

THE QUALITY OF FRIED SNACKS FORTIFIED WITH FIBER AND PROTEIN SUPPLEMENTS

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ABSTRACT

There was studied the effect of fortification of extruded potato pellets, obtained with 5 and 10 % addition of wheat bran, corn bran and corn germ, applied separately and in mixtures with 3 % addition of potato protein concentrate on fat content and physical properties of snacks fried from them. The addition of wheat bran, regardless its dose, did positively influenced on snacks texture. Yet it also caused the increase in fat content and density, as well as darkening of snacks color. The use of corn bran contributed to lower values of snacks density and fat absorption, while the addition of corn germ resulted in lighter, more desired snacks color, but at the same time it brought about increased fat content and made snacks harder. There was not recorded any significant snacks diversity concerning expansion degree, regardless the kind of additive used, as well as snacks moisture.

Keywords: potato snack, frying, bran, germ, protein preparation, physical property

INTRODUCTION

In most countries all over the world continuously growing consumption of snack products has made them a considerable component of a human diet. Therefore, snacks nutritive and energetic value should meet strictly determined requirements. These products are often fortified with wholesome or functional components, including the ones containing high content of proteins and fiber, as well as chemical compounds featuring antioxidant properties (**Dziennik Ustaw, 2007**).

One of the most popular snack products are potato chips and snacks, both extruded (collets) and fried (**Lusas and Rooney, 2001**). The quality of these products – expanded in the conditions of high-temperature extrusion or originating from intermediate products frying (pellets)–has recently become the subject of numerous research conducted in different parts of the world (**Ahamed et.al., 1997; Goel et.al., 1999; Jonnalagadda et.al., 2001; Senthil et.al., 2002**). Expanded products characterize specific rough structure, crispy texture and small size, as well as highly diverse shape and taste, while fried products feature markedly high fat content (20-40 %). Manufacturing this type of food requires not only modern technology but also precise choice of raw materials possessing strictly defined properties. Applied snacks enrichment with fiber and proteins can lead to worsening of their organoleptic and physical properties, including diminishing expansion degree, increased hardness and density of products, as well as undesired alterations in their color and flavor. The origin and purity degree of these additives, the degree of proteins denaturation and the form of preparation are of a special importance in this process (**Lusas and Rooney, 2001**).

A number of authors carried out investigations on extruded snacks supplemented with nutrients, as well as functional components. Snacks contain products of leguminae plants seeds processing and grains of different cereals (**Senthil et.al., 2002**), protein preparations, both of animals (**Lee et.al., 2003**) and plants (**Pęksa, 2006**) origin and also raw materials being waste products which have not been used in food industry so far (**Schieber et.al., 2001**), like so-called food-by-products e.g. brewer's spent grain (BSG) (**Stojceska et.al., 2008**). A by-product in dry milling industry, not applied in food production until recently, is corn-mix consisting of corn grain germ and

slight amounts of endosperm and seed coat (www.biocorn.pl). Dry milled corn germ characterizes excellent nutritional value and has been proposed for human foods. Corn bran fractions are used in foods production to increase dietary fiber content (**Hallauer, 2001; Mendonça et.al., 2000**). To preparations obtained from waste products belong those which contain partly denaturated potato protein isolated from potato juice in laboratory conditions. According to some authors, it is possible to use these products for consumption purposes, including snacks both extruded and fried (**Lusas and Rooney, 2001**). Potato protein, featuring high nutritional and digestive value, can become a valuable component of crispy snacks products, also the fried ones.

The literature is relatively poor in information about the effect of simultaneous introduction of by-products of dry milling industry and protein preparations to the recipe of deep fat-fried snacks on the quality of ready products.

The aim of the experiment was to determine the effect of fried potato snacks fortification with wheat bran, corn bran and corn germ products used separately as additives and in the mixtures with potato protein concentrate (PPC) on fat content and physical properties of the products obtained.

