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Quality Assessment in Different Stages of Maturity of Fruits, Mandarins Kinnow and Feutrell's Early Collected from the Fruit Market of Quetta City at in Relation to Their Benefits for Human Health

[1]Musarat Riaz, [2]Talat Zamir, [3]Nadeem Rashid, [1]Nelofer Jamil, [4]Zubia Masood, [1]Uzma Jabeen, [1]Fazeela Mandokhel, [1]Farida Behlil, [5]Fariha Mengal and [1]Muzaffar Khan

[1]Department of Chemistry, SardarBahadur Khan Women's University, Quetta, Pakistan
[2]Department of Chemistry, University of Balochistan, Pakistan
[3]Center of advance studies in Vaccinology and biotechnology, University of Balochistan, Pakistan
[4]Department of Zoology, University of Karachi, Karachi-75270, Pakistan
[5]Department of Zoology, SardarBahadur Khan Women's University, Quetta, Pakistan

Abstract: In the present study, fruit quality of mandarins Kinnow and Feutrell's early collected from fruit market of Quetta city were determined by using different physiochemical properties (juice contents, pH, acidity, Total Soluble Solids (TSS), TSSand acidity ratio, total sugars and vitamin C contents) of these fruits. The obtained results indicated that stage of maturity had significant effect on the quality characters of all citrus fruits. Two different trends were observed in the present study. Sugars, total soluble solids and TSS/ acidity ratio, juice contents and pH tend to increase toward maturity but at the end of the season slight decrease in these contents were observed. On the other hand, acidity and ascorbic acid contents were maximum at early stage when fruits were immature. So all fruits samples were rich in sugars, TSS and TSS/ acidity ratio and these contents were maximum only at the stage of maturity in accordance with the literature reviewed. Thus it had been concluded from the obtained results that over or under mature fruits did not possess absolute proportion of quality characteristics, hence not as beneficial for human health as mature fruits.

Key words: Kinnow · Feutrell's · Physiochemical Properties · Stage Of Maturity

INTRODUCTION

Fruits of genus citrus include oranges, mandarins, lemons, limes, grape fruits, chukotra and citron. Citrus fruits are renowned not only for special taste, flavor but their high nutritive value is responsible for recognition and fame of fruits [1-3].

The important citrus producing countries are China, Japan, Pakistan, India, Brazil, Israel, South Africa, Algeria, Tunis, Egypt, Libya etc. In Pakistan, it grips first position on the basis of area (183.8 thousand hectares) and production (1943.7 thousand tonnes) [4]. Among citrus fruits, Kinnow mandarin (*Citrus reticulata Blanco*), Feutrell's early and sweet oranges (*Citrus sinensisosbeck*) have enlarged a prime importance due to their exceptionally high economical yield potential, excellent fruit quality and useful adaptation to various agro-climatic conditions.

Quality of citrus like other fresh fruits depends on its external (i.e., colour and firmness) and internal characters viz; Total Soluble Solids (TSS) or Brix, total acid, total soluble solids / acid ratio and juice content, characters [5]. The factors influencing fruit quality characteristics include type of cultivar and stage of maturity [6]. Stage of maturity is considered more important, as it determines storage-life and final fruit quality. Immature fruits are extra subject to mechanical damage and of inferior flavor quality. Over mature fruits become mealy with insipid flavor. Fruits either picked too early or too late in their season are more susceptible to postharvest physiological disorders and less nutritive than the fruits picked at proper maturity. Therefore, harvesting of fruits at proper stage of maturity is of principal importance for attaining desirable quality and to attain its proper nutritive benefits [7].

Corresponding Author: Dr. Zubia Masood, Department of Zoology, University of Karachi, Karachi-75270, Pakistan.

