Biochemistry and Molecular Biology
2022; 7(1): 13-17
http://www.sciencepublishinggroup.com/j/bmb
doi: 10.11648/j.bmb.20220701.13
ISSN: 2575-5064 (Print); ISSN: 2575-5048 (Online)

Nutrient Content of Traditional Foods Prepared from Yellow Maize (*Zea mays* L.) Varieties in Ethiopia

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To cite this article:
Nibret Mekonen, Henok Nahusenay, Kidist Hailu. Nutrient Content of Traditional Foods Prepared from Yellow Maize (*Zea mays* L.) Varieties in Ethiopia. *Biochemistry and Molecular Biology.* Vol. 7, No. 1, 2022, pp. 13-17. doi: 10.11648/j.bmb.20220701.13

Received: February 18, 2022; **Accepted**: March 15, 2022; **Published**: March 23, 2022

Abstract: Maize (*Zea mays* L.) is one of the most important cereal grains for both human food and livestock feed. Ethiopia is among the major maize producers in Africa and ranked fourth next to South Africa, Nigeria and Egypt. Maize production takes significant share of cereals and grain in any production year. The aim of this study was to evaluate the nutrient availability of traditional foods prepared from maize varieties (BHQPY545, BH661, Melkasa-1Q and Melkasa-7). HPLC and AAS methods were used to determine beta-carotene and menial contents, respectively. AOAC methods were used to analyze the proximate composition. The results showed that there was a significant difference ($p<0.05$) in most proximate compositions of the 4 maize varieties. Total carbohydrate between maize varieties ranged from 72.39 to 74.08%, crude fiber (2.19 to 2.23%), crude protein (6.61 to 10.52%), crude fat (3.72 to 5.19%), ash (1.07 to 1.34%), and moisture (9.91 to 12.04%). The products of maize varieties (stiff porridge and flat bread) did not have any significant effect on the crude fiber, crude protein, and ash. Beta-carotene content in BHQMY545 maize was found to be 2.33±0.12, 2.72 ± 0.06 and 2.46±0.51µg/g for raw, stiff porridge and unleavened flat bread, respectively. In four maize types, there was a significant difference ($p<0.05$) in crude fat, calcium, potassium. In general, there is no need to select processing methods because the nutritional makeup of maize types retains better after processing.

Keywords: β Carotene, Maize, Minerals, Proximate Composition, Traditional Food Processing

1. Introduction

Maize (*Zea mays* L.) is a major cereal grain used for human consumption and livestock feed. Ethiopia is fourth among Africa's top maize producers, behind South Africa, Nigeria, and Egypt. In any given year, maize production accounts for a large portion of cereal and grain production. Maize came in second to tef in terms of area coverage (21.7% for maize vs. 27.4% for tef), total output (28.5% for maize vs. 19.9% for tef), and productivity [11]. Oromia, Amhara, and SNNP, three regional states, account for 94% of total yearly production [12]. According to Ethiopian Commodity Exchange reports, three-quarters of the maize produced is used for household consumption; only about ten percent is marketed, and the remainder is used for seed, in-kind payments for labor, and animal feed [9]. Maize is a staple food in Ethiopia's major maize-producing regions. Ethiopians consume roughly 60 kg of maize per year per capita [11]. In impoverished nations, plant-based foods are a major source of pro-vitamin A [2]. Yellow maize is a source of carotenoids in addition to being a nutritional supply of energy, lipids, protein, minerals, and vitamins. Carotenoids are a broad set of yellow-orange pigments that are divided into two categories: carotenes (e.g., β-carotene, α-carotene) and xanthophylls (e.g., β-cryptoxanthin, lutein, zeaxanthin). In humans, β-carotene, α-carotene, and β-cryptoxanthin are significant vitamin A precursors [17]. Carotenoids are also key physiological modulators and antioxidants [14]. Maize's carotenoides concentration in decreasing order is lutein, zeaxanthin, β-carotene, β-cryproxanthin and α-carotene. Beta-carotene contains two pro-vitamin A structures (two hydroxylated β ionone rings) and β-cryptoxanthin and α-carotene one each (single non-hydroxylated β ionone ring) [1].

