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Compositional determination of cereal flour of *Zea mays, Sorghum* and *Triticum* spp from the Timbinal community of Valle de Santiago Gto.

Determinación composicional de harina de cereales de *Zea mays, Sorghum y Triticum* spp de la comunidad del Timbinal de Valle de Santiago Gto.

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Abstract

Due to the increase in plastic waste derived from oil, and the pollution that they represent to the environment, new alternatives are being demanded to replace molecules with biomolecules that are the initial source for other future studies, for example, biopolymers in this case the biomolecule of interest is that of starch from cereals such as *Zea mays*, *Sorghum* and *Triticum* spp. In this study, the flour composition of the three cereals from the Timbinal community of Valle de Santiago Gto. Finding your compositional analysis of Corn; RH% 8.6 ± 0.2, Ash 1.33 ± 0.2, ATT (titratable acidity) 0.048 ± 0.009, ETE (Ether extract) 3.33 ±0.3, Protein 13.3 ±0.18, fiber 48 ±1.5 and pH 6.4 ±0.25. Sorghum; RH% 9.6 ± 0.2, Ash 1.16 ± 0.2, ATT 0.026 ± 0.01, ETE 10.3 ± 0.8, Protein 11.5 ± 0.18, Fiber 52.5 ± 1 and pH 6.2 ± 0.15. Wheat; RH% 7.46 ± 0.1, Ash 2.33 ± 0.2, ATT 0.39 ±1, ETE 11.6 ± 1, Protein 22 ± 0.2, Fiber 53 ± 0.9, and pH 6.0 ± 0.15. Concluding that we have young flours and free of chlorinated or bleached treatments, therefore we have optimal flours to produce the acid reaction of Bioplastics from cereal flours.

Wheat, Sorghum, Corn

Resumen

Debido al incremento acelerado de residuos plásticos derivados del petróleo, y la contaminación que representan al medio ambiente, se está demandado nuevas alternativas en sustituir moléculas por biomoléculas que sean la fuente inicial para otros estudios futuros, por ejemplo, biopolímeros en este caso la biomolécula de interés es el de almidón de los cereales como *Zea mays*, *Sorghum* y *Triticum* spp. En este estudio se determinó la composición de harina de los tres cereales de la comunidad Timbinal de Valle de Santiago Gto. Encontrando su análisis composicional de Maíz; %HR 8.6 ± 0.2, Cenizas 1.33 ± 0.2, ATT (acidez titulable) 0.048 ± 0.009, ETE (Extracto etéreo) 3.33 ±0.3, Proteína 13.3 ±0.18, fibra 48 ±1.5 y pH 6.4 ±0.25. Sorgo; %HR 9.6 ± 0.2, Cenizas 1.16 ± 0.2, ATT 0.026±0.01, ETE 10.3 ±0.8, Proteína 11.5 ±0.18, fibra 52.5 ±1 y pH 6.2±0.15. Trigo; %HR 7.46± 0.1, Cenizas 2.33 ± 0.2, ATT 0.39 ±1, ETE 11.6±1, Proteína 22 ±0.2, fibra 53 ±0.9 y pH 6.0 ±0.15. Concluyendo que tenemos harinas jóvenes y libres de tratamientos clorados o blanqueados, óptimas para producir sin alteraciones la reacción acida de Bioplásticos a partir de harinas de cereales.

Trigo, Sorgo, Maíz

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Introduction

All cereals have a similar structure, although the shape and size of the seeds are different.1 The chemical composition of cereals is fairly homogeneous. Starch is the most abundant component, with legumes and potatoes being important sources of this polysaccharide. This component is found mainly in the endosperm. Lipids are found in relatively small amounts and are preferentially stored in the germ and aleurone layers (outer covering of the endosperm). Linoleic fatty acid predominates. Proteins are located in the different parts that make up the grain (endosperm, germ and outer coverings). 2.

