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Effects of resting on drying and storage period on the metabolic defects and industrial performance of polished and parboiled rice

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Abstract

The consumption of parboiled rice in Brazil has shown great increase in the last decades, what is demanding knowledge to analyze its performance. The objective of this work is to evaluate the effect of storing period in industrial performance and incidence of defects in processed grains as conventional and parboiled rice. Rice grains were stored in 50 kg cotton bags with 13 % moisture for 12 months, with technical and operational control. Moisture, industrial performance and incidence of defects were analyzed quarterly. It was observed that: a) there is a direct relation between resting time before drying and storing period, with the incidence of defects on rice grains in both production processes, conventional polished white rice and parboiled rice; b) the increase in the storing period has smaller effect on yield and industrial performance than in the incidence of metabolic defects; c) as the length of storage period increases, the parboiling process increases more the percentages of whole grains and the occurrence of metabolic defects than the conventional polished white rice process.

Key words: Rice, Defects, Industrial Performance.

Introduction

Rice is a product of great economic importance in Brazil, being distinguished among the most produced grains, reaching an annual total production near to 12 million tons per year and an average annual consumption of 54 kg hab^{-1} ano^{-1} (Irga, 2006). The state of the Rio Grande do Sul is the biggest national rice producer, participating with almost half of the production (Conab, 2006). Thus, the country demands a technology generation for rice processing, concerning production, processing and industrialization sector of the product. Integrated in this context, the Federal University of Pelotas, that has an strategic geographic localization, because is inserted in the biggest production and industrialization polar region of Brazil, is an institution of Superior Education that for many years have been investing in generation of new technologies of conservation, industrialization and consumption of rice, mainly in the after-harvest, Industrialization and Quality of Grains Laboratory in College of Agronomy “Eliseu Maciel”, an institution of more than 120 years (Elias et al., 2005).

After-harvest technologies are used in a corporate form, covering since the product arrival from the farming to the conservation establishment, where are carry out operations of pre-cleanness,

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fast storage in lung silos, drying and transport until the silos where finally they will be stored during the period that precedes the commercialization, industrialization or consumption.

In harvest operation, grains moisture is directly associated with quality, drying efficiency, storage and industrial performance. Defects can occur and intensify during storage, harming the grains commercial classification, decreasing its quality and value (Muir, 2000).

The moisture rate of grains, the relative moisture and the room air temperature are the main factors that influence the alterations in rice in the storage (Hellevang, 1994; Scussel, 2002; Furlong, 2005). The moisture exchanges can occur for process of water sorption or desorption for the grains, depending on differences of steam pressure and/or temperature between these and the air that surrounds them. The constant exchanges of heat and water, occurred during storage, can modify rice grains structure and become them more sensible to fissured and breaking during the process (Velupillay and Pandey, 1990).

With industrial processing evolution, verified through the new techniques development, better equipment and greater knowledge of the operating factors in the process, the acceptance of parboilled rice has shown significant improvements, passing from five to more than 20% of the total industrialized rice in Brazil, in the two last decades. If, by ones side exist all this growth, for another one, these data show that there are still a great space in the market to be explored.

The techniques used at the beginning of the parboiling process in the country were deficient in scientific knowledge, which caused low quality products, with intensification of some undesirable sensorial characteristics, as color, flavor and odor. These factors have limited the consumer acceptance of parboiled rice (Henemann et al., 2005). Parboiled rice is one of most popular products of rice in Europe and it becomes more important for the fact to not only present greater nutritional value, but also for the superior properties of coking and processing that are desirable for the industries and the consumers (Schulle, 2006).

Currently this technique have been extended use and have been improved through scientific research and activities of industries, resulting a product with characteristics of flavor, odor and coloration less accented and some techniques make possible the production of parboiled rice with similar sensorial properties to the ones of the polishing white conventional system of grains.

The consumption market of parboiled rice is in ascension in Brazil and grows more every year, deserving deepened studies from research institutions. Some direct benefits can be evidenced through parboiling process, as increase in rice and bran storability, increase of industrial performance and breaking resistance during process and concentration of organic, mineral nutrients and vitamins, as well as reductions in the percentages of hull, bran and broken grains; in enzymatic activity and the load of contaminating microorganisms, are some grains acquired characteristics with the parboiling (Rombaldi, 1988; Hennemann et al., 2006).

