



Evaluation of Mineral Profile and Selected Component of Improved Onion (*Allium cepa* L.) Varieties in Ethiopia

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To cite this article:

Kebede Dinkecha, Yohannes Habteyesus. Evaluation of Mineral Profile and Selected Component of Improved Onion (*Allium cepa* L.) Varieties in Ethiopia. *International Journal of Biochemistry, Biophysics & Molecular Biology*. Vol. 4, No. 1, 2019, pp. 13-18. doi: 10.11648/j.ijbbmb.20190401.13

Received: May 15, 2019; **Accepted:** June 20, 2019; **Published:** September 25, 2019

Abstract: Because of its significant ingredient in various dishes, medicinal property, nutritional worth and energy value, red onions (*Allium cepa* L.) impart numerous health benefits to users. The purpose of this research was to determine mineral composition and selected physicochemical properties of different red onion (*Allium cepa* L.) varieties grown at same field management condition in Ethiopia as well as comparative study among varieties and between study varieties and standard reference. All field and laboratory data was analyzed using statics 10.0 soft ware and the result of both macro and micro nutrient mineral content in the onion bulbs revealed significant difference among the varieties at ($P < 0.05$). Comparative study was conducted to investigate the mineral composition between studied improved varieties and standard reference and the result showed that Ethiopian onion cultivars were high in Na (147.75 – 189.05ppm), K (10219 – 11013ppm) and Ca (1223.2 – 1566.9ppm, Mg (609.07 – 703.56ppm), TP (2609.7 – 3055.8ppm), S (456.40 – 540.34ppm), Cu (2.179 – 2.47) and Fe (48.353 – 61.43ppm) content than standard (40.0, 1460, 230, 100, 1642.3, 168.0, 0.403 and 21.0ppm respectively) but low in Mn (9.55 – 14.457), Zn (14.84 – 22.483) and B (4.81 – 6.02ppm) than standard (12.9, 17.0, 6.10ppm) respectively). The result of soil data for both macro and micronutrient were low in the studied area.

Keywords: Macro and Micronutrient, Mineral Analysis, Onion, Standard, Varieties

1. Introduction

Onion (*Allium cepa* L.) is one of the most consumed vegetable planted widely across the world with a global annual production of 90 million tones [1]. It is a natural part of the daily diet for most of the population and is a crop of great economic importance all over the world [11]. It is considered as one of the most important vegetable crops produced on large scale in Ethiopia. Onion also occupies economically important place among vegetables in the country. The area under onion is increasing from time to time mainly due to its high profitability per unit area and ease of production, and the increases in small scale irrigation areas [3].

Raw and cooked onions are consumed as young green plants or as bulbs. They are valued for their distinctive pungency and flavor which improve the taste of other foods. Onion either green or bulbs are used almost daily in every

home and are essential ingredient in Ethiopia diet [14].

Onion contains chemical compounds such as phenolics and flavonoids that basic research shows to have potential anti-inflammatory, anti-cholesterol, anticancer, antioxidant properties and mineral contents [12]. It can protect against cancer, fight fungi and bacteria, promote cardiovascular health, reduce high blood pressure and insulin resistance, aid in weight loss, possess antioxidant activity, fight chronic bronchitis, infections, fever etc. [2, 8].

Minerals or chemical elements which are inorganic nutrients are usually required in small amounts from less than 1 to 2500 mg/ day depending on the mineral. The dietary focus on chemical elements derives from an interest in supporting the biochemical reactions of metabolism with the required elemental components [7]. Appropriate intake levels of certain chemical elements have been demonstrated to be required to maintain optimal health. Some of the minerals of much biological importance are Ca^{2+} , Mg^{2+} , Mn^{2+} , K^{+} , P^{-} ,

Na^+ , Fe^{2+} , Zn^{+2} , $\text{SO}_4\text{-S}$. A rising from the use of onions in almost all meals in a typical Ethiopia family, the safety, nutritional and anti-nutritional composition of this plant which may be responsible for its reported [3] medicinal abilities must be investigated to unravel new information, authenticate earlier claims or counter same. This study was designed to determine quantitatively the ant nutrients and mineral composition of onion bulbs. Onion has low mineral content but there is no clear research done whether or not and since its ingredient in various dishes, used in almost all food preparation and daily intake better to know essential minerals like Zn, Fe, Ca and Mg and if low enrich through biofortification or food processing [2].

