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Nutritional Profile and Physicochemical Properties of Improved Apple (*Malus domestica* L.) Varieties in Ethiopia

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Abstract

Because of its significant advantage for many households including youth different areas like job creation, medicinal property, nutritional worth, income generate, conservation of soil and the environment, apple appears to be one of the potential and strategic fruit crops in the highlands of the country. This research was, therefore, conducted to test nutritional profile and selected physicochemical properties of different apple varieties in Ethiopia. The experiment was carried out at Holeta agricultural research of the EIAR using 13 improved apple varieties planted in the field. The results showed that fruits of improved apple varieties had greater amount of ash (1.645%), protein (2.049%), fat (0.407%) and fiber (6.136%) than the standard reference (0.366, 0.443, 0.223, and 2.786%, respectively) but, lower carbohydrate content and energy value (89.757, and 370.90% respectively). They also exhibited higher mineral content (K (0.444%), Mg (0.024%), Fe (62.964%) and Zn (4.081%)) than the standard reference (0.120, 0.005, 1.600, and 0.447%, respectively), except for Ca (0.015%) while the fruit quality result revealed low moisture content and high titrable acidity (TA) (1.177%) and total soluble solid (TSS) content(13.333%). Nevertheless, variations among the thirteen apple varieties were significant for proximate composition and mineral content as well as for moisture content, total soluble solid and titrable acidity. The study also showed that the improved apple varieties fit the WHO standard nutritional quality of proximate and mineral values, but not for carbohydrate and calcium contents.

Keywords: Mineral and Nutrient content Physical quality

Introduction

Nutritional and functional characteristics of fruits are closely related to their quality and are usually influenced by genotype and ripening stage, as well as by environmental conditions and orchard management practices [14]. Apple (Malus domestica L.), is an exogenous crop to Ethiopia since it's a temperate region. It has phosphorus and sodium minerals, important in human nutrition which have a role in bone and teeth formation and other important body functions [9]. It is also a good source of soluble carbohydrates such as starches, sugars and a fiber pectin, which helps to reduce cholesterol levels in humans by lowering the secretion of insulin [6]-[9]. Despite this nutritional advantage, previously apple production was restricted to some pocket areas of southwestern Ethiopia. Subsequently, its production has been expanded in several highland areas of Gamo Gofa, Sidama, Gedeo and Guraghe zones of SNNP region, North Shewa, Arsi and Addis Ababa Zuria of Oromia region, North Shewa, North and South Wello, North and South Gondar and West and East Gojam zones of Amhara region [17], through the support of government and nongovernment institutions, and private growers including smallholder farmers [10].

Growing apple is therefore, becoming an important horticulture activity in the highlands of Ethiopia which helps farmers to balance their diets, serve as cash crops to generate incomes, diversify production, conserve soil and environment and create employment opportunities for many households including youths. Although apple growing is new for the Ethiopian farming community, it has been found as it is highly promising and financially feasible both in terms of fruits and seedlings production and becoming an interesting business for both rural and urban smallholders [12]-[22].

The rise in demand for apple is mainly due to the transition to a wide urban middle-income class and lifestyle change of consumers in Ethiopia. Ethiopian fruit import in general, apple import, in particular, increased from 350 tons in 2007 to 50,000 tons in 2016 excluding fruit syrup imports [7]-[13].

Apple varieties are a source of vitamin C, potassium, dietary fiber, and folic acid. They also contain calcium, iron and have a high protein quality, ratio of mg amino acid/gram protein, low in sodium and fat content. They are medium in calories with greater than 30 calories per serving, yet add abundant flavor to a wide variety of foods. Apples are also cholesterol-free and provide dietary fiber, vitamin C, vitamin B6, potassium, and other key nutrients.

So far about 13 apple varieties were improved and adopted through research from Ethiopian Institution of Agriculture Research, Holetta agriculture research center and these varieties were demonstrated to consumers and they are used for house consumption and local markets. However, the information on their nutritional profile and quality parameters value during adaptation due to environmental factors, agronomy management, and soil type and nutrient application variation in terms of flavor, provide health-promoting phytochemicals, antioxidant proximate composition, as well as mineral content, is scanty [2]. The present study was conducted to determine the nutritional quality, physicochemical properties of improved and adopted thirteen apple varieties in Ethiopia.

