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Physico-chemical and mineral characterization of eight apple varieties: Identifying unique attributes and health benefits

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Abstract

A comprehensive quality analysis was conducted on eight distinct apple varieties Kala Kula, Sparton, Winter Banana, Royal Gala, Mondial Gala, Kashmiri Ambri, Sky Spur and Golden Delicious to evaluate their proximate composition, physical attributes, biochemical properties and mineral content. The study revealed significant ($p<0.05$) varietal differences across all measured parameters. Proximate analysis established that all varieties had high moisture content, ranging from 67.13% in Winter Banana to 80.66% in Kala Kula. Physical and chemical quality assessments showed a wide range in verities. Firmness was highest in Winter Banana (8.04 kgf) and Golden Delicious (7.60 kgf). Titratable acidity was inversely related to pH with Golden Delicious having the highest acidity (1.03%) and Kala Kula the lowest (0.52%). Total soluble Solids (TSS) an indicator of sweetness were highest in Kala Kalu (12.1%) and Kashmiri Ambri (11.6%). Biochemically, Kala Kalu and Kashmiri Ambri were statistically superior in total sugars content (10.29% and 10.20% respectively). However ascorbic acid (vitamin C) content was highest in Sky Spur (15.36 mg/100 ml) while Kala Kalu had lowest (3.37 mg/100 ml). Antioxidant capacity was greatest in Kala Kalu (83.8%) which also along with Golden Delicious recorded the highest total phenolic content (1258 and 1250 µmol GAE/100 g) indicating strong potential health benefits. Mineral analysis confirmed that apples are a valuable dietary source of essential elements. Kala Kalu also showed high level of Magnesium (26.2 mg/100 g) and Calcium (31.6 mg/100g). In conclusion the study demonstrates substantial diversity among the apple varieties. Kala Kalu stands out for sweetness, high antioxidant activity and phenolic, while Golder delicious excels in minerals and firmness. These findings provide critical data for consumers seeking specific nutritional benefits and for the food industry in selecting appropriate varieties for processing and fresh market sales based on desired quality traits.

Keywords: Antioxidants, Apple, Biochemical properties, Phenols, Physical attributes

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Introduction

Fruits and vegetables are the main component of healthy diet. They are the good source of fiber, minerals, vitamins and antioxidants. These fruits and vegetables are almost available through the year and they have not only good taste but they have favorable contributes of texture, color and flavor (Britannica, 2024). Fruits are low in calories, fat and they have no cholesterol, rich source of carbohydrates and fiber. They contain vitamins. Regular consumption of apples has been associated with a reduced risk of cardiovascular disease, cancer, diabetes and other chronic conditions (Hyson, 2011). Apple (*Malus domestica*) production has seen a consistent growth worldwide, reaching 84 million tons in 2022 and establishing itself as the world's third most produced fruit (FAO, 2025). This expansion is largely driven by technological advance, particularly the development of new cultivars and dwarfing rootstock. Pakistan is blessed with agro-climate weather which allows the production of both tropical and temperate fruits (Shah et al., 2022). The fruit is popular dietary component for all age groups and its demand continues to grow. This is largely driven by increasing consumer awareness about its health benefits as apple juice is a flavored nonalcoholic beverage. Boyer and Liu (2004) highlight that apples possess significant therapeutic properties which can help lower the risk of various diseases. These benefits are attributed to their high content of antioxidant including vitamin C and E coupled with their pleasant taste and aroma. The nutritional qualities of apple fruit are often undervalue. It contains 83.1% moisture, 9.2% sugar, 1.87% protein, 2.0 mg sodium, 8.7 mg potassium, 2.7 mg calcium, 0.22 mg iron, 0.11 mg copper, 5.1 mg phosphorous and 4.5 mg vitamin C per 100 g of whole fruit (Okokon, 2019). Moisture is the most abundant component, contributing the fruit juice, crunchy texture and perishability. Carbohydrate is primarily composed of sugars (glucose, fructose and sucrose), which impart sweetness and smaller portion of insoluble carbohydrates like dietary fiber and pectin. Dietary fiber is actually pectin nutritionally significant components linked to health benefits. Apples are not a good source of protein and fats.

