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Dynamic Viscosity of Water and Milk Suspensions of Extruded Corn Porridge

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Abstract: The purpose of this study was to determine the effect of temperature and the content of extruded corn porridge on the dynamic viscosity of water and milk suspensions. Extrusion-cooking process was carried out using a single extrusion-cooker TS-45. During the measurements it was noted that the viscosity of the suspensions was affected by the kind of liquid used, the temperature of the suspension and the content of porridge in the mixture. The highest viscosity was found in a 20% milky suspension tested at 20ºC.
Key words: extruded, extrusion-cooking, corn porridge, suspensions, viscosity, food

INTRODUCTION

Current trends show an increase in consumption of convenience food, which does not require a long time to prepare. Nowadays the consumers attach more and more importance to healthy eating, which is a challenge for manufacturers of functional foods for direct consumption. Innovations used in food processing, i.e. extrusion-cooking, micronization, expanding and combining plant additives call for the replacement of popular snacks with a new type of healthy products [7, 23, 28, 33].

Extrusion-cooking is processing of vegetable raw materials under high pressure and high temperature, which causes significant changes in their physical and chemical properties. During processing the material is mixed, compacted, compressed, melted and plasticized in the final extruder zone. Baro-thermal treatment can be performed in conditions of up to 200ºC and pressures up to 20 MPa. Extrusion-cooking technology is used in the food industry for the production of various types of food products such as snacks, instant cereal baby food, breakfast cereals, texturized vegetable protein, crisp bread, etc. [8, 13, 14, 17, 26].

Corn grits is one of the most popular material used in the production of extrusion-cooked food [10, 20]. Processing in appropriate conditions allows to obtain a new type of products different in relevant properties, texture, appearance and quality of health [5, 33, 34]. Qualitatively better products are derived from harder maize, which is caused by the higher amylose content in composition [4]. Corn products and dishes are hypoallergenic and gluten-free. Due to the different composition of protein compared to other cereals, corn products are recommended for people suffering from celiac disease. [5, 10, 31, 32].

MATERIALS AND METHODS

The main raw material used in our experimental study was commercial corn grits (Vegetus, Lubartów, Poland) with a moisture content of 13% d.m.. Extrusion was carried out in a single screw extrusion-cooker TS-45 (ZMCh Metalchem, Gliwice, Poland) using a single die of 3 mm diameter. Thermal treatment was at 130-135°C at the constant screw rotation – 120 rpm. The obtained corn extrudates were grounded in a laboratory mill type LMN10 (TestChem, Radlin) to the particle size of 1 mm [15, 19].

Moisture was determined by a drying chamber method, in accordance to standard – PN-A-888034 [1, 22, 29].

Water and milk suspensions of 10 and 20% share of extrudates were studied.

Samples were mixed for 10 minutes to obtain a uniform consistency. The values of dynamic viscosity were measured at two temperatures: 20ºC and 40ºC. Measurements were registered six-times.

Samples with hot distilled water and milk were prepared as follows: a weighed sample of the extrudate was mixed water or milk at a temperature of 85°C. Every single sample was mixed for 10 min, then cooled to 40°C, at which measurement was taken. The measurements carried out at 20°C did not require additional heating.

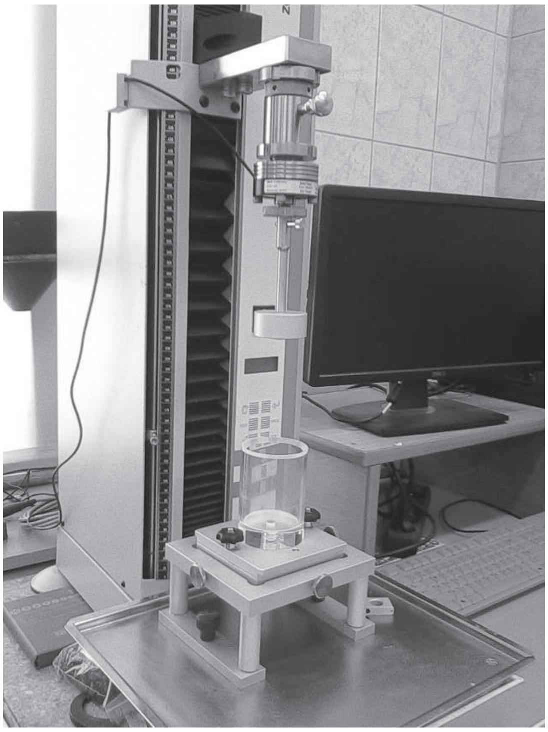

Fig. 1. Testing Machine Zwick type of BDO-FB0.5TH with mounted "back-extrusion" snap

Changes in viscosity of suspensions were measured using a universal testing machine Zwick / Roell BDO-FB0.5TH (Zwick GmbH & Co., Germany) (Fig. 1) equipped with a back extrusion snap. During measurements were used: a chamber of 60 mm height and internal diameter of 50 mm, and a plunger of 46 mm diameter and a height of 20 mm.