Keeping in view the significance of citrus fruit and effect of ripeness on the quality index, the present study was conducted to explore the descriptive characteristics of two citrus fruits regarding healthy contents of mandarin fruit i.e. Kinnow mandarin (*Citrus reticulata* Blanco) and Freutell's early at different stages of maturity throughout a marketing season at Quetta, which could help to suggest the best time of picking of fruit. Therefore, determination of the absolute proportion of quality characteristics at different stages are accounted to present the fruit in the local markets in most suitable form to improve the earnings of the growers and to avoid undue losses of the crop.

MATERIAL AND METHODS

Sampling: Citrus fruit Kinnow mandarin (*Citrus reticulata* Blanco) and Fruiters samples (n=216) at three different stages of maturity (viz., early stage when fruits were immature, mid stage when fruits were fully mature and end stage when fruits were over mature) were collected during marketing season (October 2013 to April 2014) from fresh fruit market of Quetta. Fruit samples were collected in polythene bags early in the morning with the start of fruit market and transported for analysis to laboratory of SardarBahadur Khan Women's University, Quetta. Samples were processed within five hours after receiving laboratory.

Processing: In order to remove the dust particles, fruits were washed with distilled water. There after juice was extracted with citrus fruit extractor (Nowake N-999Japan) for physiochemical analysis i.e. percent (%) juice contents, Total Soluble Solids (TSS), pH, percent (%) acidity, total sugar and vitamin C and TSS/acidity ratio of all collected citrus fruit samples.

Determination of Juice Contents: The juice contents were weighed and recorded in grams [8, 9]. The percent juice contents were calculated by using the following formula;

% juice contents = juice weight ÷ fruit weight x 100

Determination of pH and Acidity: The juice pH for each sample was determined (in triplicate) using calibrated pH meter (Jenway- 350, England) following the method previously adopted by[10]. Acidity of the juices was determined (in triplicate) by acid base titration [8].

Percentage acid = Titer x acid factor x 10/10 (ml juice)
Factor for citric acid is 0.0064 (citrus fruit)

Determination of Total Soluble Solids (TSS) and TSS to Acid Ratio: Total soluble solids of the fruit juice were determined (in triplicate) as °Brix by using Abbe's refractometer (NAR- IT, Japan) under the protocol previously adopted by [8]. In order to determine the total soluble solid to acidity ratio (TSS: acidity), the total soluble solids was divided by percent acid [8,9].

TSS: Acid = °Brix value / Percentage acid

Determination of Sugars: Chemical estimation method was used to determine the sugar (in triplicate) [11]. Strength of unknown glucose solution= $4xWxV_1/V$ gm. / litter

Where
W= Weight of glucose in 250 ml standard solution
V1= Volume of standard glucose solution used for 25 ml Fehling's solution
V= Volume of unknown glucose solution used for 25 ml Fehling's solution.

Determination of Vitamin C: Iodine titration method was used to determine Vitamin C contents in the fruit juices (in triplicate). Vitamin C in the juice sample was calculated as:

X ml iodine solution used for standard solution of vitamin C / 0.250 g Vitamin C = x ml iodine solution for juice sample / X ml Vitamin C

Statistical Analysis: Statistical analysis on data was carried out by using the analysis of variance (ANOVA) techniques with completely randomized design (CRD). Duncan's Multiple Range test (DMR) was used to compare the significance of difference ($p<0.05$) among means. Statistical package for Social Sciences (SPSS) 16 for windows was used for analysis.

RESULT AND DISCUSSION

In the present study compositional changes of juice contents, pH, acidity, TSS, TSS and acidity ratio, total sugars and vitamin C contents in the selected fruits Kinnow mandarin and fruiter at three maturity stages (immature, fully mature and over mature) were observed.

