

Roasting's Effects on Proximate and Amino Acid Content of Maize

N. F. Ejoh^{1} and C.G. Onyeulo²*

¹*Department of Applied Biochemistry, Nnamdi Azikwie University, Nigeria*

²*Department of Human Nutritional Sciences, Faculty of Agricultural Sciences and Food Sciences, University of Manitoba, Canada*

Abstract. The main objective of this research is to compare the amino acid and proximate compositions of raw and roasted maize samples. Complete randomized experimental design with triplicates replications was applied. From the analysis, we were able to obtain the following values: total carbohydrates (78.28-79.85 percent), crude protein (7.32-7.05 percent), crude fat (2.70-2.20 percent), crude fiber (2.40-2.10 percent) and ash (2.10-2.50 percent) for both raw and roasted maize seeds. Prolonged exposure to the heat from roasting altered the amino acid content as obtained from the result. The concentration of amino acids in the seeds was reduced by the heat effect. The highest concentration of leucine was contained in seeds, with a value of 1.30 g/16 g N and 0.95 g/16 g N in the case of the raw and roasted seeds, respectively. Lysine and tryptophan concentrations were low, but they contain equal quantities of amino acids containing sulphur, which are methionine and cystine.

Keywords: amino acid, corn, evaluation, maize, proximate analysis

Received 24 July 2022 | Revised 31 January 2022 | Accepted 19 March 2022

1. Introduction

The United States and several other part of the globe refer to maize as corn. Maize belongs to the Poaceae or Graminae family, which are monocotyledonous flowering plants that include bamboo, thatch and cereal grass. According to [1], it is the third essential grain of cereal grown worldwide, after rice and wheat.

In most developing countries, maize is of socioeconomic importance where it serves as staple food, flour for the baking industry and as an adjunct grain for brewing companies. In processing livestock feed, maize is also used. [2] reported that maize is grown in African, Asian and Latin American countries. Smallholder farmers are the largest maize growers around the world and are mainly used for subsistence and part of a mixed agricultural system [3], [4].

*Corresponding author at: Department of Applied Biochemistry, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria

E-mail address: ejohnonso@gmail.com

Information obtained from FAO data indicates that the land size of maize cultivation in West Africa and Central Africa which was 3.2 million hectares in 1961 increased through the years and it was 8.9 million hectares in 2005, also the production increased from 2.4 million metric tons to 10.6 million metric tons. For a higher percentage of Nigerians and many others in West Africa, maize serves as a staple meal. It accounts for around 40% of agricultural land cultivated and approximately 43% of maize grown in West Africa [5]. Between 2004 and 2007, the amount of maize produced in Nigeria varied from 5,567,000 tonnes to 7,800 tonnes, [6]. Even at that point, Nigeria has yet to fulfill its domestic maize needs. The supply is still smaller than the national demand for the most essential staple in Nigeria [7], despite the fact that it also accounts for about 43 percent of the intake of food calories. [8]; [9]. The rate of consumption of maize per day [10] is 53.20g/capital/day. Maize comes second after sorghum in Nigeria, in order of importance when it comes to cereals [11].

Maize is used for a wide range of purposes in Nigeria, serving both as food and fuel for humans and also as feed for animals and a critical raw material for most food industries [12]. Maize grain's nutritional qualities are outstanding and can be further processed to finish items such as grits, starch, cornmeal, pasta, tortillas, snacks and flakes [13]. Maize flour is commonly used in the preparation of pleasant and healthy meals like bread, cakes, cookies, soup, pasta, in addition to being a source of dextrose. The corn bran is medically successful in decreasing excrement transit times [14]. It is also used to make dough balls and fish bait [15]. Dusting powder, thickening agents, anti-caking and mould release are other products where maize is used [16].

The word "Proximate composition" refers to a food material's main components or their parts. The proximate study, on the other hand, examines the natural components of the food product, which are measured by the quantity of ash, crude protein, crude fat, crude fibre, and nitrogen-free extracts. Little or no work has been done to compare the amino acid and proximate composition of the variety of raw and roasted maize grown in Nigeria, and this is what prompted this research. This research is therefore intended to examine the proximate composition and amino acid composition of the roasted and maize seed. The findings of the study would contribute to the increased use of maize as an outstanding source of good nutrients for people and animal feed. This investigation was carried out in order to assess the proximate and amino acid contents of raw and roasted maize purchased in Nigeria.