Cereal	%HR	Carbohydrates	Proteins	Lipids	Fiber
Wheat	14	56.9	12.7	2.2	12.6
Corn	12	62.4	8.7	4.3	11
Sorghum	14	59.3	8.3	3.1	13.8

Table 1 Approximate chemical composition (g/100 g of edible portion) of different cereal grains, % RH (relative humidity)
Source: Gil Hernández. (2010)

Compositional information of cereals

The main structural, physicochemical and functional characteristics of the main grain components determine the quality of flour (carbohydrates, starch, relative humidity, ash, acidity, pH, protein, fiber, etc.)[3].

Carbohydrates

They are quantitatively the most important components, constituting 77-87% of the total dry matter. The carbohydrates present are: starch, cellulose, hemicellulose, pentoses, dextrose and free sugars.

a) Starch: It constitutes approximately 60-75% of the grain weight and its two main components are: amylose, essentially linear polymer a-(1-4) glucose linked by a-branches a-(1-6). The starch grain is insoluble in cold water and when heated with water, the starch absorbs, swells and bursts, this phenomenon is called gelation. Thanks to this property, it is used in gelling and innovation applications. The endosperm contains the largest amount of starch in the grain. Industrially, starch is of particular importance in industry and in the application of raw material for biopolymers.

b) Proteins: The protein content of the grain ranges between 7 and 18%. [4].

c) Lipids: They are present in a percentage of 1.5 to 2% and are located mainly in the germ and testa. The most important lipid components are glycerides (oleic and linoleic acid), phospholipids (lecithin) and sterols.

Alterations of cereal grains and flours

To guarantee the quality of grains, their storage is crucial, which refers to concentrating production in strategically selected places that provide the stored products with the necessary conditions so that they do not suffer damage or be treated with chemicals, due to the action of pests, diseases or the environment, avoiding loss of weight or reduction in their quality. [5].

The microbiota of cereal grains and legumes come from the soil and the storage environment, in addition to those acquired during processing. Although they have high carbohydrate and protein concentrations, their low water activity restricts microbial growth if stored properly.

Storage conditions, such as grain moisture content, temperature, and storage time, are critical factors in quality control. [6].

Protein by Kjeldahl method

The Kjeldahl method measures the nitrogen content of a sample. The protein content can then be calculated by assuming a ratio of protein to nitrogen for the feed. This method can basically be divided into 3 stages: digestion or mineralization, distillation and titration. The procedure to follow is different depending on whether, in the distillation stage, the nitrogen released is collected on a solution of boric acid or on a known excess of standard hydrochloric or sulfuric acid. This will determine how the next titration step is carried out, as well as the reagents used.

The protein content of the grain ranges from 7 to 18%. [7].

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Moisture (%RH)

The cereal milling process is very extensive; multiple parameters are controlled in the process, as well as tests at different stages. One of the main factors involved in flour quality is moisture content. Flour can retain moisture due to the cell wall structure in the cells of each cereal, as well as the tendency of flour proteins to adsorb ambient moisture. Flour containing high levels of moisture is prone to fungal or bacterial growth and spoilage. [8].

Ash

Ash consists of mineral salts, such as potassium, sodium, calcium, and magnesium, from the outer parts of the grain that are incorporated into the flour. More extracted flours contain a higher percentage of ash. The mineral matter content (ash content) defines the commercial types of flour. [8].

Ether extract or total fat (EET)

Lipids are the structural components of foods of both animal and vegetable origin. In the case of tubers, the fat content is low, as in flours; however, in the case of some grains, the lipid content can be considerable.

Crude fiber

Crude fiber is the residue obtained after the treatment of vegetables with acids and bases, it refers to the components of the food that cannot be digested, which are structural polysaccharides and lignin. [8].

Titratable acidity (TTA) and pH in flours

Flours obtained from cereals, leguminous plants, etc., show as characteristic properties a high titratable acidity value [9]. They present as characteristic properties a pH value and total titratable acidity (TTA) that can identify them from each other. The pH of flour usually lies between 6.0 and 6.8. [9]. A lower value means the possible presence of chlorinated substances used as bleaching agents, which can be detected by determining the acidity of the flour.