Table 1: Physicochemical parameters of kinnow at three stages of maturity

Stage of maturity	Juice content		pH		Acidity (%)		TSS (%)		TSS / acidity ratio		Total sugars content		Vitamin C content	
	Range	Mean±SEM	Range	Mean±SEM	Range	Mean±SEM	Range	Mean±SEM	Range	Mean±SEM	Range	Mean±SEM	Range	Mean±SEM
Early Stage	38.20-40.10	38.93^{b}±0.59	3.30-3.90	3.60±0.18^{b}	1.10-1.35	1.21±0.72^{a}	8.80-9.80	9.27^{b}±0.29	7.10-8.90	8.00^{c}±0.51	7.50-8.20	7.90^{b}±0.20	49.60-52.10	50.97^{a}±073
Mid Stage	48.30-52.40	50.63^{a}±1.21	4.40-4.60	4.50^{a}±0.058	0.55-0.65	0.60^{b}±0.03	11.84-12.00	11.94^{a}±0.05	18.21-20.00	19.39^{a}±0.60	9.20-10.00	9.57±0.23	41.50-43.10	42.30^{b}±0.46
Late Stage	49.20-50.30	49.60^{a}±0.35	4.20-4.40	4.30^{a}±0.058	0.70-0.80	0.75^{b}±0.03	11.00-11.80	11.33^{a}±0.24	14.00-15.71	14.70^{b}±0.51	8.80-9.60	9.20±0.23	42.15-45.30	43.51^{b}±0.93

^{ab}Means in column with different superscripts differ significantly (P<0.05)

Table 2: Physicochemical parameters of fruetrell's early at three stages of maturity

Stage of maturity	Juice content		pH		Acidity (%)		TSS (%)		TSS / acidity ratio		Total sugars content		Vitamin C content	
	Range	Mean±SEM	Range	Mean±SEM	Range	Mean±SEM	Range	Mean±SEM	Range	Mean±SEM	Range	Mean±SEM	Range	Mean±SEM
Early Stage	34.30-40.20	36.5^{b}±01.87	3.60-4.20	3.90±0.18^{a}	0.65-0.80	0.71^{a}±0.04	7.36-9.65	8.57^{b}±0.67	9.20-14.84	12.15^{b}±1.63	6.80-7.50	7.16^{b}±0.20	43.92-48.30	45.55^{a}±1.43
Mid Stage	47.00-50.00	48.83^{a}±0.92	4.90-5.20	5.03^{a}±0.09	0.50-0.60	0.53^{b}±0.03	10.50-12.11	11.37^{a}±0.47	19.10-21.00	20.09^{a}±0.55	8.90-10.00	9.46^{a}±0.31	38.10-40.25	39.18^{b}±0.62
Late Stage	40.10-48.35	42.88^{ab}±2.73	4.20-4.80	4.50^{b}±0.17	0.60-0.65	0.61^{ab}±0.16	8.60-9.65	09.28^{b}±0.34	14.33-16.00	15.05^{b}±0.49	7.40-8.80	8.20^{b}±0.41	38.30-40.40	39.23^{b}±0.61

^{ab}Means in column with different superscripts differ significantly (P<0.05)

The results regarding the juice contents of kinnow indicated a significant difference (P<0.05) in the stage of maturity (Table. 1). Late and mid stage with 49.60% and 50.63% showed significantly high (P<0.05) juice percentage compared to early stage yielding (38.93%). However non-significant difference (P>0.05) was noted between mid and late stage. Juice contents in citrus are dependent upon many factors generally 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 contents reveals quality decline. These findings of juice contents are in agreement with Grewal *et al.* [9], Joolka and Awasthi [12], Cheema [13] and Khan *et al.* [14] for kinnow. On the other hand including maturity stage slight differences in the juice contents during these studies might be due to number of other factors as reported by Cruse *et al*. [15] and Gillfillan *et al*. [16]. Little fluctuation in the results at any stage may be due to time period of fruit collection.

The pH of citrus juices provides the information about the state of acidity and basicity. In the present study it was observed that, pH increased up to mid stage of maturity after that it started decreasing till the late stage (Tables 1 and 2). The increase in pH might be due to decrease in acidity with the maturity and decrease in pH indicates the increased acidity of the fruit and this might be due to the formation of acidic compounds due to degradation of reducing sugars. The findings are in line with the findings of Anwar *et al.* [10] for citrus sweet varieties including kinnow.

