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ESTIMATION OF SOME CHOSEN PHYSICAL PROPERTIES OF EXTRUDATES OBTAINED FROM CORN SEMOLINA AND OAT BRAN MIXTURES

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A b s t r a c t. Some chosen properties of the extrudates obtained from corn semolina and oat bran were studied. Two component mixtures were extruded using a single screw extrusion-cooker S-45. The purpose of the research was to estimate the influence of the moisture content in raw material and the process temperature on its course, the outflow stability and such physical properties as: radial expansion, specific density, texture and water absorption index. It was observed that higher process temperature lowered water absorption of the product and water absorption index increased along with the increase of raw material moisture content and oat bran percentage. Higher content of bran altered density and lowered the level of extrudate expansion. It was found that higher moisture of raw material caused a decrease in the specific destruction energy of the extrudate.

K e y w o r d s: extrusion-cooking, physical properties, oat bran, extrudate

INTRODUCTION

Advantages of extrusion-cooking makes this technique of interesting nowadays. There is a wide range of research on the new methods of production using various raw plant materials and materials of animal origin. Lately, numerous studies on the possibility of introducing an oat component as a valuable nutrition additive with specific properties of a dietary fibre to extrudates have been carried out. Soluble fraction of oat dietary fibre, (1→3), (1→4) -β-D-glucans, affects dietary properties of oat components. β-glucans influence lipid transformation in human organism. They are able not only to lower the total cholesterol level in a blood, but first of all, to decrease LDL and VLDL cholesterol with a simultaneous increase of the HDL level. In addition, they can stabilise blood glucose [1,2]. Due to the above properties of oat components, studies on the improvement of extrusion-cooking process have been undertaken. The effect of oat bran content, raw material moisture and barrel temperature distribution profile on the process, physical properties of food extrudates (level of radial expansion, specific density, texture and water absorption index) and the influence of these parameters on the extrudate organoleptic features were carried out.

MATERIALS AND METHODS

Commercially available corn semolina, the main component of starch, obtained from PZZ Włocławek and oat bran, the main component with which fat and dietary fibre are introduced into the mixture (Table 1), were the main materials for the extruded mixtures. Mixtures of 3-18% bran were moistened up to the required level. Wetted samples were then conditioned for 4 h to obtain uniform moisture content. One-percent NaCl was added to each mixture batch to improve taste. Corn semolina and oat bran mixtures were extruded in a single-screw extrusion-cooker S-45 (L:D = 12:1, screw compression ratio 3:1), using die diameter of 3 mm and the screw speed of 100 rpm.

T a b l e 1. Chemical composition of the raw materials (d.b.)

Component	Ash	Protein Nx6.25	Fat	Crude fibre	N-free extract	NDF	ADF	ADL	CEL	HCEL
Oats bran	2.33	16.39	7.42	1.51	72.35	9.08	2.87	1.59	1.28	6.21
Corn semolina	1.54	8.2	1.1	1.22	87.94	*	*	*	*	*

*not analysed.

Process parameters and material properties were assumed on the basis of our earlier studies [6], that allowed to obtain a good quality product for direct consumption. Influence of the moisture content of the mixture ranging from 12 to 16% was studied using 9% bran and the barrel temperature profile of 145/165/130 °C. Trials on the effect of barrel temperature were carried out at the constant material moisture content of 13.5 and 9% of oat bran content at the temperature range of 125/145/130 - 160/180/130 °C, respectively. Chemical characteristics of the raw materials was estimated using generaly accepted standard methods. Estimation of the materials grinding properties was made using a laboratory screen shaker SZ - 1 type (Table 2). Moisture of the raw materials was estimated with the air oven method by drying the sample at 105 °C for 3 h. The capacity of the extrusion-cooker was calculated as a ratio of the sample weight to the time of process run. Radial expansion was estimated as a ratio of the cross section area of the extrudate to the area of the die [5]. Specific density of the sample was measured as a ratio of its weight to volume [5], including its inner pores. Texture was estimated using the method and texture tester described by Rzedzicki [4]. Water absorption index of the extrudate was estimated using the method of draining by wetting the sample with distilled water at 8 °C for 15 min followed by 15 min of draining according to Jao *et al*. [3]. Studies of radial expansion, density and texture were carried out in 50 replications and water absorption in 5 replications.

