Evaluation of hygroscopic salts and drying beads to effectively dry corn during ambient storage

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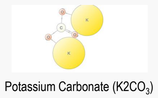
Introduction

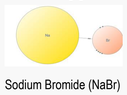
- In the humid tropics, approx. one third of food produce is lost prior to reaching the consumer, due to mycotoxin presence accelerated by high relative humidity and moisture content during storage [1].

- Developing nations are mainly affected [1], creating the need for cost effective and safe post-harvest techniques.
- Desiccants, mostly hygroscopic salts, are proposed to dehydrate corn to safe storage conditions and observe removal of water from corn [3].

Magnesium Chloride ($MgCl_2$)

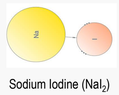


Potassium Carbonate ($K2CO_3$)



Sodium Bromide (NaBr)

Ammonium Nitrate (NH_4NO_3)



Sodium Iodine (NaI_2)

Sodium Carbonate (Na_2CO_3)

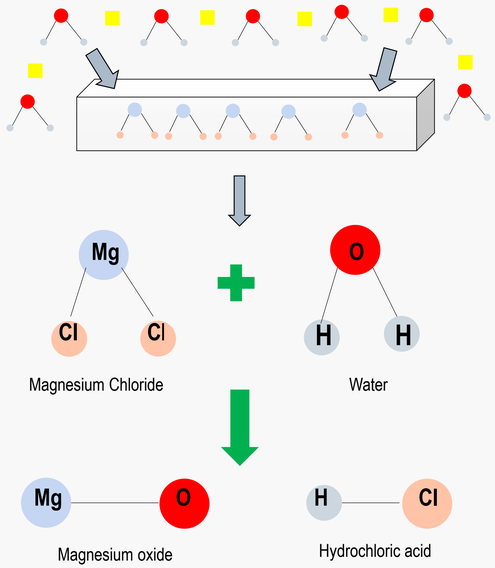


Diagram 1: Water and corn surround a Tyvek® (DuPont™, Wilmington, DE) bag with Magnesium Chloride. The arrow demonstrates the ability of the salt to adsorb the moisture, forming Magnesium oxide and Hydrochloric acid. The excess heat generated leaves the environment, reducing relative humidity [5].

- Hygroscopic salts, and a novel zeolite-based desiccant (DryBeads™) (Cento Thai, Thailand) that can dehumidify air for dehydration of corn will be tested [2].
- The proposed desiccants are able to adsorb moisture from the surrounding corn, lowering relative humidity [5] (See Diagram 1).

The Method

- **Preparation of corn**

Fill 5 gallon container with corn, add water to bring MC up to 16-18 % wb.

2 days

Prepare 96 mesh bags samples with 50g of moisturized corn.

Prepare 8-20 liter buckets for treatment groups positioned throughout the bucket (6 salts, 1 DryBeads ™, 1 control corn). Each treatment has a bottom, middle, and top sensor setup through created drilled sockets. (ZSeries, Omega) [4].

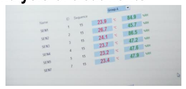
- **Preparation of treatment**

Insert 1kg of desiccant and 1kg of control corn to one Tyvek® bag for a total of 8 Tyvek bags.

Each treatment contains 12 mesh bags samples spread out evenly on bottom, middle, and top levels. At each level fill bucket with moisturized corn as you progress (11.5kg total). Place desiccant bag in centroid.

Seal the container securely.

- **Analysis of treatments**



For a period of 12 days, at ambient temperature (25 ° C) storage, record the temperature and relative humidity percentage values at bottom (B) , middle (M) , and top (T) levels for each treatment using the Zseries sensors. Data can be viewed and recorded remotely.

After 12 days, remove mesh bag samples. Visually analyze for presence of mold, germinated corn kernels, and insects.

Dry in oven to calculate water gain or loss.

Results

Dehydration of corn due to desiccants.

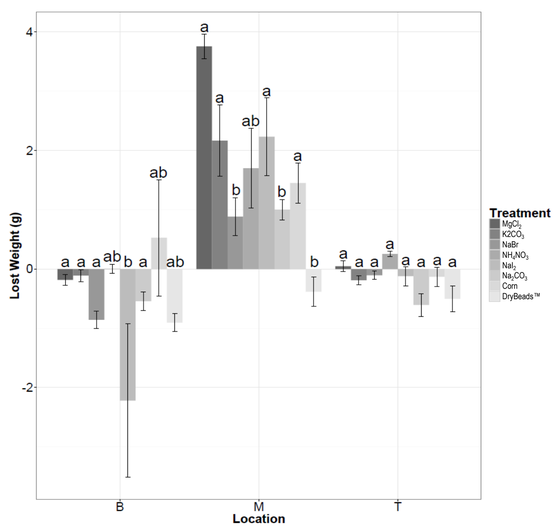


Figure 1: Lost weight (g) values comparing the different treatments (salts, drying beads, and un-treated control corn) at 3 different locations (B = Bottom, M=Middle, T=Top) were analyzed using one-factor analysis of variance (ANOVA). Significance difference between lost weight (g) means was determined using the Tukey post-hoc multiple comparisons of means test at the 95% family-wise confidence level (P = 0.05) [6]. Calculations were performed using the language and environment for statistical computing software R V3.3.1 [7].

