RESEARCH ON THE INFLUENCE OF AIR SPEED ON THE KINETICS GREEN MALT DRYING

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Abstract

In breweries its know that malt is made from barley blank, and is a natural product rich in enzymes and vitamins. In order to optimize the work for drying green malt has been investigated in laboratory conditions. The malt subjected to drying was achieved using Jacobsen germination table. Research on dryng malt were made in the laboratory with a vertical air drying with a drying agent, heated air. The main goal in this work was to monitor the work process for drying green malt moisture of 46.31 % and a thickness of 1 cm. Dehydration was carried out at different speeds of the drying agent in order to observe how and when the evaporation of water. We have used four samples of malt obtained under the same conditions from the same batch of barley with the same parameters of final moisture, but which has been dried in the same diagram of temperatures but at different speeds of the drying agent (warm air). The speed of drying agent was 1.1 m/s, 1.5 m/s, 2.1 m/s and 2.5 m/s. The air temperature in the dryer was between 44 ^{o}C and 80^{o}C. The time consumed for drying of each of the four samples was the same for each. It should be mentioned that all the four samples of malt had the same mass and the same parameters (moisture content W = 46.31) and temperature (21 °C) at the beginning of the drying. The results obtained at the end of the drying process shows different values of the humidity in the final malt, very close to the value of the air velocity at 1.1 m/s and 1.5 m/s. It should be mentioned that the lowest moisture content is obtained if the speed experience hot air was 2.5 m/s. The conclusion is that the drying agent used at the same temperature but with a higher circulation rate (in this case 2.5 m / s) to facilitate the evaporation of large quantities of water.

Keywords: malt, germination, moisture content, drying air velocity, dryer.

German Purity Law (Reinheitsgebot Deutsche) existing since 500 years ago," says clearly that beer ingredients must only be water, barley and hops." Germinated and dried barley was named malt. The main technological stages to obtain malt today are (2):

- Reception, barley cleaning and sanitizing;
- Soaking and germination;
- Resulting green malt;
- Drying green malt;
- Resulting dry malt;
- Cleaning and brushing malt;
- Cooling malt, malt storage and maturation;
- Resulting final product.

Malt manufacturing technologies differ from one manufacturer to another depending on the requirements of the market in the first place, the quality of the water to be used during the soaking and germination of barley, the quality of the raw materials, time and drying diagrams and mainly on the type of industry in which it will be used.

All phases of malt manufacturing related technology are particularly important. In this work the main attention was focused on the malt drying phase and especially on the parameters of the drying agent (hot air) temperature and speed.

The purpose of this paper is to reduce the green malt drying time without changing malt quality parameters.

MATERIAL AND METHOD

Equipment used

KERN electronic scale 440-49N with 0.1 g accuracy: for weighing raw material.

Grain moisture meter model 462331247 John Dickey: for determination of cereal moisture before the germination phase.

pH meter: determining pH of green malt extract

Thermocouple Thermometer: For determining the temperature inside the layer of barley during the germinating process.

Galvanized vase 5 liters fitted with an overflow which acts gently soaking in miniature.

Cylindrical cassettes (diameter: 24 cm and height: 7 cm) with galvanized mesh bottom

Jacobsen germination table – in which were put the cylindrical cassettes filled with layers of barley of 3 cm thickness .

Parameters of the water temperature, water level and soaking times were controlled by an air conditioning computer built into the Jacobsen germinator.

Experimental facility for drying green malt - vertical dryer (Fig. 1), belonging to the Department of Agricultural Mechanization, University of Agricultural Sciences and Veterinary Medicine with which experiments were carried out for drying green malt. It comes with digital display electronics for controlling and monitoring the drying process parameters:

- The temperature of the drying agent: up to 120^{o}C;
- The speed of the drying agent up to 2.5 m / s;
- The required drying time.