Bleaching substances for flour bleaching are used for two purposes: to bleach the flours by destroying the carotenoids present and to improve their properties in flour kneading by modifying the gluten structure.

The phenomena involved, oxidations in both cases, are similar to those that occur naturally when flour is allowed to age. ATT is defined as the total amount of titratable hydrogen in the aqueous extract of a flour dilution that comes from the organic acids that are structural constituents. The % ATT should not exceed 0.25% in the case of flour. The acidity of the aqueous extract increases with storage time.

Bleaching agents

Flours generally have a pH between 6 - 6.8; when they have been bleached with chlorine they have a lower pH. [8].

Methodology

Methodology for obtaining cereal flour. The three cereals *Zea mays, Sorghum* and *Triticum spp*. were cleaned to remove physical contaminants and a brief investigation was carried out to ensure that the grain had not been subjected to any previous treatment or neutralization that could alter the quality of the flour.

Once the grain had been cleaned, it was milled using a 1 HP Fumasa MN-80 nixtamal mill. The milling result was weighed to obtain 1± 0.1 kg.

HIGHTOP flour sifter at 100 microns. Subsequently, tests were carried out to determine the flour composition.

Relative humidity

It was carried out according to NOM-116-SSA1-1994.Introduce the capsules with the previously evaporated sample into the oven, place the lids so that at the end of the drying time they can be quickly covered, close the oven and dry for 4 hours at 100° ± 2°C. Open the oven, cover the capsules and place them in the desiccators, allow to cool to room temperature and weigh immediately to the nearest 0.1 mg [10].

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Titratable acidity (ATT)

Using the methodology of standard NMX-FF-10-1982. Calibrate the potentiometer, using the buffer solutions of known pH. Transfer by means of a volumetric pipette to a beaker with magnetic stirrer 25 cm³ of the prepared sample. Start stirring and quickly add the NaOH solution contained in the burette, until the pH is around 7.0, then slowly add more solution, until pH 8.1 ± 0.2 and note the volume of NaOH spent, using the formula of the standard. [11].

Ash

The determination of ashes followed the NMX-F-066-S-1978 standard. In a crucible at constant mass, put 3 to 5 g of sample to analyze; place the crucible with sample in a grill and burn the material slowly until it no longer gives off smoke, avoiding that it is projected out of the crucible. Take the crucible to a muffle and carry out the complete calcination 525-550°C. Let it cool in the muffle, transfer it to the desiccator for complete cooling and determine the mass of the crucible with ashes. Using the formula of the standard. [12].

Determination of ethereal extract or total fat (ETE)

The methodology of the standard NMX-F-615-NORMEX-2018, Foods-determination of ethereal extract (soxhlet method) in foods-test method was used.

Prepare the sample of the three cereals in a filter with the muslin cloth disc overlaying the filter paper disc, place in the Buchner funnel, moisten the cloth and paper. With the aid of the vacuum, pass approximately 100 cm^3 (ml) of the suspension of diatomaceous earth (until the pores are saturated), wash with one dm3 (liter) or less of water and apply the vacuum until all the water has been filtered. Pass the acidified sample through the prepared filter. Apply the vacuum until all the water has been filtered and is received in a 2 dm3 Kitazato flask. The filtrate from the Kitazato is measured with a measuring cylinder to quantify the sample volume. Place the extraction cartridges in beakers, bring to dryness in a 376K (103°C) electric oven for 30 minutes, place the cartridge in the Soxhlet extraction apparatus, with the flask whose mass has been previously determined.

