A preliminary study was conducted to determine the effect of a high temperature on some strength characteristics of wheat grain. The grain’s moisture content (15, 20, and 30%) was tested in a microwave oven and a roaster of the ‘jet-sploder’ type. The strength characteristics of heat-treated wheat grain were tested on Instron 4302 apparatus. After heat treatment of grain wetted to 20% moisture content the shearing forces decreased compared to the control grain.

Keywords: wheat grain, microwave, heat treatment, strength characteristics

INTRODUCTION

The studies of the strength characteristics of wheat grain were conducted for many years. They were connected with the harvest’s mechanization, storage and processing. In seeds, some mechanical processes occur connected with the heating and pressure effects of different processing operations. These materials are usually the weak thermal conductors and during conventional heating the rate of heat transfer inside depends on the diffusion. The solution of this problem can be volume heating in bulk, which supplies the thermal energy into the whole volume of the material. One such heating method is microwave heating [2,7]. The microwaves in the food processing industry are used mostly for sterilization, defrosting, baking, etc. An important fact is that, after processing, the taste and flavour substances remain inside when distribution of moisture content in the product is uniform [1,4,5,8,9,11,12,14].

It was also proved that the vegetable protein is more digestible after microwave processing [3,6,10,13].

The production of breakfast or instant cereals relies not only on the microwave heat (hydrothermal) treatment, but also on the jet-splodging, puffing and roasting treatments. These technologies are being improved all the time. It is necessary to continue these studies for better knowledge of their influence on the treated product.

The aim of this study was to find out how the physical characteristics of wheat grain are influenced by high temperatures.

MATERIAL AND METHODS

The study was conducted on sifted wheat grain in a standard 2 mm sieve set. Wheat grain was treated at three moisture content levels: 15, 20, and 30%. Two devices were used to reach the temperature above 100°C, namely the microwave oven and the roaster, jet-sploder type (Fig. 1). The time of heat treatment in the roaster was 15 s with a temperature of 350°C inside the chamber. Heat treatment in the microwave oven lasted 300 s at the frequency 2450 MHz and 1000 W power. The wetting process involved metering an adequate amount of water to the batch of tested grain. After mixing, the grain was conditioned for 48 h in plastic hermetic containers placed in a cooler at 5°C.

Range of the study of physical characteristics included:

- sizing of the grain,
- determination of moisture content,
- determination of single grain diameters,
- investigation of crushing process in single grain,
- investigation of shearing process in single grain.

The crushing and shearing investigations were carried out on Instron 4302 apparatus. The grain was put into the furrow on the measuring table. The diameter of the upper, shifting at the rate of 10 mm min⁻¹ punch was 50 mm. The accuracy of the measurements was 0.05 mm, the average (x) and average empirical standard deviation (σx) were calculated.
The study on physical characteristics of grain

Range of the study included:

1. Determination of moisture content using the oven method according to PN-91/A-74010 standard.
2. Determination of the geometrical dimensions of a single grain. Both heated and control grains were measured in two dimensions, width and thickness, using a device measuring their accuracy to 0.05 mm.
3. Investigations into the crushing and shearing processes of single grain were conducted on the Instron 4302 apparatus. For both tests the grain was put into the furrow on the measuring table. In crushing tests a movable punch of 50 mm diameter was used with a shifting velocity of 10 mm min⁻¹. The shearing process was conducted on grains oriented crosswise and put into the furrow. A knife 1 mm thick with an edge inclination angle of 10° was used for shearing. The knife position was perpendicular to the grain’s surface.

RESULTS AND THEIR ANALYSIS

The investigation aimed to determine the effect of two different methods of moisture content reduction on physical parameters of the wheat grain, such as thickness, width, dynamic strength as well as the shearing forces. These parameters play an important role for technological processes in the food processing industry.

- Geometrical changes of wheat grain subjected to the temperature in a microwave oven and in the roaster were presented in Figs 2 and 3. According to the results obtained, after heat treatment in a microwave oven there was an increase in both the thickness (by 2-14%), and the width (by 18-21%) of wheat grain. In case of heat treatment in the roaster, the width of wheat grain rose by 26-30%, while the thickness rose by 16-21%.
- The results showed that high temperature treatment of the moist grain resulted in a changed internal structure of the final product.
- Wheat grain samples with an initial moisture content of 20% were taken to check the effect of high temperature treatment on strength parameters of the grain. After heat treatment in a microwave oven and in the roaster, the moisture content of tested wheat grain was adequate for storage Thus the strength parameters of grain were comparable with the control grain sample.
- The strength characteristics of grain were given in Figs 4 and 5 and in Table 1. It was found that the shearing force for wheat grain wetted to 20% moisture content and subjected to heat treatment, was reduced by 93% after microwave processing and by 87% after roasting, in comparison to the control sample.
- The crushing strength of microwave-treated wheat grain was reduced too. Compared with the control grain sample, the crushing force was reduced by 17% during microwave processing, while heat treatment in the roaster increased the crushing force by 53%. In the latter case, the rise of hardness might result from the high temperature of 305°C, implemented over a period of 15 s, which might increase the grain’s crushing force.

Fig. 1. Installation for heat treatment. 1 - casing; 2 - belt conveyor; 3 - fan; 4 - heater section; 5 - batch; 6 - bolt; 7 - cyclone; 8 - power and rotational speed engine electric regulator; 9,10 - direct current engines; 11,12 - containers; 13 - thermoelement; 14 - thermometer.
The presented experimental studies are of a pioneering nature. The heat – moisture content relations, in time, as well as their impact on the physical properties of grain, should be determined further. The study of the influence of heat treatment on the changes in wheat grain characteristics may be of practical importance not only in thermal processing but also for other technological processes, like disintegration (flaking, popping etc.).

**CONCLUSIONS**

These experimental studies on the influence of heat treatment on wheat grain provide the following conclusions:
1. The heat treatment makes the wheat grain structure looser, which is proved by the rise in thickness and width.
2. Heat treatment reduces the shearing force that is helpful in the process of disintegration.

---

**Table 1.** Effect of heat treatment at 20% moisture content on the strength parameters and the dimensions of the wheat grain

<table>
<thead>
<tr>
<th>Raw material</th>
<th>Shearing force (kN)</th>
<th>Grain crushing force (kN)</th>
<th>Grain thickness (mm)</th>
<th>Grain width (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat grain - control</td>
<td>0.61 (0.16)</td>
<td>0.0453 (0.0155)</td>
<td>3.16 (0.26)</td>
<td>3.75 (0.25)</td>
</tr>
<tr>
<td>Wheat grain - microwave treated</td>
<td>0.042 (0.013)</td>
<td>0.0374 (0.0129)</td>
<td>3.39 (0.18)</td>
<td>4.22 (0.22)</td>
</tr>
<tr>
<td>Wheat grain - roasted</td>
<td>0.079 (0.038)</td>
<td>0.0696 (0.0287)</td>
<td>3.99 (0.35)</td>
<td>4.38 (0.53)</td>
</tr>
</tbody>
</table>

---

**Fig. 2.** Increase of wheat grain width depending on the method of heat treatment.

**Fig. 3.** Increase of wheat grain thickness depending on the method of heat treatment.

**Fig. 4.** Shearing strength of a single wheat grain.

**Fig. 5.** Crushing strength of a single wheat grain.
REFERENCES