CHAPTER «VETERINARY SCIENCES»

CHEMICAL COMPOSITION OF MEAT OF SLAUGHTERED ANIMALS FOR PROCESSING WASHING AND DISINFECTING MEANS

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DOI: https://doi.org/10.30525/978-9934-588-53-2-50

Abstract. Studies have found the lowest energy value of meat of slaughtered animals for doubtful degree of freshness and treatment of detergents, respectively: beef –156.01±1.24 and 124.69±1.11, 135.39±1.32 kcal/100 g (for treatment with formaldehyde solutions (10%) and chlorine (chlorine activity 3%) – at meat production capacity for 21–22 days at temperatures from –2 to –3°C; pork – 143,72±1,14 and 134,14±1,29, 133,44±1,18 kcal/100 g (for treatment with hydrogen peroxide solution (5%) and alkaline detergents) – at wholesale bases for storage for 21-22 days at temperatures from –2 to –3°C; mutton – 140,30±1,38 and 125,05±1,17 kcal/100 g (for treatment with potassium permanganate solution (5%) – for sale on the agro-food market for 3–4 days at temperatures from 0 to 6°C; meat of goat – 154.89±1.25 and 131.97±1.22 kcal/100 g (for acetic acid solution treatment (10%) – for supermarket sales for 3–4 days at temperatures (4±2)°C.

It was found that the largest mass fraction of water was 73.60±0.62% in beef treated with formaldehyde solution (10%), in mutton 73.63±0.69% in potassium permanganate solution (5%), in pork 72,14±0,73% for treatment with alkaline detergents, in meat of goat 71.44±0.71% for treatment with acetic acid solution (10%); the smallest mass fraction of fat – in beef 4.33±0.17% for treatment with formaldehyde solution (10%), in pork 5.06±0.24% for treatment with hydrogen peroxide solution (5%), in mutton 4,57±0,17% for treatment with potassium permanganate solution (5%), in goat 4,17±0,25%

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for treatment with acetic acid solution (10%); the smallest mass fraction of protein – in beef 3.08±0.17% and 3.11±0.04% for treatment with formaldehyde solutions (10%) and chlorine (chlorine activity 3%), respectively, in pork 3.69±0.10% and 3.71±0.11% for treatment with hydrogen peroxide solution (5%) and alkaline detergents, respectively, in mutton and goat – 3.47±0.15% and 3.29±0.17% for treatment with potassium permanganate solutions (5%) and acetic acid (10%), respectively; the lowest mass fraction of ash – in beef 0.64±0.01% and 0.68±0.01% for the treatment with formaldehyde (10%) and chlorine (chlorine activity 3%), respectively, in pork 0.89 ± 0, 01% and 0,90 ± 0,02% for treatment with a solution of hydrogen peroxide (5%) and alkaline detergents, respectively, in mutton and goat – 0.82 ± 0.04% and 0.78 ± 0.01% for treatment with potassium permanganate solutions (5%) and acetic acid (10%), respectively. The mass fraction of fat in beef of questionable freshness was significantly reduced by 1.24 times ($p \leq 0.001$), in beef treated with formaldehyde solution by 1.49 times ($p \leq 0.001$) and treated with chlorine solution by 1.43 times (g ≤0,001); in pork of questionable freshness, it is probably reduced by 1.40 times ($p \leq 0.001$), in pork treated with a solution of hydrogen peroxide (5%) by 1.59 times ($p \leq 0.001$), and in pork treated with alkaline detergents in 1.57 fold ($p \leq 0.001$); in mutton treated with potassium permanganate solution (5%) was 4,57 ± 0,17%, which is 1,60 times less ($p \leq 0,001$), in mutton of doubtful degree of freshness 1,22 times less ($p \leq 0,001$); in meatofgoat treated with acetic acid solution (10%) – 4,17±0,25% with a high degree of probability 1,65 times less ($p \leq 0,001$) and in low-fat meat of goat, a decrease in fat mass fraction (5.41±0.32%) was also observed, with a significant difference of 1.26-fold ($p \leq 0.001$) compared to control parameters.

Therefore, in order to obtain high-quality and safe meat with high nutritional and energy value for consumers, it is necessary to introduce a comprehensive system of state risk-oriented control of the detection of chemical hazardous factors, taking into account the requirements of the VACCP and TACCP systems when applying rapid patented methods for the production and circulation of meat of slaughtered animals.

1. Introduction

Innovative methods of testing their safety and quality must be put in place to monitor the activities of the slaughterhouse meat production, storage and circulation facilities.This will ensure that the food chain is properly monitored

in the traceability system, ie from the production of slaughtered meat to the sale in supermarkets, agri-food markets to the average consumer, and to monitor, evaluate and manage the risks involved in the production and circulation of food products [32, p. 203; 14, p. 3]. The authenticity of meat is currently receiving considerable attention in the multi-stage food chain from animal production on the farm to the consumption of the final food by consumers. The set of methods should include the analysis of the elementary and molecular components of the meat, including the chemical composition [22, p. 3].

Veterinary health inspectors can easily have developed express techniques for controlling the safety and quality of slaughtered meat for state risk-oriented controls on their production and handling facilities to verify compliance with food safety legislation and individual food quality indicators; as well as for state monitoring – to carry out a series of observations and measurements in accordance with the annual plan in order to obtain information on the national status of contaminants in the months of slaughtered animals for taking decisions on their basis and to take measures to improve the level of consumer health protection [24, p. 16].

Therefore, it is necessary to determine the nutritional value of such meat by its chemical composition, energy value, taste properties and digestibility [2, p. 19; 31, p. 2].

Topicality. In order to comply with good hygiene and production practices, the principles of HACCP system implementation, the basic provisions of the VACCP and TACCP systems for their use during the food chain at the facilities for the production and circulation of meat of slaughtered animals (beef, pork, lamb, goat), the system must be developed risk-oriented control of chemical hazardous factors using patented methods for detecting detergent residues [21, p. 19]. The operators of the market for the production and circulation of slaughtered animals must comply with food law at all stages of their production and circulation; to develop, implement and apply permanent GVP, GHP, GMP, GLP procedures based on the principles of hazard analysis and critical control points (HACCP systems) and to control hazardous factors, especially chemical ones, through the establishment of CTS at certain stages of food product [25, p. 21; 18, p. 3; 19, p. 5].

