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Evaluation of the Physicochemical Properties, Minerals and Aflatoxins in Soybeans of the *Zamboane* Variety TGZ 19046F from Zambézia, Mozambique

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Abstract

The objective of this study was to evaluate the physicochemical, properties, mineral and the presence of aflatoxin in soybeans of a new variety (of Zamboane TGZ 19046F) introduced in Mozambique. The soybeans were analyzed for physicochemical properties (protein, fat, ash, moisture and carbohydrates) and minerals (calcium, iron, phosphorus, potassium and sodium and ashes) and the presence of aflatoxins. On a wet basis, the content of the components found were 4.85% ash, 34.7% protein, 21.3% lipids, 29.3% carbohydrates, 9.3% moisture, 445.25 Kcal energy, 0.52 mg phosphorus, 16.02 mg iron, 1671.86 mg potassium, 67.16. Sodium and calcium contents were not detected. Regarding the analyses for the extraction of aflatoxins in the sample of soybeans under study, there was no aflatoxins presence. All the results found in this study are within the parameters found in the literature, and this variety can be used for animal and human consumption production.

Keywords: Soybeans; Physicochemical properties; Minerals; Aflatoxins.

Introduction

Soybeans are one of the most cultivated crops in the world and are a good source of proteins and amino acids of high biological value [1]. On average, the composition of soybeans is 40% protein, 20% lipids (oil), 5% minerals, 34% carbohydrates (sugars such as glucose, fructose and sucrose, fibers and oligosaccharides such as raffinose and stachyose) [2]. This composition is influenced by growing conditions and interactions with the genotype, causing changes in flour and feed yield [3].

Among the foods of plant origin, soy stands out, not only for the quantity, but also for the quality of proteins, the lipids presence, vitamins, minerals, as well as the isoflavonoids presence, oligosaccharides and fibers, classifying it as a functional food. The use of soy as a functional food has expanded in recent years, especially in developed countries [4]. Allied to the growing concern for a healthy diet, soy occupies a stake place in the list of preference of an increasing number of consumers [2].

Soybean is an agricultural product of great worldwide interest due to the widespread applicability of its products in human and animal food and its economic value in national and international markets [5]. In Mozambique, soybeans stand out among the main crops, due to its agro-industry that serves the market of production of flours, feed, meal, oil, water-soluble extract of soybeans (soy milk) among other products.

In developing countries, protein deficiency is one of the main problems encountered. Mozambique is no exception, and currently, soy represents one of the best alternatives for this problem, because it has an adequate source of protein among vegetables, resulting from its composition in amino acids [6].

Mycotoxin contamination of food has been reported worldwide, especially in food susceptible to fungal growth, such as grains and cereals [7]. Despite the versatility that soy presents, its use deserves attention due to mycotoxins presence of great impact on health of consumer [7]. Mycotoxins associated with grains are one of the main causes of non-compliance with safe foods and the impurities and/or present strange matter may be related to their higher occurrence [8].

During the production process until the commercialization/processing of soybeans, the grains are subject to contamination by fungi, since soybeans are food sources of these microorganisms. The most frequently found are Aspergillus and Penicilium, the so-called storage fungi [9]. Aspergillus flavus can produce aflatoxins, toxic chemicals produced by fungi from their secondary metabolism [10]. There are several types of aflatoxins, the most stand out are four, namely B1, B2, G1, G2. The biotransformation of these aflatoxins in several animal species results in the production of mycotoxins M1 and M2 [11], which cause adverse effects on humans, animals and agriculture, resulting in diseases and economic losses.

The absence of scientific data on the physicochemical properties of the Zamboane TGZ 19046F soybean variety from Zambezia Province, Mozambique, including the literature of a publicity, motivated the realization of this study, with a view to evaluating the physico-chemical, mining and aflatoxin properties of the variety under study, in order to promote its production and use in the agro-industry to obtain soybean derivatives.

Material and methods

Study site

The study was conducted at the Department of Chemistry of the National Laboratory of Food and Water Hygiene, Mozambique. The soybean variety used was Zamboane TGZ 19046F from Zambezia, supplied by the Lozane Farm Company. The soybean was received in a single batch of 50 kg and stored at room temperature. The sample was previously cleaned and crushed in a hammer mill, obtaining fine flour. The ground samples were packed in plastic bags and kept at room temperature until the time analysis.

Evaluation of physicochemical properties

Soybeans grains were analyzed for the centesimal composition (protein, fat, ash, moisture and carbohydrates). The analyses were performed according to the standard method of the Association of Official Analytical Chemists (AOAC International). All physicochemical analyses of the grain were performed in triplicate.

