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PRODUCTS EXTRUDED FROM BUCKWHEAT FLOUR AND ITS MIXTURES WITH MILK PROTEINS. I. TECHNOLOGICAL ASPECTS OF EXTRUSIONS AND THEIR RELATIONSHIP WITH THE EXPANSION AND POROSITY OF STRUCTURE

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Key words: buckwheat flour, milk proteins, extrusion, physico-chemical properties of protein.

The technological parameters of obtaining product extruded from buckwheat flour and its mixtures with milk proteins, characterized by a high coefficient of expansion and different degrees of the structure's porosity, were determined.

INTRODUCTION

Extrusion is one of the engineering variants of hydrothermal treatment, affecting changes in the physico-chemical properties of proteins and starches and having the greatest meaning in the modification of their structure [6, 18]. As a result of these changes, the quality of the final products is improved [1, 2, 5, 9], the utilization of raw material in traditional technologies is increased and the possibility of utilizing raw materials of inferior quality arises [2]. There are numerous published results of research studies concerning the application of extrusion in creating the structure of protein concentrates or isolates from oil or pulse crop seeds [22]. Equally well known are the physico-chemical properties of these texturates and the possibilities of their utilization in the food industry [15].

In recent years, the extrusion methods, apart from the use of homogenous raw substances, apply mixtures of several properly selected raw materials which makes it possible to obtain so-called "co-extrudates", products characterized by better functional properties and a higher nutritive value [25]. In order to improve the structure of products, it is suggested to combine several types of proteins, adding, among other things, gluten of wheat or hen egg albumins to the raw material [22].

Extrusion of preparations obtained from plant proteins in combination with properly prepared milk proteins is mainly an object of home studies [20, 26, 27].

The majority of studies concerning application of extrusion in obtaining cereal extruded products deal with the utilization of corn grain or its products [23, 24]. Among cereals producted in Poland, buckwheat grain is utilized only in the groats manufacturing industry. The chemical composition of this grain as well as the unique properties of starch are a basis for studies on its application in obtaining other products [8]. For this reason, the aim of the present studies was to show the possibilities of using buckwheat grain and its mixtures with milk proteins to obtain extruded products. These products, due to the quality of buckwheat proteins may be classified as gluten free products, having a specific application in diet.

EXPERIMENTAL

The raw material used in the studies was buckwheat flour and a preparation of milk proteins.

PREPARATION OF BUCKWHEAT FLOUR

Dry buckwheat grain, after separation of contaminations freely bound with grain, was dehulled in a laboratory huller. The hulls were separated from endosperm particles with the use of screens and air stream. The isolated endosperm was disintegrated and the obtained flour had a granulation of 480 um. The content of ash in flour was 0.55% DM.

OBTAINING THE PREPARATION FROM ALL AMILK PROTEINS

The preparation of milk proteins was obtained from skim milk, from which calcium paracaseinate together with whey proteins were isolated by the anzymatic method (acc. to own method) [28]. After washing with water the obtained coagulate was separated in a press, disintegrated and dried to a humidity of 8-10%.

PREPARATION OF THE RAW MATERIAL FOR EXTRUSION

The process of extrusion was carried out in the technological variants: buckwheat flour and buckwheat flour with a 25% addition of milk protein preparation. On the basis of earlier experiments [25] and literature data [14, 16, 26] moisture of the raw material was established within the range of 18-30% by weight, by wetting it to the required level.

EXTRUSION

The raw material was extruded in a Wenger x-5 extruded [13] which was subjected to rotation by means of a screw of the feeding bucket, using a constant number of rotations, i.e. 7,5 rad/s. The number of rotations of the main screw was changed within the range of 20 to 60 rad/s. The inlet steam pressure was 0.35 MPa. The extrusion temperature measured by the thermo-couple placed at the outlet nozzle was 100, 110, 120 and 130°C. During the extrusion process, an outlet nozzle with diameter 4.0 mm, was used.

The process of extrusion was characterized depending on the humidity of the raw material, extrusion temperature and speed of rotations of the main screw. The coefficient of expansion was determined acc. to Cabrery [7] and a density acc. to Tarant [30]. Besides, an organoleptic assessment of the obtained extruded products was carried out.

