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Quality comparison of some local varieties of apples grown at Murree, Punjab, Pakistan

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Abstract

Nutritional quality of 17 varieties of Apples (Nuggets, Double red, Jona gold, Starking delicious, Red golden, Spartin, King red delicious, Sky spur, Golden delicious, Golden russet, Ida red, Red chief, Golden, Amri, Meshaddi, Kandhari, Gala must) were assessed. Samples were collected from fruit hill station Murree. The study continued for a period of three years (2014, 2015 and 2016). Results bared that fruit weight (g/fruit) varied from 94.4 to 190.2, Pulp (%) from 35.8 to 49.6, Juice (%) from 43.3 to 59.1, pH from 3.0 to7.5, acidity from 0.46 to 1.18, malic acid (%) from 0.13 to 0.55, TSS (%) from 9.7 to 13.1, Total sugars (%) from 6.7to 11.2 and Vitamin-C (mg/100g) from 2.8 to 5.6. Among 17 varieties, variety Ida red and Double red were found better due to their higher percentage of juice (59.1%) and pulp (52.8%) respectively and variety Kandhari for its sweetness i.e. higher sugars (11.2%), higher pH (3.5) and lower malic acids contents (0.13%).

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Introduction

Pakistan produced 616000 tons of apples during the year 2014-15 with cultivation on an area of 100200 hectares, mostly on northern hilly tracts of the Punjab and Khaber Pukhtonkha, Pakistan (Anonymous, 2015). Various varieties of apple which are being grown in Pakistan include Amri, Red delicious, Mashhadi, Kala kulu and Golden delicious (Abid, 2005). Apples are rich in pectin, dietary fiber, organic acid, minerals and vitamins (Li *et al.*, 2002).

Apple is a highly nutritious fruit containing essential food elements such as carbohydrates, protein, fat and water. Apart from its energy value, apple is a good source of soluble and insoluble fiber (Herforth, 2000). Apple is a good source of food and nutrition (Hussain, 2001). Apples are a widely consumed, rich source of phytochemicals. Epidemiological studies have linked the consumption of apples with reduced risk of some cancers, cardiovascular disease, asthma, and diabetes due to strong antioxidant activity (Marchand *et al.*, 2000).

Apple is a very nutritious, aromatic and delicious fruit. It is very rich in Vitamin C, B and A. It contains sugar besides essential minerals in appreciable amounts. It has color appeal, appetite and is most refreshing. It can be used in many different ways. It is cooked, made into preserves, Jellies, candied, canned, prepared as fresh apple juice, and made into cider or vinegar. The peel is used for making pectin.

In terms of chemical composition fruits consist of water and dry matter. The dry matter contains vitamins, acids, sugars, polysaccharides, pectin, cellulose, polyphenols and minerals. Quality is a very complex trait with an important personal and contextual component. Furthermore, the concept of quality itself is not standardized, nowadays; consumer preferences are the ultimate and probably the most important factor to determining quality of produce. The aim of study is to find out the apple varieties among the locally grown varieties which are comparatively good in nutrition.

Materials and methods

This study was conducted at Biochemistry section, Post-Harvest Research Centre, Faisalabad, Pakistan with collaboration of Hill Fruit Research Station Murree, Pakistan.

Collection of Samples

Samples of 17 apple varieties (Nuggets, Double red, Jona gold, Starking delecious, Red golden, Spartin, King red delicious, Sky spur, Golden delicious, Golden russet, Ida red, Red chief, Golden, Amri, Meshaddi, Kandhari, Gala must), were collected at maturity from Hill Fruit Research Station Murree, Punjab, Pakistan during the month of July in 2014, 2015 and 2016. Sample size was 0.5 to 1 kg.

Sample preparation

Samples were brought to laboratory and washed with distilled water, dried with tissue paper before determination of physical as well as chemical parameters.

Physical parameters

Physical parameters included fruit weight, seed, juice, pulp percentage and firmness. Fruit weight was calculated by weighing 4 numbers of apples and dividing the weight by number of fruits. For the purpose of seed, pulp and juice percentage, three apples were sliced and seed was separated, and then the juice was obtained from sliced fruit and pulp collected separately. Both were weighed and percentage of juice and pulp were calculated. Firmness was determined by penetrometer.

