Quality Parameters and Physicochemical Properties of Improved Apple 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 14 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: Apple, 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 (Joha & Rai & Rajiv Shrama, 2012). Apple (*Malus domestica*), is an exogenous crop to Ethiopia introduced long ago from temperate regions. Is has phosphorus and sodium minerals, and is important in human nutrition with a vital role in bone and teeth formation and other important body functions (Farid, and Neda, 2014). It is also a good source of soluble carbohydrates, such as starches, sugars and fiber pectin, which helps to reduce cholesterol levels in humans by lowering the secretion of insulin (J. Liu, 2004 and Farid, and Neda, 2014). Despite its nutritional advantage, apple production has been restricted to some pocket areas of southwestern Ethiopia (Sharma Garg and Buldini, 2002). 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 zones of Oromia region, and North Shewa, North and South Wello, North and South Gondar and West and East Gojam zones of Amhara region (Melke and Fetena, 2014), through the support of government and nongovernment institutions, and private growers including smallholder farmers (Fetena and Lemma, 2014).

Growing apple is therefore, becoming an important horticultural activity in the highlands of Ethiopia which help farmers to balance their diets, serve as cash crops to generate incomes, diversify production, conserve soil and the environment and create job opportunities for many households including youths and women (ATA, and USAID, 2001). Although apple growing is a relatively new for the Ethiopian farming community, it is now becoming highly promising and financially feasible both in terms of fruits and seedlings production and an interesting business option for both rural and urban smallholders (Girmay *et al.*, 2014 and Yeshimebet, 2014).

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. The rise in demand for apple in Ethiopia is mainly due to the transition of majority of urban community to middle income class and lifestyle change of consumers in Ethiopia (Ethiopian Revenues and Customs Authority, 2017 and Hayesso, 2008). Hence, there is a strong need to satisfy the demands with demotic production.
Apple is source of vitamin C, potassium, dietary fiber and folic acid. It also contains calcium and iron and has high protein quality and high ratio of amino acid to protein and low sodium and fat contents. It is medium in calories with greater than 30 calories per serving and yet adds abundant flavor to a wide variety of foods.

So far about 13 apple varieties have been improved and adopted through research from Ethiopian Institute of Agricultural Research, Holeta agriculture research center, and these varieties were demonstrate to consumers and they are being used for house consumption and local markets. However, information on their nutritional profile and quality parameters are scanty (Akinwande and Olatunde, 2015).

The present study was therefore, conducted to determine the nutritional quality and physicochemical properties of thirteen improved and released apple varieties in Ethiopia.

Materials and Methods

Experimental set up

The experiment was conducted using samples collected from the existing field that at Holeta 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 $9^0$4'N latitude and 38^0 30’ E longitudes and at an altitude of 2391 meter above sea level. The mean maximum and minimum temperatures the center are 22°C and 6°C, respectively. The center receives mean total annual rain fall of 1144mm with erratic distribution. The soils are Nitosol and Vertisol and the soil texture class is mainly Clay to clay loam with pH of 3.8 -6.2 (Asanga *et al.*, 2015).

Sample collection

For quality analysis fruit of 14 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 (Kebede *et al.,* 2017).

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 (AOAC, 1990). 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 (AOAC,1990).

Determination of proximate composition

The moisture content of powdered apple sample was determined by drying in an oven (at 105 °C) to a constant weight. The moisture content in the sample was determined as follows (AACC, 2000).

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

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 (AOAC, 1990).

The % ash content in the apple sample was calculated as follows:

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

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.

Protein Digestion: About 2.0 g of the sample was weighed into an ash less filter paper and put into a 250 ml Kjeldahl flask. Then, 1 g of digestion mixture (as catalyst) and 10 ml of 98 % conc. Sulfuric acid were added. The whole mixture was subjected to heating in the digestion chamber at 380 ^{0}C for 2 hours until transparent residue contents were obtained. Then, it was allowed to cool. After cooling, the digest was transferred into a 100 ml volumetric flask and made up to the mark with distilled water and then distilled using Markham distillation apparatus.

Protein Distillation: Before use, the Markham distillation apparatus was steamed through for 15 min after, which a 100 ml conical flask containing 20 ml of 2 % boric acid and 1 or 2 drops of mixed indicator was placed under the condenser such that the condenser tip was under the liquid. About 5.0 ml of the digest was pipette into the body of the apparatus via a small funnel aperture. The digest was washed down with distilled water followed by addition of 3-4 drops of phenolphthalein and 5 ml of 40 % (W/V) NaOH solution. The digest in the condenser was steamed through until enough ammonium sulfate was collected. The Boric acid plus indicator solution changed color from red to green showing that all the ammonia liberated had been trapped. The solution in the receiving flask was titrated with 0.01N hydrochloric acid up to a purple end point (AOAC, 1990). Also, a blank was run through along with the sample. After 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. Then, percentage crude protein in the sample was calculated from: % Nitrogen as % crude protein =

% N x F, where, F (conversion factor) is equivalent to 6.25 (AOAC, 1990). Crude fat was determined using digital FOSS Soxtec™ 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 ^{0}C. After solvent recover, cool extraction cups in dissector and the extraction cups were weighed again (Foss Allé, 2014).