RESULTS AND DISCUSSION

The fundamental criterion for selecting optimal conditions of extruding buckwheat flour was the value of the expansion coefficient, depending on the share of milk proteins, moisture content of raw material, temperature of expansion and speed of rotations of the main screw. The speed of rotations of the feeding screw, diameter of nozzle and steam pressure were adopted on the basis of the technical characteristics of the equipment [14] and the results of own experiments [10, 26, 29].

Within the range of moisture content of buckwheat flour, assumed in the experiment, the highest value of expansion coefficient [3, 8] was noted for product obtained from the raw material with a moisture level of 20%, the lowest one (2.5) of 18% (Fig. 1).

The product obtained from a mixture of buckwheat flour and 25% share of milk proteins revealed the highest value of the expansion coefficient (2.4) at its 30% moisture content. In case of preparations obtained from raw material with 20 and 25% moisture content the coefficient of expansion was only 1.0 (Fig. 2).

The literature of the subject brings no univocal information determining the influence of the moisture of raw material on the effect of extrusion [4, 5, 17]. On the basis of own studies, it may be believed that water content in raw material affects to a high degree the rheological properties of the extruded product. At humidity above 20%, the viscosity

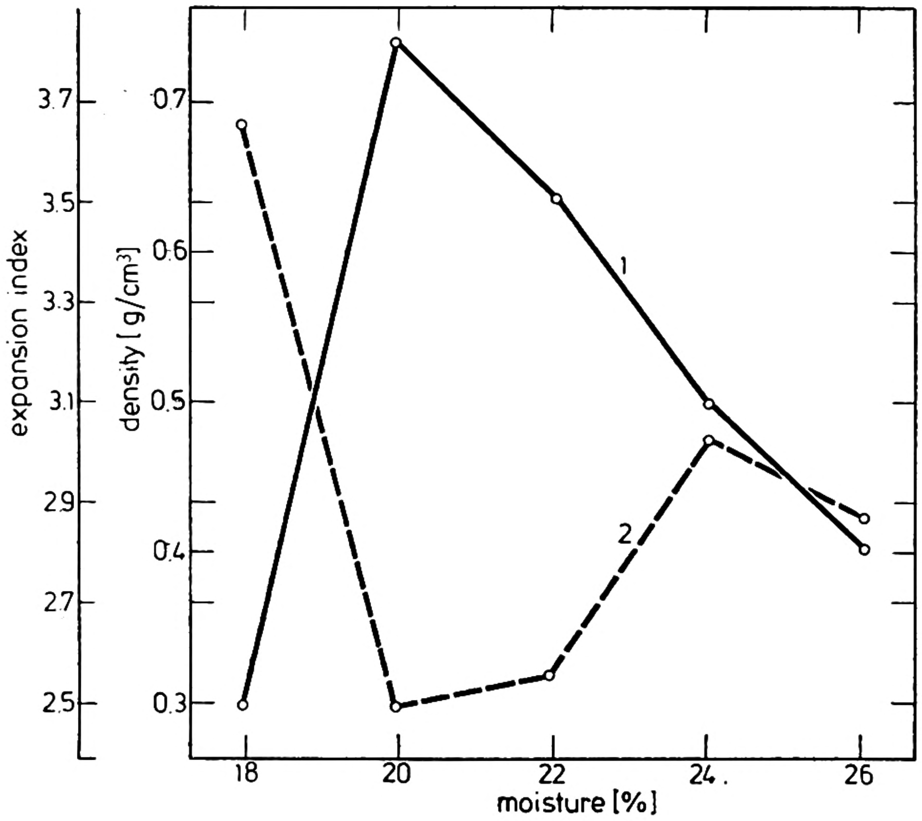

Fig. 1. Dependence of expansion coefficient and density of extruded products on the moisture content of buckwheat flour; temperature of extrusion 130°C, speed of rotations of the main screw 50 rad/s; 1 — expansion index, 2 — density