At slaughterhouse meat production facilities, the safety of biological, chemical and physical hazards is a top priority for consumers' health [1, p. 46; 5, p. 4; 30, p. 124].

After slaughter changes in meat, namely – the maturation of meat affects its biochemical, physical processes, tenderness, so the developed concept of maturing of meat with the use of optimal regimes at 0–4°C for 48 hours or at 2–4°C for 72 hours has a positive effect on the quality and energy value of raw meat [36, p. 76].

Scientists have developed the Australian Meat Standards Scheme (MSA) for lamb throughout the supply chain, taking into account carcass sorting, chemical performance and nutritional value [26, p. 47].

In case of non-observance of technological processes of slaughtered animal meat production, temperature, shelf life during storage and circulation, a number of irreversible biochemical changes (processes of deep autolysis) develop in the muscle tissue, accumulate toxic products – products of decomposition of proteins (amines, ammonia, indole, scatol) and lipids (volatile fatty acids, aldehydes, ketones) odor (suffocating-acidic), color gray-brown or gray-red for the formation of metmyoglobin, very consistent sluggish, developing microflora, resulting in reduced nutritional and organoleptic characteristics, destroys vitamins (except vitamin A), extractive nitrogen-containing and nitrogen-free compounds.Such slaughtered meat is not edible and is not allowed for sale [20, p. 62; 23, p. 4].

Detergents, if processed, increase the safety of slaughtered meat and prolong the shelf life of the product, eliminate the development of microflora. Deliberately damaging the meat of slaughtered animals with detergents can harm the brand and lead to illness and death from the use of such a product. Therefore, due to the proper control of meat at its production and circulation facilities, as well as the awareness of the service personnel for the use of detergents, their marking, storage, it is necessary to use the basic requirements of TACCP and VACCP systems [8, p. 7; 17, p. 4; 33, p. 6].

Alkaline detergents, including chlorine solution, act as antioxidants, and solutions of formaldehyde, hydrogen peroxide, potassium permanganate, acetic acid for use have a preserving effect – increase the shelf life and protect against the deterioration of bacteria, inhibit the development of other bacteria. microorganisms.

It has been proven that formaldehyde is hazardous to both human health and the environment, and it is officially recognized as a human carcinogen [27, p. 5].

Intentional processing of meat with a solution of acetic acid adjusts the pH of the medium, loosens the muscle tissue, while the treatment of

hydrogen peroxide bleaches muscle tissue and loosens, and when treated with a solution of potassium permangate darkens the muscle tissue and slightly loosens. Consumers using such meat of slaughtered animals for the deliberate treatment of detergents can have allergies, asthma, psoriasis, and some preservatives contribute to the development of malignancies, diseases of the digestive system, liver, kidney and skin diseases [4, p. 447; 35, p. 126].

International law regulates the installation of chemical reagents in foodstuffs when using a pollutant control system to assess the negative impact on the environment and consumers [6, p. 8; 7, p. 13].

Therefore, the question now is to develop rapid methods of controlling the chemical hazard in slaughtered animals in the case of detergents, and tests have been carried out to establish the chemical parameters and energy value of meat of different quality.

The purpose is to determine the effect of detergents on the chemical parameters and energy value of beef, pork, lamb and goat fresh, questionable freshness and processed by these means.

The task is to evaluate the chemical performance and energy value of the meat of slaughtered animals of different quality and in the case of treatment with detergents to hide the signs of its poor quality.

2. Materials and methods

The study included meat samples of slaughtered animals from the longest back muscle in the amount of 126, which were selected from the capacity of production and circulation of meat of slaughtered animals in the Kyiv region, which were fresh and questionable, as well as treated with detergents: beef – formaldehyde solution (10%) and chlorine solution (chlorine activity 3%) – at meat production capacity for 20, 21–22 days at temperatures from –2 to –3°C; pork – a solution of hydrogen peroxide with a mass concentration of 5% and alkaline detergents – on wholesale bases for storage for 20, 21–22 days at temperatures from –2 to –3°C; mutton – a solution of potassium permanganate with a mass concentration of 5% – on the agri-food market for 2, 3–4 days at temperatures from 0 to 6°C; goat – a solution of acetic acid (10%) – in the supermarket at 2, 3–4 days at temperatures (4±2)°C.

Preliminary tests have been carried out to determine the degree of freshness in accordance with conventional methods [15, p. 5; 28, p. 36] and by express patented techniques for establishing the treatment of detergents [3, p. 2].

The determination of the pH value in the meat-and-water extract was determined according to DSTU ISO 2917–2001 carried out by destructively measuring the pH value in a homogenized meat sample due to the measurement of the potential difference between the glass electrode and the reference electrode placed in the prepared meat sample [9, p. 4].

To detect the treatment of meat with a solution of formaldehyde (10%) used a mixture of concentrated nitric and sulfuric acids in a ratio of 1:25, which was applied to the surface of the muscle tissue of pork, beef, mutton, meat of goat with an area of 2.5x3.0 cm and through 4–6 minutes set color change: purple-red (with falsification by formaldehyde solution) or yellow-brown (in the absence of falsification).On this method obtained a Patent of Ukraine on utility model 81943, 2013 [3, p. 5].

To detect meat processing of chlorine solution (chlorine activity of 3%) used 2.0–2.1 cm^3 meat-water extract in the ratio of 1:2, to which reagents were added sequentially: 0.2–0.3 cm^3 solution potassium iodide with a mass concentration of 5.0%, 0.2–0.3 cm^3 solution of water-soluble starch with a mass concentration of 2.0% and 2.0–2.1 cm^3 of concentrated hydrochloric acid, and after 1–4 minutes the presence of color was established: blue (by adulteration with chlorine solution) or colorless (in the absence of adulteration). On this method obtained a Patent of Ukraine for utility model 81944, 2013 [3, p. 7].

To detect meat treatment with hydrogen peroxide solution (5%) used 0.5–0.6 cm^3 of concentrated sulfuric acid and 0.2–0.4 cm^3 of potassium iodine starch applied to the surface of muscle tissue of pork, beef, mutton, meat of goat with an area of 1.5x2.0 cm in size and after 1–5 minutes established the presence of color: light blue (by adulteration with a solution of hydrogen peroxide) or without color formation (in the absence of adulteration). On this method obtained a Patent of Ukraine for utility model 81945, 2013 [3, p. 9].