In Pakistan, apples are predominantly eaten fresh except seeds. However, the market faces a surplus during the peak harvest season, which coupled with the fruits highly perishable nature can lead to substantial post-harvest losses, if proper preservation methods are not employed. While cold storage extends shelf life, but the associated economic costs often make it an impractical long term solution for many producers (Sheng et al., 2017). The nutritional profile of apple juice is complex, containing various sugars, polyphenols, vitamin C, minerals and aromatic esters that contribute to its distinctive flavor and health promoting properties (Filip et al,. 2016). These anticancer effects are largely attributed to phenolic compounds and flavonoids which possess potent antioxidant activity (Khayam et al., 2019). Apples are a rich source of phenolic compounds which are known for their antioxidant activity. Furthermore, a strong correlation exists between the concentration of these phenolic compounds and the fruits overall antioxidant capacity (Andre et al., 2012). Apples are high in polyphenols and antioxidants, a variety Granny Smith knows for its bright green skin. It has the highest level of chlorogenic acid, a polyphenols which improved bold sugar management and fat metabolism. Its low sugar contents make it top choice for diabetic patients. Variety Red Delicious has high TPC contents which are linked to heart and brain and Fuji variety is very sweet and crunchy has high fiber content and long shelf life (Lee et al., 2022).The health and productivity of apple trees are fundamentally governed by the bioavailability of essential nutrients in the soil. These elements are categorized as micronutrients required in larger quantities and micronutrients required in trace amounts but both are in dispensable for specific and critical physiological functions. Nitrogen is a fundamental constituent of amino acid the building block of protein. It is also a key component of chlorophyll, the pigment essential for photosynthesis and of nucleic acid (DNA and RNA). Nitrogen is crucial for both vegetative and floral growth (Reddy et al., 2000). Phosphorus is a central component of ATP, the primary energy currency of the cell. It is also a part of the phospholipids that form cell membrane and the backbone of DNA. Potassium acts as enzyme activator for over fifty essential enzymes involved in photosynthesis, respiration and protein synthesis. Micronutrients are often the co-factors that make metabolic processes possible. Their deficiency can be a major limiting factor as highlighted by Fareed et al. (2022). Zn is a co-factor for enzymes involved in auxin synthesis and Boron is critical for cell wall formation and structural integrity.

Furthermore apple provide essential minerals and vitamins such as iron which are critical for regulating blood circulation, producing red blood cells and maintaining overall physical and mental vigor. Minerals are fundamental to human physiology constituting about 5% of body weight and playing a vital role in numerous biochemical processes. They help maintain the body acid base balance, facilitate the transport of nutrients into blood stream and cell and are indispensable for overall well-being even minor imbalance can have serious health consequences (Garrette et al., 2017). Therefore, this study was conducted to evaluate the comparison of minerals, phenolic contents and antioxidant activity in different apple varieties grown in Punjab, Pakistan.

Materials and Methods

This study compared the nutritional profiles of eight apple varieties Kala Kula, Sparton, Winter Banana, Royal Gala, Mondial Gala, Kashmiri Ambri, Sky Spur and Golden Delicious were sourced from the Hill Fruit Research Station in Murree at maturity. All nutritional analysis was conducted in the Biochemistry Section of AARI during 2023 and 2024.

Sample preparation

The fruits surface was rinsed properly, after making it dry took the weight. Half fruit cut into small pieces with knife and were placed in oven at 65^0C for dry matter and other proximate analysis and from other half apple juice were extracted using a mechanical juicer and filtered through muslin cloth. The filtered juice was immediately refrigerated at 4 °C for subsequent analysis TSS, acidity, pH, vitamin C, sugars, antioxidants and TPC.

pH

10 millimeter sample of a juice was transferred to a beaker. The pH was measured using a pH meter that had been calibrated before and with standard phosphate buffers at pH 4.0 and 7.0, following the AOAC (2005) method.

