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Green Farming Vol. **9** (2) : 379-382 ; March-April, 2018 **Research Paper**

Effect of harvesting of fruits at different stage of maturity on nutritional quality of Kinnow under Hot Arid Zone of North western India

JULIUS UCHOI[b1*], R.S. SINGH[a2], R. BHARGAVA[a3], HARE KRISHNA[a4], VENKATESAN K.[c5], ABHISHEK KUMAR[b6] and ANIL PATIDAR[b7]

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ABSTRACT

Kinnow fruits were collected from the 15 year old orchard of ICAR-Central Institute for Arid Horticulture (CIAH), Bikaner at three different time of harvesting such as immature (early), fully mature (mid) and over-mature (late) as treatments with five replications under Completely randomized design. Observations made on fifteen different parameters, which include seven physical and eight biochemical traits. Assessment of nutritional quality of Kinnow revealed the impact of each stages of fruit maturity on the quality aspect of this citrus species. Important nutritional quality parameters *viz* TSS (11.8°Brix), vitamin –C (49.0mg/100ml), total sugar (8.1%), reducing sugar (4.9%), non-reducing sugar (4.1%) are found to increase as the fruits progress towards maturity. Only antioxidant activity (2.1mMTE/L) and total phenolic content (2060.4µg/100g) revealed phenomenal changes decreasing at mid maturity and again increase in the later stage of full maturity. Although the significant difference obtained in physical and biochemical changes between the mid and late maturity stage, the maximum attainment of fruit nutritional quality at the late maturity or full ripe stages of the mandarin suggesting the right stage of consumption of Kinnow fruits.

Key words : *Citrus, Kinnow, Nutritional quality, Stage of consumption.*

INTRODUCTION

Citrus fruits are most popular in many parts of the world due to its distinctive flavor, taste, and aroma as well as multiple health benefits associated with it. The major phenolic compounds detected in different citrus fruits are categorized as flavonoids and phenolic acids (Balasundram *et al.,* 2006). Among the fruits, several species of citrus possess good amount of antioxidant properties. Kinnow (*Citrus reticulata* Blanco), an important introduced citrus crop, is widely popular and cultivated in arid region of western India. Mandarins are rich in ascorbic acid and calcium. They are a great source of vitamin C. The chemical composition of the mandarin is as given in **Table 1**. The presence of vitamins and antioxidants within the fruit provide a wide scope in combating the nutritional deficiency in ever growing population of the region. There exist an immense potential to tap and assess the various physical and biochemical activity of Kinnow mandarin in India at various stages of ripening, as quantifying and determining the amount of antioxidant activity at various stages of fruit ripening would help in determining the most suitable stage of its consumption. Therefore the present study was conducted on assessment of physical and biochemical activity of Kinnow mandarin in ICAR-Central Institute for Arid Horticulture, Bikaner, Rajasthan at 3 different months from November, 2014 (*i.e.* beginning of colour changing stage) to January, 2015 (*i.e.* full ripen stage).

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[4] Senior Scientist

Table 1. Chemical composition of Mandarin (Per 100 g of edible portion)

Chemical composition	
Moisture	82.6 - 90.2 g
Protein	0.61 - 0.215 g
Fat	0.05 - 0.32 g
Fiber	0.3 - 0.7 g
Ash	0.29 - 0.54 g
Calcium	25.0 - 46.8 mg
Phosphorus	11.7 - 23.4 mg
Iron	0.17 - 0.62 mg
Carotene	0.013 - 0.175 mg
Thiamine	0.048 - 0.128 mg
Riboflavin	0.014 - 0.041 mg
Niacin	0.199 - 0.38 mg
Ascorbic acid	13.3 - 54.4 mg

Source : Morton, J. 1987

MATERIALS AND METHODS

The experimental material 'Kinnow' fruits were collected from the 15 year old orchard of ICAR-Central Institute for Arid Horticulture (CIAH), Bikaner situated at latitude 28˚10' and longitude 73˚35'. Experiment were conducted using three different time of harvesting such as immature (early), fully mature (mid) and over-mature (late) as treatments with five replications under completely randomized design. Ten fruits from five randomly selected trees pooled together and divided into five lots with ten fruits each. Each lot was considered as a replication. Observations made on fifteen different parameters of Kinnow fruits, which include seven physical [fruit weight, length, width, volume dispersed, specific gravity, peel weight and juice recovery] and eight biochemical traits.