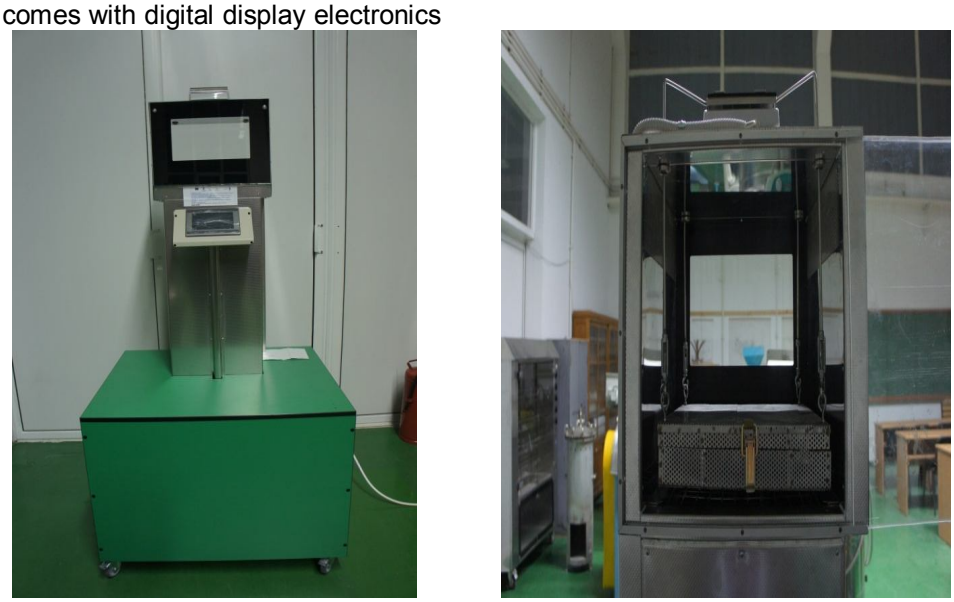

Figure 1 **Vertical dryer**

At the bottom of the dryer are located three resistors of 1.5 kW heating the air making possible the heat transfer by convection.

The fan inside the dryer, draws air from the outside and then inside it escapes into the dryer from the bottom up.

The dryer operation is discontinuous and follow these steps:

- Supply of green malt in a box with the bottom of the galvanized sieve in layers of about 1 cm
- Inserting a cassette into the drying container;
- Sealing the drying container, turning on the fan, electrical resistance switching and drying the green malt as specified in the drying the diagram;
- Cooling the dried malt;
- Removal of the product.

The dryer is provided with:

- its own thermostat which controls the heater and maintains a constant temperature
- Temperature sensors (which monitors dryer inlet air temperature and the air temperature in the dryer grill);
- Humidity sensors (monitoring humidity of intake air and drying air at the outlet of the dryer).

According to a moisture control chart, weight loss due to water removal from the product is tracked using an electronic scale mounted above the drying chamber. Air velocity is set from the touch screen interface adjusting fan speed.

Raw materials

Raw material: Barley Andreea variety (Table 1).

Table 1

Analyzed barley characteristics

No.	CHARACTERISTICS	Andreea Barley
1	Hectoliter weight	63,5
2	Foreign bodies in the sieve	0,2%
3	Organic foreign bodies	0,4%
4	Damaged, broken seeds	1,5%
5	Defects barren seeds	0,6%
6	Undeveloped seeds	0,3%
7	Humidity	13,2%
8	Uniformity	92,5%
9	Aspect	Normal
10	Color	Specific
11	Smell	Pleasant
12	Taste	Normal
13	Germination speed	5 days
14	Percentage of germinated seeds	97%

Method

Obtaining malt - laboratory process

Qualitative and quantitative reception: the reception of raw materials takes place by quality and by quantity. Barley is received in terms of quality (considering sensory and physical-chemical) and quantitative (using an electronic scale to weigh samples that will be malted barley in the laboratory).

Conditioning of raw materials: barley has already been cleaned and sorted at the supplier. Also it was purchased from suppliers after the resting time of germination.

