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Management of air temperature during static drying and storage period and their effects on industrial performance and technological properties of conventional and parboiled rice grains

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Abstract

Aiming to verify the effect of air thermal handling in the stationary drying and the time of storage on the industrial performance and rice technological properties. For this, long-fine class grains "agulhinha", produced in irrigated system, on the south of Brazil, harvested with 22 % of moisture content, were submitted to four drying conditions: 1) Use of air did not warm during all process; 2) Use of air did not warm until the grains reach 16 % of moisture content, with warm air complement up to 13 % of moisture content; 3) Use of warm air during all the process; 4) Use of warm air until the grains reach 16 % of moisture content with not warm air complement up to 13 % of moisture content. Concluding that: 1) the air temperature in the stationary rice drying provokes immediate and latent damages, with different intensities if the grains will be processed by conventional process of polishing white rice or parboiling; 2) for industrial process of polishing white rice, since sixth month of storage, dryings with air without heating during all the operation, or in part of it, complemented or preceded by warm air use, provoke higher entire grains performance without defect of that drying with warm air at 45 ºC during all the operation; 3) for rice parboiling process, since sixth month of storage, stationary drying with air without heating during all the operation provokes minors performance of entire grains without defect than that drying with warm air during all the operation, or in part of it, complemented or preceded by the use of air without heating in the operation; 4) in six months of storage at least, the thermal handling of drying air does not have effect in the grain amylose content; 5) the water sorcion in rice cooking decreased with the thermal drasticity or by the slowness of the drying operation after the third month of storage.

Key words: Polished and parboiled rice, drying, storage.

Introduction

Rice is one of the most important basic foods and the biggest carbohydrate source of Brazilians diet. Asia is responsible for almost 90 % of the world-wide production, in Latin America, Brazil showup as the larger producer, exceeding, in last years, 12,000,000 ton. On the agricultural and industrial sectors, rice chain productive participates with about 240,000 direct and indirect works, only

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in the south, where concentrates 60 % of the national production (Azambuja et al., 2004; Tavares, 2004; IRGA, 2006; CONAB, 2006).

Rice can be submitted to diverse industrial processes before being consumed, and can be grouped in two categories: a) the industrialization processes that start with dehusking, called conventional process, predominating brown and white polishing rice; b) the processes where grains are submitted to hydrotermical operations before dehusking, called parboiling (Brazil, 1988; Amato and Elias, 2005).

In dehusking process the pericarpo, aleurone and tegument layers and the germ are removed; remaining the endosperm, the grain part that will be used in human feeding. Endosperm is constituted of starch polygon composites, proteic bodies and other constituent (Bechtell and Pomeranz, 1980).

The starch contain two polysaccharides, amylose and amylopectin, whose linear and ramified carbonic chains, respectively, confer them different effect in grains technological properties according to its ratio (Martinez and Cuevas, 1989; Bobbio and Bobbio, 1992).

The amylose/amylopectin ratio is the main factor in cultivar differentiation and cooking behavior, even so this is not the only parameter to influence (Gularte, 2005).As the amylose content increase more drier and separate will be the grains after cooked (Deryckea et. al., 2005; Gonzáles et al., 2004).

Rice drying is essential to a storage free of intrinsic deterioration, microbiological and insects attack. However, the breaking rate decurrent from drying represents quality losses and commercial value. The temperature reached for the grain and the exposition time to this temperature are the factors that more influence product quality (Coons et al., 2004; Fagundes et al., 2005).

Although the intermittent drying is more used by rice producer and the industry, for the technical, operational and economic characteristics, the stationary system has pointed significant increases in the producers segment (Barbosa et al., 2005). Such system, however, needs more research information for better use of its potential. They are still scarcer, the information of air thermal handling effect in stationary drying of parboiled rice.

The aim of this work was to verify the effect of air thermal handling in stationary drying, and time of storage on industrial performance and technological properties of irrigated rice culture, long-fine class.

Material and methods

The experiment was accomplished in the Post-Harvest Grain Industrialization and Quality Laboratory, from the Science and Agro-industrial Technology Department, of Agronomy Faculty "Eliseu Maciel", Pelotas Federal University (UFPel), with rice grains cultivar EMBRAPA 7 (Taim), harvested with 22 % of moisture, produced in the south region of Rio Grande do Sul, and submitted to four thermal process in drying air: 1) air without heating, during all the operation; 2) warm air during all the operation; 3) air without heating, until the grains get 16 % of moisture with warm air complement until the end of the operation; 4) with warm air until the grains reach 16 % of moisture with ambient air complement, without heating until the end of operation. In the four process the grains were dried up to 13 % of moisture content (Brazil, 1992).