Pro-vitamin A levels in yellow maize varieties range from 0.25 to 2.5 µg/g dry weight (DW), while pro-vitamin A levels in deep yellow or orange types can reach 15 µg/g (DW) [17, 15]. White maize variants, on the other hand, are widely consumed in Africa [10], and are devoid of pro-vitamin A carotenoids. This could help to explain why VAD is such a serious public health issue in Sub-Saharan Africa. Vitamin A insufficiency is reduced in vulnerable people when yellow maize is consumed [8]. As a result, eating of such types has aided in the prevention and control of VAD, especially in countries like Ethiopia where the condition is a public health concern. Furthermore, it lowers the risk of ailments including heart disease and cancer. Yellow maize types, on the other hand, are scarce on the market. Pre-treatments, such as heat processing, are required for maize consumption, which may provide some nutritional benefits while also altering the physicochemical contents and qualities of its constituents [13]. Because the carotenoid molecules are sheltered within the tissues, they are less prone to deterioration throughout the crop. Processing that disrupts the plant matrix, including the cellular compartments and binding proteins that preserve and stabilize the carotenoid pigment, can result in the loss of carotenoids [7]. The loss of provitamin a carotenoids and other nutrients during the traditional cooking of various maize dishes must be quantified. As a result, the purpose of this study is to determine the nutritional composition of yellow maize varieties, as well as the change in nutrient levels during the preparation of some traditional foods made from yellow maize varieties, as well as their consumer acceptance in comparison to a white maize variety.

2. Material and Methods

2.1. Sample Collection and Preparation

BHQPY 545 (yellow maize) and BH 661 (white maize) maize seed samples were collected from Bako Agricultural Research Center. Melkasa Agricultural Research Center was also used to obtain two yellow maize cultivars, Melkasa -1Q and Melkasa-7. The approach outlined by [3, 5] was used for sampling.

The stiff porridge and unleavened flat bread (kitta) were prepared as follows.

2.1.1. Stiff Porridge

Maize grain was cleaned and ground into fine flour, then 250g flour was mixed with 800mL boiling water and cooked at 100°C for 20 minutes until it had the correct consistency and flavor.

2.1.2. Kitta (Unleavened Flat Bread)

It's a product that hasn't been fermented. The maize grain had been cleaned, and then ground into a fine flour A mixture of 125 g maize flour and 300 mL water was baked.

2.2. Proximate Analysis

The proximate analysis of both fresh (raw) and processed maize variety samples were determined in triplicate according to the procedure described by AOAC 2005.

2.2.1. Determination of Moisture Content

The AOAC (2005) 925.10 method was used to determine the moisture content of maize varieties, which was done in a 202-1B drying oven at 105°C for 1 hour. 2 g of pulverized maize sample was placed in a crucible and dried for one hour at 130°C, then chilled in a desiccator at room temperature before being weighed.

$$\% \text{ Moisture content} = \frac{\text{weight loss of maize}}{\text{weight of the orginal maize}} \times 100$$

2.2.2. Determination of Ash Content

Ash content was determined by the method of AOAC (2005) 923.03 using box-type resistance (SX2-4-1 OGJ) muffle furnace at 550°C for overnight.

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

2.2.3. Determination of Fat Content

The AOAC 920.39 method was used to determine fat content using the soxtec^{TM} 8000 extraction equipment. To prevent sample loss, three grams of ground sample were weighed into the Soxtec extraction thimble and cotton was employed as a stopper. The aluminum cups with thimbles were transferred into the soxtec extraction unit and 50 mL of petroleum ether was added. Water temperature, water flow rate, flow rate in the fume hood were adjusting properly. The extraction time of the soxtec was adjusting 15 min, 30 min and 10 min for boiling, rising and recovery time, respectively. The extracted and residual solvent was dried in an oven and weighed after cooling in desiccators.

$$\% \text{ Crude fat content} = \frac{\text{Extracted fat of maize}}{\text{weight of maize sample}} \times 100$$

2.2.4. Determination Crude Protein

Kjeldahl technique FOSS Analytical AB 2003 was used to assess the crude protein content of maize variety samples. 2 Kjeltabs CT 3.5 (or 7 g K_2SO_4 + 0.210 g $CuSO_4$ x $5H_2O$ + 0.210 g TiO_2) were added to a 0.5 g powdered material in a Kjeldahl digestion tube, followed by 15 mL concentrated H_2SO_4. The mixture was carefully heated for 60 minutes inside the fume hood and then cooled for 15 minutes. After distillation, the crude protein value was calculated automatically using the Kjeldahl technique.

2.2.5. Determination of Crude Fiber

The crude fiber of maize varieties were determined using Fibertec^{TM} 8000 auto fibre analysis system and the percentage of crude fiber was calculated as follows.

$$\% \text{ Crude fiber} = \frac{W2-(W3+C)}{W1} \times 100$$

Where, W1 is weight of sample, W2 is weight of (crucible + residue), W3 is weight of (crucible + ash residue) and C is blank.