Moisture percentage

A 100 g sample was precisely weighed and placed in a stainless steel container. The container with sample were then placed in an oven and dried at 130 °C for two hours. After drying the container was then placed to a desiccator to cool. The process was repeated three times at two hour intervals until a constant weight was obtained confirming the complete removal of moisture. The moisture content expressed as a percentage, calculated by formula:

$$\text{Moisture (\%)} = \frac{(\text{Weight of fresh sample } - \text{Weight of dried sample}) \times 100}{\text{Weight of fresh sample}}$$

Titratable acidity

The titratable acidity was measured according to the standard method of AOAC International (2012). 5 g of apple juice was mixed in 25 ml of deionized water and filtered it. Then this filtrate was mixed with a phenolphthalein indicator and titrated against 0.1N NaOH. Titratable acidity (TA) was calculated by using this formula:

$$\text{Titratable acidity (\%)} = \frac{\text{MNaOH} \times \text{NaOH} \times 0.09}{\text{Juice sample}} \times 100$$

NaOH = Volume of NaOH used (ml)
MNaOH = Molarity of the NaOH
0.09 = Equivalent weight of lactic acid

Ascorbic acid

The ascorbic acid concentration was determined using the AOAC (2005) method, involving the following steps. A 10g sample was homogenized with 0.4% oxalic acid solution and filtered through Whatman No. 1 filter paper. The filtrate was transferred to a 250 ml volumetric flask and made up to the mark with 0.4% oxalic acid. A 20 ml aliquot of the diluted filtrate was pipetted into a conical flask and titrated against standardized 2, 6-dichlorophenol indophenol dye solution. The titration endpoint was marked by a persistent faint pink color. The dye solution was previously standardized by titration with a known concentration of ascorbic acid. The ascorbic acid content was calculated and expressed as milligrams per 100 ml of sample (mg/100 ml). This method relies on the reduction of the dye by ascorbic acid, providing a quantitative measure of ascorbic acid concentration.

$$\text{Ascorbic acid (mg/100 ml)} = \frac{\text{R} \times \text{V} \times 100}{\text{R1} \times \text{W} \times \text{V1}}$$

R= ml of dye used in titration against I ml standard ascorbic acid solution
R1= ml of dye used in titration against V1 ml of aliquot
V= volume of aliquot made by 0.4 % oxalic acid
W= Weight pf sample
V1= ml of aliquot taken for titration

TSS (Brix %)

A TSS of apple juice was calculated by using refractometer. Standardized it with deionized water and then noted brix % of apple juice (AOAC, 2005).

Estimation of total ash

The total ash content was determined following the AOAC (2005) method. A clean dry crucible was first weighed to record its tare weight (W1). A 4g sample was then accurately added to the crucible and the combined weight was measured (W1+W0). The sample-containing crucible was incinerated in a furnace at 560 °C for approximately four hours, or until a white to grey ash residue was obtained, indicating complete combustion of organic matter. The crucible was then removed from the furnace, cooled to room temperature in a desiccator, and reweighted (W2). This process determines the ash content of the sample, with W2 representing the weight of the crucible plus ash residue.

$$\text{Ash content (\%)} = \frac{\text{W2} - \text{W1} \times 100}{\text{W0}}$$

Crude fat

The fat content was determined using ether extraction method (AOAC, 2005). A clean dry extraction thimble was weighed. Approximately 2 g of oven dried sample was added in filter paper and then put this filter paper to the thimble and combined weight was recorded. Steel containers were filled with petroleum ether (boiling point 40-60 ºC). The soxhlet extractor and a reflux condenser were assembled. The heat source was adjusted to ensure the solvent boiled gently. The thimble containing the sample was placed into extractor and then fat was extracted under reflux of 30 minutes. Under completion the thimble was removed from the apparatus, placed in an oven at 60 ºC for 30 minutes to dry, cooled in desiccator and then weighed a final time. The fat content was calculated by this formula:

$$\text{Crude fat (\%)} = \frac{\text{Thimble weight before extraction} - \text{Thimble weight after extraction}}{\text{Empty crucible weight}} \times 100$$

Estimation of crude protein

The crude protein content was determined using the Kjeldhal method as outlined in the AOAC (2005) standard. This method quantifies the nitrogen content in the sample, which is then converted to crude protein % using a standard factor of 6.25. 0.5g sample was precisely weighed and added into a kjeldhal digestion flask. A digestion mixture (3-5 g of K_2SO_4: $CuSO_4$: Se) and 10ml of conc. H_2SO_4 were added. The flask was heated at maximum temperature for 2-3 hours until the solution became clear indicating complete digestion of organic matter. The resulted digested solution was then distilled, a process which liberate ammonia. The distilled ammonia was collected in a receiving flask containing 10ml of 0.1 N H_2SO_4. The excess acid which was not neutralized by the ammonia was subsequently titrated with a standard base to determine the nitrogen content.

