sat

Cultivar having oval-pyriform fruits without neck, faintly furrowed at both ends; 4 in (10 cm) wide; peel slightly rough, less than 3/8 in (1 cm) thick; pulp has peculiar aroma; pale pinkish, divided into 11 or 12 segments; sacs very dry and loosely packed; very sweet without a trace of acid; of inferior quality [17].

2.25 Kao Pan

Subglobose in shape, flattened at base and apex; 4 1/2 in (11.5 cm) wide; peel light lemon-yellow, smooth, 3/8 to 3/4 in (1-2 cm) thick, tightly clinging; shrinks in storage; core is large and stringy. It contains 12-15 segments but difficult to separate. Walls are thick and tough, inedible; they are skinned off and the individual pulp sacs separate readily from each other and are eaten by the handful, like those of the pomegranate. They are very juicy, of sweet, faintly acid flavor with hardly a hint of bitterness [17].

2.26 Kao Phuang

Fruits are elongated-pear-shaped with neck; 5 in (12.5 cm) wide or more; peel greenish to yellow, smooth, glossy, 1/2 to 3/4 in (1.25-2 cm) thick, not clinging; pulp in 11-13 segments which separate readily; walls medium thick and tough, ordinarily not eaten. Pulp sacs are easy to separate and very juicy. It contains excellent flavor, somewhat acid, turning nearly sweet when fully ripe, non-bitter and contains few seeds [17].

2.27 Kao Yai

Fruits are in globose shape, symmetrical; very large, 5 1/2 in (14 cm) or more in diameter. Peel has light-yellow colour at outside but slightly pinkish at inside (flesh colour). It exudes a little gum when cut. Wall is 1/2 to 3/4 in (1.25-2 cm) thick. Pulp having 13 segments but sacs are irregularly arranged, clinging tightly together; juicier and sweeter than 'Kao Phuang' but they become tough and indigestible if fruit is left too long on tree; seeds numerous and fully developed [17].

2.28 Longanyou

Cv. 'Longanyou' is a selection from a local pummelo variety, having few seeds and weigh 1000-1500 g. The rind is easily peeled and the flesh is light pink, juicy and has a rich, sweet flavour. The soluble solids content is 11.2% and the

ascorbic acid content 5.29 mg/100 g. It is considered to be of the best eating quality [34].

2.29 Longdu Zaoxiangyou

Zhang [35] reported that the fruits of cv. 'Longdu Zaoxiangyou' selected from open-pollinated seedlings of pummelo, weighing around 1500-3000 g, short and conic in shape, with a greenish-yellow rind at maturity. Flesh was tender, fine, and moderately juicy, with soluble solids content of 11.2%, ascorbic acid contents of 54 mg/100 ml and a rich acid-sweet flavour.

2.30 Liangpingyou

Fruits of cv. 'Liangpingyou' were oblate to elongate-oblate in shape with a golden yellow rind. Fruits weigh 900-1000 g, with a soluble solids content of 11.8%; the flesh is juicy with a rich pleasant flavour, and is of very good eating quality [36].

2.31 Longyan Hongyou

Fruits of 'Longyan Hongyou' (sport of pummelo cv. Guanximiyou) were large, weighing 1450 g on average, and have a smooth orange-yellow rind. The flesh is tender, very juicy (with a juice rate of 48%), with a pleasant acid-sweet flavour, of top eating quality. The juice contains 12% soluble solids and 41.03 mg ascorbic acid/100 ml [37].

2.32 Nakhon

It is a seedling of 'Kao Pan' (PI 52388), fruits are broad pears in shape but small (10 cm) wide. Peel lemon-yellow in colour while pulp is white in colour. It has a fine flavor [17].

2.33 Nelspruit Ruby

It is seedling selection of Ray Ruby. The fruits are dark, red, early, have higher fruit TSS:acid ratio [38].

2.34 Oroblanco

It is a triploid pummelo cultivar derived from a cross between a diploid pummelo cultivar and a tetraploid grapefruit cultivar. The seedless fruits mature in mid-late August in the Guangzhou area, weigh around 458 g, and have a green rind. The flesh is smooth and tender, with a soluble solids content of 8.9%, acidity of 0.65 g/100 ml, and an ascorbic acid content of 55.05 mg/100 ml [39].

2.35 Pomelit

A new South African pummelo cultivar, selected from seedling trees originating from open pollinated seed of Djeroek Delima Kopjor. Pomelit trees produce medium-sized fruits (620 g) with a thin, smooth rind in the hot production areas. The quality of the seedless bi-coloured segments, which are very tender, is excellent. Juice percentage is

43.2% and total soluble solids content is 15.4% [40].

