

## RESEARCH REGARDING THE USE OF COLD IN CEREALS STORAGE

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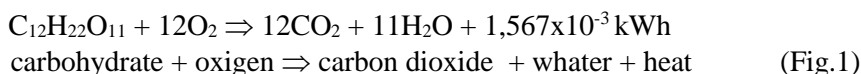
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**Abstract.** This paper addresses to one of the main problems faced by 21st century farmers, namely to cut the cost of storing cereal products, in order to get the most profit from after marketing the product. The purpose of the paper was to make a comparison between the various methods of grain storage so as to reduce as much as possible the expenses related to the storage of the cereals.

**Keywords:** cereals, storage, cooling, efficiency

### INTRODUCTION

Cereals are fundamental to mankind's food, representing about 50% of human food. At the same time, according to *FAO (Food and Agriculture Organization of the United Nations)* data, more than 20% of the harvested grain is lost annually meaning approximately 60 million tons. The factors that lead to qualitative and quantitative depreciation of grain harvest are self-heating, insect activity and the development of fungi and molds. Self-heating of the cereal products is one of the main causes of fresh harvesting degradation. Wheat, corn, soy beans are breathing, being active even after harvesting. Through this breathing process, the carbohydrates decompose with the absorption of oxygen, releasing carbon dioxide, water and heat:



Due to the loss of dry substance, weight loss results (Table 1). Increasing breathing and increasing heat release (Figure 1) depends on product humidity and storage temperature.

Table 1

Weight loss according to storage temperature

| Specification           | Storage Temperature, [°C] | Weight loss, [%] |
|-------------------------|---------------------------|------------------|
| Uncooled stored cereals | 25                        | 0,12             |
| Uncooled stored cereals | 35                        | 0,54             |
| Cooled stored cereals   | 10                        | 0,02             |

By using cold storage, cereals losses of dry matter and weight can be significantly reduced, as well as the activity of the insects and the appearance of molds and microtoxins.

Optimum grain harvesting takes place when grain humidity is at or below 14%. In exceptional cases (rainy season, high maturation, etc.) harvesting can also be carried out at higher humidity to avoid greater losses. From the field, the cereals are transported to farms where a conditioning is to be carried out, followed by, if necessary, drying and, finally,

storing. The organization of this flow depends on the type and size of the agricultural holding (Figure 2).

