

ORGANIC MAIZE: CHANGES IN AMINO ACID COMPOSITION

Dayana Cristina de Oliveira Pereira¹, Rodrigo Henriques Longaresi¹, Gustavo do Valle Pereira¹, Diego Fontebasso Pelizari Pinto¹, Sérgio Kenji Homma¹, Luiz Carlos Demattê Filho¹

ABSTRACT - The aim of this study was to assess the bromatological quality and the content of essential amino acids in maize grains produced using two different cropping systems: organic and conventional. The experimental area was four hectares, divided into two hectares per system. In the conventional management, agrochemicals from conventional maize production were used. In the organic management, inputs permitted by the current Brazilian legislation on organic production were used. For each system, 10 plots of 9 m² each were established, from which experimental samples were harvested. A significant difference was found in the bromatological quality of maize grains. The conventional management provided greater crude protein content. Significant changes were also found in the following amino acids: methionine, threonine, arginine, isoleucine, leucine, valine, histidine, and phenylalanine, which showed lower levels in the organic management. The results confirm the need to determine food composition before diet formulation, since using preestablished food compositions probably leads to differences between what was formulated and what was actually given to poultry. The type of management influenced the quality of maize grains. The management of plant nutrition in the organic system should be refined to adequately supply nitrogen, thus improving bromatological and amino acid quality of the grains.

Keywords: amino acids, ecological management, methionine, threonine.

MILHO ORGÂNICO: MUDANÇAS NA COMPOSIÇÃO AMINOACÍDICA

RESUMO - O objetivo desta pesquisa foi avaliar a qualidade bromatológica e o teor dos aminoácidos essenciais em grãos de milho produzidos em dois sistemas de produção: orgânico e convencional. A área experimental era de quatro hectares, dois hectares por tratamento. No manejo convencional utilizou agroquímicos permitidos para a produção convencional da cultura. No manejo orgânico utilizou os insumos permitidos pela legislação orgânica vigente. Para cada tratamento estabeleceu-se 10 parcelas experimentais de 9 m². Estas foram colhidas individualmente para obtenção das amostras experimentais. Houve diferença significativa na qualidade bromatológica dos grãos de milho. O manejo convencional proporcionou maior teor de proteína bruta. Também foi observado alterações significativas na porcentagem dos aminoácidos metionina, treonina, arginina, isoleucina, leucina, valina, histidina e fenilalanina, os quais foram inferiores no manejo orgânico. Tal resultado ratifica a necessidade de determinar a composição dos alimentos antes da formulação das rações, uma vez que, utilizar as composições dos alimentos preestabelecidas provavelmente implique em diferenças entre o que foi formulado e o que de fato foi consumido pelas aves. O manejo empregado alterou a qualidade dos grãos de milho. A nutrição no manejo orgânico deve ser aprimorada para disponibilizar maiores quantidades de minerais ao milho melhorando a qualidade bromatológica e aminoacídica dos grãos.

Palavras chave: aminoácidos, manejo ecológico, metionina, treonina.

¹ Researcher at Centro de Pesquisa Mokiti Okada - CPMO. E-mail address: dayana.pereira@cpmo.org.br



INTRODUCTION

The Brazilian maize yield in 2015/2016 was 82 million tons harvested in an area of approximately 16 million hectares (Conab, 2016). There are no official reports informing the proportion of organic maize, which hinders the establishment of a productive chain that meets national demands for the grain.

Low supply of organic maize partly stems from difficulties in the production process. Low efficiency in weed control without using herbicides, lack of genetic materials adapted to organic management, and low supply of efficient nitrogen sources are problems to be addressed.

It is estimated that 51% of the Brazilian maize yield is used in the poultry industry (Batista, 2016). Maize is the main energy source for these animals, as well as an important source of protein and amino acids (Lima, 2000). This cereal constitutes up to 80% of poultry diets, and its main limitation is the low content of lysine and tryptophan (Brito et al., 2005).

Although national tables of food composition provide standard nutritional values, several management-related factors may change maize production and quality (Bento, 2011), greatly affecting diet formulation. Thus, we hypothesize that maize grains differ in terms of nutritional quality depending on the cropping system (organic or conventional) adopted.

In the context of tendency of formulating diets based on the concept of precision livestock farming and due to the increasing demand for using less agrochemicals, the aim of this study was to assess the bromatological quality and the content of essential amino acids in maize grains produced using two cropping systems: organic and conventional.