Chemical analysis

Juice was used for determining malic acid (determined by acidity meter), pH, acidity, total soluble solids (TSS), reducing sugar, total sugar and vitamin C (AOAC, 1997). The experiment was repeated for three years consecutively and results were represented and discussed in the form of their average, range and standard deviation. Correlation between various quality parameters were also calculated and discussed.

Results and discussion

Fruit weight and weight of seeds

Results presented in table 1 showed that among 17 apple varieties, variety Double red was found better regarding the fruit weight (190.2±27.4g/fruit) as compared to other varieties. Fruit weight of this variety ranged from 162.8-217.6g/fruit with a mean value of 190.2g/fruit. It means that fruit size varied from small size to big one with a large variation. Similarly seeds were also found less (3.6±0.8 (%) in this variety as compared to other varieties. This variety had also good appearance and attraction for consumers due to its size. On the other hand smaller sized fruits (94.4±30.7g/fruit) were found in Meshaddi with 7.1±1.38% seed. This variety was ranked at the bottom. The fruit weight of all other varieties ranged between these two extremes (Table 1). Keeping in view the weight of seeds, the variety Double red was found the best having lowest weight of seeds (3.6±0.8%). Maximum seed (8.4±0.6%) was found in Gala must. The seed percentage in other varieties ranged between 3.6 to 8.4%. According to Abbas *et al.*, (2012) variety Star king delicious had maximum fruit weight (163.25g/fruit) and variety Golden delicious had minimum fruit weight (81.75g/fruit) in contrast to this study. Javaid *et al.*, 2011 found that average per fruit weight of Starking Delicious was significantly higher (203g) among all nine cultivars followed by Sky Spur (185g), Nugget (177.3g), Red Chief (157g), Red Golden (154.6g), Kandhari (145.3g), Ida Red (135g), Sparton (126g) and minimum per fruit weight (124g) was observed in Golden Russet. According to Milosevic and Milosevic (2015), significant differences between cultivars were observed in fruit weight, fruit firmness and soluble solids contents (Brix) during a study in Republic of Serbia. Mukhtar *et al.*, (2010) found that Red delicious was large sized apple while Golden delicious was found as smallest sized apple variety.

Table 1. Comparison of physical parameters and pH of various apples varieties.

Varieties	Fruit weight (g/fruit)	Seed (%)	Firmness (kg)	Juice (%)	Pulp (%)	pH
Nuggets	136.3 ±13.2	5.6±1.6	5.3±0.8	49.5 ±10.3	44.9 ±9.0	4.5 ±1.1
Double red	190.2±27.4	3.6±0.8	4.6 ±1.4	43.5 ±13.5	52.8±12.9	4.2 ±1.5
Jona gold	99.9±14.0	6.7±2.0	6.5 ±1.3	50.5 ±5.0	42.7 ±5.7	4.3 ±1.5
Starking delicious	150.8±25.4	4.2±1.0	5.7 ±0.4	56.7 ±6.8	39.1 ±6.4	4.3 ±1.3
Red golden	103.8±7.2	7.4±0.4	7.1 ±0.7	48.4 ±3.0	44.2 ±3.3	4.3 ±1.4
Spartin	138.6±9.9	6.1±2.1	6.7 ±1.3	54.2 ±7.0	39.7 ±5.1	4.3 ±1.4
King red delicious	135.9±32.1	4.1±2.0	4.9 ±0.5	48.9 ±8.2	47.0 ±6.4	4.4 ±1.3
Sky spur	128.9±26.6	4.2±2.5	5.1 ±0.5	50.0 ±4.2	45.0 ±5.5	4.8 ±1.0
Golden delicious	145.8±13.3	7.2±0.6	7.5 ±0.5	43.3 ±8.7	49.6 ±8.7	4.2 ±1.2
Golden russet	119.3±22.5	6.5±0.9	7.6 ±0.7	50.1 ±1.8	43.4 ±1.9	4.4 ±1.4
Ida red	125.2±16.1	5.1±0.9	6.5 ±0.6	59.1 ±3.2	35.8 ±3.4	3.0 ±0.0
Red chief	143.9±17.1	6.1±0.5	4.5 ±1.1	46.1 ±13.2	47.8±12.7	4.0 ±1.5
Golden	160.4±33.8	6.5±2.0	6.9 ±0.5	47.3 ±8.1	46.3 ±6.5	4.0 ±0.9
Amri	107.9±19.2	5.8±1.4	5.1 ±0.4	43.9 ±3.7	41.8 ±4.7	3.8 ±1.0
Meshaddi	94.4±30.7	7.1±1.4	6.2 ±0.6	46.2 ±12.5	46.8±12.6	4.5 ±0.8
Kandhari	96.8±2.0	6.4±1.1	2.5 ±0.1	52.5 ±4.9	41.1 ±4.8	7.5 ±0.4
Gala must	120.1±1.5	8.4±0.6	6.9 ±0.5	43.5 ±2.7	48.2±2.2`	6.2 ±0.7