In aliquots of the ground sample, ash, protein, lipid and moisture content were determined. For the determination of calcium, iron, phosphorus, potassium and sodium, a new subsample was submitted to calcination in order to obtain ashes suitable for these analyses.

Protein

The protein fraction was determined by the micro-Kjeldahl method for the quantification of total Nitrogen (N). In a Kjeldahl flask, 10g of sample was added to the catalyst mixture, using concentrated sulfuric acid (H_2SO_4) and 30% Hydrogen Peroxide (H_2O_2) as catalysts in the mineralization, causing the mixture to heat for another 30 minutes. In the distillation phase, the ammonia released in 4% solution was collected. The Nitrogen content (N) was obtained by titration of ammonia with Hydrochloric Acid 0.05 N. From the Nitrogen content (N), the percentage of total protein of the sample was calculated using the conversion factor 6.25 [12]. The results were expressed as a percentage (%) rounded up to tenths according to the formula % =

$N_2 = \frac{\text{N x 1.4 x VHCl x F}}{\text{m}}$, where N = normality of HCl, V = volume of HCl spent on titration, F = conversion factor and m = sample take.,

Fat

Fat content was determined by the Soxhlet extraction method (AOAC, 1990), which consisted of accurately weighing about 5 g of the sample on an analytical balance onto a cellulosic cartridge and covering it with a layer of previously defatted cotton and introducing petroleum ether into a flat-bottomed flask previously dried in the oven for 30 minutes, cooled in the desiccator for the same period and weighed. The soxhlet apparatus was assembled, where fat was extracted by heating in the hot water bath for 8 hours and the petroleum ether was evaporated in a rotary evaporator at temperature ≤100ºC. Dry the flask with the fat in the oven at 105ºC for 1 hour, cool in the desiccator and weigh. Then, the balloon was dried in the oven at 105ºC, 1 hour followed by subsequent cooling in the desiccator. Finally it weighed to constant weight. The results were expressed as a percentage (%) with rounding to tenths according to the formula

$$\%FAT = \frac{(m2\text{-}m1)}{m} X100$$

where m= mass of the sample taken for analysis, m1= weight of the empty flask and m2= weight of the flask with the fat.

Ash

Ash content was determined by incineration of the muffle sample. This method consisted of accurately weighing about 3g of the sample reduced to 1mm fragments for porcelain crucible previously placed in the muffle 550 ± 2ºC for an hour cooled and tarnished.

It was carefully charred with the bunsen nozzle and placed the crucible on the muffle to 550ºC until white ash was obtained. This operation took 4 hours. After this treatment, the crucible was transferred to the oven at 105ºC for 30 minutes placed in the desiccator for 30 minutes and weighed [13]. The results were presented in % with rounding to the tenths according to the formula,

$$\%Ash = \frac{(m2\text{-}m)}{(m1\text{-}m)} X100$$

where m= weight of crucible, m1= weight of crucible with the sample taken for analysis and m2= weight of crucible with ash.

Humidity

Humidity was determined by the gravimetric method with application of heat, which consisted of weighing accurately about 5g of sample reduced to fragments of 1 mm for a previously dry and weighed filter weigh, placed in the oven at 105ºC for 2 hours. Subsequently, it was transferred to a desiccator and allowed to cool and weighed until the constant weight was obtained, according to [13]. The moisture results were calculated based on the next formula

$$\%Humidity=\frac{(m\text{-}m1)}{m}X100$$

where: m= mass of the sample taken for analysis in grams and m1= mass of sample after drying.

Carbohydrates

The carbohydrate content was calculated by the difference: 100-S% of the solid constituents (protein, fat and ash) + % of moisture.

Energy value

The energy value (V.E) was calculated using the conversion factors for carbohydrates, proteins and fat, according to the formula, V. E= Sum of the % of protein × 4 + % fat × 9 + % carbohydrates × 3.75.

Minerals determination

The minerals were determined from the sub-sample submitted to muffle incineration at 550ºC, 3 hours. The contents of potassium (K), iron (Fe), sodium (Na) and calcium (Ca) were determined by atomic emission spectroscopy with inductively coupled plasma, with three replications.

Aflatoxins determination

The extraction of aflatoxin was performed by the fluorimetric method, using a kit for detection of Aflatoxin in cereals. 50 g of soybean sample previously ground in 125 ml erlenmyer were weighed, 20 ml of methanol solution: distilled water (80:20) and 1 g of NaCl, weighed previously on an analytical scale, were added to check the presence or absence of aflatoxins.

Statistical analysis: For the evaluation of the parameters studied, comparisons of means and standard deviation were performed.

Results and discussion

Physicochemical properties of soybeans

Table 1: Presents the results of the physicochemical composition of soybeans.