They also contain calcium, iron and have a high protein quality, ratio of mg amino acid/gram protein. Onions are low in sodium and contain no fat. Onions are also cholesterol free, and provide dietary fiber, vitamin C, vitamin B6, potassium, and other key nutrients [12].

Nutrient supply interacts with other agronomy management, pest, and climatic factors to affect quality and yield. Environmental factors that can delay maturation and increase storage loss include hail damage to plants, a cooler than normal growing season, or wet weather for field curing of bulbs. Understanding how the onion plant grows and develops is a key part of developing a strategy to supply nutrients for optimum bulb yield and quality [18].

So far five improved onion varieties namely Adama Red, Bonbay Red, Nasik Red, Nafis and Melkum were released through research from Ethiopian Institution of Agriculture Research, Melkassa agriculture research center and these varieties were demonstrate to consumers and they are used for house consumption, local and foreign markets. However, the information on their nutritional profile and quality parameters value in term of flavor, provide health-promoting phytochemicals, anti oxidant as well as mineral content is scanty [2].

The present study was conducted to determine the mineral profile, physicochemical properties of improved five onion varieties Adama red, Bonbay red, Melkum, Nasik red and Nafis.

2. Materials and Methodology

2.1. Field Experiment and Sample Collection

The field experiment was conducted at Melkassa agriculture research center (MARC) on station. Five released onion varieties and the onion seed samples were cultivated in three rapes, plot size 1.2mx5m with three triplicates for each variety and spacing 40x20x7cm on the same field to compare the nutritional quality of varieties which growing in the same condition (water requirement, soil fertility and field management). The center is found in the Ethiopian rift valley, 117 km away from Addis Ababa in the south east direction located at 8024'N and 39 012'E and an altitude of 1550 meter above sea level. The mean maximum and minimum temperature is 28.6°C and 13.8°C respectively. The center

receives mean total annual rain fall of 825.9mm with erratic distribution [10].

2.2. Data Collected in the Field

Data on date of transplanting, depth of planting; plant height and number of leaves per plant, leaf diameters and length, dry biomass, weight of dry bulbs, diameters of dry bulbs were collected. Beside data on yield and yield attributes were collected from ten randomly harvested plants from central rows by leaving boarder plant from each plot. Accordingly data on bolter plants, days to physiology maturity, split bulbs, total and marketable bulbs weight were recorded. Maturity time was recorded based on time from transplanting to the time when 50-75% of the leaf falls down to determine the days to physiological maturity. One composite soil sample before planting and five composite soil samples from fifteen plots by treatment were collected [7, 18].

2.3. Soil Chemical Properties Analysis Method

The soil pH was measured using potentiometer with a digital pH meter in the supernatant suspension of 1: 2.5 soils to water ratio [17] while soil organic carbon content was determined by the dichromate oxidation was estimated from the organic carbon content by multiplying the latter by 1.724. Total N was determined using the micro-kjeldahl digestion, distillation and titration procedure as described by Bremner and Mulvaney [5]. Soils available P was extracted by the Olsen method [15].

2.4. Method of Soil Mineral Analysis Using Inductive Couple Plasma Optical Emission Spectroscopy (ICP-OES)

2.4.1. Digestion and Analysis of Soil and Onion Samples

The collected soil samples were prepared in laboratory according to standard procedure digested at 180°C for 45 minutes after 3: 1 ratio HNO_3 and HCL mixed acid. The digested sample were filtered in 50 mL volumetric flask and final volume were marked with 2% HNO_3 [13]. Multielement was determined using ICP-OES after calibration using 1000 ppm standard solution of respective mineral as well as drift blanks. After instrument was calibrated metals were analyzed by the absorption mode of the instrument. Three readings were recorded for each digest by different ICP-OES conditions to give the maximum signal intensity [16].

