THE INFLUENCE OF THERMAL PROCESSING WITH INFRARED RAYS ON THE ELEMENTARY ENERGY CONSUMPTION IN GRINDING WHEAT GRAINS

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INTRODUCTION

Grinding is a process very widely used in food industry, especially in milling, sugar, meat, fruit and vegetable industries. It is a highly energy-consuming process, because the annual intake of energy for grinding solid bodies in the world reaches the value of 1/3 of overall produced energy and is still rising [4, 5]. Grinding is applied not only in the case of materials but also to intermediate and final products. Frequently, the material before grinding is subjected to various types of thermal processing. One of such thermal processes which modify the physical and chemical structure of loose vegetable resources, and at the same time improves their nutritional quality, is micronization. At present, the process of micronization is numbered among the group of HTST processes, in which the material is heated in less than a minute and usually reaches the temp. above 100°C [1]

Therefore, the aim of this paper was to establish the influence of the used parameters of thermal processing with infrared rays on the value of elementary energy intake of grinding wheat grains.

METHODOLOGY

PREPARATION OF THE STUDIED MATERIAL

The material accepted for the research was Kobra winter wheat grains of the 2002 crops. The moisture of the material was approx. 11.4%.

Before the process of micronization, the moisture of the material was increased to 14.0% and 17.0%. In order achieve that, water calculated according to formula 1 (below) was added to the grains:

$$M_w = \frac{W_2 - W_1}{1 - W_2} M_1 \qquad (1)$$

where:

M_w – mass of added water (g),
W_2 – moisture expected (%),
W_1 – initial moisture (%),
M_1 – mass of the material (g).

Grains were kept in hermetic containers. In order to equalize the moisture in the whole mass, the conditioned specimens were kept in a cold room at constant temperatures of 5 C for 10 days, and repeatedly shaken each day. They were taken out of the cold room an hour before the examination in order to equalize their temperature with the ambient temperature. The moisture of the material was checked by the Air-oven method acc to AACC Method 44-15A final approval 10-30-75; revised 10-28-81.

THE COURSE OF RESEARCH

After moistening, the material was subjected to the process of micronization. In order to emit infrared radiation, an infrared IR1 lamp radiator of 250 W was used. The micronization was carried out at the temperatures of 120 and 170°C for 60 and 120 s.

Directly after thermal processing, wheat grains were ground in a laboratory ML-155 buhrstone mill. The process of grinding was conducted at two different working gaps – 1 mm and 3 mm. During the process, the time of milling and the effective energy were recorded. On this basis, the elementary energy consumption e_u (kWh kg^{-1}) was calculated.

The test was repeated 5 times and the final result was the arithmetic average of these repetitions.

RESULTS

After statistical treatment, the findings were presented in Table 1 and in Fig 1-4.

In Table 1, the influence of the moisture of the material and the size of the working gap of the grinder on the numerical value of energy consumption per unit of the grinding were presented. The data prove that the increase of the moisture of the ground material in the range between 11.4 and 17.0% caused, independently of the used working gap, the increase in the value of elementary energy consumption from 36.3 10^{-4} to 71.4 10^{-4} kWh kg^{-1} during the grinding in the 1mm gap and from 23.7 10^{-4} to 47.4 10^{-4} kW kg^{-1} during the process in 3 mm gap. Additionally, a significant decrease in elementary energy consumption after enlarging the gap from 1 mm to 3 mm ought to be mentioned.

Table 1. The influence of the moisture of wheat grains on the value of energy consumption per unit e_ux10^{-4} (kWh/kg)

Moisture (%)	Gap (mm) 1.0	3.0
11.4	36.3	23.7
14.0	50.1	33.2
17.0	71.4	47.4

In Fig.1-4, the influence of the pre-grinding thermal processing with infrared rays on the value of energy consumption per unit in the process of grinding was presented. Subjecting wheat grains to micronization affected the changes of the value of energy consumption per unit at grinding. These changes depended on the used micronization parameters, i.e. time and temperature, as well as on the moisture of the material. In most cases, the increase of the value of grinding energy consumption per unit was recorded. The decrease in the value of this parameter was noticed only after a 120-second processing with infrared rays at the temperature of 170°C, especially visible during the process of grinding, using 1mm gap, of the wheat grains thermally processed for 60 s and 120 s (24.2% and 20.9%).

