Bionatura
Latin American Journal of Biotechnology and Life Sciences

Bionatura Issue 4 Vol 8 No 1 2023

Article

Study of the effect of germination on the chemical and nutritional properties of maize seeds

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Available from: http://dx.doi.org/10.21931/RB/CSS/2023.08.04.64

ABSTRACT

The research aimed to study the effect of the germination process on the chemical composition and content of phenolic compounds, phytic acid, mineral elements and amino acids of locally grown maize. The results of the chemical composition of the non-germinated maize showed that the content of protein, fat, ash, moisture, fiber, and carbohydrates were (7.75 - 10.271 - 1.46 - 6.79 -3.173 -70.886) respectively, while the results of germinated maize were from protein, fat, ash, fiber, carbohydrates (9.13- 9.167 -1.27- 5.93- 4.822- 69.861) respectively. As for the number of phenolic compounds, it increased after germination, as it reached germinated yellow maize compared to non-germinated maize (159 mg/gm-145 mg/gm) respectively, in addition to germination, it reduced the amount of phytic acid in germinated maize compared to non- germinated maize, which amounted to (2.8 mg/100gm). -48.9 mg/100 g) respectively. The percentage of mineral elements, iron, phosphorous, magnesium, potassium, zinc, and calcium for germinated maize reached (0.2883-3.87 -0.139-0.078 - 7.76-23.4), respectively. As for non-germinated maize, the percentage of iron, phosphorous, magnesium, potassium, zinc, and calcium (0.2811-3.43 -0.142-0.086-17.5-21.4) respectively. The effect of germination on the proportion of amino acids: the results showed that germination led to an improvement in the proportion of some essential and non-essential amino acids.

Keywords: yellow corn, germination, amino acids, phytic acid.

INTRODUCTION

Yellow corn (Zea mays L.) is an important annual cereal crop belonging to the family Poaceae, as the word Zea in the Latin language means stable life, while the word mays is the giver of life. One of the most famous crops in the world and the third most important crop after wheat and rice, it is considered a staple food for many people due to its high nutritional value and being a relatively stable food crop that grows within multiple climatic environments. The global production of maize reached 967 million tons/year [1]. Zea mays L. maize contains many essential nutrients, including carbohydrates, protein and fat, and its content of amino acids. It is a good source of many vitamins, including vitamins C, K, B1, B2, B6, E, and folic acid, as well as its high content. It contains selenium, potassium, calcium, iron and copper, in addition to containing what is known as phytochemicals, such as

carotenoids and phenolic compounds, which contribute to protecting humans from many chronic diseases. It also contains an abundant amount of fiber. Corn seeds are the main source of 45-50% of cooking oil, as well as the oil's high content of unsaturated fatty acids [2]. The germination of yellow corn seeds begins when the grains come into contact with the field moisture, where water begins to enter the grain through the cover of the grain. Then, the grain takes physical and chemical changes to push the main axis of growth and elongation. The percentage of phenolic compounds increased from 1.7 to 2.7 mg/kg [3]. Explained the effects of germination, fermentation and germination with fermentation on the content of protein, fat, fiber, moisture and niacin in maize cultivars ZM 607 and Tamira Pool A9, which led to a significant increase in germination and fermentation. (P 0.05) in the protein and niacin content in both types of maize, the niacin content in ZM 607 increased from 1.2 to 11.5 mg/kg, and the fat and fiber content decreased in both ZM 607 and Tamira Pool after fermentation and germination [4]. The effect of germination on minerals, vitamins and some functional properties of sprouted maize grains, as the levels of mineral elements (calcium, magnesium, iron, sodium and potassium) were increased for maize samples germinated from non-sprouted maize, and it was found that germination led to a significant increase in the contents of vitamins (A, B1, C, D). Therefore, germination is an effective treatment method for increasing vitamins and bioavailability of minerals as well as improving the functional properties of yellow corn flour, including the ability to absorb water and oil [5]. The interaction of phytates and phenolic compounds with minerals is important in grains and legumes, as fermentation and germination are commonly used to disrupt these reactions and to make nutrients and phytochemicals free and available to digestive enzymes [6]. Therefore, the research aimed to study the effect of the germination process on the chemical composition and content of phenolic compounds, phytic acid, mineral elements and amino acids of locally grown maize.