Add petroleum ether solvent to the flask up to half its capacity. To leave in reflux during 4 hours from the first cycle of recirculation, controlling the conditions of temperature to boiling of the petroleum ether, until it gives a cycle every 3 minutes approximately. Once the time of reflux is finished, empty and drain the solvent that remains in the extractor to the flask. Evaporate the solvent in a water bath at 358K (85°C) and transfer the flask to the vacuum oven at a temperature of 333K (60°C) for 30 minutes. Let the flask cool in a desiccator for a period of 30 minutes and determine its mass. Using the formula. [13].

Determination of proteins by Kjeldhal method

a) Digestion stage: a treatment with concentrated sulfuric acid in the presence of a catalyst and boiling converts the organic nitrogen into ammonium ion, according to equation 1.

$$n - c - NH_2 + H_2SO_4 \quad \rightarrow CO_2 + (NH_4)_2SO_4 + SO_2 \quad (1)$$

1 to 5 g of sample is introduced into a mineralization tube and 3 g of catalyst is added, which usually consists of a mixture of copper salts, titanium oxide and/or selenium oxide. Usually a mixture of K_2SO_4: $CuSO_4$: Se (10:1:0.1 by weight) is used as catalyst. Then 10 mL of concentrated H_2SO_4 and 5 mL of H_2O_2 are added. It is then digested at 683 K (410 ºC) for a time that depends on the amount and type of sample. It is known that the digestion is finished because the solution acquires a characteristic emerald green color. At this stage, the protein nitrogen is transformed into ammonium sulfate by the action of hot sulfuric acid. Nowadays, automatic digesters are used to carry out this process, which are capable of digesting a certain number of samples at the same time.

(b) Distillation stage: the digested sample is alkalinized and the nitrogen is released in the form of ammonia (equation 2). The distilled ammonia is collected over an unknown excess of boric acid (equation 3).

$$(NH_2)SO_4 + 2NaOH \rightarrow 2NH_3 + Na_2SO_4 + 2H_2O \quad (2)$$

$$NH_3 + H_3B0_3 \rightarrow NH_4 + H_2BO_3 \quad (3)$$

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After cooling, 50 mL of distilled water are added to the digestion tube, it is placed on the support of the distiller and a sufficient quantity of sodium hydroxide 10 N is added, in sufficient quantity (50 mL approx.) to strongly alkalinize the medium and thus to displace the ammonia of the ammonium salts. The released ammonia is carried away by the water vapor injected in the content of the tube during the distillation, and is collected on a boric acid solution (4 % w/v).

(c) Titration stage: Quantification of ammoniacal nitrogen is carried out by acid-base volumetry of the formate borate ion, using hydrochloric or sulfuric acid and as an indicator an alcoholic solution of a mixture of methyl red and methylene blue (equation 4). The equivalents of acid consumed correspond to the equivalents of ammonia distilled. [6].

$$H_2BO_{3-} + H^+ \rightarrow H_3BO_3 \quad (4)$$

Determination of Crude Fiber in Foods

The determination of crude fiber in the three cereals followed the methodology of NOM-F-90-S-1978.

The three cereals were used 2.0 g of sample and the fat was extracted. Transfer to a 600 ml beaker, avoiding contamination with paper fiber. Add 1 g of prepared asbestos and 200 ml of boiling 1.25% sulfuric acid. Place the beaker in the apparatus on the preset hot plate to boil for exactly 30 minutes. Rotate the beaker periodically to prevent solids from adhering to the walls.

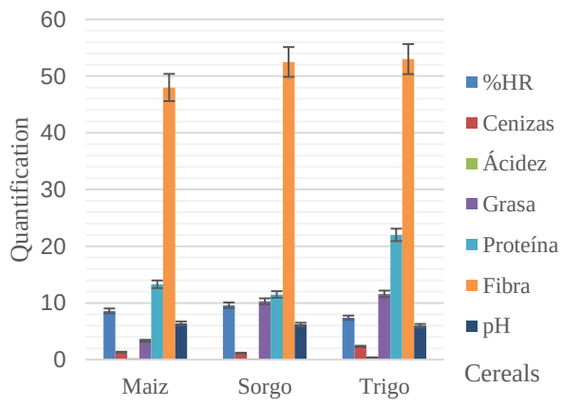
Remove the beaker and filter through filter paper. Rinse the case with 50-70 ml of boiling water and pour over the filter paper. Wash the residue as many times as necessary, until the wash waters have a pH equal to that of distilled water. Transfer the residue to the beaker with 200 ml of boiling 1.25% NaOH and heat to boiling for exactly 30 minutes. Remove the beaker and filter in buckner with filter paper of cooked mass and known ashes. Wash with water until the wash water has a pH equal to that of distilled water. Transfer the residue to a crucible at constant mass and dry at 130°C for 2 hours. Cool and determine its mass. Calcine at 600°C for 30 minutes. Cool and determine its mass. [14].