MATERIALS AND METHODS

Materials

Potato starch (18.3 % moisture content) was provided by starch factory PPS Pepees in Łomża, Poland. The remaining ingredients used for fried snacks preparation were potato semolina (8.1 % moisture content) composed of 9.38 % crude protein, 0.72 % crude fat, 1.27 % reducing sugars, 78.8 % carbohydrates (potato factory PZP in Lublin, Poland), corn semolina featuring 750-1250 nm, moisture of 11.2 % and 7.20 % of crude protein, 0.83 % crude fat, 0.71 % reducing sugars, 80.3 % carbohydrates and corn bran (by-product of dry milling) from Bio Corn Ziębice, Poland, characterizing 11.30 % moisture, 14.76 % of crude protein, 8.39 % fat and 61.45 % carbohydrates. Wheat bran of 12.59 % moisture, 15.5 % of crude protein, 4.30 % crude fat and 62.80 % carbohydrates, corn dry germ of 5 % moisture, 14.81 % of protein, 20.16 % fat and 53.0 % carbohydrates, salt and rapeseed oil for frying were purchased at the local market. As a protein additive there was used potato protein concentrate (PPC), obtained in laboratory conditions from potato juice by thermal

coagulation in the presence of CaCl₂ (Peřsa, 2006). The extrusion parameters were kept constant: die size (0,5mm

Table 1 Formulations for pellets producing

Formulations	Potato starch (g/100 g)	Potato semolina (g/100 g)	Other ingredients (g/100 g)	WB/CB/CG (g/100 g)	PPC (%)
1 (Control-0)	67	26	7	0	0
2 (Control-PPC)	67	26	7	0	3
3	62	26	7	5	0
4	57	26	7	10	0
5	62	26	7	5	3
6	57	26	7	10	3

composition of mentioned above PPC was as follows: 3.20 % moisture content, 72.73 % crude protein, 1.45 % fat, 7.25 % ash and 15.37 % carbohydrates.

Preparation of samples

The formulations of pellets are shown in Table 1. Two levels of fiber products (wheat bran–WB, corn bran–CB and corn germ–CG) mixed with potato starch, potato semolina and other ingredients were formed. Potato starch was replaced, in suitable quantity, by fiber product. One level of potato protein concentrate (PPC) was added to mixtures on the basis of sample weight. As controls, samples without any additives or containing only PPC as an additive, there were used. Duplicate batches (600g each), (fourteen samples in each) were moisten up to 40-45 %, mixed and sieved. The samples were placed in sealed polyethylene bags at 4-5 °C for 12 hours to equilibrate moisture.

Preparation of pellets

Material for pellets was extruded in a single-screw extruder (Brabender DN 20, Germany). The following

x 80mm), speed of dough supplier (38 rpm), screw speed (120 rpm), screw loading (2.8 A), barrel temperature distribution (60 °C / 70 °C / 80 °C). Previously subjected to extrusion, not expanded strands were cut into pellets of ca. 27 x 27 mm and dried at room temperature for 12 hours to ca. 12-13 % of moisture content and then sealed in polyethylene bags to equilibrate moisture until frying.

Preparation of fried snacks

Snacks were obtained from pellets after 48 hours of storing in room temperature. Samples were fried in hot (180 °C) rapeseed oil for 15-20 seconds (3 seconds after expanded product appears on the oil surface). The product to oil ratio was kept at 1:20 w/v.

Analysis

Proximate chemical analysis: Standard AOAC methods (1975) were used for the analysis of fat, total ash and the nitrogen content in raw material components and snacks and the crude protein content was calculated as Nx6.25. The moisture content of the ingredients for pellets

Table 2. Mean values of the properties of snacks fortified with different levels of fiber Supplements.

Fiber supplement	Level of fortification [%]	Moisture content [%]	Fat content [%]	Expansion	Bulk density [g/ml]	Texture [N]	Lightness [L value]
Wheat bran (WB)	0	3,22 ^a	27,55 ^c	2,96 ^a	0,185 ^c	14,9 ^a	71,84 ^a
	5	3,37 ^a	32,50 ^b	2,55 ^a	0,223 ^b	11,2 ^a	58,16 ^b
	10	2,96 ^a	36,70 ^a	2,19 ^a	0,282 ^a	8,3 ^a	51,81 ^c
	X (mean)	3,17 ^A	32,25 ^A	2,56 ^A	0,230 ^A	11,5 ^B	60,60 ^C
Corn bran (CB)	0	3,22 ^a	27,55 ^b	2,96 ^a	0,185 ^a	14,9 ^a	71,84 ^a
	5	3,73 ^a	32,45 ^a	2,73 ^a	0,148 ^b	13,2 ^a	60,51 ^b
	10	3,55 ^a	31,90 ^a	2,26 ^a	0,163 ^a	14,2 ^a	61,24 ^b
	X (mean)	3,64 ^A	30,63 ^B	2,65 ^A	0,165 ^B	14,1 ^{AB}	64,53 ^B
Corn germ	0	3,22 ^a	27,55 ^c	2,96 ^a	0,185 ^b	14,9 ^b	71,84 ^c
	5	3,47 ^a	34,85 ^b	2,86 ^a	0,275 ^a	22,8 ^a	76,48 ^a
	10	3,18 ^a	37,35 ^a	2,23 ^a	0,272 ^a	13,9 ^b	73,96 ^b
	X (mean)	3,33 ^A	33,25 ^A	2,68 ^A	0,244 ^A	17,2 ^A	74,09 ^A