Dryings were accomplished in a pilot stationary-drier, with air flow to 11 $m^3.t^{-1}.min^{-1}$. The grains temperature did not reach 41 ºC.

The parboiling process carried out through in accordance with methodology developed in the Grains Laboratory of UFPel (Elias, 1998), and the industrial performance and defects tests had followed the official methodology of Agriculture Ministry (Brazil, 1988).

The evaluation of gelatinization temperature was made by the alkaline dispersion test (Martinez and Cuevas, 1989), 1.7 % of KOH. The cooking time and water absorption were evaluated in accordance with methodologies developed for Martinez and Cuevas (1989) and Gularte (2002). The determination of amylose content was carried out by colorimetric method, with espectrophotometer 610nm (Martinez and Cuevas, 1989).

The experiment design use was completely random, with factorial in three factors and three replicates for each analysis. The comparisons between the averages were carried through Tukey

test, 5 % of significance, using the ESTAT- Statistical Analyses System (Estat, 1997).

Results and discution

In Tables 1 and 2, respectively, are presented the average percentages of grains performance without defects in rice processed for conventional processes of polishing white rice and parboiling, resultants of quarterly analyses, during six months, where samples had remained stored in jute sacs, in conventional storage system, with technical operational control.

Analyzing the results on Table 1, was verified that, the drying method that used warm air during all the operation resulted in less industrial performance whole grains without defects, when was benefited by conventional proces. When processed by parboiling (Table 2), the industrial performance whole grains without defects were equivalent.

In three months of storage, any of the drying methods provoked difference in industrial performance whole grains without defects, having reduction in the sixth month only in grains dried with not warm air during all the operation, as much as conventional process (Table 1) as in parboiling (Table 2). On the end of six months, the treatments that had used warm air combinations with air without heating, in any order, presented the higher industrial performance whole grains without defects.

Until the end of first month, the resultant tensions of warm air drying provoked broken increases during rice processing. After the hydric and thermal balances, there are an increase in the grains resistance to abrasion and friction operations of burnishing (Bonazzi al., 1997; Elias, 2004). Rice grains do not support brusque drying in the beginning of operation, when they are still with high moisture content, high hourly rates of water removal contribute to increase the broken grains percentage, mainly in conventional process of polishing white rice (Elias and Franco, 2005).

Tables 1 and 2 show up that parboiling results in higher whole grains without defects of that in the conventional process of polishing white rice, in any time of storage or used method of drying. These results are in agreement with described for other authors (Barbosa et al., 2005; Fagundes et al., 2005).

The drying method that produces more whole grains without defects in polishing white rice process is the same that presents the worst performance in parboiling. As the rough rice presents great and varied amount of enzymes, located predominantly in embryo and the peripheral layers, in parboiling, during the steeping, there are favorable conditions to metabolic activity, and in subsequent steaming and drying operations can occur chemical reactions of the rice grains constituent, as caramelization and Maillard reaction (Bobbio and Bobbio, 1992).

Table 1. Industrial performance rice grains without defects (%) submitted to four conditions of stationary drying, stored for six months and processed for conventional process of white polish[1].

	Storage months		
Drying process	1	3	6
Ambient air (without heating) during all operation[2]	55.83 Aa	54.44 Aa	53.80 Ab
Warm air during all the operation[3]	53.30 Ba	53.52 Ab	52.32 Bc
Ambient air in the beginning and warm until the end[4]	55.14 Aa	53.96 Ab	52.56 Bc
Warm air in the beginning and ambient until the end[5]	54.91 Aa	54.33 Ab	52.69 Ba

[1]Simple arithmetic average, followed by lower case letters, in same line and, for capital letters, in same column, do not differ for the Tukey test 5 % from significance ($p < 0.05$).

[2] Drying with not warm air, in the ambient condition (20 ± 5 ºC), up to 13 % of moisture content, during all operation.

[3] Drying with warm air 45 ± 5 ºC, up to 13 % of moisture content, during all operation.

[4] Initial drying without air heating, in ambient condition (20 ± 5 ºC), up to 16 % of moisture content, complemented for drying with warm air at 45 ± 5 ºC, until the end of the operation.

[5] Initial drying with warm air the 45 ± 5 ºC, up to 16 % of moisture content, complemented for drying with not warm air, in ambient condition (20 ± 5 ºC), until the end of the operation.

If, on the one hand, the drastic action of heat increases the broken grains index, reducing the income and predispose the grains to intrinsic metabolism and microorganism and insects attacks during the storage, on the other hand the slowness of air drying without heating stimulates metabolic action in the operation, what intensifies the incidence of defects to the long of storage. As this fact is more intensified in the parboiling hydrotermic operations, the metabolic phenomena and latent damages explain the results shown in Tables 1 and 2.