2. Materials and Methods

2.1. Collection of Samples

Maize Cultivar Used

There are four main types of maize cultivar: Yellow corn, pop corn sweet corn and white corn. Nearly all the maize crop grown in Nigeria is of the yellow and white varieties. The yellow variety was used for this experiment. Maize seeds (approximately 1.0 kilogram) were collected from Main Market, Onitsha, Anambra State, Nigeria.

Treatment of Samples

The samples were processed in the following way: after splitting the maize into two sections. The first was approximately 300 gram of maize was milled using a blender and processed in airtight containers until it was used for further study. This is labeled as the raw sample afterwards.

The second group was approximately 350g of the maize subjected to high heat and roasted. In a large aluminum frying pan, the procedure involves the use of fine alluvial sand that is then heated up until the enclosed sand reaches a temperature of 80°C. Raw maize was poured into the heated sand. In order to prevent the seed coat from burning, both the mixture of seeds and the sand were continuously stirred and even heat distribution within the seed was increased. The roasting with sand of the maize seed proceeded for 3-5 minutes. The sand was then sieved out of the seed, and the seeds were crushed in a hammer mill after cooling. This is then labeled as the sample being roasted.

2.2. Proximate Analysis

Proximate studies for crude fat, crude protein, crude fiber, moisture content, crude fat, and ash content were carried out using conventional procedures, [17]. The differentiation approach was used to compute total carbohydrates, [18].

Moisture Content Determination

The oven dry method was used to measure the moisture content. The procedure involves heating the sample to a temperature of 95-110°C for approximately 2 hours. Two grams of each sample were first weighed inside a dry crucible. It was labeled as (W_1). The crucible and its contents were placed in an oven and let to sit until a consistent weight was established. This was placed in a desiccator to cool and was weighed again and the new weight was labeled as (W_2).

The below formula was then used to get the moisture content (% M)

$$\% \text{ Moisture} = \left(\frac{W_1 - W_2}{\text{Sample Weight}} \right) \times 100 \quad (1)$$

Crude Protein Determination

In this circumstance, the micro-Kjeldahl technique for nitrogen analysis was applied, which was invented by Johann Kjeldahl, a brewer, in 1883.

Three Tenth gram of each sample was first put in test tubes. After that, each sample in the tube was administered a combination of digesting catalyst and concentrated Sulphuric acid (H_2SO_4). The sample was then placed inside a heater to allow the digestion process to continue until the combination turned a clear green hue, indicating that the mixture had thoroughly digested and that nitrogen had been released for titration. After the digest has cooled down, it was diluted with distilled water. It was then transferred to a distillation apparatus where 10ml of 40% Sodium Hydroxide (NaOH) was put inside both of the digested samples. Boric acid (H_3BO_3) was distilled in a conical flask below the condenser until the ammonium gas distillate was trapped by the boric acid. Hydrochloric acid (HCl) was used to titrate the distillates from both samples, and the results were recorded.

The below formula was used to estimate the Nitrogen percentage (% N) and crude protein percentage (% P).

$$\text{Nitrogen percentage (\% N)} = \frac{(\text{ml HCl} \times \text{N} \times 1.4)}{(\text{Sample Weight})} \quad (2)$$

where: N = HCl Normality; Crude protein percentage (% P) = % N x 6.25

Crude Fat Determination

The ether extract method was used to determine the crude fat [17]. The method was introduced by Soxhlet in 1879. Lipids can be extracted from foods using the ether extract method. Each sample's weighed content was placed in a previously weighed thimble, which was then placed within an extraction chamber. Following that, petroleum ether was added to the extraction apparatus to act as a solvent. Later, a weighted receiving beaker labeled (W1) was inserted into the extraction apparatus. When the heater is on, the solvent evaporates into the condenser area where it drips into the chamber where the sample is inserted and lipid extraction takes place. The beaker containing the thimbles with fat-free samples was removed from the apparatus after the extraction. It was then placed in an oven and heated for 24 hours at 100°C. This was then cooled in a desiccator, weighed and labeled (W₂).