Acidity in citrus fruits is one of the quality traits. In sweet citrus varieties, fruit quality will be better if acidity is on lower side [17]. The main organic acid found in citrus fruits, with rare exceptions is citric acid. Generally, acidity of the fruits decreased as fruits approach towards maturity and then increased as the fruit become over mature [9, 10, 18]. However in present research two distinct patterns of total acid accumulation were observed (Tables 1 and 2). In Sweet cultivars of citrus fruits especially kinnow acidity change was different. There was an initial rapid rise of titrable acids, followed by a long, gradual decline due to increasing size, mainly due to increased water content of the fruit because of dilution effect. Busling (1970) while studying the oranges found that in the season acid contents decreased with increasing maturity. At the start of maturity this deterioration was accelerated by a net loss of total acid contents [6, 19-21]. This decrease in TA might also be due to the consumption of these principal acids in the fruit respiratory process [22]. But at the end of the season acid content tend to increase that might be due to the formation of acidic compounds due to degradation of reducing sugars [10]. Acid contents in citrus juices also vary according to variety, fruit age, the climate, cultural practices and growing locality [23, 24].

Citrus fruit undergo certain changes in physical and chemical composition during growth and maturation of fruit. Increase in total soluble solids, decrease in acid contents and increase in ratio of solid to acid are main variations during the season [6, 25-31]. The contents of soluble solid are good quality index and sugars constitute approximately eighty five percent of the soluble solids of mandarins. Its levels normally increases as the fruit mature; conversely levels can decrease when fruit become over-mature. Similar trend was observed in the present research in kinnow and feutrell's early (Tables 1 and 2). In feutrell's early and kino the findings of Joolka and Awasthi[12] showed an increase in contents of total soluble solids until ripening and slow decrease followed that period, are in close conformity with the present research. Findings of present research also agreed with the observations pertaining to total soluble solids (TSS)

of sweet varieties of citrus fruit indicated constant rise till mid stage of season due to increase in the sucrose contents which is then hydrolyzed to simple sugars [10]and dehydration might be another factor [22]. TSS contents tended to decrease up till end of the season [14] that might be due to the formation of acidic compounds due to degradation of reducing sugars [10]. This variation can be due to number of factors affecting total soluble solid contents of citrus fruits. Prominent differences in TSS have been shown to be related to the position of the fruit on the tree [25, 26, 32 and 33]. Total soluble solids as a maturity index is limited by variation among varieties, area of production and season. The fruits even at different positions within the canopy showed significant differences in soluble solids contents [34].

Total soluble solids and acids in citrus juices constitute a principal flavor parameter. The concentration of the total soluble solids (TSS or Brix), total acidity and their ratios (TSS/acidity) are not static, but vary significantly during fruit development. A decrease in total acidity and an increase in total sugars are important factors in the development of flavor. The sugar: acid ratio has been used as fruit maturity index and has been found to rise with ripening of fruit and decrease as fruit become over mature [6, 9, 35]. Since these sugars and acids played an important role in fruit flavor and their nature [7]. TSS to acid ratio is also referred as permitted maturity parameter. This ratio is best measure of quality and can be used to identify the date on which a crop should be harvested to give fruits of specific nutritive quality [36].

The ratio of TSS/acidity varied significantly throughout the season (Tables 1 and 2). Its value increased toward maturity and decreased as the fruit become over mature [6]. Similar trend was observed in present research of sweet citrus fruits i.e. kinnow and feutrell's early, the results were also in accordance with [9,12, 37] who observed increased ratio up till maturity and followed by a decrease in the same sequence. Acidity depends upon a number of factors and it can vary from year to year in the same cultivars [16].

