Scientific Bulletin. Series F. Biotechnologies, Vol. XXIV, No. 2, 2020
ISSN 2285-1364, CD-ROM ISSN 2285-5521, ISSN Online 2285-1372, ISSN-L 2285-1364

I.3. EFFECT OF STORAGE CONDITIONS ON WHEAT QUALITY PARAMETERS - A MINIREVIEW

Mariana Valentina PETRE, Mona Elena POPA

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd., District 1, Bucharest, Romania

Corresponding author email: valentinamariana20@yahoo.com

Abstract

Wheat is one of the most important cereals grown worldwide. After harvesting it must be stored in appropriate conditions in order to retains its nutritional and quality properties. During storage the wheat can be degraded due to improper storage conditions. The analyzes that are assessed to establish the quality of the wheat stored for a longer period are: proteins content, humidity, ash, Falling Number test and aflatoxins incidence. This paper makes an overview of the storage conditions available worldwide, the effects of the storage conditions on the quality of the wheat preserved in silos, warehouses or halls. In order to monitor the wheat storage condition it is necessary to follow the important parameters of storage, temperature and relative humidity. Optimal storage can ensure the good quality and and ventilation. Therefore, it is very important that the storage areas are properly prepared after harvesting. This preparation involves a general cleaning, followed by disinfection, derating and repair of cracks in the walls and floor, which, could become nests conducive to the development of insect larvae. Proper storage of agricultural products but also initial quality parameters of raw material represent very important factors for maintaining their quality and quantity for a long period of time.

Key words*: wheat, storage,conditions, quality parameters, silo type.*

INTRODUCTION

Wheat is one of the largest food crops consumed globally as a basic raw material. It can be stored for more than one year with a moisture content of 12-13%, however, it requires appropriate storage and environmental conditions restrict to inhibit infestation of insects, rodents and fungi. Storage is the mandatory stage in the wheat supply chain. Losses caused by insect infestation during storage account for a major part (10-30%) of post-production wheat losses (Paliwal et al., 2004), worth around $1 trillion a year (Kumar and Kalita, 2017). Quantitative loss, metabolites produced by insects, such as excreta and by-products of protein metabolism, give off an unpleasant smell. Also, during storage, wheat develops various odors, which with the passing of time is called a storage smell. During storage time, the odors generate are generally composed by aliphatic alcohols, amine compounds, ketones and other carbonyl compounds (Zhang and Wang, 2007). The main smell is produced by *Rhyzopertha dominica* and *Tribolium castaneum* (Laopongsit et al., 2014). As storage time increases, medium polarity odors also increase with a simultaneous reduction of low polarity odors (Olsson et al., 2000). As agriculture developed on an industrial scale, and farmers have learned to grow crops in greater quantities than the quantities needed for their immediate use, the need to store and transport large quantitiesof cereals was evident.

Today, cereals consumed in industrialized countries are produced by only a small proportion of the total population through highly mechanized agricultural operations. Cereals are biological materials which interact with their immediate environment. They must be stored, transported using methods which maintain the quality of the seeds, foodstuffs or raw materials.

Storage may take place either on the farm or on commercial premises outside the farm. Wheat can be stored for different periods of time, from short-term storage in which only drying takes place, to longer periods leading to its recovery and long-term storage for special stocks. Storage on farm premises is usually smaller than commercial installations.

Cereals are usually stored in cylindrical metal silos made of metal corrugated sheets which are fixed together. The size of the farm's pubs has increased significantly in recent years, and today some of the farm's large dumps are similar in size to those observed in commercial operations. Commercial grain storage facilities are often located in grain-producing areas, factories and other processing plants, at grain-handling terminals located in railway centers and in ports. Grain hoppers are usually much larger than agricultural trash used on the farm. For these facilities, concrete reinforced cylinders are commonly used, although large metal grain bins are still common. Flat-rate storage is also observed at commercial installations where cereals are stored in storage or in piles for short-term storage.The quality control of storage in silos is done indirectly through the control of moisture and air movements. Venting system reduces damage to stored grain. The cooling of cereals during storage has received increasing attention in recent years (Wilkin et al., 1990) and has been widely used in cereal stock management (Edde, 2012; Jayas, 2012; Navarro, 2012). Keeping the temperature low provides the ability to control insects with low levels of pesticide applications (Yang et al., 2017).