The below formula was then used to estimate the percentage of the crude fat percent also known as ether extract (% E. E.):

$$\text{crude fat percent (\% C.F)} = \left(\frac{W_2 - W_1}{\text{Weight of Sample}} \right) \times 100 \quad (3)$$

Crude Fiber Determination

The method used in determining the crude fiber was developed in the 1850s. It involves treating moisture and fat-free samples using 1.25% sodium hydroxide (NaOH) and 1.25% sulphuric acid (H₂SO₄) to induce digestion and then measuring the organic food residue. The digested samples were dried in an oven.

Initially, a 1.5 gram sample was weighed and placed in a beaker. Each sample received 200 milliliters of 1.25 percent H₂SO₄ solution. The beaker was then placed in a fiber determiner and allowed to boil. A constant weight filter paper was used to filter 200 ml of distilled water (W₁). Using 200ml of 1.25 percent NaOH, the same method was followed. The sample was placed in a dry, cleaned and weighted crucible, which were then baked for 8 hours at 105°C. The sample was then placed in a desiccator to cool. The dry residue was measured (W₂) and put inside a muffle furnace after that. The crucibles containing ash residue was finally weighed (W₃). The following formula was used to compute crude fiber percentage.

$$\% \text{ Crude Fiber} = \left(\frac{W_2 - W_3 - W_1}{\text{Sample Weight}} \right) \times 100 \quad (4)$$

Calculation of Ash Content

A muffle furnace was used to determine the amount of ash in the sample [17]. One gram each of the samples was weighed in a crucible (W₁). It was then heated in a muffle furnace at 600°C for 24 hours. After that, the crucibles were removed, cooled in a desiccator, and weighed (W₂). The ash % content was calculated using the formula below.

$$\% \text{ Ash} = \left(\frac{W_1 - W_2}{\text{Weight of Sample}} \right) \times 100 \quad (5)$$

Calculation of Carbohydrate Content

The Carbohydrate content [18] or Nitrogen Free Extract [19] was calculated by combining moisture, crude protein, crude fat, ash, and crude fiber and subtracting the total from 100, as shown below:

$$\% \text{ Carbohydrate} = 100 - (\text{Moisture} + \text{Crude Protein} + \text{Crude Fat} + \text{Ash} + \text{Crude Fiber}) \quad (6)$$

2.3. Analyses of Amino Acids

The amino acids analysis was performed on both raw and roasted maize samples according to the technique given by [20]. The samples were first dried till a constant weight was attained and then it was defatted. The defatted sample was weighed before it was hydrolyzed for 22 hours in a sealed pyrex tube with 7ml of 6N HCl at 105°C. It was then cooled and filtered through a nonabsorbent cotton wool filter. The filtrate was then dried using a rotary evaporator at 40° C. The amino acids in the flask were then diluted with 5ml of acetate buffer (pH 2.0) before being put into the cartridge of a Technicon Sequential Multi sample amino acid analyzer (TSM). The steam carrying the amino acid reagent combination passed through a heating bath, where the colorful reaction product occurred. The absorbance was measured using a colorimeter and was proportionate to the content of each amino acid.

2.4. Data Analysis

The data collected were subjected to analysis of variance in a completely randomized design with triplicate replications and the result was expressed as means of three values. Microsoft Excel was used to conduct all of the analyses.

3. Results and Discussion

The proximate composition reveals that both raw and roasted seeds had somewhat larger moisture levels, with raw maize seed having the higher moisture content. (Table 1). The crude fiber composition of the raw maize seed was evidently higher than that of the roasted corn seeds. The ash composition of raw corn seeds was greater than that of the roasted maize seed (Table 1). The protein content of the two seeds differed, with the untreated maize seed having the larger value. The results also show that the two seeds had a significant quantity of carbs, indicating that they may be classified as carbohydrate rich seeds. (Table 1). The roasted maize seed has a greater carbohydrate content.

