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Assessment of Proximate Chemical Compositions and Tryptophan Content of Released and Improved Ethiopian Maize Varieties

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Maize is an important crop with great use in agriculture, food and other industries. The aim of this study was to evaluate the proximate chemical compositions and tryptophan content of 37 Ethiopian maize varieties. The proximate chemical compositions (ash, moisture, fat, protein, crude fiber and total carbohydrates) of 37 maize varieties was obtained in the range of 0.90% – 1.53%, 8.52% – 12.86%, 4.01% – 5.99%, 7.48% – 11.60%, 1.39% – 2.05%, 67.64% – 74.88% respectively. In general, maize is rich in the chemical composition of carbohydrate and proteins. There was a significant difference in most maize varieties (p < 0.05) in the proximate composition of the 37 maize varieties. The tryptophan profiles of the maize varieties have a significant difference in most maize varieties (p < 0.05). Tryptophan content of maize varieties was found in the range of 0.04 – 0.11%. BHQPY545, BHQPY548, MHQ 138, Melkasa-6 varieties have the criteria of quality protein maize according to the tryptophan contents. Therefore, the chemical composition and tryptophan traits, which could be utilized for various food preparations and selection for breeding purpose. It also shows the utilization of maize and suggests the future strategy for the nutritionist, health advisors and dieticians as to how to make best use of the maize germplasm.

Key Words: Maize variety, Proximate compositions, Tryptophan, Carbohydrate, Proteins

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INTRODUCTION

Cereals are important sources of proteins in human nutrition (Shewry, 2007). Maize (*Zea mays L)* is a type of cereal with great use in agriculture, food, and other industries and it has a significant role throughout the world (Špalekov and Gálová, 2018; Nwalo, 2010). Its origin is not clear, but most of the experts are agreeing in Mesoamerica before 5000 BC (Nuss and Tanumihardjo, 2010). Maize is an important commodity and it is belonging to the genus Zea, family Poaceae, and tribe Maydeae (Qamar et al., 2017). It is widely grown across the world at different seasons, ecologies. Maize is not indigenous to Ethiopia; however, it is grown in various agro-ecological zones and grows altitudes ranging from 500 to 2400 m above sea level (Mengistu and Shimelis, 2012). Globally it is ranked after wheat, and rice in production and it is a diverse crop species (Zhao et al, 2006; Demeke, 2018); however, in Ethiopia maize production is the second dominant crop next to tef

(*Eragristis teff*) from cereals (Demeke, 2018). It is widely used in the production of animal feed, organic fertilizers, different household utensils, adhesives, textile manufacturing, cosmetics, alcoholic beverages, fuel alcohol, syrups, sweeteners, jams, jellies, compostable plastics, packaging films and pharmaceuticals and as a component of many food products (Mengistu and Shimelis, 2012). Maize (*Zea mays*) is the cheapest cereal, which affords a good quality protein (Rai et al., 2012).

Maize is used as a basic food ingredient for humans, either in its original or modified form. It is prepared in the form of tortillas, porridge, and popcorn (Saeed et al., 2013; Abiose and Ikujenlola, 2014). It is a good source of carbohydrate, ash, protein, fiber, oil, vitamins, and minerals (Saeed et al., 2013). 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 (Suryadi et al., 2017). Until now, 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. Hence, the aim of this study was to evaluate the proximate composition and tryptophan value of 37 Ethiopian maize variety over the existing local varieties to select the best variety have a good national value and compared with the worldwide maize respect to proximate composition and tryptophan value.

MATERIALS AND METHODS

Sample collection

37 maize samples were collected from Melkassa agricultural research center, Jimma agricultural research center, Bako agricultural research center, Ambo agricultural research center, and Menagesha Poiner Hybrid. 1.0 kg of maize sample was collected from the agricultural research center, from each sampling site and stored in paper bags under room temperature conditions. It was ground in an electronic grinder (foss cyclotec 1093, USA) with a mesh size of 0.5 mm for chemical and nutritional analysis.