Cleaning and disinfection: in this case, barley was only washed in a galvanized container which is has an overflow through which are eliminated waters with light impurities. The bottom of the container is provided with a tap and with its help the dirty waters were eliminated. From the washing container barley was transported with the help of the waters that facilitate the hydraulic transporter into the cylindrical boxes with galvanized mesh bottom, where it is placed in layers of 3 cm. The boxes filled with barley were then added inside the tank of the Jacobsen germination table, and they were filled with water until the layers of barley were entirely submerged. This operation took place in 72 minutes. From this moment on began the soaking / germination process.

Soaking / barley germination: The germination took place in the Jacobsen germination machine following the germination diagrams previously established.

Figure 2 **Jacobsen Germinating Table**

Operation of soaking / germination was halted when the size of the roots reached 18 mm and 5mm in stem. At this stage germinated barley practically became green malt that was passed to the next stage of drying. Drying was performed using the laboratory dryer presented in Chapter " Materials and methods". In the case of malt drying, heat transfer is carried out from the outside to the inside of the grains of malt and grain moisture diffuses from the inside to the outside and led to the hot air which is drying agent. The mechanism water diffusion is shown below (Fig. 3).

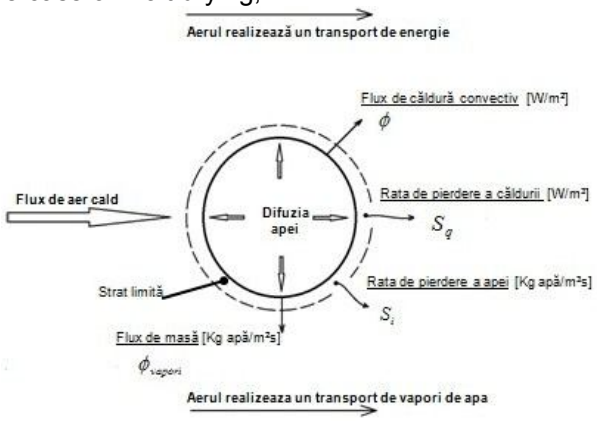

Figure 3 **Water diffusion mechanism**

The main parameters outlined in the mechanism of drying is determined by the relations (Halsey, 1984):

$$\emptyset = 3{,}95 \times e^{(2{,}2 \times v)} \times \left(T_a - T_p\right)$$

$$S_i = c \times 3^{(2{,}39 \times v)} \times e^{\left(\frac{17{,}2 \times t_a}{t_a - 238{,}3}\right)} \times \left(a_w - \frac{\emptyset_a}{100}\right)$$

$$S_q = h_{av} \times S_i$$

$$\emptyset_{vapori} = c \times e^{(2{,}39 \times v)} \times \left(\emptyset_a \times T_p - a_w \times T_p\right)$$

$$a_w = exp\left(-\frac{A}{RT_p \times \left(W_e/W_m\right)^b}\right)$$

Φ is convective heat flux [W/m^2];
e – exponential;
v – air speed, [m/s];
T_a – air temperature, [^{o}K];
T_p – wall temperature of the product (covering the grains of barley), [^{o}K];
S_i – the rate of water loss, [kg/m^{3}s];
S_q – rate of heat loss, [W/m^2]

The drying mechanism is determined by the emergence of complex thermo physical processes (diffusion, thermo diffusion) inside the grains of the malt layer subjected to drying and simultaneous mass and heat transfer in the coating of the grain separating the grain surface from the thermodynamic agent known as drying agent (warm air).

During the drying process water evaporation occurs on the surface of the grains first. Gradually, it penetrates inside the grains and the water vapors are forced to diffuse through the outer dried covering layer and then evaporating into the air. (10) Dry malt was studied on the basis of considerations on the equilibrium of the wet material and the drying agent (static drying) and the drying rate (kinetic or dynamic drying) (Jâşcanu V., 1984).Specifically in the experiments conducted in the laboratory for drying of malt were used diagrams identical to the temperature set for the drying agent and drying time.