$$\text{Crude protein (\%)} = \frac{\text{Titre value} \times \text{Acid normality} \times 0.014 \times 100 \times 6.25}{\text{Sample weight (g)}}$$

Sugar contents

The total sugar content was estimated by the method of Chow & Landhäusser (2004). A 25 ml (or g) sample was transferred into a 250 ml volumetric flash. Distilled water was added, followed by the sequential addition of 25ml lead acetate and 10 ml of potassium oxalate solution to clarify and deproteinize the sample. The volume was then made up to the 250 ml mark with distilled water and the mixture was filtered. A 25 ml aliquot of the resulting filtrate was taken, mixed with 5 ml HCl and 20ml of distilled water and left to stand for 24 hours to allow for complete hydrolysis of sucrose into reducing sugar. The solution was then precisely neutralized using 5 N NaOH solution with phenolphthalein as an indicator and diluted to a known with water. For titration, 10 ml Fehling solution was placed in a conical flask, diluted with water and brought to boil. The prepared sample solution was placed in a burette and titrated dropwise into the boiling Fehling solution until the endpoint was reached, indicated by the appearance of a brick red precipitate of cuprous oxide. A few drops of methylene blue indicator were added near the endpoint to enhance its visibility.

Total phenolic contents (TPC)

According to Skerget et al. (2005), the total phenolic content (TPC) was qualified with the Folin-Ciocaleuu assay. The absorbance of the reacted solutions was read at a wavelength of 765 nm on a 721-VIS spectrometer. A standard curve was generated using Gallic acid, and the TPC was calculated and expressed as microgram of sample (µgGAE/100 g).

Total antioxidants

The total antioxidant activity was evaluated by using the standard DPPH (2, 2 diphenyl -1- picrylhdrazyl) radical scavenging assay following the procedure described by Engeda et al. (2015). A stock solution of DPPH was prepared by dissolving 0.004 g of DPPH in 100 ml of methanol, resulting in a 0.004% (w/v) concentration. This solution was used as a blank. An extraction solvent mixture was prepared from methanol acetone and HCl in a 90:8:2 ratios. One gram of fruit pulp was homogenized with 5ml of this extraction mixture using a vortex and the resulting mixture was centrifuged. The supernatant was collected for analysis. For the assay, 0.3 ml of the plant extract supernatant was homogenized with 5 ml of the 0.004% DPPH solution. The reaction mixture was placed in a dark at room temperature for 35 minutes during which the color changed from violet to yellow indicating radical scavenging. The absorbance was measured at 517 nm using a UV-VIS spectrometer. The percentage of DPPH radical scavenging activity was calculated using the following formula:

$$[\%\text{ DPPH Activity}] = \frac{(\text{A0} - \text{A})}{(\text{A0})} \times 100$$

A_0 = Reading with 0.004% DPPH was used as blank

A = Samples reading

Mineral contents

The analysis of specific mineral elements (such as Sodium, Potassium, Calcium, Magnesium, Iron and Zinc) is typically conducted using analytical techniques like Atomic Absorption Spectrophotometry (AAS).

Mineral contents

1 g of sample is accurately weighed into a conical flask or digestion tube. The organic matrix is broken down using a process called wet digestion. A mixture of three acids concentrated nitric acid (HNO_3), per chloric acid ($HClO_4$) and sulphuric acid (H_2SO_4) in the ratio (5: 2: 1) was added in the same tube. The tube is heated on a block digester or hotplate until the solution becomes clear and colorless, indicating complete oxidation of organic matter and release of minerals into the solution. The resulting digestate is then cooled filtered to remove any particulate matter and diluted to a known volume with deionized water in a volumetric flask. For sodium (Na) and potassium (K) the diluted sample digest aspired into a flame photometer. The instrument measures the intensity of the characteristic light emitted by each element when vaporized in a flame which is proportional to its concentration. For a wide range of minerals (Ca, Mg, Fe, Cu and Zn) the diluted digest is analyzed using Atomic Absorption Spectrometer, the sample is atomized and a lamp emitting light specific to a mineral is used, the amount of light absorbed is measured.

