Alan Mario Zuffo
(Organizador)

A produção do Conhecimento nas Ciências Agrárias e Ambientais

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APRESENTAÇÃO

A obra “*A produção do Conhecimento nas Ciências Agrárias e Ambientais*” aborda uma série de livros de publicação da Atena Editora, em seu I volume, apresenta, em seus 28 capítulos, com conhecimentos científicos nas áreas agrárias e ambientais.

Os conhecimentos nas ciências estão em constante avanços. E, as áreas das ciências agrárias e ambientais são importantes para garantir a produtividade das culturas de forma sustentável. O desenvolvimento econômico sustentável é conseguido por meio de novos conhecimentos tecnológicos. Esses campos de conhecimento são importantes no âmbito das pesquisas científicas atuais, gerando uma crescente demanda por profissionais atuantes nessas áreas.

Para alimentar as futuras gerações são necessários que aumente à quantidade da produção de alimentos, bem como a intensificação sustentável da produção de acordo como o uso mais eficiente dos recursos existentes na biodiversidade.

Este volume dedicado às áreas de conhecimento nas ciências agrárias e ambientais. As transformações tecnológicas dessas áreas são possíveis devido o aprimoramento constante, com base na produção de novos conhecimentos científicos.

Aos autores dos diversos capítulos, pela dedicação e esforços sem limites, que viabilizaram esta obra que retrata os recentes avanços científicos e tecnológicos, os agradecimentos do Organizador e da Atena Editora.

Por fim, esperamos que este livro possa colaborar e instigar mais estudantes, pesquisadores e entusiastas na constante busca de novas tecnologias para as ciências agrárias e ambientais, assim, garantir perspectivas de solução para a produção de alimentos para as futuras gerações de forma sustentável.

Alan Mario Zuffo

SUMÁRIO

CAPÍTULO 25

CAN THE PHYSICOCHEMICAL CHARACTERISTICS OF THE SOIL OF THE COASTAL PLAIN OF THE BRAZILIAN STATE OF RS INTERFERE IN THE NUTRITIONAL VALUE OF PUITA INTA CL RICE?

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ABSTRACT: Rice (*Oryza sativa*) is one of the most consumed foods in the world, being one of the most important grains in global economic terms. This research was to evaluate if the physicochemical characteristics of the soil in rice fields of the Internal and the External Coastal Plain of the Brazilian State of RS have the potential to modify the nutritional value of the rice cultivar PuitaInta CL. This study evaluated the nutritional composition, the total phenolic compounds content and the antioxidant activity of brown and polished grains of PuitaInta CL rice from two different areas. Samples were collected during two crop years.The nutritional content, phenolic content and antioxidant content were tested by the Mann Whitney method, in which samples are compared, obtaining the result that brown rice and polished rice have different characteristics, depending on the place where it is cultivated ($p < 0.001$), and that there is no temporal difference ($p > 0.05$). The 18 physicochemical variables were analyzed by principal component analysis (PCA), followed by MANOVA. Results from PCA showed that the first three axes explain 74.19%. The first axis (47, 12%) includes the variables: regions, phosphorus, pH, potassium saturation, calcium / magnesium ratio, clay and organic matter. The second axis (15.79%) includes: calcium / potassium ratio and effective electron exchange capacity. The third axis includes: (11, 28%) potassium. The resulting spatial pattern shows a significant difference between the soils of each region as demonstrated by MANOVA (Wilk's Lambda: 0.008, $p < 0.0001$ and $F = 61.6$).

KEYWORDS: *Oryza sativa*, Coastal Plain, soils, nutrients.

1 I INTRODUCTION

Rice is one of the most cultivated cereals in the world for direct human nutrition and as an input to the food industry. Trends in the food industry are making rice, especially organic and brown, to be increasingly sought after due to its health benefits (CONAB, 2018).

