PS8-4 – 6263

Effects of air temperature in drying on white oat grains quality

M.C. Elias[1,*], L.J. Marini[2], L. da C. Oliveira[3], E. Aosani[3], R.B. Prestes[5], L.C. Gutkoski[6]

Abstract

Oat is a cereal of high nutritional value, but the high lipid content of the grains is affected by intense deterioration during the storage. Low moisture in storage reduces these damages, but there is a lack of studies about the effect of air temperature used in drying on characteristics of this grain and its components. The objective of this work is to determine the oat grains drying dynamic and to evaluate the effect of this operation in the germinability and the grain enzymatic activity. Germination, vigor, lipase and peroxidase activity, acidity of ether extract (free fatty acids) were evaluated through official methodology. White oat grains were harvested with moisture of 25 % and dried until 13 % in stationary drier in three different levels of temperature (50, 80 and 110 °C). The drying at 110 °C presented high water removal rate, reaching 7.8 points percent (pp) per hour at the first hour; while the other samples had loss of 2.5 pp, within the same period. The drying operation at 110 °C was completed with in 5.25 hours, while with temperature of 80 and 50 °C, the operation was completed with 12.25 and 14 hours, respectively. In the comparison between the water removals rates it was observed that in the operation at 50 °C there was a more uniform variation than using air temperature levels of 80 and 110 °C. With the increase of air temperature there was reduction of the running time. However there was reduction in the quality of the grain. A reduction in the percentage of germination and of vigor in function of the increasing of the drying temperature was also observed. Moreover the increase in air temperature showed a reduction of the lipase and peroxidase activity.

Key words: oat, drying, quality.

Introduction

The production of oat grains increased in Brazil. The state of Rio Grande do Sul and Paraná are the largest producers, following by Santa Catarina, Mato Grosso do Sul and São Paulo (CONAB, 2006). The number of processing industries of oat grains for human use has been increasing significantly in Brazil. However the amount of grains destined to the human consumption is still small and this is due, mainly, the lack of alimentary habit. The increase in the number of processing industries can be proven with the crescent increase of new products the oats base, about 110 available items in the Brazilian market, fact generated by the important

[1] Agronomist Eng., Dr. Professor; [2] Agronomist Eng., M.Sc.; [3] Food Chemistry, Science and Technology Agroindustry Master Degree Student, [4] Agronomist Eng., Science and Technology Agroindustry Master Degree Student, [5] Agronomy student, [6] Agronomist Eng., Dr., University Passo Fundo (UPF), Associate Professor of Science and Technology Agroindustry Course-UFPEL.

[1] Post-harvest, Industrialization and Grains Quality Laboratory, Science and Technology Agroindustry Department. Agronomy Faculty. Federal University of Pelotas. Phone: +55 53 3275 7258. Campus Universitário, UFPel, Caixa Postal 354, CEP 96010-900, Capão do Leão, RS. Brazil. E-mail: eliasmc@ufpel.tche.br.

* Corresponding author.

functional properties of this cereal and the appeal of a healthier diet (Sila et al., 1998 e Carvalho, 1991).

Oat (*Avena sativa* L) is a cereal of excellent nutritional value. It stands out among the other cereals for its protein content (12.4 to 24.5 %) and quality, varying from in the peeled grain; and for its high lipid content (3.1 to 10.9 %) distributed by the whole grain, with predominance of unsaturated fatty acids. Besides, it is constituted of 9-11 % of alimentary fiber and being an important source of soluble fibers (Costa and Francisco, 2002; Silva et al., 2005).

One of the fraction of alimentary fiber present in oats and considered of great importance for the human health is the beta-glucan, a polymer found in small amounts in several tissues of the many cereals (Brennann and Cleary, 2005). Beta-glucans called attention due to their physiologic response and technological properties, as a thickener and may act as fat substitute for formulation of diet and light foods.

Due to its high fat content oat grains are subject to the intense deterioration during the storage.

Drying is one of the most important operations in the preparation of grain for storage. It has to purpose to bring moisture to advisable levels to avoid deterioration and the loss of the quality during the storage process. Fermentations and high temperature should be avoided during the drying process in order to maintain the quality of the product and its uniformity (Elias, 2002).