Moisture exchange is an important management process, as cereals adsorb or dehydrate moisture under different environmental conditions. Globally, more than two billion tons of cereals are harvested annually (D. S. Jayas, 2012). The harvested cereals must be stored safely in order to meet the food demand of the population and, in particular, to meet emergency needs such as disaster and hunger. Safe grain storage can be achieved by handling two important physical factors: Temperature and moisture content (D. S. Jayas, 2012).

Compared to temperature monitoring, grain moisture detection is more difficult for different seed distribution phases. A non-destructive and economical wheat moisture detection system has been implemented with WiFi, i.e. Wi-Wheat. The proposed system does not need any dedicated device, which means that it will cost less with easy deployment. Using WiFI and specialized apparatus, it can be experimentally proved to detect wheat moisture using amplitude and phase differences data. The detailed design of the Wi-Wheat system proposes extracting and processing amplitude data. The amplitude and difference data are extracted in front of the operating receivers of the installations. Once data is collected, the device processing module consists of pre-processing data, feature extraction, and classification of support vector technology. To pre-process data, we use external detection, data normalization, and noise elimination to obtain amplitude data that can detect the increase in stored wheat moisture (Wi-Wheat: Contact-free Wheat Moisture Detection with Commodity WiFi, 2018).

SILAGE MODELS WITH AERATION SYSTEMS

This silage model consists of a vertical cylindrical part (silo body), conical part (bunker) and roof made of zinc-coated steel. The tank and roof reinforcement rings were 50 mm wide and 10 mm thick. Silos can be considered as a rigid steel silo with smooth walls. The dimensions of the silos are 1 m high and 0,5 m in diameter, and the wall of the bunker has a tilt angle of 15 degrees with a height of 0,3 cm and a discharge opening diameter of 0,33 m. The aeration system consists of a vertically pierced pipe of the blower located centrally on the inside for the air inlet distribution along the height of the silos, the air flow control valve (Thermal and mechanical analysis of grain storage silos under forced aeration conditions using advanced modeling methods, 2019).

STRESS, TEMPERATURE AND RELATIVE HUMIDITY SENSORS

The stress measurement device consists of three vertical (Type S) and horizontal (Type L) load cells, which are calibrated at the concrete testing laboratory at the Engineering Faculty at Kafresheikh University. The temperature and humidity control method for the silos in which the seeds were stored was presented by investigating different aeration strategies and geometric shapes of the silos. The difference, between temperature measurements and grain pressure in a vertical and horizontal plane, with the response surface can effectively represent the performance of the control system that helps to classify operating parameters. The thermal and mechanical model of silo was developed based on empirical measurement. The developed prototype may predict the heat and moisture behavior of the grain storage silos with an aeration system similar to the environment at different specific air enthalpy (Thermal and mechanical analysis of grain storage silos under forced aeration conditions using advanced modeling methods, 2019).

MEASURING WHEAT MOISTURE

Existing methods for measuring wheat moisture can be classified in: American society of Agricultural Engineers, 2001, capacity method (W. Wang et al., 2011), resistance method (Z. Liu et al., 2015), microwave method (K. Kim et al, 2006) and neutral method (Y. Yang et al., 2000).