The cultivation systems employed for the production of irrigated rice are: conventional, direct, minimum and pre-germinated (EMBRAPA, 2016). Each system is characterized by different types of soil management and the crop itself. The State of Rio Grande do Sul presents several lowland soil classifications, which may be suitable or not for irrigated rice cultivation such as Planosols, Gleysols, Chernosols and Neosols, among others (PINTO et al., 2004). The soil is composed of microhabitats that differ in their physicochemical properties (CARSON et al., 2009). These characteristics determine a diversified composition of microorganisms where any change, physical or chemical, causes modifications in the community of organisms (PANIZZON et al., 2016). The availability of oxygen, moisture ratio, temperature range, available organic matter and pH are factors that directly affect the soil and consequently the plants and their products that are used in both animal and human feeding (FEIGI et al., 1998).

In foods, antioxidants, for example, are molecules capable of reducing or preventing oxidation. Due to the risks of consuming synthetic antioxidants, research studies on natural products that contain antioxidant activity have increased with the aim of replacing the synthetic antioxidants (MENDIOLA et al., 2010). Among the sources of phenolic compounds, rice plays an important role in diet because it contains distinct phenolic compounds, such as tocopherols, tocotrienols and g-oryzanol, mainly associated with the pericarp. However, grain polishing reduces the concentration of phenolic compounds in the endosperm, which remain in the bran from where be limited to carbohydrates or proteins making the hydrolysis process important to obtain the maximum yield of phenolic acids if you want to recover them (OLIVEIRA et al., 2012).

The present work aimed to examine if the physicochemical characteristics of the soil can influence the nutritional composition of polished and brown rice of the cultivar Puitá INTA-CL, cultivated in the crop years 2013/14 and 2014/15, in the rice-growing regions of the Internal Coastal Plain and the External Coastal Plain, RS-Brazil.

2 I MATERIAL AND METHODS

The analyzed sites (Fig. 1) were the districts of Santo Antônio da Patrulha (PCE)-RS: 29°50’18’’S and 50°30’58’’W and Charqueadas (PCI) - RS: 29°97’04.9’’S and 051°31’33.2’’W.