Drying temperature range for the seed and for the oat grains destined to the industrialization should be of 40 and 50 °C, respectively. For storage, the moisture of the grains should be lower than to 13 % (Marini, 2005).

Heating of the air should be controlled to avoid physico-chemical and biological damages. The main damages caused to the grains during the drying operation with warm air is the fissure of the grain, formation of a an external crust, color alteration, unstructured of the starch and the death of the grain, which provokes reductions in the industrial performance and in the commercial value, besides they reduce the conservability (Fagundes and Elias, 2005). When conducted without the due care, drying may induce reduction of the quality of seeds and grains. The effects of the drying in high temperature may not be immediate, because only after some time of storage those effects become measurable.

Oat grains, without any damaged, stored at room temperature with moisture below 12 % present small variations in the levels of oil acidity. However, higher moisture and temperature values, as well as partial or total desegregation of the grain are enough conditions for the action of enzymes, mainly lipase and peroxidase (Gutkoski et al., 2000).

The objective of this work is to evaluate the effect of the air temperature of drying on the chemical, physical and biological quality of white oat grains.

Material and methods

The white oats (*Avena sativa* L.), produced in the Palm Agricultural Center, UFPel, Capão do Leão, RS, were harvest with 25 % moisture dried to 13 % moisture in intermittent dryer with three levels of temperature (50, 80 and 110 °C) in the Laboratory of Post-Harvest, Industrialization and Grain Quality of FAEM/ UFPel.

In order to monitoring oat's quality, we analyzed:

Germination test

The germination test was accomplished in agreement with recommended by the Rules of Analyses of Seeds (Brazil, 1992).

Vigor test

Vigor was evaluated by the test of accelerated aging, using 220 oat seeds of each drying treatment, place in gerbox, on a screen of stainless steel, containing 40 ml of distilled water, which were maintained in BOD camera at 42 ºC and 100 % relative humidity. After 72 hours, the

seeds were put to germinate and accomplished counting, at 5 and 10 days were expressed in percentage of normal radicle and embryonic axis.

Volumetric weight

Volumetric weight was determinate by the Dalle Molle hectoliter weight balance with a capacity of ¼ liter. The results are the average of five repetitions expressed in kg m^{-3}.

Weight of a thousand grains

Determined in agreement with the official methodology (Brazil, 1992).

Acidity index

Accomplished in agreement with the method Ca5a-40 of AOCS (2000) and the results expressed in mg of KOH g oil^{-1}.

Lípase activity

The residual activity of the enzyme lípase was determined in agreement with the methodology proposed by Kaur et al. (1993).

Peroxidase activity

The residual activity of the enzyme peroxidase was determined through the dispersion of sample 0.625 g in 25 ml of TRIS-HCL 0.2 M. pH 8.5, agitation for 10 minutes and centrifugation for 15 minutes to 2,000 x g. Aliquot of 0.5 mL of the supernatant was mixed with 3 mL of the substrate solution, and reading in spectrophotometer at 420 nm absorbance. A peroxidase activity corresponds to an increase of 0.001 in the absorbance at 420 nm min^{-1} g^{-1} of sample.

β -glucans

The determination of β -glucans was conducted as methodology proposed by AOAC (1997), method n° 995.16.

Results and discussion

Figure 1 shows that drying at the temperature of 110 ºC the rate of water removal was very high, reaching 7.8 points percent (pp/hour), what is well above the recommended (Elias, 2002); while the other treatments had a lower rate of 2.5 pp, at the same time. Those results are in agreement with Simioni et al., in the study about drying of oat with air temperatures of 60, 85 and 110 °C. Comparing the rates of water removal, it was observed that in the operation with smaller temperature there was a more uniform variation than when using temperature of 80 or 110 °C.

In Figure 2, it is observed that in just three hour of drying at 110ºC the temperature of the mass of grains reaches 49ºC, while in the drying at 80ºC this temperature is reached only after seven hours of operation and it is not reached during whole the process at 50ºC, where the maximum temperature obtained was 36ºC.

