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Scientific study

Influence of semolina moisture content on extrudate properties

Summary
The aim of this research was to investigate potentiality of utilisation of semolina in production of expanded products.
Semolina was extruded in laboratory extruder at moisture set at two different values (15% and 20%) and physical and pasting properties, and resistant and damaged starch content were determined.
The results showed that moisture content of semolina prior to extrusion process influenced properties of extruded products. Although semolina expanded less when moisture content was set to 15%, hardness of the extrudate was lower than when moisture was increased to 20%. Extrusion resulted in significant starch damage which was in accordance with high increase of water absorption index and viscosity changes compared to non-extruded semolina. Resistant starch content slightly decreased after extrusion, which is indicative of higher digestibility of semolina after extrusion.
Keywords: *semolina, extrusion, physico-chemical properties, damaged starch, resistant starch*

Introduction

Extrusion, considered as HTST process, is widely applied in food industry for processing pasta, snack products, breakfast cereals, confectionary etc. (Mulla et al., 2011). This is highly efficient and cost-effective process compared to other cooking operations, with large versatility of potential products (Jozinović et al., 2012). Due to high temperatures, shearing and pressures which are applied during extrusion, food material is extensively changed during the process – starch is gelatinised, proteins are denatured, lipids are modified, Maillard reaction occur etc. (Mulla et al., 2011).

Raw materials for extrusion are protein or starch rich materials, such as corn, rice, barley, wheat, soya flours etc. (Guy, 2001). Wheat has already been subject of scientific researches regarding extrusion. Bhattacharya et al. (1999) extruded potato: soft wheat flour blend (1:1) in twin screw extruder and investigated influence of moisture content and screw speed on pasting properties of extruded products, Mulla et al. (2011) mixed semolina and potato flour in ratios from 30:70 to 70:30 and monitored acrylamide formation during different extrusion processes, Ding et al. (2006) studied effect of extrusion conditions on functional and physical properties of wheat-based expanded snacks and Chanvrier et al. (2007) tried to elucidate exact influence of gluten and starch on properties of extruded wheat flour.

The aim of this research was to investigate influence of semolina moisture content on functional properties of extrudates.

Materials and Methods

Semolina was kindly provided by Žito d.o.o. Osijek. Moisture content was set to 15% or 20%

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prior extrusion by mixing semolina with deionised water.

Extrusion was conducted in laboratory single screw extruder Do-Coder, Brabender 19/20 DN, GmbH, Duisburg, Germany with screw: 4:1; die: 4 mm; at temperature profile: 135/170/170 °C.

Extrudates were air-dried overnight.

Extrudate diameter (d_e) and expansion ratio (ER) were measured according to Brnčić et al. (2008). Extrudate diameter was measured in five replicates by micrometer and expansion ratio was calculated according to the Eq. 1:

Expansion ratio = extrudate diameter (mm)/die diameter (mm)	(Eq. 1)

Bulk density of extrudates was measured according to Pan et al. (1998). Mass of 100 cm^3 extrudate was measured and bulk density was calculated according to Eq. 2:

Bulk density (g/cm^3) = mass (g) / 100 (cm^3)	(Eq. 2)

Hardness and fracturability of extrudates were measured on Texture Analyser TA.XT2 Plus, Stable Micro System using method „Measurement of the hardness and fracturability of pretzel sticks“ supplied with the apparatus.

For water absorption index and viscosity measurements, as well as for determination of resistant and damaged starch extrudates were milled in laboratory mill.

Water absorption index was measured according to Sosulski (1962). WAI is calculated according to Eq. 3:

WAI (%) = [(dried sample mass – original sample mass) / original sample mass] × 100	(Eq. 3)

Viscosity measurement was done on Brabender micro visco-analyser Model 803202. The flour suspensions (10% d.w.; 100 g total weight) were heated at 7.5 °C/min from 32 to 92 °C, held at 92 °C for 10 min, cooled at 7.5 °C/min to 50 °C, and held at 50 °C for 1 min.

Starch damage was determined according to AACC method 76-31 and *resistant starch content* was determined according to AOAC 2002.02 method.

Results and Discussion

Extrudate diameter and expansion ratio are shown in the Fig. 1. As can be seen from results, both extrudate diameter and expansion ratio were higher when semolina moisture was set to 20%. However, other researches have shown that expansion ratio is higher for materials with lower moisture (Onwulata & Konstance, 2006; Ryu & Ng, 2001; Kebede et al., 2010).

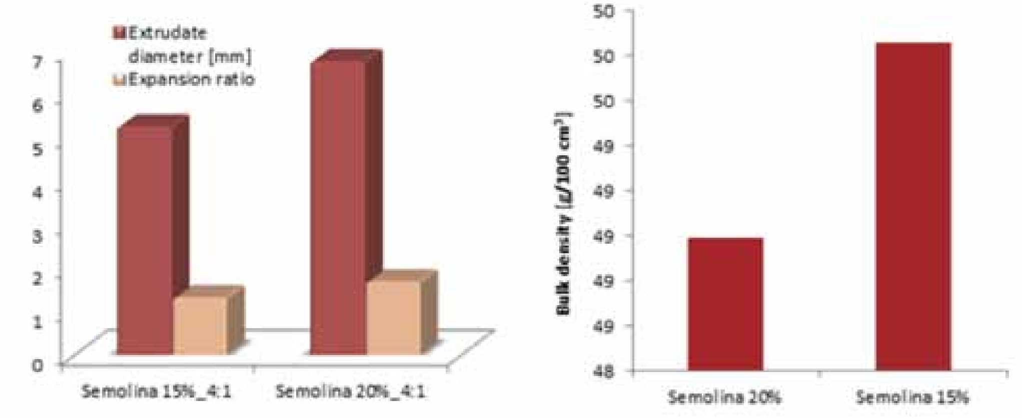

Fig. 1. Influence of semolina moisture content (15% and 20%) on extrudate diameter, expansion ratio and bulk density of extrudates.

