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Physico-Chemical and Nutritional Characteristics of Soriz Flour (Sorghum Oryzoidum)

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PHYSICOCHEMICALANDNUTRITIONALCHARACTERISTICSOFSORIZFLOURSORGHUMORYZOIDUM

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Rodica Siminiuc [α] & Dinu Țurcanu [σ]

Abstract- The assortment of gluten-free flours in the Republic of Moldova is very small, and the properties of these flours are not sufficiently studied. Sorghum (Sorghum Oryzoidum) is a relatively new cereal, the industrial production of which has recently begun, and the use of sorghum and derivatives, especially flour, are current. The purpose of this study is to determine the chemical composition and nutritional value of sorghum flour. This would have a direct impact on human well-being, contribute to the development of novel foods and reduce food insecurity in the Republic of Moldova, including people with gluten-related disorders. Physico-chemical methods were used to determine the chemical composition and nutritional aspects of the flour. The obtained results showed that the chemical composition of soriz flour is complex and similar to cereal flours, with a predominance of carbohydrates, followed by proteins, lipids etc. Protein fractions of flour are predominant of prolamins and glutenins, but are not generators of gluten. Soriz flour proteins are unbalanced in most essential amino acids relative to the reference protein, especially lysine. Therefore, it is justified to combine it with other foods such as eggs, meat, fish, milk, whose proteins are balanced in essential amino acids. Soriz flour is a good source of potassium and magnesium, but it is poor in such elements as phosphorus, calcium, iron and sodium. The content of tannins and phytates is close to the values mentioned in the literature for other categories of cereal flours. Soriz could be used in both common and gluten-free diets, helping to diversify the range of cereals, but also to increase food security.

Keywords: chemical composition; nutritional value; sorghum flour (sorghum oryzoidum).

I. Introduction

Cereals and cereal products are the basic element in ensuring the food security of the population, providing the major share of energy and nutrients in the daily diet (Kulamarva et al., 2009), (Sarwar, 2013). The importance of cereals and cereal derivatives is also supported by the fact that global food security depends to a large extent on cereal production, which amounts to approximately 2762 million tonnes per year (FAO, n.d.). Regarding the importance of cereals and the challenges in food consumption patterns, it should be emphasized that the analysis of energy and nutrient sources is crucial to ensure their adequate nutritional quality (Laskowski et al., 2019). Diversified nutrition is one of the principles of rational nutrition, with direct benefits for human well-being and lifestyle.

Sorghum is one of the main basic food crops, traditional in many developing countries, being the fifth most important cereal crop in the world after rice, wheat, corn and barley. It is the main grain food for over 750 million people living in the semi-arid tropical regions of Africa, Asia and Latin America. Sorghum is also an interesting ingredient in gluten-free product formulations (Schober et al., 2005). Gluten-related disorders are on the rise, wreaking havoc on both children and adults. For people diagnosed with malabsorption, celiac disease, allergy or sensitivity to gluten, the consumption of products containing gluten, more precisely containing toxic prolamins, is strictly forbidden, because even in very small quantities, they can cause serious health disorders, and in extremely severe cases they can lead to cancer or even death(Renzetti et al., 2008), (Marengo et al., 2015).

Soriz is a hybrid of sorghum that is characterized by glassy endosperm, similar to rice. It was obtained at the Institute for Scientific Research for Maize and Sorghum in the Republic of Moldova, by crossing Sudan grass (S. sudanense) and bicolor sorghum (S. bicolor)(Galaiev et al., 2011). It is a relatively new cereal crop for the Republic of Moldova. The advantages of cultivating soriz are manifested in the production process, which does not require major investments: the plant is not demanding to soil conditions, fertilizers and has tolerance to diseases and pests (Rodica Siminiuc and Țurcanu, 2020). Previous research on the chemical composition of whole soriz grains shows a starch content - 74.12% ... 82.0% dm, protein - about 13.0% dm, sugars - 0.24% - 0.37% dm , lipids - 0.1% ... 0.5% dm, ash - 0.36% - 2.0% dm In the whole soriz bean, the dominant protein fractions belong to prolamins (56.0% of the total protein), followed by glutelin (22.4%), globulins (7.3) and albumin (6.7) (Siminiuc Rodica et al., 2012).