Firmness

Firmness is a significant criterion to describe quality of apple. Firmness of fruit always helps and proves beneficial during handling and storage. The variation in appearance and firmness among different varieties is very important as it makes the fruit attractive, good looking, identification of cultivars become easier and provides choice of consumer to choose the fruit of their interest.

In present study it was found that the Golden russet, Golden delicious and Red golden had firmness 7.6±0.7, 7.5±0.5 and 7.1± 0.7kg respectively.

The lowest firmness (2.52±0.14 kg) was found in Kandhari. The fruit of Kandhari variety was found soft and easy to eat. But at the same time this variety was vulnerable to injuries and pathogenic attack during storage and transportation. On the other hand varieties Golden russet, Golden delicious and Red golden were found hard as compared to other varieties. The results were agreed with Nasir *et al.*, (2001). According to Khan *et al.*, (2005) all their tested varieties had thin, tough skin and sweet taste except kala kulu, which had thick skin and was slightly acidic in taste.

Juice, peel and pulp

The most important parameter to determine the quality of apple is its juice and pulp quantity. The quantity of juice in various apple varieties varied from 43.5±2.7% to 59.1±3.2%, highest in variety Ida red and the lowest was found in Gala must. On the other hand, variety Double red had maximum quantity of pulp i.e. 52.8± 12.9% and the lowest quantity of pulp was found in Ida red (35.8±3.4%). The juice contents of apple depend on water present in it (Allan *et al.*, 2003). Jan *et al.*, 2012 found that various apple cultivars vary in their juice contents and maximum juice contents (58.54%) were found in variety Red delicious. In case of variety Double red the variation in pulp quality was very high as indicated by its standard deviation (SD) value. The quantity of pulp in Double red varied from 39.9 to 65.7% with the mean value of 52.8%. Therefore it was depicted that the variety Double red was not of a good quality variety with respect to pulp and juice quantity. While the Ida red proved the best variety as it contained more quantity of juice (59.1%) and less quantity of pulp (35.8%) table 1. Variety Gala must was also found better with regard to its pulp quantity. Pulp quantity in this variety ranged from 46.0 to 50.4% with the mean value of 48.2±2.2%. A keen look at data revealed that the fruits more in weight (Double red) had more quantity of pulp.

Malic acid and pH

Results presented in table 2 regarding the malic acid content revealed that it ranged from 0.13±0.05% in Kandhari to 0.55±0.08% in Starlking delicious. Malic acid contents of other apple varieties ranged between these two limits. Malic acid contents are inversely proportional to sweetness of fruits. If malic acid contents are more, then sweetness will be less. Among these varieties Starking delicious had malic acid contents 0.55±0.08% i.e. this variety was less sweet. Results revealed that the sweetest variety among these selected varieties was Kandhari as indicated by its lowest malic acid contents 0.13±0.05%. It is reported by Markowski *et al.*, (2009) that malic acid is the main organic acid present in apples (0.3–1.0%), and its content closely correlates with titratable acidity. The quantity of malic acid was also affected by varieties in addition to other factors (Ackermann, *et al.*, 2009).