The American society of Agricultural Engineers (2001) method is widely used. Although this method is fairly accurate, it is intended for the laboratory environment; it does not meet the requirements for online moisture detection in the field. Method for detecting capacity humidity (W. Wang et al., 2011) fairly widespread, but its performance is limited by the fact that measurement values are not only sensitive to temperature, but also to the flow rate of the grain. The method involves checking several parameters and after each use of the device its sensor must be fixed. In the case of the resistance method (Z. Liu et al., 2015), the grain moisture detector is designed based on the model of the relationship between measurement frequency and grain moisture and non-linear temperature correction method. The device consists of two computers. The lower computer mainly senses resistance values; the upper computer focuses on the conversion of humidity and frequency and non-linear temperature correction. Microwave method (K. Kim and et al., 2006) and neutral method (Y. Yang et al., 2000) these two methods show high accuracy, fast detection speed, non-destructive and non-invasive measurements and can additionally measure the inert moisture of the wheat grain, but the measurement equipment is complex at high cost.

DRYING AND STORAGE PRACTICES

Over time it was found that a superior storage is required for the impression quality of grain and not. Studies have shown the importance in improving food storage, especially in areas deficient of moisture (Nduku et al., 2013). Because of the numerous efforts to reduce postharvest losses, they were implemented related to wheat in sealed bags under optimum conditions (Nash et al., 2017).Storing quality helps in storing wheat grains, seeds quantitative prevents loss due to insects, rodents and mycotoxins (Adetunji, 2007). Most often the damage is due to quantitative contamination of grain with aflatoxins (Kang'ethe, 2011; Maina et al., 2016). It has been observed that keeping wheat in airtight bags reduced its degradation caused by insects and mycotoxins (Njoroge et al., 2014; Maina et al., 2016; Williams et al., 2014). They were subjected to a storage test of wheat two methods. The sealed plastic bags sprayed with pesticide as a first method and a second method, a plastic bag with pesticides, each method was repeated 10 timesThe storage of seeds meant drying them at 12% humidity and subjecting them to the analysis of the impurity content. Shelf lasted six months (May-October) period after harvest until the next sowing. The bags are made of high density polyethylene, reducing the transfer of gas from the outside to the inside and vice versa. This method of storage was examined six months after the making and was found: moisture content of the seeds is lower in hermetic bags treated with the pesticide. Drying the seeds prior to the time increase the quality of wheat.

STORAGE CHALLENGES

Most serious problems during storage of cereals are due to hexapod and rodents. Those who keep long-term wheat have adapted to the situation and have improved storage technologies. They also use chemicals to eliminate pests, but also using the hermetic storage increased (Nicolopoulou-Stamati et al., 2016). Due to these problems the farmers emphasizes that the research conducted under airtight storage for six months is safer and more cost-effective compared to the use of chemicals (Foy & Wafula, 2016).

AVOIDING MOLD DEVELOPMENT BY CARRYING OUT DRYING

An important factor for long-term storage under 14% humidity is low, this is achieved according to the category of grain. Adjusting the drying air temperature should be performed at each time point as the pericarp of the grain moisture content of the grain becomes impermeable to water vapor (Gaceu L., 2001; Owens, G., 2003).

THE DESIGN AND THE THERMODYNAMICS OF GRAIN STORAGE SILOS

For a period of time cereals is carried out in special silos (Figure 1). The silo consists of: 1 - air outlet; 2- grain intake; 3 - the silo roof; 4- silo walls; 5 - fan; 6 - air duct; 7 - silo foundation; 8 - circular concrete distribution system; 9 - floor support; 10 - perforated floor. During the storage, biochemical phenomena lead to enhancing the density of grain moisture and temperature, for which reason it takes a regular aeration. The process aeration of stored seeds has four general objectives - prevent mold, insects inhibited emergence, maintenance durability and reduced seed grain moisture.

Cereals without aeration retains heat long because they are a good thermal insulator. In a short period of a few days, if the air does not move will be stable temperature and humidity. During action aeration, moisture in the grain must be moved in the air. The environment must have low relative humidity to have a high percentage of moisture in the transfer process. The percentage is different depending on the variety of grains, each grain having a moisture content and stability between the relative humidity of the air. When you reach a certain point Stability Guarantee, moisture transfer does not occur.Humidity's stabilityis shown in Table 1, depending on the relative humidity of the air at 20°C (Design of silos to control mold growth, 2019).