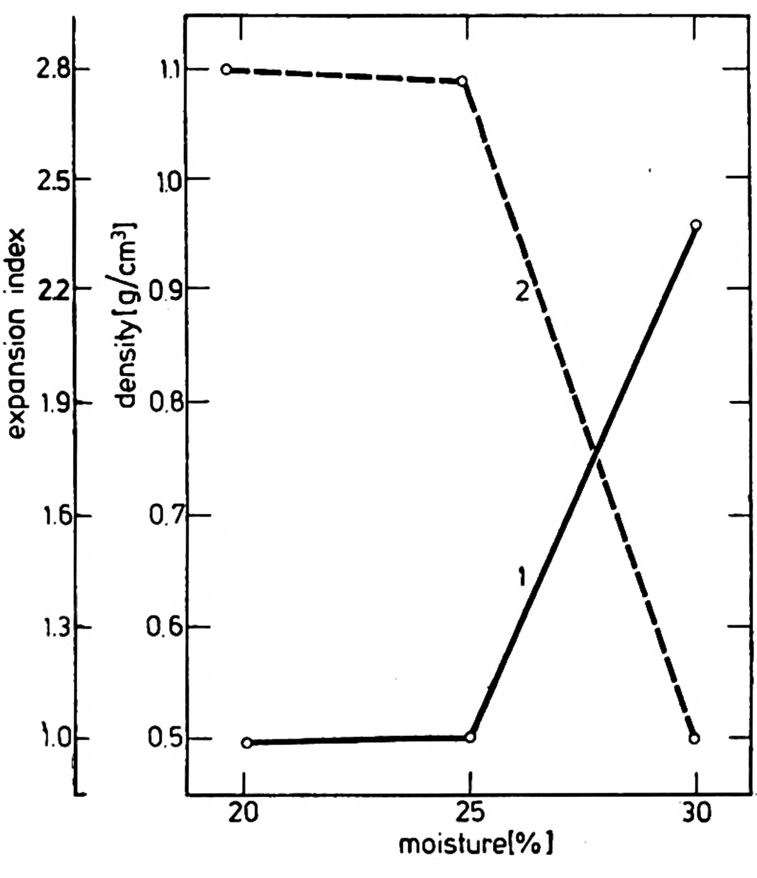

Fig. 2. Dependence of expansion coefficient and density of extruded products on the moisture content of mixture of buckwheat flour and 25% addition of milk proteins; temperature of extrusion 130°C, speed of rotation of the main screw 50 rad/s; 1 — expansion index, 2 — density

of the texturized buckwheat flour was probably too low to allow the forces of intramolecular friction to sufficiently increase the temperature of the product and to change in structure. At moisture content below 20%, the excessive forces of intramolecular friction, induced by the high viscosity of the raw material, caused a high accumulation of protein deposit "on hot" in heating heads, making diffusion of water from the product and formation of a porous structure impossible. The optimal moisture of buckwheat flour established in the present experiment is similar to that of the process of extrusion of wheat-rye grain [17]. Harper [12] and Nagucki [19] obtained good quality products extruded from a mixture of cereals with soya, with moisture 28-30%. In the case of the extrusion of plant protein preparations Aquilera and Kosikowski [3] stress the influence of the humidity of raw material on the consistency, water absorption ability and they suggest raw materials with humidity not exceeding 30%.

The conducted experiments showed that the value of expansion coefficient was dependent to a high degree on the temperature of extrusion (Fig. 3). Together with an increase of temperature a rise occured of the