Determination of Proximate Composition of Maize

Determination of Ash Content

For the determination of ash, organic matters in the sample were burnt away except inorganic residue. Crucible was heated at 500°C for 1 hour, cooled in a desiccator, and weighed. 3.0 g of the ground sample was weighed and introduced into the crucible. Sample containing crucible was ashed by the method of AOAC (2005) 923.03 using muffle-furnace at 550^{O}C for 3 h. It was cooled in a desiccator at room temperature and weighed it.

$$\%\ \text{Ash content} = \frac{\text{Weight of ash}}{\text{Weight of the orginal maize}} * 100$$

Determination of Moisture Content

Moisture content of maize varieties was determined by the AOAC (2005) 925.10 method under an oven. 2 g of ground maize sample was taken into a crucible and it was dried in an oven at 130^{o}C for one hour. Later it was cooled in a desiccator at room temperature and weighed it.

$$\text{Moisture content} = \frac{\text{Weight loss of maize}}{\text{Weight of the orginal maize}} * 100$$

Determination of Fat Content

Fat content was determined by the AOAC (2005) 945.16 method. Five grams of the ground sample was weighed into the Soxhlet extraction thimble and cotton was used as a plug to avoid loss of the sample. The thimble was transferred into the Soxhlet extractor and sufficient petroleum ether was added. The reflux condenser was heated gently for six hours. Rota evaporator separated the extracted and the residual solvent was dried in an oven. Later it was cooled in desiccators and weighed it.

$$\text{Fat}\ (\%) = \frac{\text{Extracted fat}}{\text{Sample weight}} * 100$$

Determination of Crude Fiber Content

Crude fiber was determined by AOAC (2005) 945.16 method [16] with some modification. 2.0 g of the sample was weighed into a beaker and 180 mL preheated, 0.128 M H_2SO_4 was added and boiled for 30 min using a water pressure filter system. The moisture was filtered and the residue washed 3 times with hot water. The residue was collected and 150 mL preheated 0.22 M KOH was added and boiled for another 30 min, the mixture was filtered and the residue washed on the water pressure system 3 times with acetone. The residue was collected in a crucible, dried at 130°C for 1 h and weighed. It was ashed in a muffled furnace for 3 h at 500°C and later weighed after cooling. This was calculated according to the Saeed et al (2013) reported.

$$\text{Crude fiber (\%)} = \frac{\text{Weight loss on ignitation}}{\text{Sample weight}} * 100$$

Determination of Protein Content

Protein content of maize samples were determined by Kjeldahl technique FOSS Analytical AB 2003). 0.5 g ground sample was weighed into Kjeldahl digestion tube and 2 Kjeltabs CT 3.5 (or 7 g K_2SO_4 + 0.210 g $CuSO_4$ x $5H_2O$ + 0.210 g TiO_2) was added and followed by 15 mL concentrated H_2SO_4. It was heated cautiously under the fume hood for 60 min and it was cooled for 15 min. Protein value was determined automatically by the Kjeldahl technique. On this method, distillation and titration were performed automatically.

Determination of Carbohydrate Content

The amount of carbohydrate content of maize samples was determined by difference(Qamar et al., 2017; Ciabotti et al., 2016), which would be done by subtracting the sum percentage of moisture content, percent of ash, crude protein, crude fat, and crude fiber from 100.

$$\%\text{CHO} = 100 - [\%\,Moisture + \%\,Fat + \%\,Protein + \%\,Ash + \%\,Dietary\ fiber]$$

Where: % CHO = percentage of carbohydrate

Determination of the Tryptophan Content

Tryptophan was determined from the defatted maize flour using n-hexane solvent. Its content was determined using the colorimetric method according to Nurit et al (2009) with some modification. The color was developed in the reaction of 1 mL hydrolysate (this was obtained by digestion of defatted maize sample with papain solution at 65 °C for 16 hours) with 3 mL of reagent containing Fe^{3+} ($FeCl_3$. $6H_2O$), glacial acetic acid, H_2SO_4. This was incubated at 66 ° C for 15 min and after incubation; the absorbance was read at 560 nm using Cary-60 UV-VIS Agilent spectrophotometer. Finally, the tryptophan content was calculated using a standard calibration curve. The calibration was developed with known amounts of tryptophan, ranging from 0 to 30 µg/mL.

$$\text{Trptophan (\%)} = \frac{\text{Absorbance} * \text{hydrolysis volume}}{\text{Slope} * \text{weight of sample}} * 100$$

Statistical Analysis

Data analyses were performed using SPSS version 20. One-way ANOVA was used to test for the presence of significant differences ($p < 0.05$) of proximate composition and tryptophan content among each 37 Ethiopian maize varieties. Mean, standard deviations, and the range of chemical composition of all varieties was analyzed using SPSS version 20 software.