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

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

To determine crude fiber content, about 2 g fat free sample of powdered apple was taken into a fiber flask and 100 ml of 0.255 N H_2SO_4 was added, and then the mixture was heated under reflux with heating mantle for one hour. The hot mixture was filtered through a fiber sieve cloth. The difference obtained was and the residue was returned to the flask to which 100ml of 0.313 M NaOH was added and heated under reflux for another one hour. The mixture was filtered through a fiber sieve cloth and 10ml of acetone was added to dissolve any organic constituent. The residue was washed with 50 ml of hot water twice on the sieve cloth before it was finally transferred in to a pre-weighted 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 desiccators and latter weighted (W_1) 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 obtain (W_2) (Jurgen Moller, 2014).

The % of crude fiber was calculated as follows

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

Total carbohydrate content in the apple samples was determined by the difference method. 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 carbohydrate constituent of the sample (AOAC, 1990).

Thus:

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

The energy value of the samples was determined by multiplying the protein content by 4, carbohydrate content by 4 and fat content by 9 (AOAC, 1990).

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

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 (Maleeha Manzoor *et al*., 2012).

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).

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 Grany smith, and between Princisa and Royal gala but significant difference was observed among Crispin, Red delicious and Ariwa for moisture content. Titrable acidity showed no significant difference among variety Gala must, Gray 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) (Abolaji Bello and Adiaha Abigail, 2015).

Table 1. Fruit physicochemical properties of Apple varieties

Varieties	Moisture Content fresh (%)	Titrable Acidity (%)	Total Soluble Solid (% berix)
Anna	47.520ab	0.783hi	13.333d
Princisa	44.233bcd	0.923fg	12.333e
Dorset Golden	45.567abc	1.100de	13.333d
Gala Must	42.023cde	0.517b	11.333f
Gray Smith	45.410abc	1.300b	11.333f
Ariwa	41.263de	0.867gh	12.333e
Royal Gala	44.423bcd	1.227bc	13.333d
Jona Gold	47.550ab	1.003ef	11.333f
Yataka	41.923cde	1.557a	14.333c
Crispin	38.143e	0.697i	16.33a
Elester	48.583a	0.770hi	13.333d
Red Delicious	40.103e	1.283b	15.333b
Jona Gored	44.967abcd	0.537j	14.333c
Winter Banana	47.110ab	1.177cd	13.333d
Mean	44.201	13.262	13.262
%CV	5.43	4.35	4.35
LSD<0.05	4.0144	0.1058	0.9656

Where as, CV=Coefficient of variance, LSD=Least Significant difference. Figures followed by scheme letters with in a column are not significantly different at p≤ 0.05.

Proximate nutritive value

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 not 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).

Table 2. Proximate composition of Apple varieties

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

EV(cal)- Energy Value in calorie. Figure followed by the same letters are significantly different at P≤ 0.05

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) (Florence Abolaji and Adiaha Abigail, 2015).

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).

Table 3. Mineral Content of Apple varieties

Varieties	g/100g			mg/Kg	
	K	Ca	Mg	Fe	Zn
Anna	0.679b	0.017b	0.023cd	46.000i	5.320ab
Princisa	0.463e	0.009ef	0.023cd	34.037j	4.390e
Dorset Golden	0.802a	0.011cdef	0.023cd	86.727c	5.227bc
Gala Must	0.813a	0.013cd	0.021d	51.343h	3.943f
Gray Smith	0.508d	0.013cd	0.044b	56.933f	3.920f
Ariwa	0.445f	0.014bc	0.023cd	74.287d	4.493e
Royal Gala	0.280jk	0.008f	0.019e	61.973e	3.357g
Jona Gold	0.597c	0.010cdef	0.051a	85.660c	2.932i
Yataka	0.317h	0.013cd	0.018e	60.640e	3.283gh
Crispin	0.276k	0.010def	0.018e	90.493b	5.470a
Elester	0.282jk	0.013cd	0.016e	54.000gh	5.490a
Red Delicious	0.299i	0.012cde	0.021d	91.573ab	4.747d
Jona Gored	0.290ij	0.012cde	0.018e	55.783fg	5.087c
Winter Banana	0.412g	0.011cdef	0.024c	93.410a	3.110hi
Standard	0.120l	0.060a	0.005f	1.600k	0.447j
Mean	0.442	0.015	0.024	62.964	4.0810
%CV	1.79	14.43	5.15	2.531	3.02
LSD≤0.05	0.0132	0.0032	0.002	2.661	0.206

CV=Coefficient of variance. LSD=Least significant difference. Figures followed by same letters with in a column are not significantly different at p≥0.05.

In this study fruit 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 Grany smith and Jona gored for Fe content (Table 3). Similarly, fruit Zn content showed no significant difference between variety Princisa and Ariwa, Gala must and Gray smith, and between Royal gala and Yataka but the difference among other varieties was significant difference (Table 3).

Conclusions

The result of proximate composition showed that improved apple varieties have 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 in carbohydrate content and energy value. As quality indicates, fruit moisture content was lower due to less water and high quality. TA and TSS contents had higher moisture content with respective values of 1.177 and 13.333%. The results of fruit mineral content revealed higher values of K (0.444%), Mg (0.024%), Fe (62.964%) and Zn (4.081%) than the standard reference which is (0.120,0.005,1.600, 0.447%) respectively, except for Ca (0.015%). Variety Anna showed considerable high fat and fiber contents while Anna, Cripsin and Elester had high Zn content. The study also showed that the improved apples varieties full fill the WHO quality standards in proximate composition and mineral content except for carbohydrate and Calcium. However, further studies are required to investigate the bioactive and antibiotic compounds for tested varities.

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