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Development of Sheepskin Processing Technology Using Whey

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Abstract
In this study, the possibility of using whey as a preservative and aldazan as an antiseptic was studied in order to reduce the consumption of sodium chloride, enhance the effect of preservation, and reduce the duration of sheepskin processing during preservation. The whey-salt method proposed for preserving raw sheepskin allows to reduce the consumption of sodium chloride through the use of whey in preservative compositions by up to 50%, the duration of the process of processing skins in comparison with the traditional method by 1.5-2 times (traditional method - 80 hours, proposed - 54-56 hours), the preservation process from 8 to 4 hours, the drying process from 72 to 48-50 hours, the cost of the preservation process, as well as the water consumption and pollution of wastewater from enterprises.

Keywords
sheepskin, preservative, antiseptic, curing composition, preservation.

1. Introduction

Skins are raw material for dressing leather, and sheepskins are used in specialized industries. However, the quality of the manufactured products is reduced due to the low grade of sheepskins entering production. The decrease in the grade of sheepskins is due to the presence of a large number of defects, as a result of which the useful area of the skins decreases. Also, the commodity and technological properties deteriorate, which leads to the loss of scarce raw materials.

It is known that the quality of leather and fur coat raw materials largely depends on the method of their conservation, which is laborious and time-consuming. In this regard, it is necessary to develop new methods for the primary processing of skins, taking into account their technological features to increase their grade by increasing the physical and mechanical properties in the process of biotechnological processing.

After the slaughter of the animal and the cessation of the metabolism, complex chemical processes occur in the skin, leading to structural changes and the destruction of tissues: autolysis and decay. The inhibition and complete cessation of these processes can be achieved by treating skins with chemicals that have bactericidal or bacteriostatic properties (preservatives and antiseptics) [1-3].

The main preservative substance for leather and fur coats is sodium chloride because it is the most accessible and cheapest product. However, this product has disadvantages - it is a food product; most of the sodium chloride flows into the sewer during the preservation process; and sodium chloride solutions used for preservation cause the corrosion of equipment. All of this indicates that sodium chloride does not meet the set of requirements for a preservative. Salts are difficult to remove from wastewater, which is one of their main disadvantages [4-5].

Therefore, replacing sodium chloride with another preservative that does not have such a negative environmental impacts is an important environmental issue. Milk whey, being a potential source of a complex of organic acids, can be considered a component of a preservative solution for processing sheepskins [6-7].

In addition to sodium chloride, to enhance the effect of preservation, antiseptics are used - chemical compounds that can destroy microorganisms. Currently, the following antiseptics are used that meet the requirements of microbiological efficacy and toxicity: alcohols, acids and alkalis, oxidizing agents, and aldehydes [8-9].

However, there is no antimicrobial antiseptic that combines a wide range of antimicrobial activity, low toxicity, stability, and compatibility with other substances. Combinations improve the properties of antiseptics through their combined use [10-12].

Given the importance of the problem, it is necessary to find new preservatives compositions that could ensure the high quality of canned raw materials and, to a certain extent, achieve a reduction in the consumption of sodium chloride.

The aim of the work was to develop a new curing composition using a preservative from dairy production waste, which makes it possible to exclude toxic antiseptics, as well as replace sodium chloride with a new curing component as much as possible.

To achieve the goal, the following tasks were set:
1. Develop a new curing composition for the preservation of sheepskins.
2. Develop a method for preserving sheepskins with a new curing composition.

2. Materials and methods

Objects of the study: sheepskin (steam, preserved), preservative agent (sodium chloride (Laborpharma, Kazakhstan), whey); antiseptics

(pervomur – formic acid 85% (TOO "Smart Chim Trade", Russia), aldazan (Pharmachem Holding EAD, NIHFI Ltd, Germany), formaldehyde (LLP Zhayik-AS, Kazakhstan), phosphopag (ROO-IETP, Russia), chloramine (Jiaxing Grand Corporation, China)), curing composition, preservation process, physical and chemical studies, organoleptic evaluation, histological and bacterioscopic evaluation, preservation parameters, and short-term storage.

2.1. Methods of research and study of the possibility of using whey

The following methods and standard methods were used for the study:

- study on the selection of preservatives and antiseptics: when selecting preservatives (whey, sodium chloride) in order to study the possibility of using whey in the process of preserving sheepskin coat raw materials, organoleptic, physicochemical (fat, solids, density, titratable acidity, active acidity, whey temperature) and microbiological properties of whey, as well as sheepskin leather (moisture, salt, pH).
- determination of organoleptic indicators (taste and smell, texture, appearance and color) according to GOST 34352-2017;
- determination of the mass fraction of whey fat according to GOST 5867-90;
- determination of the mass fraction of dry substances by the refractometric method according to GOST 33957-2016;
- determination of density according to GOST 33957-2016;
- determination of the titratable acidity of whey according to GOST 33957-2016;
- determination of the active acidity (pH) of whey according to GOST 33957-2016;
- determination of serum temperature according to GOST 33957-2016;
- microbiological indicators of whey according to GOST 34352-2017;
- determination of sodium chloride content in leather tissue according to GOST 13105-77;
- determination of moisture content in leather tissue according to GOST 13104-77;
- determination of the pH of aqueous extract of leather tissue according to GOST 32165-2013;
- determination of organoleptic indicators according to GOST 28509-90;
- determination of the total microbial contamination of skin tissue by bacteriological analysis according to GOST 25311-82, GOST 26670-91, GOST 10444.15-94.

The choice of antiseptic (pervomur, aldazan, formalin, phosphopag-D, chloramine B) was carried out experimentally with five variants of antiseptics, whose antiseptic properties were studied, determined by the method of determining the total microbial contamination.

The total microbial contamination of the skin tissue was determined by bacteriological analysis based on the ability of living bacterial cells to form macrocolonies on nutrient media under optimal cultivation conditions [13-14].