To detect the treatment with a solution of acetic acid (10%) used a 0.5–0.6 cm^3 of sodium hydroxide solution with a mass concentration of 0.1 mol/dm^3 and 0.1–0.2 cm^3 indicator of an alcohol solution of phenolphthalein with a mass concentration of 1% was applied to the surface of the muscle tissue of pork, beef, mutton, meat of goat with an area of 2.0x2.5 cm and after 0.5–1.0 minutes established the presence or absence of color: pink (by adulteration with acetic acid solution) or without color

formation (in the absence of fraud). On this method obtained a Patent of Ukraine for utility model 102019, 2015 [3, p. 11].

To identify the processing of meat with a solution of potassium permanganate used 0.4–0.5 cm^3 solution of sulfuric acid with a mass concentration of 0.5 mol/dm^3, which was applied to the surface of the muscle tissue of pork, beef, mutton, meat of goat size 2,0x2.5 cm and after 0.5–1.0 minutes the presence of color was determined: slightly pink (with falsification by a solution of potassium permanganate) or without color formation (in the absence of falsification). On this method obtained a Patent of Ukraine for utility model 102020, 2015 [3, p. 12].

To identify the processing of meat with alkaline detergent solutions used 0.2–0.3 cm^3 alcohol solution of bromothymol blue with a mass concentration of 0.04%, which was applied to the surface of the muscle tissue of pork, beef, mutton, meat of goat size 2,0x2,5 cm and after 2–3 seconds established the presence of light yellow color (negative reaction – no falsification) or the presence of blue-blue color of different intensity depending on the amount of alkaline detergents added:light blue (positive reaction) – the presence of alkaline detergents on the surface of muscle tissue up to 5.0%; blue-blue (positive reaction) – presence of application of alkaline detergents on the surface of muscle tissue more than 5,1%. On this method obtained a Patent of Ukraine for utility model 116831, 2017 [3, p. 14].

Tests were conducted to determine the chemical parameters (mass fraction of water, dry matter, fat, protein, ash), carbohydrate content, and energy value of slaughtered animal meat. The studies were conducted at the accredited Central Testing State Laboratory of the State Consumer Service in the Kyiv region and the city of Kyiv.

The mass fraction of water was determined according to DSTU ISO 1442: 2005 [10, p. 6] by mixing homogenized meat sample having a temperature of 25°C with sand and drying it at (103±2)°C, and then calculating the formula in percent.The mass fraction of dry matter in the meat of slaughtered animals was determined by calculating the difference of 100% and the mass fraction of water. Determination of mass fraction of fat (without conversion to dry matter) was performed by the Soxhlet method (without protein hydrolysis) according to DSTU ISO 1443:2005 [11, p. 3] by boiling the test sample of meat with dilute hydrochloric acid to release bound and unbound of lipid fractions, filtration of the resulting mass, drying

and extraction of the fat remaining on the filter using n-hexane or petroleum ether, and then subtracting the total fat content, expressed as a percentage by weight, were calculated by the formula. Determination of protein mass fraction (without solids) was performed by the Kjeldahl method according to DSTU ISO 937:2005 [12, p. 7] by determining the nitrogen content in meat by burning the test portion with concentrated sulfuric acid using copper sulfate (II) as a catalyst for conversion of organic nitrogen to ammonia ions, alkalization, distillation of released ammonia to excess boric acid solution, titration with hydrochloric acid to determine the ammonia bound by boric acid, and calculation of the nitrogen content in the sample, based on the amount of distilled ammonia.The nitrogen content, expressed as a mass fraction, in percent (%) is calculated by the formula, the conversion factor of the mass fraction of nitrogen to the mass fraction of protein is 6.25.

Determination of the mass fraction of ash (excluding dry matter) was carried out according to GOST 26226–1995 [16, p. 6] by determining the mass of the residue after burning the sample of meat and subsequent calcining and subtracting the mass fraction of crude ash in the percentage by the formula.Measurement of nutritional and energy value of meat was carried out in accordance with the Test procedure «Determination of energy and nutritional value in raw materials, products of animal and vegetable origin», approved. State Scientific Research Institute of Laboratory Diagnostics and Veterinary and Sanitary Examination, Minutes of the Academic Council No. 8 dated July 17, 2017 [34, p. 4]. The determination of the energy value in the meat of slaughtered animals was carried out by a calculation method with a preliminary determination of the nutritional value, namely proteins, fats, carbohydrates per 100 g of product.

Determination of nutritional value in the meat of slaughtered animals was to carry out physico-chemical studies to determine the mass fraction of fat, the mass fraction of protein, the mass fraction of solids and the mass fraction of ash, with subsequent determination of the calculated method of carbohydrates, namely the determination of carbohydrates by subtraction solids (dry residue) is the sum of the mass fractions of protein, fat and ash.

Determination of the energy value (calorie) of meat was determined by calculating the formula of already known nutrition information (mass of protein, carbohydrates, fat) using energy values (4.0 – 1 g of protein or 1 g of carbohydrates in the product, kcal/g; 9.0 – 1 g of fat in the product, kcal/g).

3. Chemical parameters and energy value of beef of different quality and for treatment with formaldehyde and chlorine solutions

It should be noted that, according to the conventional methods, beef at slaughterhouse capacities for storage for 20 days at –2 to –3°C corresponded to the parameters of fresh meat: the number of microorganisms in smears-prints from deep layers of muscles – 6±1, the reaction with copper sulfate is positive, the pH value is 5.76±0.02, the content of amino-ammonia nitrogen is 0.65±0.02. On 21–22 days, a doubtful degree of freshness of beef was established: the number of microorganisms in smear-prints from deep layers of muscles was 12±1, the reaction with copper sulfate was negative, the pH value was 5.97±0.01, the content of amino-ammonia nitrogen 1.28±0.02 mg.

Beef of questionable degree and treated with a solution of formaldenide (10%) for 21–22 days at temperatures of –2 to –3°C had the following parameters: the number of microorganisms in smears-imprints from deep layers of muscle – 12±1, the reaction with copper sulfate is negative, the pH value 6.32±0.01, amino-ammonia nitrogen content 1.29±0.02 mg.And the beef of questionable degree and treated with a solution of chlorine (chlorine activity of 3%) for 21–22 days at temperatures of –2 to –3 ºC had the following parameters: the number of microorganisms in smears-prints from deep layers of muscles – 12±1, the reaction from copper sulfate is negative, pH value is 6.29±0.01, the content of amino-ammonia nitrogen is 1.30±0.02 mg.

