EXISTENTIAL BIOLOGICALLY ACTIVE SUBSTANCES IN HYDROTHERMAL AND MASS-SELECTIVE PROCESSING OF SECONDARY ANIMAL RAW MATERIAL

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Abstract – The process of the main nutrient extraction upon aqueous-thermal treatment of animal secondary raw material was studied. The regularities in the formation of component composition (proteins, fats, carbohydrates), which influence the aromatic properties of the obtained broths, were established.

Key Words – broth, meat-and-bone raw material.

I. INTRODUCTION

During animal raw material processing, the secondary products, which are rich in proteins, fats, mineral salts, vitamins, carbohydrates and other wholesome substances, play a significant role [1]. As a result of cattle processing, meat mass and meat-and-bone residue (MBR), which is used for dry feed production, are obtained. When processing, the protein collagen part of MBR practically is not used for food purposes [2, 3]. At the same time, the MBR remained after the mechanical boning contains high amount of wholesome substances and can serve as a potential raw material for food product production [4].

Significant quantity of MBR manufactured in Russian meat processing enterprises every year in the quantity of more than 400 thousand tones can be processed into food broths with high biological value. Broths are an additional source of readily available animal proteins, lipids, carbohydrates, and can be intended for the elimination of their deficiency and improvement of metabolism in a human body. Broths alleviate the course of cold; they facilitate reduction in blood viscosity, and thus, prevent thrombus formation [5].

An effective way of MBR processing into broths is aqueous-thermal treatment, concentration by ultrafiltration with subsequent drying of wet products. Therefore, the aim of this work was investigation of effective production of dry broths from MBR, simplification and cheapening of the processes of broth production with the simultaneous improvement in their quality and enhancement of their biological value.

II. MATERIALS AND METHODS

The experimental samples of broths were obtained by the aqueous-thermal treatment of the pork and bovine MBR. The process of the main nutrient extraction from the pork and bovine MBR was performed at a temperature of 95–98°C and a hydromodule of 1:1.5 for 4 hours. In order to increase extraction, the pork MBR was defatted beforehand by baking in a cabinet oven at a temperature of 180°C for 30 min. The rendered fat accounted for 20% of the raw material mass. During the aqueous-thermal treatment, foam and fat were repeatedly removed.

The chemical composition of the MBR and broth samples, content and composition of proteins, lipids and total carbohydrates were detected by standard methods [1]. The fraction composition of protein substances was detected by electrophoresis in 12% polyacrylamide gel. The amino acid composition was studied by the method of ion-exchange chromatography using the amino-acid analyzer LC-3000 (Eppendorf-Biotronik, Germany). Analysis of volatile components, cholesterol and aromatic hydrocarbons was performed using chromatograph 7890A with Mass Selective Detector 5975C VLMSD AgilentTechnologies (USA). Investigation of the free carbohydrate composition was carried out using BioL with the chromatographic system consisted of the gradient pump GS50, electrochemical detector ED50, eluent generator EG50 10mM NaOH and CarboPac PA20 column produced by DIONEX (Germany).

The process of broth concentration was carried out on Vivaflow 200 Polyethersulfone membranes with nominal molecular weight limit (NMWL) 5 kDa at a pressure of 2.5 atm.

III. RESULTS AND DISCUSSION

The process of component extraction upon hydrothermal treatment of an animal raw material takes place in time. Over 4 hours, the content of dry substances increased from 0.2 to 4.5%, the amount of cholesterol dropped from 0.9% to less than 0.1%, the total concentration of organic alcohols, ethers and esters, and unsaturated substances in the liquid phase reduced from 5.5 to 2.5%. With that, the dry matter content in the broth from the bovine MBR was 0.5-1% higher compared to the broth from the porcine MBR.

The chemical composition of the initial porcine and bovine MBR was characterized by the following indicators, %: protein 20.0–25,0, fat 9.8–11.0, carbohydrates 1.3 – 3.0, ash 28.0–31.0, moisture 35–39. The obtained liquid broths contained up to 4% of dry residue, 80 – 90% of which were proteins, 2.5 – 3.5% free carbohydrates, 2.5 – 3.0 ash.