a,b,c – Means in the same column with different letters differ significantly (P ≤ 0,05) by Duncan’s multiple range test

A,B,C - Means in the same column with different capital letters differ significantly (P ≤ 0,05) by Duncan’s multiple range test

preparation, the samples of the dough for the extrusion, obtained pellets and snacks was determined by the reduced weight after drying at 102 °C and until constant weight was achieved (AACC,1962). The carbohydrates content was calculated by difference.

Physical properties of snacks: The expansion of snack was calculated as a quotient of snack size to pellet size. Results are the means of 20 measurements. To calculate bulk density (g/ml) ground snacks were poured into weighing glass vessel with a known volume and their weight was determined (BN, 1991). The texture of the snacks was determined by using an Instron type 5544 texture-measuring device with Merlin software. The minimal force (N) necessary to break up a snack was measured using a share blade at blade displacement rate of 250 rpm. Results are the means of 20 measurements. The colour of snacks (L value) was determined objectively by using a Minolta CR-200 chromameter against white reference standard, measuring values of Hunter's scale (Clydesdale, 1976).

Statistical analysis

The results obtained in the experiment were subjected to statistical calculations according to the Statgraphics programme v. 6.0. Multifactor analysis of variance and means separation according to Duncan ($P \leq 0.05$) were used for determination of significance of the influence of the additives, and interactions between them and the level of fortification with fibre products on moisture and fat contents in snacks and on their physical properties.

RESULTS

The effect of fibre type and PPC addition on moisture and fat content in snacks

Depending on the kind and amount of fibre used, moisture content in snacks ranged from 2.96 to 3.73 % (Table 2).

There was not observed any significant influence of the kind or amount of fibre additive on snacks moisture. Yet there was recorded a slight effect of simultaneous introduction of PPC and the examined fibre products to pellets (Fig. 1), regardless their quantity and kind, on the increase in oil absorption when frying these products in comparison to the samples enriched only with protein preparation.

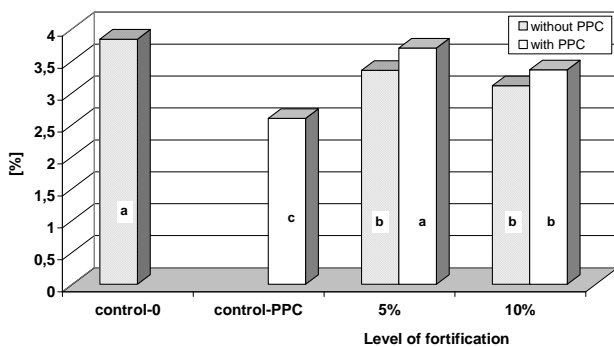


Fig. 1. The influence of the level of fibre fortification and PPC addition on the moisture of snacks

Fat content in the snacks, obtained by frying examined pellets which contained 5 and 10 % addition of fibre products ranged from 32.45 to 37.35 % and it was higher than that of snack samples without fibre and protein

products supplement (27.55 %) (Table 1). The increase in wheat bran or corn germ contribution to pellets resulted in increased fat content in snacks. However, there was not recorded any significant effect on fortification level of pellets due to corn bran (Table 1). Additionally, there was noted that snacks made from half products containing wheat bran and corn germ did not significantly differ and contained more fat than snacks fortified with corn bran (30.63 %).

Introduction of not high amount (3 %) of PPC into pellets was statistically insignificant regarding its effect on fat content in snacks, regardless the addition of fibre product (Fig. 2). However, there was observed a tendency to decreased absorption of fat by products fortified exclusively with corn bran, as well as by those combining corn bran and PPC.