MATERIALS AND METHODS

Yellow corn kernels

The maize kernels of the al-maha variety were used, which is a synthetic variety derived locally by the research staff of the Public Authority for Agricultural Research, harvested in the year (2021), and it is considered one of the best locally produced varieties prepared by the Agricultural Research Department / Yellow Maize Research Department. Germination process: The method mentioned in [7] was followed with some modifications. The corn kernels were cleaned of impurities, washed and then soaked in water for 16 hours, then placed in plastic trays containing a piece of medical gauze to prevent contamination and entered into the incubator at a temperature of 31 m away from the light for 48 hours with the humidification process carried out every 6-8 hours per day. xxx8 mash, then fill in glass containers and store in the refrigerator until use.

Chemical composition

The percentage of protein, fat, ash, fiber, moisture and carbohydrates was estimated for samples of germinated maize and non-germinated maize, as stated in [8].

Determination of phenolic compounds

The proportion of phenolic compounds was estimated using the method presented in [9].

Determination of phytic acid

Determination of phytic acid for samples of germinated maize and germinated maize flour in the Ministry of Science and Technology / Department of Environment and Water / Food Research Center by HPLC according to the method mentioned by [10].

Analysis of mineral elements

The mineral elements were estimated using a flame photometer and atomic absorption device, and the method mentioned by [11].

Determination of amino acids:

The examination was conducted in the laboratories of the Ministry of Science and Technology / Department of Environment and Water using an amino acid analyzer (Korean origin). The method presented by the scientist was used [12].

statistical analysis

The statistical program Statistical Analysis System -SAS (2018) was used in data analysis to study the effect of different factors on the traits according to a complete random design (CRD), and the significant differences between the means were compared with the Least Significant Difference-LSD test.

RESULTS

The chemical composition of germinated and non-germinated corn:-

It is clear from Table (1) a comparison between the chemical composition germinated maize and non- germinated maize, where the results showed the percentage of protein in germinated maize 9.13%, while non- germinated maize 7.75%, it was found from the results an increase in protein after the germination process and this increase depends on the type of grain or seed as Illustrated by [13]. The increase in proteins is due to dry weight loss as some carbohydrates and fats are used during respiration, and some amino acids are synthesized during germination [14],15. This result is consistent with the results of [16], where an increase in the percentage of protein after germination of buckwheat for 72 hours was found due to the higher rate of protein synthesis compared to the proteolysis. As for fats, there was a decrease in the percentage after germination. It was 10.271% for maize before germination, while after germination, it was 9.167%, as shown in Table (1). We also noticed a decrease in the percentage of ash after the germination of corn; it was 1.46% before germination, but after germination, it decreased to 1.27%, as shown in Table (1). From the same Table, we notice a decrease in the percentage of moisture, which was 6.79 % before germination. However, after germination, it became 5.93% due to the drying processes that occur after the germination process, which is one of the main and important stages to end the germination process, as indicated by the researcher [17]. In addition, it is important to increase the storage period because it reduces the moisture content in it, which reduces the growth of microorganisms, which was explained by the researcher [18]. As for the percentage of fibers, it increased in germinated maize compared with non-germinated maize, where the percentage before germination was 3.173% and increased after germination to 4.822% as stated in Table (1). As shown in Table (1), the percentage of carbohydrates decreased in the germinated maize, as it was 70.886% before germination, but after germination, it decreased to 69.861%. As for the calories in maize, it decreased from 406.983% before the germination process to 398.467% after the germination process.