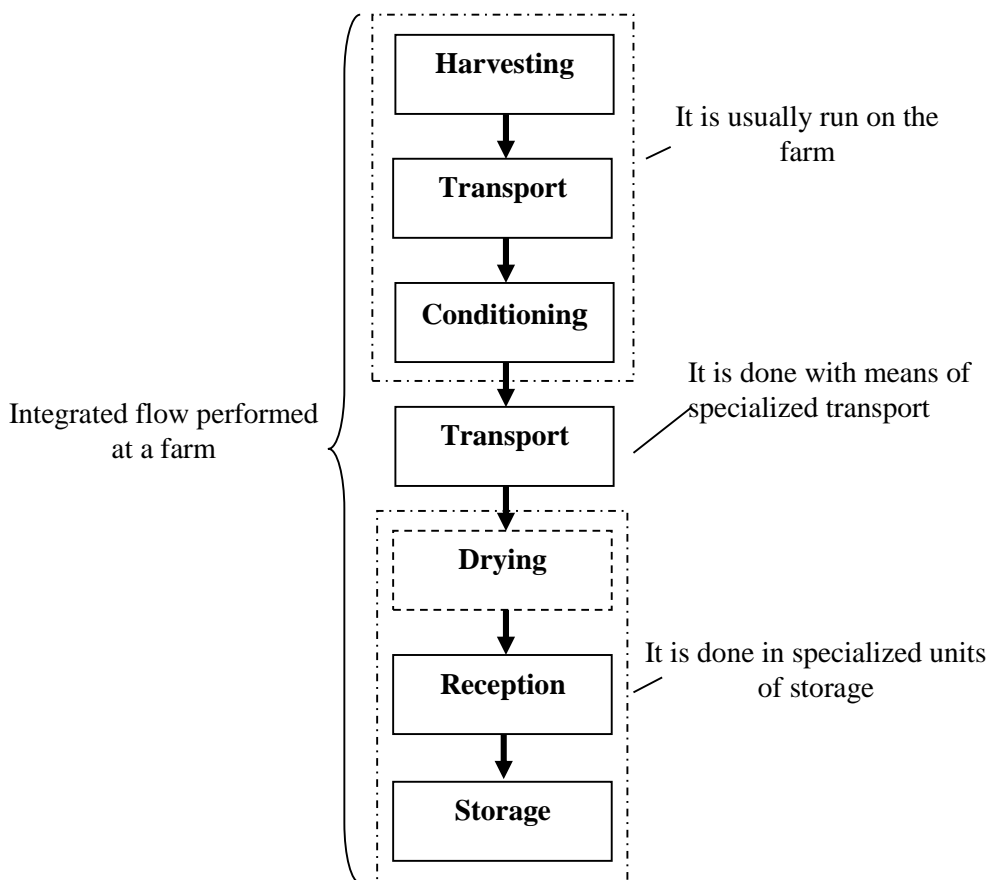


Fig. 2. Grain flow from harvest to storage (Al.Naghiu, 2017-Tehnică frigului și climatizare în industria alimentară)

**MATERIAL AND METHOD**

The study was conducted in a vegetable farm located in the central area of Transylvania, in Mures County, more precisely Mureni. The farm operates in an area of approximately 20 km<sup>2</sup>, a land owned and leased on a total surface of 600 hectares, in plots with areas ranging from 0.6 ha to 29 ha. During 2015 when the study was done, crops were sown, the areas are presented in table 2, as following:

Table 2

The situation of farm crops

| Crop      | Surface (ha) | Estimated yield (kg/ha) |
|-----------|--------------|-------------------------|
| Rapes     | 130          | 4 000                   |
| Grains    | 110          | 6 500                   |
| Triticale | 90           | 6 700                   |
| Alfalfa   | 70           | 750-800                 |
| Corn      | 200          | 10 000                  |

The research that has been done has addressed some aspects of the overall efficiency of crop production costs and costs of storage of cereal products. As far as the storage of the harvested products, the farm has a 6,000-tonne warehouse which allows storage of the entire harvest for a fairly long period. The warehouse is provided with a facility for taking over, conditioning and drying the stored products so that the flow of the feed is continuous, the feeding of the installations being made in continuous flow. In the case of cereal conditioning plants, the farm has a grain dryer with a capacity of 40 t/h, two pre-cleaners, with a total capacity of 40 t/h, to eliminate large impurities in the product mass. The dryer used is a tower dryer with a drying capacity of about 40 t/h at a humidity of 20% to 15% and about 25 t/h at a humidity of 25% to 15% which operates on Liquefied Petroleum Gas (LPG). The costs of setting up crops are related to a number of artificial and natural factors that can lead to an increase or decrease in the cost of each crop.

Table 3

Factors influencing crop production costs

| <b>Artificial factors</b> | <b>Natural factors</b>        |
|---------------------------|-------------------------------|
| Poor soil preparation     | Lack/Excess of precipitations |
| Seeds and seeding         | Temperature of soil/air       |
| Care work                 | Light                         |
| Fertilization             |                               |
| Crops rotation            |                               |

The set up costs for straw cereals can be represented as following:

Table 4

Costs with soil works

| <b>Work</b>              | <b>Cost (lei/ha)</b> |
|--------------------------|----------------------|
| Plowing                  | 250                  |
| Disking                  | 200                  |
| Seeding                  | 100                  |
| Fertilizers              | 60                   |
| Phytosanitary treatments | 60                   |
| Harvesting               | 250                  |
| Transport                | 20                   |
| <b>Total</b>             | <b>940</b>           |

