ABORDAGENS BIOTECNOLÓGICAS NO PROCESSAMENTO DE MATÉRIAS-PRIMAS SECUNDÁRIAS DA INDÚSTRIA DE CARNE

BIOTECHNOLOGICAL APPROACHES IN PROCESSING OF SECONDARY RAW MATERIALS OF MEAT INDUSTRY

БИОТЕХНОЛОГИЧЕСКИЕ ПОДХОДЫ ПРИ ПЕРЕРАБОТКЕ ВТОРИЧНЫХ РЕСУРСОВ МЯСНОЙ ПРОМЫШЛЕННОСТИ

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RESUMO

A mudança radical na qualidade das matérias-primas processadas, que não atendem às normas, exige a aplicação de métodos biotecnológicos para melhorar sua qualidade e obter alto valor nutricional e biológico dos produtos manufaturados em conformidade com os requisitos estabelecidos para alimentos funcionais. A utilização de culturas iniciadoras para realizar a biomodificação de subprodutos de gado torna possível fornecer a justificativa para o uso de matérias-primas secundárias de carne de baixo valor a fim de expandir a faixa de fabricação e aumentar a eficiência econômica de plantas de processamento de carne. Este artigo visa, primeiramente, revisar as abordagens para o desenvolvimento de novas formas de fontes biologicamente completas e ambientalmente seguras de matérias-primas para aumentar a eficiência econômica e reduzir os custos nas plantas de processamento de carne do complexo agroindustrial da Região Econômica Central da Terra Negra e, segundo, para fundamentar a seleção e propositadamente aplicar bifidobactérias como parte do consórcio para biotransformação de proteínas do rúmen de animais de fazenda. Como resultado da pesquisa, foi sugerida a tecnologia de modificação do rúmen visando seu uso posterior como parte de produtos cárneos, principalmente, produtos cárneos de conveniência picados. Os dados do artigo podem ser usados para desenvolver fórmulas de fabricação em fábricas de processamento de carne e também ser úteis para engenheiros de processo e cientistas que trabalham na indústria de alimentos.

Palavras-chave: *rúmen, subprodutos, biotransformação, capacidade de ligação à água*

ABSTRACT

The radical change in the quality of the processed meat raw materials, which does not meet the standards, calls for the necessity to apply biotechnology methods in order to improve the quality and obtain high nutritional and biological value of manufactured products in compliance with the requirements set for functional food. The use of starter cultures to perform biomodification of cattle by-products makes it possible to provide the rationale for the use of low-value secondary meat raw materials in order to expand the manufacturing range and increase the economic efficiency of meat-processing plants. This article aims to, first, review the approaches towards the development of new forms of biologically complete and environmentally safe sources of raw materials to increase the economic efficiency and reduce costs at meat-processing plants of the agro-industrial complex of the Central Black Earth region and, second, to substantiate the selection and purposefully apply bifidobacteria as part of the consortium for biotransformation of proteins of the rumen of farm animals. As a result of the research, the technology of rumen modification was suggested aimed at its further use as part of meat products, primarily, minced convenience meat products. The article data can be used to develop manufacturing formulas at meat-processing plants and also be useful for process engineers and scientists

working in the food industry.

Keywords: *rumen, by-products, biotransformation, water-binding capacity*

Аннотация

Радикальное изменение качества перерабатываемого мясного сырья, не отвечающего требованиям стандартов, вызывает необходимость привлечения методов биотехнологии для улучшения качества вырабатываемой продукции с высокой пищевой и биологической ценностью, отвечающей требованиям, предъявляемым к продуктам функционального питания. Использование стартовых культур для биомодификации субпродуктов крупного рогатого скота позволит обосновать целесообразность использования малоценного вторичного мясного сырья с целью расширения ассортимента выпускаемой продукции и повышения экономической эффективности мясоперерабатывающих предприятий. Цель статьи заключается в рассмотрении подходов к разработке новых форм биологически полноценных, экологически безопасных сырьевых источников для повышения экономической эффективности и снижения издержек на мясоперерабатывающих предприятиях агропромышленного комплекса ЦЧР; обоснование выбора и целенаправленного применения бифидосодержащих микроорганизмов в составе консорциума для биотрансформации белков рубца сельскохозяйственных животных. В результате исследований предложена технология модификации рубца для дальнейшего его использования в составе мясосырья, преимущественно рубленых полуфабрикатов. Представленные в статье материалы могут быть использованы для разработки производственных рецептур мясоперерабатывающих предприятий, а также полезны инженерам-технологам и научным работникам пищевой промышленности.

