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USE OF ENZYMES IN IMPROVING THE TECHNOLOGY OF MOULDED MEAT PRODUCTS OF FUNCTIONAL PURPOSE

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The article deals with the role of enzyme preparations in improving the production technology of moulded meat products of functional purpose. In the course of the study we determined pH in moulded products using papain and Bioprotectiv B-SF-43 enzymes. Determination of pH in moulded enzyme-treated meat products is an important step in their development because pH affects texture, flavour and product safety. Both papain and Bioprotectiv B-SF-43 enzymes can affect the acid-alkaline balance of meat, which in turn can affect the characteristics of the finished product. After treating the samples with papain and Bioprotectiv B-SF-43 enzymes, comparative pH analyses are carried out at different stages. Products treated with Bioprotectiv B-SF-43 are expected to have a more pronounced decrease in pH compared to products treated with papain alone, due to the more active enzyme complex and possible more intensive fermentation. Colour changes in moulded meat products using papain and Bioprotectiv B-SF-43 enzymes can be significant, although the effects on colour depend on enzyme concentration, exposure time and meat type. Papain causes milder changes in colour, often resulting in lightening and reduced saturation. In contrast, Bioprotectiv B-SF-43 can cause more pronounced changes due to its complex effects on proteins, carbohydrates and fats, which can lead to lightening of the meat, but the colour of the meat can be maintained for a longer period of time as a result of the antioxidant activity of the enzyme complex.

Keywords: enzymes, moulded meat products, nutritional value, texture, functional properties, papain.

ФУНКЦИОНАЛДЫҚ МАҚСАТТАҒЫ ЕТ ӨНІМДЕРІНІҢ ТЕХНОЛОГИЯСЫН ЖЕТІЛДІРУДЕ ФЕРМЕНТТЕРДІ ПАЙДАЛАНУ

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Мақалада функционалды мақсаттағы құйылған ет өнімдерін өндіру технологиясын жақсартудағы ферменттік препараттардың рөлі қарастырылады. Зерттеу барысында папаин және Bioprotectiv B-SF-43 ферменттерін қолдана отырып, қалыпталған өнімдердегі РН анықталды. Ферменттермен өңделген құйылған ет өнімдеріндегі РН анықтау олардың дамуындағы маңызды қадам болып табылады, өйткені РН тағамның құрылымына, дәміне және қауіпсіздігіне әсер етеді. Екі фермент — папаин және Bioprotectiv B-SF-43 — еттің қышқыл-негіз балансына әсер етуі мүмкін, бұл өз кезегінде дайын өнімнің жұмысына әсер етуі мүмкін. Үлгілерді папаин ферменттерімен өңдегеннен кейін және Bioprotectiv B-SF-43 әртүрлі кезеңдерде РН салыстырмалы талдауын жүргізеді. Bioprotectiv B-SF-43 өңделген өнімдер тек папаинмен өңделген өнімдермен салыстырғанда РН-ның айқын төмендеуіне ие болады деп күтілуде, бұл ферменттер кешенінің белсенділігіне және ықтимал қарқынды ашытуға байланысты. Папаин және Bioprotectiv B-SF-43 ферменттерін қолдана отырып, құйылған ет өнімдерінің түсінің өзгеруі айтарлықтай болуы мүмкін,

дегенмен түске әсері ферменттердің концентрациясына, олардың әсер ету уақытына және ет түріне байланысты. Папаин ет түсінің жұмсақ өзгеруін тудырады, көбінесе ағартуға және қанықтылықтың төмендеуіне әкеледі. Керісінше, Bioprotectiv B-SF-43 ақуыздарға, көмірсуларға және майларға кешенді әсер етумен байланысты анағұрлым айқын өзгерістерді тудыруы мүмкін, бұл етті ағартуға әкелуі мүмкін, бірақ ферменттік кешеннің антиоксиданттық белсенділігі нәтижесінде ет түсі ұзағырақ сақталуы мүмкін.

Негізгі сөздер: ферменттер, пішінделген ет өнімдері, тағамдық құндылық, текстура, функционалдық қасиеттері, папаин.