TSS (Brix) was determined by hand-refractometer. The titratable acidity (%), total and reducing sugar content were estimated by using the methods described in A.O.A.C. (1990), Dubois *et al.* (1951) and Nelsons modification of Somogyi method (Somogyi, 1952), respectively. Total phenol and antioxidant content of Kinnow juice were measured on the basis of Folin–Ciocalteu colorimetric method using gallic acid solution (Singleton *et al.,* 1999) and CUPRAC method using UV-VIS spectrophotometer at 450 nm (Meng *et al.,* 2011), respectively. Data were subjected to one way ANOVA using SPSS software. The means of significant parameters, among the treatment were compared using critical difference (CD) tests at probability level of 5%.

RESULTS AND DISCUSSION

In the present study, changes in seven physical and eight biochemical traits were observed in the selected fruits of Kinnow mandarin at three maturity stages (early, mid and late) (**Fig. 1**) and it revealed the presence of significant differences (5% level) in three physical and four biochemical traits among

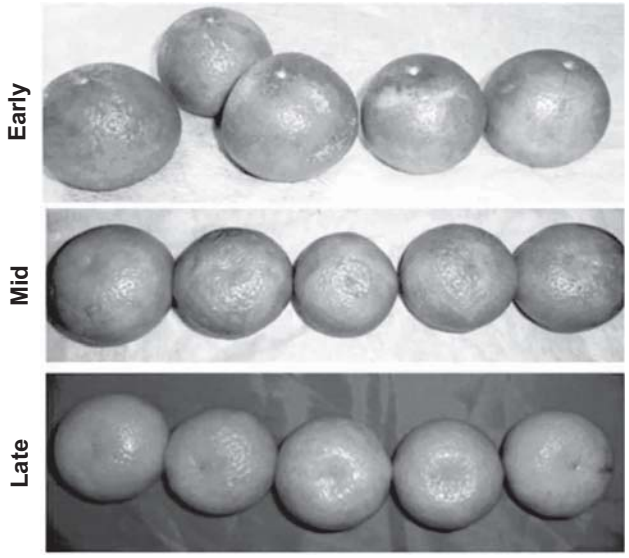

Fig. 1. A view of the Kinnow fruits at three different stage of harvesting (Early, mid and late)

Kinnow fruits collected at different stages (**Table 2 and 3**). Although, differences in physical changes occurred between Kinnow fruits harvested at early and late maturity stage with respect to fruit weight (g), length (cm), width (cm) and volume dispersed (cc) [as (152.0 and 170.4), (5.8 and 6.3), (7.1 and 7.3) and (146.0 and 183.0), respectively], very little difference noted in these characters between mid and late stage. Decreasing trend was observed in specific gravity of fruits from early to mid and mid to late stage of maturity as 1.1 to 1.0 and 1.0 to 0.9, respectively. But the peel weight (g) of fruits increased from 36.6 at early stage to 82.9 at mid stage of maturity and then, decreased (77.9) in late stage of maturity.

In case of juice recovery of Kinnow, late and middle stage of maturity showed high juice recovery percentage as 51.8 and 41.2%, respectively with significant difference at 5% level as compared to early stage (35.9%). In general, juice contents in citrus fruits increase towards maturity and then decrease when fruits become over-mature. These contents remain variable for the entire period of fruit development. Decrease in juice

Table 2. Physical parameters of the Kinnow fruits at three different stage of harvesting

	Different stages of fruit			CD
	Early	Mid	Late	
Fruit weight (g)	152.0	172.4	170.4	35.14
Fruit length (cm)	5.8	6.2	6.3	0.44
Fruit width (cm)	7.1	7.3	7.3	0.52
Volume dispersed (cc)	146.0	180.0	183.0	40.37
Specific gravity	1.1	1.0	0.9	0.08*
Peel weight (g)	36.6	82.9	77.9	11.18*
Juice recovery (%)	35.9	41.2	51.8	7.31*

* Significant at 5% level

Table 3. Biochemical activities of Kinnow fruits at three different stage of harvesting

	Different stages of fruit			CD
	Early	Mid	Late	
Acidity (%)	1.7	0.4	0.3	0.10*
TSS (Brix)	10.3	11.0	11.8	1.15
Total sugar (%)	6.5	7.3	8.1	0.23
Reducing Sugar (%)	3.6	4.5	4.9	1.91
Non reducing sugar (%)	2.9	3.4	4.0	0.26*
Vit-C (mg/100ml)	46.3	48.0	49.0	15.30
Total phenol (µg/100g)	991.4	179.4	2060.4	50.68*
Antioxidant activity (mMTE/L)	0.3	1.0	2.1	0.05*

* Significant at 5% level

content reveals quality decline (Riaz *et al.,* 2015). Whereas in present study, the juice content of Kinnow increased in over-mature stage which means that there was improvement in quality. It might me due to the effect of weather condition of area such as rainfall, high humidity or cultural operation (irrigation management) before fruit collection (Cruse *et al.,* 1982) and it might also be picking season of fruit (Gillfillan *et al.,* 1972).

