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DEVELOPMENT OF BIOPOLYMER BASED COLORIMETRIC INDICATOR FOR MONITORING OF MEAT AND FISH FRESHNESS

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The need to extend food products' shelf lives is growing as a result of efforts to cut expenses and minimize food waste. The food industry is interested in solutions that would make it easy to keep food fresh and safe for as long as the product is on sale. The purpose of the study is to develop a biopolymer-based colorimetric indicator for monitoring of meat and fish freshness. The significance of the research is to provide food safety via control of the freshness

using green and cheap methods. The objects of the study are natural and artificial indicators. The paper presents natural indicators such as curcumin, pomegranate, beetroots, and carrot juice which were incorporated into the compositions of food freshness indicators. The obtained indicators were compared with an artificial indicator, bromothymol blue, and phenol red, concerning their volatile amine monitoring. Additionally, a model of volatile amine release based on the different ammonia solutions was applied in the research. The response of freshness indicators was estimated by the observation of color changes. Compared to the artificial indicators, the curcumin and pomegranate juices gave a similar response. Beetroot and carrot juices did not provide a desirable color change. Further research was made on the development of biopolymer containing freshness indicators based on bromothymol blue and phenol red. The indicators were evaluated for their response to the spoilage of fish and meat samples in the test tubes and in food packaging. Thus, two artificial indicators could be incorporated into effective food freshness indicators for smart packaging.

Keywords: meat, fish, food spoilage, indicator, biopolymer.

ЕТТІҢ ЖӘНЕ БАЛЫҚТЫҢ БАЛҒЫНДЫҒЫН БАҚЫЛАУҒА АРНАЛҒАН БИОПОЛИМЕР НЕГІЗІНДЕ КОЛОРИМЕТРЛІК ИНДИКАТОРДЫ ӘЗІРЛЕУ

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Шығындарды қысқарту және азық-түлік қалдықтарын барынша азайту әрекеттерінің нәтижесінде азық-түлікті сақтау мерзімін ұзарту қажеттілігі артып келеді. Тамақ өнеркәсібі өнімдерді тарату кезінде жаңа және қауіпсіз сақтауды жеңілдететін шешімдерге қызығушылық танытады. Зерттеудің мақсаты – ет пен балықтың балғындығын бақылау үшін биополимерлер негізінде колориметриялық индикатор жасау. Зерттеудің өзектілігі жасыл және арзан әдістерді пайдаланып балғындықты бақылау арқылы азық-түлік қауіпсіздігін қамтамасыз ету болып табылады. Мақалада тағамдық балғындық көрсеткіштерінің құрамына кіретін куркумин, анар, қызылша, сәбіз шырындарының табиғи индикаторлары берілген. Алынған табиғи индикаторлар ұшқыш амин мониторингі үшін жасанды индикаторлар бромтимол көк және фенол қызылымен салыстырылды. Сонымен қатар, зерттеуде әртүрлі аммиак ерітінділері негізінде ұшпа аминдерді шығару моделі қолданылды. Балғындық көрсеткіштерінің реакциясы түс өзгерістерін байқау арқылы бағаланды. Жасанды көрсеткіштермен салыстырғанда, куркумин мен анар шырыны ұқсас нәтиже берді. Қызылша мен сәбіз шырындары қажетті түсті өзгертуді қамтамасыз етпеді. Бромтимол көк және фенол қызыл негізіндегі балғындық көрсеткіштері бар биополимерді жасау үшін одан әрі зерттеулер жүргізілді. Көрсеткіштер сынауықтардағы және тағамдық қаптамалардағы балық пен ет үлгілерінің бұзылуына реакциясымен бағаланды. Осылайша, екі жасанды индикаторды смарт орау үшін тиімді тағам балғындық көрсеткіштеріне қосуға болады.

Негізгі сөздер: ет, балық, тағамның бұзылуы, индикатор, биополимер.