Table1. Proximate Analysis of Both Raw and Roasted Maize Seed

Proximate Analysis	Raw Maize (%)	Roasted Maize (%)
Crude protein	7.32	7.05
Ash	2.10	2.50
Crude fiber	2.40	2.10
Crude fat	2.70	2.20
Moisture content	7.20	6.30
Total carbohydrate	78.28	79.85

The amino acids analysis of the two seeds (Table 2) revealed that they were high in leucine, isoleucine, tyrosine, and phenylalanine. Leucine and isoleucine were most concentrated in the raw seed with the value of 1.3 and 0.53 respectively. The maize seed was deficient in lysine and tryptophan. However, it has a substantial proportion of sulphur-containing amino acids (methionine and cysteine). Cystine was discovered to have the lowest concentration and the

most limiting amino acid, with values of 0.12 and 0.07, respectively for raw and roasted seeds. This was followed by Histidine, which had values of 0.27 and 0.19 for raw and roasted seeds, respectively.

Table 2. Analyses of Amino Acids in Raw and Roasted Maize Seed

Amino acids	Raw maize seed (g/16 g N)	Roasted maize seed (g/16 g N)
Arginine	0.35	0.31
Threonine	0.37	0.34
Leucine	1.30	0.95
Isoleucine	0.53	0.50
Valine	0.46	0.37
Tryptophan	0.00	0.00
Lysine	0.00	0.00
Histidine	0.27	0.19
Phenylalanine	0.42	0.38
Tyrosine	0.52	0.49
Cystine	0.12	0.07
Methionine	0.13	0.08

The variability in proximate composition of raw and roasted maize seed accessions was calculated, and the amino acid profile was analyzed. The proximate composition values for ash, moisture, fats (lipids), protein, fiber, and carbohydrate in raw and roasted maize seed were determined. These happened in the following order in the maize seed: carbohydrate > protein > moisture > fiber > lipid > ash. The proximate composition of maize seed varied greatly between raw and roasted seed. The crude protein range of 7.50- 7.32 percent achieved in this study is lower than the range of 7.9- 8.7 percent reported by [8] for several types of maize farmed in Ikwo Local Government Area of Ebonyi State, Nigeria. The moisture content of raw and roasted maize seed was 7.20% and 6.30%, respectively. Crops with high moisture content are subject to microbial infestation and, as a result, spoilage [21]. The moisture content of any food is a measure of its stability and susceptibility to microbial contamination [22], as well as an indication of its water activity [23]. These somewhat higher moisture levels also imply that dehydration would raise the relative concentration of other dietary nutrients, improving the seeds' shelf-life or preservation. It is also necessary to keep the seeds in a cool environment if they are to be retained for an extended length of time without spoiling, especially in the tropics where crop waste is estimated to be approximately 50% due to high moisture content [24]. The fraction of food that is not digested by humans is known as crude fiber, yet the regular functioning of the digestive system is dependent on the existence of enough fiber. It raises the bulk of the stool and shortens the time waste items spend in the gastrointestinal system. Fiber aids in the preservation of human health and has been shown to lower the body's cholesterol levels [25]. Low fiber meals have been linked to heart disease, colon and rectum cancer,

varicose veins, phlebitis, obesity, appendicitis, diabetes, and even constipation [26]. The presence of ash in a food sample is a representation of inorganic materials.