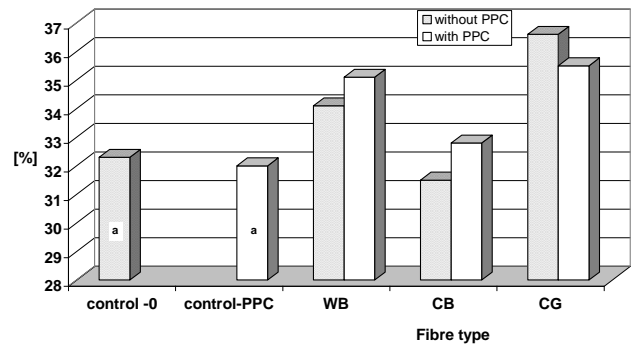


Fig. 2. The influence of the type of fibre product and PPC addition on fat content in snacks

Effect of fibre type and PPC addition on physical properties of snacks

As it can be seen in Table 1, the degree of snacks expansion amounted average 2.96, for snacks containing 5 % supplement of these products ranged from 2.55 to 2.86, while for snacks fortified with 10 % addition it did not exceed 2.26. No significant statistical differences, regarding this property, was determined between snacks fortified and not fortified with fibre additives. Also fibre type did not affect on the expansion of snacks obtained. Snacks without any additives characterized higher degree of expansion (3.53) than the remaining products (2.21-2.73) (Fig. 3).

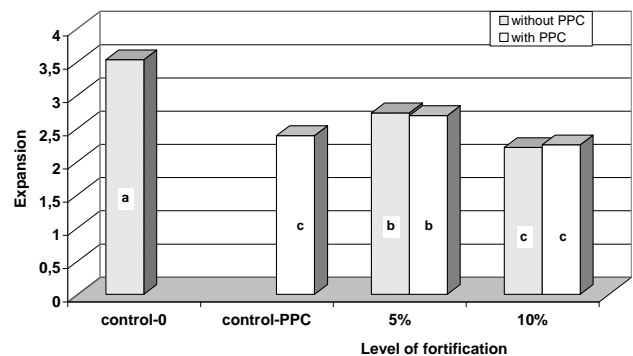


Fig. 3. The influence of the level of fibre fortification and PPC addition on snacks' expansion

Application of potato protein concentrate as the only additive, combined with higher addition of fibre product, caused similar diminishing of snacks expansion, while pellets containing lower amount of fibre products

expanded to a slightly higher degree, regardless the addition PPC.

Fortification of fried potato snacks with the examined fibre products, regardless the kind of additive and PPC introduction, brought about increased density of ready products (Fig. 4), from 0.185 g/ml (snacks not fortified), through 0.215g/ml after application of 5 % supplement, to average 0.239g/ml determined for the samples with 10 % fortification. Snacks obtained with the addition of corn bran, regardless their fortification level, featured lower density (average 0.163g/ml) (Table 1) than other samples of obtained products. The increase in fortification level due to maize germs application did not cause statistically significant differences in their density.

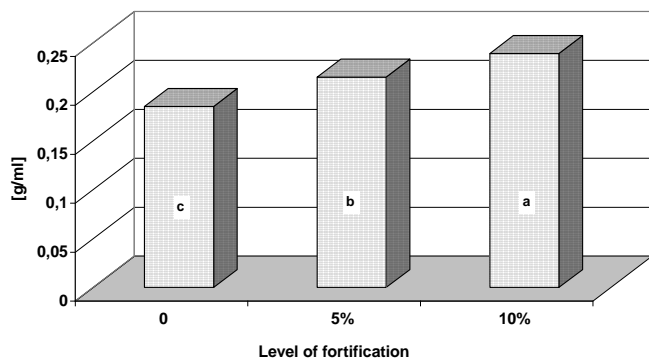


Fig. 4. The influence of the level of fibre fortification on bulk density of snacks

However, the use of corn bran as an addition to fried snacks contributed to the decrease in their density in relation to the samples without fibre additions.

Average results of texture measurements regarding snacks with 5 and 10 % fortification with three different fibre products, shown in Table 1, prove that snacks fortification level did not have any influence on the texture of the products examined. Measurement results, expressed by shearing force (N) were found within the range of 11.2-8.3N (snacks with wheat bran), 13.2-14.2N (with corn bran), as well as 22.8-13.9N (with corn germ). There was recorded statistically significant difference between the texture of products fortified with wheat bran and corn germ however, snacks with the addition of wheat bran featured lower hardness than those containing corn germ. As it can be concluded from fig. 5, ready products obtained from pellets fortified with wheat bran, both with PPC and those without it characterized less hard texture than samples with the addition of the remaining fibre products.