RESULT AND DISCUSSION

Proximate composition of Ethiopian Maize varieties

Proximate compositions of 37 maize varieties are shown in Table 1. 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 37 maize varieties growing at different Ethiopian ecological regions is shown in Table 1. From those, the highest moisture content was obtained in BH661 (12.86%). The lowest level of moisture content was obtained in Jabi (8.52%), in general, the interval of moisture content was present from 8.52% - 12.86% and its average value were 10.8. This is computable with the literature investigated by Ullah et al (2010). 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. Ash content of 37 maize varieties grown in Ethiopia was found in the range 0.90% - 1.53%. Ullah et al (2010) and Suryadi et al (2017) have reported ash content of different maize varieties were found in the range of 0.7% - 1.3% and 0.82% - 1.47% respectively, which is computable with the present study.

Fat is the third nutritional component after carbohydrate and proteins in maize (Nuss and Tanumihardjo, 2010). The fat content of Ethiopian maize varieties was ranged from 4.01% up to 5.99% with the average value of 4.90%. Suryadi et al (2017), Ijabadeniyi and Adebolu (2005) were investigated, which fat content was found in the range of 2.48% up to 4.80%, and 4.77 - 5.00 respectively. In general, the present research was computable with the literature. Protein is the second dominant proximate composition after carbohydrate in maize (Ullah et al., 2010). As shown in table 1, protein contents of 37 maize varieties were found in the range of 7.48 - 11.60 with the average value of 10.27. MHQ138 (11.60) is highest the protein content and Gibe-3 (7.48) has the lowest level of protein content. Ullah et al (2010) were reported nearly similar to the present study. Carbohydrates are the first dominant chemical composition of maize, it was found in the range of 67.64 - 74.88 with the average of 71.23 and crude fiber is the fourth dominant nutritional composition

Table 1: Proximate chemical composition and tryptophan content of 37 Ethiopian maize varieties.