2.4.2. Instrument Calibration and Method Validation

Recovery tests for the Uv-visible spectrophotometer and IC-OES methods were performed using nonspiked and spiked samples in order to ascertain the reliability and efficiency of the analytical procedures. Important instrument such as Uv-visible spectrophotometer for phosphorous analysis and ICP-OES for exchangeable base (Na, K, Ca, Mg) and micronutrient were calibrated by using standard solution [6].

Statistical analysis of the data was carried out by using statics 10.0 Analytical Software and analysis of variance (ANOVA) for comparing nutrient in soil variation among the treatment and nutrient content in different onion varieties while associative test for correlation (Pearson) [19].

2.5. Optimization of Digestion Procedure for Soil and Onion Samples

The basic requirement for sample preparation for analysis is to get an optimum condition for digestion. To select an optimum procedure for digestion, parameters like digestion time, reagent volume, volume ratio of reagents, and digestion temperature were optimized by varying one parameter at a time and keeping the others constant. These optimum conditions were selected based on clarity of digests, minimum reagent volume consumption, minimum digestion time, simplicity and minimum temperature applied for complete digestion of samples [9].

3. Result and Discussion

3.1. Instruments Calibration and Method Validation

Calibration of instrument using working standard solution was done for Uv- visible spectrophotometer and ICP-OES which are used to determine the concentrations of available Phosphorous, exchangeable cations and micronutrients in onion and soil samples respectively. The linear correlation coefficients (R^2) obtained for soil sample for Uv-visible spectrophotometer and ICP-OES, ranging between 0.9973-0.9996 and 0.998-0.999 respectively, are in acceptable ranges

[6]. The result recovery tests for onion and soil samples for evaluation of analytical methods and the result were within the range of 88.7-112% and 91.6- 109.3% for both soil samples and onion varieties respectively. The acceptable range is (80 - 120%) [4].

For optimization of digestion procedure, the result showed that the mixture of 9mL HNO_3 , and 3mL HCl, digestion time 45 min, pressure 80W and digestion temperature of 180°C were found to be the optimal condition for 0.5g of soil and onion and 2mL water samples were selected from eight treatments [9].

3.2. Yield Performance of Onion Varieties

The vegetative and quality performances of released onion varieties were not significant at $p < 0.05$ except for leaf length (Table 1). Nafis variety gave significantly the highest leaf length (59.3cm) than Melkam but there was no significant difference with the rest varieties for these parameters (Table 1). Though there was no significant difference among the onion varieties, Nasif gave the highest plant height (72 cm) than all the test varieties. Regarding number of leaves per plant Bombay Red gave the highest number (12.3) than the rest; but there was no significant difference among the varieties. Nasik Red and Nafis gave better average bulb weights than the rest varieties (Table 1). Adama Red, Nasik Red and Nasif showed better bulb quality in terms of total soluble solids (about 13%) than Bombay red and Melkam (11%); however there was no significant difference among the varieties.

Table 1. Average vegetative and yield performances of released onion varieties at Melkessa, 2016.

Varieties	PH	NL	LL	ABW	%TSS
Adama Red	68	9.0	53.7ab	48.0	13.0
Bonbay Red	69	12.3	58.0ab	60.0	11.3
Melkam	64	9.3	49.7b	53.3	11.3
Nafis	72	10.0	59.3a	73.3	12.7
Nasik Red	68	10.0	54.7	78.3	12.7
Mean	68.1	10.2	55.07	62.6	12.0
F-test	NS	NS	*	NS	NS
CV (%)	5.5	13.15	5.65	21.56	10.15

PH-Plant height [cm], NL-Number of Leaves per plant, ABW- Average bulb weight [g],%TSS-total soluble solid in percent, NS- non significant, *- significant at 5% of probability level. Means followed by the same letter are not significantly different at 5% level.

3.3. Selected Soil Data Before Plant and After Harvesting

Major soil data parameters of onion field before planting and after harvested are shown in Table 2. The pH and EC result indicate that the soil was slightly alkaline and normal electric conductivity. No significant difference was observed between Adama Red, Bonbay Red, Nafis and before planting of field plot at $P < 0.05$ while there was a significant difference for Melkum and Nafis plot. Organic matter also did not show significant difference among the plot except Nasik at $p < 0.05$.