This study's amino acid profile of maize seed reveals that maize seeds are a great supply of essential amino acids, particularly isoleucine, tyrosine, and leucine. The remaining amino acids are present in modest levels, although tryptophan and lysine are missing. As stated by [27], the lack of tryptophan and lysine was detected. The protein content of the raw seed was lower than that of the roasted seed. Raw maize seed processing, particularly roasting, is detrimental to the amino acid content and quality. The concentration of amino acids was decreased with heat treatment. Leucine was found to have the greatest content in maize, with 1.3 g/16 gN for the raw seed and 0.9 for the roasted seed, closely followed by Isoleucine, with 0.53 g/16 gN for the raw seeds and 0.5 g/16 gN for the roasted seeds. Cystine was found to have the lowest concentration and the most limiting amino acid, with values of 0.12 g/16 gN and 0.07 g/16 gN for raw and roasted seeds, respectively, followed by methionine with 0.13 g/16 gN and 0.08 g/16 gN for raw and roasted seeds. The nutritive value of plant protein quality is often assessed by comparing its essential amino acid content to World Health Organization reference standards for optimal protein quality [28], which are based on the amino acid requirements for children aged 2 to 5 years. As a consequence, our findings indicated that maize seed contains adequate protein and nearly all of the necessary amino acids required, with several exceeding the 100 percent relative chemical score. This means that the amino acids in maize seed have a high biological value and could contribute significantly to addressing human needs for these critical amino acids. Raw maize seeds are recommended in complementing cereals for weaning foods, but not roasted seeds. These findings indicate that maize seeds may be a source of edible vegetable oil, and the extracted meal may be a valuable supply of carbohydrate, fiber, and protein for animal feeds. Its utilization is thus worth investigating in this context. Because of the presence of dietary fiber, maize seed consumption would considerably improve digestibility and assist in the prevention of non-communicable illnesses.

4. Conclusion and Recommendation

This study has added significant nutritional information on maize seed. Maize's amino acid composition is comparable to that of traditional plant protein sources. Raw maize seeds are indicated as a beneficial feed element for monogastric animals at both the residential and industrial sectors. Maize production of high-protein genotypes should be encouraged.

Acknowledgments

Funding from the Agriculture and Environment Department of the Onitsha North Local Government Council in Anambra State, Federal Republic of Nigeria, sponsored this work. The authors would like to thank the Projects Development Institute (PRODA) for providing some of

the research facilities for this work. We are also grateful to the Nnamdi Azikiwe University Library for supplying research materials.

REFERENCES

- [1] P. N. Golob, A. Kutukwa, R. E. Devereau, Bartosik, and J. C. Rodriguez, "Chapter two: Maize", in *Crop Post-Harvest: Science and Technology Volume 2*, R. Hodges and G. Farrell, Eds. Ames, Iowa: Blackwell Publishing Ltd., 2004.
- [2] A. Yaouba, N. Tatsadjieu, D. P. M. Jazet, and C. M. Mbofung, "Inhibition of fungal development in maize grains under storage condition by essential oils", *International Journal of Bioscience*, vol. 2, no. 6, pp. 41-48, 2012.
- [3] FAO, "Irrigation water requirements", in *Irrigation Potential in Africa: A Basin Approach*. Rome: FAO, March, 2020. [Online]. Available: <http://www.fao.org/docrep>.
- [4] D. C. Nkamigbo, O. A. Atiri, B. O. Gbughemobi, and N. J. Obiekwe, "Comparative analysis of costs and returns in hybrid and nonhybrid maize production in Osun State, Nigeria", *Journal of Agriculture and Veterinary Sciences*, vol. 7, no. 2, pp. 56-70, 2015.
- [5] J.E. Iken and N.A. Amusa, "Maize research and production in Nigeria", *African Journal of Biotechnology*, vol. 3, no. 6, pp. 302-307, 2004.
- [6] FAO, "FAO production maize", 2008. [Online]. Available: <http://www.foodsecurityportal.org/api/countries/fao-production-maize>.
- [7] R. O. Babatunde, E. O. Olorunsanya, and A. D. Adejola, "Assessment of rural household poverty: evidence from Southwestern Nigeria", *American-Eurasian J. Agric. & Environ. Sci*, vol. 3, no. 6, pp. 900-905, 2008.
- [8] F. I. Nweke and J. A. A. Akorha, "Determinants of adoption of new technology among smallholder and implementation for administration of transfer programmes. A case study of rice production of Plateau State of Nigeria Agricultural Administration", *AGRIS*, vol. 12, pp. 17-19, 1983.
- [9] NARP [National Agricultural Research Project], *National Agricultural Research Strategy Plan for Nigeria (North-West Zone: Draft Report)*, Nigeria: NARP, 1994.
- [10] FAO, "FAOSTAT: Food and Agriculture Organization statistic database", 2007. [Online]. Available: <http://faostat.fao.org>.
- [11] D. Ape, N. Nwogu, E. Uwakwe, and C. Ikedinobi, "Comparative proximate analysis of maize and sorghum bought from Ogbete Main Market of Enugu State, Nigeria", *Greener Journal of Agricultural Sciences*, vol. 6, no. 9, pp. 272-275, 2016.
- [12] H. K. Dei, "Assessment of maize (*Zea mays*) as feed resource for poultry" in *Poultry Science*, M. Manafi, Ed. London, UK: IntechOpen, 2017 [Online]. Available from: <https://www.intechopen.com/books/5315> doi: 10.5772/61986.
- [13] F. Hossain, V. Muthusamy, J.S. Bhat, S.K. Jha, R. Zunjare, A. Das, K. Sarika, and R. Kumar, "Maize-broadening the genetic base of grain cereals", Springer, pp. 67-88, 2016.
- [14] R. Bressani and E. Elias, "Guidelines for the development of processed and packaged weaning foods", *Food Nutr. Bull*, vol. 5, pp. 32-36, 1983.
- [15] M. Ozor, "Economic analysis of dry maize in the South East States of Nigeria", Ph.D. thesis, Dept. of Agric. Econ. and Extent., Chukwuemeka Odumegwu Ojukwu University, Igbaram Campus, Anambra State, Nigeria, 2017.
- [16] O. S. Fasasi, I. A. Adeyemi, and O. A. Fagbenro, "Proximate composition and multi-enzyme in vitro protein digestibility of maize-tilapia flour blends", *J. Food Technol*, vol. 3, no. 3, pp. 342-345, 2005.