Ключевые слова: рубец, субпродукты, биотрансформация, влагосвязывающая способность

INTRODUCTION

The maximal and rational use of all food components of the initial agricultural raw materials is essential to the creation of the robust national food economy. Proteins hold a special place among such components as they serve major critical-to-life biological functions.

Over recent years in Russia, the trend has been towards the constant rise in the deficiency of edible protein, which is the essential nutrition component. In the estimation of specialists, current values of such deficiency amount to about 600 thousand tons and grow by 100 thousand tons each year.

The protein deficiency of food intake leads to a number of severe diseases, such as anemia, stunted growth in children, irreversible metabolic disorders, etc. Therefore, world specialists and scientists try to create meat products that combine conventional consumer properties and the possibilities to use meat alongside with other types of protein-containing raw materials of animal and plant origin.

In order to compensate for the protein deficiency, an increased focus in modern food technologies is placed on the rational use of

slaughter by-products, increased processing depth, and creation of wide range of products with high nutritional and biological value.

Taking into account the import phase-out policy, current interests of the meat industry are vested in the pilot projects on the rational use of protein-containing raw materials in order to expand the range of reasonably priced competitive meat products made from eco-friendly materials, including the products for healthy eating (Antipova and Glotova, 2006, p. 384; Kochetkova and Nesterova, 2002; Klepikov *et al.*, 2016; Titov *et al.*, 2015). Hence, the issue of the manufacturing application of slaughter by-products, such as offals, secondary products of poultry processing, etc., takes on greater and greater importance. High protein content makes these types of raw materials a valuable protein product, the potential capacity of which is not fully realized. When slaughtering and processing of farm animals, the content of these types of protein-containing by-products ranges from 9 to 21 %.

Low-value by-products are primarily used to make feedstuff. A reasonable way to combat the current deficiency in the edible protein of animal origin is to include underutilized by-

products with a high content of food fibers into the formulas of meat products. In case of farm animals, the portion of by-products equals to 10-12%. In relation to the meat weight, the yield of beef by-products totals 22%, including 3% for rumen.

The rational use of the meat industry secondary raw materials can not only significantly save material resources and develop waste-free technologies but also promote environmental enhancement.

Therefore, it is of immediate interest to create biologically complete and functional sources of raw materials for the manufacture of convenience meat products based on the integrated utilization of secondary meat raw materials biomodified by probiotic complexes and bifidobacteria. Such utilization makes it possible to control the quality and correct defects of meat raw materials in order to expand the application range and to enrich raw materials with physiologically active substances. The use of cattle by-products is promising in this regard.

As far as chemical composition and nutritional value are concerned, various by-products are far from being of equal worth (see Table 1) Cattle rumen is rich in protein substances and, therefore, the high content of collagen (45%) is of special interest for the research. Also, because of such high content, the rumen is usually used to produce gelified products.

For the rational use of protein-containing raw materials, it is currently important to study the composition and properties of the rumen and then create model systems that have distinguishing consumer characteristics by using microorganisms as the means for obtaining the probiotic complexes (Biavati *et al.*, 2000; Eun *et al.*, 2010; Khramtsov *et al.*, 2018; Zinina *et al.*, 2016).

MATERIALS AND METHODS

The targets of the study are secondary meat collagen-containing raw materials, specifically cattle rumen (2nd category by-product) per GOST 32244-2013 (ZAO UK Agropromyshlennaya gruppa BVK, Belgorod region, Gubkin, Logovaya St., 1), and commercially-available probiotic complexes based on fermented milk microorganisms, bifidobacteria and starter cultures, specifically

probiotic Narine **Lactobacillus acidophilus** n.v.Ep317/402 (OOO Ferment, Russia), **Lactobacillus plantarum** (OOO Kaprina, Russia), Bifidumbacterin (Bifidumbacterium siccum) (ZAO Partner, Russia), **Staphylococcus carnosus St 9.06** (AiBi®, GK SOUYZSNAB).