This work aimed to evaluate effects of waiting time to drying and storage time in the industrial performance and the incidence of rice grains defects in the parboiling and polishing white rice conventional processes of industrialization.

Materials and methods

Were used rice grains of cultivar BR-IRGA 410, harvested with 23 % of moisture, pre-cleaned and submitted to drying up to 13 %, in adapted intermittent system, with mass temperature not superior to 40 ºC. After dried they were stored in cotton bags, during twelve months, in room conditions, with technical operational control.

In each four months were analyzed parameters of storability and industrial performance, as moisture, industrial performance and defects incidence of commercial classification, using the official methodology of the Ministry of Agriculture, as well as fungus incidence.

Results and discution

Figure 1 contains moisture evaluations results, while in Figure 2 are the results of rice grains duhusking performance, cultivar BR-IRGA 410, harvested with moisture average of 22 %, pre-cleaned and submitted to waiting time to drying for up to five days, in environment with temperature of 20 ºC to 30 ºC, stored by conventional system, in cotton bags, for twelve months, with maintenance technical control of mass temperature not superior to 20 ºC.

Analyzing the data of Figure 1, it is possible if to verify variations in grains moisture during storage. This is explained due to hygroscopic characteristics of grains that tend to equalize steam pressures between air-grains in the stored environment. For each determined relative air moisture correspond a grain water rate, called hygroscopic equilibrium.

In Figures 2 and 3 are presented, respectively, the whole grains percentages and incidence of general defects, metabolic and not metabolic of whole grains without defects in rice kept in waiting time to drying, stored in conventional system and processed by polishing white rice conventional process of industrialization and by parboiling. In Figure 4 are presented the percentages of whole grains without defects in the same condition. The percentages result from the agreed action of the polishing operation that produces whole and broken grains and bran, with the incidences of metabolic and not metabolic defects.

There are metabolic and non-metabolic defects (Elias et al., 2005). The ones in the first group keep unchanged incidence in normal conditions of storage and, therefore, are called not metabolic, being its main representatives the opaque and red grains. The metabolic ones, in turn, increase intensity during storage, depending

