Behavior of Wet Corn Stored With Aeration

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ABSTRACT

Conduct aeration in a wet holding bin reduces from additional investing in oversized dryers and avoid the heating of the grain mass while the drying operation is awaited. From this assumption, the temperature behavior, the moisture content and the development of molds were studied during 6 days of continuous aeration of corn (*Zea mays L*.) in a laboratory scale wet holding bin. A flow of 0,60 $m^3min^{-1}m^{-2}$ of air in ambient conditions was blown into a mass of corn of 125 kg with initial moisture content and average temperature of 17,76% (w.b.) and 37,95 ºC, respectively. The temperature was measured with thermocouples and recorded on a data acquisition system; the moisture content was analyzed at he beginning and after six days of aeration by the oven standard-method at 105 ± 3 ºC and for 24 hours; health tests were carried out by the blotter test method. all data was obtained for the superior (A), intermediate (B) and inferior (C) layers of the grain mass. The aeration period required so that the average temperature of the grain mass passed from 37,95 ºC to 20 ºC was of 2 days. During the other days, the temperature remained fairly stable around 21 ºC. Only the grains in layer A kept the initial average moisture content, in the other layers, B and C there was a reduction of this moisture content after six days of aeration, according to the Tukey test. The average values of moisture content in the layers A, B and C were respectively 16.99%, 15.13% and 13.88%. By Tukey test for comparison of means, we can say that there is evidence that the mold *Aspergillus* spp., *Penicillium* spp. and *Fusarium* spp. showed no significant development in grains of corn stored under aeration in the period of 6 days.

Keywords: Grains, temperature, moisture content, microorganisms, molds, Brazil

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1. INTRODUCTION

Newly harvested grain, and therefore wet, even if free from the action of insects and rodents are subject to loss of quality due to high respiration rate of the grain and the development of molds. The process of respiration involves the resurfacing of nutrients in the product and heating the mass of grains, making the environment conducive to the development of mold.
According to Silva (2000) the main factors influencing the development of mold are: moisture content, temperature, degree of infestation by mold in the field, presence of foreign material and activity of insects and rodents.
Temperature and moisture are the major factors directly or indirectly affecting the quality of grain during storage (Chang and Steele, 1995).
The main damage caused by mold on grains are discolored, heating, reduction in germination, production of mycotoxins and rot (Silva, 2000). The mycotoxins such as aflatoxins and Ochratoxina are toxic to animals and to humans, capable of causing irreversible liver diseases, can lead to liver cancer. The action of mold also causes the reduction of the original grains weight (Weber, 2001).
The execution of drying operation after harvesting the grains is essential for maintaining the quality during storage. Puzzi (2000) states that grains stored dry, between 11% and 13% according to species, have a slight respiratory process.
Generally dryer static capacity of unit of improvement or property agricultural isn't sufficient to accomplish the drying of the whole production in a single transaction, due to economic viability. Thus, the product awaiting drying is stored in a wet holding bin.
According to Silva (2000), to prevent heating of the grain in wet holding bin aeration should be performed with large volumes of air to keep the product in wet conditions of high quality before the drying operation.
Aeration can slow the rate of deterioration of high-moisture grain, but most grains should be 14% (w. b.) or below for storing several months or longer (Akdogan and Casada, 2006).
Loewer et al. (1994) states that the wet holding bin acts as a deposit for the grain before drying. The wet holding bin has two primary functions: to allow a faster unloading of delivery vehicles for the harvest does not delayed and allow the immediate filling of the dryer, thereby increasing its capacity dynamics.
Wet holding bin is used for grain storing in the short term. If it used to hold the grain for more than a day, aeration mechanisms should be considered depending on the temperature during harvest (Loewer et al., 1994).
Puzzi (2000) and Lasseran (1981) defines aeration as the forced movement of the air through the grain mass, to improve the storage conditions, using small air flow, generally in the range 3 to 12 $m^3.h^{-1}t^{-1}$. Only in very particular cases is used artificially cooled air for refrigeration equipment.
According Lasseran (1981), the aeration is performed under insufflation or aspiration of air and driven by a fan into the mass of grains through conduits, which is properly distributed by a ducts system. The efficiency of aeration is due in large part to the homogeneity of the air distribution.
The aeration process is normally used to cool grain and stop moisture migration inside the bins by distributing the temperature inside the bin uniformly (Casada and Alghannam,1999).
Ferreira (1979) states that mechanical aeration with natural air blown through the corn grains mass is presented as a very feasible for the São Paulo State.

