Effects of protein-in-oil emulsion on the physicochemical and sensory properties of the pâté

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Abstract. The effects of adding protein-in-oil emulsion (POE) with biotechnologically processed by-products, sunflower oil and various types of flour – oat, chickpeas and corn flour – to pâté, were investigated. Physicochemical and sensory properties in samples of pâté prepared with the addition of 30, 40 and 50% POE, were determined. Samples with 30% of protein-in-oil emulsion based on chickpea flour or 40% of protein-in-oil emulsion based on oat flour had optimal sensory properties. The protein content of the pâté samples varied from 14.6 to 16.4%, fat content – from 13.6 to 16.7%, moisture content – from 58.7 to 65.3%. The trend of a decrease in protein and moisture content and an increase in fat content with increasing the protein-in-oil emulsion in the formulation of pâté was noted. According to the results of the research, the authors recommend introducing 30% of protein-in-oil emulsion based on chickpea flour or 40% of protein-in-oil emulsion based on oat flour into pâté. The use of by-products in the form of the protein-in-oil emulsion with sunflower oil and various types of flour allows for the production of the pâtés with good consumer properties and that makes rational use of raw materials.

1. Introduction
Processed meat and meat products have high nutritional values and provide excellent eating satisfaction, and are an essential factor in modern lifestyles.

At the same time, not only does the meat have high nutritional value, but so does its by-products and the offal generated when the animal is slaughtered. However, much meat by-products are only infrequently consumed because they are costly to treat and are mainly directed towards the production of animal feeds [1, 2]. Certain meat by-products, such as liver, lung, heart, kidney and spleen, are used in a variety of food products. The disadvantage of by-products is their rigidity, their specific sensory characteristics. Therefore, such materials are of limited use in the production of meat products. Many by-products have important technological properties due to their high protein content [3]. The increase in global demand for protein has promoted the development of research into the more complete and rational use of by-products that have a high protein content.

Various chemical, physical, and enzymatic methods to improve the quality of by-products are proposed. In recent years, propionic acid bacteria and bifidobacteria have led many researchers to consider the enzymatic treatment of raw meat [4] because it has a high proteolytic activity and protective properties relative to pathogenic and opportunistic pathogenic microflora.
One of the meat products produced from offal is pâté. For example, pork liver pâté is a very popular product and is consumed worldwide. It is made of minced by-products from the meat industry (offal, liver, back fat, low-category meat) mixed with water, spices, curing salt, and other ingredients according to the particular manufacturer’s recipe [5, 6]. Pâté production technology allows for the combine and make rational use of various types of raw materials. Plant components and other food ingredients can be added to its composition in addition to raw meat materials. Often, meal, starch, carrageenan, and other ingredients are added into the mixed meat and by-products during the processing of the pâté to obtain the desired texture. Potato pulp, from the processing of potato flour, is used as a fat substitute in liver pâté [7]. Pâtés with added blanched and roasted broccoli florets have high nutritional value [8]. Pâté produced with inulin gels as fat replacers have a reduced fat content, and consequently a decreased energy value [9]. Not only can wheat flour be used as a source of vegetable protein, but so can other types of flour such as oat, maize, and chickpea flours. These flours have high nutritional and biological values.

There are good reasons to use oils in the form of protein-fat emulsions to reduce the fat content in meat products. It has been found that the stability of beef emulsion systems increased when beef fat was completely replaced by the double emulsions made from olive oil and sodium caseinate [10].

The objective of this research was to investigate the qualitative indicators pâté made with added protein-in-oil emulsion based on biotechnologically processed by-products and different types of flour.

2. Materials and Methods

2.1. Preparation of Pâté

Test samples of pâté were made by replacing the animal fat and flour in the protein-in-oil emulsion, which included sunflower oil, various types of flour (corn, oats, chickpeas) and water with added biotechnologically processed by-product.

Lung, rumen, ears, lips, liver, heart, and spleen, which were used as by-products, were obtained from five cows grown on the farm. By-products (except for the liver, heart, and spleen) were washed and ground through 5-mm meat grinder plates (Fimar 32/RS Unger, Italy). The bacterial concentrate Bifilact-Pro (An Experimental Biofactory of the Russian Agricultural Academy, Uglich, Russia) was activated in skim milk at the temperature of 38±1°C for 3 h. Prepared by-product, bacterial concentrate, and lactulose syrup (10:2:1) were mixed. The biotechnological processing was at temperature of 37±1°C for 4 h. After that, biotechnologically processed by-products was cutting 4 min until smooth.

The liver, heart, and spleen were blanched in a small amount of water for 20 min. The refined oil and various types of flour (corn, oats, chickpeas) was obtained from a local market and stored at room temperature in a dark environment.

Protein-in-oil emulsion (POE) was prepared as follows: immediately after the cutting treated by-products, added ice water, sifted flour, drinking water, and chopping for 4 minutes. The resultant mix then had filtered sunflower oil added and was chopped for 4 min. The amount of water and sunflower oil added was dependent on the type of flour used (Tab. 1).