The concentration of each mineral was calculated by comparing the instrument readings against a calibration curve prepared using standard solutions of known concentration. The mineral content us typically expressed in milligram per 100 gram of sample (mg/100 g) using the formula:

$$\text{Mineral content (mg/100 g)} = \frac{(\text{C} \times \text{V} \times \text{D})}{(\text{W})} \times 100$$

Where:
C = Concentration of the mineral from standard curve
V = Final volume of the digested sample (ml)
D = Any further dilution factor
W = Weight of the original sample (g)

Statistical analysis

The experiment was conducted over three consecutive years with three replications each year. Data was subjected to analysis of variance (ANOVA) using Statistix 8.1 (Analytical Software, Tallahassee, FL, USA). Means were compared using the Least Significant Difference (LSD) test at 5% probability level ($p \leq 0.05$).

Results and Discussion

Quality analyses

Different apple varieties were collected from the field area of Hill Fruit Research Station, Murree and brought to Horticulture Research Institute AARI, Faisalabad for analysis. Data regarding the proximate analysis of flesh of different apple fruits are given in Table 1. The shelf life and processing suitability of fruits are fundamentally shaped by their moisture content, as this properly directly determines water activity "a key indicator of a products stability and vulnerability to microbial spoilage" (Yaun et al., 2022). In essence, the moisture percentage represents a fruits capacity to hold water, and when this level is high, the commodity becomes highly perishable (Adeleke and Abiodun, 2010). This relationship between moisture, stability and microbial growth implies that food products with elevated water contents such as apple fruit juice are inherently predisposed to a shorter shelf life. Higher value of moisture content was observed in variety Kala Kula (80.66%) which is statistically at par with Golden Delicious (78.68%) and lower value (67.13%) was in Winter Banana. All the values are statistically significant. This work was correlated with Campeanu et al. (2009). Kheiralipour et al. (2008); Campeanu et al. (2009) indicated the moisture level in different apple varieties vary from 77-88 %. Our results matched with previous findings. Ash content is the measurement of total amount of mineral present in fruit. Percentage of ash content in different apple varieties ranged from 1.13 to 1.76%. Maximum ash content (1.76%) was recorded in Kala Kula variety followed by Kashmiri Ambri (1.56%) as shown in Table 1. The amount of ash present can be translated to the quantity of minerals present in the samples (Coimbra & Jorge, 2011). The variation on ash may be due to the quantity of minerals present in the apples (Ghafoor et al., 2024). The lowest crude protein was observed in variety Sky Spur (2.16%) higher in Kala Kula (3.23%). Crude protein content is a crucial indicator of fruit and vegetable quality and nutritional value. While maximum crude fiber was present in variety Sparton (7.5%). Proteins essential as life's building blocks, are predominantly associated with animal sources, although certain fruits contain proteins. A diet rich in proteins aids in muscle building, metabolism enhancement, and bolstering immunity. Fruits are recommended as one of the sources of protein intake. Concerns regarding protein's impact on acid production underscore the importance of higher fruit and vegetable intake rather than reduced protein intake due to the alkalizing effect these foods provide (Heaney & Layman 2008). Dietary fiber mainly consists of cellulose, hemi cellulose, lignin and pectin by Ciriminna et al. (2016). Variety Kala Kula was significantly better due to higher ash content, crude protein and moisture content.

Table 1 Proximate analysis of apple varieties

Varieties	Moisture content (%)	Ash (%)	Crude protein (%)	Crude fiber (%)
Kala Kula	80.66 a	1.76 a	3.23 a	5.49 c
Sparton	77.04 abc	1.26 cd	2.19 d	7.50 a
Winter Banana	67.13 d	1.48 b	2.66 bc	3.93 e
Royal Gala	75.28 bc	1.45 bc	2.49 c	3.63 e
Mondial Gala	73.60 c	1.47 bc	2.57 c	2.70 f
Kashmiri Ambri	77.27 abc	1.56 ab	2.69 bc	5.17 c
Sky Spur	74.46 bc	1.13 d	2.16 d	4.43 d
Golden Delicious	78.68 ab	1.23d	2.87 b	6.17 b
CV	3.41	8.74	4.73	4.13
LSD	4.50	0.21	0.21	0.35