The total amino acid composition (g/100 g of protein) of the porcine and bovine MBR can be presented, respectively, as: Ile 3.03 and 1.85, Leu 5.64 and 4.20, Lys 6.48 and 4.28, Met 0.43 and 0.30, Cys 0.11 and 0.11, Phe 3.20 and 2.60, Tyr 2.25 and 1.30, Thr 3.21 and 2.40, Trp 1.14 and 2.0, Val 3.84 and 3.70, Ala 6.08 and 7.90, Arg 6.61 and 6.66, Asp 7.28 and 6.52, His 3.10 and 2.57, Gli 9.47 and 15.81, Glu 13.08 and 10.44, Pro 6.28 and 9.63, Ser 3.27 and 3.21. The ratio of the nonessential amino acids (E) to the total amount of amino acids (T) contained in protein was 31.1 and 24.8. The free amino acid content in amounts of 1.1 – 1.2% of the sum of total amino acids was, respectively, (mg/100 g of raw material): Tau 14.9 and 13.5, Asp 11.2 and 10.3, Thr 14.0 and 13.7, Ser 16.5 and 16.1, Glu 2.4 and 2.2, Pro 6.9 and 6.7, Gly 12.0 and 11.0, Ala 52.1 and 53.4, Cys 2.3 and 2.4, Val 17.9 and 17.7, Met 6.3 and 6.2, Ile 13.7 and 13.3, Leu 27.9 and 26.1,Tyr 12.8 and 12.5, Phe 14.9 and 11.5, His 5.2 and 4.7, Lys 19.5 and 18.7, Arg 11.7 and 10.3. Protein amino acid composition after 4 hours of treatment differed little from initial; the content of free amino acids, which influence the taste and aromatic gamut of broth, was 1.5% of the sum of total protein amino acids.

Fatty acid composition of lipids in the pork and bovine MBR was respectively (% of total lipids): C4 : 0 0.08 and 0.06, C6 : 0 0.1 and 0.07, C8 : 0 0.2 and 0.1, C10 : 0 0.14 and 0.1, C12 : 0 0.2 and 0.9, C14 : 0 1.9 and 3.2, C15 : 0 0.06 and 0.1, C16 : 0 25.1 and 25.4, C17 : 0 0.27 and 0.5, C18: 0 13.9 and 15.3, C19 : 0 1.0 and 0.8, C20 : 0 0.3 and 0.2, C22 : 0 0.55 and 0.3, C14 : 1 0.08 and 0.3, C15 : 1 0.3 and 0.1, C16 : 1 2.44 and 2.9, C17: 1 1.2 and 1.1, C18 : 1 n9c 34.8 and 32.7, C18:1n9t 2.7 and 3.2, C20 : 1 0.7 and 0.5, C22 : 1 n9 0.8 and 0.4, C18 : 2 n6c 7.8 and 3.8, C18 : 3 n6 1.3 and 0.6, C18 : 3 n3 0.5 and 0.3, C20 : 2 0.2 and 0.1, C20 : 3 n6 0.4 and 0.2, C20 : 4 n6 1.2 and 1.6, C22:2 0.4 and 0.2, C22:6 n3 0.2 and 0.1. With that, mass fraction of free fatty acids in the lipid component of the initial raw material was at the level of 1.3 – 1.9%. In their composition, the proportion of short chain (C4–C10) fatty acids, which significantly affect the taste of an obtained product, was about 0.3 – 0.5% of the sum of fatty acids and decreased to 0.1% after 4 hours of aqueous-thermal treatment.

Proteins, fats, carbohydrates, minerals, vitamins and the products of their destruction, which are generated in the process of aqueous-thermal treatment, take part in the formation of a complex of substances that determine aroma and taste of broths. During aqueous-thermal treatment, complex mixtures of substances are formed, in which composition complex and simple aliphatic alcohols, higher fatty acid esters, carbonyl compounds, pyridines, amino acids and fatty acids are found [6,7].