РАЗРАБОТКА КОЛОРИМЕТРИЧЕСКОГО ИНДИКАТОРА НА ОСНОВЕ БИОПОЛИМЕРА ДЛЯ МОНИТОРИНГА СВЕЖЕСТИ МЯСА И РЫБЫ

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Необходимость продления сроков годности продуктов питания растет в результате усилий по сокращению расходов и минимизации пищевых отходов. Пищевая промышленность заинтересована в решениях, которые позволили бы легко сохранять продукты свежими и безопасными в течение всего времени их реализации. Целью исследования является разработка колориметрического индикатора на основе био-

полимеров для контроля свежести мяса и рыбы. Значимость исследования заключается в обеспечении безопасности пищевых продуктов путем контроля свежести с использованием экологически чистых и дешевых методов. В статье представлены натуральные индикаторы: куркумин, гранатовый, свекольный, морковный соки, включенные в составы индикаторов свежести пищевых продуктов. Полученные природные индикаторы сравнивали с искусственными индикаторами: бромтимоловым синим и феноловым красным, на предмет их мониторинга летучих аминов. Кроме того, в исследовании была применена модель выделения летучих аминов на основе различных растворов аммиака. Реакцию показателей свежести оценивали путем наблюдения за изменением цвета. По сравнению с искусственными индикаторами, куркумин и гранатовый сок дали аналогичный ответ. Свекольный и морковный соки не обеспечили желаемого изменения цвета. Дальнейшие исследования были проведены по разработке биополимера, содержащего индикаторы свежести на основе бромтимолового синего и фенолового красного. Показатели оценивались по их реакции на порчу проб рыбы и мяса в пробирках и упаковке пищевых продуктов. Таким образом, два искусственных индикатора могут быть включены в эффективные индикаторы свежести продуктов питания для умной упаковки.

Ключевые слова: мясо, рыба, порча пищевых продуктов, индикатор, биополимер.

Introduction

Food preservation requires fast, cheap, and safe analytical methods to analyze food deterioration. There is rising demand for increasing the shelf life of food products due to the promotion promote to decrease costs and reduce food waste throughout the whole shelf life (production, storage, shipment, and consumption) [1]. These food tracking approaches could help to maintain items on sale while being in good condition and replacing the ones in non-optimal conditions. Solutions that would make it simple to monitor and maintain the freshness and safety of food products throughout the shelf life of the product are of interest to the food industry [1]. Smart sensors and smart labels that can be included in containers and monitor temperature changes, and conditions, detect gases related with the spoilage of the food, and provide a "quality index" of a product in real time are very desirable by the food industry. [1,2] Additional features can be included to increase food safety can be containers with a coating that has improved oxygen shield to stop food from spoiling are also sought after. Current approaches and trends to inform about the quality of the food via smart packaging focuson chemical and biological sensors [1]; so consumers can assess the freshness of the items without having to open the packaging [3-5].

Meat, fish, and seafood are high-value foods that can be sold in commercial packaging [6]. These foods naturally degrade while being stored or on display. However, without opening the container to reach the product, it is not possible to identify the state of the food using standard testing techniques [6]. The level of deterioration that meat and seafood products go through before being consumed may be tracked using color markers [6]. Any product that is spoiled, like a meat or fish product, tends to show its spoilage in terms of its organoleptic characteristics, such as smell, taste, texture, and appearance [7].

Since meat and fish products are perishable products [8], they are very sensitive to the conditions of their storage. Therefore, the reason for such changes is various chemical and physical environmental factors, which include storage temperature, air humidity, pressure, pH, salt concentration, and so on.

