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Physicochemical and Nutritional Quality Evaluation of Maize Varieties highland agro-ecologies of Ethiopia

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Abstract

Maize or corn (Zea mays L.) is globally known as queen of cereals because of its highest genetic yield potential and it is an important crop with great use in food and other industries. Maize is among the major cereals produced and consumed in Ethiopia. The aim of this study was to evaluate the physico chemical and nutritional compositions of three Ethiopian maize varieties. The materials were collected from Maize breeding program of Kulumsa Agricultural Research Center and standard methods were used for Laboratory analysis. The results of Hectoliter weight, of three maize varieties was obtained in the range (78.36 to 80 kg/hl)) and the color L*, a* b* ranged from (70.13 to 95.6), -0.95 to 3.00,4.75 to 24.86) respectively. The nutritional compositions (moisture, fat, protein, and total starch) of three maize varieties were obtained in the range of 8.85 -9.2%, 4.7% – 5.05%, 9.05% – 9.87%, respectively. In general, maize is rich in the chemical composition of starch and fat as indicated in this study. There was a significant difference in most maize varieties ($p < 0.05$) in nutritional composition. Oil content has a significant difference in among the maize varieties ($p < 0.05$). Starch content of maize varieties was found in the range of 67.91% – 69.97% and all maize varieties have the criteria of quality maize according to the physico-chemical qualities of these varieties with compared to maize qualities standards. Therefore, the chemical composition and physical quality traits could be utilized for various food preparations and selection for breeding program. It also shows the utilization of maize and suggests the future strategy for the food and nutrition security as to how to make best use of the maize genotypes. From this study it was suggested that highland maize grown in Arsi (Kulumsa condition) can fit the maize quality criteria as other agro-ecologies of Ethiopia.

Keywords: Maize; Physico-chemical; Starch; Protein

Introduction

Maize or corn (Zea mays L.) is globally known as queen of cereals because of its highest genetic yield potential [1]. Maize is the only food cereal crop that can be grown in diverse seasons, ecologies and uses. It is cultivated globally on more than 160-million-hectare area across 166 countries [1]. Maize is among the major cereals produced and consumed in Ethiopia. The crop grows in various agro-ecologies of the country and, thus, its breeding program has been focused on increasing stability and yield potential regardless of its nutritional quality under different abiotic and biotic stress conditions [2].

In Ethiopia the crop is widely cultivated at altitudes ranging from 1500–2200 meters above sea level of Western, Southwestern, and Southern parts of the country. The high altitude, sub-humid maize agro ecology (1800-2400 m.a.s.l.) in Ethiopia is estimated to cover 20% of the land devoted to annual maize cultivation. Adoption of maize is increasing in the highland agro-ecology [3]. Maize production takes significant share of cereals and grain in any production year among cereals, Maize ranks second after *teff* in area coverage and first in total production. Cereals are important sources of proteins in human nutrition. The chemical composition of the maize kernel and its nutritional value give it a good position among the group of cereals in the "agrifood" category [4]. It is a good source of carbohydrate, ash, protein, fiber, oil, vitamins, and minerals [5]. In addition, maize contains essential amino acids such as lysine and tryptophan, which are useful for the growth of fetus to prevent miscarriage and it contains tocopherol and unsaturated fatty acids that are very useful for a diet of in modern lifestyle. In Ethiopia, maize is a staple food in major maize producing areas. The per capita consumption of maize in Ethiopia is about 60 kg per annum.

The color of maize, in addition to being dietary source of energy, lipids, protein, minerals and vitamins, it is a source of carotenoids. Carotenoids are a diverse family of yellow-orange pigments generally categorized into two groups; carotenes (eg. β-carotene, α-carotene) and xanthophylls (eg. β-cryptoxanthin, lutein, zeaxanthin). βcarotene, α-carotene and β-cryptoxanthin are important precursors of vitamin. The full characterization and proximate composition of the quality attributes of maize produced from seeds of mentioned locally cultivated maize varieties has not yet been investigated. Food composition data is important in nutritional planning and provides data for epidemiological studies. However, there is limited information about the nutritional content of the different maize varieties growing in Ethiopia. This study was planned to provide information on nutritional composition of three maize varieties grown in highlands of Ethiopia [6].

Materials and Methods

Sample Collection and Sample Preparation

Materials

Three maize varieties were collected from Kulumsa agricultural research center 2.0 kg of maize sample was collected from the agricultural research center, from each sampling site and stored in

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paper bags under room temperature conditions. K0lba, BH661 and Jibat varieties were collected from Kulumsa Agricultural Research center. Sample preparation for analysis was done according to [7].

Methods

Thousand kernel weight

The maize sample was taken on the analytical balance after counting 1000 wheat kernels on seed counter (India Mart, VT54, India), whereas, test weight was determined with Schopper Chondrometer (Graintec, QLD4350, Australia).

Hectoliter weight

Test weight was measured in special Seedburo Filling Hopper (model 151) according to method No. 55-10 [8]. After cleaning and passing through specific sieves, the hopper was filled with the sample. Excess grains were scraped off with a strike. Reading was noted on the scale and result calculated as Kg/hl.

Methods for analysis nutritional composition maize of varieties

Chemical characteristics for protein, moisture, starch and oil content were determined from the 300 g grain sample of each maize variety using Near Infrared (NIR) Spectroscopy technique by running the grain samples through FOSS Infratec 1241 as per method No. 39-11. The Infractec 1241 grain analyser is a Near Infrared Transmission (NIT) instruments which is capable of simultaneous and accurate determination of several constituents in wholegrain/flour samples. It is a standard method for cereals quality analysis. In this technique, the light from the light source strikes a diffraction grating in the monochromatic generateing monochromatic light. By turning the grating, a spectrum of monochromatic light ranging from 570 to 1100 nm at a wavelength was created.