The controversial information on the origin of sorghum in the category of gluten-generating cereals, as well as the provisions of European legislation

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regarding the control and proper management of raw materials used in the manufacture of gluten-free products were imperative factors for testing soriz in the presence of toxic prolamins. The results of laboratory tests by ELISA method (Enzyme-Linked Immunoassay R5 Mendez) confirmed the gluten-free character of soriz and, respectively, the admissibility of its inclusion in the diet of people with gluten-related disorders (Siminiuc, Rodica, 2012).

The assortment of gluten-free flours in the Republic of Moldova is very small, and the properties of these flours are not sufficiently studied. Soriz is a relatively new cereal, and the industrial production of soriz flour, due to its high glassiness, has recently begun. Attempts are made to use soriz flour in the elaboration of bakery, pastry, biotechnology products, but the need for research still remains current (R. Siminiuc and Ţurcanu, 2020), (Siminiuc, Rodica, 2020). Therefore, the purpose of this study is to identify the nutritional and technological and functional value / quality of sorghum flour.

This will help to capitalize on this cereal crop and, respectively, to diversify the diet. At the same time, it would have a direct impact on human well-being, contribute to the development of novel foods and reduce food insecurity in the Republic of Moldova, including people with gluten-related disorders.

II. Materials and Methods

For the determinations, soriz flour was used, with the following organoleptic characteristics (Table 1) (Siminiuc, Rodica., 2014).

Table 1: Organoleptic characteristic of soriz flour

Indices	Eligibility conditions
Color	White color with yellowish tinge
Odor	Specific to sorghum flour, without foreign odor, rancid or moldy
Taste	Neutral taste, no foreign taste, sour or bitter.

The determinations for the identification of the physico-chemical and nutritional characteristics of sorghum flour are presented in Table 2.

Table 2: Methods used for determinations

Determined indices	Method / source
Moisture Determination	(Horwitz and AOAC International, 2006)
Protein Determination	Kjeldahl method (Association of Official Analytical Chemists and Helrich, 1990)
Protein fractions	The method is based on extracting protein fractions from cereals by solubilizing them in various media(Heldt and Heldt, 2011)
Amino acids	(Kosarenko, T., D. /**КозаренкоТ.,Д.**, 1975)
Starch content	(ISO 10520:1997, 1997)
Total Carbohydrate	(Association of Official Analytical Chemists and Horwitz, 2000)
Cellulose	(Association of Official Analytical Chemists and Horwitz, 2000)
Fat Content Determination	Soxhlet extraction method utilizing n-hexane (AOAC, Method 4.5.01) (St. Paul, MN.USA., 2000)
Ash Determination	(Association of Official Analytical Chemists and Helrich, 1990)
Mineral elements	(Association of Official Analytical Chemists and Helrich, 1990)
Phytates	(Latta and Eskin, 1980)
Tannin Content	(Burns, 1971)

III. Results and Discussions

a) The chemical composition of soriz flour

As a rule, the chemical composition of cereal derivatives is close to that of the grains from which they come, depending on the processing processes to which they are subjected.

Soriz flour contains 86.03% / d.m. total carbohydrates, of which 83.5% belong to starch, 1.83% / d.m. mono and disaccharides and 0.7% / d.m of cellulose. The lipid content is 1.9% / d.m. (Figure 1). The respective values are lower than some varieties of sorghum flours, whose numerical values oscillate between 2.89 ... 3.17% / d.m. The humidity of soriz flour is 11.2 ± 0.1%.Cereal proteins form the second main component after carbohydrates, the average content of which varies between 7% and 17%. The protein content in soriz flour is 11.2% / d.m. and is similar to the values of sorghum flours mentioned in the literature (10.26 ... and 12.14% / d.m.)(Verma, et al., 2018).