When meat deteriorates, various types of spoilage can occur, such as microbial spoilage (mold growth and rotting, enzymatic processes) and physicochemical spoilage (oxidation, coloration, odor, and taste changes). One of the most common and dangerous types of meat deterioration is rotting, during which changes occur in the color, smell, taste, and structure of the product. Meat acquires an unpleasant odor and a bluish-red color by the action of putrefactive microorganisms in meat, which destroy protein compounds and form mycotoxins, such as aflatoxins, patulin, and ochratoxin A [7]. The accumulation of amino acids and ammonia in meat is one of the obvious causes of putrefaction: proteins are cleaved by enzymes from organisms, which leads to the appearance of polypeptides and peptides, which later form amino acids and peptones. Later, amino acids break down to substances that include indole and skatole (as well as: ammonia, amines, fatty acids, and mercaptans), which are derivatives of the aroma of the product, that is, bad-smelling substances [8]. At the beginning of microbial spoilage of fish, the following occurs: formation of trimethylamine from reduction of trimethylamine oxide, degradation of amino acid to primary amines, degradation of urea to ammonia, which contribute to the unpleasantly pungent smell of spoiled fish [9-11]. Formation of amino acids, amines, ammonia and hydrogen sulphide from splitting of protein occurs when proteolytic activity of microorganisms is carried out. Fermentative activity of microorganisms is the cause of degradation of carbohydrates into acids, alcohols and gases. Fatty acids and glycerol are formed from splitting of fats by lipolytic activity of microorganisms [11]. Microorganisms proliferate on the surface of the vegetable product. The deterioration is affected by morphological features of some products. For example, if an object has an uneven, rough surface, the probability of damage is much higher than that of objects with a flat and smooth surface. With the deterioration of the quality of vegetable products, harmful compounds are formed, caused by the enzymatic breakdown of proteins and lipid components. In the reaction itself, there are also catalysts the form of enzymes that react with phenolic compounds and oxygen, which leads to the formation of brown pigments. Enzymatic spoilage in this scenario leads to darkening and softening of the tissues of the product, which is one of the main signs of deterioration in the quality of vegetables [12].

At present, natural and synthetic indicators [13] are in use to report the degree of spoilage. Because the pH of meat and seafood products increases to 8 as a result of the excessive amounts of amines and other organic substances that are produced during the decomposition process [11], a substance indicating with its color or intensity changes in pH can serve as a good indicator. For instance, currently electrochemical biosensors and colorimetric indicators based on immobilized dyes on various matrices are being used to track the pH of food products in the market, while synthetic colorimetric indicators are in development with low technology readiness [13]. Such color signaling substance that can assist the customer in assessing the quality of food products without having to remove them can be incorporated in additives in the films used for food packaging in sealed container, making it a simple and cost-effective approach. Such substances should have sensitivity to particular by-products of food spoilage responses. The development of biopolymer based colorimetric indicator for the monitoring of the microbiological deterioration of food is essential for packaged foods.

Microbial decomposition of carbohydrate, protein, or lipids may result in the formation of a range of volatile nitrogenous compounds (ammonia, trimethylamine, dimethylamine etc.), which in turn raise the pH level in the packaged foods [13]. In addition, when the volatile chemicals that result from spoilage are released, the pH-sensitive dye that can be trapped by the polymer matrix of the packaging responds with visible changes [1,13]. The findings demonstrated that it is possible to quickly and reliably identify compounds that lead to food spoilage in packaged foods using colorimetric techniques.

In our study biopolymer based colorimetric indicator for monitoring of meat and fish freshness was developed.

Materials and research methods

Reagents and materials

Bromothymol blue and phenol red (both with 100% purity) were obtained from Laborpharma (Almaty, Kazakhstan) and prepared by dissolving 0.1 g of bromothymol blue and phenol red in 100 ml of ethanol/water mixtures (50/50%). Filter paper FBIII was purchased from Laborpharma (Almaty, Kazakhstan).

Methods

Fruits and vegetables (pomegranate juice, carrot, beetroot, and curcumin) were ground and extracted with a sieve for 1 h. A solution of artificial indicators was prepared in ethanol/water mixtures (50/50%) by dissolving 0.1 g of bromothymol blue and phenol red. As a result, solutions of the artificial and natural indicators were obtained, which were used for further experiments. Ammonia solution (25%) was chosen as a reagent simulating a weakly alkaline medium. Ammonia solution (25%) was diluted to obtain the following ammonia solutions with concentrations 2%, 1%, 0.1%, 0.01%, and 0.001%.