Materials and Methods

Experiment set up

The experiment was conducted using samples collected from the existing field that at Holetta Agriculture Research Center (HARC) in the 2018 off-season (January - May) at Soil and Nutrition Laboratory. The center is found in the Ethiopian highlands, 34 km away from Addis Ababa in the west direction located at 904'N and 380 30'E and an altitude of 2391 meters above sea level. The mean maximum and minimum temperatures are 22°C and 6°C respectively. The center receives a mean total annual rainfall of 1144 mm with erratic distribution. The soils are Nitosol and Vertisol and the soil texture class is mainly clay to clay loam with a pH of 3.8 - 6.2 [4].

Sample Collection

For quality analysis fruit of 13 apple varieties were collected from experimental plots and cured in the store. Finally the cured apples fruits were sampled and then unnecessary plant impurities as gravels and others were removed. Depending up on the purpose of analysis, two types of sample preparations methods were followed. In the first method, the samples were ground into fine powder by using automatic gridding machine, sunlight dried and ready ready for physicochemical (Ash, Crude protein, Crude fat, and Crude fiber) analysis. The powdered samples were stored in an air tight bottle at room temperature until further analysis. In the second methods, cleaned fruit samples were ground by gridding machine and filtered and the aliquot liquid or juice was and immediately analyzed for physicochemical analysis (TSS, TA, pH, Color, Juice volume and juice weight) within less than 8 hours[16].

Determination of physicochemical properties

Total soluble solid (TSS) was determined by refractometer Index using drop of apple juice while titrable acidity was determined by titrating certain juice volume using NaOH as a titrant and phenolphtein indicator until the pH became to 8.1, and pH was determined by using potentiometric method after the pH meter

was calibrated at 4, 7 and 9.2 using buffer solution [3]. Juice volume and juice weight were determine by weighing certain mass of apple fruit and preparing the juice and finally weight of 100g per juice volume was measured [3].

Determination of Proximate Composition of Apple Varieties

Determination of Moisture Content

The moisture content of the powdered apple sample was determined by drying in an oven (at 105 °C) according to the procedure described in AACC (2000). The moisture content in the sample was determined as follows [1]:

$$Moisture\ Content\ (\%) = \frac{Weight\ of\ original\ sample - Weight\ of\ dried\ sample}{Weight\ of\ original\ sample} x\ 100$$

Determination of Ash Content

Ash was determined using about 3 g of finely ground dried sample which was weighed into a porcelain crucible and incinerated at 550 ^{0}C for 6 hours in an ashing muffle furnace until ash was obtained. The ash was cooled in desiccators and reweighed [3]. We calculated ash content in the apple sample as:

$$Ash\ (\%) = \frac{Weight\ of\ ash}{Weight\ of\ original\ sample} x\ 100$$

Determination of Crude Proteins

The powdered apple sample was tested for crude protein content according to the Kjeldahl's method as described in AOAC, which involved protein digestion and distillation and titration. The % nitrogen was calculated using the formula:

$$\%\ Nitrogen = \frac{(Vs - Vb) x\ Macid\ x\ 0.01401}{Weight\ of\ original\ sample} x\ 100$$

Where, Vs = Volume (ml) of acid required to titrate sample; VB = Volume (ml) of acid required to titrate the blank; M acid= Molarity of acid; W=Weight of sample:

Then, the percentage of crude protein in the sample was calculated from:

$$\%\ Nitrogen\ as\ \%\ crude\ Protien = \%\ Nitrogen\ x\ F$$

Where as, F (the conversion factor) is equivalent to 6.25 [3].

Determination of Crude Fat

Crude fat was determined using digital FOSS SoxtecTM 8000 through the steps of boiling, rinsing, recovery and auto-shutdown and finally using gravimetric method as follows.

About two grams of powdered peach sample was weighed in thimbles and the thimbles insert in the rack i.e the thimbles and extraction cups was loaded, put the solvent recovery flack then add solvent. Select the program and press start for boiling, automatic randell extraction (rinsing), remove the extraction cups and dry in oven at 105 0C. After solvent recover, cool extraction cups in dissector and the extraction cups were weighed again[11].