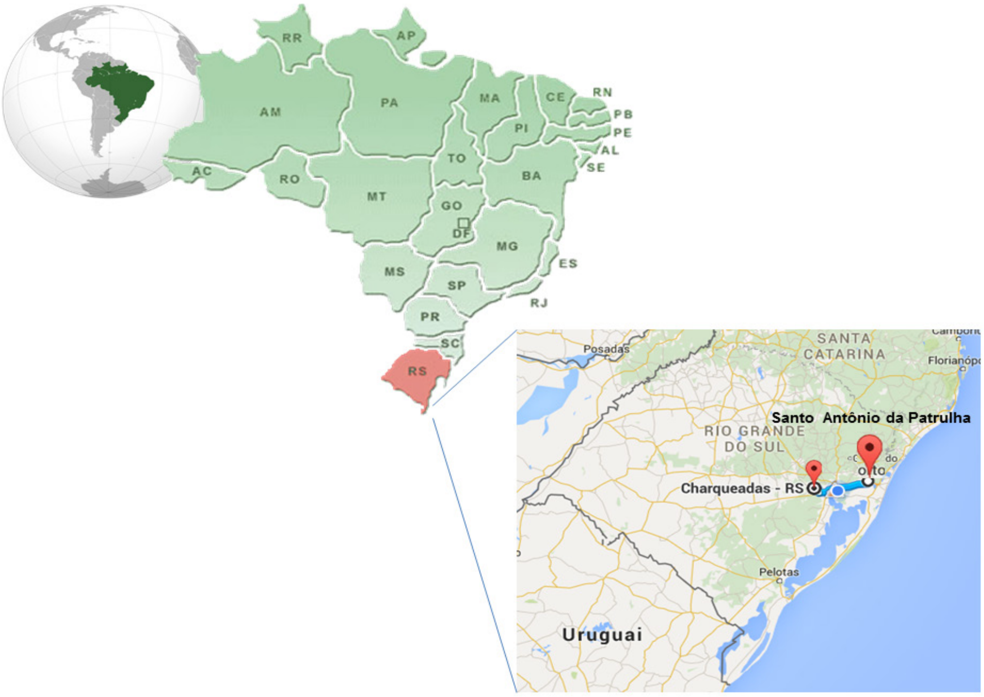


Figure 1: Sampling sites in the External Coastal Plain(large dot) and Internal Coastal Plain (Small dot) of Rio Grande do Sul State, areas in Brazil, during the crop years of 2013/14 and 2014/15, evaluated in this study.

This article is a continuation of a survey conducted at UNISINOS. We used the same methodology for a grain and soil collection by Panizzon et al (2017). However, the present article aimed to disseminate physicochemical compounds of the soil with a nutritional part of the grain produced in this area.

2.1 Studied rice plant

The sampled cultivar was Puitá INTA-CL in crops of minimum tillage, which are areas that are not heavily manipulated throughout the planting process. Cultivar Puitá INTA-CL is a variety resistant to herbicides, with an average cycle of 125 days, having low height, with an average height of 86 cm which makes it resistant to lodging. Samples were collected in four periods of the crop cycle: one collection after soil before sowing, two collections in the vegetative phase, two collections in the reproductive phase and two during seed maturation, with a total of seven collections in each crop year for each crop (IRGA, 2018).

2.2 Rice samples

The grains were collected by tractor in each of the studied properties and were taken to the Rice Experimental Station (IRGA), which carried out actions such as grain transport, reception, pre-cleaning, drying and storage. Essentially, consisting of the industrial process of turning the rice grain from the crop into a processed food product: polished rice and brown rice (IRGA, 2018).

2.3 Centesimal composition

The analyses of nutritional composition were performed according to the norms of the Adolfo Lutz Institute (2008). The dry extract was obtained by determining the humidity by subjecting the samples to oven heating at 105° C to constant weight. The ashes were obtained by incineration in a muffle furnace at 550° C. Lipids and proteins contents were obtained by the methods of Gerber and Kjedhal, respectively. Fiber content was determined by the AOAC (2012) method and the determination of carbohydrates was obtained by the difference of the others. All analyses were performed in triplicate.

2.4 Rice extract

2 g of milled rice was added to 40mL of the acetone / water / acid solution (70:29:1, v/v/v) and left to stand for 1 hour in an ultrasonic water bath. The mixture was centrifuged at 5000 rpm at 20° C for 20 minutes. The supernatant was collected for the determination of antioxidants and phenolic content. This extract was used for the determination of DPPH and phenolic compounds (QIUA et al., 2010).

2.5 DPPH method

Antioxidant activities were determined using DPPH as a free radical. For each antioxidant, different concentrations were tested (expressed as the number of moles of antioxidant / mole of DPPH). The antioxidant solution of methanol (0.1 mL) was added to 3.9 mL of 6 x 10-Smol / L of DPPH solution. The decrease in absorbance was determined at 515 nm at 0min, with every 15 min the reaction being expected to reach a plateau. The initial DPPH index was calculated by concentration (CDPPH) in the reaction medium from a calibration curve with the equation whose absorbance of 515nm = 12509 × (CDPPH) - 2.58 x 10^{-3} as determined by linear regression. For each antioxidant concentration tested, the kinetic reaction was plotted. From these graphs, when the percentage of DPPH is maintained at steady state the values of DPPH residues are determined as the function of the molar ratio of antioxidant to DPPH anti-radical activity, with the result expressed in mM / g m.s (BRAND-WILLIAMS et al.,1995).

2.6 Folin-Ciocalteu method

This method was used to determine the total phenolic content. Each sample of rice extract was diluted in 50 mL with distilled water and filtered. This solution (0.5 mL) was then mixed with 2.5 mL of 0.2 N Folin-Ciocalteureagent for 5 minutes and 2 mL of 75 g / L sodium carbonate (Na_2CO_3). After incubation for 2 h, the absorption of the reaction was measured at 760 nm against a blank of methanol. Gallic acid (0-200mg / L) was used as the standard to produce a calibration curve, with the result expressed in: Mg EAG / g m.s (MEDA et al., 2005).