2.2.6. Determination of Carbohydrate Content

The difference, i.e. 100 percent - other proximate chemical compositions, was used to calculate carbohydrate content using the formula:

Percent of carbohydrate (%CHO) = 100- (% crude protein +% fat +%ash +% moisture content +% fiber).

2.3. Beta Carotene Analysis

2.3.1. Beta Carotene Standard Preparation

1000 mg/L stock standard solution of β-carotene was prepared by dissolving 100 mg β-carotene standard in 100 mL acetone. Using serial dilution law, a standard series of β-carotene (0.5 to 10 mg/L) was prepared from the stock solution.

2.3.2. HPLC Condition

Agilent 1220 infinite series HPLC was used for the analysis. The carotenoids were separated on an Agilent SB-C8 (4.6 X 150mm, 5µm) with a 0.5 mL/min flow rate. The mobile phases were acetonitrile, methanol, and chloroform (47:47:6), respectively. The wave length of UV visible was selected at 450 nm to measure the amount of β-carotene. The injection volume was 20 µL. The beta carotene content was calculated using the following formula.

$$\text{Concentration of Beta carotene}, \frac{\text{mg}}{\text{kg}} = \frac{(\text{C}-\text{B}) \times \text{V} \times \text{DF} \times \text{mcf}}{\text{m}}$$

Where:
C = Instrument reading of the sample (mg/L);
B= Instrument reading of the blank (mg/L);
V= extract volume (mL);
DF stands for dilution factor (if applicable);
Moisture correction factor (mcf) (to convert in to dry basis).

2.4. Retention

The apparent retention rate was used to calculate retention. The ratio of the nutrient content in the cooked meal to the nutritional content in the raw food, stated on a dry weight basis, is known as apparent retention [3].

$$\%\ \text{Apparent retention} = \frac{\text{Nutrient content per g of cooked food(dry basis)}}{\text{Nutrient content per g of raw food (dry basis)}} \times 100$$

2.5. Analysis of Mineral Content

The mineral contents (Fe, Zn, Ca and K) of each sample were determined by Atomic Absorption Spectrometry (AAS) after dry ashing of the samples. 0.5 g of each ash sample was digested with 5 mLof concentrated HNO_3 and 5 mL concentrated HCl acid solutions. The mixture was swirled gently and heated on hot plate until yellow fumes released and the solution became clear. After that cooling the solution and filter by Millipore filter (0.4µ) and leveled the volume to 50 mL by deionized water [4].

2.6. Statistical Analysis

The data was analyzed using the Statistical Package for Social Sciences (SPSS) version 20.0. The descriptive statistics mean and standard deviation (SD) were obtained from the analysis, and the data was expressed as mean ± SD. Duncan's new multiple range and two-way ANOVA were used to compare the means statistically. At a $p < 0.05$ level, the variations in means were declared significant.

3. Results and Discussion

The proximate composition of traditional foods prepared from maize varieties is shown in Table 1. The moisture content (how much water is in the product) was measured in each traditional food prepared from maize varieties. The maximum amounts of moisture content of 12.04 ±0.01% and 7.84 ±0.02% were found in BHQPY545 (raw) and Melkassa 7 (stiff porridge), respectively. The minimum amount of moisture content is 9.91±0.01% of Melkassa 1Q (raw) and 4.84± 0.01% of BH661 (flat bread), respectively. The results are computable with [16]. After total combustion of organic materials, ash refers to the remaining or remnant portions, primarily inorganic compounds. The weight loss caused by complete oxidation of the sample at a high temperature of 550°C±3°C is used to calculate the ash content. The interval of ash content for traditional food prepared from maize varieties was 1.01±0.02 to 1.43±0.07%. The range corresponded to the range reported by [6]. Fat is an extractable matter from extraction with a specific solvent like n-Hexane. Crude fat is a mixture of crude fat and soluble material in the sample that provides energy in the body. The value of crude fat in traditional foods prepared from maize varieties ranged from 2.59±0.02 to 5.02±0.03%. Proteins are made up of many building blocks known as amino acids, and their second-ranked proximate composition is next to carbohydrates [16]. The amount of crude protein in traditional foods prepared from maize varieties ranged from 6.37±0.02 to 10.99±0.03%. Fiber (roughage) is the part of plant-based foods such as grains, fruits, vegetables, nuts, and beans that the body cannot break down. The amount of crude fiber in traditional foods prepared from maize varieties ranged from 2.02 ± 0.01 to 2.2 ± 0.06%. There is no significant difference ($p > 0.05$) in crude fiber content among maize varieties. The proximate composition of traditional foods made from maize cultivars is generally consistent with [16]. Table 2 shows the results of β-carotene testing in maize cultivars. In all uncooked, stiff porridge, and unleavened flat bread, the value of β-carotene in BHQMY545 (yellow) maize was found to be higher than others. In the body, beta-carotene is converted to vitamin A (retinol), which is essential for a healthy immune system, good vision, and eye health. The value of β-carotene in BH661 (white) maize was not discovered in any raw, stiff porridge, or unleavened flat bread, indicating that these products do not contain enough β-carotene. Table 3 shows the mineral values (in mg/100g) for Fe, Zn, Ca, and K. In all maize types, potassium (K (mg/100g)) was found to be higher than the others, while zinc (Zn (mg/100g) was found to be the lowest.