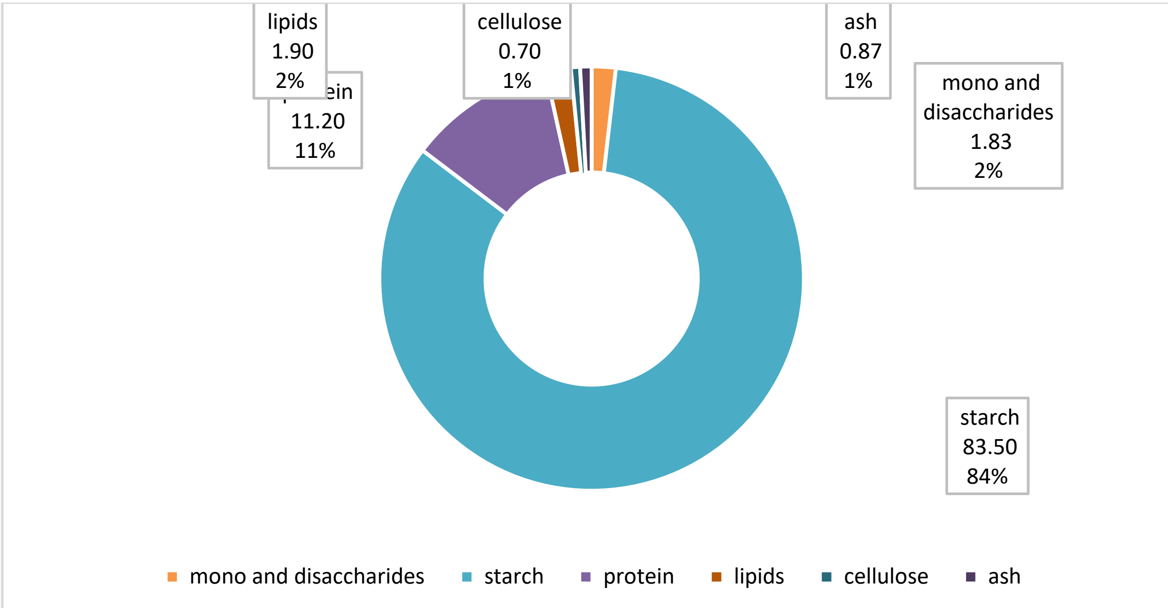

Figure 1: The chemical composition of soriz (Sorghum Oryzoidum) flour

Protein fractions in cereals directly influence their technological properties. Osborne classifies proteins according to solubility: gliadins are soluble in 70% ethanol, glutenins are soluble in dilute acid or alkaline solution, albumin is soluble in water, and globulins are soluble in dilute NaCl solutions. The focus of research on the qualitative aspects of proteins has been influenced by the technological importance of this category of nutrients. The share of albumin and globulins in the protein of sorghum flour is relatively small, constituting 12.9%. Gluten is the main protein fraction in wheat and other grains and is made up of glutenins and prolamins.

Prolamins (gliadins) and glutenins are recognized as major grain storage proteins, accounting for about 75-85% of all cereal proteins. The majority of protein fractions in soriz flour is represented by prolamine-about 58.4%, being close, by content, to sorghum (24.0… 55.0%) and followed by wheat (40.0… 42.0 %) and corn (22.6… 44.0%). The share of glutelin is about 22.1% of total protein (Figure 2). In bibliographic sources there are values of glutenin content between 18.3% and 40.0% (wheat), 39.0… 40.0% (sorghum), 26.6… 4.0 (corn) and 40, 0… 60.1% (rice).