% components	non- germinated maize	germinated maize	aize value LSD
Protein	7.75	9.13	1.36 *
fat	10.271	9.167	0.784 NS
ash	1.46	1.27	0.291 NS
moisture	6.79	5.93	1.082 NS
fiber	3.173	4.822	0.662 *
carbohydrates	70.886	69.861	3.79 NS
Calories Kcal/ 100g	406.983	398.467	17.6 NS

Table 1. The chemical composition of germinated and non-germinated. *P≤0.05 ،(NS) : insignificant

Determination of phytic acid in corn before and after germination:

Table (2) shows the values of phytic acid in germinated and non-germinated maize, and according to the statistical examination of the content of phytic acid in corn, there were significant differences after germination at the probability level ($P < 0.05$). 2.8) mg / 100 g, while before germination, it was (48.9) mg / 100 g. The decrease after germination is due to the increase in the activity of the phytase enzyme, which analyzes and reduces the level of phytic acid. Phytic and then reduce its amount in foods processed from it.

Sample	Concentration of total phenolic compounds mg/g	Phytic acid concentration mg/100 g
Germinated maize	159	2.8
non-Germinated maize	145	48.9
Values LSD	* 12.65	* 6.271

Table 2. Phytic acid content and total phenolic compounds in Germinated and non-germinated maize.*(0.05>P)

Content of total phenolic compounds in Germinated and non- Germinated maize:-

Through the extraction method and using the standard curve of gallic acid, the amount of total phenolic compounds in Germinated and non-germinated corn was determined in mg/g. After germination, its ratio became 159 mg/g. The results after germination showed significant differences at the probability level ($P < 0.05$) in the statistical analysis of the concentration of total phenolic compounds in corn.

Mineral content of Germinated and non- Germinated maize:-

Table (3) shows the mineral element content of the corn before and after the germination process. The results showed that the corn contains 6 metallic elements, which are as follows (iron, phosphorous, magnesium, potassium, zinc, and calcium), where the value of the elements before the germination process was (0.2811, 3.43, 0.142, 0.086, 7.51, 21.4), respectively. As for after germination, a difference was found in the results. We noticed an increase in most elements after the germination process, such as (iron, phosphorous, zinc, and calcium).

metallic elements (mg/100g)	non- germinated maize	germinated maize	Values LSD
Iron	0.2811	0.2883	0.022 NS
phosphorous	3.43	3.87	0.492 NS
magnesium	0.142	0.139	0.028 NS
potassium	0.086	0.078	0.025 NS
zinc	7.51	7.76	0.371 NS
Calcium	21.4	23.4	1.86 *

Table 3. Mineral content of germinated and non-germinated maize insignificant ، NS: (P≤0.05)*

The percentage of amino acids in Germinated and non- Germinated maize protein:-

Table (4.4) shows the number of amino acids in Germinated and non-germinated maize. It was noted that there were 13 amino acids in Germinated and non-germinated maize. The number of essential amino acids was 7, namely (methionine, phenylalanine, valine, lysine, leucine, histidine, and threonine). The percentages of amino acids for germinated maize were (279.9, 114.8, 88.9, 214.9, 158.9, 36.9, 94.9) mg/100 g, respectively, while the non-germinated maize reached (214.8, 88.6, 74.9, 174.6, 125.6, 24.6, 74.5) mg. /100 g respectively. As for the non-essential amino acids in Germinated maize, it was 6 (aspartic, glutamic, arginine, proline, alanine, and finally serine) (59.8, 74.9, 120.5, 82.4, 69.8, 104.8) mg / 100 g, respectively as for in non- germinated maize reached its (59.8, 74.9, 120.5, 82.4, 69.8, 104.8) mg. /100 g where the results showed a clear increase in the essential and non-essential amino acids in corn after germination, to increase the solubility of protein complexes after the germination process.

