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DRYING RATE OF GRAIN MAIZE

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Maize is harvested after reaching maturity when its moisture content generally ranges from 30 % to 34 %, while the optimum moisture for storage is around 14–15 %. This moisture is usually achieved by thermal drying. Apart from initial moisture, the total drying time is affected by the temperature of the drying environment, atmospheric conditions and properties of the dried material. The present paper provides a description of the process of moisture loss and subsequent drying rate of grain maize from various growers. Obtained results are processed in a tabular and graphical form. After 30 minutes of drying, all the maize samples (10 samples two times in total) reached a moisture of 14 % and less, whereas 6 samples already after 20 minutes of drying. The rate of moisture loss was proportional to the initial moisture content. The drying of grain maize is considered one stage of the technological procedure in post-harvest treatment. Moreover, it is an essential preventive measure for wet harvest. Contemporary technologies of maize drying in modern dryers favourably influence the energy consumption in the process while maintaining the qualitative parameters of the dried material.

Keywords: maize, moisture, drying curve, drying rate

Maize is one of the oldest locally grown plants. It is grown mainly for livestock feed in the form of grain or silage, or as a raw material for the processing industry. In the food industry, maize serves as a source of maize starch, glucose, fructose syrup and bioethanol (Vítěz and Trávníček, 2011).

The future usage of maize for the production of biodegradable plastics and proteins for medical purposes is considered. Maize is a biological material containing a large number of microscopic pores and capillaries (Vitázek, 2004). These pores and capillaries contain water that has a considerable impact on further storage of maize grains. Thermal drying is nowadays the most important method of conservation, by means of which the moisture content is reduced to the required level (Los and Pawlica, 2010). Maize is always harvested with a higher moisture content than suitable for storage, and the drying season often ends in late autumn. Due to the bad weather in autumn 2010, growers complained to varying duration of the drying process, which always lasted longer than the manufacturer had claimed. At the request of the importer, the impact of a longer drying process was scrutinised. For this purpose, we have requested samples of materials from several growers. Afterwards, we measured in laboratory conditions the drying curves and drying rate curves of supplied maize samples.

The aim of this paper is to determine the moisture release rate of the supplied samples and assess the impact of measured drying rate on the total duration of the process.

Material and methods

We measured the moisture content of supplied samples by means of weighing the weight loss at a constant temperature according to STN 12 6013. Weight was determined by laboratory scales KERN EG 420 with an accuracy of 0.001 g (Figure 1). The heating of the samples was provided by a laboratory oven MEMMERT UFE 400. The measurement process consisted of two sets of measurements. The measurements were made at equal intervals of 10 minutes

Figure 1 Laboratory scales KERN

Figure 2 Laboratory oven MEMMERT

until the total time of 60 minutes. The final moisture content of material was observed after 180 minutes (Vitázek, 2011a). The temperature of the drying environment was 105 °C. Obtained values were processed in a tabular and graphical form. Supplied samples were labelled according to the location of delivery; a precise marking of hybrids could not be determined.

The calculation of moisture and drying rate was done using the following relations (Vitázek, 2011a):
The moisture of material is calculated from the relationship:

$$w = \frac{M_V}{M_M} 100\,,\ \%\qquad (1)$$

where:
M_v – moisture mass, i.e. a change in mass at the beginning and at the end of the experiment
M_M – the original mass of the sample material

Table 2 contains the calculated moisture values of sample materials in selected time intervals, which are based on the determined maximum moisture content.

The moisture content of material in the given time interval is calculated by the formula:

$$w_\tau = w - \frac{\Delta M_V}{M_M}\,,\ \%\qquad (2)$$

where:
ΔM_v – a change in moisture mass in the given time interval

Drying rate:

$$N = \frac{w_\tau}{d_\tau}\,,\quad \text{kg.kg}^{-1}.\text{h}^{-1}\qquad (3)$$

Results and discussion

Experimental measurements were carried out in two sets. Table 1 contains the calculated values of moisture, while in these intervals a gradual loss of moisture of the given sample from its maximum value can be observed. Table 2 contains the calculated values from the second set. Tables 3 and 4 contain the calculated values of drying rate. Tabulated data are processed graphically. Figure 3 and Figure 4 show the drying curves, i.e. graphical relationships of moisture course during the given time interval. We chose the moisture content wet basis of the material (Vitázek,

Table 1 Calculated values of moisture w_τ during the first set of measurements

Sample name	Initial moisture in %	Time interval in minute* / moisture w_τ in %					
		10*	20*	30*	40*	50*	60*
Holice	17.51	16.99	12.37	9.72	7.85	6.17	4.61
Královský Brod	19.06	16.98	14.45	11.72	9.69	7.72	5.99
Takács	22.89	20.41	16.79	13.43	11.81	9.27	7.44
Furio	15.89	13.86	11.86	9.35	7.67	6.31	4.83
Stredne	15.33	12.83	11.01	8.56	7.02	5.78	4.62
Šamorín	23.04	20.19	18.39	14.62	12.18	9.64	7.30
Žikavec	17.09	14.63	12.07	9.71	7.94	6.30	4.74
Poľnoreál	18.07	15.54	13.17	10.48	8.53	6.91	5.41
Dedina Mládeže	18.63	15.93	13.24	10.67	8.79	7.20	5.73
Pionier Trstice	22.40	19.40	16.16	12.99	10.84	8.58	6.25