Table 1 presents the chemical parameters and the non-energy value of fresh, doubtful freshness and doubtful freshness for formaldehyde and chlorine treatment.

Table 1 shows that the mass fraction of water in beef of dubious freshness was not significantly increased by 1.01 times (by 0.73%), but in beef treated with formaldehyde and chlorine solutions for 21–22 days at temperatures from –2 to –3ºC was probably increased respectively by 1.10 times ($p \leq 0.001$) and 1.05 times ($p \leq 0.01$) compared to the control values (fresh beef) for 20 days at temperatures from –2 to –3 ºC. According to the increase in the mass fraction of water – the mass fraction of dry matter in beef of doubtful freshness is reduced by 1.02 times, in beef treated with formaldehyde solution (10%) – by 1.26 times ($p \leq 0.001$), in beef treated with chlorine solution (chlorine activity of 3%) is 1.11 times ($p \leq 0.001$) compared to the control values.

Table 1

Chemical parameters and energy value of beef of different quality and for treatment with formaldehyde and chlorine solutions, M ± m, n = 9

Chemical parameters	Beef of different quality			
	fresh beef (control)	beef of dubious freshness	beef treated with solution formaldehyde (10%)	Beef treated with chlorine solution (3% activity)
Mass fraction of water,%	66.84±0.66	67.57±0.61	73.60±0.62***	70.11±0.79**
Mass fraction of dry matter, %	33.16±0.49	32.43±0.52	26.40±0.51***	29.89±0.62***
Mass fraction of fat,%	6.45±0.18	5.13±0.10***	4.33±0.17***	4.51±0.15***
Mass fraction of protein,%	6.12±0.41	4.27±0.19***	3.08±0.17***	3.11±0.04***
Mass fraction of ash,%	1.08±0.01	0.84±0.01***	0.64±0.01***	0.68±0.01***
Carbohydrate content, g/100 g	19.51±0.56	23.19±0.63***	18.35±0.69	20.59±0.51
Energy value, kcal/ in 100 g	160.57±1.27	156.01±1.24*	124.69±1.11***	135.39±1.32***

Note: * – p≤0.05; ** – p≤0.01;*** – p≤0.001

The mass fraction of fat, protein and ash in beef of dubious freshness and treated with formaldehyde and chlorine solutions was likely to decrease. Thus, the mass fraction of fat in beef of questionable freshness was significantly reduced by 1.24 times (p≤0.001), in beef treated with formaldehyde solution – 1.49 times (p≤0.001) and treated with chlorine solution – 1.43 times (p≤0.001);the mass fraction of protein in beef of dubious freshness – 1.43 times (p≤0.001), in beef treated with formaldehyde solution – 1.99 times (p≤0.001) and treated with chlorine solution – 1.47 times (p≤0.001); the mass fraction of ash in beef of dubious freshness is 1.29 times (p≤0.001), in beef treated with formaldehyde solution – 1.69 times (p≤0.001) and treated with chlorine solution – 1.59 times (p≤0.001) compared to control metrics.

Carbohydrate content of beef of questionable freshness was significantly increased by 1.19 times (p≤0.001), and in beef treated with chlorine

solution it was not significantly increased by 1.06 times; in beef treated with formaldehyde solution not significantly reduced by 1.06 times.At the same time, the lowest energy value of the bulbs was set in beef treated with formaldehyde solution – 124.69±1.11 kcal/100 g and in beef treated with chlorine solution – 135.39±1.32. It should also be noted that the energy value of beef of dubious freshness and treated with formaldehyde and chlorine solutions was likely to decrease 1.03 times ($p \leq 0.05$), 1.29 times ($p \leq 0.001$) and 1.19 times ($p \leq 0.001$) respectively compared to fresh beef.

4. Chemical parameters and energy value of pork of different quality and for treatment with hydrogen peroxide solution and alkaline detergents

According to the conventional methods, pork on wholesale bases for storage for 20 days at temperatures of –2 to –3 ºC corresponded to the parameters of fresh meat: the number of microorganisms in smears-prints from deep layers of muscle – 7±1, the reaction with copper sulfate is positive, pH 5,80±0.02, amino-ammoniacal nitrogen content 0.72±0.02 mg. On 21–22 days, a doubtful degree of pork freshness was established: the number of microorganisms in smear-prints from deep layers of muscle was 12±1, the reaction with copper sulfate was negative, the pH value was 6.03±0.01, the content of amino-ammonia nitrogen 1,37±0.02 mg.The pork of doubtful degree and treated with a solution of hydrogen peroxide (5%) for 21–22 days at temperatures of –2 to –3°C had the following parameters: the number of microorganisms in smears-imprints from deep layers of muscles – 14±1, the reaction with copper sulfate negative, pH value 6.45±0.01, amino-ammonia nitrogen content 1.38±0.02 mg. And pork of doubtful degree and treated with alkaline detergents for 21–22 days at temperatures of –2 to –3°C had the following parameters: the number of microorganisms in smears-prints from deep layers of muscles – 15±1, the reaction with copper sulfate is negative, the pH value 6.74±0.01, amino-ammonia nitrogen content 1.39±0.02 mg.

Table 2 presents the chemical parameters and the non-energy value of pork fresh, dubious freshness and dubious freshness when treated with a solution of hydrogen peroxide and alkaline detergents.

From the table 2 shows that the mass fraction of water in pork of dubious freshness and treated with a solution of hydrogen peroxide and alkaline detergents for 21–22 days at temperatures from –2 to –3 ºC was significantly

Table 2

Chemical parameters and energy value of pork of different quality and for treatment with hydrogen peroxide solution and alkaline detergents, M ± m, n =9

Chemical parameters	Pork of different quality			
	fresh pork (control)	pork of doubtful freshness	pork treated with a solution of hydrogen peroxide (5%)	pork treated with alkaline detergents
Mass fraction of water,%	67.37±0.69	70.31±0.69**	71.90±0.63***	72.14±0.73***
Mass fraction of dry matter, %	32.63±0.60	29.69±0.67**	28.10±0.76***	27.86±0.63***
Mass fraction of fat,%	8.06±0.26	5.76±0.16***	5.06±0.24***	5.12±0.23***
Mass fraction of protein,%	6.63±0.12	5.41±0.17***	3.69±0.10***	3.71±0.11***
Mass fraction of ash,%	1.16±0.05	0.96±0.01**	0.89±0.01***	0.90±0.02**
Carbohydrate content, g/100 g	16.78±0.64	17.56±0.62	18.46±0.72	18.13±0.76
Energy value, kcal/ in 100 g	166.18±1.47	143.72±1.14***	134.14±1.29***	133.44±1.18***

Note: ** – p≤0.01; *** – p≤0.001

increased accordingly 1.04 times (p≤0.01), 1.07 times (p≤0.001) compared to controls.At the same time, the mass fraction of dry matter was probably reduced in pork of doubtful freshness by 1.10 times (p≤0.01), in pork treated with a solution of hydrogen peroxide (5%) and alkaline detergents, respectively 1.16 (p≤0.001) and 1.17 times (p≤0.001).