2.7 Proteins BCA

A second method (BCA) of protein determination was also tested using the colorimeter-spectrophotometer, with the result being expressed in µg / mL. A curve is made with a blank, generating a standard curve, where x is the concentration and y is the absorbance. The higher the concentration of proteins, the greater the coloration. The rice samples were filtered, then centrifuged. A dialysis of 12 hours was made and the measurement was done on the device. (ZAIA et al., 1998).

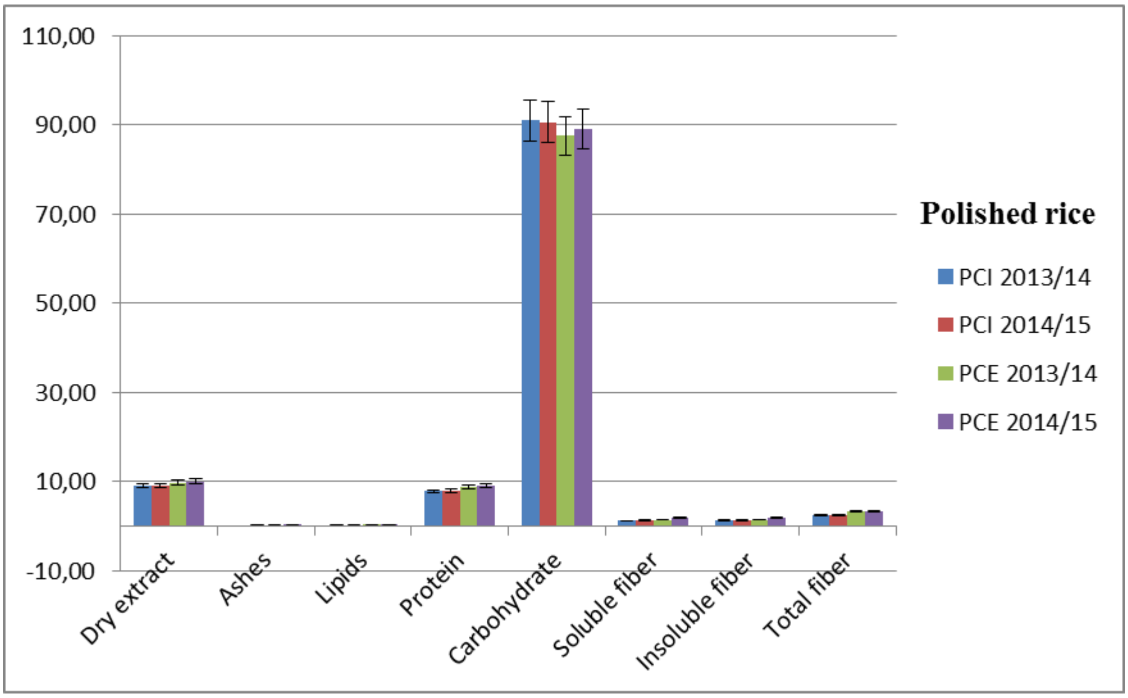
2.8 Statistical analysis

To determine the grouping of the physicochemical elements, a principal component analysis (PCA) was performed. A MANOVA was then performed to verify if there was a difference in soil characteristics among the studied regions that could nutritionally modify the rice consumed. Since the data were not normalized, a Mann Whitney analysis was performed with the grains produced in the areas to evaluate if there was difference of nutritional components between the rice of each region and between the studied cycles (ZAR, 1999).