In Tables 3 and 4 the degrees of alkaline dispersion consist, evaluated in the concentration of 1.7 % of KOH.

It is verified that have not important technological differences, still having significant statistical differences among periods of storage, and that the drying methods had not influenced in dispersion degree. It is also observed that had not differences between the drying methods in both processes (Tables 3 and 4). The grain restructuring in the parboiling (Table 4) explains the higher values presented in relation to not parboiling grains (Table 3).

Table 2. Industrial performance whole grains without defects (%) submitted to four stationary drying conditions, stored for six months and processed for parboiling process[1].

	Storage months		
Drying process	1	3	6
Ambient air (without heating) during all operation[2]	59.96 Ab	59.44 Aa	55.76 Cc
Warm air during all the operation[3]	59.34 Ab	60.03 Aa	58.59 Bb
Ambient air in the beginning and warm until the end[4]	59.15 Ab	59.77 Aa	59.19 ABa
Warm air in the beginning and ambient until the end[5]	59.89 Aa	59.85 Aa	60.07 Aa

[1] Simple arithmetic average, followed by lower case letters, in same line and, for capital letters, in same column, do not differ for the Tukey test 5 % from significance ($p < 0,05$).
[2] Drying with not warm air, in ambient condition (20 ± 5 ºC), up to 13 % of moisture content, during all operation.
[3] Drying with warm air 45 ± 5 ºC, up to 13 % of moisture content, during all operation.
[4] Initial drying without air heating, in ambient condition (20 ± 5 ºC), up to 16 % of moisture content, complemented for drying with warm air at 45 ± 5 ºC, until the end of operation.
[5] Initial drying with warm air 45 ± 5 ºC, up to 16 % of moisture content, complemented for drying with not warm air, in ambient condition (20 ± 5 ºC), until the end of operation.

Table 3. Alkaline dispersion with concentration of 1.7 % of KOH in rice grains submitted to four stationary drying methods, in drier-silo, stored in jute sacs, for six months and processed for conventional polishing white rice process [1].

	Storage months		
Drying process	1	3	6
Ambient air (without heating) during all operation[2]	3.17 Ab	3.23 Aa	3.33 Aa
Warm air during all the operation[3]	3.16 Ab	3.30 Aa	3.30 Aa
Ambient air in the beginning and warm until the end[4]	3.10 Ab	3.12 Ab	3.37 Aa
Warm air in the beginning and ambient until the end[5]	3.13 Ab	3.30 Aa	3.33 Aa

[1] Simple arithmetic average, followed by lower case letters, in same line and, for capital letters, in same column, do not differ for Tukey test 5 % from significance ($p < 0.05$).
[2] Drying with not warm air, in ambient condition (20 ± 5 ºC), up to 13 % of moisture content, during all operation.
[3] Drying with warm air 45 ± 5 ºC, up to 13 % of moisture content, during all operation.
[4] Initial drying without air heating, in ambient condition (20 ± 5 ºC), up to 16 % of moisture content, complemented for drying with warm air at 45 ± 5 ºC, until the end of operation.
[5] Initial drying with warm air 45 ± 5 ºC, up to 16 % of moisture content, complemented for drying with not warm air, in ambient condition (20 ± 5 ºC), until the end of operation.

In Tables 5 and 6 the averages percentage of gravimetrical performance, resultant of water absorption are presented, in rice polishing grains processed by conventional processes and parboiling, respectively, with quarterly analyses, during six months of storage.

The data in Table 5 allows to observe that polishing white rice absorbed more water in the cooking than parboiled (Table 6), and that both had water reduction absorption on cooking in the six months of storage in the more drastic dryings parameters: the one that used heat during all operation and the one that took longher time to complete, for having been carried out with air without heating. The bigher conservation (Tables 1 and 2) verified in grains dried in mild conditions explains the gotten results.

The gelatinization, followed by starch retrogradation in the parboiling, with consequent grains reorganization that provokes more difficulties for parboililed rice absorption water, and these typical phenomena that hydrotermic operations explain the behaviors, as well as explain the higher time (21 minutes in average) necessary to cook the parboiled rice than the white (16 minutes).

Table 4. Alkaline dispersion with concentration of 1.7 % of KOH in rice grains submitted to four stationary drying methods, in drier-silo, stored in jute sacks, for six months and processed for the parboiling process[1].