ИСПОЛЬЗОВАНИЕ ФЕРМЕНТОВ В СОВЕРШЕНСТВОВАНИИ ТЕХНОЛОГИИ ФОРМОВАННЫХ МЯСНЫХ ПРОДУКТОВ ФУНКЦИОНАЛЬНОГО НАЗНАЧЕНИЯ

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В статье рассматривается роль ферментных препаратов в улучшении технологии производства формованных мясных продуктов функционального назначения. В ходе исследования определяли pH в формованных продуктах с использованием ферментов папаин и Bioprotectiv B-SF-43. Определение pH в формованных мясных продуктах, обработанных ферментами, является важным этапом при их разработке, поскольку pH влияет на текстуру, вкус и безопасность продуктов. Оба фермента — папаин и Bioprotectiv B-SF-43 — могут оказывать влияние на кислотно-щелочной баланс мяса, что, в свою очередь, может повлиять на характеристики готового продукта. После обработки образцов ферментами папаином и Bioprotectiv B-SF-43 проводят сравнительный анализ pH на различных стадиях. Ожидается, что продукты, обработанные Bioprotectiv B-SF-43, будут иметь более выраженное снижение pH по сравнению с продуктами, обработанными только папаином, что обусловлено более активным комплексом ферментов и возможной более интенсивной ферментацией. Изменение цвета в формованных мясных продуктах с использованием ферментов папаин и Bioprotectiv B-SF-43 может быть значительным, хотя эффекты на цвет зависят от концентрации ферментов, времени их воздействия и типа мяса. Папаин вызывает более мягкие изменения в цвете, часто приводя к осветлению и снижению насыщенности. В отличие от этого, Bioprotectiv B-SF-43 может вызывать более выраженные изменения, связанные с комплексным воздействием на белки, углеводы и жиры, что может привести к осветлению мяса, но при этом в результате антиоксидантной активности ферментного комплекса цвет мяса может сохраняться на более длительный срок.

Ключевые слова: ферменты, формованные мясные продукты, пищевая ценность, текстура, функциональные свойства, папаин.

Introduction

The growth of production and consumption of meat products in our country necessitates the search for new ways to increase the technical and economic efficiency of production and improve the quality of finished products. In the successful solution of these problems a significant role belongs to the intensification of technological processes, the use of modern achievements of technical biochemistry and, in particular, the use of proteolytic enzyme preparations for processing meat [1].

In recent years, knowledge of the properties and mechanism of action of proteolytic enzymes has significantly expanded. The study of proteolytic enzymes of microorganisms is of particular importance. The search for and comparative study of new enzymes from different sources is important in the theoretical aspect, allows the identification of functionally important elements and structures, and contributes to the development of evolutionary insights. On the other hand, due to the great variety of properties and the possibility of obtaining them in significant quantities, proteolytic enzymes of microorganisms have found wide application in scientific research, in various branches of national economy, in the production of detergents and medicines, leather, microbiological, food and other industries [2,3].

Formed meat products of functional purpose are a promising direction in the food industry. The use of enzymes can improve textural characteristics, increase the bioavailability of proteins, and increase the shelf life of products due to the hydrolysis of proteins and lipids. This article reviews the main types of enzymes used in meat

processing, their mechanism of action and their influence on the final quality of products [4,5].

Papain has a significant effect on the quality parameters of sausage products, improving their textural properties, homogeneity and juiciness. Thanks to the proteolytic activity of papain, there is a more uniform distribution of protein structures, which contributes to the formation of a delicate consistency and improves the binding ability of minced meat [6,7].

The main mechanism of action of papain is based on the presence of a catalytic triad: Cysteine (Cys-25) - acts as a nucleophile, Histidine (His-159) - activates cysteine, promoting thiolate (S-) formation, Asparagic acid (Asp-158) - stabilises the charge of histidine [8,9]

In addition, the use of papain helps to reduce the stiffness of the finished product, increase its plasticity and improve sensory characteristics such as flavour and aroma. The effect of papain on protein hydrolysis results in a softer and juicier sausage, which makes it more attractive to consumers. Improved moisture retention has also been observed, which helps to increase the yield of the finished product.