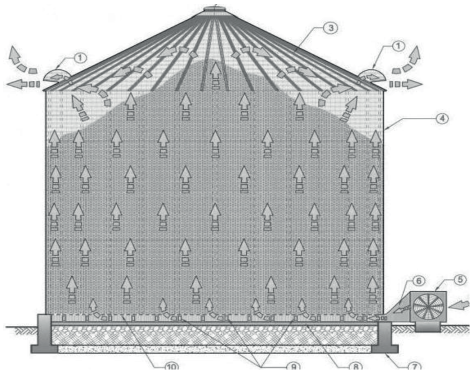

Figure 1. Typical grain silo diagram
https://www.mgtrade.ro/en/

Table 1. Equilibrium moisture [%], depending on the relative humidity of the air, at 20°C (Gaceu L., 2001)

Species	Air Relative Humidity, %				
	20	30	50	70	90
Wheat	7.8	9.2	11.8	14.3	19.9
Rye	8.3	9.5	12.2	15.2	20.8
Barley	8.3	9.5	12.0	15.2	20.9
Corn	8.2	9.4	11.9	14.9	19.2
Sunflower	-	-	5.9	7.8	11.4
Soy	-	-	6.4	8.1	12.8

THE PROCESS OF COOLING AND DRYING

The models of equipment used for aerating the cereals are designed to carry out two forms of processes: cooling with air and also drying with air. The process of cooling by aeration may be achieved by a low flow of air 2-3 liters/second/ton. As long as air drying lasts, the environment can be heated more by using a heat sink device. There are 3 modes of action aeration by moisture grain: Grains that meet market specifications have a moisture content between 12 and 14%. They may be subjected only to a cooling process, removing the drying, so much diminishes the appearance and growth of the insect, and will maintain quality during storage. Grain having a moderate humidity (16% for wheat) require drying by aeration to reduce moisture, this is done to maintain quality during storage.

When drying cannot be carried out immediately on moderately moist grains, they will cool for a period of time, thus reducing mold and insect growth until a piece of equipment is free. When drying has been carried out, cereals in the category with a moisture content of between 12 and 14 % will be cooled to retain their qualities (Grains Research and Development Corp., 2011).

MAINTAINING A LOW TEMPERATURE IN WINTER

Costs aeration in winter of cereals are much lower, which brings a very high gain. When the weather is very cold, humidity is very low and the ventilation in the cold did remove some of the moisture content of the grain. Grains are a good thermal insulator, and after aeration they remain at very low long-term elevated temperature. The restart process of aeration humidity increased, the occurrence of moisture on the surface of the occasions of cold cereals, mushrooms influencing enhancing development (Grain Storage fact sheet, 2011).

CONCLUSIONS

Storage of grain in a sealed environment maintain constant temperature and moisture content.

Warehouse where wheat is stored should be fine-tuned to reduce microbiological contamination and improve grain quality.

Selected storage grains should have a low contamination level, have to be cleaned and passed through a specific selection test.

The storage can inactivate metabolic changes but we cannot permanently stop these reactions.

Advanced storage method is more convenient to use, increase the length of life, improves the organoleptic properties during storage.

Advanced storage method consumes less time processing is easier and reduce costs.

A storage which follows certain procedures will greatly reduce the risk of degradation while wheat and reduce harmful mycotoxins development of people and animals.

Mold growth in the storage of grain is a special issue because of the harmful consequences of mycotoxins on human health.

Thermal insulation properties and hygroscopicity grain causes the aeration process is carried out in an appropriate manner, to prevent the growth of grain moisture and condensation.