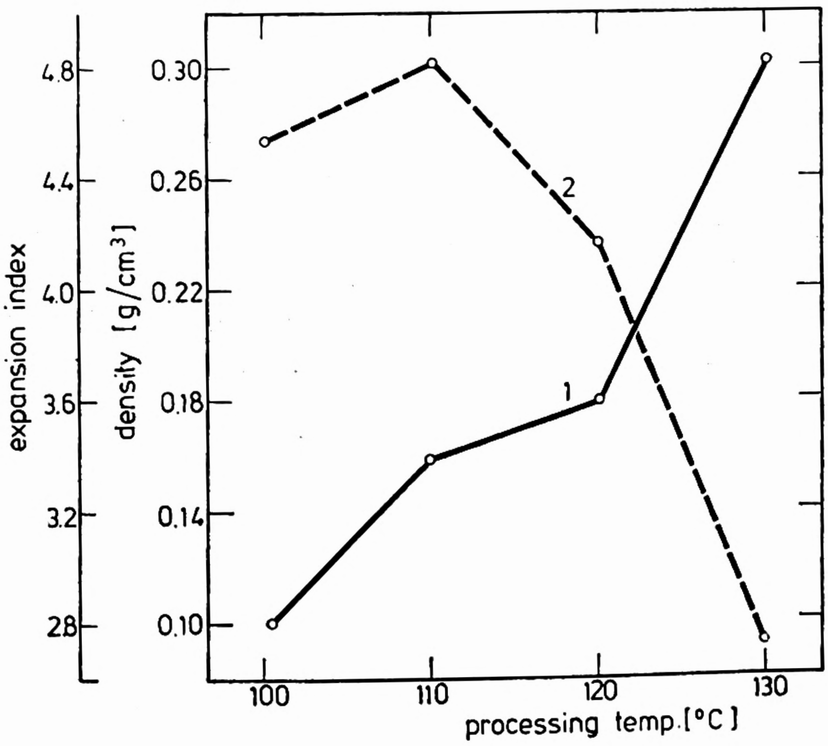

Fig. 3. Dependence of expansion coefficient and density of extruded products obtained from buckwheat flour on the temperature of extrusion; moistare content of buckwheat flour 20%, speed of rotations of the main screw 50 rad/s; 1 — expansion index, 2 — density

value of the products expansion coefficient. In case of extrusion of buckwheat flour, the highest value of expansion coefficient (4.8) was noted for products extruded at 130°C (Fig. 3). Similarly, products with a share of milk proteins were characterized by the highest value of expansion coefficient in the process of extrusion of raw material at 130°C (Fig. 4). Under these conditions, both evaporation of water and changes in proteins and starch, leading to the formation of a new structure were the most intensive. The action of the extrusion process taking place at 130°C affected the solubility of nitrogen compounds in case of extruding buckwheat flour as well as in case of mixture with milk proteins [26, 29].

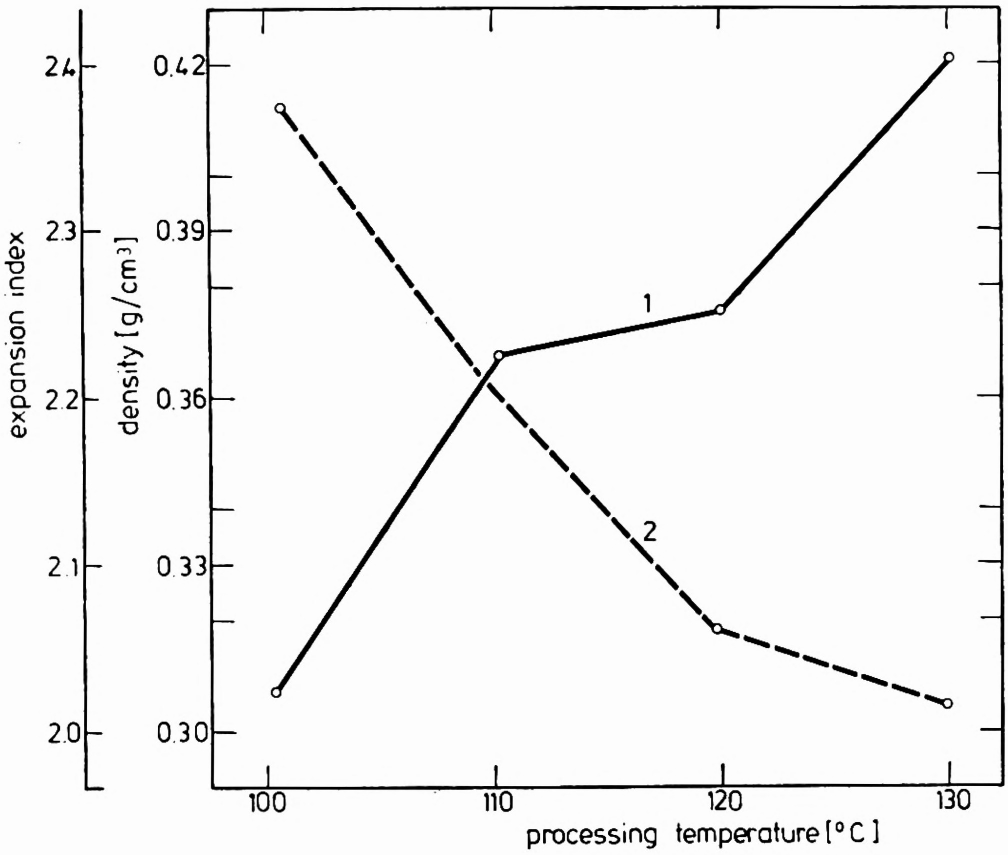

Fig. 4. Dependence of expansion coefficient and density of extruded products obtained from mixture of buckwheat flour and 25% milk proteins on the temperature of extrusion; moisture content of mixture 30%, speed of rotations of the main screw 50 rad/s; 1 — expansion index, 2 — density

The published results of the experiments concerning the extrusion of cereal raw material confirm clearly the favourable effect of heating on the quality of the final products [6, 9, 16]. It results from the studies of Taranto et al [30] that by the extrusion of skim cotton flour at 149°C a product with the lowest density (0.25 kg/dcm³) and the longest diameter (0.68 cm) was obtained. At this temperature the raw material became flexible and when leaving the nozzle of the extruder, it expanded in the highest degree, giving a product with the most favourable diameter.