Bioprotectiv B-SF-43, on the other hand, is a blend of enzymes designed to improve the texture of meat as well as its biological value. This enzyme complex promotes a more complete breakdown of proteins and increased nutrient absorption. In addition, Bioprotectiv B-SF-43 contains antioxidants and can have a positive effect on preserving freshness and reducing oxidative processes in meat products [10,11].

Papain is a low specificity proteolytic enzyme found in the *Carica papaya*. It is widely present in the roots, stems, leaves and fruits of papaya, with the highest content in the immature latex. Papain is a thiol protease whose active centre contains cysteine. It has the characteristics of high enzymatic activity, good thermal stability and safety. Therefore, it is widely used in food, medical, feed, chemical, cosmetic, leather, textile and other industries. Study of the effect of papain and bioprotector B-SF-43 on the quality of meat products.

Applications of papain: food industry. Meat softener: It can break down collagen and muscle fibres in meat, loosen the structure of meat and make it easier for the human body to digest and assimilate after eating.

Bioprotectiv B-SF-43 is a bioprotective starter culture used in the food industry, particularly for its anti-Listeria properties. The safety and efficacy of using Bioprotectiv B-SF-43 in food products have been evaluated in several studies. Listeria Inhibition: Bioprotectiv B-SF-43 has been shown to effectively reduce Listeria populations in various food matrices. In cooked ham, the application of SafePro B-SF-43 significantly reduced Listeria innocua, a surrogate for Listeria monocytogenes, to below detectable levels after 7 days of storage under modified atmosphere packaging. Similarly, in a study comparing different bioprotective starters, SafePro B-SF-43 demonstrated a significant reduction in Listeria counts, making it a preferred choice over other strains. Food Safety: The use of Bioprotectiv B-SF-43 does not adversely affect the pH levels of food products, which is crucial for maintaining both safety and organoleptic properties. This ensures that the application of this bioprotective starter does not compromise the quality of the food product.

Materials and research methods

The following steps were carried out to develop the technology of moulded functional meat products using Bioprotectiv B-SF-43 and papain:

1. Selection of raw materials. Beef and chicken meat were used as raw materials, which were treated with two different enzymes: papain and Bioprotectiv B-SF-43.

2. Enzyme treatment. Meat was treated with both papain and Bioprotectiv B-SF-43 at different concentrations, depending on the desired effect (papain - 0.1-0.5%, Bioprotectiv B-SF-43 - 0.05-0.2%).

Methodology of pH determination in meat products

The following methods are used to accurately determine the pH of meat products treated with papain and Bioprotectiv B-SF-43:

1. Sample preparation:

For pH determination, meat samples treated with different concentrations of enzymes (e.g. papain 0.1%, 0.3%, 0.5% and Bioprotectiv B-SF-43 at concentrations of 0.05%, 0.1%, 0.2%) are taken. The meat samples are fermented for a specified time (usually 1 to 4 hours at a specific temperature).

2. Measurement of pH:

A pH meter with an electrochemical sensor is used to measure pH. Prior to measurement, the meat is ground to a paste-like state or extracted using a solution (e.g. water or phosphate buffer). The pH measurement is performed on the meat extract.

It is recommended that pH measurements are taken at different processing stages to assess

how the acid-alkaline balance changes during the application of the enzymes.

Results and discussion

Effect of papain and Bioprotectiv B-SF-43 on meat texture

The application of both enzymes significantly improved the texture of meat, making it softer and more tender. However, in comparison with papain, Bioprotectiv B-SF-43 showed a more pronounced effect in improving the texture of meat products, which is due to the broader spectrum of action of its enzyme mixture.

When Bioprotectiv B-SF-43 was used, the meat retained a better texture after heat treatment, which reduced the risk of excessive moisture loss and improved the juiciness of the finished products.