A high degree of probability (p≤0.001) of the mass fraction of fat, protein and ash was found in pork treated with a solution of hydrogen peroxide (5%), respectively, 1.59 times, 1.80 and 1.30 times compared to the control parameters. In pork of dubious freshness, the mass fraction was reduced: fat – by 1.40 times (p≤0.001), protein – by 1.23 times (p≤0.001), ash – by 1.21 times (p≤0.01).In pork treated with alkaline detergents and disinfectants also the mass fraction was reduced: fat – by 1.57 times (p≤0.001), protein – by 1.79 times (p≤0.001), ash – by 1.29 times (g ≤0.01).

The carbohydrate content of pork of questionable freshness and pork treated with hydrogen peroxide solutions (5%) and alkaline detergents was not significantly increased, respectively, by 1.05 times, 1.10 times and 1.08 times compared to the control indicators.The lowest energy value of pork was its treatment with alkaline detergents and a solution of hydrogen peroxide (5%) – 133,44±1,18 kcal/100 g and 134,14±1,29 kcal/100 g, respectively in 1,25 times ($p \leq 0.001$) and 1.24 times ($p \leq 0.001$) and in pork of doubtful freshness – 1.16 times ($p \leq 0.001$) less than the control indicators – fresh pork.

5. Chemical parameters and energy value of mutton of different quality and for treatment with potassium permanganate solution

According to the conventional methods of mutton for sale on the agro-food market for 2 days at temperatures from 0 to 6 ºC corresponded to the parameters of fresh meat: the number of microorganisms in smears-prints from deep layers of muscle – 6±1, the reaction with copper sulfate is positive, the pH value is 5,92±0.02, the content of amino-ammoniacal nitrogen 0.87±0.02 mg. On 3–4 days, a doubtful degree of mutton freshness was established: the number of microorganisms in smear-prints from deep layers of muscles was 16±1, the reaction with copper sulfate was negative, the pH value was 5.85±0.01, the content of amino-ammonia nitrogen 1.32±0.02mg. Mutton of doubtful degree and treated with a solution of potassium permanganate (5%) for 3–4 days at temperatures from 0 to 6°C had the following parameters: the number of microorganisms in smears-prints from deep layers of muscle – 17±1, the reaction with copper sulfate is negative, the value pH 5.41±0.01, amino-ammonia nitrogen content 1.29±0.02 mg.

Table 3 presents the chemical parameters and the energy value of fresh mutton, doubtful freshness and doubtful freshness when treated with potassium permanganate solution (5%).

Analyzing the table 3, it should be noted that the mass fraction of water in muttons of dubious freshness and lamb treated with a solution of potassium permanganate (5%) for 3–4 days at temperatures from 0 to 6°C, when sold on the agri-food market, was probably slightly increased, respectively, by 1.05. times ($p \leq 0.001$) and 1.08 times ($p \leq 0.001$) compared to the control indicators of fresh mutton.Accordingly, the mass fraction of

Table 3

Chemical parameters and energy value of mutton of different quality and for treatment with potassium permanganate solution, M ± m, n = 9

Chemical parameters	Mutton of different quality		
	fresh mutton (control)	Mutton of doubtful freshness	Mutton treated with potassium permanganate solution (5%)
Mass fraction of water,%	68.22±0.88	71.51±0.77**	73.63±0.69***
Mass fraction of dry matter, %	31.78±0.63	28.49±0.72**	26.37±0.77***
Mass fraction of fat,%	7.32±0.20	6.02±0.30***	4.57±0.17***
Mass fraction of protein,%	6.31±0.19	5.23±0.23**	3.47±0.15***
Mass fraction of ash,%	1.15±0.10	0.94±0.05*	0.82±0.04***
Carbohydrate content, g/100 g	17.00±0.83	16.30±0.81	17.51±0.71
Energy value, kcal/ in 100 g	159.12±1.37	140.30±1.38***	125.05±1.17***

Note: * – p≤0.05; ** – p≤0.01; *** – p≤0.001

dry matter in the studied mutton samples decreased somewhat: in mutton of doubtful freshness – by 1.12 times (p≤0.01), in lamb treated with potassium permanganate solution (5%) – by 1.21 times (p≤0,001) compared to control indicators.

The smallest mass fraction of fat, protein and ash were found in mutton treated with potassium permanganate solution (5%), respectively – 4.57±0.17%, 3.47±0.15 and 0.82±0.04%, respectively. had a high degree of probability (p≤0.001), respectively, 1.60 times, 1.82 and 1.40 times compared to the control indicators.In the mutton of doubtful degree of freshness, there was also a probable decrease of mass particles of fat, protein and ash by 1.22 times (p≤0.001), 1.21 times (p≤0.01) and 1.22 times (p≤0,05) compared to control indicators.

Carbohydrate content of mutton of doubtful freshness was reduced by 1.13 times, and in mutton treated with potassium permanganate solution

(5%) increased by 1.03 times compared to the control parameters, but the difference was not significant. The highest energy value was found in fresh mutton – 159.12±1.37 kcal/100 g, and the lowest in mutton treated with potassium permanganate solution (5%) – 125.05±1.17 kcal/100 g, which in 1,27 times (p≤0,001) less than the control indicators. Mutton of dubious freshness also has a high degree of probability of energy value of 1.04 times (p≤0.001) compared to the control indicators.