At the initial stage of the experimental studies, preservatives and antiseptics, their dosage, and methods of application to sheepskins were selected.

When selecting preservatives as a neutral salt, sodium chloride consumption was reduced, and skimmed milk whey was used as an acid agent.

Other studies have explored the possibility of using whey as a preservative. For this study, whey prepared by combining cheese whey and curd whey at the milk processing enterprise KH "Kalikhanuly", in the city of Semey, Abay region, Kazakhstan, was used. The whey was filtered from curd particles remaining in the whey. During storage in the receiving tanks, the whey was stirred to prevent separation and sedimentation, and the acidity and temperature of the whey were monitored.

When selecting preservatives in order to study the possibility of using whey in the process of preserving sheepskin coat raw materials, we studied the physicochemical (fat, solids, density, titratable acidity, active acidity, whey temperature), organoleptic, and microbiological properties of whey as well as the properties of sheepskin leather (moisture, salt, pH).

Experimental studies on the selection of an antiseptic and its concentration were carried out in the laboratory of the Semey branch of the LLP "Kazakh Research Institute of Processing and Food Industry" in the city of Semey, Abay region, Kazakhstan.

The study used prototypes of paired sheepskin coats (three-fold repetition). Raw materials were obtained from peasants, farms, and slaughterhouses in the city of Semey, Abay region, Kazakhstan. Sheepskin untreated with an antiseptic was used as a control sample.

To enhance the effect of conservation, we selected antiseptics with bactericidal and bacteriostatic properties: pervomur - a mixture of hydrogen peroxide and formic acid; aldazan - a mixture of formaldehyde with glutaraldehyde; formalin (formaldehyde solution); phosphopag-D (polyhexamethylene guanidine phosphate); and chloramine B (sodium salt of chloramide benzene sulfonic acid).

The technological scheme for processing sheepskin prototypes with antiseptics was as follows: preparation of working solutions of antiseptics with calculation of the concentrations required for processing sheepskins; treatment of sheepskins with antiseptics with solution concentrations (w) from 0.5 to 2.5 %, t = +20 °C, τ = 6 h; flow around, τ = 2 h; and drying in air, τ = 48-50 h.

After preparing working solutions of the antiseptics, test samples of sheepskins that had undergone ritual and skinning were soaked for 6 hours in solutions of five different antiseptics (pervomur, aldazan, formalin, phosphopag-D, chloramine B) with a concentration of

0.5 to 2.5% at a temperature of +20 °C. The skins were then laid out on a horse to drain for up to 2 hours and then air-dried for 48-50 hours.

2.2. Development of a method for preserving sheepskins with a new curing composition

The sheepskin preservation process is one of the most important technological operations affecting the quality of the final product, in particular, such indicators as the pH level, shrinkage temperature and moisture content [15-16].

The quality of sheepskin conservation was assessed by the physicochemical parameters of the leather tissue:

– Determination of the shrinkage temperature is based on the determination of the temperature of the leather tissue when heated to one hundred degrees Celsius.
– Determination of moisture content consists of the determination of brine by the mass fractions of moisture in the raw hides.
– Determination of the pH of aqueous extract of the skin tissue is based on measuring the concentration of hydrogen ions in the test solution.

The quality of a pair of sheepskins and preserved sheepskins after 7, 10, and 15 days of storage was evaluated by the following indicators:

Determination of the total microbial contamination of the skin tissue by bacteriological analysis based on the ability of living bacterial cells to form macrocolonies under optimal cultivation conditions on nutrient media.

Histological examination of skin tissue sections was carried out, which consists of studying specially prepared sections of raw materials under a microscope.

The reliability of the results obtained is ensured by selecting the required number of parallel measurements of the parameters of the objects under study.

Studies to identify the optimal variant of the ratio of the components of the preservative mixture were carried out in the laboratory of the Semey branch of LLP “Kazakh Research Institute of Processing and Food Industry”.

For the research, three variants of a sheepskin coat sample were conserved with a curing mixture. The compositions of the preservative mixture included active antiseptics - aldazan, pervomur, and formalin with a solution concentration of 2% and whey in the amount of 100%. The amount of salt varied from 70 to 150 g/l. After 48 hours of air drying, samples were taken for the total microbial contamination of the skin tissue.

The total microbial contamination of the skin tissue was determined by bacteriological analysis based on the ability of living bacterial cells to form macrocolonies under optimal cultivation conditions on nutrient media.

Studies on the choice of the optimal variant and conservation parameters using a new curing mixture were carried out under the conditions of a pilot production process of IE “Rakhimov Zh.M.”, in the city of Semey, Abay region, Kazakhstan.

A scheme was developed for processing sheepskin-fur coat raw materials with a whey-salt method. It included the following technological operations: acceptance, ritual, fleshing – making of leather;, preservation;, wrapping skins, drying, storage, sorting, labelling, and packaging.

To perform this operation, 4 batches of sheepskin coats, 25 pieces each, were preserved using the whey-salt method.

The control sheepskins were preserved in the dry-salted way (brine, drying). As a control sample, skin samples were used that had undergone treatment with brine with a salt concentration of 350 g/l, a solution concentration of 25.6%, and a preservation time of 6-8 hours.

Preservation was carried out at air temperatures from + 20 to + 30 °C. The relative humidity in the room was 60%. Before preservation, the area of the sheepskins was measured. Labels listing all of the data were attached to each skin. Preparatory processes and operations (acceptance, ritual, skinning) were carried out according to generally accepted technology. The technological scheme for the processing of sheepskin coat raw materials by the whey-salt method is shown in Figure 1.

The skins of small ruminants were taken from the shop for the primary processing of livestock and were counted by quantity and halves and pieces by weight. The sheepskins obtained were examined from the wool and skin side.

Skins before preservation were divided into bulk and non-bulk. In the process of removing the pile, the skins were irrigated with water, and then the remains of cuts of meat, fat, and subcutaneous tissue (mezdra) were removed.