	Storage months		
Drying process	1	3	6
Ambient air (without heating) during all operation [2]	5.13 Aa	5.17 Aa	5.00 Ab
Warm air during all the operation[3]	5.10 Aa	5.23 Aa	5.03 Ab
Ambient air in the beginning and warm until the end[4]	5.13 Aa	5.23 Aa	5.00 Ab
Warm air in the beginning and ambient until the end[5]	5.10 Aa	5.20 Aa	4.97 Ab

[1] Simple arithmetic average, followed by lower case letters, in same line and, for capital letters, in same column, do not differ for Tukey test 5 % from significance ($p < 0.05$).
[2] Drying with not warm air, in ambient condition (20 ± 5 ºC), up to 13 % of moisture content, during all operation.
[3] Drying with warm air 45 ± 5 ºC, up to 13 % of moisture content, during all operation.
[4] Initial drying without air heating, in ambient condition (20 ± 5 ºC), up to 16 % of moisture content, complemented for drying with warm air at 45 ± 5 ºC, until the end of operation.
[5] Initial drying with warm air 45 ± 5 ºC, up to 16 % of moisture content, complemented for drying with not warm air, in ambient condition (20 ± 5 ºC), until the end of operation.

Table 5. Water absorption (g/100 g) in rice grains submitted to four stationary drying methods, in drier-silo, stored in jute sacs, for six months and processed by conventional polishing white rice process[1].

	Storage months		
Drying process	1	3	6
Ambient air (without heating) during all operation[2]	181.72 Aa	184.45 Aa	178.54 Bb
Warm air during all the operation[3]	187.19 Aa	186.95 Aa	177.00 Bb
Ambient air in the beginning and warm until the end[4]	184.40 Aa	186.20 Aa	183.64 Aa
Warm air in the beginning and ambient until the end[5]	183.03 Aa	181.68 Aa	182.78 Aa

[1] Simple arithmetic average, followed by lower case letters, in same line and, for capital letters, in same column, do not differ for Tukey test 5 % from significance ($p < 0.05$).
[2] Drying with not warm air, in ambient condition (20 ± 5 ºC), up to 13 % of moisture content, during all operation.
[3] Drying with warm air 45 ± 5 ºC, up to 13 % of moisture content, during all operation.
[4] Initial drying without air heating, in ambient condition (20 ± 5 ºC), up to 16 % of moisture content, complemented for drying with warm air at 45 ± 5 ºC, until the end of operation.
[5] Initial drying with warm air 45 ± 5º C, up to 16 % of moisture content, complemented for drying with not warm air, in ambient condition (20 ± 5 ºC), until the end of operation.

Table 6. Water absorption (g/100 g) in rice grains submitted to four stationary drying methods, in drier-silo, stored in jute sacs, for six months and processed by parboiling process[1].

Drying process	Storage months		
	1	3	6
Ambient air (without heating) during all operation[2]	165.62 Aa	162.05 Aa	154.58 Bb
Warm air during all the operation[3]	163.49 Aa	163.71 Aa	155.62 Bb
Ambient air in the beginning and warm until the end[4]	162.12 Aa	160.18 Aa	160.51 Ab
Warm air in the beginning and ambient until the end[5]	163.17 Aa	162.39 Aa	160.94 Ab

[1] Simple arithmetic average, followed by lower case letters, in same line and, for capital letters, in same column, do not differ for Tukey test 5 % from significance ($p < 0.05$).
[2] Drying with not warm air, in ambient condition (20 ± 5 ºC), up to 13 % of moisture content, during all operation.
[3] Drying with warm air 45 ± 5 ºC, up to 13 % of moisture content, during all operation.
[4] Initial drying without air heating, in ambient condition (20 ± 5 ºC), up to 16 % of moisture content, complemented for drying with warm air at 45 ± 5 ºC, until the end of operation.
[5] Initial drying with warm air 45 ± 5º C, up to 16 % of moisture content, complemented for drying with not warm air, in ambient condition (20 ± 5 ºC), until the end of operation.

The amylose rates in rice processed for conventional and parboiling processes, pointed that between 25.61 and 26.39 %, for white rice, between 25.71 and 26.82 %, for parboiled rice, there is no significant differences in management air temperature during drying, neither the storage time or the process.

Conclusions

a) the air temperature in stationary rice drying provokes immediate and latent damages, with different intensities if the grains will be processed by conventional polishing white rice process or by parboiling;

b) for processed by industrial polishing white rice process, since the sixth month of storage, dryings with air without heating during all operation, or in part of it, complemented or preceded by warm air use, provokes greaters performance whole grains without defect than that drying with warm air at 45 ºC during all operation;

c) for industrial rice processed by parboiling process, since sixth month of storage, stationary drying with air without heating during all the operation provokes minors incomes of entire grains without defect than that drying with warm air during all operation, or in part of it, complemented or preceded by without heating air in the operation;

d) at least in six months of storage, there are no effect by the management thermal air drying in grains amylose parts, in both improvement process;

e) The water sorcion in rice cooking less with the thermal drastic or the slowness of drying operation after the third month of storage.

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