Investigations of the influence of speed of main screw rotations showed that at slow rotations (20 rad/s) of the main screw, a product with expansion coefficient 0.25 was obtained whereas at a high number of rotations of the screw (60 rad/s) the product had a higher expansion coefficient (3.93) (Fig. 5). This relationship was confirmed by Aquilera and Kosikowski [3] who assumed that apart from heating and pressure mechanical forces were the most important factors forming the structure during the extrusion. Rossem and Miller [21] report that mechanical energy supplied to the screw is used for a displacement of the material along the heads of the extruder and it partially changes into heat. Harper [12] reports that about 30% energy fed to the screw may be transformed into heat what leads to an increase of the temperature of the process.

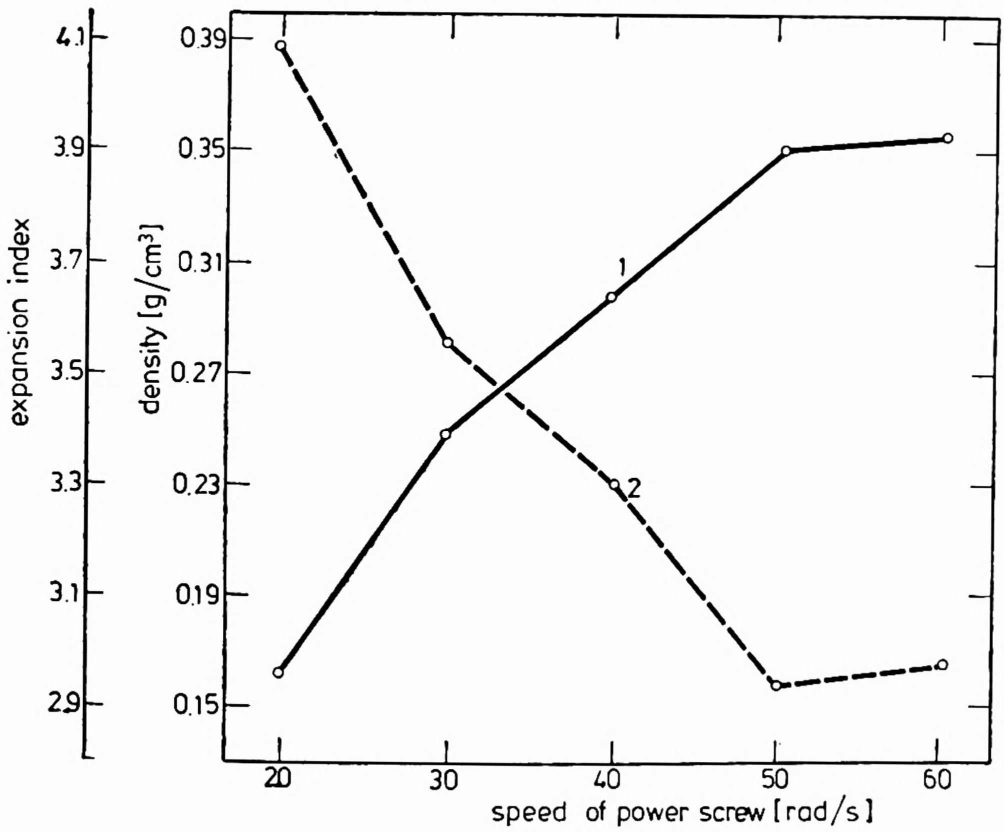

Fig. 5. Dependence of expansion coefficient and density of extruded products obtained from buckwheat flour on the speed of rotations of the main screw; moisture content of buckwheat flour 20%, temperature of extrusion 130°C; 1 — expansion index, 2 — density

The addition of a preparation from all milk proteins to buckwheat flour before the extrusion affected to a high degree its density and value of expansion coefficient (Fig. 2 and 4). Product with the addition of 25% milk proteins revealed a density higher in the average by 0.2 g/cm³ than a product without the addition of milk proteins. The expansion coefficient of product obtained from raw material without the addition of milk proteins, in case of extrusion at 130°C, was about twice higher in comparison with the expansion coefficient of the product obtained with the addition of milk proteins.