Table 1. *Proximate composition of raw and food product from yellow and white maize varieties.*

Parameters	Melkassa 7			Melkassa 1Q		
	Raw	Stiff porridge	Flat bread	Raw	Stiff porridge	Flat bread
crude fiber	2.21±0.03^{baA}	2.20 ±0.06 ^{aA}	2.02±0.01^{aA}	2.19±0.01^{baA}	2.19±0.06^{aA}	2.17±0.02^{aA}
crude fat	3.72± 0.20^{bA}	3.63± 0.10 ^{aA}	3.71 ± 0.01^{aA}	4.46±0.01 ^{aC}	4.17± 0.20 ^{aC}	4.22± 0.23 ^{aC}
crude protein	10.31±0.01 ^{aC}	10.29±0.02 ^{aC}	10.29±0.09^{aC}	10.52 ±0.01^{aC}	10.41±0.01 ^{aC}	10.49±0.03 ^{aC}
Ash	1.29± 0.05^{aB}	1.34± 0.02 ^{aB}	1.34± 0.02 ^{aB}	1.31± 0.01 ^{aB}	1.28± 0.02 ^{aB}	1.31± 0.06^{aB}
Moisture	10.08±0.04^{bA}	7.84±0.02 ^{aA}	7.24±0.01^{aA}	9.91±0.01 ^{bA}	6.77±0.08 ^{aA}	6.58±0.02 ^{aA}
CHO	72.39 ±0.32^{aA}	74.7±0.40 ^{bA}	75.4 ±0.10^{bA}	71.61±0.33 ^{aA}	75.18 ±0.71^{bA}	75.23±0.10 ^{bA}
Energy	364.28 ±0.41^{aA}	372.63 ±0.72^{bA}	376.15 ±0.43^{bA}	376.15±0.08 ^{aB}	379.89 ±3.35^{bB}	379.89±0.28^{bB}

Table 1. *Continued.*

Parameters	BHQPY545			BH661		
	Raw	Stiff porridge	Flat bread	Raw	Stiff porridge	Flat bread
crude fiber	2.23±0.06^{baA}	2.02±0.01^{aA}	2.02±0.05^{aA}	2.19±0.05^{baA}	2.05±0.05^{aA}	2.05±0.02^{aA}
crude fat	5.19± 0.12 ^{aD}	5.02± 0.20 ^{aD}	5.02 ± 0.30^{aD}	4.03± 0.20 ^{aB}	3.79 ± 0.20^{aB}	3.88 ± 0.20^{aB}
crude protein	8.8±0.02 ^{aB}	8.47±0.03 ^{aB}	8.24±0.01 ^{aB}	6.61±0.03 ^{aA}	6.42±0.08 ^{aA}	6.37±0.02 ^{aA}
Ash	1.34± 0.04 ^{aB}	1.33± 0.07 ^{aB}	1.32± 0.03 ^{aB}	1.07± 0.20 ^{aA}	1.06± 0.20 ^{aA}	1.01± 0.20 ^{aA}
Moisture	12.04±0.01 ^{bA}	7.5±0.06 ^{aA}	6.93±0.07 ^{aA}	12.02±0.01 ^{bA}	7.59±0.02 ^{aA}	7.84±0.01 ^{aA}
CHO	70.4±0.18 ^{aA}	75.66±0.01 ^{bA}	76.47±0.14 ^{bA}	74.08±0.07 ^{aB}	79.09±0.25 ^{bB}	78.85 ±0.01^{bB}
Energy	363. 51±0.18 ^{aB}	381.7±0.96^{bB}	384.02±0.04 ^{bB}	359.03±0.19 ^{aA}	376.15±1.62$^{b A}$	375.8±0.12^{bA}

Mean within the same row followed by the same letter are not significantly difference by the Duncan's new multiple range (p> 0.05). The different lowercase letters for processing method comparison and different capitals letters for variety.