Methods for color analysis of maize varieties

The grain colour was analysed by using Differential Scanning Calorimeter (DSC) -60 Plus Series. The sample size was about 100 g. but it depends on the cover parts of the instruments cup for readings to light penetration in correct ways. The colour of samples was measured by reflectance measurement using Hunter Lab, (Aeros, Dual-beam Non-Contact Reflectance Spectrophotometer (USA) as described by [9]. The reflectance of the whole visible spectrum (420 to 700 nm) was recorded at a wavelength interval of 10 nm. D65 lamp, used as a reference light source, and the detector was fixed at an angle of 101 concerning the light source. The equipment was calibrated before use with a standard white tile and a black box for 100 and 0% reflectance, respectively [10]. Colour parameters used were CIE L∗(lightness/whiteness), a∗(redness/greenness), b∗(Yellowness/blueness) uniform colour space. Wheat grain colour results reported in terms of 3-dimensional colour values based on the following rating scale:

L* value whiteness 100 white, 0 black

a* value positive values (red colour), negative values (green colour)

b* value positive values (yellow colour), negative values (blue colour)

Statistical Analysis

Data analyses were performed using SPSS version 20. One-way ANOVA was used to test for the presence of significant differences ($p<0.05$). Mean separation was used LSD.

Results and Discussion

The physico-chemical properties of Ethiopian Maize varieties grown at Kulumsa agricultural Research center of three maize varieties are shown in Table 1. The hectoliter weight of maize varieties was ranged from 78 to 80 kg/hl (BH661, Jibat) respectively. Thousand kernel weight of maize verities was ranged from 287.40 to 35 4.86g (BH661, Kalba102) respectively.

The results were reported by Mean ±Standard Deviation and significance level was at $p<0.05$. The moisture content was measured in order to know the amount of water present in each variety, it is important in terms of productivity. The moisture content of three maize varieties growing at different kulumsa agricultural research center is shown in Table 2. From those, the highest moisture content was obtained in Kalba102 (9.19%). The lowest level of moisture content was obtained in Jibat (8.85%), in general, the interval of moisture content was present from 8.85% - 9.19%. This is computable with the literature investigated by [11]. With some deviations and the deviation may come from agro-ecology or maize handling methods. In the other cause, ash is a part of the proximate composition and it is defined as the number of minerals. The level of ash content was a mixture of inorganic components that are located on food ingredients. Fat content of 3 maize varieties grown in Ethiopia was found in the range 4.70% - 5.08% have

Table 1: Physico-chemical characteristics and yield of maize varieties.

	Quality parameters					
Genotypes	**HLW(kg/hl)**	**TKW(g)**	**Yield(T/h)**	**Grain color L***	**Grain color a***	**Grain color b***
Kalba102	79.36 ± 0.50^{ab}	354.86 ± 4.38^{a}	8.21 ± 0.80^{a}	95. 61 ± 0.70^{a}	-0.96 ± 0.05^{b}	4.75 ± 0.10^{b}
BH661	78.36 ±1.20^{b}	279.60 ± 8.52^{b}	7.91 ± 1.34^{a}	71.59 ± 0.5^{b}	2.95 ± 0.05^{a}	24.86 ± 0.90^{a}
Jibat	80.80 ± 0.60^{a}	287.40 ± 6.29^{b}	5.37 ± 0.98^{b}	70. 13 ± 0.35^{c}	3.0 ± 0.3^{a}	24.76 ± 0.10^{a}
*The results were reported by Mean ±Standard deviation and significance level was at p <0.05.						

Table 2: Nutritional composition of maize varieties.

Genotypes	**Parameters**			
	Moisture(%)	**Protein (%)**	**Fat (%)**	**Starch(%)**
Kalba102	9.19 ± 0.40^{a}	9.87 ± 0.10 ^{a}	5.08 ± 0.40^{a}	67.91 ± 0.19^{b}
BH661	9.10 ± 0.20^{a}	9.05 ± 0.50^{c}	4.84 ± 0.10^{b}	69.76 ± 0.13^{a}
Jibat	8.85 ± 0.80^{b}	9.33 ±0.13^{b}	4.70 ± 0.80^{c}	69.97 ± .22^{a}
The results were reported by Mean ±Standard Deviation and significance level was at p <0.05.				

reported. The fat content of Ethiopian maize varieties was ranged from 4.01% up to 5.99% with the average value of 4.90% were investigated which is comparable with the present study. Fat is the third nutritional component after carbohydrate and proteins in maize. In general, the present research was comparable with the previous literature. Protein is the second dominant proximate composition after carbohydrate in maize. As shown in table 1, protein contents of 3 maize varieties were found in the range of 9.05 to 9.87% with the average value of 9.41. Kalba (9.87) is highest the protein content and BH661 (9.05) has the lowest level of protein content were reported nearly similar to the present study. Starch is the first dominant chemical composition of maize; it was found in the range of 67.91 - 69.97% with the average of 69.88% which is similar to previous study.

Conclusion

This study gives information on the nutritional composition and some quality traits of 3 Ethiopian maize varieties grown under highlands agro-ecologies. Chemical composition, moisture, fat, protein, and starch of the 3 Ethiopian maize varieties were found with the average value of 9.04%, %, 4.87%, 9.87% and 69.88% respectively. In the cause of proximate composition, each variety has a significant difference ($p < 0.05$). Therefore, these results will be useful to know about the nutritional properties of the Ethiopian maize varieties and may guide breeders in designing strategies that maximize the utility of maize germplasm at highland agro ecologies of Ethiopia. In addition, this study will be used for the selection of maize varieties in the cause of nutritional value. The data reveal difference in nutritional composition of seven maize varieties that may be due to genetics factors.

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