T a b l e 2. Sieve analysis of components

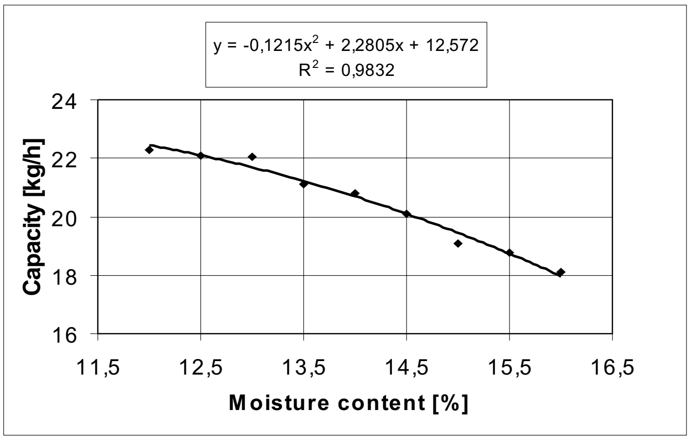
Fraction (mm)	Corn semolina	Oats bran
	(%)	
> 1.6	0	2.34
1.6 - 1.2	0.18	12.2
1.2 - 1.0	5.8	17.35
1.0 - 0.8	31.04	24.35
0.8 - 0.5	40.28	25.12
0.5 - 0.265	18.94	9.28
< 0.265	3.76	9.36
Σ of fractions <0.5	22.7	18.64
Mean diameter (mm)	0.68	0.83

RESULTS AND DISCUSSION

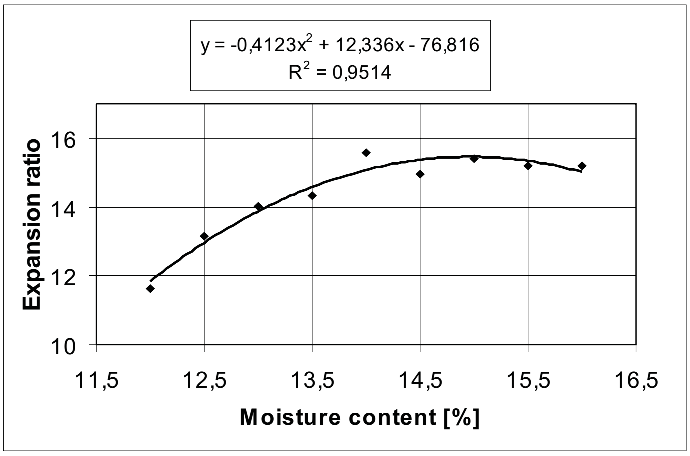
High fat content in oat bran (Table 1) as well as the specificity of oat starch make stable extrusion results difficult to obtain as extrusion disturbs proper back-flow of the material in a barrel. That is why, material sliding and interruptions in the extrusion process occur more often in the case of oat bran. At such disturbed extrusion conditions, extrusion-cooker worked as a common screw conveyor with frequent interruptions of extrusion-cooking. With the process parameters and material properties assumed for this study, it was possible to obtain stable working conditions for the extrusion-cooker when the share of oat bran in the mixture was up to 18%.

The capacity of the extrusion-cooker at studied material moisture content and barrel temperature ranges decreased together with the increase of moisture and temperature (Figs 1a and 2a), which in turn was related to the decrease in viscosity and the increase of the material back-flow in the barrel.

Process parameters significantly influenced extrudate expansion. A decrease of extrudate radial expansion was observed when the percentage of oat bran inclusion was increasing in the mixture. The lowest expansion rate was 13.56, which was still very good for this kind of product. Material moisture increase (Fig. 1b) significantly affected the increase of radial a



b



expansion. For other raw materials, especially starch ones, opposite trends could be observed.