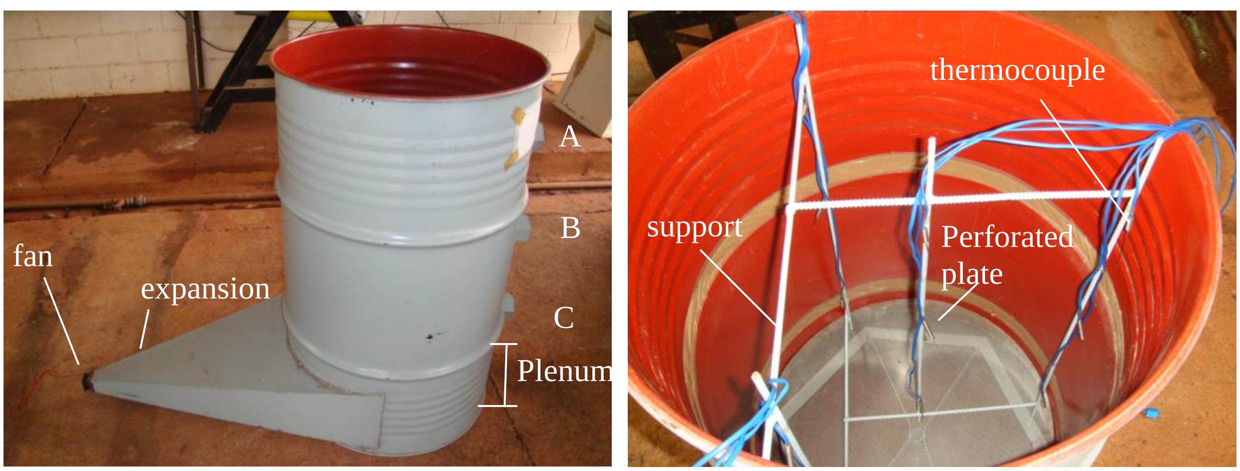
The use of aeration system in newly harvested grain awaiting the drying avoids investments in extra or oversized dryers and provides maintenance of the grains quality.
This work aims to study the behavior of temperature, humidity and development of mold in stored wet corn grains stored for six days with aeration.

2. MATERIAL AND METHODS

The work was performed at the Laboratory of Post-Harvest Technology, Faculty of Agricultural Engineering, State University of Campinas.

2.1 Material

The bin was built from drum of diesel oil, with the following dimensions: 0.57 m in diameter and 0.80 m in height. The drum was adapted to the needs of the research, by the construction of the following: plenum chamber, made with perforated plate and installed at 20 cm height to allow the passage of air; pyramidal roof with square base and 70 cm of side, whose difference form of the circular section of the silo and the roof panels allow exhaust air to the aeration; brackets for installation of thermocouples into the bin and 3 circular openings of 5.08 cm (2 ") in the silo wall, closed with threaded caps that allowed withdrawal of samples during storage.
The thermocouples were installed in the following heights of the bin: just below the surface of the grain mass (A), in the central part (B) and just above the perforated plate (C). Regarding the cross section area, three thermocouples were placed near the bin wall and one in the center, resulting in 4 thermocouples in height and totaling 12 thermocouples inside the silo (Figure 01).
The corn grains used in the experiment were provided by the Planters Cooperative of Sugar cane - COPLACANA, Piracicaba, SP. A mass of 125 kg of corn grain was used in the experiment.



a b

Figure 1. Exterior (a) and inside (b) of the bin with identification of its constituent parts.

2.2 Methods

The fan was designed based on the air maximum flow recommended for warmer regions, 0.60 $m^3 min^{-1} m^{-2}$, according to Silva (2000). It was found that the flow and pressure to be used for the mass of 125 kg of grain with initial moisture of 18% should be, respectively, of 0.08 m^3 min^{-1} and 0.52 mmca. It was acquired a microfan with a flow rate of 0.18 m^3 min^{-1} and pressure of 3 mmca and with the aid of a circuit variable speed drives to adjust the flow of the fan design. Before placing the grains in bin were moistened to 13% (w.b.) to 18% moisture (w.b.) (Equation 1) and heated with solar power until an average temperature of 37.95 º C, with the aim of simulating the process of heating spontaneously occurring during storage. The heating process was carried out with solar energy, and the grains placed in black plastic bags to avoid changes in moisture content, exposed to the sun and moved from time to time to achieve the desired temperature. The increase in temperature was monitored by thermometers inserted into the grains mass. Each bag contained 10 kg of grain.