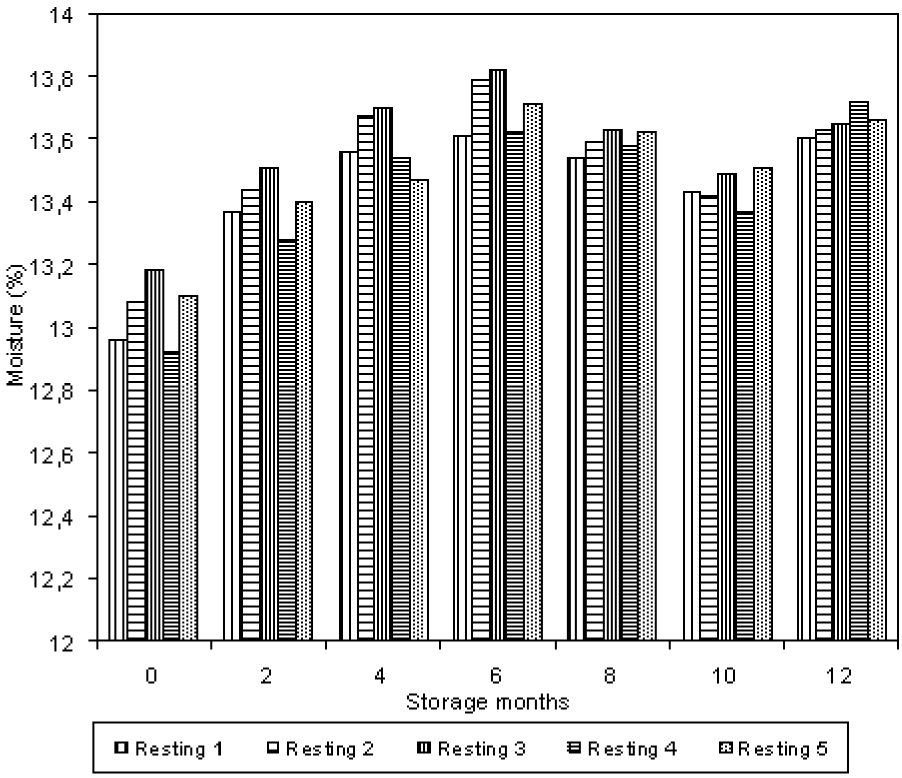

Figure 1. Rice grains moisture, cultivar BR-IRGA 410, kept to 20 ºC < t < 30 ºC in waiting time for drying and stored in conventional system.

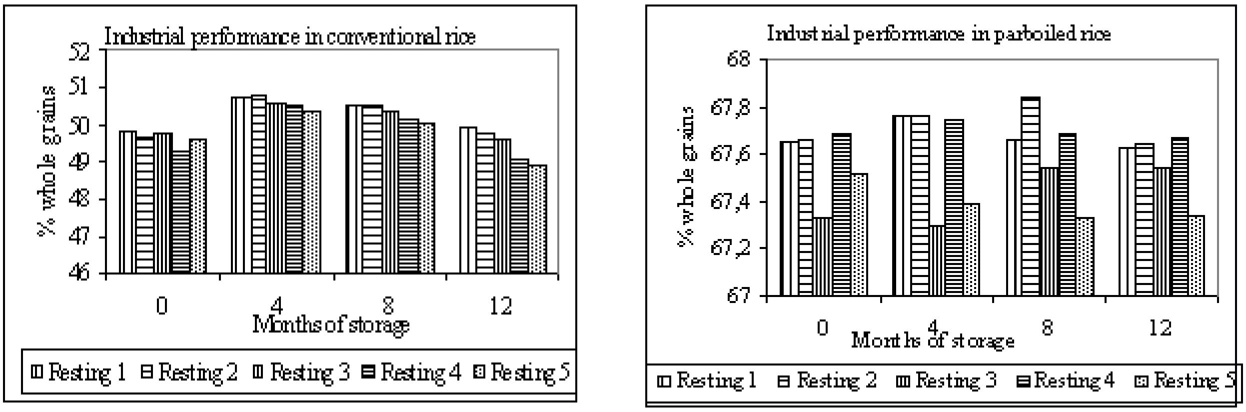

Figure 2. Industrial performance in rice grains, cultivar BR-IRGA 410, kept in 20 ºC < t < 30 ºC in waiting time to drying, stored in conventional system and processed by conventional white polishing and parboiling process.

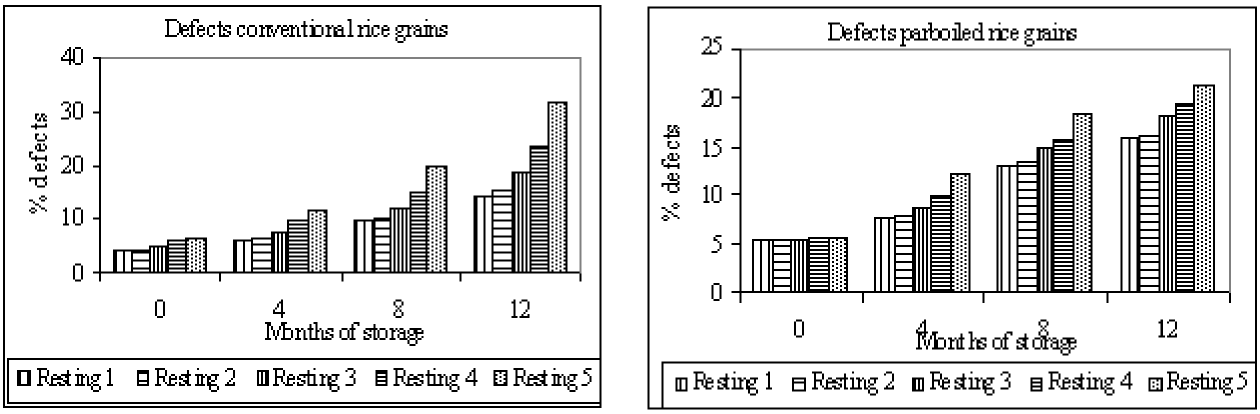

Figure 3. General defects, metabolic and not metabolic, in rice, cultivar BR-IRGA 41, kept in 20 ºC < t < 30 ºC in waiting time to drying, stored in conventional system and processed by conventional white polishing and parboiling process.