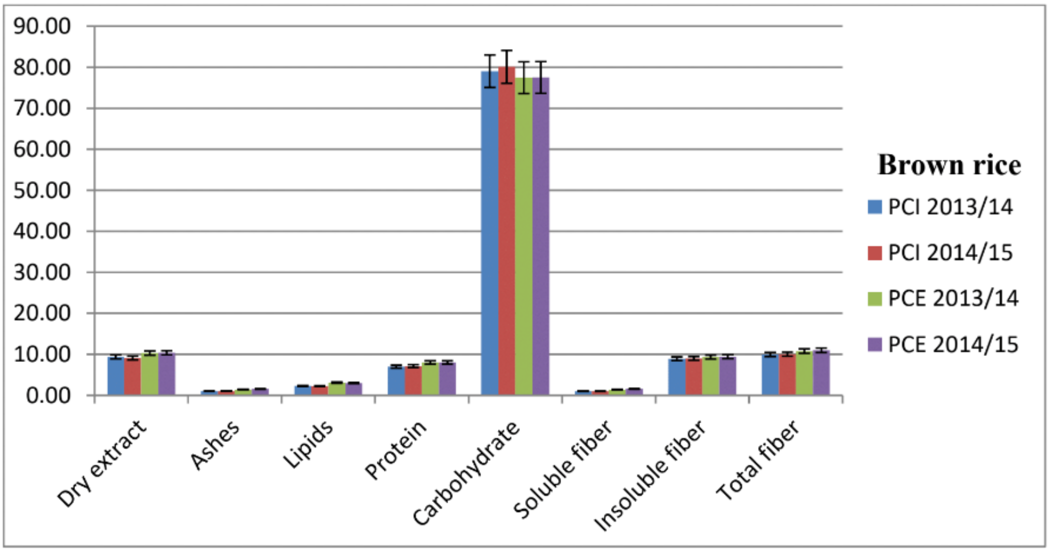
3 I RESULTS AND DISCUSSION

The parameters evaluated in the nutritional composition of polished and brown rice (Figure 2 A and B) were maintained in the two regions, Internal Coastal Plain (PCI) and External Coastal Plain (PCE), RS / Brazil. According to ZHOU et al. (2002), the composition of the grains and their portions is subject to several factors, such as variety, environmental variations, handling, processing and storage. In addition, grain polishing results in a reduction in nutrient content, except for starch, which can be observed in Figure 2 A and B, which shows that polished rice had lower concentrations of ash, lipids and insoluble fibers when compared with brown rice. According to MANO (1999), dietary fiber exerts different functions in the human body. Studies associate the reduction in blood pressure, the concentration of total cholesterol, LDL cholesterol and triglycerides, and the control of blood glucose, aiding in the prevention and in the control of some chronic diseases, such as diabetes and cardiovascular diseases.

Carbohydrates are the main constituents of rice as can be seen in the analyzes (Figure 2A and B). The protein content in rice is considered low, on average 7%, and lipids have their highest concentration in the germ. Thus, the lipid concentration is higher in the brown rice, being reduced with the polishing, corroborating with values found experimentally (WALTER et al,. 2008). The concentration of minerals differs in the grain fractions. While in husked rice silicon is a dominant component, in brown and polished rice phosphorus, potassium and magnesium stand out. Mineral content is greatly influenced by growing conditions, including fertilization and soil conditions, and by processing (ITANI et al., 2002). The content of phenolic compounds, antioxidant index (DPPH) and proteins BCA of both polished rice and brown rice were higher in PCE, where the soil is higher in nutrients, indicating that the most fertile soils produce foods with higher nutritional quality.