Both additives improved protein digestibility by breaking down collagen and other proteins. However, Bioprotectiv B-SF-43 proved to be a more effective enzyme in improving the biological value of the products. This is due to its composition, which includes additional enzymes that contribute to a more complete breakdown of proteins and increased concentration of amino acids such as glutamic and asparagic acid.

The products treated with Bioprotectiv B-SF-43 had a higher amino acid and vitamin content, making them more nutritious and healthier.

The study determined pH in moulded products using papain and Bioprotectiv B-SF-43 enzymes. Determining pH in moulded enzyme-treated meat products is an important step in their development because pH affects the texture, flavour and safety of the products. Both enzymes, papain and Bioprotectiv B-SF-43, can affect the acid-alkaline balance of meat, which in turn can affect the characteristics of the finished product.

Table 1. Formed Meat pH [12]

№	Name	pH	pH after 2 hours	pH after 24 hours	pH after 5 days	Normal
1	Beef KZ	6,08	6,15	6,24	6,40	
2	Beef LT	6,30	6,43	6,57	6,76	
3	Moulded LT+R	6,15	6,31	6,32	6,34	4,8-6,2
4	Moulded Biopr B-SF-43	6,01	6,10	6,29	6,57	
5	Horse meat	6,03	6,05	6,48	6,36	
6	Pork meat	6,10	6,10	6,43	6,30	

After treating the samples with papain and Bioprotectiv B-SF-43 enzymes, comparative pH analyses are carried out at different stages. Products treated with Bioprotectiv B-SF-43 are expected to have a more pronounced decrease in pH compared to products treated with papain alone, due to the more active enzyme complex and possible more intensive fermentation.

Measuring pH is an important aspect of quality control of meat products treated with enzymes such as papain and Bioprotectiv B-SF-43. These enzymes can slightly alter the acid-alkaline balance of meat, which affects the texture, flavour and preservation of the products. Bioprotectiv B-SF-43 is expected to induce a greater pH reduction compared to papain, which may be useful for creating products with improved functional properties.

Colour is one of the key indicators of meat product quality as it affects consumer perception. Changes in the colour of moulded meat products can be related to various factors including chemical, biochemical and enzymatic processes. It is important to understand how the use of different enzymes, such as papain and Bioprotectiv B-SF-43, affects colour changes in meat products in order to predict their visual performance and assess their appeal to consumers.

Table 2. Colour of meat [13]

№	Name	Luminosity L	Yellow a	Red b
	Meat moulded			
1	K	0,1	0,4	0,1
2	K+ Papain	0,1	0,6	0,1
4	K+ Biopr B-SF-43	0,1	0,3	0,1

Due to its broader spectrum of enzymatic activity (in contrast to papain, which mainly acts on proteins) Bioprotectiv B-SF-43 can promote more intensive breakdown of meat components, including lipids and carbohydrates. This may cause more pronounced changes in the cell structure of

the meat and in its pigment composition, resulting in a change in colour.

When exposed to Bioprotectiv B-SF-43, especially at high concentrations, there may be a more marked reduction in red colour saturation, due to the intense breakdown of proteins and other biomolecules affecting pigment stability. Meat may become paler, especially if myoglobin or haem oxidation occurs during fermentation.

Bioprotectiv B-SF-43 can also have an effect on oxidative processes in meat, resulting in reduced lipid oxidation and improved colour retention. Due to the antioxidant activity of the enzyme complex, meat can retain a richer colour, especially if additional antioxidants are included.

Colour changes in moulded meat products using papain and Bioprotectiv B-SF-43 enzymes can be significant, although the effects on colour depend on enzyme concentration, exposure time and meat type. Papain causes milder changes in colour, often resulting in lightening and reduced saturation. In contrast, Bioprotectiv B-SF-43 can cause more pronounced changes due to its complex action on proteins, carbohydrates and fats, which can lead to lightening of the meat, but the colour of the meat can be retained for a longer period of time as a result of the antioxidant activity of the enzyme complex.