2.3. Preparation of a solution for curing

The preservation of sheepskin coats by the whey-salt method consists of three preparatory stages: preparation of combined milk whey, preparation of an antiseptic, and preparation of curing-preserving solution.

The dairy curd whey used was a pale greenish liquid with a titratable acidity value of at least 240-250 °T, a lactic acid concentration of 15-30 g/dm^3, a pH of not more than 3.5, and an initial temperature of 20 °C. The whey was filtered to remove protein, casein crumbs, dust, and curd particles remaining therein . It was purified through two layers of gauze or lavsan fabric.

To prepare 1 litre of a working solution of 1% concentration of aldazan, 10 ml of aldazan was added to 990 ml of water.

The preparation of 4 variants of the experimental solution consisted of preparing a base for a preservative mixture consisting of whey - 98 l, with a lactic acid concentration of 15-30 g/dm^3, with the addition of the antiseptic aldazan

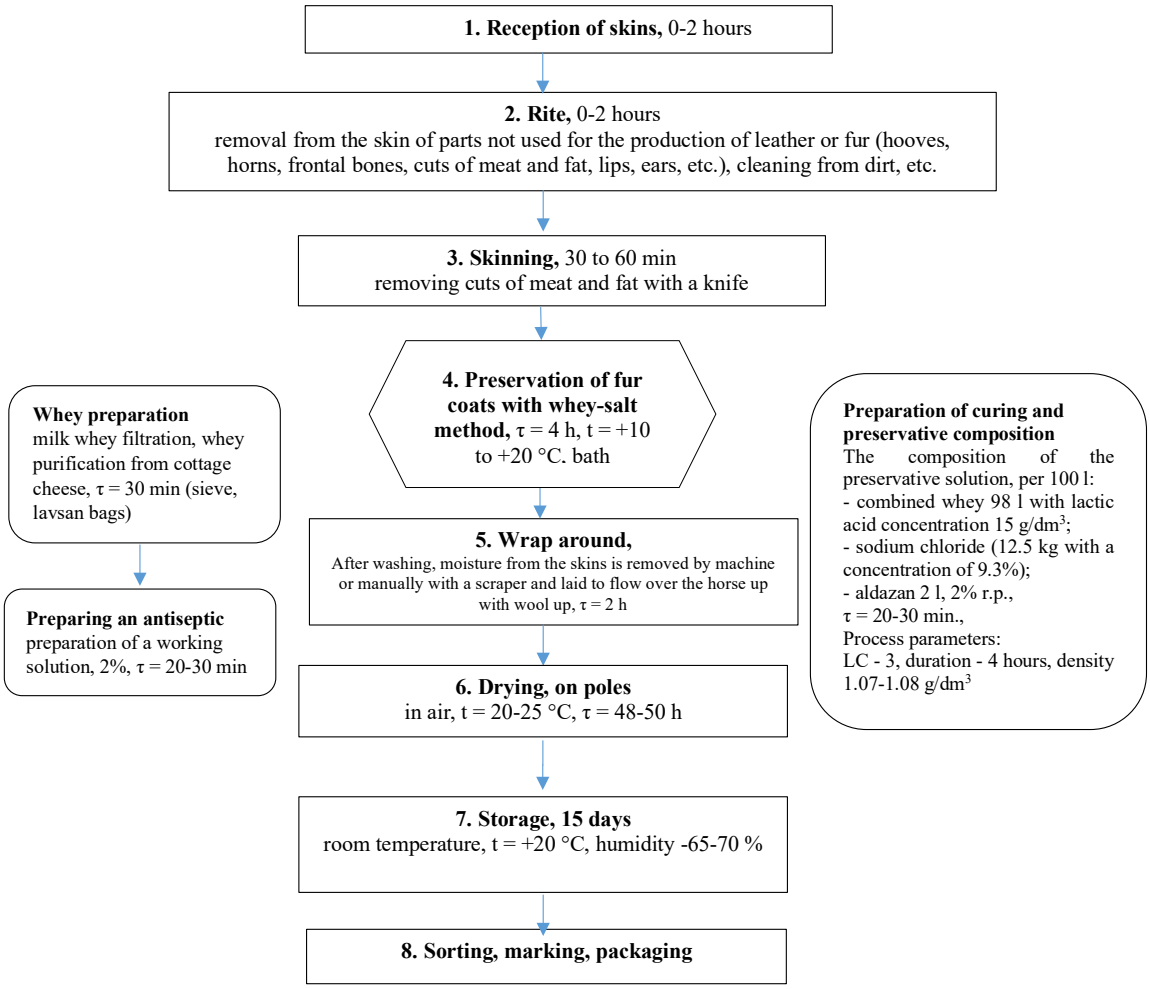

Fig. 1. Technological scheme for the processing of sheepskin-fur coat raw materials by the whey-salt method

in an amount of 2 l, at a concentration of 2%. Sodium chloride was added to the prepared base of the preservative mixture in an amount of 7 to 15 kg, depending on the option, and applied to sheepskins in an amount of 20, 30, 40, 50 % of the saturated solution. The concentration of the solution, depending on the amount of salt, ranged from 5.2 to 12.8%.

The sheepskins were preserved in a bath, where, taking into account the liquid coefficient, a preservative solution was added, including combined whey at a temperature of 35 °C, then sodium chloride was dissolved, the raw material loaded in a straightened form after the ritual, and skinning was carried out in accordance with the traditional technology of processing raw materials. It was stirred for 5 minutes every 30 minutes for 4 hours.

The curing composition for preservation was prepared using salt of grinding No. 1 or a mixture of equal parts of salt of grindings No. 1 and No. 2. To prepare a preservative solution, filtered milk whey, antiseptic aldazan, and sodium chloride were poured into a bath, and everything was mixed until the salt was completely dissolved. The temperature of the preservative solution was not lower than +10 °C and not higher than +20 °C. With stirring, the solution had a specific gravity (density) of 1.07-1.08 mg/m^3 according to a standard hydrometer.