The % fat in the sample was calculated using the formula:

$$Fat\ (\%) = \frac{Weight\ of\ fat}{Weight\ of\ original\ sample} x\ 100$$

Determination of Crude Fiber

About 2 gm of a fat-free sample of powdered apple was taken into a fiber flask and 100 ml of 0.255 N H2SO4 was added. Then the mixture was heated under reflux with a heating mantle for one hour. We filtered the hot mixture through a fiber sieve cloth. The residue returned into the flask to which 100 ml of 0.313 M NaOH was added and heated under reflux for another one hour. We filtered the mixture through a fiber sieve cloth and we added 10 ml of acetone to dissolve any organic constituent. The residue was washed with 50 ml of hot water twice on the sieve cloth before. we finally transferred in the pre-weighed crucible. The crucible with residue was oven-dried at 105 °C overnight to drive off moisture. The oven-dried crucible containing the residue was cooled in a desiccator and later weighted (W1) for ashing at 550°C for 4 hours. The crucible containing white and grey ash (free of carbonaceous material) was cooled in desiccators and weighted to get W2. The crude fiber in the sample was calculated as follows [11].

$$Fiber\ (\%) = \frac{W_1 - W_2}{Weight\ of\ sample} x\ 100$$

Determination of Total Carbohydrate

The difference method determined the total percentage of the carbohydrate content in the apple sample. This method

involved adding the total values of crude protein, lipid, crude fiber, moisture and ash constituents of the sample and subtracting it from 100. The value obtained is the percentage of carbohydrate constituent of the sample [3]. Thus:

$$\%Carbohydrate = 100 - (\%Moisture + \%Crude\ fiber + \%Protein + \%Lipid + \%Ash)$$

Determination of Energy Value

The energy value of the samples was determined by multiplying the protein content by 4, carbohydrate content by 4 and fat content by 9 [3].

$$Energy\ Value = (Crude\ protein\ x\ 4) + (Total\ carbohydrate\ x\ 4) + (Crude\ fat\ x\ 9)$$

Determination of Vitamin C

Redox titration determined vitamin C using Iodine solution of juice sample and finally determine the titrate required for standard [18].

Determination of Mineral content

About 1 g of finely ground powder sample was weighed into a porcelain crucible and incinerated at 550 ^{0}C for 3 hours in an ashing muffle furnace until ash was obtained. The ash was cooled in desiccators and soaked by 2mL of 37%HCl and 3dops of distilled water. The soaked sample was extracted in 50ml volumetric flask using filter paper and funnel and the aliquot was used to determine macro and micro minerals determined using atomic absorption spectrophotometer (AAS) after calibrated using standard solution for each element[15].

Macro and micronutrient was calculated as follows:

$$Macronutrient\ Content\ (\%) = \frac{(R-B)*Tv*Df}{Weight\ of\ sample}$$

$$Micronutrient\ (mg/Kg) = \frac{(R-B)*Tv*Df}{Wt*10{,}000}$$

Whereas, R-Sample Reading B-blank reading Tv-total volume of aliquot extracted (50mL) Df-dilution factor when sample concentration above the calibration carve the sample concentration diluted by distilled water

Statistical Analysis

The results were subjected to analysis of variance (ANOVA) technique by statics 10.0 using completely randomized design (CRD) method, and all pair-wise comparison tests were used for mean comparison, whereas the least significant difference test was used for mean separation technique at p ≤ 0:05)[20].

Result and Discussion

Physicochemical properties among apple varieties

Moisture content of fresh apple fruits of different varieties was higher than the WHO standard and showed significance difference among the varieties (Table 1). However, the difference among variety Winter banana, Elester, Jona gold and Anna, and between Crispin, Red delicious and Ariwa was not significant. Similarly, there was no significant difference between variety Dorset golden and Granny smith, and between Princisa and Royal gala but significant difference was observed among Crispin, Red delicious and Ariwa for moisture content.

Regarding juice volume and juice weight no significant difference among varieties in JW but significant difference in JV between Ariwa and Crispin and between Princisa and Jona Gold and also among Anna, Dorset Gold, and Jona Gored but the significant difference among Gala Must, Granny Smith, Royal Gala, Yataka, and Red Delicious at p≤0.05.

Titrable acidity showed no significant difference among variety Gala must, Granny smith, Royal gala and Red delicious, and between variety Anna, Elester and Crispin, but it was significantly difference for the remaining seven varieties (Table 1). The total soluble solid (TSS) content was statically similar for variety Yataka and Jona gored, and for Princisa and Ariwa. The difference among variety Anna, Dorset, Royal gala, Elester and Winter Banana was not significant, but it was significant between variety Crispin and Red delicious for TSS (Table 1) [23].

