

## Chemical composition of landrace maize seeds stored under different conditions

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### Abstract

The preservation of quality, health and nutritional value of the seeds during the storage period depends not only on the conditions of production and harvesting, but the storage and maintenance of appropriate storage conditions of the product. Thus, the aim of this study was to analyze the chemical composition of seeds of landraces maize stored under different conditions. Seeds of three maize varieties Oito Carreiras, Cabo Roxo and Lombo Baio were analyzed in relation to the contents of ash, crude protein, lipids, fatty acids, total dietary fiber, soluble and insoluble, and carbohydrates. From the results it was concluded that the content of crude protein, fat and saturated fatty acids decreased with storage and that the chemical composition of the seeds of landraces of maize did not vary with the storage condition. The chemical composition of stored seeds is modified in intensity and variable speed as it progresses deterioration in reserve substances, respiratory rate, synthesis and activity of enzymes can occur, all with direct influence on the chemical composition of the seeds.

### Keywords

*Zea mays*

Storage

Chemical analysis

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### **Introduction**

The seed is the main input for food production in agriculture and in the traditional communities of small farmers brings a high cultural value and is associated with its own rationality. The quantitative chemical composition of seeds is genetically defined and can be influenced by conditions which plants were exposed. Environmental conditions prevailing during seed formation and cultural practices (fertilization and sowing dates) may cause changes in the chemical composition of the seeds (Baudet, 2012). Thus, variations can be observed depending on the species, variety, flowering physiology, nutrition and environmental conditions (Marcos Filho, 2005; Carvalho and Nakagawa, 2012).

The fact that the oilseeds deteriorate faster than the starchy seeds, confirms that the chemical composition of the seed is closely related to their storage potential (Baudet, 2012). Moreover, qualitative losses caused by the change of color of the seeds, protein degradation, carbohydrate, sugars and the production of mycotoxins affect the quality of stored seeds, causing devaluation of the product and can endanger human health (Pimentel *et al.*, 2011).

Detection of seed deterioration through the analysis of its chemical components can be understood

as a relevant factor in assessing the physiological quality, which contributes to the solution of problems of the seed industry, such as storage. Despite the considerable increase in knowledge regarding the analysis of seeds, many varieties of landrace seeds require basic information concerning the ideal conditions for germination and vigor. These varieties have great genetic variability and demand studies regarding the assessment of physiological and sanitary quality, and also in the analysis of the chemical composition of its seeds including the storage period. Considering that the knowledge of the chemical composition is important for seed technology and being the physiological and sanitary quality influenced by the content of compounds, the objective of this study was to analyze the chemical composition of landraces maize seeds stored under different conditions.

### **Material and Methods**

#### *Materials*

The experiment was conducted in the Laboratory of Physical and Chemical Analysis and in the Integrated Center for Laboratory Analysis Development (NIDAL), Department of Food Science and Technology, Federal University of Santa

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Maria (RS), Brazil. The seeds of landrace maize Oito carreiras, Lombo baio and Cabo roxo (2011/2012 season) from the Association of Landrace Seed Keepers of Ibarama, RS (29°25'10"S; 53°08'05"W, altitude: 317 m) were used. These seed batches were produced in the same area and under the same conditions of temperature of environment (climate humid Subtropical).

#### *Storage conditions*

Maize seeds were stored for nine months under two conditions: condition 1 (C1): in paper bags kraft, brown (18 cm length x 42 cm height x 6.5 cm width) at a temperature of 10°C and condition 2 (C2): in plastic packing at room temperature, both in Santa Maria / RS (29°42'24"S; 53°48'42"W altitude: 116 m) humid subtropical climate.

#### **Determination of physicochemical properties**

At the beginning and the end of the storage period we determined:

#### *Dry matter*

At 105°C; ash in oven at 550°C.

#### *Crude protein*

By the micro-Kjeldahl method (N x 6.25) according to the techniques described in AOAC (1995).

#### *Lipid*

Was determined using chloroform and methanol as described by Bligh and Dyer (1959) and also used as a preliminary step of preparing the sample for the determination of fatty acid profiles.

#### *Total dietary fiber, soluble fiber and insoluble fiber*

Were quantified according to the enzymatic-gravimetric method N°. 985.29 and N°. 991.42 (AOAC 1995), which analytically determines the levels of insoluble dietary fiber and total and quantifies, for difference, the soluble fiber content of the sample. The enzymes used in the enzymatic methods were  $\alpha$ -amilase (Termamyl 2X<sup>®</sup>), protease (Alcalase 2.4 L FG<sup>®</sup>) e amyloglucosidase (AMG 300 L<sup>®</sup>), all produced by Novozymes Latin American Limited, Araucária, PR, Brazil.

#### *Non-fiber carbohydrate*

Was calculated by difference and obtained as described in Mayer *et al.* (2007). Analytical data were obtained in duplicate and their final values were calculated to dry basis.