Cattle rumen was studied after preliminary preparation (washing, cleaning, and drying) with further mincing. The dry combined starter (except for *Staphylococcus carnosus* St 9.06 culture, which was inoculated directly to mince from rumen) was activated via a non-transfer method as follows: dry monocomponent lyophilized concentrate consisting of lactic acid bacteria was inoculated to skim milk sterilized at a temperature of $121 \pm 2^\circ\text{C}$ for 13 ± 2 minutes and cooled down to $37 \pm 1^\circ\text{C}$ at the rate of 0.1 unit of activity for 5 dm³ of milk. The combined starter was inoculated on the basis of 0.5–5.0% against the weight of the primary raw material. Inoculated milk was held in a thermostat at $37 \pm 1^\circ\text{C}$ until the formation of curd with the acidity degree of 60–65°T and then cooled down to 5°C . The obtained consortiums were used in further research.

Experimental studies were performed in the scientific laboratory of the Department of Technology for Storage and Processing of Agricultural Products of the Voronezh State Agrarian University. Physical and chemical methods were applied to evaluate the acidity degree, pH level, amino ammonia nitrogen, functional and technological properties of natural and biomodified rumen mince, and its chemical and amino acid composition (Antipova and Glotova, 2007). The overall chemical composition was determined by the method of single weighing of the studied sample. The method consists in the sequential determination of the content of moisture, ash, and protein in the single weighed sample of the product by using a device for fast determination of the moisture and fat content of meat products (Antipova and Glotova, 2007, p. 346).

In order to determine the complex of lactic acid bacteria that can soften coarse raw materials, i.e. mince made of cattle rumen, the below cultures available on the market and used for treatment and prevention of diseases of gastrointestinal microflora were selected:

- sample 1, includes studied compositions *Lactobacillus plantarum*, *Lactobacillus acidophilus* (Narine) at the ratio 1:1;
- sample 2, includes studied compositions *Lactobacillus plantarum*, *Lactobacillus acidophilus* (Narine), *Bifidumbacterin* at the ratio 1:1:2;

- sample 3, includes studied compositions *Lactobacillus plantarum*, *Lactobacillus acidophilus* (Narine), *bifidumbacterium siccum* (Bifidumbacterin), and *Staphylococcus carnosus* St 9.06 (GK SOYUZSNAB) at the ratio 1:1:2:1;

- sample 4, rumen mince without bacterial composition (reference sample).

Figure 1 illustrates the changes in the pH level of the medium during the cultivation of microorganisms. Table 2 provides data on the changes in the acid formation of the meat mince after 5% of biomodified cattle rumen mince is added. Figure 2 illustrates the pattern of accumulation of amino ammonia nitrogen in the mince made of fragmented rumen depending on the duration of fermentation.

The prepared cultures were inoculated to the mince in the volume of 1, 3, 5, and 10 % against the weight of raw materials and in different ratios. The mince was held at $t=(20\pm 2)$ °C for 2–12 hours.

Figure 3 illustrates the changes in the water-binding capacity of fragmented rumen before and after the modification by the selected complex of microorganisms.

Table 3 contains physical and chemical parameters that characterize the obtained protein composite based on rumen.

Table 3. Physical and chemical parameters of the protein composite based on cattle rumen

Parameter	Rumen mince before the processing by the complex of microorganisms	Rumen mince after the processing by the complex of microorganisms
Weight fraction, %		
Moisture	79.10	83.80
Fat	4.70	2.42
Protein	17.90	19.10
Ash	0.51	0.34
pH	7.10	5.10

RESULTS AND DISCUSSION

As a result of the study, it was determined that the optimal composition and ratio of microorganisms required for the biotransformation of the cattle rumen mince were observed in sample 3, namely *Lactobacillus plantarum*, *Lactobacillus acidophilus* (Narine), *Bifidumbacterium siccum* (Bifidumbacterin),

and *Staphylococcus carnosus* St 9.06 (GK SOYUZSNAB) (ratio 1:1:2:1). It was found that at this ratio the pH level of meat raw materials equals 5.2. The ability of growing microorganisms to decrease the pH level of the medium is of practical importance as it helps to lower the content of pathogenic microflora in sausage products.