Table 2 Calculated values of moisture w_τ during the second set of measurements

Sample name	Initial moisture in %	Time interval in minute* / moisture w_τ in %					
		10*	20*	30*	40*	50*	60*
Holice	17.52	15.77	13.39	10.99	8.82	7.02	5.30
Královský Brod	18.62	16.92	14.06	11.40	9.24	7.45	5.68
Takács	21.71	19.67	16.31	13.60	10.69	8.51	6.51
Furio	16.00	13.97	11.32	9.12	7.38	6.05	4.76
Stredne	15.26	13.95	11.67	9.38	7.37	6.05	4.64
Šamorín	23.34	20.71	17.07	13.78	10.75	8.58	6.28
Žikavec	17.88	16.63	14.41	11.59	9.04	7.15	5.42
Poľnoreál	18.01	16.14	13.39	10.96	8.49	7.07	5.40
Dedina Mládeže	18.66	16.78	13.35	10.87	8.74	7.10	5.36
Pionier Trstice	22.31	20.09	16.79	13.38	10.62	8.43	6.30

Table 3 Calculated rate of drying N of the first set of measurements

Sample name	Time interval in minute* / Rate of drying N in kg.kg^{-1}.h^{-1}					
	10*	20*	30*	40*	50*	60*
Holice	0.05	0.23	0.08	0.04	0.03	0.02
Královský Brod	0.20	0.12	0.09	0.05	0.03	0.02
Takács	0.24	0.18	0.11	0.04	0.05	0.03
Furio	0.20	0.10	0.08	0.04	0.02	0.02
Stredne	0.24	0.09	0.08	0.03	0.02	0.01
Šamorín	0.28	0.09	0.12	0.06	0.05	0.03
Žikavec	0.24	0.12	0.07	0.04	0.03	0.02
Poľnoreál	0.25	0.11	0.08	0.04	0.03	0.02
Dedina Mládeže	0.26	0.13	0.08	0.04	0.03	0.02
Pionier Trstice	0.29	0.16	0.10	0.05	0.04	0.03

Table 4 Calculated rate of drying N of the second set of measurements

Sample name	Time interval in minute* / Rate of drying N in kg.kg^{-1}.h^{-1}					
	10*	20*	30*	40*	50*	60*
Holice	0.17	0.11	0.08	0.05	0.03	0.02
Královský Brod	0.16	0.14	0.08	0.05	0.03	0.02
Takács	0.20	0.16	0.09	0.07	0.04	0.03
Furio	0.20	0.13	0.07	0.04	0.02	0.02
Stredne	0.13	0.11	0.07	0.05	0.02	0.02
Šamorín	0.26	0.18	0.10	0.07	0.04	0.03
Žikavec	0.12	0.11	0.09	0.06	0.03	0.02
Poľnoreál	0.18	0.13	0.08	0.06	0.03	0.02
Dedina Mládeže	0.19	0.16	0.08	0.05	0.03	0.02
Pionier Trstice	0.22	0.16	0.11	0.06	0.04	0.03

2011b) as it has a higher predictive value. The drying rate curves are shown in Figure 5 and Figure 6.

The results obtained indicate that the required value of moisture content below 14 % was reached in both sets of measurements after 20 minutes of drying in most cases; in other intervals, the material was already excessively dried. Only in cases of initial moisture content above 20 %, the material has reached the required moisture content in the time interval up to 30 minutes.