A



B

Figure 2: Nutritional composition in percentage (%) of rice produced in two rice regions of RS / Brazil. (A) Polished rice; (B) Brown rice. PCI = Internal Coastal Plain; PCE = Extern

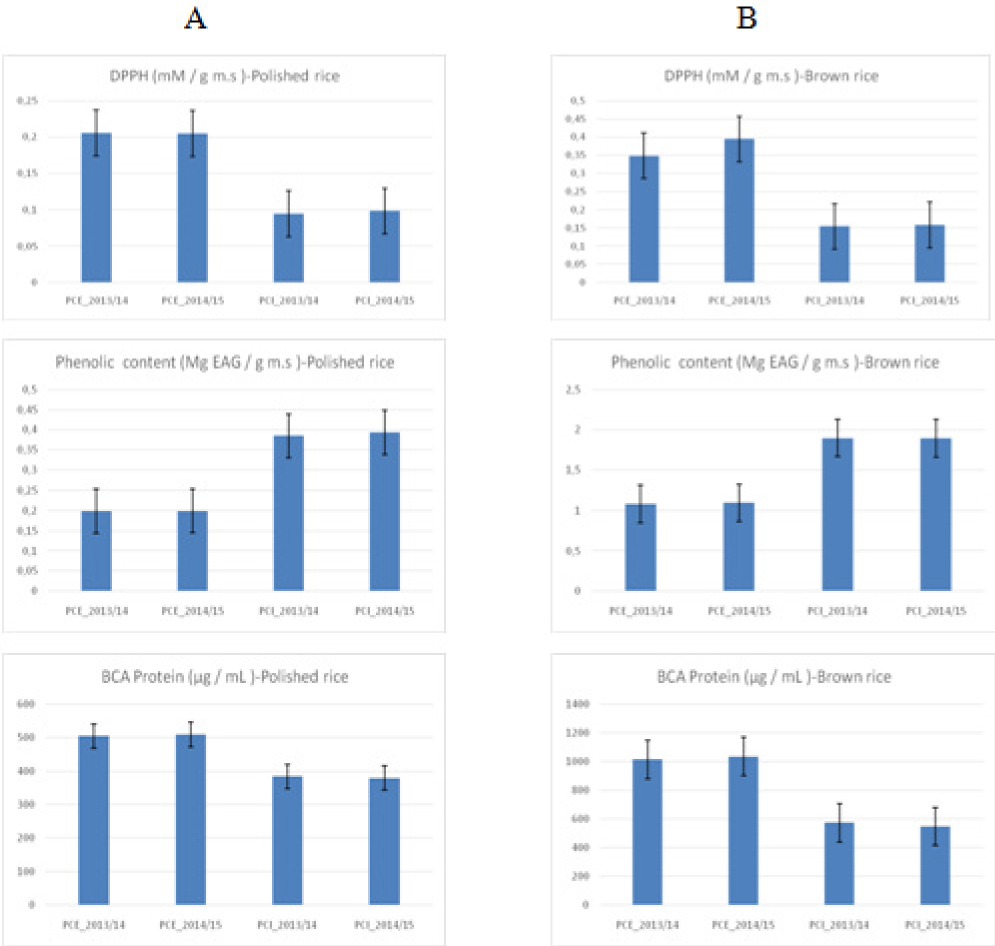


Figure 3: Content of phenolic compounds, antioxidants (DPPH) and proteins BCA of rice produced in two rice regions of RS / Brazil. (A) Polished rice; (B) Brown rice. PCI = Internal Coastal Plain; PCE = External Coastal Plain.

The Mann Whitney tests showed that the nutritional content, phenolic content and antioxidant content of the grains grown in the crops did not vary significantly between the crop years ($p > 0.05$). However, a variation of the same nutritional components was detected between the grains generated in the Internal and the External Coastal Plain ($p < 0.0001$). All nutritional components analyzed were higher in the External Coastal Plain, except carbohydrates, because starch, despite being the predominant polysaccharide in rice, is a result of the sum of the other nutritional components, indicating that if the other components are higher, its content will be reduced. Starch is the main form of energy storage of plants, being used in the industry due to its low cost.

Among the various classes of natural occurrence of antioxidant substances, phenolic compounds have attracted special attention because they inhibit lipid peroxidation and lipo-oxygenation *in vivo* (KRISTINOVA et al.,2009). Therefore, the chemical structures that allow the neutralization or sequestration of free radicals, as well as the chelation of transition metals, prevent the propagation of oxidative processes. Vegetable tissues are good sources of these compounds, and rice, despite not having many of these food features, is a food consumed by a large part of the population (OLIVEIRA et al., 2007).