Preparation of a carrier for applying indicators

Taking advantage of the absorbent character of paper, it was used to absorb the dyes. The filtered paper was cut into several squares or rectangles (3x4 cm) and placed in Petri dishes, where they were individually pre-filled with the prepared solutions of artificial indicators of bromothymol blue and phenol red, and natural solutions of curcumin, pomegranate, carrot, and beetroot. The remaining excess liquid was removed, and the paper was dried in the laboratory for 3-4 days.

Preparation of a sustainable biopolymer

We used methodologies to obtain biodegradable biopolymer based on starch raw materials in the presence of various organic acids (citric acid, acetic acid, lactic acid) and plasticizers (glycerol, polyvinyl alcohol, nanomaterial) described in our previous paper [14]. Citric acid as an organic acid and glycerol as plasticizer have chosen for obtaining biodegradable biopolymer. Durable and cost-effective biopolymer was obtained, capable of re-processing and biodegrading biological waste, including starch-containing garbage. The developed biopolymer has successfully passed all physical and chemical tests.

Biopolymers are polymers made from natural sources [14-15]. 10 g of starch were weighed and mixed with 60 ml of water. To the resulting mass a 5% solution of acetic acid was added. Then 10 ml of glycerol was added to the mixture. Following, 5 ml of bromothymol blue solution (or phenol red solution) was applied. The mixture was heated up to 80 °C for 5-6 minutes until a thick consistency was obtained, which was then poured in Petri dishes (Figure 1).

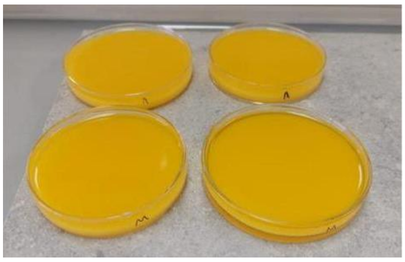

Figure 1 – Preparation of biopolymer based on starch.

For preparation of biopolymers based on starch and citric (or lactic acid), 6 g of cornstarch was added to a container with 60 ml of distilled water. Next, 5 ml of glycerol and 5 ml of citric (in the second case, lactic acid) acid were added to the resulting mass and heated up for 5-6 minutes. Solution of 2 ml of 0.1 M NaOH was added to the viscous mass. Then, 5 ml of bromothymol blue was slowly added to the prepared solution by heating in a water bath, in the second case, a phenol red indicator was added. The resulting viscous mass was poured into Petri dishes and left to dry for several days. The resulting citric acid biopolymer has a good shape and consistency compared to the lactic acid biopolymer.

Results and discussion

Research on the selection of natural and artificial indicators

During spoilage of meat and fish products, amino acids are decomposed and as a result, amines are released which alters the pH from 6 to 8, which corresponds to the intervals of these indicators. Acid-base indicators such as phenol red and bromothymol blue change color within that pH range. Natural dyes can also be used to indicate changes in color within these conditions. For example, juice of coloring vegetables, flowers, berries, and so on, among them, the substances obtained in our experiment: curcumin (the main curcuminoid found in the root of turmeric, used as a food coloring); pomegranate juice; beetroot juice; carrot juice.

Experiments simulating a weak alkaline environment

Ammonia solution (25%) was chosen as a reagent simulating a weakly alkaline medium. Ammonia solution (25%) was diluted to obtain the following ammonia solutions with concentrations of 2%, 1%, 0.1%, 0.01%, and 0.001%. Next, 5 mL of the diluted ammonia solutions (2%, 1%, 0.1%, 0.01%, and 0.001%) were poured into five tubes. Afterward, indicator papers were made from artificial and natural dyes were attached to the top of each test tube. Thus, the experiment made it possible to monitor the rate of color change of the above indicators (Figure 1). Effects of exposure to ammonia solutions on the stability and color-changing abilities of the indicator papers examined within a week. During that time the stability of color of the indicator showed positive result. According to the results of the study, no changes in the color of carrot and beet indicator papers were detected (table 1). Figure 2 showed that pomegranate indicator papers changed their color from crimson to black in 2%, 1%, and 0.1% of ammonia solutions. Curcumin indicator papers changed color from yellow to orange at concentrations of ammonia solution other than 0.001% solution (pH 7.8), showing a good result. Bromothymol blue indicator changed its color from yellow to blue in all ammonia solution concentrations (pH 6 to 8). However, little change was found at the lowest concentration. Phenol red changed color from yellow to red in all solutions except 0.01% ammonia solution.