In addition to these costs, the input costs are added, such as: the seed - about 500 lei / ha, the chemical fertilizers represented by NPK and N, - 520 lei / ha and the costs of phytosanitary treatments, amounting to about 150 lei / ha. At this expense is added the rent of 600 kg / ha, which at a selling price of 0.60 lei / kg, represents 360 lei. Thus the total cost of production per hectare of grain cereals amounts to: Soil works (960 lei) + seed, fertilizers and treatments (1170 lei) + rent (360) = 960 + 1170 + 360 = 2490 lei / ha costs of setting up the crop. If the production is sold at the time of collection at an estimated price of 0.56 lei / kg, at a production of 6 500 kg / ha, a profit of 1 150 lei / ha is obtained. For grazing cereals the differences in the costs of setting up the crop are the costs of inputs where the seed price is about 620 lei / ha and the herbicide can rise up to the amount of 380 lei / ha. Thus, the costs of setting up a hectare of hoeing plants amount to 2820 lei. At an estimated production of 10,000 kg, and at a price of 0.49 at the time of harvest, a profit of 2080 lei / ha is obtained.

## RESULTS AND DISCUSSION

Since it is known that the cereal price at the time of harvesting is low, the farm stores the entire harvest to sell it at a price even 40-50% higher than at the time of harvesting, of course there are other storage costs such as drying the product subject to storage.

The farm mainly dries corn at a storage moisture content of about 15% to avoid processes that lead to product quality degradation. For the current year, considering that the farm has sown 200 hectares of maize, with an estimated production of 10 t / ha, a storage space of around 2000 tonnes is required. If we consider that the maize harvested has an average moisture content of about 20%, the drying costs of the product would be calculated as follows:

At an average of 40 tons of dry product per hour, it takes approximately 50 hours of dryer operation to dry 2000 tons of corn. Knowing that the dryer consumes 949 liters of LPG / h, it results that 47450 liters of LPG is needed in 50 hours of operation. At a price of 1.75 lei / 1 / LPG, there is a cost of 83037.5 lei. In addition to these costs, there are the costs of transporting products, namely the electricity used for the lifters that are powered by three-phase electric motors with a total output of 9 kW.

The electric motors of the conveyors produce a consumption of 9 kWh so at a price of 0.22 lei / kWh, it results a cost of 1.98 lei / h. For 50 hours, it costs 99 lei. If we collect the LPG costs and the electricity used by the conveyors, we have a total cost of 83136.5 lei.

In our case, we consider the storage life of about 90 days at a storage temperature of about + 22 °, resulting in a loss of about 14.5 tonnes. If the 14.5 tons of the 2000 total is reduced, 1985.5 tonnes remain. Dividing the remaining 1985.5 tons to 200-hectare area that is cultivated with corn, we get 9.9 t / ha of dry maize per hectare. Splitting this cost to the surface cultivated with maize of 200 hectares results in a cost of 415.7 lei / hectare, so if we add up to the total cost of setting up (2820 lei), it results a cost of 3235.7 lei production cost.

We consider that the price increases by about 30% during storage as compared to the time of harvest, resulting in a price of 0,637 lei / kg of corn. At a production of 9.9 t / ha, there is a price of 6306 lei / hectare, decreasing from this amount the costs of setting up the culture, amounting to 3235.7 lei, it results a profit of 3070.3 lei / hectare. By making a comparison between the profit that would have been obtained if the crop was sold at the time of harvesting, and the profit obtained after storage, a profit of about 40% would be achieved. This profit may increase if conditioning and storage technology is replaced by refrigeration storage. Refrigeration storage has countless advantages over classical storage. The most important being to avoid quality losses and weight loss due to living organisms in the cereal mass, storage at a temperature that does not allow the growth of pests, which leads to another advantage, namely the fact that it is not necessary to use chemical treatments on products. Another advantage of refrigeration installations is that the plants are fully automated and allow for continuous operation, without the need for permanent surveillance.

Refrigerating corn at a moisture content of up to 17.5% over a period of up to 7 months results to excellent quality maintenance, which reduces drying costs, drying is done from 20% humidity only up to 17.5%, which means a lower cost of LPG consumption, which halves from 47450 to 23725 liters at a cost of 41518.75 lei. Another cost that no longer appears is the amount of product lost after drying, stored at a temperature of 10 ° C, is only 0.02%, ie 400 kg of 2000 tonnes, insignificant amount.