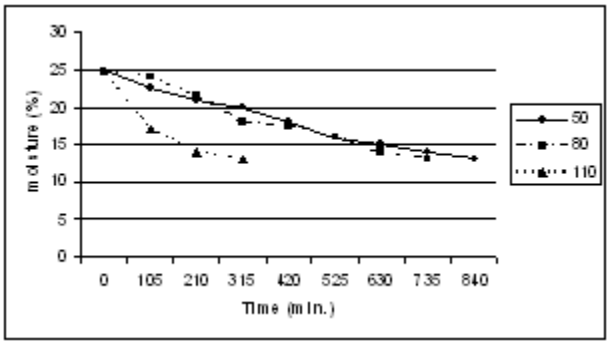

Figure 1. Dynamics of oat grains drying with three different air temperature.

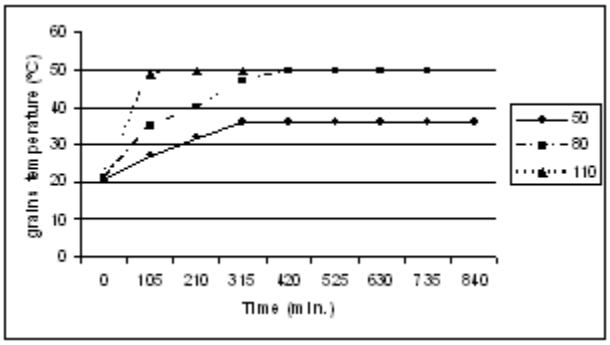

Figure 2. Temperature of the mass of oat grains during the drying process at three levels of air temperature.

The high temperature of the air there is an operational benefit as there is a decrease of the operation time, however there is also a decrease in the quality of the grains; as it is shown in the data of vigor and germination power.

Tables 1 and 2 present values of the oat grains germination and vigor, respectively, submitted to 3 different air drying temperature levels and stored in conventional system for 6 months. Those parameters, typical of evaluation of physiological quality of seeds were analyzed in the oat grains to check its biological quality, once it is related to grains metabolism in storage, and this interferes directly in maintenance of the quality or in the deterioration.

Tables 1 and 2 show that the percentages of germination and vigor were low in the beging of the storage, indifferent of the grain drying temperature used. Starting from the first month there was a significant increase in the germination and in the vigor, and that is probably due to the high rate of dormance of the oat seeds. At the end of six months storage it is observed that the values decreased in all of the treatments demonstrating the reduction in the physiologic quality. These results are similar to the found by Rupollo (2006), studying drying systems and storage of oats. It can be observed that with the drying at 110 ºC, the percentage of germination and vigor was significantly inferior since the beginning of the storage, demonstrating that the thermal damage in that condition is immediate.

Apparently, the drying effects in higher temperatures cannot be immediate, because only after some time of storage those effects become quantifiable (Baker et al., 1991). Germination and vigor may be used as grain conservation parameters, because a decrease of their values indicates deficiency in the drying and/or in the storage with consequent loss of grain quality.

Tables 3 show the data of volumetric weight of oat grains submitted to 3 different drying levels of air temperature, stored in conventional system for 6 months.

It is observed significant differences in the results of volumetric weight (Table 3) and the weight of a thousand grains after drying at hight temperature. The treatment at 110 °C presented the smallest volumetric weight at the end of 6 months. This results from the grain deterioration

Table 1. Germination (%)* in oats grains dried at 50, 80 and 110 °C and stored by 6 months.

	Months of storage		
Drying temperature (°C)	1st	3rd	6th
50	66 Ba	84 Aa	81 Aa
80	61 BCab	66 ABb	71 Ab
110	58 Bb	66 Ab	63 ABc

* Arithmetic average of three repetitions, accompanied by distinct small letters in the same column and big letters in the line show significant difference at 5 % by Duncan test.

Table 2. Vigor (%)* in oats grains dried at 50, 80 and 110 °C and stored by 6 months.

	Months of storage		
Drying temperature (°C)	1st	3rd	6th
50	65 Bb	73 Aa	71 Aa
80	57 Bc	63 Ab	52 Ab
110	44 ABd	46 Ac	43 Bc

* Arithmetic average of three repetitions, accompanied by distinct small letters in the same column and big letters in the line show significant difference at 5 % by Duncan test.

processes, reflecting the total quantitative losses due to it intrinsic metabolism, microbial activity and associated pests. The smallest variations correspond to a better conservation of the grains during the storage (Elias et al., 2002).

In the Figure 3 the values of ethereal extract acidity of oat grains are presented, submitted to 3 different drying air temperature levels and stored in conventional system for 6 months.