$$Ui = \frac{Pai}{Pt} \therefore Pai = Ui \times Pt$$

$$P_{MS} = Pt - Pai$$

$$Ud = \frac{Paf}{Paf + P_{MS}} \quad \text{Equation 1}$$

$$Par = Paf - Pai$$

where, Ui: water content (decimal, w.b.); Pai: the water of the initial grains (g); Pt: total mass of grains (g); P_{MS}: dry matter of grain (g); Ud: moisture desired (decimal, w.b.); Paf: mass of water at the end (g) Par: real mass of water to be added (g).
The aeration experiment by air-blowing began in mid-November 2008 and lasted 24 days. During aeration period followed up the behavior of temperature, moisture content and health tests in the corn grains, to verify the occurrence of microorganisms *Aspergillus* spp., *Penicillium* spp. and *Fusarium* spp.
For monitoring the temperature a acquisition system recorded the data obtained by thermocouples installed inside the bin (Figure 1). The moisture content was determined with the oven standard-method at 105 ± 3 ° C for 24 hours, according to Brazil (1992), from each sampling for bin height, A, B ou C, at intervals of three days, were three replicates for each height .
Health tests at the beginning and after six days of aeration were realized. The methodology used was the Blotter Test. The sampling was performed by insertion of sampler in each opening in order to draw a sample representative of the bin diameter in the horizontal direction. From the sample each height, after homogenization of grain, 40 grain is removed for analysis.
The grains were placed in boxes gerbox properly spaced, with a filter paper moistened with distilled water. The product was incubated in chamber B.O.D. at 20 °C under alternating 12 hours light and 12 hours of dark for a period of 8 days (Brazil, 1992).
An obstacle that can be found in the conduct of this method refers to the rapid germination of some seeds. This makes it difficult to evaluate, and compromise the viability of the method by the possibility of secondary contamination of the grains from outside of the recipient. Inhibition of germination was realized by freezing. After a period of water absorption of 24 hours of incubation at 20 °C, the grains remained for another 24 hours in freezer, transferring them, after that period, again to a temperature of 20 °C in B.O.D. for 8 days.

The identification of microorganisms reproductive structures was done according to Barnett and Hunter (1972). The result was based on the grains number infected with each molds.

3. RESULTS AND DISCUSSIONS

The aeration period necessary for the average temperature of the grains mass rising from 37.95ºC to 20 ºC was two days. Devilla et. al. (2004) studied of temperature variation and moisture content in corn grains aerated also had greater reduction in the temperature of the grains mass between 24h and 48h of aeration.

It was found in the other days of aeration the temperature of the grains mass has remained fairly stable around 21 ºC. Ferreira (1979) obtained temperatures around 19 ºC all year in storage of grain with aeration.

It can clearly see the aeration effect reducing the temperature of the grains located first at C, near the entrance of air, then the height of B were cooled, located in the middle of the bin, and finally the height grains A, above, were cooled by air aeration (Figure 1).

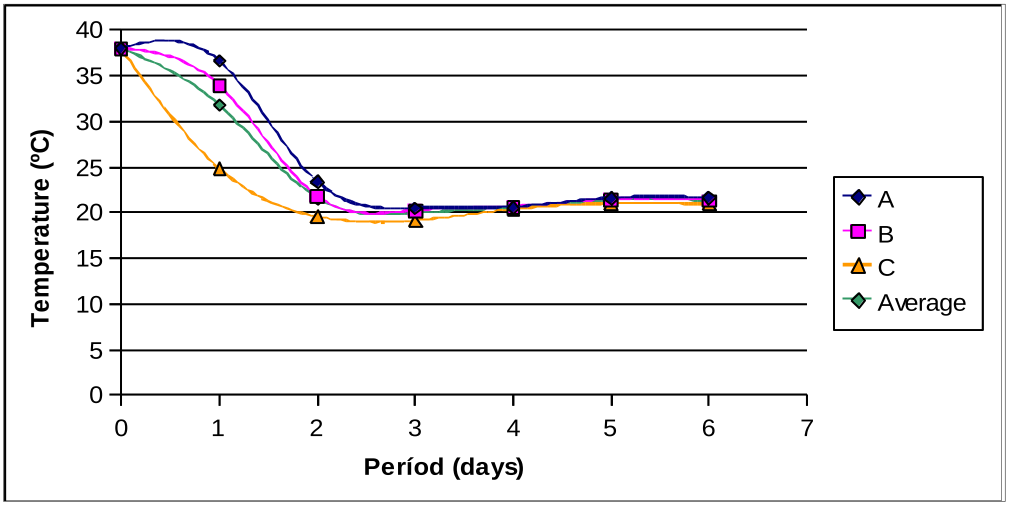


Figure 1. Behavior of average temperature on the height A, B, C the grain mass during the six days of aeration.

By Tukey test for comparison of means, it was found that only the grains of the layer A remained with the average initial moisture content, the other layers, B and C, the moisture content was reduced after 6 days of aeration. Similarly as the effect of cooling, the further reduction of moisture occurred in layer C, to be located closer to the entry of air.

The average levels of final moisture of the layers A, B and C were 16.99%, 15.13% and 13.89% respectively.

In Figure 2, you can check the difference between the initial moisture of heights A, B and C and after 6 days of aeration.