6. Chemical parameters and energy value of meat of goat of different quality and treatment with acetic acid solution

According to the conventional methods, meat of goat when sold on the agro-food market for 2 days at temperatures from 0 to 6 ºC corresponded to the parameters of fresh meat: the number of microorganisms in smears-prints from deep layers of muscle – 5±1, the reaction with copper sulfate is positive, the value is positive 5.82±0.02, amino-ammonia nitrogen content of 0.77±0.02 mg. On 3–4 days, a doubtful degree of freshness of the meat of goat was established: the number of microorganisms in smears-imprints from deep layers of muscle 13±1, the reaction with copper sulfate negative, pH value 5.78±0.01, the content of amino-ammonia nitrogen 1.34±0.02mg. The goat of questionable degree and treated with acetic acid solution (10%) for 3–4 days at temperatures from 0 to 6°C had the following parameters: the number of microorganisms in smears-prints from deep layers of muscles – 14±1, the reaction with copper sulfate negative, pH value 5.61±0.01, amino-ammonia nitrogen content 1.35±0.02 mg.

Table 4 presents the chemical parameters and the non-nutritive value of fresh meat of goat, doubtful freshness and doubtful freshness when treated with acetic acid solution (10%).

From the data table 4 it was found that in meat of goat of doubtful freshness and goat treated with acetic acid solution (10%) for 3–4 days at temperature (4±2)°C an increase of mass fraction of water was found, respectively, 1.02 times and 1.08 times (p≤0,001) compared to control indicators.Accordingly, the mass fraction of dry matter in the studied samples of goat meat decreased: in the goat of doubtful freshness – by 1.03 times, and in the goat treated with a solution of potassium permanganate (5%) – by 1.19 times (p≤0.001) compared to the control parameters.

Table 4

Chemical parameters and energy value of meat of goat of different quality and treatment with acetic acid solution, M ± m, n = 9

Chemical parameters	Meat of goat of different quality		
	fresh meat of goat (control)	meatof goat of doubtful freshness	meat of goattreated with acetic acid solution (10%)
Mass fraction of water,%	65.98±0.68	67.13±0.82	71.44±0.71***
Mass fraction of dry matter, %	34.02±0.73	32.87±0.49	28.56±0.70***
Mass fraction of fat,%	6.82±0.11	5.41±0.32***	4.17±0.25***
Mass fraction of protein,%	5.71±0.21	4.55±0.18***	3.29±0.17***
Mass fraction of ash,%	1.13±0.05	0.91±0.02**	0.78±0.01***
Carbohydrate content, g/100 g	20.36±0.75	22.00±0.79	20.32±0.77
Energy value, kcal/ in 100 g	165.66±1.30	154.89±1.25***	131.97±1.22***

Note: ** – p≤0.01; *** – p≤0.001

It should be noted that the smallest mass fraction of fat (4.17±0.25%), protein (3.29±0.17%) and ash (0.78±0.01%) were detected in meat of goat treated with vinegar solution acid (10%) and a high degree of probability (p≤0.001) was found to be 1.65 times, 1.74 times and 1.45 times, respectively, compared to control indicators.Reduced mass fractions of fat (5.41±0.32%), protein (4.55±0.18%) and ash (0.91±0.02%) were also found in the goat of doubtful freshness, with a significant difference of 1.26 times (p≤0.001), 1.25 times (p≤0.001) and 1.24 times (p≤0.01) compared to control indicators. Carbohydrate content was slightly increased in the meat of goat of doubtful freshness by 1.08 times, and in the goat treated with a solution of acetic acid (10%) – slightly reduced compared to the control indicators, but no significant difference was found. The highest energy value was set in fresh meat of goat – 165.66±1.30 kcal/100 g, and the lowest in goat treated with acetic acid solution (10%) – 131.97±1.22 kcal/100 g, which in 1,26 times (p≤0,001)

less than the control indicators. In the meat of goat of doubtful freshness, a high degree of probability of energy value was also established at 1.07 times ($p \leq 0.001$) compared to the indicators of control – fresh meat of goat.

It is necessary to apply the methods of control of meat and meat products in the legislative field, since they are the source of high nutritional values proteins, minerals, vitamins to improve the growth of profitability of the meat industry and the efficient use of available resources [29, p. 65]. The mass fraction of fat, protein and ash in pork of questionable freshness and pork treated with hydrogen peroxide solutions (5%) and alkaline detergents were significantly reduced. This is due to the fact that volatile fatty acids, ammonia, ketones, etc. are formed during the spoiling of meat and the treatment of disinfectants [22, p. 13; 35, p. 125]. The use of rapid patented methods for detecting chemical agents in the meat of slaughtered animals, namely detergents for the elimination of signs of spoilage, is important for the use of simple tests in the veterinary medicine specialists in accredited public service laboratories [13, p. 5].

Therefore, it is necessary for veterinary medicine or veterinary inspectors to supervise the terms of storage and sale of slaughtered animals' meat at production facilities and wholesale bases above the set time of 20 days at temperatures –2–3°C; in the agro-food markets for 2 days at temperatures from 0 to 6 °C; in supermarkets for 2 days at temperatures (4±2)°C, use express patented methods of establishing the processing of meat with detergents to hide the signs of spoilage, the expulsion of meat as a result of changing the label. Therefore, we have developed a comprehensive system of state risk-oriented control of the detection of chemical hazardous factors, taking into account the requirements of VACCP and TACCP systems [5, p. 2; 21, p. 20; 32, p. 204] when applying express patented methods at the facilities for the production and circulation of meat of slaughtered animals.

7. Conclusions

1. In order to obtain high-quality and safe meat with high nutritional and energy value for consumers, it is necessary to introduce a comprehensive system of state risk-oriented control for the detection of chemical hazardous factors, taking into account the requirements of VACCP and TACCP systems when applying rapid patented production facilities animals, storage (wholesale bases) and circulation (agri-food markets, supermarkets, shops).

2. The lowest energy value of meat of slaughtered animals in doubtful degree of freshness and treatment with detergents was set respectively in beef – 156.01±1.24 and 124.69±1.11, 135.39±1.32 kcal/100 g (for treatment with formaldehyde solutions (10%) and chlorine (chlorine activity 3%) – at meat production capacity for 21–22 days at temperatures from –2 to –3°C; in pork – 143.72±1.14 and 134.1±1.29, 133.44±1.18 kcal/100 g (for treatment with hydrogen peroxide solution (5%) and alkaline detergents) – at wholesale storage bases for 21–22 days at temperatures from –2 to –3°C; in mutton – 140,30±1,38 and 125,05±1,17 kcal/100 g (for treatment with potassium permanganate solution (5%) – for sale in the agro-food market for 3–4 days at temperatures from 0 to 6°C; in meat of goat – 154.89±1.25 and 131.97±1.22 kcal/100 g (for treatment with acetic acid solution (10%) – for sale in the supermarket for 3-4 days at temperatures (4 ± 2)°C.