There were no significant difference in total nitrogen among the plot except before planting while a significant difference were observed in available phosphorous Adama Red, Melkum and BP field plot. This was due to application of DAP fertilizer and uptake by plant in the form of P_2O_5 according to Weldemariam [22] recommendation, but no difference among Melkum, Nasik and Nafis grown field plot. There was no significant different in sulfur content among the field plot except before planting at $p < 0.05$.

Table 2. Mean \pm SD result of soil analyzed.

Treatment	PH (1: 2.5H ₂ O)	EC (μ S/mol)	%OM	%TN	AP ^S(ppm)	S (ppm)
Adama Red	7.4 \pm 0.07 ^a	123 \pm 2.87 ^b	2.61 \pm 0.08 ^a	0.21 \pm 0.03 ^{ab}	13.74 \pm 0.15 ^c	17.42 \pm 0.27 ^a
Melkum	7.1 \pm 0.18 ^b	131 \pm 1.98 ^{ab}	2.74 \pm 0.07 ^a	0.189 \pm 0.06 ^b	17.13 \pm 0.14 ^a	17.5 \pm 0.25 ^a
Bonbay red	7.2 \pm 0.03 ^{ab}	127 \pm 2.26 ^b	2.49 \pm 0.08 ^{ab}	0.22 \pm 0.08 ^{ab}	14.92 \pm 0.13 ^b	17.3 \pm 0.14 ^a
Nasik	7.1 \pm 0.06 ^b	133 \pm 2.79 ^a	2.28 \pm 0.09 ^b	0.27 \pm 0.06 ^a	18.27 \pm 0.21 ^a	16.64 \pm 0.19 ^{ab}
Nafis	7.3 \pm 0.04 ^a	130 \pm 3.1 ^{ab}	2.68 \pm 0.11 ^a	0.23 \pm 0.07 ^{ab}	15.67 \pm 0.26 ^{ab}	15.62 \pm 0.11 ^b ^c
BP	7.4 \pm 0.07 ^a	137 \pm 3.27 ^a	2.47 \pm 0.15 ^{ab}	0.24 \pm 0.04 ^a	14.89 \pm 0.17 ^b	23.31 \pm 0.13 ^a

OM- organic matter, TN- Total Nitrogen, AP- Available Phosphorous, S-sulphur, ppm-pert per million.

Soil mineral parameter of onion field before planting and after harvested was evaluated at $p < 0.05$ as shown in (Table 3). The result of this study indicates that the soil of study area is low in exchangeable cation and the nutrient up take also varies among varieties.

The Ca result shows no significant difference between Bonbay Red and Melkum and between Adama red and Nasik but while there was significant difference among Bonbay, Melkum Nafis and BP plot and, between Adama red and Nafis plot. K also did not show significant difference among Bombay, Nasik and Melkum and between Nafis and BP plot.

But there was significant different among Bonbay, Adama and Nafis plot at $p < 0.05$. No significant among Bombay, Nasik and Nafis and also between Adama red and Melkum but significant different between BP and other treatments for Mg. The result of this study area were indicated that there were no significant difference in Na among the Bonbay, Nasik, Nafis and among Adama red, Melkum and BP while significance different between BP and other treatment except Melkum and Adama red plot was observed. The result of Al and Si shows significant difference among treatment in Si but not significant difference for Al among treatment (Table 3).

Table 3. Result of exchangeable cation in soil sample experimental plot before planting and after harvested in mg/Kg.

Treatment	Ca	K	Mg	Na	Al	Si
Bombay Red	4776.2 ^a	1384.5 ^b	549.72 ^{ab}	159.73 ^a	954.63 ^b	944.76 ^b
Adama red	4519.6 ^c	1443.6 ^a	527.75 ^{cd}	149.46 ^b	939.66 ^c	950.45 ^b
Nafis	4377.2 ^d	1335.8 ^d	551.45 ^{ab}	163.62 ^a	908.39 ^d	927.26 ^c
Nasik	4516.4 ^c	1372.4 ^{bc}	558.24 ^a	162.15 ^a	926.12 ^c	925.84 ^c
Melkum	4726.3 ^a	1363.6 ^{bc}	520.57 ^d	151.60 ^b	970.57 ^a	978.60 ^a
BP	4623.8 ^b	1347.0 ^{cd}	537.21 ^{bc}	151.69 ^b	927.80 ^c	937.63 ^{bc}
Mean	4578.2	1381.6	539.96	154.76	937.42	943.75
CV (%)	0.64	1.05	1.55	2.13	0.73	0.8
LSD (≤ 0.05)	53.780	26.683	15.433	6.0991	12.706	13.980

Same letters in a column shows no significance difference while different letter in one column shows significance different letter.