REFERENCES

Adetunji, M. O. (2007). Economics of Maize Storage Techniques by Fanners in Kwara State, Nigeria. *Pakistan Journal of Social Sciences*, 4(3), 442-45. https://doi.org/10.1080/10454440802537280. Design of silos to control mold growth (2019).

Edde, P. A. (2012). A review of the biology and control of Rhyzoperthadominica (F.) the lesser grain borer. *Journal of Stored Products Research*, 48: 1-18.

Foy, C., & Wafula, M. (2016). *Scaling up of Hermetic Bag Technology (PICS) in Kenya: Review of successful scaling of agricultural technologies*. United States Agency for International Development. Retrieved from https://www.agrilinks.org/sites/default/files/resource/files/BFS%20Scaling%20Review%20-%20Kenya%20Report%20REVISED%20508%2011-16-16.pdf.

Gaceu L. (2017). Aspects regarding electrochemical detection of the antioxidant activity for subcritical extracts from *Pleurotus ostreatus*, *Journal of EcoAgriTourism*, Vol. 13, No. 1, ISSN 1844-8577, pp. 53-57, ref.12.

Gaceu L. (2017).Comparative study regarding the antioxidant activity of subcritical extracts from *Vitis semen*, Mustard and *Polygonum cuspidatum*, *Journal of EcoAgriTourism*, Vol. 13, No. 2, ISSN 1844-857, pp. 48-52, ref.12.

Grain storage fact sheet (2011). *Grains Research and Development Corporation*. Available at: https://agridrydryers.com/wpcontent/uploads/2019/01/Dealing-withHigh-Moisture-Grain.pdf.

Grains Research and Development Corp. (2011). Stored Grain Project. Aerating sored grain. Cooling or drying for quality control. A Grains Industry Guide. Available at: https://www.graintec.com.au/media/34545/ Aerating%20stored%20grain%20%20A%20Grains%20Industry%20Guide.pdf.

Jayas, D.S. (2012). Storing Grains for Food Security and Sustainability. *Agricultural Research*, 1:21-24.

K. Kim, J. Kim, C. Lee, S. Noh, and M. Kim (2006). “Simple instrument for moisture measurement in grain by free-space microwave transmission”, *Trans. ASABE*, vol. 49, no. 4, pp. 1089-1093.

Kang’ethe, E. (2011). Situation analysis: *Improving food safety in the maize value chain in Kenya*. Report prepared for FAO. College of Agriculture and Veterinary Science, University of Nairobi, Nairobi. Retrieved from http://www.fao.org/fileadmin/user_upload/agns/pdf/WORKING_PAPER_AFLATOXIN_REPORTDJ 10thOctober.pdf.

Kumar, D., Kalita, P. (2017). Reducing postharvest losses during storage of grain crops to strengthen food security in developing countries. *Foods*, 6(1), 8.

Maina, A. W., Wagacha, J. M., Mwaura, F. B., Muthomi, J. W., &Woloshuk, C. P. (2016). Postharvest practices of maize farmers in Kaiti District, Kenya and the impact of hermetic storage on populations of Aspergillus spp. and aflatoxin contamination. *Journal of Food Research*, 5(6), 53. https://doi.org/10.5539/jfr.v5n6p53.

MG Trade Engineering. *Silos, Dryers*, *Flat storage facilities, Seed installations, Feed mills*. Available at: https://www.mgtrade.ro/en/.

Nash, J., Peña, O., Galford, G., Gurwick, N., Pirolli, G., White, J., &Wollenberg, E. (2017). Reducing food loss in agricultural development projects through value chain efficiency. *CCAFS Working Paper*, No. 204. Retrieved from https://ccafs.cgiar.org/ publications/ reducing-food-loss-agricultural-development-projects-thr ough-value-chain-efficiency#.W84afvZRdpk

Navarro, S. (2012). The use of modified and controlled atmospheres for the disinfestation of stored products. *Journal of Pest Science*, 81:1-24.