Table 1. Formulation of POE.

| Form of POE      | Percentage of protein-in-oil emulsion components, % |
|------------------|----------------------------------------------------|
|                  | biotechnologically processed by-products | water | flour | oil  |
| with oats flour  | 40 | 20 | 20 | 20  |
| with chickpeas flour | 40 | 25 | 15 | 20  |
| with corn flour  | 40 | 15 | 25 | 20  |
Protein-in-oil emulsion was added as a component of meat pâté during the mince preparation stage in proportions of 30, 40, and 50% by weight of the raw materials. The basic formulation of the pâté and the formulation of the pâté samples are shown in Table 2.

All components used according to the formulation were mixed and homogenized until smooth in the cutter, adding broth as necessary (Robot Coupe R2, France). The resulting pâté mass was poured into metal forms and baked in an air-o-steam (Rational AQ, Germany) at a temperature of 130 ± 2°C to a temperature in the pâté of 71 ± 1°C. The pâté samples were cooled to 20–25°C for 1 h, then stored in a refrigerator at 4°C for 24 h.

Table 2. Formulation of the pâté.

| Component                             | Control sample of pâté | 30% POE | 40% POE | 50% POE |
|---------------------------------------|------------------------|---------|---------|---------|
| Blanched liver, spleen, and heart     | 74.4                   | 59.6    | 49.6    | 39.6    |
| Wheat flour                           | 7.6                    | -       | -       | -       |
| Back-fat                              | 7.6                    | -       | -       | -       |
| POE                                   | -                      | 30.0    | 40.0    | 50.0    |
| Onion                                 | 8.0                    | 8.0     | 8.0     | 8.0     |
| Ground spices                         | 0.2                    | 0.2     | 0.2     | 0.2     |
| Nitrite-curing mixture                | 2.2                    | 2.2     | 2.2     | 2.2     |
| Broth                                 | 10 L                   |         |         |         |

The following samples designations were used: S-C – control sample; S 30%POE-OF, S-40%POE-OF, S-50%POE-OF – oat flour was added to the sample in the proportions of 30, 40, and 50%, respectively; S-30%POE-CPF, S-40%POE-CPF, S-50%POE-CPF – chickpeas flour was added to the sample in the proportions 30, 40, and 50%, respectively; S-30%POE-CF, S-40%POE-CF, S-50%POE-CF – corn flour was added to the sample in the proportions of 30, 40, and 50%, respectively.

2.2. Sensory Analysis
Sensory quality was determined using quantitative descriptive analysis (ISO 13299:2003). The preparation of the samples for the sensory evaluation consisted of cutting cold pâté into slices of approximately equal size, and weight (around 10 g), and placing the slices in plastic odourless containers. Each pâté sample was evaluated three times. Water was provided to cleanse the tasters’ palates between samples. Processed samples of pâté were subjected to a sensory evaluation consisting of 16 characteristics, as carried out by 12 experienced panellists (Tab. 3).

2.3. Physicochemical Analysis
Physical-chemical analyses of the pâtés were performed 24 h after their preparation. The following physical-chemical indicators were determined: the fat content (Soxhlet method), sodium chloride content (Mohr method), total nitrogen content (Kjeldahl method), and ash and moisture content, according to the AOAC methodology (2002). The percentage of moisture was calculated by the weight loss from the pâté sample when dried in the oven (SNOL 67/350) at 105°C to a constant weight. Each analysis was carried out in triplicate.

2.4. Statistical Analysis
Calculated values are presented as the mean ± SEM. Probability values ≤ 0.05 were taken to indicate statistical significance. The data were analysed by one-way ANOVA using the free web-based software offered by Assaad et al. (2014) [11].
3. Results and Discussion
As shown by the results of the descriptive sensory analysis of the pâté (Fig. 1), the most pronounced taste and aroma of spices, as well as baked meat aroma, were characteristic of the control sample. Not typical colour for pâté with a yellow tinge was found in samples with 50% POE-CF and 50% POE-CPF, which was probably due to the high yellow flour content in these samples, namely that of corn and chickpeas.

Table 3. List of the sensory attributes used for the sensorial analysis of pâté.

| Sensory attribute       | Definition                       | Border values        |
|-------------------------|----------------------------------|----------------------|
| Odour                   |                                  |                      |
| odour of liver          | odour of liver                   | 1 – absent, 10 – very intensive |
| spicy aroma             | intensity of spices odour        | 1 – absent, 10 – very intensive |
| sour aroma              | intensity of sour odour          | 1 – absent, 10 – very intensive |
| baked meat aroma        | intensity of baked meat odour    | 1 – absent, 10 – very intensive |
| Appearance              |                                  |                      |
| uniformity              | uniformity of pate               | 1– not much, 10 – very |
| colour                  | intensity colour of the pate      | 1– non-specific, 10 – specific |
| Texture                 |                                  |                      |
| firmness                | intensity of firmness            | 1 – absent, 10 – very intensive |
| cohesiveness            | intensity of cohesiveness        | 1 – absent, 10 – very intensive |
| fattiness               | intensity of fattiness           | 1 – absent, 10 – very intensive |
| Flavor                  |                                  |                      |
| liver flavour           | intensity of liver flavour       | 1 – absent, 10 – very intensive |
| fatty flavour           | intensity of fatty flavour       | 1 – absent, 10 – very intensive |
| spicy flavour           | intensity of spiciness           | 1 – absent, 10 – very intensive |
| sour flavour            | intensity of sour flavour        | 1 – absent, 10 – very intensive |
| bitterness              | intensity of bitter flavour      | 1 – absent, 10 – very intensive |
| saltiness               | intensity of saltiness           | 1 – absent, 10 – very intensive |
| Overall quality         | total quality of pâté            | 1 – undesirable, 10 – desirable |