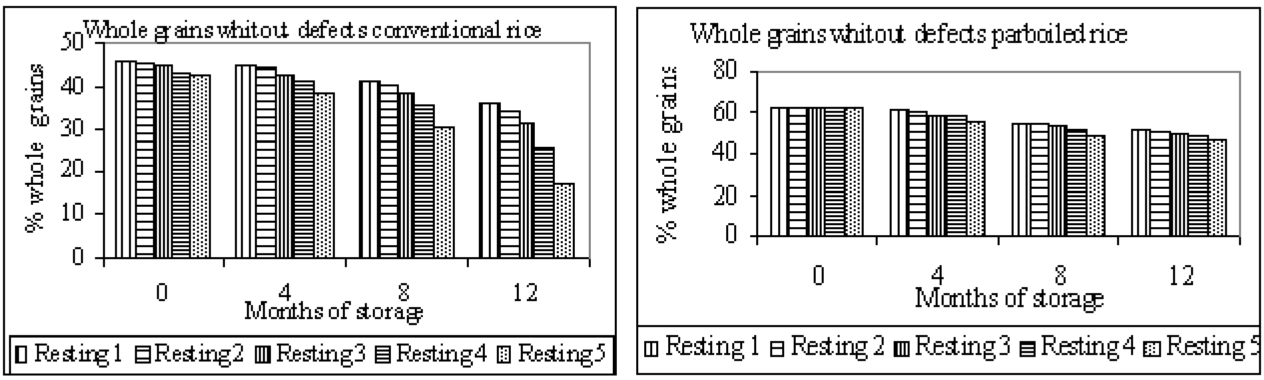

Figure 4. Whole grains without defects in rice, cultivar BR-IRGA 410, kept in 20 ºC < t < 30 ºC in waiting time to drying, stored in conventional system and processed by conventional white polishing and parboiling process.

on some factors, being its main representatives the defects called yellow, perforated, spotted, several contamination and black grains.

Data on Figure 3 show that the waiting time for drying and storage present positive correlation with the incidence of these defects, or either, the incidence of defects in the grains intensifies with increasing waiting time for drying, as well as storage period. In the samples submitted to the biggest waiting time for drying, were observed very expressive increases in the percents of yellow and several contamination grains, when the process was the conventional polishing white rice and in the ones of several contamination and black, when the improvement were by parboiling. The parboiling eliminates the occurrence of opaque grains, a common defect in cultivar BR-IRGA 410 processed by conventional process.

Due to the fact that it is a product that is stored alive, in contact with the associated organisms, some reactions continue since they are harvest. The delay to drying allows an increase in grains metabolic activity and these associated organisms. Some of the grains classification defects have metabolic origin, either of the proper grains or the associated organisms, as microorganisms, mites or insects.

For the rice grains nature its processing before the consumption is necessary. The usual methods to process are the polishing white conventional and parboiling. The consumption preference of rice by Brazilians is the conventional of polishing white grains, who correspond almost for 75 % of the national consumption, followed by parboiled, with 22 % of the preference, and the brown rice with approximately 3 %. For a cultural question, the Brazilian consumer, who in its great majority prefers long rice or mainly long-fine, because associates this fact to the soltability of these grains when cooked.