Acidity in citrus fruits is one of the quality traits and it should be lower in sweet oranges for better quality (Nawaz *et al.,* 2012). In general, acidity decreased as fruits approach towards maturity and then increased as fruit become over-mature (Grewal *et al.,* 2000; Anwar *et al.,* 1999). In present study, there was an initial rapid rise (1.7) of titratable acids at early stage of maturity, followed by dip in mid and late (0.4 and 0.3, respectively) stage of maturity due to dilution effect, because of increase in size of fruit mainly water content. Trends of total soluble solids and acidity from early to late maturity stage of Kinnow fruits obtained in our study followed the chemical changes occurring in citrus fruits during growth and maturation of it (Syverstsen *et al.,* 1983; Cohen, 1988; Mcaneney *et al.,* 1995; Yamanishi, 1995; Yamanashi and Hasegawa, 1995; Yakushiji *et al.,* 1996). TSS is good quality index of Kinnow fruits and sugars constitute 85% of it. Normally, it increases as fruit become mature and then decreases as over-mature and a similar trend (at early, mid and late stage of maturity as 10.3, 11.0 and 11.8 brix respectively) observed in our study. This rise might be due to increase in sucrose contents, which hydrolyzed to simple sugars during maturity of fruits. Its content varies on basis of position of fruits on tree (Syverstsen *et al.,* 1983; Fallahi and Moon, 1989).

TSS is inversely related with titratable acidity (%), as the fruit attain towards ripening the amount of total soluble solids and other sugar compound increases while the organic acids present in the fruit juice decreases. The increase in sugars accumulation may be due to lower pH which enhanced the sink strength of the fruits (Hockema and Atxeberria, 2001).

Sugars are the major components of citrus juice's soluble solids and sweetness of citrus juice is intrinsic to its sugar composition. Sucrose is present in the largest amounts in citrus juice followed by fructose and glucose (Kelebek & Selli, 2011). The increasing trend observed in total sugar content of Kinnow fruits till maturity (6.5 at early stage to 8.1% at late stage of maturity) in present study also reported in earlier work (Miller and Evans, 1997). Potential factors responsible for variability in sugar content of Kinnow fruits are: variety, rootstock, geographical location, weather and cultural practices. The vitamin-C (ascorbic acid) content showed increasing trend without significant differences at early to late stage of maturity from 46.3 to 49.0 mg/ 100ml. This finding was contrary to the work reported by Danielle *et al.* (2014), where they reported that in citrus vitamin-C concentration decreases with ripening and vitamin-C was found to be at the highest during matured stage than the green stage because the fruit juice volume and fruit size increases in mature fruit. The changes in ascorbic acid can be attributed by effect of processing, storage time, variety, exposure to light and other factors (Gillfillan *et al.,* 1972).

The highest concentrations found in Citrus sp. correspond to flavanone glycosides, followed by flavones, flavonols and the fully polymethoxylated flavones (PMFs) (Kawaii *et al.,* 1999). Hesperidin, narirutin, naringin, eriocitrin and neohesperidin are the major flavanone glycosides (Peterson *et al.,* 2006). Vitamin C is considered to be one of the most important nutrients found in citrus fruit, and it is an important water-soluble antioxidant that plays a crucial role in the suppression of superoxide radicals (Kaur and Kapoor, 2001). In citrus, vitamin-C and phenolic compound constitute the major portion of antioxidants. In present study, the amount phenol content (µg/100g) and anti-oxidant activity (mMTE L^{-1}) observed as 991.4 to 2060.4 and 0.3 to 2.1 at early and late stage of maturity, respectively.

Evidence of increased antioxidant activity in ripe fruits is contradictory to an earlier work of Rekha *et al.* (2012), wherein they reported that as the fruit advances towards ripening, there is a reduction in phenolic and other antioxidant contents as compare to unripe ones. The antioxidant activity may be contributed by integral effect of both ascorbic acid and phenolic compounds present in the citrus juice and also with the possibility of other factors such as the type of citrus cultivar, stage of maturity and the methodology selected for analyzing antioxidants (Juihaimi and Ghafoor, 2013). Being antioxidant rich fruit, consumption and the right stage of harvesting of Kinnow to obtain maximum benefit of this antioxidant identified in present study could provide a wide scope in combating the nutritional deficiency in ever growing population of the region. Although the significant difference obtained in physical and biochemical changes between the mid and late maturity stage,

the maximum attainment of fruit nutritional quality at the late maturity or full ripe stages of the mandarin suggesting the right stage of consumption of Kinnow fruits.

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