#### *Fatty acid*

The extracted lipids were used for derivatization of triglycerides into fatty acid methyl esters (FAME) according to the method of Hartman and Lago (1973). Lipids were derivatized using KOH (0.4M) and sulphuric acid (1M) methanolic solutions with heating by 10 min in a water bath at 100°C for each solution. The FAME were extracted with hexane and determined by gas chromatography Agilent Technologies 6890N series, equipped with a capillary column (Supelco SP2560, Sigma-Aldrich) (100 m x 0.25 mm id x 0.2  $\mu$ m thick film) and a flame ionization detector (FID). The heating program was started with the column 170°C for 2 minutes, and gradual increase of 3°C per minute to a final temperature of 240°C and remained so for 7 minutes. Nitrogen was used as the carrier at 0.9 mL.min<sup>-1</sup> gas. The injected sample volume (split mode) was 1  $\mu$ L. The temperature used for the detector (FID) was 280°C. The fatty acids were identified by comparison with retention times of reference standards (Supelco 37 FAME mix ref. 47885-U, Sigma, Bellefonte, USA). The retention times and areas were automatically computed by Agilent ChemStation software.

#### *Statistical analyses*

The experimental design was a completely randomized with treatments arranged in a 2 x 2 factorial (condition x storage time). Comparisons between treatment means were performed using Tukey test at 5% probability.

## **Results and Discussion**

Through data analysis of chemical composition variables in maize seeds (initial and after nine months of storage), we observed no significant difference in the two storage conditions for Oito carreiras, Cabo roxo and Lombo baio seeds. Thus, the results are presented indicating for each variable, only the differences between the storage times (initial and final).

At the end of the storage period had a significant increase in the percentage of ash in landrace maize seeds regardless of storage conditions used (Table 1). Similar results observed by Radünz *et al.* (2004) with different storage methods in different periods concluded that, regardless of the storage system, maize seeds showed significant increase in ash content, reflecting in a reduction of quality.

During the storage period, the mineral content represented by the ash content is the fraction that showed the lowest changes in its total content. The metabolic activity of seeds and associated

Table 1. Percentage of ash, crude protein, lipid and non-fiber carbohydrates in seeds of landraces of maize evaluated at different times (0 and 9 months) and storage conditions

Chemical composition	Storage	Condition 1	Condition 2
Ash	Initial	1,45 b*	1,45 b
	Final	2,44 a	2,03 a
Crude protein	Initial	10,13 a	10,13 a
	Final	9,75 b	9,37 b
Lipids	Initial	5,79 a	5,79 a
	Final	4,50 b	5,04 b
Non-fiber carbohydrates	Initial	64,05 <sup>ns</sup>	64,05 <sup>ns</sup>
	Final	65,63 <sup>ns</sup>	66,48 <sup>ns</sup>

\* Averages followed by the same lowercase letter in the column do not present relevant difference at 5% of probability level by Tukey's test. <sup>ns</sup> = not significant

microorganisms consume the organic matter metabolizing it to carbon dioxide, without changing the mineral composition. Consequently increasing the intake of organic material the ashes will raise (Elias, 2008).

Considering the crude protein content at the end of the storage period, there was a significant decrease in its content, regardless of storage conditions (Table 1). Similar results were obtained by Radünz *et al.* (2004), with a significant reduction in the percentage of total protein after six months of storage in seed corn. Taking into account the physical, chemical and biological factors on storage conditions, protein losses occur due to the intrinsic chemical characteristics of degradation and/or of a request of its constituents (Ferrari Filho, 2011; Schuh *et al.*, 2011).

According to Carvalho and Nakagawa (2012) proteins (basic components of all living cells) also act as a backup material. During storage, the protein fraction undergoes chemical reactions with other components of the seeds themselves. Some of these reactions characterize the process of putrefaction seeds, giving them strong and unpleasant odors. These changes may cause darkening on the seeds, decrease in protein nitrogen content and increased content of non-protein nitrogen (Elias *et al.*, 2002).

The percentage of lipids of maize seeds decreased significantly at the end of the storage period, regardless of storage conditions used, with values ranging from 5.79% to 4.50% (condition 1)

Table 2. Percentage of fatty acids in seeds of landraces of maize evaluated at different times (0 and 9 months) and storage conditions

Chemical composition	Storage	Condition 1	Condition 2
Saturated fatty acids	Initial	21,34 a*	21,34 a
	Final	17,25 b	17,80 b
Monounsaturated fatty acids	Initial	32,43 b	32,43 b
	Final	33,56 a	33,69 a
Polyunsaturated fatty acids	Initial	42,56 <sup>ns</sup>	42,56 <sup>ns</sup>
	Final	45,96 <sup>ns</sup>	46,29 <sup>ns</sup>

\* Averages followed by the same lowercase letter in the column do not present relevant difference at 5% of probability level by Tukey's test. <sup>ns</sup> = not significant

and 5.04% (condition 2), as can be seen in Table 1. The largest variations in the percentage of lipids are due to increased consumption of reserve substances seeds, due to the occurrence of biochemical processes in seed mass (Radünz *et al.* 2004).