Rice grain breakage, that makes decrease industrial performance of whole grains (Figure 2) in the process, generally are caused by genetic, mechanical or thermal causes, being influenced for plant genotype, drying conditions, with damages and/or thermal shocks, and by operations that include grains movement and/or friction, with mechanical damage. Opaque grains and with white center tend to break easiness in the process, probably due to its heterogeneous texture, presenting polygon cells strongly compacted in the translucent areas and rounded cells, with air spaces between itself, in the opaque areas. The biggest plaster incidence appears in the grains of the base of panicles, mainly of the secondary ones. During the operations of dehusking and polishing, occur higher braked grains; mainly of those already present previous fictions to the process, as already told Velupillay and Pandey (1990).

On the other hand, rice grains submitted to parboiling process suffer an internal reorganization. Starch suffers gelatinization, followed by retrogradation, and the proteins, that constitute the protein matrix, where starch granules are contained, suffer partial denaturation. With this, occurs interstitial air expulsion in the space, simultaneously with a cellular rearrangement that results in mass compacting and aggregation, turning the grains more resistant to frictional and abrasion actions, that occur in the following operations of polishing, thus keeping higher the stability indices in industrial performance throughout long storage periods.

The presence of many defects in rice grains (Figure 3) can be proceeding from living organism action or a result of alterations in grain metabolism. The fungus development causes constituent changes and in caryopses coloration, originating a product with minor quality. The fungus attack can still start in the field, continuing during storage and in the processed product (Scussel, 2002; Furlong, 2005).

Lost of quality by grains defects occurrence, even in whole grains, in processed rice (Figure 4) depend directly on the quality of the raw material, the alterations that suffers during storage and from the process employed. Increases in storage and process time by parboiling intensify defects occurrence, but the parboiling process provokes reductions in the percents of broken grains.

In Figures 5, 6 and 7, respectively, are presented the analysis results of total fungus incidence, together with the incidences of fungus with phytopatogenic potential and typically of storage, with toxigenic fungal potential, in rice grains, cultivar BR-IRGA 410, submitted to waiting time for drying for up to seven days, stored during 12 months, for the conventional system in cotton bags, in technical controlled environment.

The results analysis express in the behaviors shown in Figure 5 shows increases in the total fungus contamination and the incidence of fungus with phytopatology potential, in differentiated intensities, but increasing with waiting time for drying and with storage time. The data also show synergic effect between the factors, what explains the incidences with typically exponential behaviors.

In the called group fungus with phytopatology potential, the biggest detected occurrences were from the generous *Alternaria, Cladosporium, Curvularia, Epicocum, Fusarium, Helmintosporium, Nigrospora, Phoma, Pyricularia, Rhynchosporium, Trichoconiella,* without verifying predominance of them on the others and even of anyone among them that could characterize correlation with waiting time for drying, time of the year and even with storage time. Similar behavior, even with raised percentages of incidence, in the group of the potentially producing micotoxins fungi, was detected the occurrence of *Aspergillus, Fusarium* and *Penicillium*, also without registering tendency of one generous predominance in order to configure correlation with some of those parameters. However, the participation of fungus storage incidence in the total of the contaminations grows with storage time increase, for any of the waiting time for drying.

As after drying, all samples, of all treatments, were submitted to the same storage psychometrics conditions and after to reach the hygroscopic balance did not have significant differences ($P < 0,05$) in the moisture degree among samples (Figure 1), to that it seems the competitiveness among generous depends on other factors that not the ones studied in the present work. The presence of *Alternaria* or

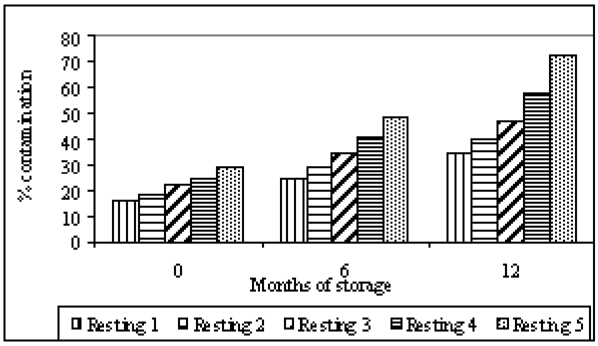

Figure 5. Total fungus incidence in rice grains, cultivar BR IRGA 410, kept in 20 ºC < t < 30 ºC in waiting time to drying, stored in conventional system.