2.36 Rabab Tenga

Bharali and Saikia [41] studied the changes in physical and biochemical parameters in Rabab Tenga (pummelo, white flesh) fruit to determine the optimum time of harvest. They found that the highest fruit weight (673.00 g), fruit volume (1107.33 cc), fruit length (14.55 cm), fruit diameter (13.62 cm), rind weight (238.33 g), seed number (100.66), seed weight (38.77 g), and volume of juice (205.50 ml) were recorded at 200 days after fruit set. Highest TSS (10.85%), reducing sugar (5.85%) and sugar acid ratio (9.32) were recorded at 180 DAFS.

2.37 Sunwuiluk Strain

It has largest fruit having weight of 1646 g having spheroid to oblate shape. The fruit contains 13 segments, 26.4% juice content, 9.6°B TSS and edible portion of 47.3%. The flesh has light pink colour and coarse to fine texture [13].

2.38 Seeloompang

Fruits are pronouncedly oblate in shape but flattened at both ends. This cultivar has an unique character of peel green even when fully ripe, smooth, thin, brittle; pulp red in colour, segment membranes non-adherent; juice sacs densely compacted, very juicy, acid-sweet and somewhat astringent [17].

2.39 Sijiyou

Sijiyou is a rare pummelo variety which flowers 4 times a year. Fruit quality is highest for the first and second flowering periods. On average, Sijiyou fruits weigh 800-1200 g, are seedless, have a soluble solids content of 9.25-11% and are of relatively good eating quality [42]. Chen [43] reported that the fruits of pummelo cv. Sijiyou are medium sized (800-900 g), obovate with a thin rind. The flesh is juicy, acid-sweet, with an ascorbic acid content of 41.2-50.5 mg/100 g.

2.40 Shuitu Wuhehongxinyou

It is a seedless red-celled pummelo and selected from pummelo (*Citrus maxima*) cv. Shuitu Hongxinyou. Fruits mature in mid-late October, are large, weighing 1000-1300g, obovoid in shape, with a smooth rind. The seedless juice-sac is pink, with a soluble solids content of 11.1% and a pleasant sweet-acid flavour. Eating quality is very good [44].

2.41 Shuyou

Shuyou a selection from local pummelo variety Anjiang Xianyou, is high yielding, producing very large (2031 g on average),

elongate-ovate, smooth-skinned fruits which have fine, tender, juicy flesh with a soluble solids content of 9.3% and an ascorbic acid content of 331 µg/ml. Fruits contain 6.2 seeds on average [45]. It is recommended for commercial cultivation. Lan [46] reported that the increased in average fruit weight by 57g (1253g) when spraying of BR-120 (brassinolide).

2.42 Shatianyou

Li [47] found that the bagged fruits of pummelo (cv. Shatianyou) in polyethylene film bags (25 x 25cm) had a smooth golden yellow rind with fine-textured tender flesh, had higher juice (38.12%) and soluble solids (0.4%) than control. Liu et al., [48] reported that bagged fruits had less attacked by pests and diseases and no obvious negative effect on the fruit eating quality. However, the soluble solids content of bagged fruit seemed lower than non-bagged fruit. Newspaper bags were best for packaging of fruits, but its resistance to wind and rain and control of pests were not as good as the bag soaked with wax and pesticide. Pummelo cv. Shatianyou bagged with large white single-layer semi-transparent bags indicated golden colour and very smooth fruits with higher juice (4%) and edible contents (0.87%), but lower soluble solids content (1%) and ascorbic acid (21.2 mg/100 ml) than non-bagged fruits. Bagged fruits had lower levels of chemical residues than non-bagged fruits [39].

2.43 Shanghang Miyou

Fruits of pummelo cv. Taiguo Miyou were large, weighing 1745g on average, round in shape and having a yellow rind. Flesh is yellowish white, fine and tender, juicy with 11-13.6% soluble solids content, 55.90mg/100 ml ascorbic acid content and few seeds (10-15), a pleasant acid sweet flavour and is of very good eating quality [49]. Huang [50] reported that the Changshan Huyou (a pummelo and orange hybrid) has large fruit, with a glossy, smooth rind, and of good eating quality.

2.44 Tahitian

A typical pummelo but with a thin peel and amber-colored, very juicy pulp. The flavor and quality are excellent and it is locally popular [17].

2.45 Thong Dee

Fruits of Thong Dee are oblate shaped, large, 6 in (15 cm) wide, pinkish coloured flesh with 3/8 in (1cm) thick white pulp is white with light-brown streaks; pulp sacs large, separating easily from the segment walls. It is very juicy cultivar with good flavor and seedy [17].