Bulk density (Fig. 1.) was higher for samples extruded at higher moisture content. This is corresponding to results of extrudate diameter and expansion ratio. However, these results do not correspond to literature data. Namely, Ding et al. (2006) reported bulk density proportional to moisture content, as well as other researchers (Lazou & Krokida, 2010; Hagenimana et al., 2006; Thymi et al., 2005; Garber et al., 1997).

Texture properties of extrudates are shown in Fig. 2. Higher hardness was determined for samples extruded at higher moisture content, whereas fracturability wasn't influenced by moisture. These results can be correlated to research of Ryu & Ng (2001) and Jozinović et al. (2012), who reported that extrudates produced at lower moisture content had lower hardness.

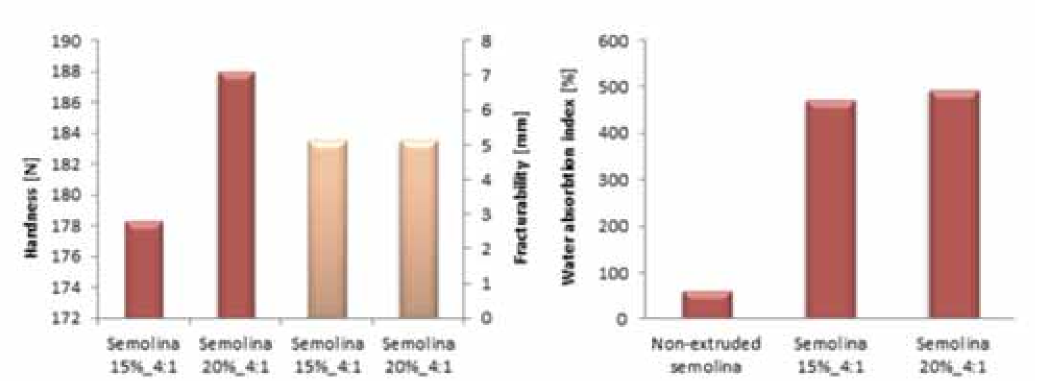

Fig. 2. Influence of semolina moisture content (15% and 20%) on texture of extrudates and water absorption index of semolina.

Water absorption index of semolina (Fig. 2) increased after extrusion, proportionally to moisture content. Non-extruded semolina had significantly lower water absorption index than extruded samples. Increase of water absorption index after extrusion reported Jozinović et al. (2012) and Lazou & Krokida (2010). However, Ding et al. (2006) reported that higher moisture content during extrusion resulted in lower water absorption index.

Extrusion of semolina resulted in increase of peak viscosity with more pronounced effect when lower moisture content was applied (Tab. 1). Bhattacharya et al. (1999) reported higher viscosity for samples extruded at higher moisture content, as well as Hernandez-Diaz et al. (2007).

Further heating at 92 °C resulted in slight drop of viscosity, while cooling pastes to 50 °C caused viscosity increase due to starch retrogradation. Cold paste viscosity was higher for non-extruded semolina, probably due to starch pregelatinisation during extrusion (Gupta et al., 2008; Hagenimana et al., 2006) and starch damage which occurred during extrusion (Tab. 1).

Table 1. Influence of extrusion on viscosity properties of semolina and resistant starch (RS) and damaged starch (DS) content.

	Non-extruded semolina	**Semolina 15%_4:1**	**Semolina 20% _4:1**
Peak viscosity [BU]	430.5 ± 19.5	496.5 ± 0.5	484.5 ± 17.5
Viscosity at 92 °C [BU]	429.5 ± 19.5	476 ± 20.0	473.5 ± 13.5
After mixing at 92 °C [BU]	396 ± 10.0	423 ± 2.0	376.5 ± 44.5
Viscosity na 50 °C [BU]	882 ± 2.0	771 ± 11.0	702 ± 71.0
After mixing at 50 °C [BU]	812.5 ± 17.5	781.5 ± 12.5	700 ± 81.0
RS (% d.w.)	1.90	1.46	1.35
DS (%)	1.21	45.07	47.33

Although extrusion resulted in significant increase of starch damage, resistant starch content (Tab. 1) wasn't significantly influenced by extrusion, even though slight decrease was observed in this research, as well as in the research of Jozinović et al. (2012).

Conclusion

Semolina has potential for production of expanded products which can be seen from physical properties of extrudates shown in this research. However, additional research should be conducted to examine influence of extrusion parameters other than moisture.

Viscosity and water absorption index measurements showed that extrusion significantly modifies semolina. This indicates that extruded flour could be applied in bakery and confectionary industry as texture modifier and for water retention.

Very low content of resistant starch is indicator of easy digestion of semolina, which is important nutritional factor.

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