Results

Table 2 shows the compositional results of flour from the cereal grains *Zea mays*, *Sorghum* and *Triticum spp*. showing quality parameters within the Official Mexican NOM-247-SSA1-2008 [15]. Such as relative humidity, ash, protein, ethereal extract or total fat, ATT, pH and fiber.

Quantitative	Cereals Maize (*Zea Mays*)	Sorghum (*Sorghum*)	*Wheat* (*Triticum*)
%HR a	8.6 ± *0.2*	9.6 ± *0.2*	7.46± *0.1*
%CENIZAS bs a	1.33± *0.2*	1.16± *0.2*	2.33 ± *0.2*
%ATT bs a	0.048± *0.09*	0.026±*0.01*	0.39 ±*1*
ETE% bs a	3.33 ±*0.3*	10.3 ±*0.8*	11.6±*1*
%PROTEIN bs a	13.3±*0.18*	11.5 ±*0.18*	22 ±*0.2*
%FIBRA bs a	48 ±*1.5*	52.5 ±*1*	53 ±*0.9*
pH	6.4 ±*0.25*	6.2±*0.15*	6.0 ±*0.15*

Table 2 Compositional determination of *Zea mays*, *Sorghum* and *Triticum* flours. Mean a (PROM), ±DS Standard deviation, % percent, bs dry basis, ATT titratable acidity, ETE ethereal extract



Graphic 1 Graphical representation of compositional analysis of *Zea mays*, *Sorghum* and *Triticum flour*

Graphic 1 shows graphically the results of the analysis of the three cereals, *Zea mays*, *Sorghum* and *Triticum* showing higher bars in carbon content with amounts ranging between 50-70%, these carbon components can be starch, cellulose, hemicellulose, pentoses and free sugars. Proteins are found in a parameter of 11-22%, being within the parameters established by Gil 2010, and by the NOM-247-SSA1-2008 standard, which mentions that the parameters are 7-18%.

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Lipids are found in different amounts according to the author, so it is considered recent young grains after harvesting that is corroborated with their pH according to Bennon 1971 young flours range from 6.0-6.8 and the results obtained were 6.2-6. 4 presuming that the flour is young derived to that its acidity shows neutral parameters considering that pH and acidity are directly related, which guarantees two things one; that the grain was not submitted to any method of conservation or treatment and the flour therefore does not present any other treatment as bleached or treated or neutralized flours, this can be evidenced because the parameters are within the mentioned Norms and the grains were young because values increase according to the time of storage of the flours.

Another important factor to consider is moisture, which is an essential factor in identifying the storage time of the grains or, failing that, of the flours, the longer the time the degree of hydration decreases, and the results obtained according to Table 2, have values of 7.4 to 9.6 %. Again, they are within the NOM-247-SSA1-2008 standard, which establishes a maximum of 15%. The amount of ashes is between 1- 3% in parameters established by the norm we should have a maximum limit of 3%.

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Conclusions

According to the results obtained, it is concluded that the flour was made from a young grain and is free of any previous storage treatment or chlorinated or bleached flours, so it is optimal for use in innovation products or as is the case of future projects for the elaboration of biopolymers from cereal starch. Ensuring that there is no other factor that affects the acid reactions produced in bioplastics.

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