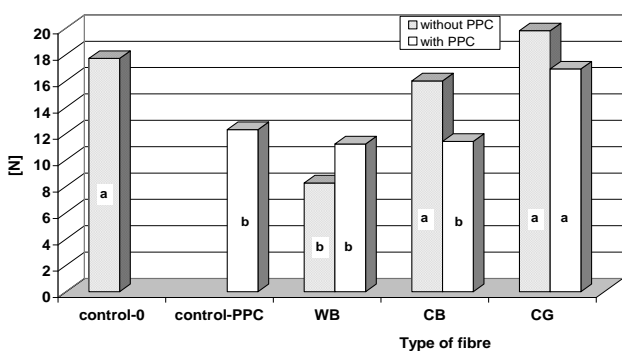


Fig. 5. The influence of the level of fibre fortification and PPC addition on the texture of snacks

The application of additives, as well as the level of pellets fortification with fibre products did considerably effect on lightness of fried products obtained (L values according to Hunter scale) (Table 1). Regardless the dose, 5 or 10 %, products resulting from the addition of corn bran did not differ in lightness (60.51 and 61.24 respectively) while when the remaining two fibre products were used, increased level of fortification resulted in darker color of fried ready products. The lightest proved snacks with the addition of corn germ (average L=74.09), and the darkest occurred snacks fortified with wheat bran (L=60.60). The increase in the level of fortification with fibre, regardless PPC addition, brought about darkening of snacks (Fig. 6).

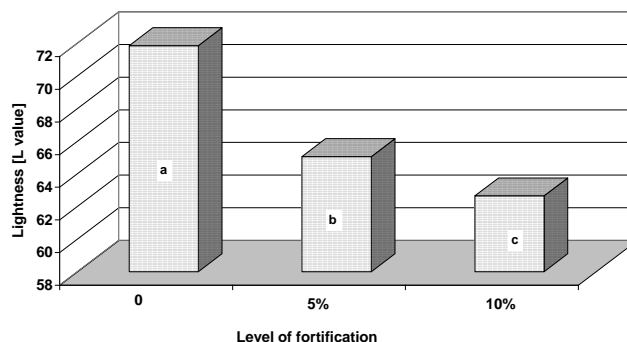


Fig. 6. The influence of the level of fibre fortification on the lightness of snacks

DISCUSSION

Fibre products applied in extruded pellets production proved to influence on fat content and physical properties of snacks fried from them in a diverse way. Snacks fortification with fibre products reflected in altered mainly such properties as: fat content, texture, density and lightness but not their moisture content. The doses of particular fiber supplements were of significant effect on expansion degree featuring snacks obtained from pellets, namely on density, lightness and fat content. Simultaneous fortification of the examined products with potato protein concentrate and fiber products, according to the amount of fiber addition, resulted in diversity of such snacks properties as expansion and moisture.

Basic properties analyzed for the assessment of fried snack products are their moisture and fat content. The products prepared by **Senthil et.al. (2002)** from starch raw materials, did not contain more than 4 % of water, which also meets the requirements of the **Polish Standard (PN, 1996, 1998b)**. Regardless additions applied, this value was not exceeded in any snacks obtained. **Ahamed et.al. (1997)** stated that regardless starch origin, the increase in its contribution to fried snacks provides for significant decrease in fat content in ready products. Introduction of fiber products to pellets recipe, and, therefore, diminishing starch content in pellets, resulted in the increase in fat content in fried snacks. The mentioned increase reached the highest degree, by about 33 % with 10 % content of wheat bran, as compared to samples without fiber addition. However those quantities did not exceeded the highest permissible quantity, like 45 % (**PN, 1996, 1998b**).

Expansion degree of snacks obtained in the experiment decreased after the use of additives, both fiber products and protein preparation, within the range of 23–37 %.