Bromothymol blue can be in protonated form, which transmits yellow light in acidic solutions or deprotonated form, exhibits results in a highly conjugated structure and transmits blue light in alkaline media. Conjugated form is responsible for the length and nature of the color change the of indicator's active pH range of 6.0 to 7.6.

Phenol red indicator color exhibits a gradual transition from yellow to red over the pH range 6.6 to 8.0. Above pH 8.1, phenol red turns to a bright pink color. This observed color change is explained by protons lose (and changes color) as the pH increases.

Curcumin is a natural yellowish-orange dye from turmeric and other compounds. At acidic and neutral condition, its relatively stable with no color change, while at increasing pH above 8, its color changed from yellow into brownish-orange. The changes are related to the phenolic compounds and unsaturated bonds structure of curcumin. Color changes in pomegranate juice associated with anthocyanins, which are sensitive in alkaline condition.

Thus, the color change increases with increasing concentration of ammonia solutions, which is indicated in Table 1. For subsequent experiments, 2 artificial (bromothymol blue and phenol red) and 2 natural indicators (curcumin and pomegranate juice) were chosen, since they showed positive results, changing their color in the certain range of pH level from 6 to 8. Sensitivity and selectivity of the indicators simply compared visually by color changes within the specified range.

Natural indicators (curcumin, pomegranate juice, beetroot juice, carrot juice) used in our studies has limitations compared to artificial ones due to their low sensitivity and selectivity. Their low sensitivity and selectivity can be explained by the presence of dyes and other compounds that interfere with each other, thus, decreasing sensitivity and selectivity.

Figure 2 – Discoloration of artificial and natural indicators with increasing concentration of ammonia solution from 0.001% to 2%.

Table 1 – Results of model experiments with different concentrations

Ammonia %	Artificial and natural indicators					
	Pomegranate	Carrot	Beetroot	Curcumin	Bromothymol blue	Phenol red
0.001	Not changed	Not changed	Not changed	Not changed	Changed	Not changed
0.01	Not changed	Not changed	Not changed	Changed	Changed	Changed
0.1	Changed	Not changed	Not changed	Changed	Changed	Changed
1	Changed	Not changed	Not changed	Changed	Changed	Changed
2	Changed	Not changed	Not changed	Changed	Changed	Changed

Experiments on meat and fish products

The filter papers impregnated with dyes were tested with meat and fish products. Fresh samples of meat (beef) and fish (perch) (5-10 g) were placed in tubes. After that, the prepared indicators (pomegranate, curcumin, bromothymol blue, phenol red) were placed in them, cut into four parts: two in a test tube with meat and two with fish. One indicator was located in close proximity to the meat and fish samples, while the second one was attached to the wall of the test tube. The tubes were stoppered to simulate containers for meat and fish. At the end, the rack was placed with the samples on a window illuminated by sunlight to speed up the deterioration of the samples. The process was observed for five days, and the following changes were obtained (Figure 3).

No changes were found on day one. On the second day, bromothymol blue changed its color from yellow to blue only in a test tube with fish. As well as phenol red, which changed its color from yellow to red only on fish. Pomegranate changed its color from dark red to gray only in a test tube with fish. While curcumin showed no change. On the third day, bromothymol blue changed its color from yellow to blue in two test tubes with meat and fish. The same results were shown by phenol red, changing color from yellow to red. Pomegranate and curcumin remained unchanged. On the fifth day, the indicator papers all returned to their original color.