Amino acid µg/gm	non- Germinated maize	germinated maize	Values LSD	
	Essential amino acids			
Methionine	214.8	279.9	25.07 *	
Phenylalanine	88.6	114.8	13.52*	
Valine	74.9	88.9	6.91 *	
Lysine	174.6	214.9	18.47 *	
Leucine	125.6	158.9	16.95 *	
Histidine	24.6	36.9	7.30*	
Threonine	74.5	94.9	11.06 *	
	Non-Essential amino acids			
Aspartic acid	59.8	74.9	7.41 *	
Glutamic acid	74.9	89.7	7.55 *	
Arginine	120.5	148.9	16.38 *	
Proline	82.4	102.6	11.94 *	
Alanine	69.8	94.8	8.52 *	
Serine	104.8	174.9	13.67 *	
	***(P≤0.05)**			

Table 4. The percentage of amino acids in Germinated and non- Germinated maiz eprotein

The proportion of fatty acids in Germinated and non- Germinated maize

Table (5) shows the percentage of fatty acids in Germinated and non-germinated maize, where it was observed that there are 8 types of fatty acids in corn, which are as follows (palmitic, stearic, oleic, linoleic, linolenic, arachidonic, saturated fatty acids, and unsaturated fatty acids). The percentage of fatty acids before germination reached (13.5, 3.6, 29.4, 51.1, 2.2, 0.24, 17.1, 82.94) respectively. In contrast, the results of fatty acids for maize after germination became (14.8, 2.9, 28.8, 50.8, 2.3, 0.44, 17.7, 82.34 respectively, the results were found to vary between increase and decrease, as the results showed a decrease in fatty acids in (stearic, oleic, linoleic, unsaturated fatty acids) and the increase in fatty acids was (palmitic, linolenic, Arachidonic, saturated fatty acids).

Fatty acid %	non- germinated maize	germinated maize	L.S.D
Palmatic(C16:0)	13.5	14.8	1.08 *
Stearic(C18:0)	3.6	2.9	0.447 *
Oleic (C18:1)	29.4	28.8	1.04 NS
Linoleic (C18:2)	51.1	50.8	2.37 NS
Lenolenic(C18:3)	2.2	2.3	0.41 NS
Arachidonic (C20:4)	0.24	0.44	0.147 *
Total saturated fatty acid (TSFA)	17.1	17.7	1.06 NS
Total unsaturated fatty acid (TUFA)	82.94	82.34	2.59 NS

Table 5. The percentage of fatty acids in Germinated and non- Germinated maize *insignificant NS :(P≤0.05)

DISCUSSION

The germination effect on carbohydrates largely depends on the activation of hydrolytic enzymes and enzymes, resulting in a decrease in starch and an increase in simple sugars in a time-dependent manner. Additionally, it facilitates germination and enzymatic hydrolysis of carbohydrates into simple sugars by activating endogenous enzymes such as α-amylase and thus improving digestibility [19]. As a result of starch hydrolysis, it provides energy for seed development [16].

The results are in agreement with study [20], where he studied the percentage of phytic acid in wheat flour, where he noticed a decrease between the results before and after germination of wheat, and the values were (25.9, 6.3) mg / 100 g, respectively.

The results of this study were better than those suggested by [22], who investigated how improved functional qualities of wheat flour affect germination temperature, impregnation time and duration.

The results after the germination process reached (0.2883, 3.87, 7.76). , 23.4) mg / 100 g, respectively, and that this increase was due to the enzyme phytase, which works on the decomposition and reduction of phytic acid, which is one of the chelating factors, as it holds the two- and three-valent mineral elements such as iron, zinc and calcium, as indicated by the researcher [22].

This increase in amino acids is useful for human food as They bind to each other to form proteins and regulate the most basic functions in the body. It also works to regulate and maintain the body by converting to enzymes or hormones and providing the body with energy. Germination duration and germination conditions, such as temperature, moisture, and oxygen, are associated with increased amino acid content [23].

CONCLUSIONS

The results of the research showed that the process of germination of yellow corn has improved the properties of the chemical composition as well as improved the proportion of phenolic compounds and reduced the proportion of phytic acid. The results showed that germination improved the proportion of essential amino acids and essential fatty acids.

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Received: May 15, 2023/ Accepted: June 10, 2023 / Published: June 15, 2023
Citation: Sbhie, H.A.; Mahommed, B.H. Study of the effect of germination on the chemical and nutritional properties of maize seeds. Revista Bionatura 2023;8 (2) 63. http://dx.doi.org/10.21931/RB/CSS/2023.08.04.64