The duration of the process in the experimental variants was 4 hours. In the control version, according to traditional technology, it was 6 hours. At the end of the preservation, the skins were taken out, wrung out, hung with the wool side up on the horse for up to 2 hours to drain the brine, after which they were hung on wooden poles with the skin side out.

The skins were dried under a canopy at an air temperature not lower than 20 °C and not higher than 35 °C. The duration of drying of the experimental skins was 48-50 hours. The skins preserved according to the traditional technology (control variant) were dried for 72 hours. After drying, they were stacked for storage.

The mode of conservation depended on the characteristics of the raw materials being processed and was determined by the concentration of the components of the curing solution, as well as by the duration, temperature, and liquid coefficient. The parameters that provide high-quality products at the lowest cost of raw materials, labour, and time are optimal.

Indicators	Shrinkage temperature of leather tissue by days of storage in experimental batches and control			
	5 days	7 days	10 days	15 days
Experimental variant 1- (20 %) (n=8)				
M	67,13	67,75	64,75	67,88
±δ	0,22	0,38	0,38	0,22
CV (%)	0,33	0,56	0,59	0,32
Experimental variant 2 - (30 %) (n=8)				
M	67,25	67,88	67,13	64,13
±δ	0,38	0,22	0,22	0,22
CV (%)	0,57	0,32	0,33	0,34
Experimental variant 3 - (40 %) (n=8)				
M	67,5	68,13	67,63	68,88
±δ	0,5	0,22	0,47	0,22
CV (%)	0,74	0,32	0,69	0,32
Experimental variant 4 - (50 %) (n=8)				
M	66,88	63,63	68,5	66,63
±δ	0,22	0,47	0,5	0,47
CV (%)	0,33	0,74	0,73	0,71
Control (n=8)				
M	67,13	62,63	62,88	62,13
±δ	0,22	0,47	0,22	0,22

M values are the average vales of the test results of leather tissue samples (n=8) for shrinkability, ±δ are the standard deviations of the test results, CV (%) is the coefficient of variation

Table 1. Dynamics of the temperature of the leather tissue shrinkability during storage for 15 days after salting in the experimental curing mixture and in the control curing liquid

The process of preserving sheepskins was carried out by the dipping method (complete immersion of the skin in a curing-preserving solution) and by spray methods with the following technological parameters: liquid coefficient (l. k.: 2.5-4; brine temperature: 10-20 °C; periodic mixing (duration of the process - 3-5 hours); concentration of reactants (sodium chloride - from 5.2 to 12.8%, whey with lactic acid concentration from 15 to 30 g/dm^3 - 95-98 l, aldazan antiseptic - 2%); and specific gravity (solution density) from 1.03 to 1.1 mg/m^3. After 5 days, samples were taken for physical and chemical analysis, and the area of the sheepskins was measured.

2.4. Statistical analysis

To determine the significance of the results of the shrinkability temperature obtained, statistical processing was carried out. The average values (M) of measurements (n = 8) of the temperature of the shrinkability of the leather tissue were determined, and the standard deviation (±δ) and the coefficient of variation of deviations from the average value of the measurement results, expressed as a percentage (CV (%)), were calculated. All intermediate calculations were carried out in Excel tables.

According to Table 1, the coefficient of variation (CV (%)) of the values obtained does not exceed one percent, which indicates good uniformity of the values obtained from the test of the shrinkability of the leather tissue of all test samples.

3. Results

Organoleptic and physico-chemical properties of whey were studied.

The results of studies of organoleptic and physico-chemical parameters of the combined whey are shown in Table 2.

It was established that, in terms of organoleptic and physico-chemical parameters, samples of the combined whey meet the requirements of GOST 34352-2017 “Whey - raw materials. Specifications”, GOST 5867-90 “Milk and dairy products. Methods for determination of fat”, GOST 33957-2016 “Whey and beverages based on it. Acceptance rules, sampling and control methods.

The results of microbiological indicators of the combined whey are presented in Table 3.

According to the results of the studies, it was established that the microbiological parameters of samples of the combined whey meet the requirements of GOST 34352-2017 “Whey - raw material. Specifications”. It was established that the use of whey for preserving sheepskins does not require distinctive organoleptic characteristics nor a strict composition of the microflora of dairy products, since

Name of indicator	Combination serum options				Normative documentation on research methods
	1	2	3	4	
Appearance and texture	Homogeneous translucent liquid with the presence of a protein precipitate				The determination of organoleptic indicators is carried out visually and organoleptically at a whey temperature of (22 ±2) °C according to GOST 34352-2017 "Whey - raw materials. Specifications»
Color	Pale green				
Taste and smell	Characteristic of whey, sour				
Mass fraction of fat, %	0,4	0,2	0,2	0,3	GOST 5867-90 "Milk and dairy products. Methods for determining fat «
Mass fraction of solids, %	5,1	5,7	5,4	5,9	GOST 33957-2016 "Whey and drinks based on it. Acceptance rules, sampling and control methods»
Density, kg/m^3	1025	1024	1026	1028	
Titratable acidity,°T	88	90	87	91	
Active acidity, pH	3,96	3,85	3,98	3,98	
Temperature,°C	6±2	6±2	6±2	6±2	

Table 2. Organoleptic and physico-chemical parameters of combined whey

Name of indicator	Norm according to normative documentation	Actual performance	Normative documentation on research methods
Quantity of mesophilic aerobic and facultative anaerobic microorganisms (QMAFAnM), CFU/g	no more than 1×10^5	$3,9\times10^4$ – $6,5\times10^4$	GOST 34352-2017. Whey - raw material. Specifications
Bacteria of the Escherichia coli group (Coliform bacteria) in 0.1 g	not allowed	not detected	
Pathogenic, including salmonella in 25 g	not allowed	not detected	
S. aureus in 0.1 g	not allowed	not detected	
Yeast, CFU/g	not allowed	not detected	
Molds, CFU/g	not allowed	not detected	

Table 3. Microbiological parameters of combined whey

it is used for technical purposes and the main indicator of suitability is the value of titratable acidity. It was established that the combined whey, prepared in the Peasant Economy "Kalikanuly" of Semey, proposed for processing sheepskin and fur coats, contains lactic acid from 1.08 to 1.35 g/dm^3, which corresponds to pH 3.1. Given this fact, it is proposed to control the combined whey by a value of titratable acidity of at least 250 °T. It was shown that the combined whey can retain acidity for 15 days at a temperature of 10±1 °C; acidity increases with increasing storage temperature.