Jaworska et al. (2008) noted that flavour is always the most important attribute of food products, followed by texture and appearance [12]. Xiong et al. (2016) determined that with an increased proportion of sunflower oil in the production of liver pâté, hardness and cohesiveness decreased [13]. Results of this study indicated that with increasing POE content of samples with chickpea and corn flour, the colour of the pâté deteriorates. Samples S-30% POE-CPF and S-40% POE-OF had the best sensory properties.

The results of physicochemical analysis (Tab. 4) showed that the protein content in all samples with POE was higher than in the control. However, the highest protein content was observed in samples with chickpea flour – 16.4%. When analysing the moisture content results in pâté, a trend of decreasing moisture content with increasing POE content was observed. The lowest fat content was obtained in samples with 30% POE ranged from 13.6 to 14.0%. The highest protein content in samples with chickpea flour can be explained by the fact that the greatest amount of protein is contained in chickpea flour. Gorlov et al. (2016) determined a protein content in pâté with added chickpea beans ranging from 15.36 to 15.50% [14]. The trend of reducing protein content with increasing POE content was noted when adding all types of flour. At the same time, the protein content for all pâté samples...
was in the range of 14.6 to 16.4%, which was in agreement with science-based recommendations as to protein content for meat-vegetable pâtés [14]. According to their recommendations, the protein content should be 12–18 g per 100 g of product. In this study, the moisture content ranged from 58.7 to 65.3% (P < 0.05). Similar results were obtained by Tolik et al. (2015), in their study of pâté with added deboned poultry meat, the moisture content was found to be 59.1% [15]. The fat content was 22.5%, which was significantly higher than our results. This was apparently due to the initially higher fat content in the pâté recipe, the authors used 30% pork jowl.

![Figure 1. Results of the descriptive sensory analysis of the pâté with POE added: a) via oat flour, b) via chickpea flour, c) via corn flour](image)

| Samples       | Protein  | Fat        | Moisture   | Ash        | Sodium chloride |
|---------------|----------|------------|------------|------------|----------------|
| S-C           | 14.6 ± 0.155<sup>c</sup> | 16.2 ± 0.267<sup>b</sup> | 62.8 ± 0.758<sup>a</sup> | 1.82 ± 0.051<sup>d</sup> | 1.37 ± 0.029<sup>d</sup> |
| S-30%POE-OF   | 16.1 ± 0.203<sup>b</sup> | 13.6 ± 0.194<sup>c</sup> | 65.1 ± 0.521<sup>a</sup> | 1.82 ± 0.048<sup>d</sup> | 1.41 ± 0.032<sup>d</sup> |
| S-40%POE-OF   | 15.6 ± 0.194<sup>b</sup> | 14.9 ± 0.216<sup>a</sup> | 64.1 ± 0.41<sup>a</sup> | 1.91 ± 0.042<sup>c</sup> | 1.38 ± 0.029<sup>c</sup> |
| S-50%POE-OF   | 15.1 ± 0.199<sup>c</sup> | 16.1 ± 0.226<sup>b</sup> | 63.1 ± 0.292<sup>a</sup> | 1.94 ± 0.049<sup>d</sup> | 1.42 ± 0.030<sup>d</sup> |
| S-30%POE-CF   | 16.4 ± 0.192<sup>b</sup> | 14 ± 0.181<sup>c</sup> | 65.3 ± 0.428<sup>a</sup> | 1.79 ± 0.064<sup>d</sup> | 1.4 ± 0.035<sup>d</sup> |
| S-40%POE-CF   | 16.1 ± 0.182<sup>b</sup> | 15.4 ± 0.304<sup>b</sup> | 64.3 ± 0.366<sup>a</sup> | 1.81 ± 0.041<sup>c</sup> | 1.42 ± 0.032<sup>c</sup> |
| S-50%POE-CF   | 15.7 ± 0.266<sup>b</sup> | 16.7 ± 0.31<sup>b</sup> | 63.4 ± 0.428<sup>a</sup> | 1.92 ± 0.049<sup>c</sup> | 1.42 ± 0.032<sup>c</sup> |
| S-30%POE-CF   | 15.8 ± 0.177<sup>b</sup> | 13.9 ± 0.27<sup>c</sup> | 62.5 ± 0.353<sup>a</sup> | 1.8 ± 0.048<sup>d</sup> | 1.38 ± 0.031<sup>d</sup> |

Table 4. Physical-chemical indicators of pâté.
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