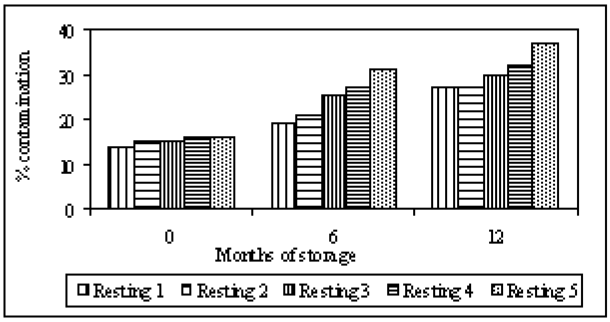

Figure 6. Fungus potentialy phytopatologic in rice grains, cultivar BR IRGA 410, kept in 20 ºC < t < 30 ºC in waiting time to drying, stored in conventional system.

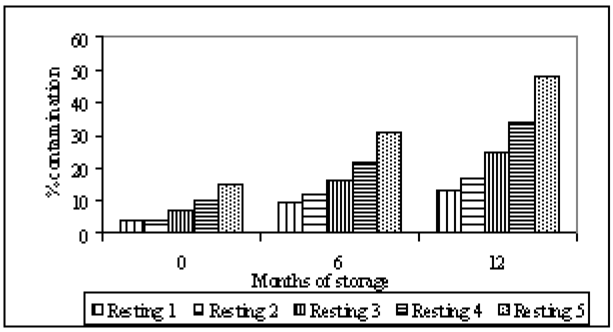

Figure 7. Fungus typically of storage rice grains, cultivar BR IRGA 410, kept in 20 ºC < t < 30 ºC in waiting time to drying, stored in conventional system.

Trichoconiella padwiikii, however, when it occurred, was without regularity.

If among generous of the same group did not characterize no predominance trend, among the groups there were always bigger increase, with passing of the months in the warehouse, of the typical fungus of storage than of that with phytopathology potential. The analysis of total fungus incidence, evaluated for the percentage of grains contaminated for at least one sort, of any group, shows increase in the total of grains contaminated with the increase of wait period, in each time of considered storage, as well as show increase of total of grains contaminated with increased storage time, in any waiting time for drying that was submitted.

The biggest proportional increments in the indices of fungus contamination correspond to the times of the year where the grains moisture in the warehouse was bigger (Figure 1).

The conditions of high moisture grains in hygroscopic balance and the room air temperature increase the grains metabolism, what favors the microbial and plagues growth, accelerating its activity. The gradual increase of moisture and the mass temperature, in function of grains intrinsic metabolic activity and the associated organisms originates a set of specific and accumulating processes physicist-chemistries in the grains deterioration, highly correlated with the microbial development and succession.

Fungus contamination pre-storage potential is reduced with the decrease of growth tax and metabolic activity reduction of its constituent during the storage, in function of the adverse conditions created and of the pressure of selection exerted by specific fungi of storage, propitiating particular conditions of succession, that reflect in grains degradation. The toxin production, the deteriorative potential and the saprophyte character characterize the generous *Fusarium*, *Penicillium* and *Aspergillus*, as the main storage fungus. The presence of these organisms, however, not always is a positive evidence of the toxin production in the grains (Scussel, 2002; Furlong, 2005).

The microorganisms that attack in the field can cause damages as ovule fecundate abortion, grains mal-formation, size reduction, rottenness, superficial or deep necrosis, reduction of the germinater capacity and appearance of spots, among others. In the storage caused damages in general continue, and provoke reduction or lost of the germinater capacity, alteration in color or formation of spots, biochemists transformations, consuming of nutritional reserves, losses of weight, toxins and odors production (Hellevang, 1998; Scussel, 2005).

Conclusion

a) There is direct relation between waiting time for drying and storage period with rice defect incidence, even by conventional white polishing or parboiling rice processes;

b) The increase on storage time has minor interference in the industrial performance than in the incidence of grains metabolic defects;

c) Compared with the conventional process, parboiling increases the percentages of whole grains, but intensifies the incidence of grains defects.

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