TRENDS IN GRAIN STORAGE IN WAREHOUSES AND SILOS

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Abstract

Cereals are grown in a relatively short period of time and consumed in approximately constant quantities throughout the year. Cereal seeds, after harvesting, represent complex ecosystems with a rich enzymatic activity, mainly located in the germ, contaminated with micro-organisms and possibly infested with insects. To ensure a continuous and homogeneous production, but also for a constant quality of the finished product, the grains must be stored. For this, a warehouse must have a storage capacity of at least 30 days, be equipped with receiving facilities, internal transport, be equipped with dosing devices and be compartmentalized in such a way that there is the possibility for the grains to be stored in batches with similar qualitative indices. The storage of cereal seeds is necessary for the creation of stocks that ensure the continuous operation of the mills, over a longer period of time, and for the formation of mixtures (lots) of raw material, homogeneous in quality, with a constant technological regime of processing, in in order to obtain uniform and high quality finished products. This requires its storage in such a way as to ensure the necessary from one harvest to another. Grain preservation is a set of technical measures applied to control the physico-chemical and biological processes in the grain mass in order to preserve it in good conditions and with minimum losses. The main objective of preservation is to maintain the quantitative integrity and qualitative properties of the stored products with low energy and fuel consumption. The purpose of the work is to highlight the main constructive types of warehouses used for grain preservation.

Key words: cereals, storage, constructive types

Among the factors that influence microbiological processes (temperature, composition of the warehouse atmosphere, interactions between microbial species), humidity is the most important because it initiates, maintains and amplifies the activity of microorganisms that act on the preservation conditions. Thus, depending on the moisture content of the grains, the following molds can develop:

- at humidity over 20% and temperatures higher than 15°C aerobic and anaerobic mesophilic microflora develop rapidly, including lactic acid bacteria, yeasts and molds with a strong degrading action (*Aspergillus candidus, flavus, Penicillium cyclopium*) which contribute to the increase in temperature of the grain mass at 60 – 70°C, which causes protein denaturation. In some cases, self-combustion can be reached through the autoxidation of the lipids in the grains;

- at humidity below 15%, only xerotolerant molds can develop, which can consume the lipids and carbohydrates from the seeds, with the production of heat, water and carbon dioxide (Hill R., Lacey J., 2008).

For wheat grains, at moisture below 14 %, shelf-life conditions are safe, as xerophilic moulds cannot develop below this water value. *Figure 1* shows the diagram of storage conditions of wheat grains as a function of temperature and humidity, from which it can be seen that these parameters have a significant influence on storage conditions (Flor O. *et al*, 2022).

In the light of the above, the conditions for the conservation of seeds of agricultural crops can be defined, namely:

- grains are only well stored if all the processes taking place in them are extremely slowed down. The greatest influence on the intensity of the processes in the grain mass is exerted by humidity, temperature and oxygen supply;

- cereal and technical plant seeds can be preserved by three methods: drying the grains by reducing the moisture content below the preservation limit (below 14% for wheat); storing the grains at low temperatures; and preserving the seeds in controlled-atmosphere chambers;

- before storing the grains, cleaning, disinsectisation and disinfection of the storage

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rooms and the creation of conditions for post-harvest ripening (drying, active ventilation with dry air, etc.);

- the dry storage of agricultural crop seeds is based on the fact that their respiration rate is extremely low. At the same time, most insects and mites, which are specific pests, cannot damage whole dry grains and cannot obtain sufficient moisture. Under these conditions, the micro-organisms stop multiplying and gradually die out;

- storage at low temperatures is based on the fact that, even at 10°C, the respiration rate of the grain mass decreases, many insects become inactive and stop reproducing. Further cooling leads to the fact that all insects and mites stop reproducing and die after some time. The lower the temperature, the faster the insects are killed. At low temperatures, the growth of microbes stops, but they are not destroyed. This mode gives good results for maintaining grain quality during short storage. For long-term storage, the grain should be dried;

- very good seed preservation results are obtained by combining the methods of storage by drying and cooling. When lowering the storage temperature, it should be borne in mind that freezing of the grain (cooling to negative temperatures) can lead to loss of germination.

- The preservation of agricultural crop grains in a controlled atmosphere, without access to air, is based on the fact that oxygen in the sealed storage enclosure is consumed due to respiration of the seed mass and a large amount of carbon dioxide accumulates. As a result, pests and aerobic microflora in the grain mass are destroyed. It should be noted that the anaerobic microflora, the amount of which is significantly less than 1% of the total microflora, cannot cause significant damage to the stored grain. Anaerobic storage conditions can be significantly improved by introducing inert gases (carbon dioxide, nitrogen) into the grain mass.