pH is another parameter which describes the quality of apples. pH of various varieties ranged from 3.0±0.3 to 6.8 ±0.4. The pH of rest varieties was found between these two limits. The lowest value of pH indicated the sourness of the fruits and the higher value associated with sweetness. Keeping in view these criteria, variety Kandhari was found lesser sour with the highest pH (6.8 ±0.4) as compared to other varieties. Variety Ida red was found as the sourest variety having pH 3.0±0.3 and malic acid 0.51%. Results (table 2) revealed that variety Kandhari proved the best and Ida red ranked at bottom with respect to their sweetness. Ketiku (1973) and Athanasopoulos *et al.*, (2000) reported the similar results.

Vitamin C

Vitamin C is very important quality parameter because it acts as antioxidant and helps in maintaining the good health. Fruits providing ample quality of this vitamin always considered good for human health. According to this criteria Kandhari, Meshaddi, Golden russet, King red Delicious and Jona gold ranked at top with vitamin C 5.56±0.01mg/100ml. While the lowest vitamin C content 2.78±0.01mg/ 100 ml was found in varieties Starking delicious, Golden red and Amri. Results in table- 2 revealed that these varieties were not good source of vitamin C. it was also predicted from the results that vitamin C had no correlation with other quality parameters like malic acid, pH and sugars. The results are in agreement with the findings of Marcelle (1995).

Table 2. Comparison of quality parameters of various apples varieties.

Varieties	Malic acid (%)	Vitamin-C (mg/100ml)	TSS (%)	Acidity (%)	Reducing sugar (%)	Total sugars (%)
Nuggets	0.32 ±0.02	3.1 ±0.9	12.0±1.1	0.48 ±0.04	4.2±0.4	9.0 ±2.0
Double red	0.44 ±0.04	3.2 ±1.1	10.6±1.0	0.50 ±0.07	4.8±1.1	10.2 ±1.1
Jona gold	0.52 ±0.03	5.6 ±0.0	10.7±0.4	0.51 ±0.08	2.4±0.3	8.2 ±1.4
Starking delicious	0.55 ±0.08	2.8 ±0.0	11.0±0.1	0.75 ±0.29	3.1±0.1	6.7 ±1.9
Red golden	0.40 ±0.03	2.8 ±0.0	11.2±1.6	0.62 ±0.15	2.9±0.4	7.1 ±1.5
Spartin	0.40 ±0.02	4.6 ±1.4	9.7 ±0.4	0.70 ±0.27	3.5±0.2	8.1 ±1.9
King red delicious	0.47 ±0.02	5.6 ±0.0	11.8±1.2	0.54 ±0.14	3.6±0.6	7.9 ±1.8
Sky spur	0.32 ±0.02	3.7 ±1.4	11.6±1.5	0.48 ±0.06	4.4±0.5	8.2 ±2.3
Golden delicious	0.34 ±0.01	4.6 ±1.4	10.7±0.2	0.92 ±0.13	3.0±0.6	7.1 ±1.7
Golden russet	0.46 ±0.02	5.6 ±0.0	10.6±0.3	0.71 ±0.12	3.8±0.3	6.8 ±2.2
Ida red	0.51 ±0.01	4.6 ±1.6	11.9±0.4	0.58 ±0.02	3.1±0.2	8.4 ±0.1
Red chief	0.53 ±0.01	5.1 ±1.1	11.4±0.2	0.52 ±0.07	3.8±0.5	9.5 ±0.5
Golden	0.35 ±0.04	4.6 ±1.4	10.9±0.4	1.01 ±0.32	4.6±1.1	9.0 ±0.8
Amri	0.41 ±0.06	2.8 ±0.0	11.7±0.9	0.54 ±0.09	4.6±0.8	10.0 ±0.2
Meshaddi	0.50 ±0.04	5.6 ±0.0	13.1±0.2	0.46 ±0.11	3.4±1.0	9.9 ±1.3
Kandhari	0.13 ±0.05	5.6 ±0.0	12.2±0.1	1.18 ±0.05	3.5±0.5	11.2 ±0.1
Gala must	0.50 ±0.02	3.7 ±1.6	11.0±0.2	0.83 ±0.05	3.6±0.9	10.0 ±0.3