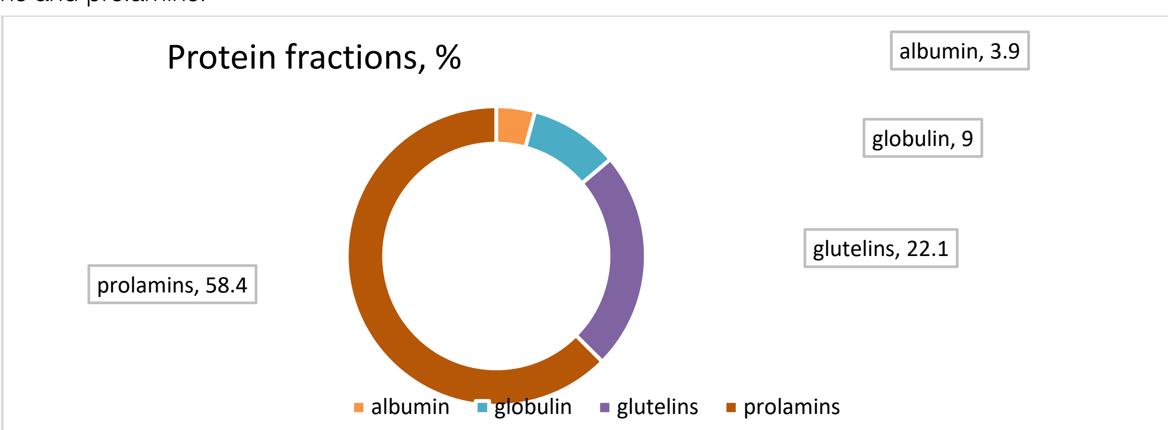

Figure 2: Protein fractions of sorghum flour

Both gliadin and glutenin comprise numerous protein components, characterized by minimal structural compositional differences (micro heterogeneity (Figoni, 2011).

These properties justify the primary role of gluten in the manufacture of bakery products. Gliadin controls the extensibility and volume of bread, and glutenins are responsible for the elasticity of the dough and its kneading conditions (Barak et al., 2014).

Although soriz flour contains gluten-generating protein fractions, it should be noted that the properties of gluten are determined by the tertiary and quaternary structure of proteins, the primary and secondary structure having a smaller role. There is a correlation between the rheological properties of the dough and the content of -SH and -SS- groups.

As the strength of the flour increases, the content of -SS- groups increases and that of -SH decreases. For a -SS - / - SH ratio of 15/19 a maximum volume of bread is obtained. The volume of bread increases with increasing protein content of flour, but depends on their quality. It is accepted that the elastic-viscous properties of the dough, which determine the quality of bakery products are the results of the interaction between the polymers of glutenins, but also between them and gliadin.

The glutenin / gliadin ratio was considered as a flour quality factor, and the optimum is assumed to be 43.5 / 46.5 or 1.0 / 1.06. The ratio of non-gluten and gluten fractions (glutenin / gliadin) in soriz flour is 1 / 2.6, which confirms the inability to form gluten in aqueous medium, and the use of flour in the manufacture of bakery products is a major challenge (Lásztity, 1996).

b) Nutritional value

i. *Amino acid content*

Cereal proteins are second - and third - class proteins, with an average biological value, compared to standard proteins, due to the presence of lysine (in some cereals threonine) in proportions lower than human needs. Knowing the amino acid content of proteins, especially the essential ones, are important indicators in assessing the nutritional quality of traditional cereal products as well as those obtained from new sources of raw materials.

Soriz flour proteins are poor in such amino acids as lysine, methionine, tryptophan, which is directly correlated with the low content of protein fractions: albumin and globulin. These nutritional fractions are usually well balanced in amino acids. The quantitative content of amino acids is found in Figure 3(Laze et al., 2019).