The 18 physicochemical variables (PANIZZON et al.,2017) were analyzed by the principal component analysis (PCA) technique, after which a MANOVA was performed to test if the regions had similar values of the variables. Results from the PCA (figure 4) showed that the first three axes explain 74.19%: the first axis (47, 12%) includes local variables, phosphorus, pH, potassium saturation, calcium / magnesium ratio, clay and organic matter; the second axis (15.79%) includes calcium / potassium ratio and effective electron exchange capability; and the third axis (11, 28%) includes potassium.

The studied soils presented physicochemical characteristics significantly different, as detected by MANOVA (Wilk's Lambda of 0.008, p <0.0001 and F = 61.6). Figure 4 is a detail of the data found in the PCA.

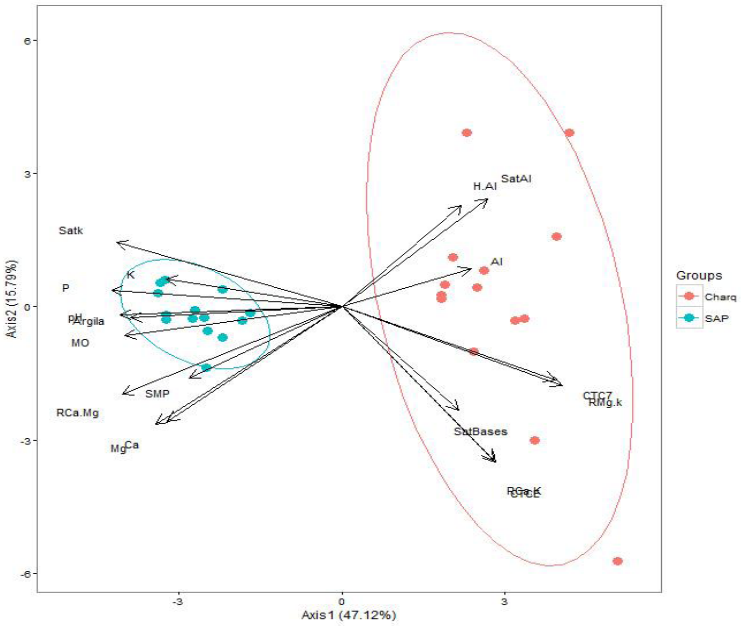


Figure 4: Principal component analysis of physicochemical elements of the soil of the Internal Coastal Plain (Charq) and the External Coastal Plain (SAP) – RS, Brazil, in the crop years of 2013/14 and 2014/15.

In this way it is possible to observe that the parameters are highly correlated with the axis levels totaling 74.19%. With the PCA analysis it is evident that the most important elements are the regions, phosphorus, pH, clay and organic matter for the difference between the points, especially since the correlation between the variables is greater than 0.8. Among the variables of the second component the correlations higher than 0.7 were considered, which consisted of calcium / potassium ratio and effective electron exchange capability. For the third axis, the variable above 0.6 was potassium, according to Table 1.

In a study on the quality of water in rice fields, similar results were found, including the variables that mostly affect rice: pH, phosphorus, potassium and calcium (PANIZZON et al., 2012). A similar study to the previous one found the values of electrical conductivity, pH and phosphorus as signifiers for the growth of the plant, mainly in the phase of maturation, which is when it begins to form the grain of rice (RECHE et al., 2016).