Vitamin C showed no significant difference between variety Princisa and Ariwa, between variety Dorset Golden and Jona Gored, and between variety Red Delicious and Granny Smith and also no significant difference among variety Gala must, Elaster and among variety Yataka, Crispin and Winter Banana at p≤ 0.05 (Table 1).

Table1. Physicochemical properties of apple varieties

Varieties	% Moisture content fresh	% Juice weight	% Juice volume	pH	%TA	TSS (%)	Vitamin C (mg/100g)
Anna	47.520ab	19.277b	61.263abcd	3.167de	0.783hi	13.333d	5.3967f
Princisa	44.233bcd	22.600b	58.333e	3.4100bc	0.923fg	12.333e	7.440a
Dorset Golden	45.567abc	17.773b	63.333abcd	3.157de	1.100de	13.333d	5.947cd
Gala Must	42.023cde	17.630b	59.000cde	3.377bcd	0.517b	11.333f	6.357b
Grany Smith	45.410abc	21.833b	58.667de	2.850f	1.300b	11.333f	4.900g
Ariwa	41.263de	17.037b	66.000a	3.287bcd	0.867gh	12.333e	7.730a
Royal Gala	44.423bcd	23.000b	53.000f	3.463b	1.227bc	13.333d	4.730g
Jona Gold	47.550ab	20.743b	57.000ef	2.993ef	1.003ef	11.333f	6.163bc
Yataka	41.923cde	29.547ab	61.333a-e	3.193cde	1.557a	14.333c	5.713de
Crispin	38.143e	31.667ab	64.333ab	3.163de	0.697i	16.33a	5.643def
Elaster	48.583a	38.563ab	63.667abc	3.330bcd	0.770HI	13.333d	6.297b
Red Delicious	40.103e	17.590b	60.333bcde	3.740a	1.283B	15.333b	4.907g
Jona Gored	44.967abcd	15.400b	63.333abcd	3.303bcd	0.537j	14.333c	5.947cd
Winter Banana	47.110ab	14.690b	61.333abcd	3.347bcd	1.177cd	13.333d	5.837d
Mean	44.201	21.961	60.781	3.2700	13.262	13.262	5.898
CV (%)	5.430	7.470	4.890	4.430	4.350	4.350	3.110
LSD (0.05)	4.014	26.488	4.970	0.243	0.104	0.966	0.307

Whereas, TA - Titratable acidity; TSS - Total soluble solid. Figures followed by scheme letters with in a column are not significantly different at P≤ 0.05.

Proximate Nutritive Value

Moisture content of apple fruits showed no significant difference among all varieties except for Jona Gored at p≤0.05. The result of ash content of apple fruits showed that all varieties had higher values than the WHO standard which fit WHO. Nevertheless, there was different varietal difference for ash content, though difference among variety Princisa, Ariwa and Winter banana, and variety Gala must, Dorset golden, Gray smith, Jona gold, Yataka, Elester and Jona gold where not significant (Table 2).

All varieties showed higher values than the standard reference for protein content. However, there was no significant difference among variety Gray smith, Dorset, Ariwa, Red delicious and Winter banana, and between gala must, Jona gored among Jona gold, Royal gala and the standard (Table 2). Fat content of apple varieties was higher than the standard reference USDA (2018) and there was no significant difference between variety Anna and Grany smith, and Crispin and Winter banana, as well as between variety Yataka and the standard. Similarly, the difference among variety Princisa, Gala must, Jona gold, and between Royal gala, Elester and Jona gored was not significant, but variety Dorset and Ariwa significantly different from others and from each other for fat content (Table 2).

There was significant difference (P≤0.05) among apple varieties for crude fiber content of fruits. However, the difference among varieties Ariwa, Royal gala, Gala must and Jona gold, and between varieties Anna, Jona gored and Winter banana as well as between variety Princisa, Dorset and Yataka and between Elester and Red delicious was not significant. On the other hands, significant difference was observed between variety Crispin and the standard for crude fiber content (Table 2).