2.46 Tresca

Fruit is oblate to round, obovoid, or pear-shaped; of medium size, 4 in (10 cm) wide; peel light-yellow, smooth, thick; albedo cream-colored to white; pulp pale-orange, or pink, in 12 to 14 segments; of good flavor; very juicy; many, medium-sized seeds [17].

2.47 Tosa Buntan

Susanto *et al.*, [51] found that the weight of seedless fruits of cv. Tosa Buntan was similar to that of the seeded ones at various harvest times. The shape of the seedless fruits was pyriform and necked with thick peel and the degreening of fruit rind slower compared with seeded fruits. Total soluble solids (TSS) and acids contents of the seedless fruits were lower than those of the seeded fruits during fruit maturation. The TSS content of both seedless and seeded fruits considerably increased from mid Nov. to mid Feb. in the following year and the TSS level in mid Feb. remained almost unchanged until mid March. The acid content of seedless fruits decreased more slowly than that of seeded ones.

2.48 Tantian Juyou

A pummelo hybrid cv. 'Tantian Juyou', derived from the cross Shangtian Satsuma (*C. reticulata*) x Bashuoyou (*C. maxima*) is precocious, productive, resistant to diseases and highly adaptable to various growing conditions. Fruits mature in mid-late December, contain 3-5 seeds and are large, with an average weight of 250g. They are oblate in shape with orange-yellow rind and orange flesh, very juicy and sweet, with a mixed aroma of mandarin and pummelos. The cultivar contents 12.5-14.0% of soluble solids, 0.68% of titratable acidity and 37.84mg/100 ml juice of ascorbic acid [52].

2.49 Wuheputaoyou

This cultivar was discovered in 1985 as a sport of a local cultivar. It produces large (300-500 g), elongate-oblate, orange fruits of very good eating and keeping quality. The rind is 0.42 cm thick and the flesh is tender and juicy, with a rich sweet rather than bitter flavour. The ascorbic acid content is 52.3 mg/100 g [53].

2.50 Wanbaiyou

Shi [54] reported that the pummelo cv. Wanbaiyou produced larger fruit (1120g) with 57.8% juice content, 10.5% soluble solids and 0.95% citric acid and have comparatively few seeds (31.5). It had also the longest storage life, with fruits harvested in late December storing well at room temperature until April or May.

2.51 Winling Gaocheng

A natural hybrid between pummelo (*Citrus maxima*) and orange (*C. sinensis*) having fruit weight of 400-500g on average but can reach up to 1000g with 12-14% soluble solids, 8.8g sugar, 1.57-1.72g acids, 45.36-50.72mg ascorbic acid, 14.47mg riboflavin and 0.04mg vitamin E. Fruits are suitable for table purpose and for processing. The fruit juice could be an alternative to grapefruit juice [55].

2.52 Yuhuanyou

The fruits of cv. 'Yuhuanyou' were large, weighing 1250-2500g, oblate or elongate-round in shape and have a light-yellow rind. Flesh is creamy-yellow and very juicy, with a soluble solids content of 12.5%. Eating quality is good. However, it is susceptible to fruit cracking [56]. Lin [57] reported that the fruits of cv. Yuhuanyou matures in early November. The fruits weighing about 1000-2515g with orange-yellow rind and light yellow flesh, which is tender, crisp, juicy with a soluble solids content of 12.5% and a pleasant sweet acid flavour.

Wang and Shen [58] graded the pummelo cultivars in two type i.e. top grade (weight 1.25-1.50 kg, rind thickness 1.8 cm, soluble solids content 12.5%, citric acid content 0.30%, edible parts 42%, with a glossy skin) and first grade (weight 1-1.24 kg, rind thickness 2.00 cm, soluble solids content 12.0%, citric acid content 0.35%, edible parts 40%, and a glossy skin).

Murthy *et al.*, [59] studied on various cultivars of pummelo and revealed that, the oblate type of fruit had highest fruit weight (1.49kg), fruit circumference (56.9cm), number of segments (18.85), segment weight (4.88g) and titratable acidity (298.6 mg/100 ml juice) while oblong type fruits had most juice per 100g of pulp (58.6g). The ovoid type had the highest total soluble solids content (10.64%) and the spherical type scored most in the organoleptic test.

Pichaiyongvongdee and Haruenkit [12] classified pummelo fruits into two groups on the basis of juice color, i.e. either white or pink and revealed that Tong Dee and Tha Khoi comes under pink group and Kao Yai, Kao Paen, Kao Nampheung, Kao Tanggkya, Kao Hom, Kao Phuang and Pattavee comes under white group.