The drying agent (hot air) movement speeds were different while the 4 experiments took place: V_1 = 1 m/s; V_2 - 1,5 m/s; V_3 = 2,1 m/s and V_4 - 2,5 m/s. The final results for the moisture in each experiment, are presented in the following diagrams.

RESULTS AND DISCUSSIONS

In the present study we observed technological stages of obtaining dried malt, the charts used were similar except that we used different speeds of movement of hot air (drying agent) for each experience. As a result of the 4 experiments there is a higher rate of evaporation of water in experiments 3 and 4 (V_3 = 2,1 m/s and V_4= 2,5 m/s) in comparison with the rate of evaporation of water from the experiments 1 and 2, due to the higher running speeds of hot air (V_1=1m/s; V_2=1,5 m/s). Both heat transfer and mass transfer were accelerated in the use of higher air flow speeds. The final humidity values are lower in the experiments 3 and 4 (5,6 % and 5,9%) in comparison with experiments 1 and 2 (6,84% and 6,49%) (Fig. 1, 2, 3, 4). The time used for green malt drying (with equal humidity parameters at beginning of the drying process) was the same for each experiment. The quantities of green malt subjected to drying were equal and manufactured under the same conditions and from the same batch of barley.

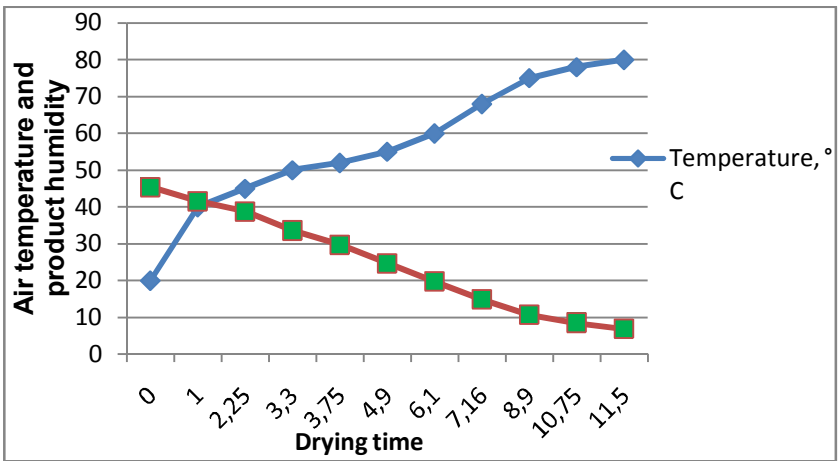

Figure 4 **Monitoring humidity diagram of Andreea malt loss by drying in the presence of hot air at a temperature of 80^0 C and 1,1 m/s speed.**

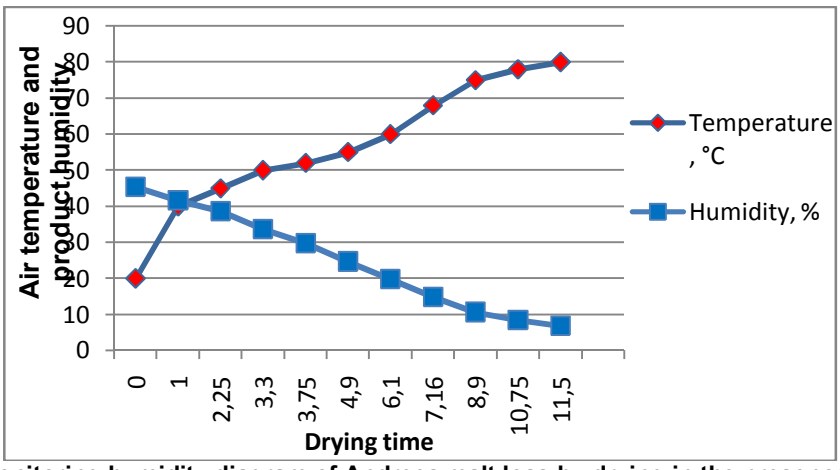

Figure 5 **Monitoring humidity diagram of Andreea malt loss by drying in the presence of hot air at a temperature of 80^0 C and 1,5 m/s speed.**