MATERIALS AND METHODS

The experiment was conducted during the 2015/2016 harvest in the municipality of Mogi Guaçu, state of São Paulo, Brazil, at the geographic coordinates 22° 07' 58" S, 47° 10' 30" W, and at an altitude of 648 meters. This is a tropical wet climate region characterized by dry winters and rainy summers. Maximum, minimum, and mean temperatures were 33.5°C, 19°C, and 26.3°C, respectively. Precipitation in this period was 1,057 mm. Soil in the experimental area consisted of oxisol with 14%, 14%, and 72%

of clay, silt, and sand, respectively, at a depth of 0 to 20 cm. Chemical fertility of the soil layer used for conventional and organic management is shown in Table 1.

The two cropping systems were implemented in an experimental area of four hectares, divided into two hectares per system. Conventional management used the necessary and sufficient inputs to establish the crop with no phytosanitary and phytotechnical damages (Table 2). Organic management, in turn, used only inputs permitted by the law no. 10.831, of December 23, 2003 (Brasil, 2003) and regulated by the regulatory instructions no. 46, of October 6, 2011 (Brasil, 2011) and no. 17, of June 18, 2014 (Brasil, 2014).

The final population of hybrid maize consisted of 60,000 plants ha⁻¹ with plants spaced 45 cm. The experiment lasted 156 days, which was the period between sowing and harvesting.

Fourteen days after seedling emergence, the area of each cropping system was divided into 10 plots of 9 m² each. Cobs were manually harvested to obtain experimental samples. The method described by Silva & Queiroz (2002) was used to determine bromatological quality. Near-infrared reflectance spectroscopy (NIRS) was used to quantify essential amino acids.

Data were evaluated using analysis of variance (ANOVA). The Shapiro-Wilk test and Bartlett's test were used to assess normality of data and homogeneity of variances. Means were compared using Tukey's post hoc test at the 5% significance level.

RESULTS

A significant difference was found in the bromatological quality of maize grains. The conventional management provided greater crude protein content. The other variables did not show a statistically significant change (Table 3).

Regarding the content of essential amino acids, organic management showed lower levels ($P < 0.05$) of methionine, threonine, arginine, isoleucine, leucine, valine, histidine, and phenylalanine (Figure 1).

Abbreviations: Met: methionine, Lys: lysine, Thr: threonine, Trp: tryptophan, Arg: arginine, Ile: isoleucine, Leu: leucine, Val: valine, His: histidine, Phe: phenylalanine.



Table 1 - Soil fertility in the conventional and organic management systems

Management	pH	OM	P	S	K	Ca	Mg	H+Al	Al	V
	CaCl ₃	g dm ⁻³	mg dm ⁻³		mmol dm ⁻³					%
Conv.	5.8	10.0	27.0	9.6	0.9	18.0	5.4	17.0	0.4	59.0
Org.	6.1	15.0	22.0	6.7	1.5	21.0	5.6	15.0	0.4	65.0

Abbreviations: Conv: conventional, Org: organic, OM: organic matter, P: phosphorus, S: sulfur, K: potassium, Ca: calcium, Mg: magnesium, H+Al: hydrogen + aluminum, Al: aluminum, V: base saturation.

Table 2 - Description of inputs used in the conventional and organic maize management systems

Management	Basal fertilizer application, kg ha ⁻¹	Top-dressing fertilizer application, kg ha ⁻¹	Pest control	Weed control
Conv.	200 kg of organomineral fertilizer 4-8-6	200 kg of organomineral fertilizer 4-8-6	Methomyl, teflubenzuron, sulfur, lambda-cyhalothrin,	Chlorpyrifos, atrazine, S-metolachlor
Org.	200 kg ha ⁻¹ of organic fertilizer ¹ 3-3-3	200 kg ha ⁻¹ of organic fertilizer ¹ 3-3-3	chlorantraniliprole Azadirachtin A/B, <i>Bacillus thuringiensis</i>	Mechanical cultivator

Abbreviations: Conv: conventional, Org: organic. ¹Microgranular poultry manure.

Table 3 - Bromatological quality of maize grains from conventional and organic management systems

Management	Dry matter (%)	Crude protein (%)	Crude fiber (%)	Ethereal extract (%)	Mineral matter (%)
Conv.	86.59 ± 0.15 ^a	9.86 ± 0.17 ^a	2.51 ± 0.10 ^a	3.48 ± 0.28 ^a	1.43 ± 0.02 ^a
Org.	87.14 ± 0.20 ^a	9.28 ± 0.12 ^b	2.49 ± 0.10 ^a	3.65 ± 0.46 ^a	1.34 ± 0.02 ^a
CV (%)	0.50	4.99	9.00	23.90	5.00

(1) Same letter along the same column denotes no significant difference by Tukey's post hoc test at the 5% significance level. Abbreviations: Conv: conventional, Org: organic, CV: coefficient of variation.