The flowchart and optimal modes to obtain the protein composite from the fragmented cattle rumen were developed (see Figure 4).

It is observed that the amino nitrogen is accumulated quicker in test samples, i.e. fragmented rumen with the complex of microorganisms (modified cattle rumen), if compared with the reference sample, in which only starter *Lactobacillus plantarum*, *Lactobacillus acidophilus* (Narine) is used. This is illustrative of the intensity of raw materials hydrolysis with the selected bacterial preparations. The reduction of active acidity levels is observed in all samples. The increase of the weight fraction of starter intensifies the rate of pH reduction.

The accumulation of lactic acid is observed during the process of treatment with bacterial preparations. Up to 128.0-134.0 mg/L of acid is accumulated throughout the holding period (8-10 hours).

It is determined that the biomodification has a positive impact on the mince made of cattle rumen. The use of the selected biotechnological approaches promotes the improvement of functional and technological properties of the raw materials sources. Thus, the water-binding capacity has increased from 55.6 up to 70.8%.

The selected consortium of microorganisms to modify the rumen mince contains *Lactobacillus plantarum* and *Lactobacillus acidophilus* cultures, which fit the meat raw materials to the most extent and have high fermentation capacity. These cultures are salt-tolerant and antagonistic towards pathogenic microflora (Kidyaev 2015; Kurchaeva *et al.*, 2013; Potoroko *et al.*, 2013; Zinina and Rebezov, 2016; Zinina 2016).

CONCLUSIONS:

The conducted study confirms the positive influence of the bacterial biotransformation on the properties of the mince made of cattle rumen. In particular, it improves the functional and technological properties of related meat systems. It is expedient to apply the obtained protein

composite in order to enrich convenience meat products with protein, particularly with essential amino acids, which makes it possible to resolve the issue of multipurpose utilization of raw materials and to use them in order to create functional products.

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Figure 1. Changes in the pH level of a medium during the cultivation of microorganisms in the mince made of fragmented rumen

Figure 2. Pattern of the accumulation of amino ammonia nitrogen in the mince made of fragmented rumen depending on the duration of fermentation

Figure 3. Changes in the water-binding capacity of fragmented rumen during the fermentation with combined starter

Figure 4. Flowchart to obtain the protein composite based on cattle rumen

Table 1. Chemical composition of cattle by-products

Cattle, meat	Ratio, % of meat content			Nitrogen of incomplete proteins, % of total nitrogen	
	Protein substances	Lipids	Water	Collagen	Elastin
Head	18.1	12.5	67.8	38.3	1.3
Tail	19.6	6.5	71.2	42.2	0.7
Lips	20.8	3.3	73.7	58.0	17.0
Ears	25.2	2.3	69.8	68.0	9.2
Tongue	13.6	12.1	71.2	18.3	0.7
Heart	15.2	3.0	79.0	15.2	0.6
Rumen	14.8	4.2	80.0	45	4
Lungs	15.2	4.7	77.5	30.6	6.7
Kidneys	12.5	1.8	82.7	14.8	0.3
Udder	12.3	13.7	72.6	53	
Spleen	16.0	2.3	78.3	-	-
Brain	9.0	9.3	80.8	7.0	0.3

Reference: Kochetkova and Nesterova, 2002; Titov *et al.*, 2008

Table 2. Changes in the acid formation of meat mince when selecting the optimal ratio of cultures in a combined starter (5.0% against the weight of the mince made of cattle rumen)

Starter variant	Duration of cultivation, hours								
	0	4	8	12	16	20	24	28	32
Lactobacillus plantarum, Lactobacillus acidophilus (Narine) at the ratio 1:1	6.52	6.46	6.41	6.31	6.22	6.12	6.05	5.90	5.80
Lactobacillus plantarum, Lactobacillus acidophilus (Narine), bifidumbacterium siccum (Bifidumbacterin), and Staphylococcus carnosus St 9.06 (GK SOYUZSNAB) at the ratio 1:1:2:1;	6.52	5.82	5.21	5.10	4.67	4.42	4.10	3.90	3.70
Lactobacillus plantarum, Lactobacillus acidophilus (Narine), Bifidumbacterin at the ratio 1:1:2	6.52	6.41	5.87	5.75	5.45	5.20	4.80	4.65	4.40