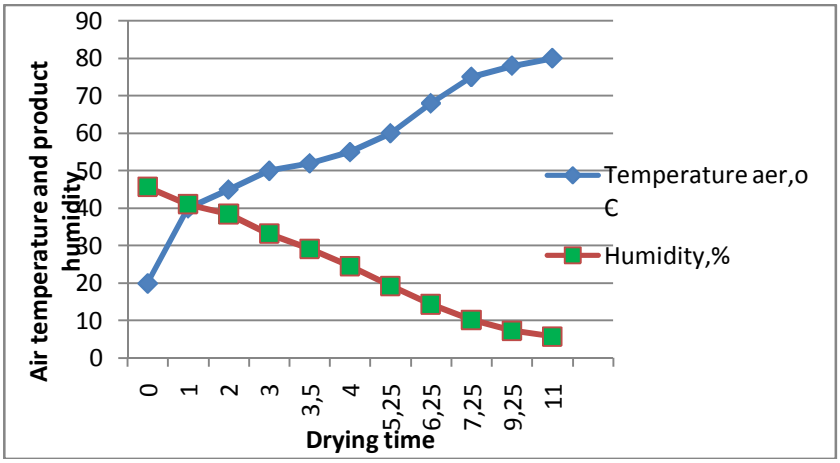

Figure 6 **Monitoring humidity diagram of Andreea malt loss by drying in the presence of hot air at a temperature of 80^0 C and 2,1 m/s speed**

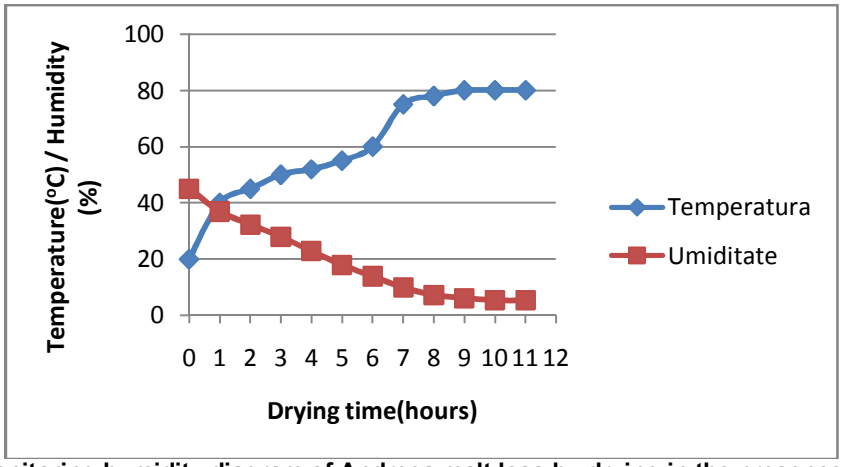

Figure 7. **Monitoring humidity diagram of Andreea malt loss by drying in the presence of hot air at a temperature of 80^0 C and 2,5 m/s speed.**

CONCLUSIONS

This paper is structured in two stages:

In the first stage the germination took place using the Jacobsen germinator..

In the second stage took place the drying of green of malt with the same time and temperature parameters, but with different hot air speeds. Following the results obtained we can conclude that in laboratory conditions presented the green malt drying process is more effective when the velocity of the hot air (drying agent) is high. It is noted that the moisture of dried malt with a hot air velocity of 2.5 m/s is smaller by 1.24% than the speed of 1.1 m/s. These results encourage further research in the field to find new solutions on shortening processes for obtaining various types of malt.

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