Nduku, T. M., De Groote, H., &Nzuma, J. M. (2013). Comparative analysis of maize storage structures in Kenya. *4th Conference of the African Association of Agricultural Economists (AAAE)*. Retrieved from https://pdfs.semanticscholar.org/4097/4684765e2cbedf51180c96466c873d4718ec.pdf.

Nicolopoulou-Stamati, P., Maipas, S., Kotampasi, C., Stamatis, P., & Hens, L. (2016). Chemical pesticides and human health: The urgent need for a new concept in agriculture. *Frontiers in Public Health*, 4, 148. https://doi.org/10.3389/fpubh.2016.00148.

Njoroge, A. W., Affognon, H. D., Mutungi, C. M., Manono, J., Lamuka, P. O., & Murdock, L. L. (2014). Triple bag hermetic storage delivers a lethal punch to Prostephanustruncatus (Horn) (Coleoptera: Bostrichidae) in stored maize. *Journal of Stored Products Research*, 58, 12-19. https://doi.org/10.1016/j.jspr.2014.02.005.

Olsson, J., Börjesson, T., Lundstedt, T., Schnürer, J. (2000). Volatiles for mycological quality grading of barley grains: determinations using gas chromatography–mass spectrometry and electronic nose. *Int. J. Food Microbiol*., 59(3), 167-178.

Owens G. (2003). *Cereals processing technology*, Woodhead Publishing Limited Abington Hall, Abington Cambridge, England, 238 pp., ISBN 1 85573 561 X.

Paliwal, J., Wang, W., Symons, S.J., Karunakaran, C. (2004). Insect species and infestation level determination in stored wheat using near-infrared spectroscopy. *Can. Biosyst. Eng*., 46, 7.17-7.24.

Thermal and mechanical analysis of grain storage silos under forced aeration conditions using advanced modelling methods (2019).

W. Wang and Y. Dai (2011*). A grain moisture detecting system based on capacitive sensor*, *Int. J. Digital Content Technol. Appl.*, vol. 5, no. 3, pp. 203–209, Mar.

Williams, S. B., Baributsa, D., &Woloshuk, C. (2014). Assessing Purdue Improved Crop Storage (PICS) bags to mitigate fungal growth and aflatoxin contamination. *Journal of Stored Products Research*, 59, 190-196. https://doi.org/10.1016/ j.jspr.2014.08.003.

Wi-Wheat: Contact-free Wheat Moisture Detection with Commodity WiFi (2018).

Wllkin, D. R , Armitage, D M., Cogan, P. M. and Thomas, K. P. (1990). *Integrated pest control strategy for stored grain*. Project Report No. 24, 87 pp. Home-Grown Cereals Authority, London, UK.

Y. Yang, J. Wang, C. Wang et al. (2000). Study on on-line measurement of grain moisture content by neutron gauge, *Trans. Chinese Society of Agricultural Engineering*, vol. 16, no. 5, pp. 99-101.

Yang, Y.; L. T. Wilson; F. H. Arthur; J. Wang and C. Jia. (2017). Regional analysis of bin aeration as an alternative to insecticidal control for post-harvest management of *Sitophilus oryzae* (L.) and *Rhyzopertha dominica* (F.). *Ecological Modelling* 359, 165-181.

Z. Liu, et al. (2015). Research on online moisture detector in grain drying process based on V/F conversion, *Hindawi Math. Problems Eng*., vol. (2015), p. Article ID 565764.

Zhang, H., Wang, J. (2007). Detection of age and insect damage incurred by wheat, with an electronic nose. J. *Stored Prod. Res*. 43(4), 489-495.

Zhang, H.,Wang, J., Ye, S.,Chang, M. (2012). Applicationof electronic nose andstatistical analysis to predict quality indices of peach. *Food Bioprocess Technol*., 5(1), 65-72.

FOOD BIOTECHNOLOGY