c

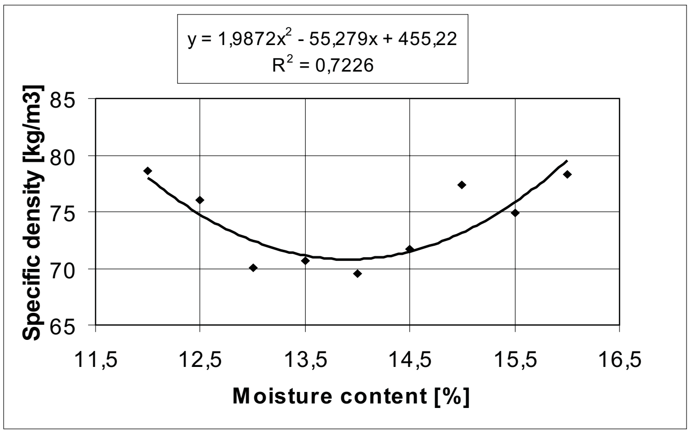
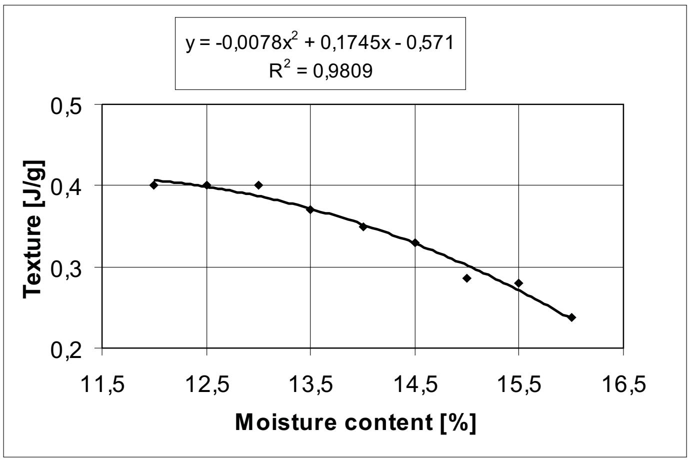


Fig. 1. The influence of the moisture content of the raw material on the: capacity of the extrusion-cooker (a), radial expansion (b), specific density (c), texture (d), water absorption index (e) of the extrudate (temperature 165 ^{o}C, rate of oat bran 9%).

d



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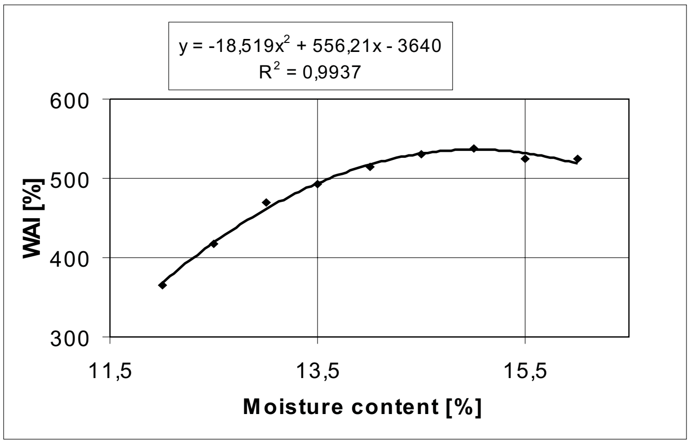


Fig. 1. Continuation.

Very high determination coefficient value (R^2 = 0.95) proves that the results were not obtained by chance, but that they were regular. Process temperature (Fig. 2b) also significantly affected radial expansion. At the studied temperature ranges, a decrease of expansion with the temperature rise was noted. The lowest expansion level did not drop below 14, which was still very good for extruded snacks. However, scatter of the results was observed, as the determination coefficient R^2 amounted to 0.81. Changes in expansion were accompanied by the variation in the specific density. However, these relations were not proportional.

An increase in the amount of oat components caused a slight increase in the product density. However, the highest values noted did not exceed 75 kg m^{-3}. Thus, they were still excellent parameters for the snacks produced for direct consumption. Raw material moisture slightly affected the specific density (Fig. 1c) as well. All the values obtained ranged from 69 to 79 kg m^{-3}. A significant influence of the longitudinal expansion was observed in this case because density changes were not accompanied by proportional variations of the radial expansion. Similar trends were observed as related to the effect of temperature on the specific density (Fig. 2c). The values obtained ranged from 68 to 76 kg m^{-3} and they were also the result of the longitudinal and radial expansion interactions.