Table 1: Mean values of the centesimal composition (% wet base) of soybeans compared to other author.

Table 1: Presents the average results of the physicochemical properties of the soybean grains under study (Variety Zamboane TGZ 19046F) and those of other authors.

Parameters (g/100g)	Present Work	Brunelli *et al.* (2012)	Ciabotti *et al.* (2006)
Protein	34.7	37.03	32.77
Fat	21.8	18.79	15.74
Ash	4.85	4.57	3.64
Humidity	9.32	9.87	9.59
Carbohydrates	29.3	29.76	----

It is observed in Table 1 attached that the results of the physicochemical properties of the soybeans under study are found in the present study are within the values found by other authors [14,15].

The protein content of soybeans of the Zamboane TGZ 19046F variety was (34.7%). This value was higher than that found by [14]. Who obtained (32.77%) using the grain variety of common Soybean Cultivars (SC) and below the value found by [15]. Which was (37.03%) using the BRS 213 variety, which can be explained by the difference in the soybean variety used, the same can be said for the fat content (21.8), which is above the values obtained by [15]. Which was (18.67%) and above those found by [14] which was (15.74%).

Found [14,15] moisture contents (9.59% and 9.87%; respectively), similar to those found in this study.

The carbohydrate content (29.3) was similar to those found by [15] that found (29.76%).

Although the results found in the Zamboane TGZ 19046F variety are in line with those found in the common Soybean Varieties (SC) and BRS 213, there is a slight difference in the centesimal composition, which can be explained by the difference in the soybean variety used.

Minerals determination

The concentrations of phosphorus, iron, potassium, sodium and calcium are shown in Table 2.

Table 2: Average mineral contents of soybeans compared to other authors.

Parameters (g/100g)	Present Work	Felberg *et al.* (2004) [16]	Ciabotti *et al.* (2006) [14]
Phosphorus	0,52	613.05	0.664
Iron	16.02	2.82	72.266
Potassium	1671.86	1830.04	1.696
Sodium	67.16	nd	----
Calcium	nd	164.88	0.170

*nd- non detected.

Table 2 shows that the mineral contents found in this study are different from those found in this study by [16] who worked with the IAS-5 variety and by [14] who used soybean BRS 133. These differences may be associated with the soybean variety used.

In the work presented by [14] the soybean mineral composition was: calcium 0.170 g/100 g, phosphorus 0.664 g/100 g, iron 72.266 g/100 g, potassium 1,696 g/100 g and sodium not detected. In the present work the mineral composition of the soybean was phosphorus 0.52 g/100 g, iron 16.02 g/100 g, potassium 1671.86 g/100 g and calcium not detected.

The difference between the composition of the minerals of the soybeans in this study and those in the literature quoted may be associated with the differences in variety methodologies used.

The calcium content was not detected in the soybean variety under study, this fact may be associated with genetic, environmental, soil, mineralization, among others, even though soybean has an extremely low content of this mineral in its composition.

Aflatoxins determination

In soybeans of the Zamboane TGZ 19046F variety, the presence of Aflatoxins was not detected. Similar results were found by [17], when studying samples of soybeans analyzed at the Instituto Biológico between 1989 and 1999.

When [18] they evaluated the values of aflatoxins in soybean grain samples from different microregions of the states of Brazil, they found aflatoxins, despite the values being low. The averages were between 0.00 and 2.80 ppb. These authors agree that the presence of aflatoxins in these grains may be associated with production, harvesting, transport, storage and/or processing processes.

In the process carried out from cultivation to marketing/processing of soybeans, the grains are exposed to fungal contamination, as these grains are food sources of these microorganisms [18].

The major source of aflatoxin and zearalenone contamination are impurities and/or foreign matter. At the shipping stage, in order to ensure food safety in the soy production chain, a zero limit ofimpurities, [8]. The most frequently encountered genera are Aspergillus and Penicillium, the so-called storage fungi.

The absence of mycotoxins in the Zamboane TGZ 19046F soybean variety reveals that the production chain, up to the time of the analysis, observed adequate storage condition.

Conclusion

The soybeans of the Zamboane TGZ 19046F variety from Zambezia presented physicochemical and mineral properties within the parameters found in the literature.

Regarding aflatoxins, there was no presence in the soybeans under study, which does not pose a risk to public health. The mycotoxins absence, especially aflatoxins in soybeans of the Zamboane TGZ 19046F variety was largely due to favorable storage conditions. Therefore, this Zamboane TGZ 19046F soybean variety can be used for both human and animal feed. It can also be used in the improvement of population diet through of grains transformation into soybean flour, production of cooking oil, soy milk, as well as source of foreign exchange through its commercial value given its significant nutritional composition.

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