Sugars

Apples are rich source of sugars (reducing and non-reducing). Total sugars were found in the range of 6.8±2.2 to 11.2±0.1%, minimum in variety Golden russet and maximum in variety Kandhari. Sugar contents of other varieties were found between these two values. Parameters like pH, malic acid and sugars indicated that variety Kandhari ranked at top as compared to other varieties under trial. Similarly the lowest reducing sugar 2.4±0.3% contents were found in variety Jona golden. Reducing sugar contents of other apple varieties were observed between values i.e. 4.8±0.4 and 2.4±0.3%. The higher sugar content in Kandhari was found well correlated with malic acid and pH. Variations in sugar contents was due to varietal differences and it was also found by Mikulic, (2009) and Roth, *et al*., (2007) who reported that a variety properties has usually much more significant impact on sugar contents than storage time. Apple fruit accumulate starch at the early stages of maturation; this is later on hydrolyzed to sugars at edible maturity (Magein and Leurquin, 2000). The starch to sugar conversion continue during storage and transportation (Beaudry *et al*., 1989), resulting in increased total sugars with the passage of time (Crouch, 2003). Sugar level, organic acids and fatty acids concentrations have great quantitative differences in fruit of various apple cultivars (Wu *et al*., 2006).

Total soluble solids and acidity

Results regarding the total soluble solid (TSS) were presented in table (2). The highest TSS 13.1±0.2% was observed in variety Meshaddi, while the minimum value for TSS 9.7±0.4% was found in variety Spartin. TSS in various varieties ranged from 9.7 to 13.1%. Data regarding the acidity revealed maximum value of acidity (1.18±0.05%) in Kandhari and minimum value 0.46±0.11% for this parameter was found in Meshahdi. Range of acidity under trial varieties was found 0.46 ±0.11 to 1.18 ±0.05%. Javaid *et al*., 2011 found that maximum TSS was found in Sky Spur (16%) and was significantly higher than other cultivars and was followed by Starking Delicious, Nugget and Red Golden having 14.5, 14.5 and 13.0% respectively while lowest TSS was observed in Kandhari (10.48%).

Correlations

A Negative correlation was observed between juice and pulp percentage (r = - 0.85383), pH and malic acid (r = - 0.54285) while a positive correlation was observed between fruit weight and pulp percentage (r = 0.45375), pH and acidity (r = 0.571797), pH and sugars (r = 0.466996) and TSS and sugars (r = 0.428893) (table 3). Riekstina-Dolge *et al*., (2014) found that there was a moderately close correlation (r=0.50) found between the soluble solids and the titratable acidity of apple juice. Fruits having high pH and TSS were found sweeter with high sugars contents. Considering the above criteria, the varieties Kandhari and Gala must were found at top rank.

Table 3. Correlations between quality parameters of various varieties of apples.

S. No.	Parameters		Correlation	Correction
	X	Y	Negative/Positive	Co-efficient (r)
1	Juice	Pulp	Negative	-0.85383
2	pH	Malic acid	Negative	-0.54285
3	Fruit weight	Pulp	Positive	0.45475
4	pH	Acidity	Positive	0.571797
5	pH	Sugars	Positive	0.466996
6	TSS	Sugars	Positive	0.428893

Conclusions

Among 17 varieties of apples, the variety Kandhari found comparatively better than other varieties due to its high acidity (1.18±0.05%), sugars (11.2±0.1%), vitamin C (5.56±0.01mg/100 ml), pH (6.8 ±0.4), and lowest malic acid (0.13±0.05%). According to physical parameters, variety, Ida red was proved comparatively better due to its high juice quantity (59.1±3.2%), variety Double red was found better due to its bigger size of fruit (190.2 ±27.4g/fruit), and variety Double red had maximum quantity of pulp i.e. 52.8± 12.9%.

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