Variety Name	Ash	Moisture	Fat	Protein	Crude fiber	Carbohydrate
GIBE 1	1.03 ± 0.06	11.5 ± 0.6	5.33 ± 0.51	9.97 ± 0.72	1.54 ± 0.12	70.6
BH546	1.21 ± 0.10	12.4 ± 1.0	5.33 ± 0.35	10 ± 0.46	1.68 ± 0.08	69.4
GIBE 2	1.14 ± 0.05	12.3 ± 1.0	4.49 ± 0.46	10.3 ± 0.85	1.72 ± 0.16	70.0
Gambella com	1.03 ± 0.02	11.7± 0.7	5.99 ± 0.32	10.6 ± 0.66	2.02 ± 0.10	68.7
BH540	1.11 ± 0.08	12.0 ± 0.7	5.33±0.42	10.3 ± 0.75	1.64 ± 0.01	69.6
SBRH	1.11± 0.04	9.91 ± 0.8	5.18 ± 0.28	10.8 ± 0.84	1.55 ± 0.14	71.4
BH660	1.02± 0.09	11.8 ± 0.9	4.01 ± 0.42	11.5 ± 0.82	1.56 ± 0.05	70.2
GUTO	1.21± 0.07	10.2 ± 0.8	4.73 ± 0.49	10.2 ± 0.93	1.72 ± 0.12	71.9
BH547	1.20± 0.08	11.6 ± 0.98	5.33 ± 0.35	10.6 ± 0.72	1.89 ± 0.11	69.5
BHQPY545	1.23 ± 0.04	12.2 ± 0.82	5.33 ± 0.36	11.5 ± 0.46	2.05 ± 0.18	67.6
BHQPY548	1.53 ± 0.07	10.2 ± 0.53	5.19 ± 0.29	9.72 ± 0.85	1.76 ± 0.01	71.6
SPRH	1.25 ± 0.08	10.5 ± 0.45	4.85 ± 0.23	9.7 ± 0.66	1.81 ± 0.09	71.9
KULANI	1.07 ± 0.09	11.8 ± 0.73	5.33 ± 0.45	10 ± 0.75	1.95 ± 0.08	69.8
ABO BAKO	1.02 ± 0.03	11.2 ± 0.55	5.33 ± 0.52	9.86 ± 0.84	1.59 ± 0.06	71.0
Gibe-3	1.21 ± 0.05	9.45 ± 0.79	5.3 ± 0.39	7.48 ± 0.82	1.68 ± 0.13	74.9
GIBE AWASH	1.13 ± 0.10	10.5 ± 0.72	5.33 ± 0.38	10.4 ± 0.93	1.88 ± 0.16	70.8
BH661	0.93 ± 0.08	12.9 ± 0.65	5.33 ± 0.42	10.4 ± 0.62	1.54 ± 0.11	68.9
BH543	1.02 ± 0.06	11.3 ± 1.1	5.33 ± 0.51	9.66 ± 0.70	1.47 ± 0.06	71.2
Hora	1.02 ± 0.07	11.63 ± 0.98	4.75 ± 0.34	10.8 ± 0.46	1.39 ± 0.05	70.4
AMH850(WENCHI)	1.16 ± 0.09	11.86 ± 1.2	4.24 ± 0.43	11 ± 0.52	1.43 ± 0.07	70.3
AMH853	1.20 ± 0.10	10.3 ± 0.74	4.75 ± 0.50	10.8 ± 0.33	1.41 ± 0.06	71.5
JIBAT	1.31 ± 0.12	11.7 ± 0.97	4.36 ± 0.41	10.8 ± 0.39	1.57 ± 0.09	70.3
MHQ 138	0.90 ± 0.05	10.7 ± 0.85	4.65 ± 0.32	11.6 ± 0.70	1.42 ± 0.08	70.7
MELKASA-3	1.20 ± 0.08	9.81 ± 0.57	4.54 ± 0.38	10.8 ± 0.84	1.80 ± 0.15	71.9
MELKASA-1Q	1.08 ± 0.02	9.12 ± 0.49	4.76 ± 0.48	10.7 ± 0.65	1.39 ± 0.10	72.9
MELKASA-1	1.19 ± 0.09	10.9 ± 0.71	4.41 ± 0.35	11.2 ± 0.82	1.87 ± 0.09	70.4
MELKASA-4	1.09 ± 0.05	10.1 ± 0.67	4.36 ± 0.40	10.8 ± 0.46	1.54 ± 0.12	72.1
MELKASA-7	1.18 ± 0.07	9.41 ± 0.59	4.2 ± 0.31	10.6 ± 0.35	1.68 ± 0.08	72.9
MH-130	1.04 ± 0.04	9.92 ± 0.82	4.48 ± 0.27	10.1 ± 0.65	1.72 ± 0.16	72.7
MELKASA-6	1.25 ± 0.09	9.43 ± 0.75	4.81 ± 0.41	10.5 ± 0.56	2.02 ± 0.10	72.0
MELKASA-5	1.05 ± 0.03	11.5 ± 0.94	4.22 ± 0.28	10.6 ± 0.74	1.64 ± 0.01	70.9
MELKASA-2	1.11 ± 0.06	9.79 ± 0.63	4.53 ± 0.32	10.6 ± 0.71	1.55 ± 0.14	72.4
AMHB760Q	1.23 ± 0.08	12.5 ± 1.3	4.77 ± 0.39	9.45 ± 0.49	1.56 ± 0.05	70.5
Morka	1.07 ± 0.05	8.98 ± 0.52	5.36 ± 0.47	9.56 ± 0.55	1.72 ± 0.12	73.31
SHONE(PHB30G19)	1.15 ± 0.09	9.82 ± 0.68	4.8 ± 0.29	9.43 ± 0.52	1.89 ± 0.11	72.9
Limmu(3812w)	1.01 ± 0.03	9.58 ± 0.71	5.13 ± 0.46	7.95 ± 0.32	2.05 ± 0.18	74.3
Jabi	1.23 ± 0.06	8.52 ± 0.62	5.11 ± 0.37	9.64 ± 0.56	1.76 ± 0.01	73.7
Minimum	0.90	8.52	4.01	7.48	1.39	67.64
Maximum	1.53	12.86	5.99	11.60	2.05	74.88
Average	1.13	10.78	4.90	10.27	**1.69**	71.23