Soil micronutrient content in each plot of onion field is indicated in Table 4. Result indicates the soil minerals of study area were low to medium except Mn. The result of Cu in onion field plot was show no significant different between Bonbay and Nafis and also among Adama, Nasik, Melkum and BP while significant difference between Adama red and Nafis as well as Adama red and Bombay red plot was relived. The result of Fe shows no significant difference among plot except Bombay and Nafis. There was significant difference

among treatment except between Adama red and Nasik in Mn content (Table 4). The result of Zn in onion grown field indicate that no significant difference among Adama red, Melkum and BP as well as between nafis and Nasik while Bombay plot showed significance difference from other treatment. The result of B, Mo and Co indicates no significant difference among treatment because no blended fertilizer was used on the field plot.

Table 4. Result of micro nutrient content in soil sample in mg/Kg.

Treatment	Cu	Fe	Mn	Zn	B	Mo	Co
Bombay	2.853 ^{bc}	91.163 ^{ab}	351.92 ^b	5.207 ^a	1.0400 ^{ab}	0.2600 ^a	2.5967 ^{ab}
Adama red	2.723 ^{bc}	87.280 ^c	343.18 ^c	4.393 ^c	1.0167 ^{ab}	0.2500 ^a	2.5900 ^{ab}
Nafis	2.673 ^c	92.487 ^a	329.96 ^d	4.753 ^b	0.9980 ^b	0.2567 ^a	2.4600 ^b
Nasik	2.860 ^b	88.270 ^{bc}	337.84 ^c	4.703 ^b	1.0400 ^{ab}	0.2567 ^a	2.4733 ^b
Melkum	2.883 ^{ab}	87.860 ^c	359.68 ^a	4.287 ^c	1.0100 ^{ab}	0.2633 ^a	2.6700 ^a
BP	3.057 ^a	86.593 ^c	312.19 ^c	4.357 ^c	1.0567 ^a	0.2633 ^a	2.4600 ^b
Mean	2.842	88.942	339.13	4.617	1.0269	0.2583	2.5417
CV (%)	3.54	2.00	1.20	2.82	2.81	3.39	3.00
LSD (≤ 0.05)	0.183	3.238	7.42	0.237	0.0626	0.015	0.1386

B- Boron Mo- Molybdenum Co- Cobalt CV-Coefficient of Variance LSD-least significant difference.

3.4. Comparison of Macro Mineral Among Onion Varieties

Results of the mineral composition in studied sample

materials are in agreement with Akinwande and Olatunde (2015) (Table 5). The Na showed were no significant different between Adama red and Nasik as well as between

Nafis and Melkum varieties at $p < 0.05$ but, significant different among Bombay, Nasik, Melkum and standard [20].

In this study the K contents of onion varieties showed no significant different between Adama red and Nasik and, Nafis and Melkum varieties while significant difference from Bombay and standard due to K_2O application on field plot. Regarding Ca there were no significant difference between Bombay and Nafis, between Adam red and Nasik but Melkum and standard were significant difference from other varieties as well as between each other. There was no significant difference among varieties in Mg content except

for standard [21].

The result of TP revealed no significant difference between Bombay and Melkum, between Adama red and Nasik but significance from Nafis and standard as well as between them due to DAP application. The result of S in onion varieties indicated no significant difference among Bombay, Nasik and Melkum except Adama red and Adam red variety which had high sulfur content means pungent than other varieties which agreement with Kebede et al., (2017). In general all onion varieties improved in Ethiopia had high mineral content than standard as shown in Table 5 [20].