3. The largest mass fraction of water was found in beef 73.60±0.62% for formaldehyde treatment (10%), mutton 73.63±0.69% for potassium permanganate solution (5%), pork 72.14±0,73% for treatment with alkaline detergents,in meatofgoat 71.44±0.71% for treatment with acetic acid solution (10%); the smallest mass fraction of fat – in beef 4.3 ±0.17% for treatment with formaldehyde solution (10%), in pork 5.06±0.24% for treatment with hydrogen peroxide solution (5%), in mutton4.57±0,17% for treatment with potassium permanganate solution (5%), in meat of goat 4,17±0,25% for treatment with acetic acid solution (10%).

4. The mass fraction of fat in beef of questionable freshness was significantly reduced by 1.24 times ($p \leq 0.001$), in beef treated with formaldehyde solution by 1.49 times ($p \leq 0.001$) and treated with chlorine solution by 1.43 times ($g \leq 0,001$); in pork of questionable freshness, it is probably reduced by 1.40 times ($p \leq 0.001$), in pork treated with a solution of hydrogen peroxide (5%) by 1.59 times ($p \leq 0.001$), and in pork treated with alkaline detergents in 1.57 fold ($p \leq 0.001$); in mutton treated with potassium permanganate solution (5%) was 4,57±0,17%, which is 1,60 times less ($p \leq 0,001$), in mutton of doubtful degree of freshness 1,22 times less ($p \leq 0,001$); in meat of goattreated with acid solution (10%) – 4.17±0.25% with a high degree of probability 1.65 times less ($p \leq 0.001$) and in meat of goat of doubtful freshness, fat mass fractions were also observed (5, 41±0.32%) with a probable difference of 1.26 times ($p \leq 0.001$) compared to the control indicators.

5. The smallest mass fraction of protein was found in beef 3.0±0.17% and 3.11±0.04% for treatment with formaldehyde solutions (10%) and chlorine (chlorine activity 3%), respectively, in pork 3.69±0,10% and 3.71±0.11% for treatment with hydrogen peroxide solution (5%) and alkaline detergents, respectively, in mutton and meat of goat – 3.47±0.15% and 3.29±0.17% for treatment with solutions of potassium permanganate (5%) and acetic acid (10%), respectively; the lowest mass fraction of ash is 0.64 ± 0.01% in beef and 0.68 ± 0.01% in the case of formaldehyde (10%) and chlorine (chlorine activity 3%), respectively, in pork 0.89±0,01% and 0,90±0,02% for treatment with hydrogen peroxide solution (5%) and alkaline detergents, respectively, in mutton and meat of goat – 0,82±0,04% and 0,78±0,01% for treatment with potassium permanganate solutions (5%) and acetic acid (10%), respectively.

References:

1. Bashinsky, V.V., Ostapyuk, M.P., & Semenchuk, O.S. (2009). Requirements of European food law: Collection of information materials. Kyiv: Vetinform LLC, 1, 327 p. (in Ukrainian)

2. Benet, J.J., & Bellemain, V. (2005). Responding to consumer demands for safe food: a major role for veterinarians in the 21st Century. In Proc. Seminar 28th World Veterinary Congress: 'Challenges in responding to new international and social demands on the veterinary profession', 17 July, Minneapolis, Minnesota. World Organisation for Animal Health (OIE), Paris, 17–29. Available at: www.oie.int/doc/ged/D1965.PDF (accessed 15 May 2020).

3. Bogatko, N.M. (2019). Control of the of safety meat of slaughtered animals dbring the establishment of falsification by express methods: scientific and methodical recommendations. Bila Tserkva, 24 p. (in Ukrainian)

4. Goodwin, J., & Shoulders, C. (2013). The future of meat: A qualitative analysis of cultured meat media coverage. *Meat Science*, 95(3), 445–450. doi: 10.1016/j.meatsci.2013.05.027.

5. Codex Alimentarius Comission. Risk Analisis Policies of the CAC. Report of the Session of the CAC. Geneva. Switzerland. 2-7 July. 2001. CAC. Rome. Italy. Available at: http://www.fao.org/tempref/codex/Reports/ Alinorm01/al01_12e.pdf

6. Council Directive 320/88/ EEC of 9 June 1988 on the approximation of the laws of the EU Member States relating to the inspection and verification of compliance with established rules for laboratories (UPL) (88/320/ EEC) to carry out the organizational procedures and conditions under which plans, conditions, the results of tests of chemicals used in industry to assess the effects of such substances on humans, animals and the environment are recorded and presented. Available at: http://www.reachteam.eu/chinese/REACH-ME/engine/sources/directivathe radiation-320-1988-EC.html (in Ukrainian)

7. Council Directive 23/96 of 29 April 1996 on the control measures for certain substances and their residual content in live animals and products of animal origin, adopted in violation of EEC Directives 85/358 and Decisions 89/187/EEC and 91/664/ EEC. Available at: http://www.reachteam.eu/chinese/REACH-ME/engine/sources/directiva the radiation-23-1996-EC.html (in Ukrainian)

8. 8 DSTU GOST 31340:2009. Warning marking of chemical products. General requirements. [Effective 2010-01-01]. Kyiv, 2010, 16 p. (National Standards of Ukraine). (in Ukrainian)

9. DSTU ISO 2917–2001. Meat and meat products. Determination of pH (control method). (ISO 2917: 1999, IDT). [Valid from 2003-10-01]. Kyiv, 2002, 6 p. (National Standards of Ukraine). Available at: https://zakon.rada.gov.ua/laws/show/z0524-02 (in Ukrainian)

10. DSTU ISO 1442:2005. Meat and meat products. The method of determining the moisture content. (ISO 1442: 1973, IDT). [Effective 2007-04-01]. Kyiv, 2007, 8 p. (National Standards of Ukraine). (in Ukrainian)

11. DSTU ISO 1443:2005. Meat and meat products. The method of determining the total fat content. (ISO 1443: 1973, IDT). [Effective 2007-04-01]. Kyiv, 2007, 4 p. (National Standards of Ukraine). (in Ukrainian)