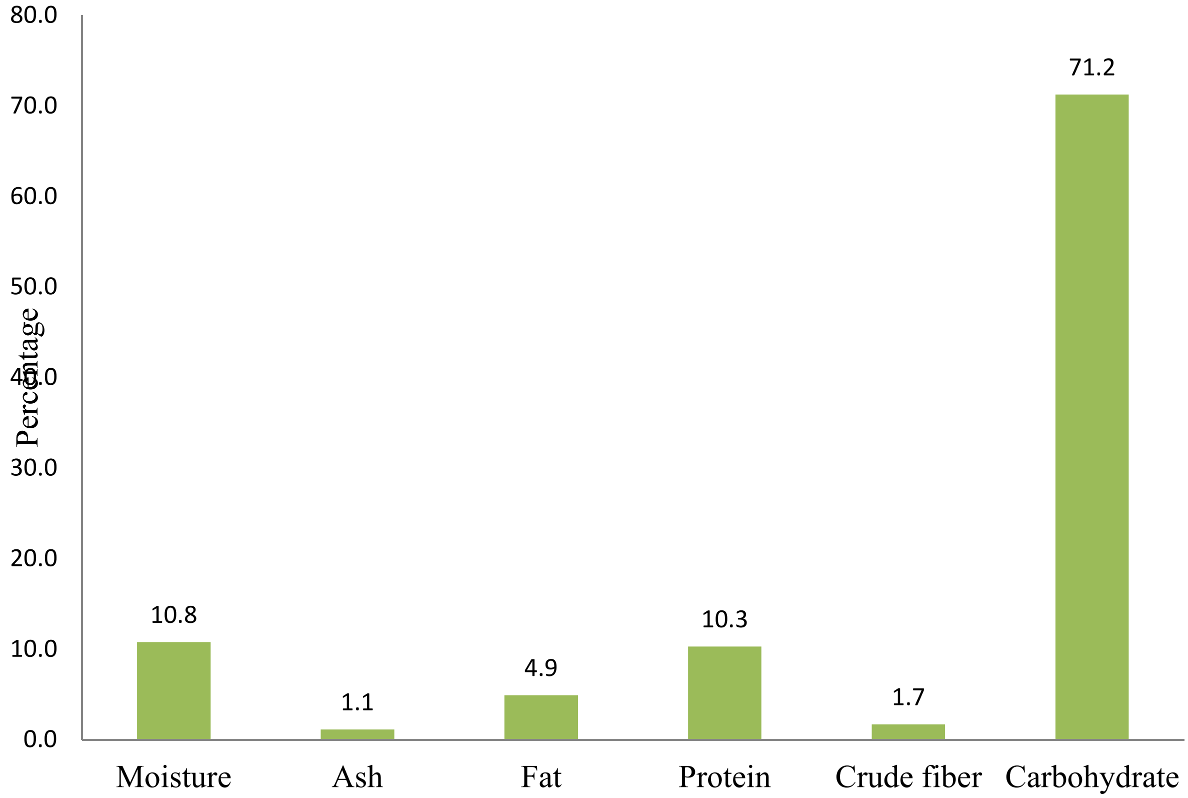

Figure 1:- The mean proximate composition value of 37 Ethiopian maize varieties

present in maize, it was found in the range of 1.39 - 2.05 with the average value of 1.69. Proximate chemical compositions of 37 Ethiopian varieties have not significance difference (P > 0.05) among each variety.

In general, the dominant chemical compositions of maize crops are carbohydrate, moisture, crude protein, crude fat, and crude fiber (Ullah et al., 2010). In this research carbohydrate is the highest chemical composition of Ethiopian maize, it followed by moisture, crude protein, and crude fat and crude fiber respectively as shown in Figure 1.

Tryptophan

Tryptophan standard in deionized water was prepared with a series dilution of 0, 10, 15, 20, 25, 30 µg/mL and it was analyzed using Cary-60 UV-VIS Agilent spectrophotometer. This was used to calculate the tryptophan content from the calibration curve of the absorbance of the standard versus concentration of the standard (Figure 2). The regression coefficient value was R^2 = 0.993, it indicated a good regression value and obtained respectable precision.