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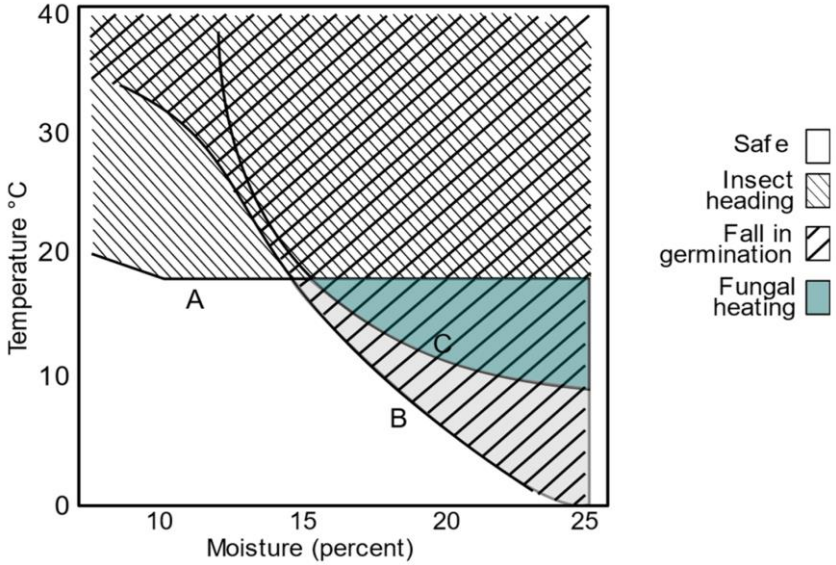

Figure 1 **Diagram of wheat grain storage conditions as a function of moisture and temperature (Flor O. et al, 2022).**

MATERIAL AND METHOD

Being a theoretical approach, in the work I used information from the specialized literature to highlight the importance of the most used types of warehouses used to preserve grains.

RESULTS AND DISCUSSIONS

After harvesting, the cereal berries are cleaned and conditioned, then transferred to storage for long-term preservation. Storage facilities for cereal grains and technical plants must meet the following requirements:

- be provided with forced ventilation to allow mechanical ventilation or aeration of the grain mass, respectively cooling or conditioning of the seed with pressurised air;

- have storage capacity as required by the design theme and be provided with back-up ventilation facilities;

- be equipped with transport machinery to allow mechanised feeding and removal of grain from silos;

- the transport equipment (elevators, chain and scraper conveyors, sieve conveyors, etc.) must be equipped with ventilation systems to prevent the air in the silo enclosure from being polluted by vegetable dust, which, at high concentrations, presents an explosion hazard;

- the atmosphere inside the silo must meet all fire and explosion safety requirements;
- equipment for ventilation and air-conditioning systems in large storage rooms must operate in accordance with permissible noise and vibration levels;
- be equipped with temperature and humidity systems and sensors to continuously monitor the storage conditions and health of the stored grain;
- the premises inside the silo must allow access for operators to carry out cleaning, disinfection and disinsectisation work.

The horizontally arranged warehouses are in the form of sheds, with the possibility of mechanised transport of cereal seeds, ensure the storage of raw materials in a 2.5 - 5 m thick layer and have a capacity of 1000 - 5000 tonnes. Product feeding and discharge into and out of the storage rooms is carried out by bucket loaders. Some sheds are equipped with belt conveyors (5, figure 2) for feeding the grain into the store.

An important advantage of such horizontal warehouses is that they can be used both for storing grain and for protecting machinery from the weather outside the agricultural season and after the sale of the harvest.

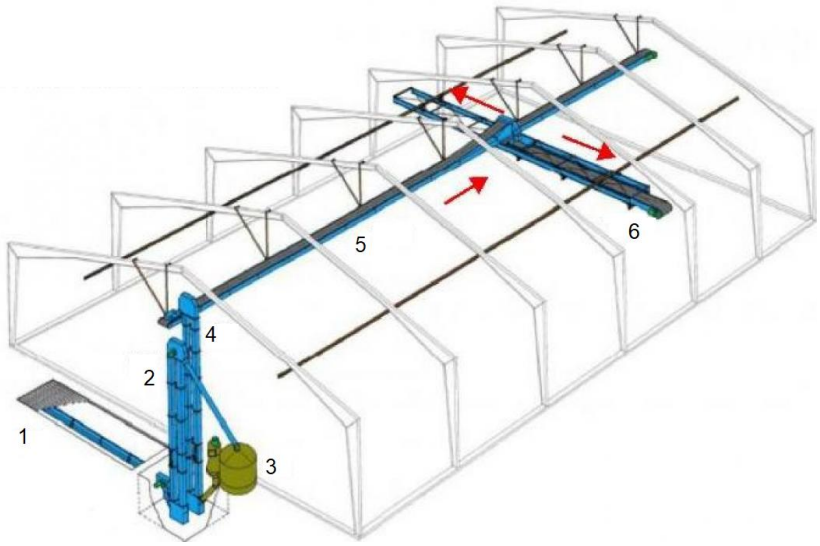

Figure 2 **Grain feeding system in a horizontal grain warehouse (www.gmagrotehnic.ro).**
1 - grain reception, 2, 4 - elevators, 3 - air precleaner, 4 - belt conveyor and mobile trolley, 6 - reversible belt conveyor

Vertical warehouses or silos. These warehouses take the form of vertically built assemblies, called cells, which can be unitary or grouped to form batteries of cells.