12. DSTU ISO 937:2005. Meat and meat products. Determination of nitrogen content (control method). (ISO 937: 1978, IDT). [Effective 2007-07-01]. Kyiv, 2007, 8 p. (National Standards of Ukraine). (in Ukrainian)

13. DSTU ISO/IEC 17025–2002. General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025: 1999, IDT). [Valid from 2002-01-01]. Kyiv, 2002, 66 p. (National Standards of Ukraine). (in Ukrainian)

14. European Food Rapid Response System. Available at: https://ec.europa.eu/food /safety/rasff_en

15. GOST 23392−2016. Meat. Methods of chemical and microscopic analysis of freshness. [Effective 1980–01–01]. Kyiv, 2016, 7 p. (Interstate standard). (in Ukrainian)

16. GOST 26226–1995. Feed, compound feed, compound feed. Methods for determining crude ash. [Introduction 1998-01-01]. Kyiv, 1997, 8 p. (Interstate standards). (in Russian)

17. ISF Advisory Program in Europe and Central Asia. ISF Food Safety in Ukraine Project. Implementation of food safety management systems at Ukrainian food industry enterprises. Kyiv, 2011, 20 p.

18. Khmel, V.M., Griftsova, Y.L., & Prikhodko, N.I. (2005). HACCP: Hazardous Factors Analysis and Critical Control Points in Food and Raw Materials Production: A Teaching Method. manual. Kyiv: State Enterprise «UkrNDNTS», 70 p. (in Ukrainian)

19. Khmel, V.M., Barabola, L.O., & Kalita, O.V. (2006). Recommendations for the implementation of the HACCP system in the meat processing industry of Ukraine: a teaching method. manual. Kyiv: State Enterprise "UkrNDNTS", 122 p. (in Ukrainian)

20. Langelaan, M., Boonen, K., Polak, R., Boaijens, F., Post, M. & van der Schaft, D. (2010). Meet the new meat: tissue engineered skeletal muscle. *Trends Food Sci. Technol*., 21(2), 59–66. doi: 10.1016/j.tifs.2009.11.001

21. Mallett Richard (2012). From secure factory perimeters to secure food supplies. From HACCP to TACCP and VACCP. *HACCP International. Food Safety bulletin*, 12, 18–20.

22. Monohan, F.J., Schmidt, O., Moloney, A.P. (2018). Meat provenance: Authentication of geographical origin and dietary background of meat. *Meat science*, 144, 2–14. doi: 10.1016/j.meatsci.2018.05.008

23. Nutritional and biological value of meat and meat products. Available at: https://studopedia.org/13-118914.html (in Ukrainian)

24. On State Control of Compliance with Food, Feed, Animal By-Products, Animal Health and Welfare: Law of Ukraine. BP information dated 18.05.2017, № 2042-VIII. Available at: https://zakon.rada.gov.ua/laws/show/2042/2018BP (in Ukrainian)

25. On the basic principles and requirements for food safety and quality: Law of Ukraine. BP information dated 23.12.97 No. 771/97–BP as amended on 24.10.02; as amended by Law No. 2809-IV of 6 September 2005; as amended by Law No. 2042-VIII, OIA, 2017, No. 31. Available at: https://zakon.rada.gov.ua/laws/771/97-BP/edition 04.04.2018/ (in Ukrainian)

26. Pannier, L., Gardner, G.E., O'Reilly, R.A., Pethick, D.W. (2018). Factors affecting lamb eating quality and the potential for their integration into an MSA sheepmeat grading model. *Meat Science*, 144, 43–52. doi: 10.1016/j.meatsci.2018.06.035

27. Regulation (EC) No 648/2004 of the European Parlament and of the Council on detergents. Available at: https://zakon.rada.gov.ua/laws/show/994-961 (in Ukrainian)

28. Rules for the pre-mortem veterinary inspection of animals and the veterinary examination of meat and meat products. Order of the State Department of Veterinary Medicine of June 28, 2002 No. 28; register. in the Ministry of Justice of Ukraine from 21.06. 2002 under No. 524/6812. Available at: https://zakon.rada.gov.ua/laws/show/z0524-02. (in Ukrainian)

29. Sarah, A. Lynchab, Anne Maria, Mullena Eileen O'Neill, Liana Drummond, Carlos Álvareza (2018). Opportunities and perspectives for utilisation of co-products in the meat industry. *Meat Science*, 144, 62–73. doi: 10.1016/j.meatsci.2018.06.019

30. Shekhar, Chandra (2016). The role of veterinarians in quality meat production. *Vet. Sci. Res. J*., 7(2), 122–128. doi: 10.15740/HAS/VSRJ/7.2/122-128

31. Slorach, S, Maijala, R, Belveze I. (2002). Exampeies of comprehensive and integrated approach to risk analysis in the food chain experiences and learned. Conference paper FAO/ European Conference on Food safety and Quality. Budapest. Hungary, 25–28 February. 2002. Available at: http://www.fao.org/3/a-y3696e.pdf

32. Stibel, B., & Simonov, M. (2018). Food safety management. Lviv, LLC «Galician Publishing Union», 230 p. (in Ukrainian)

33. Technical Regulation of detergents. Close Resolution of the Cabinet of Ministers of Ukraine dated 20.08.2008 No. 717; amending the Resolution of the Cabinet of Ministers of Ukraine dated 12.06.2013 year, making changes No. 88 from 12.02.2020 year. Available at: https://zakon.rada.gov.ua/laws/show/717-2008 (in Ukrainian)

34. Test procedure. Determination of energy and nutritional value in raw materials, products of animal and vegetable origin. Approved by the Scientific Research Institute of Laboratory Diagnostics and Veterinary and Sanitary Examination, Minutes of the Academic Council № 8 dated 17.07.2017, 5 p. (in Ukrainian)

35. Tsehmistrenko, S.I., Tsehmistrenko, O.S. (2014). Biochemistry of meat and meat products. Bila Tserkva, 192 p. (in Ukrainian)

36. Yuan, H. Brad Kim, Danyi, Ma, Derico, Setyabrata, Mustafa, M. Farouk, Steven M. Lonergan, Elisabeth, Huff-Lonergan, Melvin, C. Huntd (2018). Understanding postmortem biochemical processes and post-harvest aging factors to develop novel smart-aging strategies. *Meat Science*, 144, 74–90. doi: 10.1016/j.meatsci.2018.04.031