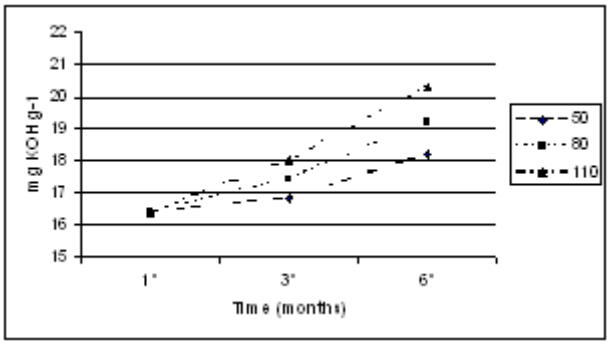

Figure 3. Ethereal extract acidity in oat grains submitted to 3 different drying air temperature levels and stored for 6 months.

In all of the treatments there was an increase of the ethereal extract acidity, being that proportional increase to the temperature increase. The index of acidity varied between 16.45 mg.KOH.g^{-1} and 20.36 mg.KOH.g^{-1}. The results found in the present work are in agreement with told them by Molteberg et al. (1995), that to the they study oats storage, they verified significant increase in the values of acidity. The index of acidity is a good indicator of grains deterioration and their products, because the lipid hydrolyze happens more quickly than in proteins and carbohydrate. With that, conditions are had of detecting losses soon in the beginning, making possible the socket of appropriate measures to avoid larger damages.

The residual activities of the enzymes lipase and peroxidase in oat grains submitted the drying with 3 different air temperature levels, are presented in the Table 4.

The activity of the enzymes lipases and peroxidase (Table 4) decreased with the increase of the drying air temperature, even though the

Table 3. Volumetric Weighs (kg m^{-3})* in oat grains, submitted to the drying with different air temperature, stored in conventional system by 12 months.

	Month of storage		
Drying temperature (°C)	1st	3rd	6th
50	319.64 Aa	319.78 Aa	319.74 Aa
80	317.87 Aa	317.31 Aa	318.56 Aa
110	311.20 Aa	319.74 Aa	310.65 Bb

* Arithmetic average of three repetitions, accompanied by distinct small letters in the same column and big letters in the line show significant difference at 5 % by Duncan test.

Table 4. Residual Activity of the enzymes lipase and peroxidase in oat grains submitted to different drying air temperature and stored in conventional system for 6 months.

	Enzyme	
Drying temperature (°C)	Lípase (% de hidrólise)	Peroxidase (Abs 420$_{nm}$ min^{-1}g^{-1})
50	22.77 a	7008 a
80	19.08 b	6334 b
110	18.13 b	5792 c

* Arithmetic average of three repetitions, accompanied by distinct small letters show significant difference at 5 % by Duncan test.

grain mass temperature not having surpassed 50°C. Ekstrand et al. (1992) observed decrease in the lípase activity when drying above 60°C, but in the same work reductions of the residual activity of peroxidase were not verified, demonstrating that this enzime has larger thermal stability. Weber et al. (2002), evaluating effect of the water temperature and immersion time, observed drastic decrease in the values of lípase activity in the treatments with higher temperature.

Figure 4 shows the drying air temperature effect in the beta-glucan content of oat grains.

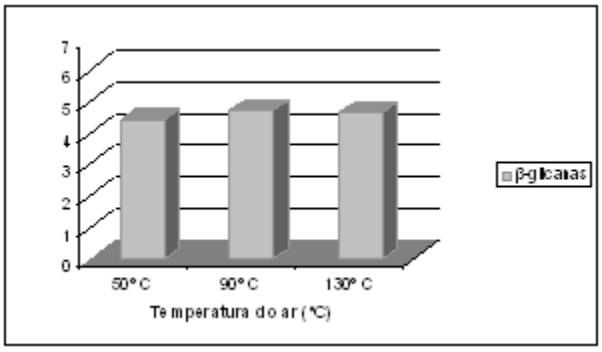

Figure 4. Beta-glucans contents in white oat grains submitted to 3 different drying air temperature levels and stored for 6 months.