Although, they showed no result significant difference between variety Gala must and Winter banana, Ariwa and Jona gold, and among Princisa, Dorset golden and Red delicious varietal response was generally significant for fruit carbohydrate content (Table 2). Similarly, energy value showed no significant difference among

variety Royal gala, Dorset, Yataka and Crispin, and among variety Anna, Princisa and Jona gored, and between Grany smith, Jona gold and Winter banana. But, significant difference was observed between variety Elester and Red delicious, and between Ariwa and Gala must for energy value (P ≤0.05) (Table 2) [23].

Table2. Proximate composition of apple varieties in %

Varieties	Moisture content	Ash	Protein	Fat	Fiber	Carbohydrate	EV (cal.)
Anna	11.000b	1.713c	1.847d	0.726a	6.723abc	88.991e-h	369.89cde
Princisa	9.277b	2.087a	1.715de	0.460bcd	5.863cd	89.87c-f	370.50cde
Dorset Golden	10.667b	1.842bc	2.697b	0.530abc	5.807cd	89.125c-f	372.06bc
Gala Must	8.333b	1.899b	2.298c	0.465bcd	7.238ab	88.10fgh	365.77ef
Grany Smith	16.167b	1.811bc	2.370bc	0.623ab	7.416ab	87.779gh	366.20def
Ariwa	9.667b	2.118a	2.743b	0.400cde	7.450a	87.290h	363.73f
Royal Gala	8.000b	1.349g	1.435e	0.344c-f	4.851a	92.023b	376.92b
Jona Gold	14.667b	1.890b	3.143a	0.472bcd	7.184ab	87.311h	366.06def
Yataka	12.333b	1.510ef	1.49de	0.179f	5.580cd	91.24bc	372.54bc
Crispin	9.667b	1.556de	1.663de	0.303def	5.370d	91.107bcd	373.81bc
Elaster	9.167b	1.424efg	1.551de	0.317c-f	6.113bcd	90.595b-e	371.43c
Red Delicious	7.667b	1.702cd	2.369bc	0.397c-f	6.130bcd	89.402c-f	370.65cd
Jona Gored	40.667a	1.404fg	2.2453c	0.396c-f	6.703abc	89.251d-g	369.55cde
Winter Banana	9.4967b	2.0693a	2.729b	0.283def	6.83abc	88.087fgh	365.82def
Standard	12.033b	0.3667h	0.443f	0.223ef	2.7867e	96.180a	388.50a
Mean	12.587	1.6495	2.0493	0.4079	6.1365	89.757	370.90
CV (%)	14.980	5.37	9.45	12.17	8.83	1.32	0.79
LSD (0.05)	12.050	0.148	0.391	0.219	1.313	1.982	4.870

Where, EV (cal.) - Energy Value in calories. Figure followed by the same letters are significantly different at P< 0.05

Fruit Mineral Content

There was no significant difference between variety Dorset and Gala must, and between Red delicious and Jona gored as well as between Royal gala, Elester and Crispin, though other varieties showed significant difference for K content (Table 3).

Similarly, fruits Ca content showed no significant difference between variety Anna and Ariwa, Red delicious and Jona gored and among Gala must, Gray smith, Yataka and Elester, as well as between variety Dorset golden, Jona gold and Winter banana, but there was significant difference between the other varieties (Table 3). In general, fruit content both K and Ca in apple varieties was in agreement with the finding of Maleeha Manzoor et al (2012) and higher than the standard reference. The result of Mg content in apple fruits showed no significant difference between variety Gala must and Red delicious, Princisa, Dorset and Ariwa and Anna among variety Royal gala, Yataka, Crispin, Elester and Jona gored (Table 3). The results obtained phosphorus and sulfur lower but higher than standard reference, and we observed significant differences among varieties at p≤0.05.

Table3. Mineral content of apple varieties in %

Varieties	Na	K	Ca	Mg	TP	TS
Anna	0.007b	0.679b	0.017b	0.023cd	0.040i	0.003g
Princisa	0.005d	0.463e	0.009ef	0.023cd	0.058e	0.019b
Dorset Golden	0.008a	0.802a	0.011cdef	0.023cd	0.046h	0.041a
Gala Must	0.008a	0.813a	0.013cd	0.021d	0.057e	0.011d
Gray Smith	0.005d	0.508d	0.013cd	0.044b	0.094b	0.003g
Ariwa	0.004e	0.445f	0.014bc	0.023cd	0.077c	0.008e
Royal Gala	0.003f	0.280jk	0.008f	0.019e	0.052fg	0.005f
Jona Gold	0.006c	0.597c	0.010cdef	0.051a	0.098a	0.019b

