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IRYNA SIMONOVA, BOHDAN TSIZH, ULIANA DRACHUK,
BOHDAN HALUKH, IRYNA BASARAB, HALYNA KOVAL,
ROSTYSLAV VOLOSHYN, LIUDMYLA PESHUK

THE UTILIZATION OF NEW TYPES OF MARINADES BASED ON FRUIT RAW MATERIAL FOR USE IN THE TECHNOLOGY OF SEMI-FINISHED RABBIT MEAT

S u m m a r y

Background. All over the world, rabbit meat is in consumer demand for its excellent nutritional properties, well-balanced amino acid composition, high content of minerals and vitamins. One of the stages of technological processing of semi-finished products from rabbit meat is the technological process of pickling, which ensures the formation of the necessary technological and consumer properties of raw materials, as well as finished products. The use of viburnum juice and sea buckthorn puree can act as a promising source of raw materials for marinating meat semi-finished products.

Results and conclusions. Two samples of marinades were produced: based on viburnum juice and sea buckthorn puree. It was established that the optimal amount of salt for use in the marinade is 10 %, which ensures the production of dietary meat products with a low salt content of 2.2 %. The most favorable for sensory sensations in marinades will be the amount of viburnum juice of 20 % and sea buckthorn puree of 30 % will be the most favorable for sensory sensations in marinades. The optimal time for keeping rabbit meat in a marinade based on viburnum juice and sea buckthorn puree is 12 days, because during this time the marinade has the best effect on the structure of the meat fibers, it becomes soft and tender. Marinating semi-finished rabbit meat in these marinades increases the ability of the meat to bind water, which reduces losses during heat treatment and they are 40.62 and 44.83 % (3^{rd} day), 39.34 and 42.78 % (9^{th} day), 38.97 and 39.57 % (12^{th} day).

Keywords. Marinades, viburnum, sea buckthorn, semi-finished products, rabbit meat

Dr inż. I. Simonova ORCID: 0000-0001-8775-219X, Katedra Technologii Mięsa, Mięsnych i Olejowo-Tłuszczowych Wyrobów, Wydział Technologii Żywności i Biotechnologii, Lwowski Narodowy Uniwersytet Medycyny Weterynaryjnej i Biotechnologii im. S.Z. Gżyckiego, ul. Pekarska 50, 79010 Lwów, Ukraina; dr hab. inż., Prof. UKW B. Tsizh ORCID: 000-0002-1319-1016, Katedra Materiałów Konstrukcyjnych i Biomateriałów, Wydział Inżynierii Materiałowej, Uniwersytet Kazimierza Wielkiego w Bydgoszczy, ul. Chodkiewicza 30, 85-064, Bydgoszcz; dr inż. U. Draczuk ORCID:0000-0002-2737-5967; dr inż. B. Halukh ORCID: 0000-0002-7824-4983; dr inż. I. Basarab ORCID: 0000-0002-5487-2790; dr H. Koval ORCID: 0000-0002-7120-9253; Dr R. Voloshyn ORCID: 0009-0002-6819-6196, Katedra Technologii Mięsa, Mięsnych i Olejowo-Tłuszczowych Wyrobów, Wydział Technologii Żywności i Biotechnologii, Lwowski Narodowy Uniwersytet Medycyny Weterynaryjnej i Biotechnologii im. S.Z. Gżyckiego, ul. Pekarska 50, 79010 Lwów, Ukraina; dr hab., Prof. L. Peshuk ORCID: 0000-0002-0967-8892, Katedra Technologii Żywności, Narodowy Uniwersytet Olesia Honczara Dnipro, Aleja Gagarina, 72, 49000 Dnipro, Ukraina. Kontakt e-mail: tsizhb@ukw.edu.pl

Introduction

Meat has always been and will be the primary irreplaceable source of animal proteins, biologically active substances, and one of the most demanded food products. Modern approaches to creating meat products are modeling organoleptic and technological indicators, resulting in a food product acceptable to the modern consumer [11].