The silos are provided with special constructions in which the cleaning and sorting machines, dryers and conveying equipment and aeration facilities are located. Vertical silos are made of concrete construction (less used today) or metal construction in the form of modules.

In the following we will only talk about those with metal structure

Regardless of the geometric shape, metal silos can be flat-bottomed, which are mounted directly on the foundation, or truncated-bottomed, which are fixed to the foundation by means of metal supports.

Figure 3 shows the construction of a vertical, flat-bottomed silo made of corrugated and galvanized sheet metal panels. The silo consists of the following components: air vents (1), inlet (3), silo roof (4), corrugated galvanized sheet metal walls (5), fan for aerating the stored product (8), connection between fan and silo (9), silo foundation (10), weak circular concrete slab (11), fully perforated floor for efficient aeration of stored grain (12).

The panels, from which the outer walls are made, are made of corrugated sheet steel, assembled together with screws, nuts, flat washers and rubber washers. Corrugated sheet panels are protected by galvanizing. The sheet steel panels are made by rolling and the screw holes are punched to allow the holes to line up when mounting.

The resistance structures are manufactured from hot-dip galvanized steel profiles, their shape being specially designed to ensure maximum resistance to compression. These resistance structures are used, in particular, for very high silos and for areas with high seismicity. The stiffening columns, within the resistance structures, transfer the loads from the walls of the silo to its foundation.

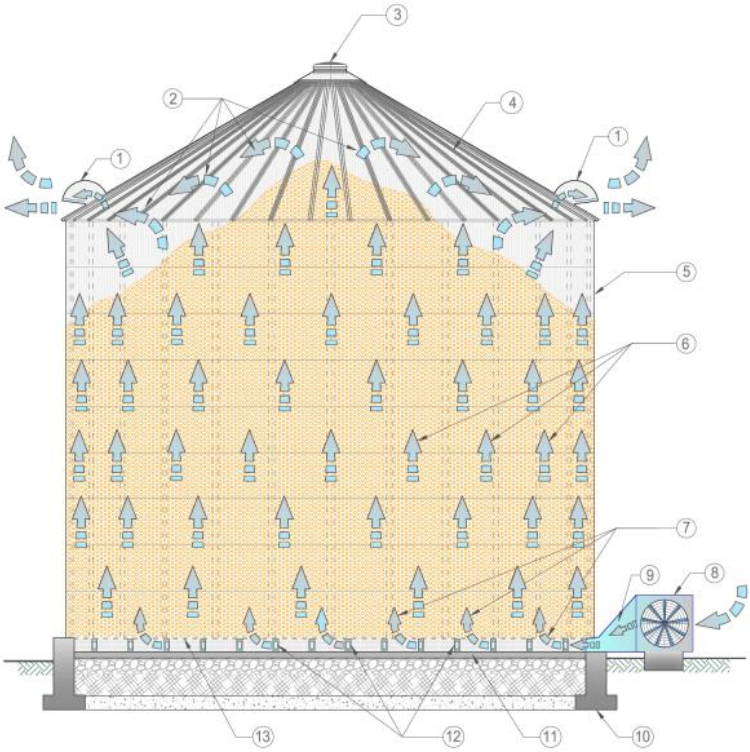

Figure 3 Construction of a metal flat-bottom silo (www.mgtrade.ro/).
1 - vent, 2 - air coming out of the grain mass, 3 - inlet, 4 - silo roof, 5 - silo wall, 6 - air flow through the grain column, 7 - atmospheric air under pressure, 8 - fan, 9 - transition, 10 - silo foundation, 11 - circular concrete slab, 12 - floor supports, 13 - fully perforated floor

The roof is made of several panels, ensuring a very good insulation against the weather. The roof panels are provided with stiffening ribs to ensure the necessary resistance to snow and ice loads. The roof panels are fixed together with screws.

These types of metal grain silos can be equipped with temperature measurement sensors inside the grain mass, sensors that reach between the stored seeds by means of conductors that take the information and transmit it to a central panel. Thus, the amount of seeds stored in a metal grain silo is permanently monitored, and measures can be taken to prevent possible problems if an inappropriate temperature is found for the grain storage environment.

CONCLUSIONS

The choice of a cereal warehouse (vertical or horizontal) must be made in such a way as to provide good conditions for the stored cereals and protect them from factors that can degrade their quality, and at the same time the possibility of technical improvement (implementation of monitoring and control devices for the warehouse) must be taken into account.

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