Variables PCA	Axis 1	Axis 2	Axis 3
Local	0,9713	0,09171	-0,1107
Clay	0,8145	0,04894	-0,2
pH	0,821	0,02829	-0,1501
SMP	0,5461	0,3305	-0,4891
P	0,8459	-0,09832	0,1616
K	0,6351	-0,1443	0,6573
M.O	0,8075	0,124	-0,1512
Al	-0,4517	-0,1625	-0,3084
Ca	0,6606	0,5112	0,03162
Mg	0,6842	0,527	0,232
H + Al	-0,4459	-0,4615	0,5451
CTC E	-0,5533	0,7105	0,2812
CTC 7	-0,7817	0,3461	0,3756
SatBases	-0,4406	0,4645	0,04213
Sat Al	-0,5141	-0,4751	-0,5816
Sat K	0,8208	-0,3098	0,123
R Ca / Mg	0,8176	0,3933	-0,04307
R Ca / K	-0,5303	0,7134	-0,1546
R Mg / K	-0,7983	0,3762	-0,2179

Table 1: Matrix of correlation of physicochemical variables of this study, and the three main components of the varimax rotation method.

Subtitle: Clay (%), pH, Index of analysis and correction of acidity - SMP, Phosphorus (mg/L), Potassium (mg/L), Organic Matter - MO (mg/L), Aluminum (mg/L), Calcium (mg L), Magnesium (mg/L), Hydrogen + Aluminum (mg/L), Effective electron exchange capacity – CTC E (mg/L), Electron exchange capacity pH 7 – CTC 7 (mg/L), Saturation (Sat) Bases (%), Sat Al (%) Sat K (%), Relationship (R) Ca/Mg (mg/L), RCa/K (mg/L) e RMg/K (mg/L).

The spatial pattern resulting from the distribution of the samples at two distinct locations demonstrates the soil difference and thus defines a different pattern for each region, resulting in grains with statistically different nutritional qualities (PANIZZON et al., 2017 and Figure 4). Other studies show that soil spatial variability occurs naturally (ZHAO et al.,2011). These variations can be affected by human activity, flora and fauna. The soil affects the agricultural activities and is capable of generating foods with distinct nutritional characteristics in the same plant species (RODRÍGUEZ-GARAY et al., 2016).

Currently, there are researches that add silicon to the soil through the straw and the husk of rice. Although silicon is not considered an essential element for plants, its effects on monocotyledons, including rice, have been evaluated as positive. It is known that silicon comprises up to 10% of the dry matter of straw and rice husk, being much higher than other mineral nutrients. If this husk is applied before preparation of the soil, it is possible to increase the initial soil pH throughout the cycle (PINHEIRO, et al., 2016). This is a good option to try to regulate the level of pH in the Internal Coastal Plain that presented values lower than the External Coastal Plain. Another important factor is early irrigation, which can bring advantages to the nutrition of the rice plants, because the availability of nutrients in the soil solution increases with the flood. Therefore, the earlier irrigation is started, more readily rice plants will be able to receive this benefit (NASCIMENTO et al., 2009), making rice more regular in the requirements for its production, thus generating more uniform grains with better nutritional value.

Studies have shown that the presence of phosphorus and potassium, even in soils with low organic matter, results in good grain yield (BEUTLER et al., 2016), as observed in the Internal Coastal Plain. In addition, soil macroporosity is an important physical attribute in soil pore distribution analysis (SIMIONI et al., 2016). With greater porosity the nutrients are more accessible to plants. The amount of calcium needed for monocotyledonous growth is lower than for dicotyledonous. However, calcium was an element that appeared with relative importance in PCA (Figure 4), because it reduces soil acidity and facilitates root growth (GIONGO et al., 2016).

4 I CONCLUSIONS

Under the conditions in which these studies were carried out, based on collections of soil samples and rice grains from the crop years of 2013/14 and 2014/15, it can be inferred that: (i) the two rice regions, the Internal and the External Coastal Plain, presented different physicochemical characteristics of soil, being the values of pH, organic matter and clay higher in PCE; (ii) soil physicochemical elements produce grains with significantly different nutritional qualities; (iii) the polished and brown rice of the External Coastal Plain, for having a more fertile soil, produced better quality PuitaInta CL rice grains.

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