Table 2. *β-Carotene values of traditional food prepared from maize varieties.*

Maize Varieties	Color	β-Carotene µg/g (DW)		
		Raw	Stiff porridge	Unleavened flat bread
Mellkassa-1q	Yellow	1.64 ± 0.42^{aB}	1.54 ± 0.20^{aB}	1.57 ± 0.30^{bB}
Mellkassa-7	Yellow	1.61 ± 0.02^{aB}	1.44 ± 0.15^{aB}	1.24 ± 0.26^{bB}
BHQMY 545	Yellow	2.33 ± 0.12^{aC}	2.27 ± 0.06^{aC}	2.26 ± 0.51^{bC}
BH 661	White	0±00^{A}	0±00^{A}	0±00^{A}

Means within the same column followed by the same letter are not significantly different by the Duncan's new multiple range (p >.05). The different lowercase letters for processing method comparison and different capital letters for variety.

Table 3. *Same mineral contents in (mg/100g) of traditional food prepared from maize varieties.*

Parameters	Mellkassa-7			Mellkassa-1Q		
	Raw	Stiff porridge	Flat bread	Raw	Stiff porridge	Flat bread
Fe	3.65 ± 0.06^{aBA}	3.10 ± 0.08^{aBA}	3.03 ± 0.05a^{BA}	2.98 ± 0.03^{aA}	2.73 ± 0.15^{aA}	3.38 ± 0.20^{aA}
Zn	2.52 ± 0.49^{aA}	2.55 ± 0.23^{aA}	3.06 ± 0.42^{aA}	2.36 ± 0.41^{aA}	2.64 ± 0.21^{aA}	2.38 ± 0.05^{aA}
Ca	26.08± 0.30^{aB}	27.75 ± 0.01^{aB}	27.15 ± 0.24^{aB}	22.83 ± 0.52^{aA}	21.60 ± 0.08^{aA}	21.38 ± 0.10^{aA}
K	164.55±0.30^{aA}	206.79±0.40^{aA}	363.41 ±0.20^{aA}	363.12±0.35^{aC}	398.40±0.50^{aC}	369.12±0.10^{aaC}

Table 3. *Continued.*

Parameters	BHQPY545			BH661		
	Raw	Stiff porridge	Flat bread	Raw	Stiff porridge	Flat bread
Fe	3.25 ± 0.28^{aBA}	3.10 ± 0.06^{aBA}	3.28 ± 0.02 ^{aBA}	2.69 ± 0.40^{aA}	2.67 ± 0.46^{aA}	2.53 ± 0.37^{aA}
Zn	3.20 ± 0.29^{aBC}	3.15 ± 0.05^{aBC}	3.24 ± 0.10^{aBC}	2.76 ± 0.01^{aAB}	3.01 ± 0.07^{aAB}	2.84 ± 0.34^{aAB}
Ca	30.50 ± 0.17^{aC}	31.08 ± 0.14^{aC}	30.43 ± 0.21^{aC}	40.05 ± 0.32^{aD}	39.10 ± 0.25^{aD}	39.45 ± 0.41^{aD}
K	365.24±0.15^{aB}	305.54±0.06^{aB}	293.27±0.09^{aaB}	415.44±0.02^{aC}	369.25±0.04^{aC}	212.63±0.10^{aC}

Means within the same row followed by the same letter are not significantly different by the Duncan's new multiple range (p >.05). The different lowercase letters for processing method comparison and different capital letters for variety.

4. Conclusion

This study examines the nutritious content of traditional dishes (stiff porridge and flat bread) made from the maize types BHQPY 545, BH 661, Melkasa-1Q, and Melkasa-7. There were no significant (p > 0.05) changes in ash, moisture, crude fiber, or crude protein between yellow maize types (Melkasa-1Q and Melkasa-7), and no significant differences in moisture and crude fiber content between BHQPY 545 (yellow) and BH 661 (white) varieties. On the other hand, maize BHQMY 545 contains higher provitamin A and was not detected in the BH661 maize variety. There was a significant difference ($p<0.05$) in retention of β-carotene on stiffed porridge and unleavened flat bread made from different varieties, and more than 80% of β-carotene was retained during cooking. Therefore, consuming yellow maize varieties such as BHQPMY 545 will help to combat VAD and improve the health of rural communities.

Acknowledgements

The Ethiopian Institute of Agricultural Research's directorate of food science and nutrition research has provided financial assistance for this project. The author wishes to convey their heartfelt gratitude for their assistance and contribution to the completion of this article.

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