Considering that whey contains a large amount of water (93.7%), 100% concentration of whey was chosen for further research, and further calculation of the preservative mixture is per 1 liter, g/dm^3. When using milk whey for the preservation of sheepskins, two methods of applying whey were chosen: the dipping method (by the type of brine) and spray method.

Sodium chloride was used as the neutral salt. The chemical and organoleptic characteristics of sheepskins treated with NaCl were studied.

In the study of physicochemical and organoleptic parameters of sheepskins treated with NaCl, it was established that the most optimal concentration of sodium chloride is from 8.5 to 12.8% (115-150 g/l), at which the NaCl solution has the highest bacteriostatic properties, significantly reducing the growth of bacteria during short-term treatment.

In the study of the total microbial contamination of the leather tissue of sheepskins, it was established that under the same conditions for processing sheepskins with different concentrations (from 0.5 to 2.5 %) of antiseptics, pervomur, aldazan, and formalin have the highest microbial activity. In aldazan, bacterial growth is not observed at a concentration of 2 %, and in formalin - at a concentration of 2.5 %. When using other antiseptics, microbial growth continues; but the smallest is observed in pervomur - 10 colonies at a solution concentration of 2.5 %.

Based on the research, a new curing composition for sheepskin preservation was developed, including: milk whey (kg/l) - 95-98 1 with a lactic acid concentration of 15 to 30 g/dm^3;

Name of indicator	Sheepskin processing options				Normative documentation on research methods
	1	2	3	4	
Organoleptic indicators					
Appearance	The hairline of the skin is slightly damp. The skin is soft, not elastic	The hairline of the skin is dry. There is some moisture at the junction of the skin and hair. The skin is elastic	The hairline of the skin is dry. The skin is elastic	The hairline of the skin is dry. There are places with a small touch of salt. The skin is elastic	GOST 28509-90. Leather raw material. Sheepskins are undressed. Specifications
Mezdra (a layer of subcutaneous fatty tissue, meat, fat, and pieces of tendons that are removed from the skin in the process of preparatory operations) color	Mezdra gray shade	Mezdra light milky color	Mezdra light milky color	Mezdra with a milky yellow tint	
Chemical indicators					
NaCl concentration, g/l	70 (20% of saturated solution)	100 (30% of saturated solution)	125 (40% of saturated solution)	150 (50% of saturated solution)	GOST 13105-77 Leather raw materials. Methods for determining the components of preserving
Moisture, %	17,8	16,2	15,5	15,1	GOST 13104-77. Leather raw material. Methods for determining salt and net weight
NaCl, %	6,7	10,6	11,7	12,8	GOST 13105-77 Leather raw materials. Methods for determining the components of preserving
pH	5,4	5,1	4,9	4,7	GOST 32165-2013. Dressed fur and sheepskin skins. Method for determining the pH of an aqueous extract
microbiological indicators					
QMAFAnM, CFU/g	5×10^2	6×10^2	2×10^2	2×10^2	GOST 25311-82. Feed flour of animal origin. Methods of bacteriological analysis. GOST 26670-91. Food products. Methods of cultivation of microorganisms. GOST 10444.15-94. Food products. Methods for determining the number of mesophilic aerobic and facultative anaerobic microorganisms
Mold, CFU/g	1	Not detected	Not detected	Not detected	
Halophiles	Not detected	Not detected	Not detected	Not detected	

Table 4. Chemical, organoleptic, and microbiological parameters of sheepskins treated with NaCl

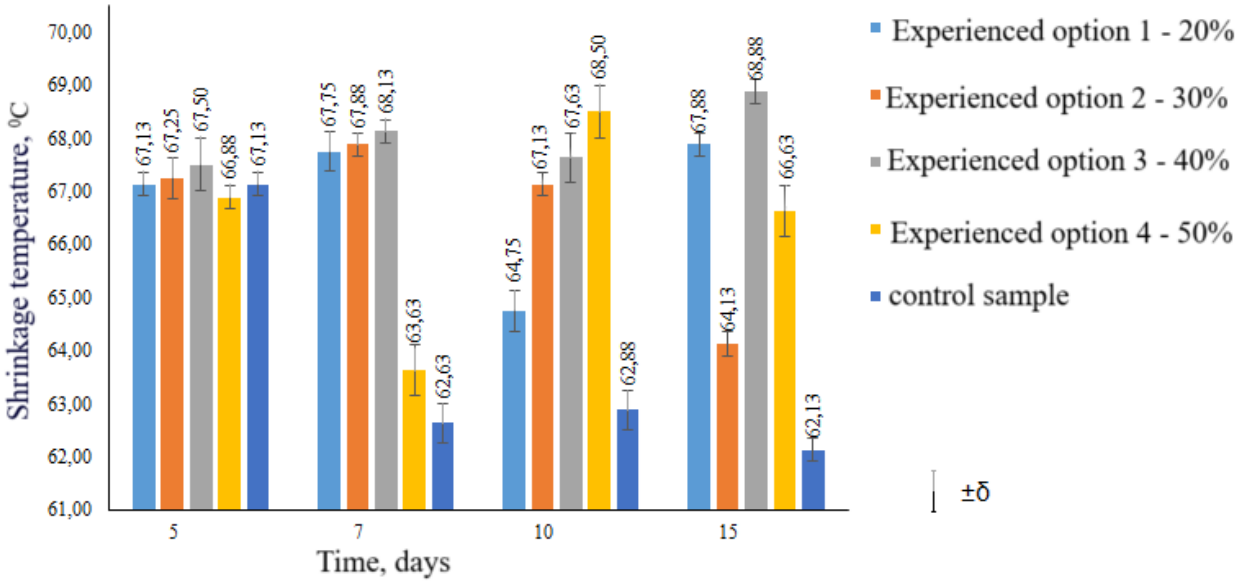

Fig. 2. Graph of the dependence of the shrinkage temperature of sheepskin leather tissue in the preservation process