If a refrigeration storage system is used for storage, the required energy consumption depends on the humidity and temperature of corn, the temperature and humidity of the air in

the atmosphere, and the ventilation mode. In the case of the storage warehouse, the plant must cool down in addition to the 2,000 tons of grain, the unloaded volume in the storage, so a GRANIFRIGOR cooling system has been chosen, (fig. 3) (a cooling plant with a capacity of cooling up to 780 tons of corn a day).

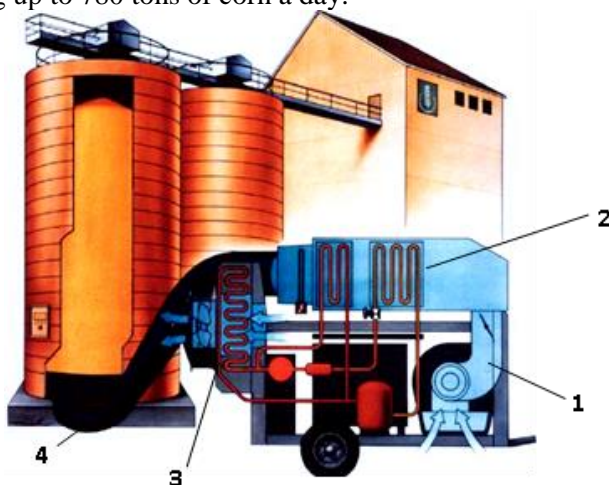


Fig. 3. Construction and operation of the cold air aeration system 1 - centrifugal suction fan; 2 - cold installation; 3 - axial compensation fan; 4 - connection tube

The consumption of the 2000 tons of corn cooling system is calculated as follows:

Knowing that the plant cools about 780 tons of corn a day, for 2000 tons it takes 3 days, ie 72 hours. Knowing that the plant has a consumption of 197 A, it results in a consumption of 75 kWh. In the 72 hours of operation, the total energy consumption is 72 hours X 75 kWh = 5400 kWh. Taking into account that the price of one kWh is variable from the area to the Luad area an average of 0.22 lei, an energy cost of 1188 lei results in a first cooling of the entire quantity of grain. It is recommended that the cooling of the grain mass is done at least 3 times during storage, thus resulting in a total cost of 1188 X 3 = 3564 ROL. In addition to these energy costs, we have the cost of drying the product that is no longer dry at 15% humidity but at 17.5% humidity, which means the cost of drying is less than that of the 47450 liters of LPG used in the process drying, only 23725 liters of LPG remain at a cost of 41518.75 lei. The costs of grain transport remain the same, the quantity to be transported is the same, ie 99 lei. Adding the above costs results in a total cost of  $3564 + 41518,75 + 99 = 45181,75$  lei, storage cost by refrigeration method.

Dividing this amount to the surface cultivated with corn, that is 200 hectares, gives us an extra cost per hectare of 225.99 lei. If the corn is selling at a price 30% higher than the time of harvesting, ie at a price of 0.637 lei / kg, at a production of 10 000 kg / ha, it results in a price of 6370 lei / ha. At the cost of setting up the crop, we add the cost for storage and result in a total cost of  $2820 + 225.99 = 3045.99$  lei. The final price reduces the total cost of setting up and results in a profit of 3325.01 lei / ha.

## CONCLUSIONS

From the calculations shown above, the profits for grain storage make the profit increase by about 40% if the cereals are stored and conditioned by the classical method ie pre-drying and drying in tower driers, from a humidity of 20% to a holding moisture of 15%,

compared to the profit that would be obtained if the cereals were sold immediately after the harvest, or directly from the field. From the same calculations it follows that by storing the cereals by the refrigeration method, the profit increases by about 10% compared to the classical method of storage, of course the product subjected to refrigeration storage is superior to that stored by the classical method. Compared to the gross sales of the product directly from the field, the profit is approximately higher with 50% when grains are refrigerated, so that is the most suitable method for long-term storage of grain in the best conditions.

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