Physicochemical analysis

Data regarding the fresh weight of apple ranged from 98.7 g to 211 g. Higher fruit weight was observed in Kala Kula (211.0g) followed by Winter Banana (187.4g) while lowest range of fruit weight was noted in Kashmiri Ambri (98.7g). A significant difference varied among all varieties of apple (Table 2). These results correlate with Ahmad et al. (2018). Titrated acidity is an important index for apple fruit evaluation (LoPiccolo et al., 2019). Apple cultivars Variety Kala Kula have high TSS (12.1%) and minimum pH (5.04) and titratable acidity (0.52%). The TSS of apple fruit increased gradually with increasing storage durations (Table 2). TSS could be attributed to the breakdown of starch or the hydrolysis of cell wall polysaccharides (Ghafoor et al., 2024). Apple juice pH correlates with titratable acidity which is inversely proportion to total soluble solids (Ameh et al., 2015). Winter Banana has significantly higher firmness (8.04 kg). Ranges of firmness of all varieties are significantly at par. A firm texture is a vital indicator of a good quality apple, as it helps fruit withstand the rigors of handling and storage. The quality of an apple is often gauged by its firmness, a characteristic that enhance its resilience during storage and transport. The variations in firmness and visual traits between cultivars are also commercially significant; these differences facilitate variety identification, enhance aesthetic appeal and ultimately provide consumers with a wider more personalized selection. Firmness a key indicator of maturity and quality; it is influenced by many factors like cultivar, storage condition and post-harvest handling (Tomala et al., 2022).

Sugar contents in freshly extracted apple juice are range from 8.67% to 10.29%. Kala Kula variety performed better due to higher sugar contents (10.29%) which are statistically at par with Kashmiri Ambri (10.20%) (Table 3). The sweetness of the fruit is determined by its soluble sugars: fructose, glucose and sucrose. Fructose is the most potent in sweetness, while glucose contributes to a favorable flavor profile (Dong et al., 2024). Additionally ascorbic acid is vital for human health. It functions to strengthen the immune system and promote wound healing. It also plays a key role in protecting the body from oxidative stress. Sparton has high acid content (6.40 mg/100 g) in our findings followed by Golden Delicious (6.16 mg/100 ml). Lowest value (3.37 mg/100 ml) was in variety

Kala Kula which has inverse relationship with sugars. The research findings were correlated with Ahmad et al. (2018). Its antioxidant properties help protect the body from damage caused by free radicals and make it an important nutrient for skin health. Variety Kala Kula (83.8%) showed maximum antioxidant contents as compared to others. Significant difference showed among all varieties. A high DPPH scavenging capacity demonstrates a strong ability to neutralize harmful free radicals. This activity directly helps in reducing oxidative stress within the body. Consequently, it can lower the risk of chronic diseases driven by inflammation. These conditions include cardiovascular diseases and cancer (Liu & Zhang, 2024). TPC contents in fresh apple juice are range from 1258 to 1043 μmolGAE/100 g. The Total Phenolic Content (TPC) of fruit juice is determined using the Folin-Ciocalteu assay. This colorimetric method operates on the principle that phenolic compounds reduce the Folin-Ciocalteu reagent in an alkaline medium, producing a blue complex (Wern et al., 2016). The absorbance measured is directly proportional to concentration of phenolics present. Among the varieties tested, Kala Kālu exhibited the highest TPC, a value that was statistically similar to the Golden Delicious. According to Shamanin et al. (2022), variations in phenolic content can be attributed to range of factors including genetics, cultivar type, ripening stage, environmental conditions and agricultural practices.

Mineral composition

Apples are a valuable dietary source of essential minerals. Analysis of eight different varieties revealed statistically significant compositional differences ($p < 0.05$). The study found that potassium (K) was the most abundant mineral in the analyzed varieties. It was followed in concentration by calcium (Ca) and magnesium (Mg). The elements iron (Fe) and sodium (Na) was present in the lowest quantities. The measured concentration of Ca, Mg, Fe, Na and K ranged from 21.7 to 37.3, 16.7 to 26.2, 0.38 to 0.97, 4.64 to 9.80 and 427 to 675 mg/100g DW (Table 4). Maximum mineral composition was found in variety Golden Delicious and variety Sky Spur showed fewer amounts of minerals. Sodium chloride acts as a browning control in apple fruits (Li et al., 2015). Potassium is the most accumulated nutrient in fruits followed by Mg and Ca, A low content of this element in fruit could cause problem in term of quality of apples, especially during storage (Campeanu et al., 2009). The sodium and potassium ratio in our diet is a key factor to control high blood pressure. Low concentration of potassium and sodium enhance blood pressure (Aziz et al., 2013). Magnesium plays an important role regulating the neuromuscular activity of heart and also stables the nervous system. Iron is directly related with chlorophyll. Higher concentration of iron in apple is harmful because it alters the taste and starts browning of fruit when a slice is direct contact with air. Significant difference observed among Mg and Na concentration. Among eight different varieties, magnesium concentration was higher than sodium concentration. Calcium and iron are macro elements with secondary part in plant development but it influence the consumption quality of fruit in a fresh state (Campeanu et al., 2009).