Upon aqueous-thermal extraction, the most valuable substances entering the liquid phase are proteins. As a liquid broth presents a highly diluted aqueous system, we used the method of ultrafiltration on semi-permeable membranes for its concentration.

The process of ultrafiltration, which was carried out during 2 hours, allowed concentration of liquid broth volume more than fourfold.

The results of the assessment of the fractional composition of the main broth component, proteins, show that the fractions with molecular mass of >200 (5.9%), 170…200 (14.6%), 100…170 (12.4%), 40…100 (29.9%), 20…40 (27.3%), 10…20 (9.9%) go into the liquid phase. The process of concentration led to reduction in the liquid phase volume and some changes in the fraction composition of the protein in the broths.

The total amino acid composition of protein (g/100 g of protein) in the broth from the pork

MBR can be presented as: Ile 3.11, Leu 5.41, Lys 5.22, Met 0.3, Cys 0.1, Phe 3.3, Tyr 1.84, Thr 3.66, Trp 2.21, Val 3.69, Ala 8.11, Arg 6.72, Asp 7.34, His 3.14, Gli 16.12, Glu 13.22, Pro 8.24, Ser 3.37.

The total composition of the free amino acid fraction, which went into the liquid phase after 4 hours of aqueous-thermal treatment of the pork MBR, correlated with the initial composition of the free amino acids in raw material (mg/100 g of the initial meat raw material): Asp 11.6, Thr 15.02, Ser 16.75, Glu 2.51, Pro 7.34, Gly 13.4, Ala 50.6, Cys1.6, Val 17.4, Met 5.5, Ile 16.3, Leu 28.1, Tyr 14.4, Phe 15.8, His 6.7, Lys 20.5, Arg 11.1. The free amino acid fraction takes part in forming taste characteristics of a product. As a result of concentration, the main fraction composition of animal proteins was not significantly changed, while the reduction of the technical volume makes the subsequent drying more economically profitable.

The obtained broths contained a quantity of minor sugars as free carbohydrates, particularly, (mg %): arabinose (Ara) 0.12, galactose (Gal) 0.05…0.1, glucose (Glc) 14…15, xylose (Xyl) and mannose (Man) 0.5…0.76, fructose (Fru) and saccharose (Sach) 0.28, ribose (Rib) 0.2, lactose (Lac) 0.03. In the broth concentrates, the free sugar content was, respectively, (mg %): Ara 0.06...0.08, Gal 0.04…0.06, Glc 12…12.5, Xyl+Man 0.4…0.51, Fru+Sach 0.16...019, Lac 0.01.

The issues of entry of some chemical substances into a final product upon aqueous-thermal treatment of meat raw material are of a particular interest. Cholesterol and its derivatives should, above all, be assigned to these substances. In the process of treatment, the cholesterol content relative to the wholesome protein decreased by several times both for the bovine and pork raw material. Moreover, this tendency was more pronounced for the pork MBR because raw material with higher fat content had more cholesterol. Aqueous-thermal treatment of meat raw material leads to production of broths with lower content of cholesterol.

The broths from the pork and bovine MBR after aqueous-thermal treatment and concentration by ultrafiltration were dried by the freeze- drying method to the residue moisture of 4%. The drying duration was 8 hours for the concentrated products and more than 14 hours for the initial systems. As a result, the samples of dry broths were obtained, which total chemical composition was (%): moisture 3.60…3.82, protein 89.1…89.6, fat 3.4…4.5, ash 2.5….2.7.

The obtained dried products had no less than 85% of protein contained practically all essential amino acids; pH of 10% broth solution was 6.0–6.2. The dried broths have high solubility (no less than 98%), good taste and aroma and energy value of 347–352 kkal. The broths are characterized by low content of fat and higher content of protein compared, in particular, to the industrial samples of bouillon cubes presented in the market, in which the ash content can reach 60%, which potentially reduces the proportion of wholesome biologically active substances in food products based on meat raw material.

IV. CONCLUSION

Therefore, the targeted aqueous-thermal treatment of secondary animal raw material allows obtaining products with high biological value, which can be used for fast food production.

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