All over the world, rabbit meat is in consumer demand for its excellent nutritional properties, well-balanced amino acid composition, and high content of minerals and vitamins. The saturated fatty acids and cholesterol content are not high in rabbit meat [14]. The muscle fibers of rabbit meat are characterized by good digestibility due to the thin fiber structure of the muscle fiber. Therefore, such meat is considered a valuable dietary product with no contraindications to consumption [9]. In the period 2010 ÷ 2020, global rabbit meat production decreased by 24.1 %. A great reduction in rabbit meat production was observed in Europe (-41.2 %), while increases occurred in Africa (+23.5 %). China and the Democratic People's Republic of Korea are the top two producers [22].

Since meat and meat products are a suitable environment for the development of bacteria, yeasts and molds that deteriorate its quality and cause spoilage, manufacturers are increasingly using various methods of processing and preserving meat to inactivate or inhibit the growth of microorganisms to preserve its organoleptic indicators, extending the product's shelf life and ensuring its quality and safety.

One of the stages of the technological processing of semi-finished products from rabbit meat is pickling. Pickling is used to produce semi-finished pork, beef and poultry products. The marinade is a liquid or dry mixture of spices, salt and acid. Salt and acid are the main marinade components that affect the technological characteristics, organoleptic properties and output. First, these components give the product specific organoleptic and technological properties [5]. In addition to salt, marinades include spices, herbs, flavorings, enzymes and vegetable oil. Today, marinating meat products is often used to extend their shelf life [12].

Rabbit meat has high protein content, low fat content, a high percentage of unsat urated fatty acids, and low cholesterol and sodium levels. Rabbit meat has relatively higher energy values (899 kJ/100 g in the forelegs and 603 kJ/100 g in the loin), which is equivalent to that of many types of red meat typically consumed. This is because of its high protein contents, which provide 80 % of the total energy of the human diet. Therefore, rabbit meat is highly recommended for pregnant women, adolescents and aged people [22].

Marinades based on pomegranate and grape juices are well-known for poultry. In particular, studies by Gök and Bor [12] established that the use of marinades affects the reduction of the hardness of turkey meat after heat treatment. Balmaceda et al. [4] investigated the influence of marinades based on mustard and wine with spices on rabbit

meat, namely the change in the total number of anaerobic psychrotrophic microorganisms, yield, color, pH, texture and sensory characteristics. They established that pickling with mustard and wine with spices makes it possible to get products with high organoleptic indicators and desirable physicochemical and microbiological characteristics [4]. However, the influence of viburnum juice and sea buckthorn puree in marinades on rabbit meat is poorly studied, which determines the relevance of this research.

The pickling process, together with salting, ensures the formation of the necessary technological (moisture-binding capacity, elasticity, resistance to destruction, tenderness) and consumer (taste, aroma, color, consistency) properties of raw materials, in particular rabbit meat, as well as finished products [21].

Among many dietary supplements available on the market, many countries prefer supplements that include natural ingredients. The use of food acids in the product regulates the pH of the food system during production. Food acids, interacting with the components of raw materials, give the product a pleasant specific taste and aroma and partially break down proteins and fats, which gives the products a delicate structure and a spicy taste [19].

The fruit of plants can be promising raw materials for the development of new types of marinades since they include organic acids and substances characterized by antioxidant properties, and this, in turn, will contribute to the production of trendy products, including for young people, with improved organoleptic properties and extended shelf life-storage [21]. Fruit raw materials claim the status of eco-products since they grow without using various pesticides, hence they can be an alternative and safe raw material for producing new food products, particularly marinades [16].