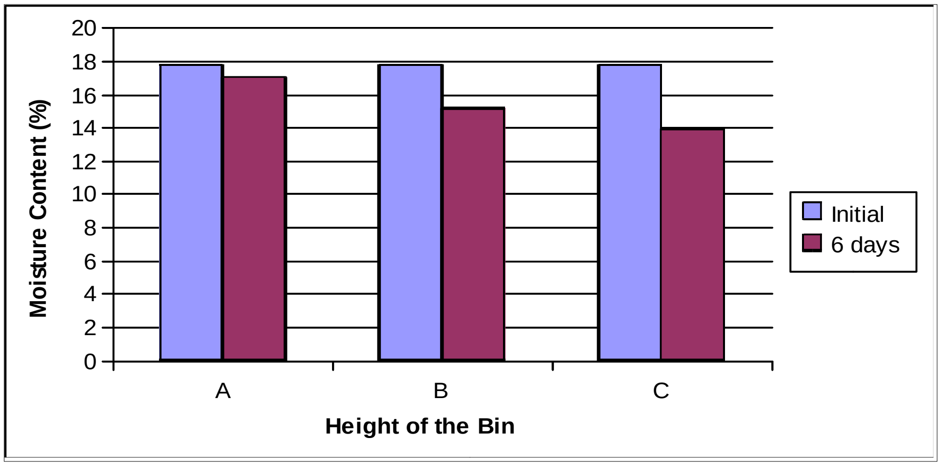


Figure 2. Moisture content of corn grains found in the height A, B and C of the bin at the beginning of the experiment and after six days of aeration.

The initial mold percentage of corn grain were: 23.3% of *Aspergillus* spp, *Penicillium* spp and 82.5% from 65.8% of *Fusarium* spp. After 6 days of aeration the average percentage between the heights A, B and C of occurrence of the molds *Aspergillus* spp, *Penicillium* spp and *Fusarium* spp was 9.17%, 70.00% and 73.33% respectively. Figure 3 shows the percentages of mold occurrence at the end of the aeration experiment in the height A, B and C.
By Tukey test for comparison of means, we can say that there is evidence that the molds Aspergillus spp, Penicillium spp and Fusarium spp showed no significant development in corn grains stored under aeration in the period of 6 days.

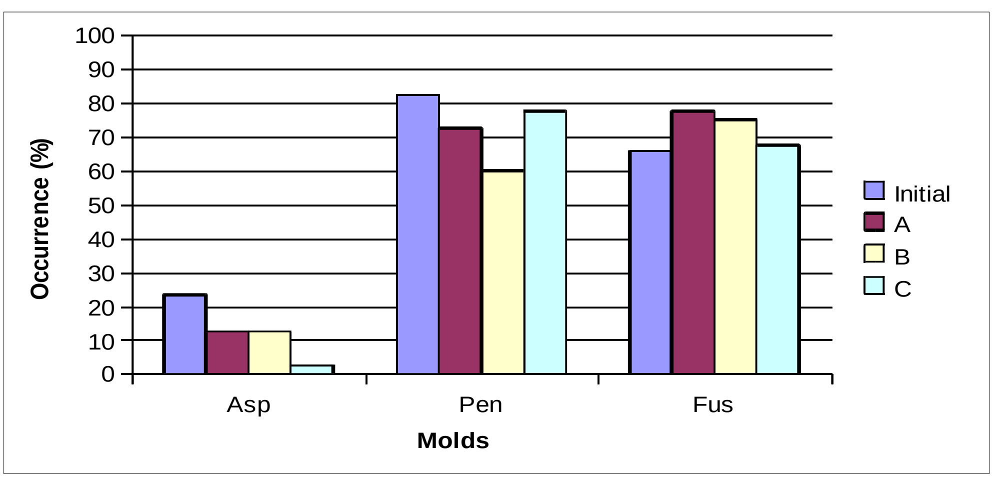


Figure 3. Percentage of occurrence of the molds *Aspergillus* spp, *Penicillium* spp and *Fusarium* spp in the height A, B and C of the mass of grains aerated.

4. CONCLUSION

The aeration of 125 kg of wet corn grains (18% moisture content) with air flow of 0.08 m^3 min^{-1} was effective in reducing the temperature of the grains from 37.95 ºC to 20 ºC in two days.
The moisture content of the grains varied depending on their position inside the bin, the closer the entry of air was increased to reduce the moisture content. The drying was not goal of aeration, however, in the case of wet grain, this is a favorable outcome to the conservation these one for a longer period.
During six days of aeration not verified development of the molds *Aspergillus* spp, *Penicillium* spp and *Fusarium* spp, the occurrence percentage these one remained approximately constant between the initial and final analysis.

5. ACKNOWLEDGEMENTS

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