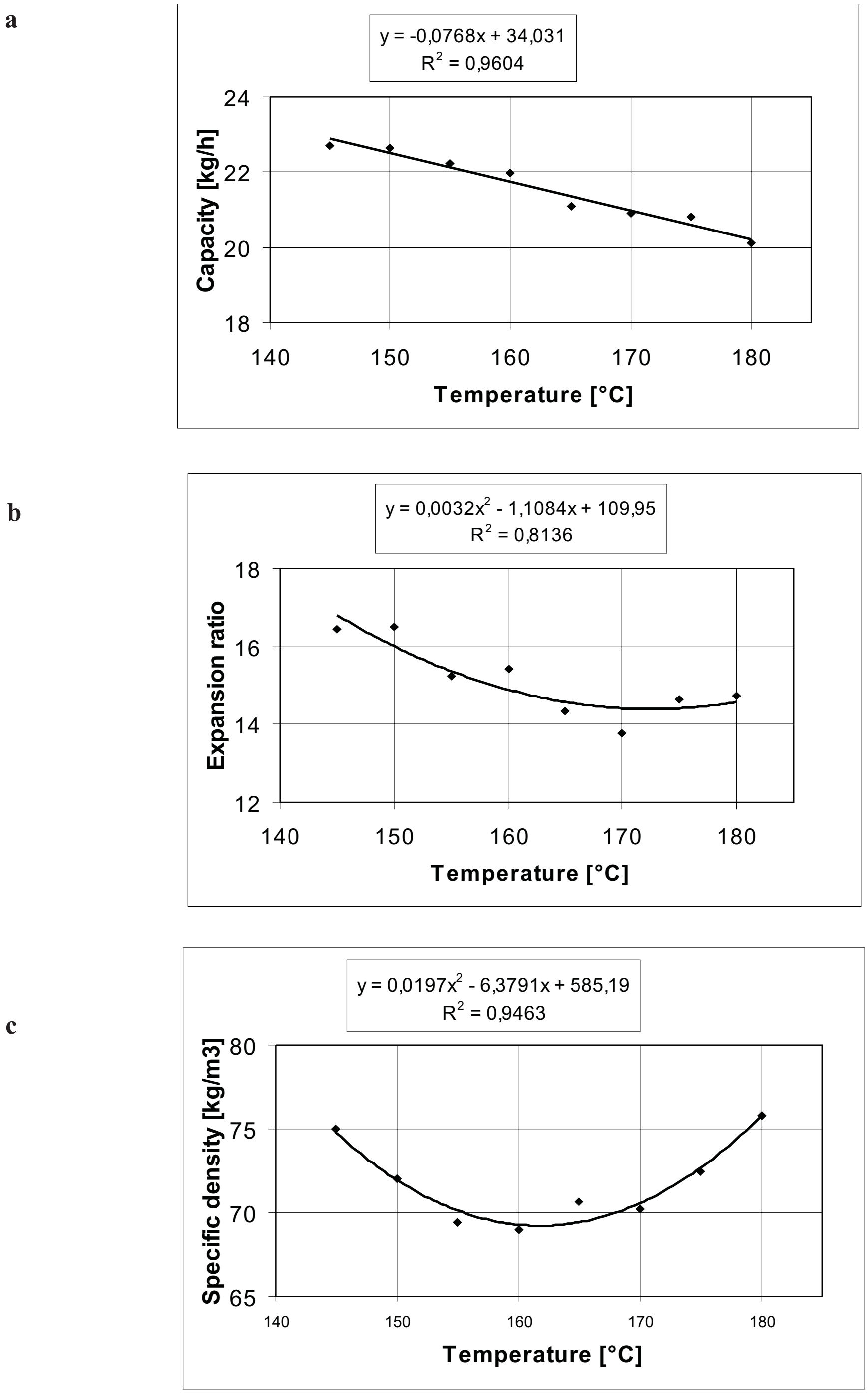
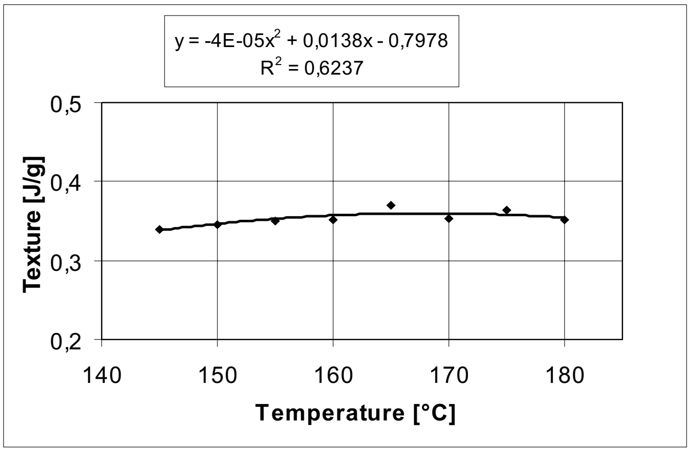