antiseptic (pervomur, aldazan, formalin) in an amount of 2 to 5 litres with a concentration of 2%; sodium chloride in an amount of 7 to 15 kg with a concentration of 5.2 to 12.8% per 100 litres of preservative solution [17-19].

At the stage of experimental studies to identify the optimal ratio of the components of the preservative mixture, the total microbial contamination of the leather tissue of sheepskins without treatment and sheepskins treated with antiseptics was investigated.

It was established that of the three variants of the preservative mixture, aldazan is an antiseptic with selective action, at a solution concentration of 2 % in the presence of sodium chloride of not lower than 125 g/l, a solution temperature of +20 °C, and an acidity level of not more than 6.0 pH, which reduces the number putrefactive bacteria by 4 times.

At the stage of experimental research on the choice of the optimal variant and conservation parameters using a new curing mixture, the optimal amount of the mixture for sheepskins was determined (with a sodium chloride content in the amount of 20, 30, 40, 50 % of the saturated solution). It was established that the best preservation results were achieved when sheepskins were preserved with a curing mixture including sodium chloride in the amount of 12.5 kg with a concentration of 9.3 %, which is 40 % of the saturated solution.

The dynamics of the preservation process using whey were studied by changing the shrinkage temperature.

It was established that an increase in the concentration of the mixture to 40% led to a more intense defibration of the leather tissue, which corresponds to a shrinkage temperature of 67.5 °C. With this treatment, rapid and significant dehydration of the sheepskin occurs: the pH shifts to the acid side under the action of formic and lactic acids that occur during the hydrolysis of aldazan. Whey causes an increase in the shrinkage temperature.

Thus, the preservation of sheepskins with whey is accompanied by a loss of strength of the leather tissue, which is confirmed by an increase in the shrinkage temperature in option 4 (Fig. 2).

It was established that the lowest moisture content and pH values are observed in options 3 and 4, where the amount of salt is 150 g/l and 125 g/l. A low pH (4.91 and 4.95) is noted in the preservative mixture with the antiseptic aldazan. When applying a mixture of 20-30 %, the moisture content is higher than when applying 40-50%, and the salt content is lower. As a result, the application of a mixture of 20 % guarantees the safety of raw materials for up to 5 days, after which a single flow of the hairline is noted (Fig. 3).

In this regard, the optimal amount of the curing mixture is 40 % of the saturated solution.

It was found that the pH of the water extract of the leather tissue of the preserved experimental sheepskins corresponded to 5.0-5.4, depending on the concentration of the mixture applied to the sheepskin. Thus, when the composition of the curing mixture is 40 %, pH = 5.0, the use of whey shifts the reaction of the medium to the alkaline side due to the presence of lactic acid in its composition, which has a slightly acidic reaction; its pH value meets the requirements and is 4.91 (Fig. 4).

Sheepskins that have been preserved according to traditional technology have a pH of 6.21 for the aqueous extract of the leather tissue.

The results of microbiological studies of sheepskins after 5,7,10 and 15 days of conservation are presented in Table 5.

It was established that the contamination of the dry-salt preservation method is 1.5 times higher than the microbial contamination of the skins of