Table 2 Variation in physical parameters of apple varieties

Varieties	Fruit weight (g/fruit)	Firmness (Kg)	pH	Acidity (%)	TSS (%)
Kala Kula	211.0 a	5.36 e	5.04 d	0.52 e	12.1 a
Sparton	157.8 c	7.25 c	5.90 b	0.82 b	10.3 c
Winter Banana	187.4 b	8.04 a	5.53 c	0.69 cd	10.2 c
Royal Gala	166.2 c	6.17 d	5.82 b	0.74 c	10.3 c
Mondial Gala	182.3 b	6.97 c	6.05 a	0.86 b	9.61 d
Kashmiri Ambri	98.7 e	5.62 e	4.84 e	0.56 e	11.6 ab
Sky Spur	126.4 d	6.23 d	5.13 d	0.64 d	11.2 b
Golden Delicious	153.2 c	7.60 b	5.49 c	1.03 a	9.56 d
CV	4.80	2.43	0.98	4.77	3.24
LSD	13.48	0.28	0.09	0.06	0.55

Values sharing the same letters are statistically similar.

Table 3 Physicochemical differences in apple varieties

Varieties	Total sugars (%)	Ascorbic acids (mg/100g)	Total antioxidant (%)	Total phenolics (μmolGAE/100 g)
Kala Kula	10.29 a	3.37 f	83.8 a	1258 a
Sparton	8.67 c	6.40 a	69.3 bc	1043 e
Winter Banana	9.64 b	4.68 d	62.9 c	1188 b
Royal Gala	9.05 c	5.10 c	77.6 ab	1236 ab
Mondial Gala	9.01 c	5.75 b	71.0 bc	1100 cd
Kashmiri Ambri	10.20 a	3.85 e	75.0 ab	1052 de
Sky Spur	9.63 b	5.36 c	77.4 ab	1125 c
Golden Delicious	8.84 c	6.16 a	71.6 bc	1250 a
CV	3.24	3.11	9.13	2.52
LSD	0.53	0.27	11.77	51.05

Values sharing the same letters are statistically similar.

Table 4 Mineral composition of different varieties of apple

Varieties	Ca (mg/100g DW)	Mg (mg/100g DW)	Fe (mg/100g DW)	Na (mg/100g DW)	K mg/100g DW)
Kala Kula	31.6 b	26.2 a	0.85 b	8.02 c	555 c
Sparton	22.3 d	18.9 e	0.44 d	7.36 e	634 b
Winter Banana	31.5 b	23.9 b	0.77 b	7.83 d	516 d
Royal Gala	27.7 c	22.5 c	0.59 c	5.58 g	489 ef
Mondial Gala	26.7 c	24.1 b	0.62 c	4.64 h	502 de
Kashmiri Ambri	25.8 c	20.3 d	0.63 c	6.37 f	477 f
Sky Spur	21.7 d	16.7 f	0.38 d	9.48 b	427 g
Golden Delicious	37.3 a	24.3 b	0.97 a	9.80 a	675 a
CV	4.80	2.86	8.72	1.14	1.57
LSD	2.30	1.10	0.10	0.14	14.7

Values sharing the same letters are statistically similar.

Conclusion

The studied showed significant differences in their proximate, physical and physicochemical characteristics. Kala Kula exhibited the highest moisture, crude protein, total sugars, antioxidant activity and total phenolic content, while Winter Banana had the highest fruit firmness and Golden Delicious showed the highest acidity and mineral composition. These findings indicate that each variety possess unique quality attributes suitable for different nutritional and commercial purpose

Conflict of interest: The authors declare that they have no conflict of interest.

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