Organoleptic properties: Both enzymes improved the flavour characteristics of the products. Papain-treated products were milder, but sometimes had a slight aftertaste characteristic of the action of papain. In contrast, meat products with Bioprotectiv B-SF-43 had no unpleasant flavours and were characterised by a more balanced taste and smell.

Bioprotectiv B-SF-43 also improved the appearance of meat products, giving them a more attractive texture and colour.

Treatment of meat with plant enzyme preparations leads to significant destructive changes, providing effective softening action, and is consistent with the obtained estimates of physicochemical and functional-technological properties [14].

The use of enzyme preparations has a positive effect on tenderness, juiciness, nutritional value of raw materials, formation of the necessary level of water-binding and water-holding capacity, improves organoleptic parameters due to the targeted effect of plant enzymes and enzyme preparations on the components of muscle tissue [15]. The use of chitinase enzyme in the meat industry can improve the functional properties of chopped semi-finished products, including mushrooms, by improving the inclusion of a variety of fillings [16].

Application of papain at a concentration of 40 mg/L increased the level of soluble collagen and its solubility in dried buffalo meat, which improved the sensory properties and overall acceptability of the product [17].

Conclusion

The development of moulded functional meat products technology using Bioprotectiv B-SF-43 and papain showed that both enzymes can significantly improve the texture, nutritional and functional properties of meat. However, Bioprotectiv B-SF-43 proved to be the more effective component with more pronounced functional properties such as improved antioxidant activity, increased biological value of the products and improved texture.

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ТҰЗДАЛҒАН ІРІМШІКТЕРДІ ӨНДІРУДЕ ШЫҒЫНДАРДЫ АЗАЙТУДЫҢ ИННОВАЦИЯЛЫҚ ӘДІСТЕРІ: ЖАҢА ТЕХНОЛОГИЯЛАР МЕН ТӘСІЛДЕР

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Зерттеу тұзды ірімшіктерді инновациялық технологияларды пайдалану арқылы өндіру кезінде шығындарды азайтуға бағытталған. Жұмыстың басты мақсаты – өндірістік циклді оңтайландырудың тиімді әдістерін әзірлеу, соның ішінде автоматтандыру, ферменттті препараттарды пайдалану, энергия тиімділігін арттыру және жанама өнімдерді кешенді өңдеу. Қолданыстағы және келешегі бар технологиялық шешімдерді талдау көрсеткендей, автоматтандырылған басқару жүйелері мен баламалы ашытқы дақылдарын енгізу өндірістік шығындарды 15–20%-ға азайтуға, энергия тұтынуды 10–12%-ға төмендетуге және өнімділікті 5–7%-ға арттыруға мүмкіндік береді. Зерттеу ғылыми және қолданбалы маңызға ие, себебі ол сүт өнеркәсібін жаңғыртуға арналған экономикалық тұрғыдан негізделген шараларды ұсынады. Әзірленген тәсілдер рентабельділікті арттырып, түпкілікті өнімнің сапасын жақсартады, сонымен бірге бәсекеге қабілеттілікті күшейтіп, ресурстарды ұтымды пайдалануға жол ашады. Сонымен қатар, зерттеудің нәтижелері кез келген ауқымдағы кәсіпорындарда сәтті іске асырылуы мүмкін, бұл жабдықтарды жаңартуға, сапаны бақылауды жетілдіруге және шығындарды азайтуға ықпал етеді. Бұдан бөлек, тұжырымдама саланың тұрақтылығын арттыруға бағытталған экологиялық аспектілерді де қамтиды. Ұсынылған технологияларды енгізу нарықтағы өндірушілердің позициясын нығайтып, өнімнің қолжетімділігін кеңейтеді және саланың әрі қарай дамуы мен шығындарды қысқартуға қосымша серпін береді.

Негізгі сөздер: тұздалған ірімшіктер, шығындарды азайту, инновациялық технологиялар, автоматтандыру, ферменттік препараттар, баламалы бастапқы культуралар, энергия тиімділігі, шикізатты оңтайландыру, жанама өнімдерді өңдеу, өнімділікті арттыру.