Snacks with lower amount of fiber supplement, regardless its kind, achieved expansion not lower than 2.55, so slightly lower than obligatory norms (PN, 1998b), i.e. 3. Also in the research by other authors (Hsieh et al., 1989; Kita et al., 2002; Stojceska et al., 2008; Yanniotis et al., 2007) introduction of fiber of different origin to expanded snacks resulted in diminished expansion, the more decreased the higher amount of additive was applied. A necessary condition to achieve appropriate snacks expansion is the presence of suitable amount (about 52-65 %) of gelatinized starch in a by-product (Case et al., 1992; Lee et al., 2000; Lusas & Rooney, 2001). Low degree of starch gelatinization in pellets is connected with their low viscoelasticity and makes it difficult to form permanent, featuring proper roughness, structure of ready product. Such additives like fiber and protein, which make difficult the process of starch gelatinization, determine all properties of snacks, to a degree depending on the amount, origin and composition of these additives (Hsieh et al., 1989; Lue et al., 1991; Lusas & Rooney, 2001; Yanniotis et al., 2007). To these properties belong density and texture.

Application of wheat fiber, as well as dried corn germ, especially in higher doses, caused the increase in snacks density in comparison to samples without fiber products addition, while the use of corn bran in the form of corn mix, brought about the opposite effect. The increase in density of snacks with the addition of corn germ could result from interaction between gelatinizing starch (amylose fraction) and fat present in high quantity in the preparation (Case et al., 1992; Lee et al., 2000; Lusas & Rooney, 2001).

The most considerable differences in fried snacks texture were determined between samples fortified with wheat bran and corn germ. Products characterizing the lowest hardness were obtained using wheat bran as an addition, both with and without PPC. Increased dose of fiber products under examination did not effect on snacks texture in a strictly determined way. According to different authors, the increase in fiber (Hsieh et al., 1989; Kita et al., 2002; Peřksa et al., 2004) and protein content in expanded products (Goel et al., 1999; Lue et al., 1991; Peřksa et al., 2007) leads to the increase in their hardness. In manufacturing snacks originating from extruded by-products, i.e. pellets, an important role in texture forming is played by treatments performed before and after thermal processing (frying, baking, microwaves) causing snacks expansion, which also involves drying and conditioning. Therefore, it has not been satisfactory explained which factor influences fried snacks texture and other physical properties (Jonnalagadda et al., 2001; Lusas & Rooney, 2001; Singh et al., 1994).

The color (L value) of snacks obtained depended both on the kind of fiber used and its dose. PPC addition was insignificant regarding snacks lightness. Application of wheat bran in increasing doses brought about gradual darkening of fried products (lower L values). Snacks with corn bran were lighter than those with wheat bran, yet darker from the sample without fiber products added. Corn germ, regardless the amount of additive, provided lighter color of snacks. In examination by Senthil et al., (2002) fried wheat snacks fortified with various quantities of soy (from 20 to 40 %) showed slight diversity in snacks

lightness (L values from 61.75 to 62.34). The addition of brewer's spent grain (BSG) in the amount of 10-30 % resulted in significant decrease in snacks lightness (Stojceska et al., 2008), while higher quantity of corn bran additive, up to 50 % in the composition of extruded snacks made of oats flour resulted in darkening of ready products (Holguin-Acuna et al., 2008). Apart from the conditions of extrusion, drying and frying, the color of snacks, originating from pellets frying, is also affected by the kind of raw materials used. The latter ones, when intensively stained, can lead to darker shade of ready products (Holguin-Acuña et al., 2008; Senthil et al., 2002).

CONCLUSION

On the basis of the results it can be concluded that introduction of wheat bran and corn germ into pellets recipe, especially in a higher dose, provided for significant increase in fat content, as well as snacks' density, in comparison to the samples without any additives or to snacks obtained with corn bran. Snacks fortified with wheat bran, both with PPC and without it, characterized darker color, yet crispy and delicate texture-the most desirable one out of the samples subjected to examination. Corn germ applied in the production of fried potato snacks, regardless PPC addition, resulted in light color and crispy ready products, although they were harder than the samples with other supplements. The use of corn bran allowed to obtain products featuring the lowest density out of the examined samples and lower fat content than in snacks manufactured with the use of the remaining two fiber products, regardless the presence of PPC. Each of additives used in the experiment caused the decrease in expansion degree of obtained snacks. However, there was not recorded any significant diversity in snacks' expansion in relation to the amount or kind of added fiber product.

Examination results point to the fact that introduction of by-products of milling industry, as well as PPC to the recipe of deep fat-fried snacks did positively affect majority of snacks properties. Making use of products so far being only fodder additives in food production can become an advantageous alternative for their range of application.

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