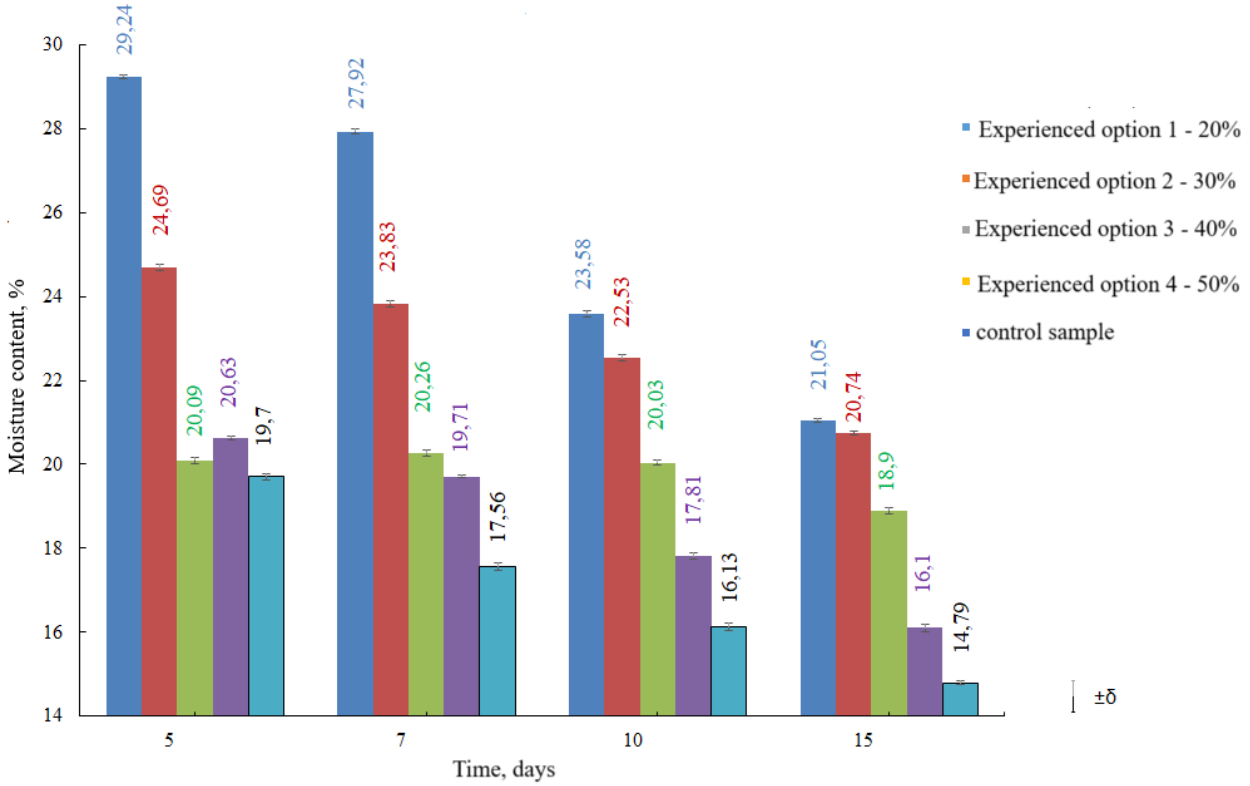

Fig. 3. Graph of the dependence of the moisture content of sheepskin leather tissue in the preservation process

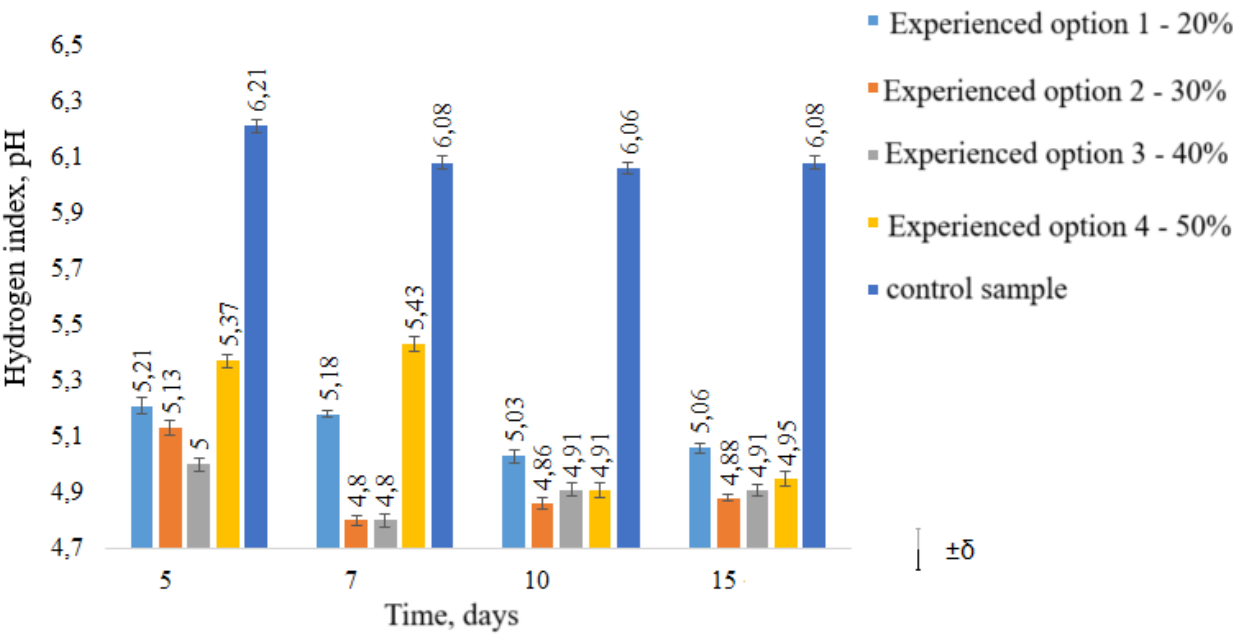

Fig. 4. Graph of the dependence of the pH of the aqueous extract of the leather tissue of sheepskins in the preservation process

experimental samples. After 7, 10 and 15 days of conservation, the amount of halophilic microflora in the process of storing the skins of control samples increases slightly, while in the skins of whey-salt preservation with the use of Aldazan, it practically remains at the same level. The number of mold fungi in stored skins increases slightly. The growth of microorganisms on experimental skins is minimal, which indicates the fungiostatic, antifungal properties of aldazan.

4. Discussion

The whey-salt method proposed for preserving sheepskin raw materials allows for the following:

– reducing the use of sodium chloride through the use of whey in

Experienced options	Sheepskins after preservation	
	QMAFAnM, CFU/g	mold, CFU/g
Sheepskins after 5 days of preservation		
paired	8×10^6	30
1 option (20%)	14×10^3	18
2 option (30%)	12×10^3	10
3 option (40%)	9×10^3	2
4 option (50%)	5×10^3	1
Control	13×10^3	16
Sheepskins after 7 days of preservation		
1 option (20%)	3×10^3	18
2 option (30%)	2×10^3	10
3 option (40%)	$1,2\times10^3$	2
4 option (50%)	$1,1\times10^3$	1
Control	5×10^3	19
Sheepskins after 10 days of preservation		
1 option (20%)	2×10^3	20
2 option (30%)	2×10^3	12
3 option (40%)	1×10^3	2
4 option (50%)	1×10^3	1
Control	3×10^3	20
Sheepskins after 15 days of preservation		
1 option (20%)	$1,1\times10^3$	24
2 option (30%)	$1,3\times10^3$	13
3 option (40%)	9×10^2	3
4 option (50%)	5×10^2	2
Control	1×10^3	26

Table 5. Microbiological indicators of sheepskins after 5,7,10 and 15 days of preservation

preservative formulations; The need to reduce the use of sodium chloride for preserving skins is pointed out by numerous researchers around the world [20-22].