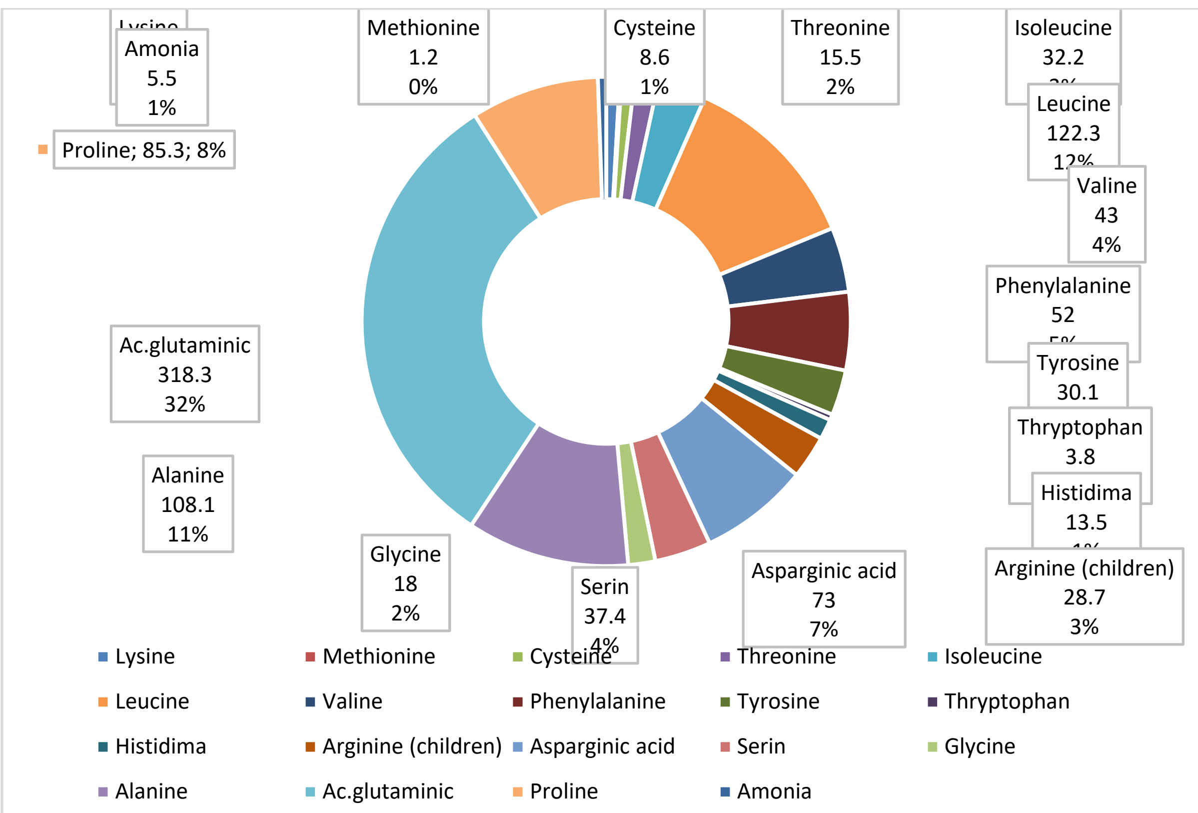

Figure 3: The amino acid content of sorghum flour

The sum of non-essential amino acids is about 68% of their total in protein (Table 3). The high content of alanine (96.0%), proline (90.01%) and glutamic acid (302.0%) is explained by the percentage distribution of protein fractions, the majority of which, in soriz flour, belongs to prolamins and which is characterized by a high content of glutamic acid (13.7 - 43.3%) and proline (6.3-19-3%) (Laze et al., 2019). The content of aromatic amino acids is 82.1 mg / g protein and, although not part of the essential amino acids, is considered to directly amplify the mental energy level.

Table 3: The amino acid content of sorghum flour Totalisation

Amino Acids	mg / g protein
∑ the total amount of AA	1000
Nitrogen metabolism index	1005,5
∑ non-essential AA	682,3
∑ essential AA	317,7
∑ glycogenic AA	295
∑ ketogenic AA	249,0
∑ proteinogenic AA	1000
∑sulfur AA	9,8
∑aromatic amino acids AA	82,1

Essential amino acids make up 32% of the total number of amino acids. According to the results obtained, the flour flour proteins are unbalanced in most of the essential amino acids in relation to the reference protein, namely: sulfur amino acids (methionine and cysteine) (IC = 28), threonine (IC = 38.5), isoleucine (IC = 80.5), valine (IC = 86), tryptophan (IC = 38) (Figure 4).

However, the limiting amino acid remains lysine (IC = 16), which is characteristic of most cereals except corn, in which the limiting amino acid is tryptophan (Zaparrart and Salgado, 1994).