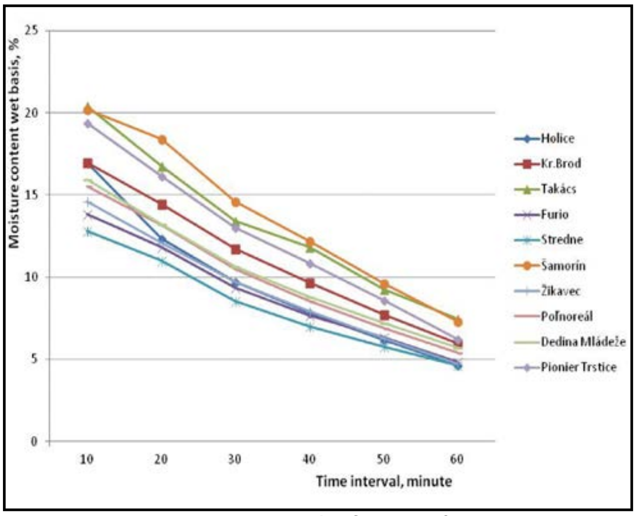

Figure 3 Drying curves – the first set of measurements

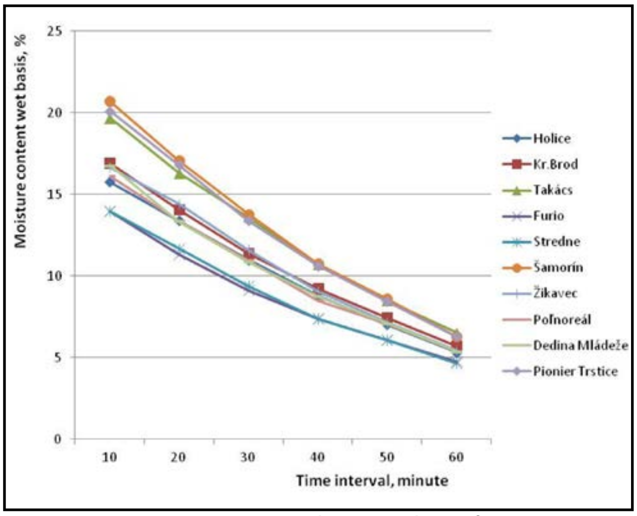

Figure 4 Drying curves – the second set of measurements

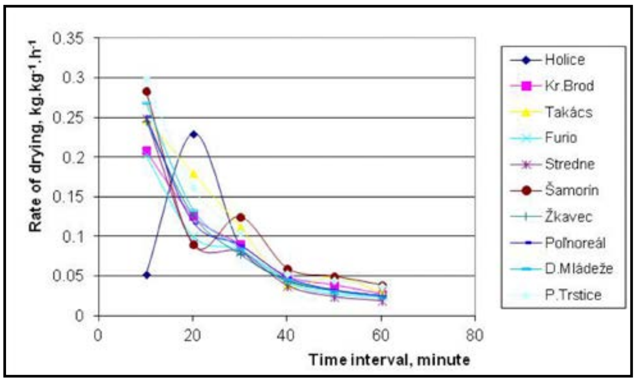

Figure 5 Drying rate – the first set of measurements

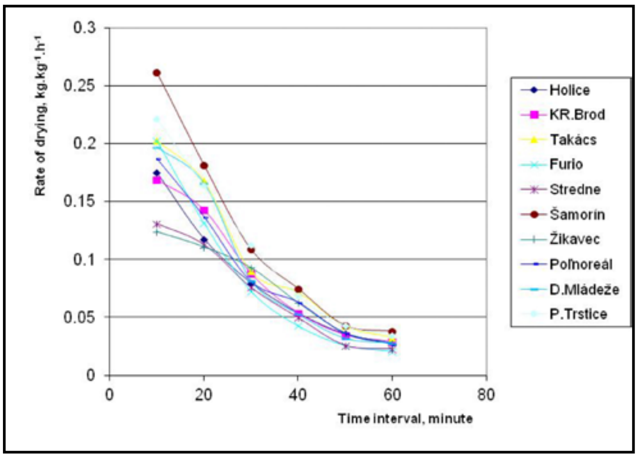

Figure 6 Drying rate – the second set of measurements

The drying rate curves show that higher drying rates are achieved in the samples with a higher initial moisture content in the first three intervals. Then, the drying rates equalised. This relates to moisture binding in the wet material when free water is removed more easily (Vitázek, 2011b).

From these measurements we may draw the following conclusions. The drying rate, as well as the duration of the process, depends mainly on the initial moisture content. It is necessary to consider this when setting the dryer and to sort the material at the entrance according to moisture. Do not mix materials with various moisture contents. A reliable hygrometer is a necessity.

Drying curves do not indicate any considerable differences among the samples from various growers. The duration of the process will be significantly affected by atmospheric conditions, measurement of the initial moisture content, cleanliness of the dryer and overall compliance with the technological process. The effect of external conditions was dealt with in the study by Vitázek (2010).

Conclusion

In the present paper, we address the issue of detection of moisture loss in the process of drying of grain maize. Data processed in a tabular and graphical form provide information on the drying rates of particular samples.

The highest drying rates were obtained in the first time interval; then, the drying rate gradually declined. Out of the 10 samples, in 6 cases was the obtained moisture lower than 14 % after 20 minutes of drying. In the third stage, all samples were dried to the storage moisture. During other intervals, the material was already dried below 10 %. A negative impact of excessive drying at very low drying rates was proved along with increased energy consumption if the process was carried out in operating conditions.

During the season of 2010, the situation was unfavourable when considering atmospheric conditions. Drying went on even at the end of November, often in temperatures below zero and a high relative humidity of air. The impact of weather was analysed in a study requested by Jurex, s. r. o. (private limited company). Experiments were conducted in order to complete the information. As mentioned already, the variety of maize and growing conditions of different suppliers have no significant impact on the total length of drying.

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