Molecular or compositional factors contribute to the observed differential responses of indicators to meat (beef) and fish (perch) spoilage depends on various mechanisms, such as microbial spoilage (mold growth and rotting, enzymatic processes) and physicochemical spoilage (oxidation, coloration, odor, and taste changes).

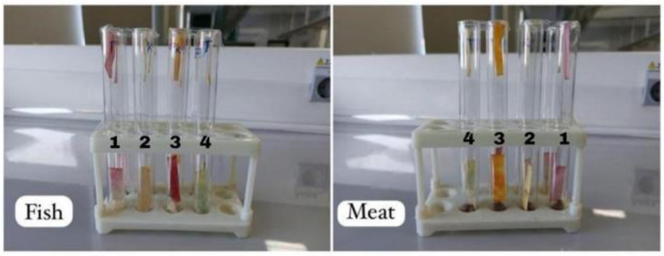

Figure 3 – Experiment on meat and fish products (1-pomegranate; 2-curcumin; 3-phenol red; 4-bromothymol blue).

Testing the prepared indicator biopolymers on samples of meat or fish products

For testing indicator biopolymers, four containers were taken, two containers each for meat and fish products. Two of them were filled with a biopolymer with the addition of a bromothymol blue indicator, and the next two with a biopolymer with a phenol red indicator. Next, the sample containers were placed on a sunlight surface to speed up the sample deterioration process (Figure 4). The samples were observed for five days (Table 2).

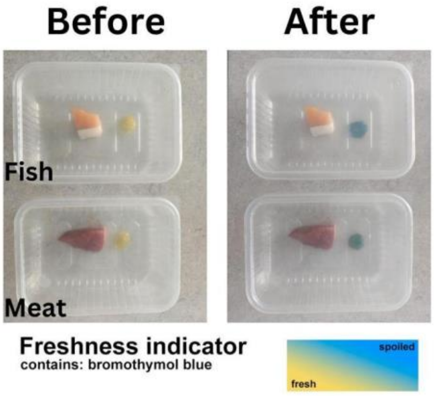

Figure 4 – Changes in the color of the indicator biopolymer when the quality of meat and fish products deteriorates

Table 2 – Color changes of Biopolymer Indicators on Meat and Fish Samples

Sample	Days	Bromothymol blue		Phenol red	
		Meat	Fish	Meat	Fish
1	1	Not changed	Changed	Not changed	Changed
2	2	Changed	Changed	Not changed	Changed
3	3	Changed	Changed	Not changed	Not changed
4	4	Not changed	Changed	Not changed	Not changed
5	5	Not changed	Changed	Not changed	Not changed

The table 2 shows the color change within five days. On the first day, the bromothymol blue biopolymer changed color from yellow to blue, and the phenol red biopolymer from yellow to red only on the fish samples. On the second day, the bromothymol blue biopolymer also changed its color to blue from yellow on the meat sample, while the phenol red biopolymer remained unchanged. On the third day, the bromothymol blue biopolymer also showed a positive result, while the phenol red biopolymer returned to its original color on the fish sample. On the fourth day, the bioplastic with bromothymol blue returned to its original color on the meat sample. On the fifth day, the biopolymer with bromothymol blue and phenol red returned to its original color in all samples. Phenol red changed its color from yellow to red only in the fish samples, while the color of bromothymol blue changed for both foods. As a result, it can be stated that phenol red is applicable only to fish products, and bromothymol blue is applicable to both food products. Selected indicators showed good performance in real-time applications within a week, and changed color remained for and extended periods.