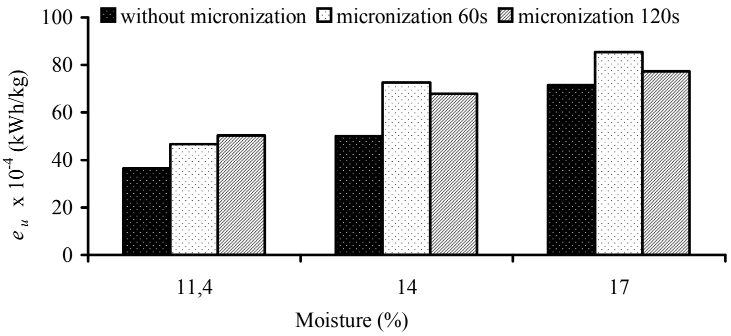

Fig. 1. The influence of micronization on energy consumption per unit of grinding. Working gap of grinder – 1.0 mm, micronization temperature 120°C

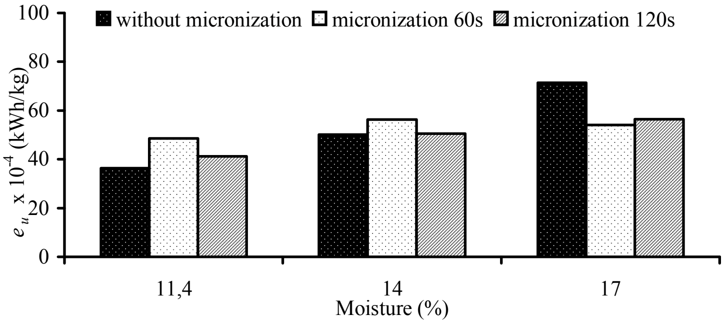

Fig 2. The influence of micronization on energy consumption per unit of grinding. Working gap of grinder – 1.0 mm, micronization temperature 170°C

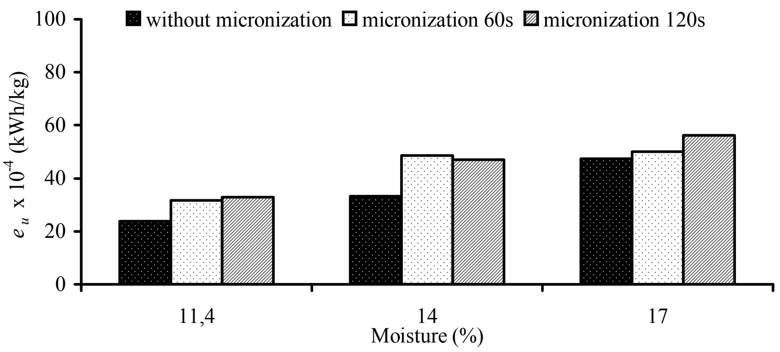

Fig 3. The influence of micronization on energy consumption per unit of grinding. Working gap of grinder – 3.0 mm, micronization temperature 120°C

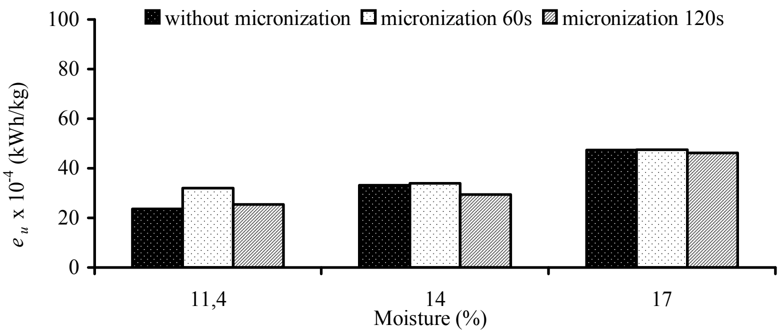

Fig 4. The influence of micronization on energy consumption per unit of grinding. Working gap of grinder – 3.0 mm, micronization temperature 170°C

The increase in the value of grinding energy consumption per unit can be explained by a significant plasticization of the material after the thermal processing, which, as it is known, is not beneficial in the process of grinding.

The observed decreases in the grinding energy occurred only in the case of a material with relatively high initial moisture (17%), which in the process of heating with infrared, decreased significantly, and owing to that, the energy required for grinding the unit of the material's mass was lower [2, 3].

CONCLUSIONS

The observations conducted during the research as well as the final results have led to the following conclusions:

1. The change of moisture of wheat grains between 11.4 to 17.0% results in the increase in the value of energy consumption per unit intake in the process of grinding.

2. The increase in the size of gap of the grinder affects the decrease in the value of the energy needed to grind the unit of wheat grain mass.

3. The pre-grinding use of thermal processing with infrared rays results in the changes in the value of the energy needed to grind the unit of wheat grain mass. These changes depend on the parameters of the used thermal processing (time and temperature) and the initial moisture of the material. The decrease in the value of energy consumption per unit occurs only during grinding the material of an initial moisture 17.0% subjected to micronization at the temperature of 170°C for 60 s and 120 s.

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SUMMARY

The paper presents the results of measuring elementary energy consumption in the process of grinding thermally processed wheat caryopsis. The caryopses were thermally processed with infrared rays at the temperatures of 120 and 170 C for 60 and 120 s. Subsequently, they were ground in a grain shredder. The influence of parameters of used thermal processing on the value of elementary intake of energy at grinding wheat grains was established.