There are several kinds of sugars present in fruits, out of which prominent in citrus juices namely sucrose, glucose and fructose [20]. In previous study on total sugars of citrus, it is observed that this level increased with fruit maturity [38]. Such increase has been attributed to a concurrent increase in the sucrose contents which is then hydrolyzed to simple sugars that affects both the taste and the texture of the fruit and the rise in sugars makes the fruit much sweeter [10]. Increase in the concentration of juices as a result of dehydration might be another factor [22]. But at the end of the season these contents tend to decrease that might be due to the formation of acidic compounds due to degradation of reducing sugars [10]. Differences in the proportions of sugar contents are due not only to variety, but are also greatly influenced by rootstock, geographical location, weather and cultural practices.

Results observed in the present investigation revealed decrease in ascorbic acid contents toward maturity and slightly increase at the end of the season (Figures 1 and 2). In sweet cultivars [39, 40] also reported

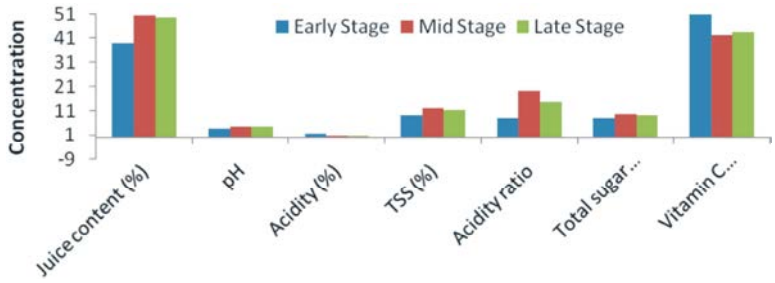

Fig. 1: Physicochemical properties of kinnow at three stages of maturity

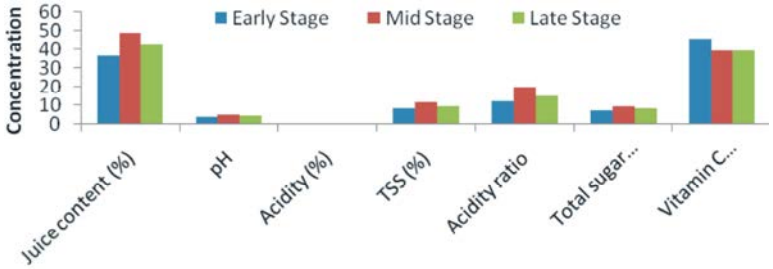

Fig. 2: Physicochemical properties of fruetrell at three stages of maturity

decrease in ascorbic acid content with maturity and then increased as fruit become over mature. Observations in the research undertaken also resemble to the findings of other researchers in case of lemon where opposite trend was observed due to opposite trend of acidity [18]. These variations in ascorbic acid contents were due to change in acid and sugar contents of fruit juices with level of maturity. This loss of ascorbic acid can be attributed to the effect of processing, storage time, variety, exposure to light and other factors [7, 16].

CONCLUSION

This study is likely to represent the data on the juice contents, sugars, TSS, total acidity, TSS/acidity ratio and ascorbic acid contents in kinnow and feutrell's early (fruiter) available in fresh fruit market of Quetta city at different maturity stages. Juice contents were increased from immature to mature fruits in both citrus varieties while slightly decreased at the end of the season. An increase in the composition of sugars, pH, TSS, TSS/acidity ratio toward mid stage of maturity was observed in kinnow and fruiter while at the end of the season these contents were decreased. The second trend was the decrease in total acidity and ascorbic acid contents as the maturity progressed in two analyzed sweet varieties. From all the obtained results, it is revealed that fruit quality is better if acidity is on lower side.

It is recommended that these mature fruits should be used widely to meet the nutritional demand of the local communities as well as exported to generate revenue only because an under and over mature fruits does not contain absolute proportion of nutrients hence usually not acceptable in international markets and also not beneficial for the health.

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