Conclusion

A selection of artificial (bromothymol blue and phenol red) and natural pH indicators (pomegranate juice, beetroot, carrot, curcumin solution) was carried out according to their color transition intervals, the main criterion, which was a color change in the range of 6 to 8 when reacting with volatile amines. A selection of solid carriers for applying indicator solutions was carried out in order to develop indicator paper, which will serve as a temporary indicator in determining the quality of meat and fish products. Experiments simulating a weak alkaline environment were carried out using an ammonia solution to determine the best quality indicator. Tests were carried out on meat and fish products using indicator paper, as a result of which a positive result was detected in papers with a solution of two artificial indicators and natural indicators. Biopolymer based on starch and citric/acetic acid was used instead of indicator paper as a more durable film. The developed indicators were tested in relation to their response to the spoilage of fish and meat samples in the test tubes and in food packaging. As a result, it was revealed that two artificial indicators (bromothymol blue and phenol red) could be incorporated in effective food freshness indicators for smart packaging.

We propose to control the food freshness with pH-sensitive indicators integrated into biopolymers. It will eliminate the need to open the package of high-value products of animal origin (meat and fish): the smart label will react with the released volatile compounds of the content instead. The indicators provide safety and quality assessments of food products and extend their shelf life. The universal properties of the new indicator-loaded biopolymers will be implemented to ensure the food security of the Republic of Kazakhstan

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ХАЛЫҚАРАЛЫҚ СТАНДАРТТАРҒА СӘЙКЕС ЖАС ІРІ ҚАРА МАЛ ҰШАЛАРЫН МҮШЕЛЕУ ЖӘНЕ АЖЫРАТУ ТЕХНОЛОГИЯЛЫҚ СХЕМАСЫН ӘЗІРЛЕУ

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Қазіргі жағдайда сойылған мал мен ет сапасына қойылатын ғылыми негізделген талаптар шикізатты өндіру, оларды өңдеу жағдайларын тұтынушылардың талаптарын ескеретін стандарттармен анықталады. Стандарттар өнімнің сапасын бақылайтын шараларды егжей-тегжейлі тұжырымдайды және реттейді. Өндірістің, айналыстың және тұтынудың барлық кезеңдеріндегі сатып алу бағалары, сыйлықақылар және жеңілдіктер стандарттарға негізделеді. Стандарттар ұзақ уақыт бойы өзгеріссіз қала алмайды, өйткені ет сапасына қойылатын талаптар үнемі өзгеріп отырады. Ғылыми жұмыс жақын және алыс шетелдерге экспортталатын халықаралық талаптарға сәйкес ірі қара мал (ары қарай ІҚМ) етін мүшелеу және ажыратудың стандартын әзірлеуге бағытталған. Бұл мақалада жас ІҚМ ұшасын мүшелеу мен ажырату кезіндегі зерттеулердің нәтижелері халықаралық стандарттармен байланыстығы келтірілген. Мұнда, жас ІҚМ етінің майлылығын бағалау, сонымен қатар оларды кластарға және қосымша кластарға, санаттарға жіктеу жүргізілді. Жас ІҚМ етінің химиялық және морфологиялық құрамы, жасы мен тұқымына байланысты зерттелді. Жас ІҚМ етіндегі сойғаннан кейінгі өгерістердің сапа көрсеткіштері, ондағы еттің жетілу, бұзылу дәрежелері сыналды. Сондай-ақ олардың алдыңғы және артқы ширек шекаралары және кесінділері анықталды. Жүргізілген зерттеулердің нәтижесінде ет пен майдың түстерінің, мәрмәрдің стандартты үлгілері зерттеліп анықталды. ЖК «Манашов А.А.» және ЖШС «Meat Processing and Service» ет өңдеу кәсіпорындарында ІҚМ ұшасын мүшелеу және ажыратудың инновациялық әдістемесі енгізілді. Жүргізілген талдау нәтижелері халықаралық стандарттарға сәйкес келетін жас ІҚМ ұшаларын мүшелеу және ажыратудың технологиялық схемасын әзірлеу және Қазақстан Республикасының ет өңдеу кәсіпорындарында енгізу кезінде осы деректерді есепке алу қажеттігін куәландырады.

Негізгі сөздер: стандарт, жас ірі қара мал еті, ұшаларды жіктеу, ұшаның шығымы, малды сою, ет сапасы.