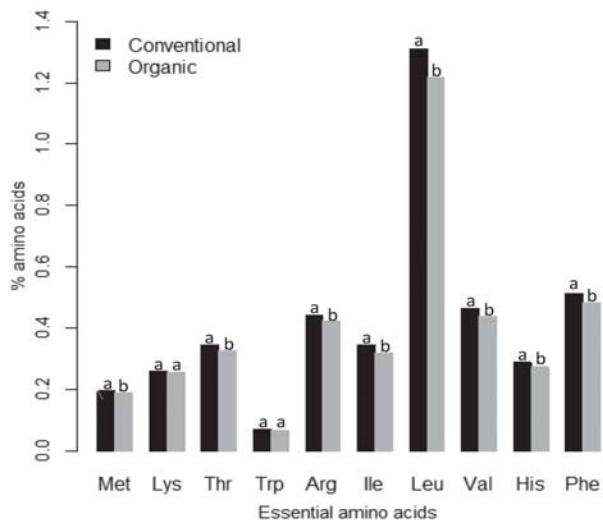


Figure 1 - Essential amino acid quantification (%) in conventional and organic maize grains.

Abbreviations: Met: methionine, Lys: lysine, Thr: threonine, Trp: tryptophan, Arg: arginine, Ile: isoleucine, Leu: leucine, Val: valine, His: histidine, Phe: phenylalanine.

DISCUSSION

Several studies have shown changes in maize quality due to agricultural management and emphasized the influence of nitrogen fertilization on the percentage of crude protein (Hawkesford et al., 2012). Thus, the greater crude protein content found in the conventional management may be associated with the type of input used in each system. In the organic management, an organic source was used, while in the conventional management, a combination of organic and mineral (organomineral) fertilizers was used. This shows the need to refine the organic management in order to increase nitrogen content in maize crops. Possible solutions include the use of legumes in rotation, intercropping, and the development of specific fertilizers to this management modality.

Another point to be considered is the genetic material used in the experiment. Pereira et al. (2017) also compared the quality of organic and conventional

maize grains and found higher levels of crude protein in the organic cropping system, which used open-pollinated cultivars. According to Made & Lambert (2007), open-pollinated seeds have not been genetically modified to increase productivity, a process that results in loss of nutrients such as protein and oil. Therefore, initiatives that promote the production of seeds adapted to organic management are necessary.

Regarding to the maize essentials amino acids, the crop managements provided differences on their profiles. The conventional maize showed higher content in eight out of ten essential amino acid, when it was compared to the organic maize ($P < 0.05$) (Figure 1). The methionine and threonine were among these eight higher amino acid contents and they are considered the first and third limiting amino acid to poultry growing. Ribeiro (2016) found similar result in a study which the higher dose of mineral nitrogen provided greater foliar nitrogen and total amino acid content.

The change in amino acid levels may be related to the availability of nutrients. In organic fertilizers, commonly used in organic management, the percentage of total mineralized nitrogen is approximately 40 to 60%, in a process that depends on soil moisture and temperature. Conversely, mineral fertilizers such as urea show a mineralization rate above 90% (Agehara & Warncke, 2005). Furthermore, yield increase has been reported when mineral nutrients are associated with organic material in fertilization (Kiehl, 1993). Such interaction, thus, may have contributed to increase differences in maize quality in the present study, since this association was used only in the conventional management.

In addition to issues related to fertilization management, it should be noted that the principle of the organic system is soil and productive environment balance, which, according to Theodoro (2001), requires 2- to 3-year intervals. Another important point is that the contents of protein (9.28) and essential amino acids found in organic maize grains are consistent with, or in some cases even higher than, the results described by Rostagno et al. (2011).

The lower content of essential amino acids found in organic grains shows the importance of the regulatory instruction n°. 17 (Brasil, 2014), which permitted the use of synthetic amino acids in the Brazilian organic production. The main objective of this permission was

to prevent deficiency diseases, in view of the importance of proteins in immune response (Trevisol, 2016) and the lack of natural and efficient sources of amino acids (Demattê et al., 2015). The results of the present study also confirm the need to determine food composition before diet formulation, since using preestablished food compositions probably leads to differences between what was formulated and what was actually given to poultry.

CONCLUSIONS

Higher levels of protein and essential amino acid contents were found in the conventional management; however, the levels found in the organic grains are compatible with the recommended values in the literature. The management of plant nutrition in the organic system should be refined to adequately supply nitrogen, thus improving bromatological and amino acid quality. Furthermore, genetic materials should be developed with the purpose of accumulating greater amino acid content in organic management systems.

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