– reducing the duration of the process of processing skins in comparison with the traditional method by 1.5-2 times (the traditional method is 80 hours, the proposed one: 54-56 hours), the preservation process from 8 to 4 hours, and the drying process from 72 to 48-50 hours;
– reducing the cost of the preservation process (whey is cheaper than sodium chloride) and reducing the water consumption and pollution of wastewater from enterprises;
– - improving the quality of skins.

Due to the high content of lactic acid and the ability to defibrillate the dermis without damaging the fibres [23-24], the use of milk whey in preservative compositions makes it possible to reduce the consumption of sodium chloride by up to 50% without the additional introduction of minerals and/or organic acids.

The introduction of an antiseptic at a working solution concentration of 2% allows one to enhance the effect of conservation and reduce the growth of bacteria during short-term processing.

According to researchers, sheep skin samples showed a significant contamination with various bacteria and mold fungi; thus in India researchers conducted research on the surface of sheep skin tissue, where an average of up to 1.83×10^8 CFU/g was detected [25-27]. According to our research, indicators of the general contamination of raw hides after conservation were much lower, in the range of 2×10^2 - 5×10^3 CFU/g. At the same time, the lowest rate of 2×10^2 CFU/g was achieved using an experimental curing mixture of 40% and 50% of a saturated sodium chloride solution.

The scheme developed (Figure 1) allows one to effectively process whey. The cost of whey is cheap, with additional transportation costs; thus, the technology is economically viable.

Thus, the total duration of the technological process of preserving skins in the traditional way (control variant) is 80 hours, which is 24-26 hours more than the time spent on preserving the skins of experimental samples (54-56 hours). The study allowed the selection of preservatives and antiseptics, their dosage, and methods of application to sheepskins. The time of conservation

of fur sheepskin skins proposed by us is much less than that stated by other authors [23]. Thus, the method proposed of processing leather tissue using lactic acid provides for a processing time of 90-100 hours [28-29].

A new curing composition for sheepskin preservation was developed. It includes: milk whey - 95-98 l with a lactic acid concentration from 15 to 30 g/dm^3, antiseptic (pervomur, aldazan, formalin) in an amount of 2 to 5 litres at a concentration of 2%, and sodium chloride in an amount of 7 to 15 kg with a concentration of 5.2 to 12.8% g/l (per 100 l of preservative solution). The processing method proposed by authors from Uzbekistan [23] provides for the use of sodium chloride of 60 g/l, which is environmentally less safe compared to the sheepskin preservation method proposed by us. Considered by the authors from Ethiopia in [30], the method of the reuse of sodium chloride for skin treatment requires the use of sodium chloride of 80 g/l. Moreover, additional costs are required for the recovery of salt from the curing liquid used.

When organoleptically assessed, a semi-finished fur coat has a soft leather tissue; there is no runny hairline or the smell of ammonia. An increase in the yield coefficient of the area of preserved sheepskins is noted. Obtaining a higher area yield of preserved sheepskins is considered a positive effect in the processing of hides [31-32].

It was established that the contamination of the dry-salt preservation method is 1.5 times higher than the microbial contamination of the skins of experimental samples. After 7, 10, and 15 days of conservation, the number of mould fungi in the control skins increases slightly, while the growth of microorganisms on experimental skins is minimal, which indicates the fungiostatic, antifungal properties of the antiseptic aldazan. Histological studies of sections of the leather tissue of sheepskin coats show changes in the structure of tissues that occur during conservation with a curing mixture of various concentrations. It was established that the leather tissue of sheepskins after conservation with a curing mixture applied in an amount of 40% of a saturated solution was well developed and loosened, which complies with GOST 13106-67.

Changes in the structure of the leather tissue of sheepskin coats that occur during preservation with a curing mixture of various concentrations were studied by histological analysis of stained sections of leather tissue. The histological studies carried out confirm the possibility of storing skins preserved with a curing composition with a salt concentration of 40% of a saturated solution for 15 days. During storage, all histological elements of the leather tissue are preserved, including cell nuclei.

The terms of short-term preservation of skins were determined. It was established that in option 4, the shelf life of skins was from 7 to 10 days, in option 3 - up to 15 days, and in options 1 and 2 skins were not stored.

5. Conclusions

The optimal variant of the ratio of components of the preservative mixture was revealed. It was established that aldazan with a solution concentration of 2 % in the presence of sodium chloride of at least 125 g/l, at a solution temperature of 20 °C and acidity level of no more than 6.0 pH is an antiseptic with selective action, which reduces the number of putrefactive bacteria by 4 times.

The optimal amount of the mixture for sheepskins was determined. It was established that the best preservation results were achieved when sheepskins were preserved with a curing mixture including sodium chloride in the amount of 12.5 kg with a concentration of 9.3 %, which is 40 % of the saturated solution.

The optimal option for preserving sheepskins using a new curing mixture was chosen. The Okunochny method of preserving sheepskins was selected with the following modes and process parameters per 100 litres of the curing mixture: combined whey - 98 litres with a lactic acid concentration of 15 g/dm^3; aldazan antiseptic- 2 litres with a concentration of 2%; sodium chloride - 12.5 kg at a concentration of 9.3 % in an amount of 40 % of the saturated solution; liquid coefficient - 3; temperature of the preservative solution - 20 °C; periodic mechanical action; preservation duration - 4 hours; specific gravity (solution density) - 1.07-1.08 g/cm^3; and moisture content in treated sheepskins - 18-20 %.

The optimal time for preserving skins was chosen to be 4 hours. The presence of an antiseptic is a limiting factor for the development of putrefactive microflora (*Bacillus subtilis*, yeast, mucous bacteria) but ensures high stability of microbiological processes, accelerating the time of preserving skins.

The terms of short-term preservation of skins were determined. It was established that in option 4, the shelf life of skins was from 7 to 10 days; in option 3, it was up to 15 days, and in options 1 and 2, the skins were not stored.

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