Fig. 2. The influence of the barrel temperature on the: capacity of the extrusion-cooker (a), radial expansion (b), specific density (c), texture (d), water absorption index (e) of the extrudate (moisture content 13.5%, rate of oat bran 9%).

d



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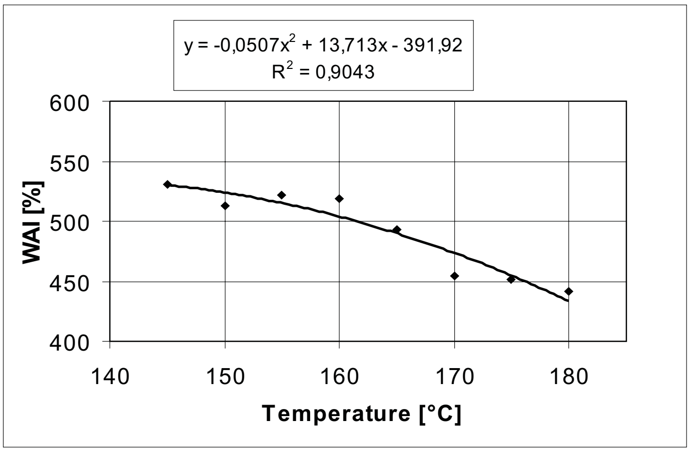

Fig. 2. Continuation.

In addition, texture of the extrudate determines its commercial usefulness. The range of the analysed parameters allowed to obtain an acceptable texture for the consumers. Only slight texture increase was observed with the bran content increase. The values of destruction energy observed ranged from 0.36 to 0.38 J g^{-1}. The influence of material moisture was very surprising (Fig. 1d) as a decrease in the value of destruction energy was observed when the moisture content increased. Those values ranged from 0.23 to 0.41 J g^{-1} with a very high determination coefficient R^2 = 0.98. Opposite trends were observed when the effects of temperature on the extrudate texture (Fig. 2d) were analysed. Destruction energy increased with the temperature increase. At the same time, large scatter of results was observed since determination coefficient amounted only to R^2 = 0.62.

Extrudates with oat bran were characterized by high water absorption index. However, it was changing considerable with changing process conditions. Along with the increase of bran percentage inclusion, water absorption index increased from 450 up to 575 at 18% of bran inclusion. Raw material moisture increase was accompanied by extrudate water absorption index increase (Fig. 1e). About 550% values were noted for this trait. Opposite relations were found for the influence of process temperature on water absorption (Fig. 2e). Extrudate water absorption index decreased when temperature was raised.

Extrudates were also subjected to organoleptic assessment using a 9-score grade. Crispness, taste, stickiness and product presentation were estimated. Samples with 9-12% bran inclusion with 13.5-14% raw material moisture content, 135/155/130-140/160/135 ^{o}C barrel temperature profile were evaluated as high as even 9 points and they were worth recommendation for the practical application.

CONCLUSIONS

1. Proper choice of raw material moisture content, barrel temperature, die diameter and screw speed allows to stabilise extrusion conditions for oat bran inclusion up to 18%.

2. Oat bran inclusion rate and temperature increase are accompanied by the decrease of radial expansion; moisture content increase - by extrudate expansion increase.

3. Significant effects of process parameters on the specific density was not observed at the process parameters assumed for the experiment. Changes were small and they did not affect product quality.

4. Extrudates with oat bran content are characterized by a very good texture. The highest destruction energy values did not exceed 0.4 J g^{-1}.

5. Extrudates with oat bran inclusion are characterized by a very high water absorption index reaching even up to 550%.

6. The following parameters are recommended for practical application: oat bran percentage of 9-12%, raw material moisture of 13.5-14%, barrel temperature profile of 135/155/130-140/160/130 ^{o}C, die diameter of 3 mm, screw speed of 100 rpm.

7. Very good quality extrudates with oat bran inclusion should be recommended as popular and convenient food product.

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