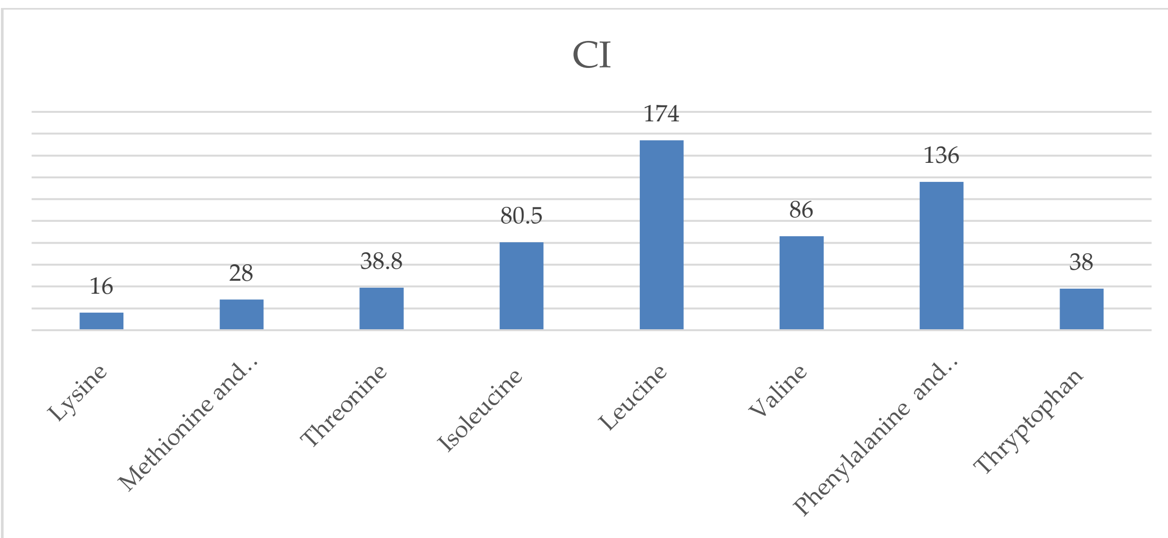

Figure 4: Chemical Index (CI) of sorghum flour

ii. *Mineral content*

The concentration of mineral elements in cereals and cereal derivatives varies depending on genotypic and environmental influences, as well as the degree of technological processing. Table 4 presents the experimental data on the content of mineral elements in soriz flour. Although the content of mineral elements in soriz flour respects almost entirely the consistency specified in the literature, namely: K> P> Mg> Ca> Na> Fe (120,1> 89,04> 33,16> 4,5> 1,19 > 1.07)(Paola Pontieri* and Jacopo Troisi, 2014), with the exception of Ca and Na, however, it is necessary to mention that the values obtained are lower than the values indicated in specialized references for sorghum and their derivatives (Tasie and Gebreyes, 2020). Soriz flour is a good source of potassium and magnesium, but is poor in calcium, iron and sodium phosphorus.

Table 4: Conţinutulunor elemente mineraleînfăina de soriz

Mineral elements	Soriz flour, mg/%.d.m.	Husked sorghum mg/g^{-1} (FAO.Codex Alimentarius Commission, 1995)	Sorghum Bicolor (L) mg kg^{-1} (Gerrano et al., 2016)
Na	1,19 ± 0,03	-	30,83
Ca	4,5 ±0,2	21	277,5
Fe	1,07 ± 0,05	2,8	55,13
K	120,1 ±0,3	1,8	1262,5
P	89,04 ± 0,06	1,15	2944,5
Mg	33,16 ±0,02	0,3	1237,5

iii. *Content of antinutritional substances*

In addition to the nutrients so necessary for the development of vital processes, cereals also contain a number of factors (tannins, phytates), which reduce or block the assimilation of nutrients. Subsequently, it has been shown that tanning substances have the ability to precipitate saliva proteins, combine non-specifically with food proteins, forming complexes resistant to gastrointestinal enzymes, inhibit the absorption of Fe, Zn and some vitamins. Enzymes inhibited by tanning substances include proteases, lipases and amylases, which are indispensable for the subsequent degradation of proteins, lipids and polysaccharides in food into simpler and easily assimilable substances (Wu et al., 2012).