Table 5. Macronutrient Content in Onion Varieties in mg/Kg.

Varieties	Na	K	Ca	Mg	TP	S
Bombay	164.04 ^{bc}	10219 ^c	1370.0 ^b	609.07 ^b	2821.8 ^b	470.68 ^b
Adama red	179.13 ^{ab}	10952 ^a	1663.5 ^a	692.45 ^a	3055.8 ^a	540.34 ^a
Nafis	153.05 ^{cd}	10716 ^b	1387.8 ^b	625.49 ^b	2609.7 ^c	456.40 ^c
Nasik	189.05 ^a	11013 ^a	1566.9 ^a	703.56 ^a	3032.7 ^a	473.53 ^b
Melkum	147.75 ^d	10635 ^b	1223.2 ^c	633.84 ^b	2749.9 ^b	473.53 ^b
Standard	40.00 ^c	1460 ^d	230.00 ^d	100.00 ^c	1642.3 ^d	168.00 ^d
Mean	145.50	9165.8	1240.2	560.73	2652.0	430.4
CV (%)	6.02	0.81	4.5	3.06	1.55	1.1
LSD (≤ 0.05)	15.929	134.68	101.49	31.194	74.543	8.576

The same letter in a column shows no significant difference while different letter in a column shows significant difference. TP- Total Phosphorous S- sulfur.

3.5. Comparison of Micro Mineral Among Onion Varieties

The result of micronutrient content in onion varieties show that all improved Ethiopian onion varieties were higher in Cu, Fe and Zn content than standard but lower than standard in Mn and B content (Table 6) [20]. With regarded to Cu, there was no significance different among varieties except between Nasik and Nafis. Also for Fe, there was no significance difference among Bombay Nafis, Nasik and Melkum and also between Adama red and Nasik (Table 6).

The result of Mn in this study indicated no significance difference between Bombay and Melkum, Nafis and Nasik

while Bombay was below the standard. Zn is an important element in food and its deficiency can be risky but fortunately most of the varieties studied are not below standard. Nafis and Adama red varieties were high Zn in content but, no significance difference among varieties except Adama red while significance among Bombay, Adama red and Nafis (Table 6). The studied result shows no significance difference between Adama red and Melkum but significant difference was observed among Bombay, Adama red, Nasik and Nafis varieties in B content.

Table 6. Micronutrient Analyzed in Onion Varieties in mg/Kg.

Varieties	Cu	Fe	Mn	Zn	B
Bombay	2.3767 ^{ab}	48.353 ^b	9.550 ^d	17.930 ^b	4.8100 ^d
Adama red	2.3533 ^{ab}	59.690 ^a	14.457 ^a	22.483 ^a	5.6000 ^b
Nafis	2.1767 ^b	49.890 ^b	11.503 ^{bc}	14.840 ^c	5.0100 ^c
Nasik	2.4700 ^a	61.430 ^a	12.353 ^b	18.250 ^b	6.2233 ^a
Melkum	2.1967 ^b	51.223 ^b	10.563 ^{cd}	15.660 ^{bc}	5.5600 ^b
Standard	0.4033 ^c	21.000 ^c	12.900 ^{ab}	17.000 ^{bc}	6.1000 ^a
Mean	1.0061	48.598	11.889	17.694	5.5506
CV (%)	6.97	7.47	7.99	8.34	1.89
LSD (≤ 0.05)	0.253	6.6069	1.7271	2.6844	0.1911

4. Conclusion

Field management, fertilizer application and other environmental factors affect onion productivity and nutritional quality parameters. Significant differences of the mineral composition and antioxidant activities among the onion cultivars were observed, Adama Red varieties was showed considerable high mineral content (Ca, Mg, Fe and Zn) and antioxidant activity which could be developed for functional food that benefits human health.

The study also showed that Ethiopian onion cultivars were fall within WHO standard in the quality of mineral nutritive value for macro and micro element except for manganese and boron. From the study Ethiopian onion varieties still need high sulfur content like Adama variety for pungent, ant disease, other bioactive and ante oxidants increment. Further studies are required on *Allium cepa* L. for bioactive and antibiotic compounds since its sulfur and pungency was remarkable.

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