Maize is a major cereal crop for human nutrition. Its proteins have essential amino acids such as lysine, and tryptophan (Bantte and Prasanna, 2004). In the human nutrition viewpoint, lysine is the first most important limiting amino acid in the maize protein and followed by tryptophan. Tryptophan contents of 37 Ethiopian maize varieties samples were determined by Cary-60 UV-Vis spectrophotometry and its content was shown in Table 1. The tryptophan content in all maize varieties was observed in the range of 04% − 0.11% with the average value of 0.05%. The highest tryptophan content was obtained in BHQPY548 variety with the value of 0.11%, while the lowest tryptophan contents were obtained in more than 5 varieties with the value of 0.04%. Tryptophan content of 37 Ethiopian maize varieties had a significant difference (p < 0.05) among each variety. Tryptophan contents of quality protein maize samples are >0.07% as Nurit et al, (2009) reported. In this research, BHQPY545, BHQPY548, MHQ 138, MELKASA-6 varieties were indicated as quality protein maize according to their tryptophan content.

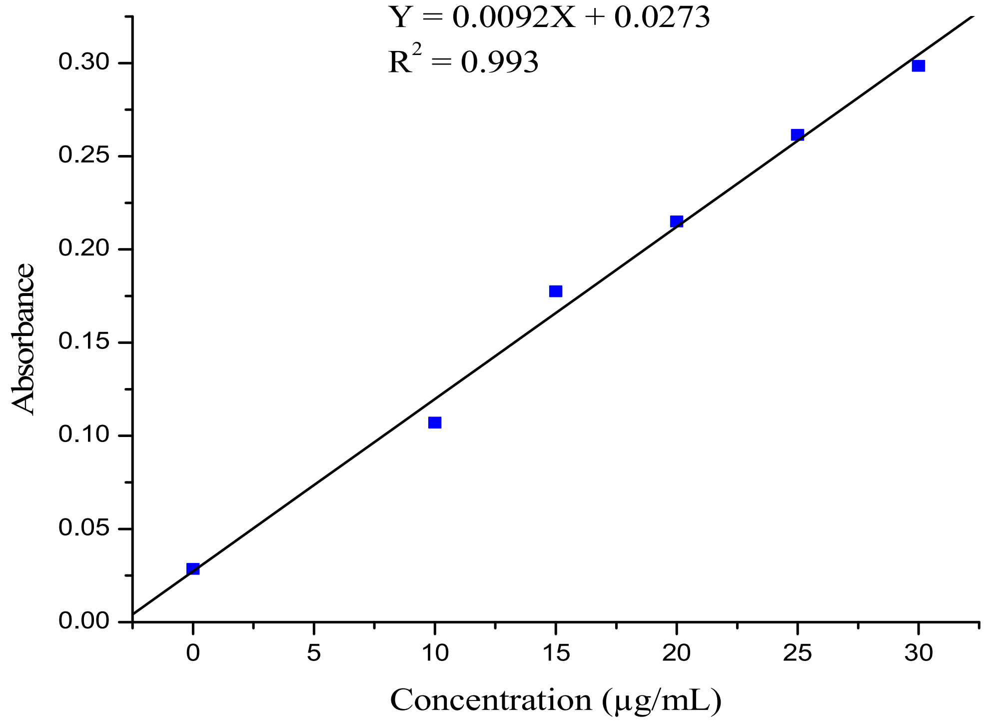

Figure 2: Calibration curve of tryptophan standard

CONCLUSION

This study has an information on the proximate chemical composition and tryptophan content of 37 Ethiopian maize varieties. Chemical composition ash, moisture, fat, protein, crude fiber, and carbohydrates of the 37 Ethiopian maize varieties were found with the average value of 1.13%, 10.78%, 4.90%, 10.27%, 1.69%, and 71.23% respectively. In the cause of proximate composition, each variety has not a significant difference. However, in terms of tryptophan, they have a significant difference ($p < 0.05$). Some varieties like BHQPY545, BHQPY548, MHQ 138, and Melkasa-6 varieties have been showed the criteria of quality protein maize according to the tryptophan contents. 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. In addition, this study will be used for the selection of varieties in the cause of nutritional value.

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