It is observed that there are no significant differences in beta- glucans contents in function of the different drying temperature levels, however one cannot affirm if there are structural damages to the fiber, due to the treatments. According to Wood et al. (1989), the grains processing can affect the contents and the structural, functional and molecular properties of this fiber. It is necessary to understand and to manipulate the process of beta-glucan isolation to assure that the possible alterations in its structure do not compromise the functional, nutritional and sensorial quality of the food the which the fiber is added (Brennan & Cleary, 2005).

Acknowledgements to CNPq, CAPES, SCT-RS (Technological Innovation Poles) and COREDE-SUL.

References

AOCS. OFFICIAL and tentatives of American OIL Chemistry Society 2000, New York, D.C.

AOAC- Association of Official Analytical Chemistry. Official methods of analysis of the Association of Official Analytical Chemistry. 1997. 16 ed. Arlington: Washington, v. I e II.

Baker, K.D., Paulsen, M.R., Zweden, J.V., 1991. Hybrid and rying rate effects on seed corn viability. Transactions of the ASAE 34, 499-506.

Brasil, 1992. Ministério da Agricultura, do Abastecimento e da Reforma Agrária. Secretaria Nacional de Defesa Agropecuária. Regras para análise de sementes. Brasília: MAPA.

Brennan, C.S., Tudorica, C.M., Kuri, V., 2005. Soluble and insoluble dietary fibres (non starch polysaccharides) and their effects on food struture and nutrition. Food Industry Journal 5, 261-272.

Brennan, C.S., Cleary, L.J., 2005. The potential use of cereal beta-glucans as functional food ingredients. Journal of Cereal Science 1-13.

Carvalho, G., 1991. Uso de la avena brasileira por Quaker. IN: Congresso Sudamericano de Avena, (1), Três Arroyos. Anais. Argentina.

Companhia Nacional de Abastecimento, Levantamento de safra – Safra 2004/2005. CONAB, 2006. Disponível em: <http: www.conab.gov.br>.

Costa, B., de Francisco, A., 2002 Caracterização química de genótipos brasileiros de aveia (*Avena sativa L.*) Acta Científica Venezolana. 53, 3.

Ekstrand, B., Gangby, I., Akesson, G., 1992. Lipase activity in oats- distribution, pH and

heat inactivation. Cereal chemistry 69, 379-381.

Elias, M.C., 2002 Armazenamento e conservação de grãos em média e pequenas escalas. 3 ed. Pelotas.

Fagundes, C.A.A, Elias, M.C., 2005. Secagem de arroz. In.: II Simpósio Sul-Brasileiro de Qualidade de Arroz, Pelotas, 243-256.

Gutkoski, L.C., Pedó, I., 2000. Aveia: Composição química, valor nutricional e processamento. 1 ed. Varela Editora ltda, Passo Fundo.

Kaur, J., Ramamur Thy, V., Kothari, R.M., 1993. Characterization of oat lipase for lipolysis of rice bran oil. Biotechnology Letters 3, 257-262.

Marini, L.J., Gutkoski, L.C., Elias, M.C., Mezzomo, N., 2005. Efeito da secagem intermitente na estabilidade de grãos de aveia. Brazilian Journal of Food Technology 8, 3.

Molteberg, G.L., Vogt, G., Nilsson, A., 1995. Effects of storage and heat processing on the content and composition of free fatty acids in oats. Cereal chemistry 72, 88-93.

Rupollo, G., Gutkoski, L.C., Martins, I. R., Elias, M.C., 2006. Efeito da umidade e do período de armazenamento hermético na contaminação natural por fungos e a produção de micotoxinas em grãos de aveia. Revista Ciência e Agrotecnologia 30, 1.

Sila, A.C., Bittencourt, J.M., Mafioletti, R., Bonin, J., 1998. Produtos derivados de aveia In: Reunião da comissão brasileira de Pesquisa de aveia, 18, Londrina. 58-65.

Silva, L.P., Ciocca, M.L.S., 2005. Total, insoluble and soluble dietary fiber values measured by enzymatic-gravimetric method in cereal grains. 18, 113-220.

Weber, F.H., Gutkoski, L.C., Elias, M.C., 2002 Processo de estabilização de farinha de aveia por imersão das cariopses em água quente. Brazilian journal of food techology 5, 225-235.

Wood, P.J., 2001. Cereal b-glucans: struture, properties and health claims. In.: McCleary, B.V., Prosky, L. Advanced dietary fibre technology. Blackwell science, London, 315-327.