Phytic acid is found in virtually all cereal seeds, especially on the outside (coating), but also on the inside, constituting up to 80% of the plant's reserve phosphorus. The content of phytic acid in cereals varies from 0.5 to 2.0%. Due to its chemical structure, phytic acid chelates multivalent metal ions: Ca, Mg, Fe, Zn and Cu, but also forms complexes with proteins (Coulibaly et al., 2010). The bonds formed are so strong that to be cleaved requires the action of phytase, an acid phosphatase found in seeds and activated in the germination process (presence of water and acidic environment), releasing minerals for plant growth(He et al., 2007). This process is welcome for the plant, but the human body does not synthesize phytase, so it is important to know the possibilities of reducing phytates in the human diet.

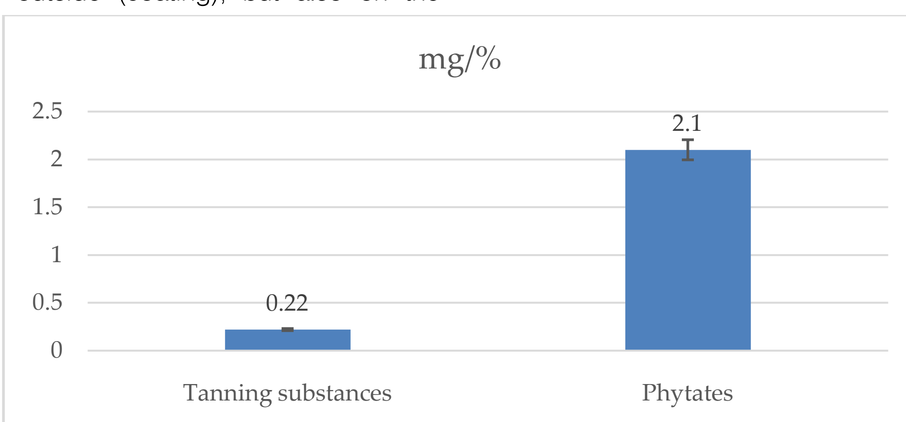

Figure 5: The content of tannins and phytates in sorghum flour

The average content of tannins and phytates is shown in Figure 5. The results obtained are comparable to the content of tannins in other cereals such as sorghum (0.23 ... 0.51mg /%), white Indian millet (0.06%) , brown Indian millet (3.74 mg /%). In the human diet the daily consumption of tanning substances in a varied diet can be estimated at 1.0 - 2.5 grams E to mention that the action of anti-nutrients on the body, in general, is weaker than natural toxins and is manifested only in following an unbalanced diet. Quantitative knowledge of the content of anti-nutritive substances allows the selection of appropriate technological / biotechnological processes for processing cereals, in order to reduce, to the admissible limit, the amount of nutrients.

IV. Conclusions

The chemical composition of soriz flour is complex and similar to cereal flours, with a predominance of carbohydrates, followed by proteins, lipids, etc. Protein fractions of flour are predominant of prolamins and glutenins, but are not gluten-generating. The proteins of soriz flour are unbalanced in most essential amino acids in relation to the reference protein, namely: sulfur amino acids, threonine, isoleucine, valine, tryptophan. The obtained results confirm that the nutritional quality of sorghum flour proteins, evaluated according to the chemical index, is low. Therefore, their association with other foods such as eggs, meat, fish, milk, whose proteins are balanced in essential amino acids, is justified. Soriz flour is a good source of potassium and magnesium, but is poor in minerals (phosphorus, calcium, iron and sodium).The content of tannins and phytates is close to the values mentioned in the literature for other categories of cereal flours. Soriz can be used in both common and gluten-free diets, helping to diversify the range of cereals and increase food security.

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Conflicts of Interest: Declare conflicts of interest or state "The authors declare no conflict of interest."

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