Yataka	0.003f	0.317h	0.013cd	0.018e	0.059e	0.003g
Crispin	0.003f	0.276k	0.010def	0.018e	0.054f	0.011d
Elaster	0.003f	0.282jk	0.013cd	0.016e	0.050g	0.005f
Red Delicious	0.003f	0.299i	0.012cde	0.021d	0.059e	0.016c
Jona Gored	0.003f	0.290ij	0.012cde	0.018e	0.050g	0.008e
Winter Banana	0.004e	0.412g	0.011cdef	0.024c	0.074d	0.011d
Standard	0.001g	0.120l	0.060a	0.005f	0.012j	0.004fg
Mean	0.005	0.442	0.015	0.024	0.059	0.012
%CV	11.84	1.79	14.43	5.15	2.18	8.06
LSD<0.05	0.009	0.0132	0.0032	0.002	0.0028	0.0015

P - Phosphorous, S - sulfur, CV - Coefficient of variance, LSD - Least significant difference

Micronutrient content among apple varieties

In this studied fruit Cu, Mn, Fe and Zn content of apple varieties were higher than the standard reference and in agreement with the finding of Maleeha et al (2012). It was observed that there was no significant difference between variety Winter Banana and Red Delicious, and Royal Gal and Yataka as well as between Granny smith and Jona Gored for Fe content (Table 4). Similarly, fruit Zn content showed no significant difference between variety Princisa and Ariwa, Gala Must and Granny Smith, and between Royal Gala and Yataka but the difference among other varieties was significant difference (Table 4).

The result of Cu in apple varieties were showed no significant difference between variety Princisa and Ariwa, and among variety Gala Must, Grany Smith and Winter Banana and also among variety Royal Gala, Crispin, Elaster and Jona Gored but no significant difference among Anna, Dorset Golden, Yataka and Winter Banana at P≤0.05. It was observed that the result of Mn in apple varieties showed no significant difference between variety Granny Smith and Ariwa, between variety Gala Must and Princisa, between variety Dorset Golden and Jona Gold and also among variety Anna, Jona Gored and Elaster but, significant difference among Royal Gala, Yataka, Red Delicious and Winter Banana at P≤0.05 (Table 4).

Table 4. Micronutrient in apple varieties in ppm

Varieties	Cu	Fe	Mn	Zn
Anna	3.837bc	46.000i	1.1833g	5.320ab
Princisa	3.417e	34.037j	1.5833ef	4.390e
Dorset Golden	3.607de	86.727c	2.2533d	5.227bc
Gala Must	4.107a	51.343h	1.7567e	3.943f
Grany Smith	3.923ab	56.933f	2.7900b	3.920f
Ariwa	3.413e	74.287d	2.8167b	4.493e
Royal Gala	1.8733hi	61.973e	0.7167i	3.357g
Jona Gold	3.680cd	85.660c	2.1500d	2.932i
Yataka	2.540g	60.640e	0.9233h	3.283gh
Crispin	1.550ij	90.493b	1.5300f	5.470a
Elaster	1.4167ij	54.000gh	1.0933gh	5.490a
Red Delicious	1.2167j	91.573ab	2.4500c	4.747d
Jona Gored	1.4267ij	55.783fg	1.1733g	5.087c
Winter Banana	2.873f	93.410a	3.0667a	3.110hi
Standard	0.147k	1.600k	0.4733j	0.447j
Mean	2.6018	62.964	1.7307	4.0810
CV (%)	5.20	2.53	6.73	3.02
LSD (0.05)	0.226	2.661	0.194	0.206

Figure followed by the same letters are significantly different at P< 0.05

Conclusion

The result of mean proximate composition showed that improved apple varieties have greater amount of ash, protein, fat and fiber than the standard reference but lower in carbohydrate content and energy value. In addition, these varieties were characterized by being more firm and showed the highest amount of fiber, protein, and minerals such as Ca and P. Significant differences were observed among the apple varieties for proximate composition and mineral content.

The study also showed that the improved apples varieties full fill the WHO quality standards in proximate composition and mineral content and over all nutritive value, except for carbohydrate and Calcium. However, further studies are required for sensorial, bioactive and antibiotic compounds to cosine up with a more comprehensive conclusion.

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