Temperature and Relative Humidity changes for treatments.

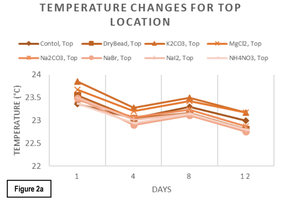


Figure 2a

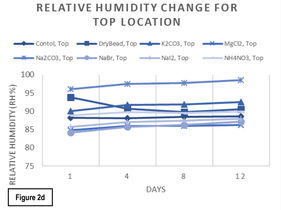


Figure 2d

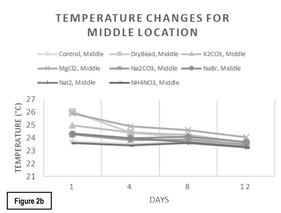


Figure 2b

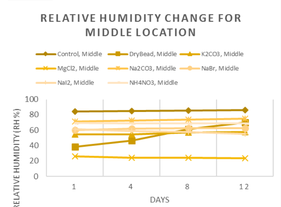


Figure 2e

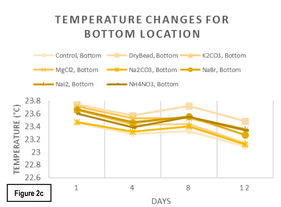


Figure 2c

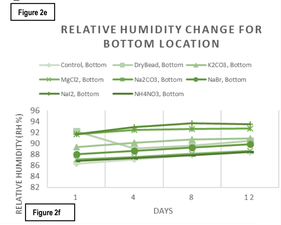


Figure 2f

Figure 2(a-f): Temperature (left side) and Relative Humidity (right side) changes for the top, middle, and bottom locations of corn sacks are shown based on an average taken from the first, fourth, eighth, and twelfth day of experimentation. The values were obtained through the Omega Engineering Zseries sensors [4].

Conclusion

- Magnesium Chloride ($MgCl_2$) , Potassium Carbonate (K_2CO_3), and Sodium Iodine (NaI) based in the middle location (M) of Fig. 1, show a significantly higher capacity to remove water from corn. Therefore, these salts can be considered for further experiments.
- The middle location (M) showed a significantly higher water reduction in corn, (Fig. 1), due to its proximity to the salts. This infers, that containers need to be aerated to remove internal humidity.
- Magnesium Chloride ($MgCl_2$) showed a lowering of the relative humidity (Figure 2 -b) in the middle location (M), which confirms that depending where the desiccant is located, it has a higher and positive potential to dehydrate corn.
- The DryBeads ™ desiccant showed a lowering of relative humidity in top and bottom (Figure 2-d to 2-f). However, the DryBeads ™ did not remove as much moisture from corn (Fig. 1). Therefore, this indicates that the DryBead ™ can be re-engineered for better performance at removing moisture from corn.

How can our research impact the industry?

"We complete the research on a industrial scale, analyze, and prepare a report for real-world applications"

"We interact with you to help apply findings to your specific needs"

"We establish a long-term relationship through outreach efforts"

References

[1] "Aflatoxin." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 13 Jan. 2012. Web. <https://www.cdc.gov/nceh/hsb/chemicals/aflatoxin.htm>.

[2] "Drying Beads Info." *Drying Beads*. N.p., 01 Sept. 2014. <http://www.dryingbeads.org/?page_id=72>.

[3] Uhriq, J. William. "Costs of Drying High-Moisture Corn." *Grain Quality Fact Sheet #3*. Purdue University, Oct.-Nov. 1992. Web. <https://www.extension.purdue.edu/extmedia/gq/gq-3.html>.

[4] "High Power Wireless Sensor." *High Power Wireless Sensor*. Omega Engineering, n.d. <http://www.omega.com/pptst/ZED-P_SERIES.html>.

[5] "Young, J. F. (1967), Humidity control in the laboratory using salt solutions—a review. J. Appl. Chem., 17: 241–245. doi:10.1002/jctb.5010170901

[6] "An Introduction to Statistical Methods and Data Analysis, 7th Edition.", Ott and Longnecker 2001

[7] "R V3.3.1" http://cran.r-project.org.

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