Among 12 germplasm, B3 recorded moderately higher results in respect of all physical parameters, along with least seed number, which altogether proved it most desirable germplasm. No such single germplasm was found which was most superior in respect of all chemical characters. Five germplasms (B1, N1, H1, H2 and No 1) showed moderately desirable results in respect of these characters. Corresponding physical and chemical parameters of H1, B3, H2 and B1 scored best among the 12 selected germplasms [60].

Suthanukool *et al.*, [61] reported that SK-0032 was the best clone with 43 fruits/tree and 6.65 kg/tree. The fruit had light pink flesh with 13°B and good smell. Other clones were SK-0108, with red flesh, sweet with a little bit sour, 11.8° B; SK-0073, with dark red flesh, sweet with little bit sour, 12.9° B, many fruit; and SK-0030, with honey white color, sweet with little bit sour and 12.8° B.

Among 24 cultivars of pummelo, Bog-6, Din-29 and Pab-42 were found better in respect of fruit characteristics. Cultivar Din-29 produced maximum number of fruits/plant (48.0) followed by Bog-6 (40) and Pab-42 (38). The fruits of cultivar Raj 75 were the heaviest (1370.0 g) whereas cultivar Rang-40 produced the smallest fruit (608.5 g). The maximum total soluble solid (TSS) was recorded in Pab-42 (13.3%) followed by Din-29 (12.4%), Rang-50 (12.2%), Raj-32 (12.0%), Raj-51 (11.6%), Bog-6 (11.6%) and Raj-48 (11.1%). The total acid varied from 0.11 to 0.88%. Considering the quantitative and qualitative characteristics, Bog-6, Din-29 and Pab-42 were better cultivars [62].

Samarasinghe, [63] found that the fruit weight ranged from 690 to 1400 g, fruit shape varied from spheroid to pyriform, oil glands density was low, number of segments 10-14, pulp flesh colour pink and white, number of seeds per fruit ranged from 8 to 60, degrees Brix ranged from 8.7 to 10.3, and taste was good while study on 82 pummelo (*Citrus grandis* [*Citrus maxima*]) trees.

Shen *et al.*, [64] studied 102 pummelo cultivars and they reported that, among the cv. Shatianyou selections, Shatianyou 2 had the thinnest rind (1.14 cm thick), the highest sugar content (8.52%) and the highest vitamin C content (158 mg/100 ml). Among the mid-season cultivars, Lijiahe Baipiyou 6 had the highest soluble solids content (12%). Among the early cultivars and selections, Wu 1 fruits had high soluble solids contents and low acidity.

Chandra and Chandra, [65] studied the physico-chemical characteristics of oval and pear-shaped pummelo fruits and the characteristic round fruits of the grapefruit cultivar Duncan. They found that the pear-shaped fruits had maximum weight (1550 g) followed by oval fruits (1175 g) and 348 g in Duncan. Pear-shaped fruits also had maximum length (26.3 cm) compared with 19.50 in oval fruits and 9.25 cm in Duncan. Rind thickness was minimal in Duncan (0.50 cm), 3.0 cm in oval and 3.2 cm in pear-shaped fruits. Pear-shaped fruits had highest juice content (52.32%) and maximum TSS (8.2%). Acidity was minimum in oval fruits (0.39%), 0.54% in pear-shaped fruits and 0.73% in Duncan. Oval fruits had a TSS:acidity ratio as high as 20.0 followed by 15.2 in pear-shaped fruits and 10.7 in Duncan.

3. Conclusion

In this article, we studied the different cultivars of pummelo. Each cultivar has their own distinguish characteristics. Pummelo fruit can be classified based on shape, size, colour of mesocarp and pulp vesicles. Generally, the fruit ranges from nearly round to oblate or pear-shaped and usually weighing 1–2 kg. It is usually pale green to yellow when ripe, with sweet white (or, more rarely, pink or red) flesh and very thick pudgy rind. The flesh, divided into about sixteen to eighteen segments. Some pummelos contain an excess of seeds and others are nearly seedless. It is an excellent source of vitamins, proteins, flavonoids, potassium, phosphorus, folic acid, citric acid, water, Protein, Fat, and Carbohydrates etc. It is not unlikely that some more cultivars may still be there and which have escaped from our notice since the range of variation is wide in the pummelo. There is ample scope for development of cultivars through genetic engineering or other means. Further research and development is needed for proper characterization of pummelo fruit.

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