Besides, Elias *et al.* (2002) and Elias (2008) reported that lipids characterize the constituent fraction more susceptible to seed deterioration during storage, either by reducing their total and/or the susceptibility to structural changes content. The chemical instability of lipids is one of the main factor in the decrease in performance of the seeds of various species factors. Some of them like grasses, for example, despite the predominance of starch in the endosperm lipids present in the embryo, making them also prone to deterioration (Marcos Filho, 2005).

The results of this study are similar to those obtained by Gutkoski *et al.* (2009), which showed a reduction in lipid content during the storage of dried corn seeds and stored in fence granary with forced natural air. Likewise, Abreu *et al.* (2013), working with sunflower seed concluded that oil content in the seeds declined over time regardless of storage condition. As for the percentage of non-fiber carbohydrates, it was observed that there was no significant difference in seed corn (Table 1), regardless of the period and storage condition. Similar results were obtained by Belmiro *et al.* (2010) who found that the carbohydrate content in pumpkin seeds (*Curcubita moschata*) remained unchanged after the storage period.

Although not significant in this study, the increase in the percentage of carbohydrates is

Table 3. Percentage of dietary fiber in landrace maize seeds assessed at different times (0 and 9 months) and storage conditions

Chemical composition	Storage	Condition 1	Condition 2
Total dietary fiber	Initial	18,57 <sup>*ns</sup>	18,57 <sup>ns</sup>
	Final	17,54 <sup>ns</sup>	17,19 <sup>ns</sup>
Soluble fiber	Initial	1,35 <sup>ns</sup>	1,35 <sup>ns</sup>
	Final	1,19 <sup>ns</sup>	1,14 <sup>ns</sup>
Insoluble fiber	Initial	17,23 <sup>ns</sup>	17,23 <sup>ns</sup>
	Final	16,34 <sup>ns</sup>	16,04 <sup>ns</sup>

\* Averages followed by the same lowercase letter in the column do not present relevant difference at 5% of probability level by Tukey's test. <sup>ns</sup> = not significant

related to the decrease between the protein and lipid fractions during storage (Schuh *et al.* 2011). Regarding the fatty acids, we have observed that the content of saturated fatty acids decreased during the storage period with values ranging from 21.34% to 17.25% (condition 1) and 17.80% (condition 2) (table 2). There was also a significant difference in the percentage of monounsaturated fatty acids with values ranging from 32.43% to 33.56 (condition 1) and 33.69% (condition 2) and there was no significant difference in the content of polyunsaturated fatty acids, regardless condition used.

According Biaggioni *et al.* (2007), the loss of seed quality during storage, long before being detected by any loss in viability is accompanied by other deteriorative changes, among which we can highlight the increasing levels of fatty acids. Thus, the evaluation of fatty acid is an efficient conservative control parameter during storage, since the increase in the content thereof is directly correlated with the rate and extent of deteriorating process seeds (Elias *et al.* 2002). The release of fatty acids is not uniform and the degradation occurs differently from an acid to another (Jham *et al.*, 2008).

Thus, the content of fatty acids can be an indicator of seeds deterioration, since during storage the hydrolysis of fatty materials starts before hydrolysis of carbohydrates and proteins. Therefore using the analysis of fatty acids is important to monitor the quality of the seeds from maturation because the lost of the vigour leads the lost of viability (Biaggioni and Ferreira, 1998). According to Freitas (2009), the intensity and speed of deteriorating process in seeds may be related to the chemical composition thereof.

Thus the seeds with higher fat content will have greater predisposition to the deteriorating process, especially in those with higher content of unsaturated fatty acids.

The studies of these authors Coradi *et al.* (2008), Saath *et al.* (2012), Ribeiro (2013) observed increases in fatty acid content in coffee seeds through the fat acidity test, due to the increase of the storage period. Also, Pereira *et al.* (2010) found that the amount of fat acidity increased during storage of soybean seeds refrigerated and non-refrigerated. As a percentage of total soluble and insoluble dietary fiber in maize seeds (Table 3) it was observed that there was no significant difference over the storage period in both conditions used. Similar results were obtained by Belmiro *et al.* (2010) in relation to the storage time in the pumpkin seeds where averages of crude fiber showed no statistical variation throughout the study period (180 days).

At the end, it is important to consider that the chemical composition of stored seeds is modified in intensity and speed. As the deterioration progresses changes in reserve substances, respiratory rate, synthesis and activity of enzymes can occur, all with direct influence on chemical composition of the seeds (Marcos Filho 2005). Qualitative losses caused by deterioration affecting the quality of stored seeds, causing devaluation of the product and threat to human health (Pimentel *et al.*, 2011).

## Conclusions

The crude protein, lipid and saturated maize seed fatty acids decreased with storage. The chemical composition of maize seeds did not vary with the storage condition.

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