- [17] AOAC International, *Official Methods of Analysis*. Gaithersburg: AOAC International, 2005.
- [18] S. Ali, S. Nazir, S. Usman, Z. Nasreen, U. Kalsoom, and T. Inam, "Study on the biochemical effects of barley fiber on the hypercholesterolaemic rats", *African Journal of Plant Science*, vol. 8, no. 5, pp. 237-242, 2014.
- [19] S. O. Serna-Saldivar, *Cereal Grains. Laboratory Reference and Procedures Manual*, Boca Raton: CRC Press/Taylor & Francis Group, 2012.
- [20] D. H. Spackman, W. H. Stein, and S. Moore, "Automatic recording apparatus for use in the chromatography of amino acids", *Analyt. Chem.*, vol. 30, pp. 1990-1991, 1958.
- [21] B. B. Desai and D. K. Salunkhe, "Fruits and Vegetables" in *Foods of Plant Origin: Production, Technology and Human Nutrition*, D.K. Salunkhe and S.S. Deshpande, Eds. New York: Van Nostrand Reinhold, 1991, pp.301-355.
- [22] K. R. Davey, "A predictive model for combined temperature and water activity on microbial growth during the growth phase", *Journal of Applied Microbiology*, vol. 65, no. 5, pp. 483-488, 1989.
- [23] W. S. Frazier and D. C. Westoff, *Food Microbiology*. New York, USA: McGraw Hill, 1978.
- [24] A. Thompson, *Postharvest treatments*. in: *postharvest technology of fruit and vegetables*. Cambridge, USA: Blackwell Science Ltd, 1996.
- [25] M. O. Bello, O. S. Falade, S. R. A. Adewusi, and N. O. Olawore, "Studies on the chemical compositions and anti-nutrients of some lesser-known Nigeria fruits", *African Journal of Biotechnology*, vol. 7, no. 21, pp. 3972-3979, 2008.
- [26] L. Saldanha, "Fiber in the diet of U.S. children: results of national surveys", *Pediatrics*, vol. 96, pp. 994-996, 1995.
- [27] FAO, "Improvement of maize diet", in *Maize in human nutrition*. Rome: FAO, 1992 [Online]. Available from: <http://www.fao.org/3/T0395E/T0395E0c.htm>.
- [28] FAO/WHO/UNU. *Protein quality evaluation*. Rome, Italy: Food and Agricultural Organization of the United Nation, 1991.