All products obtained by the extrusion method from buckwheat flour and with the addition of milk proteins were characterized by a porous structure and a fragile or slightly hard consistency (Table). Extrusion of raw materials at 100°C allowed to obtain a product with a dense structure and low porosity. Increase of temperature of the extrusion process to 130°C made it possible to obtain texturate with a high porosity and grater fragility, with numerous air bubles surrounded with thin walls, in the cross-section. Similarly, after extrusion of mixture of buckwheat flour and milk proteins, a texturate with a high degree of porosity and

Table. Organoleptic assessment of axtruded products obtained from buckwheat flour or with the share of milk proteins

Type of preparation	Temperature of extrusion °C	Organoleptic assessment of extruded products		
		colour	flavour	structure and consistency
Product from buckwheat flour	100	grey	typical of buckwheat	porous, hard
	110	grey-brown	typical of buckwheat	porous, slightly brittle (fragile)
	120	grey-brown	typical of buckwheat	porous, fragile
	130	grey-brown	typical of buckwheat	porous, fragile
Product from buckwheat flour with the addition of 25% milk proteins	100	grey-brown	without flavour, tastelles	porous, hard
	110	grey-brown	without flavour, tastelles	porous, slightly hard
	120	grey-brown	without flavour, tastelles	porous, slightly hard
	130	grey-brown	without flavour, tastelles	porous, fragile

with a mutual penetration of components of buckwheat flour and milk proteins, was obtained [27, 29]. The share of milk proteins in formation of structure seems to have an influence on the formation of protein-starch complexes or their closure in the structure of gelatinized starch. An explanation of the interrelationship of the components during extrusion are, among other things, the results of the studies on the structure of extruded products [11].

CONCLUSIONS

1. The technological parameters determined in the experiments confirm the possibility of utilizing buckwheat flour for obtaining the extruded products. The most favourable conditions of extrusion of buckwheat flour and its mixture with milk proteins are as follows: humidity 20% for buckwheat flour and 30% (for mixture with milk proteins), temperature of the process 130°C and speed of rotations of the main screw —

2. Products extruded from buckwheat flour or with the share of milk proteins were characterized by a porous structure with vissible air bubbles and capillaries of various size and shape, of a grey or grey-brown colour and taste typical of buckwheat.

3. Extrusion of buckwheat flour or its mixture with milk proteins allows to obtain products with new structural and physico-chemical properties which increases the possibility of the utilization of these raw materials in food technology.

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EKSTRUDOWANE PRODUKTY Z MĄKI GRYCZANEJ I JEJ MIESZANIN Z BIAŁKAMI MLEKA. I. TECHNOLOGICZNE ASPEKTY EKSTRUZJI I ICH ZWIĄZEK ZE STOPNIEM EKSPANSJI I POROWATOŚCI STRUKTURY

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Streszczenie

Ustalono parametry technologiczne otrzymywania produktów ekstrudowanych z mąki gryczanej i jej mieszaniny z białkami mleka. Stwierdzono, że wartość współczynnika ekspansji zwiększa się wraz ze wzrostem temperatury procesu (od 100-130°C) i szybkości obrotów śruby głównej (20-50 rad/s). Natomiast zależność wartości współczynnika ekspansji od wilgotności surowca kształtuje się inaczej dla mąki gryczanej niż jej mieszaniny z białkami mleka. Ustalono zatem, że najkorzystniejsze warunki ekstrudowania są następujące: wilgotność 20% (dla mąki gryczanej) i 30% (dla jej mieszaniny z białkami mleka), temperatura procesu 130°C, szybkość obrotów śruby głównej 50 rad/s. Dla przyjętych warunków procesu stwierdzono najwyższą wartość współczynnika ekspansji [3, 8], dla produktu otrzymanego z mąki gryczanej oraz dla produktu z dodatkiem 25% białek mleka [2, 4]. Produkty ekstrudowane charakteryzowały się porowatą strukturą z widocznymi pęcherzykami i kapilarami o różnej wielkości i kształcie. Udział białek mleka wydaje się oddziaływać na tworzenie struktury i powstawanie kompleksów białkowo-skrobiowych lub ich zamykanie w strukturze skleikowanej skrobi.