Resistance force was recorded during movement of the piston through the slurry in two measuring cycles: down and up, which was converted to the value of the coefficient of viscosity. Profiles of the dynamic viscosity, average decrease in shear strength, and the standard distance were recorded. The test Xpert 10v11 was used for the proper measurements procedure [2, 3, 6, 12, 16, 25].

RESULTS AND DISCUSSION

The moisture content of the extruded corn porridge has a great importance during storage, for maintaining the sensory qualities as well as the microbiological safety [22]. Taking all these aspects into account we can say that our products were very safe, their moisture content was less than 8% at average.

Dynamic viscosity of water suspensions made from the extruded corn porridge significantly changed with increasing its percentage share. The increase of the extrudate in the suspension resulted in higher values. Viscosity of water suspension at 20°C reached 0.54 Pa·s at the concentration of 10%. At the double concentration – 20% the obtained value was 18.15 Pa·s. Heating of the suspension up to 40°C resulted in the lowering of viscosity index, which varied from 0.33 Pa·s at 10% concentration for corn porridge to 12.40 Pa·s at 20% concentration for corn grits (see Fig. 2).

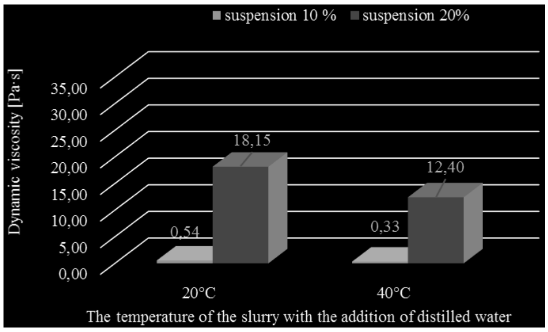

Fig. 2. Effect of corn grits and temperature on the viscosity of aqueous solutions of corn grits

Fig. 3 shows the viscosity of milk suspension at 20ºC and 40ºC, respectively. During the measurements it was found out that milky suspension was characterized by higher levels of dynamic viscosity compared to the water solutions. For example the viscosity of the milk suspension containing 10% extruded corn was almost twice as high as that of the water suspension and amounted up to 1.03 Pa·s at 20⁰C.

Also in that case we can say that the temperature of the suspensions played an important role. Higher temperature decreased the viscosity value. The highest viscosity value (30.26 Pa·s) was obtained for 20% milk suspension at 20°C. For the same suspension at 40ºC the dynamic viscosity was 18.91 Pa·s.

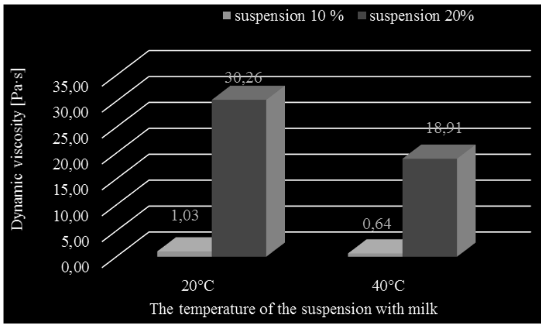

Fig. 3. Viscosity of corn grits – milk suspension

CONCLUSIONS

1. The study confirmed the possibility of using extrusion-cooking technology in the production of safe instant corn porridge. The average moisture content of the extruded products was 7.42%.
2. Increased temperature decreased the dynamic viscosity of the suspensions. The highest dynamic viscosity was measured for the milky suspension at 20°C.
3. Increasing amount of the extruded corn porridge in the mixture resulted in the increasing of the dynamic viscosity of the suspension.

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WYZNACZANIE LEPKOŚCI ZAWIESIN Z UDZIAŁEM EKSTRUDOWANEJ KASZKI KUKURYDZIANEJ

Streszczenie: Celem badania było określenie wpływu temperatury oraz udziału ekstrudowanej kaszki kukurydzianej na zmiany jej wodnych i mlecznych roztworów. Ekstruzję prowadzono używając jednoślimakowego ekstrudera TS 45. W czasie pomiarów odnotowano, że lepkość zawiesin zależała od obróbki termicznej, rodzaju cieczy oraz udziału procentowego kaszki. Najwyższe wartości lepkości miała mleczna zawiesina kaszki o 20% udziale przetrzymywana w temperaturze 20ºC.

Słowa kluczowe: ekstruzja, ekstrudowana kaszka kukurydziana, zawiesina, lepkość dynamiczna