Common viburnum (*Viburnum opulus*), widespread in Europe, deserves special attention. Viburnum fruit contains carbohydrates (sucrose, fructose, glucose, mannose, galactose, xylose, rhamnose, arabinose, polysaccharides, pectin), organic acids; triterpenoids (α-amyrin and β-amyrin derivatives, oleanolic and hederagenic acids and their acetyl derivatives, ursolic acid), steroids (β-sitosterol); vitamins C, carotenoids, phenolic acids and their derivatives (chlorogenic, neochlorogenic, derivatives of n-dihydroxycinnamic acid), tannins; catechins; flavonoids (quercetin, kaempferol, peonoside), anthocyanins (sambucin); higher fatty acids (myristic, palmitic, stearic, oleic, linoleic, linolenic, arachinic, behenic, lignoseric, cerotic) [15, 17, 20].

Sea buckthorn fruit (*Hippophae rhamnoides L.*) consists of pulp (68 %), seeds (23 %) and skin (7.75 %). Its moisture content ranges from 80 to 87 %. Carotenoids found in the fruit – 0.02 %: phytofluin, β-carotene, γ-carotene, poly-cis-lycopene B, lycopene, zeaxanthin, neocarotene, lutein, cryptoxanthin, isocryptoxanthin, violaxanthin, neoxanthin; vitamins: C – up to 270 mg %, E, B1, B2, B6, B9, B12, K1; carbohydrates and related compounds – 1 ÷ 3.26 %: glucose – 1.27 ÷ 1.8 %, fructose – 0.71 ÷ 2.33 %, sucrose – 0.07 ÷ 0.3 %, pectin – 0.15 ÷ 5.5 %, polysaccharides – 2.5 %;

cyclitols: quebrachite – 0.35 %; organic acids – 1.04 ÷ 4.46 %: malic, oxalic, tartaric; triterpenoids: ursolic acid – 1.34 ÷ 1.6 %, oleanolic acid; phenolic acids and their derivatives (chlorogenic); flavonoids: isorhamnetin, rutin, 3-rutinoside of isorhamnetin, 3-O-β-D-glucopyranoside and 3-O-β-D-glucopyranosido-7-O-α-L-L-rhamnopyranoside of isorhamnetin, quercetin, myricetin; catechins; leucoanthocyanins; tannins – 0.025 ÷ 0.53 %; higher fatty acids; nitrogen-containing compounds: betaine; macro- and microelements: K, Ca, Mg, Fe, Zn, Cu, Mn, B, J. The fruit contains fatty oil – 1.89 ÷ 13.7 %, which includes palmitoleic, palmitic, oleic, linoleic glycerides, linolenic and other fatty acids; steroids – 2.4 ÷ 2.6 %: β-sitosterol, stigmasterol; vitamins: E, K1, carotenoids; phospholipids – 1 ÷ 1.8 %, in the hydrolyzate – lecithin, cephalin, triacylglycerols [3, 24].

Taking into account the chemical and vitamin content of the viburnum and sea buckthorn fruit described above, adding it to rabbit meat marinades can significantly improve the taste of ready-made products, will enrich the chemical composition of finished products, improve technological and organoleptic indicators, and extend the shelf life.

Therefore, the purpose of our research was to find the optimal technology for making marinades based on viburnum juice and sea buckthorn puree for the production of semi-finished products from rabbit meat. In this regard, to solve the goal set, it is necessary to perform the following tasks:

- to establish the optimal amount of salt to be used in marinades, which will ensure obtaining dietary meat products with a low salt content;
- to determine the optimal concentration of viburnum juice and sea buckthorn puree in marinades;
- to establish the term of keeping semi-finished products from rabbit meat in marinades and its effect on changes in moisture retention capacity and moisture loss during the heat treatment of semi-finished products from rabbit meat.

Materials and methods

Rabbit meat (carcasses and their parts) was used for the research [23]. A 200 g sample was chosen. To determine the amount of NaCl and fruit raw materials in the marinades, a control sample (K) was prepared (dorsal-lumbar part of the rabbit, to which NaCl solution was added in concentrations from 8 to 12 % and 2 g of citric acid, dry spicy-aromatic plants (thyme – 0.1 %, motherwort – 0.1 %, rosemary – 0.1 %, basil – 0.1 %,), and experimental samples: marinade based on viburnum juice (MV) (back-lumbar part of the rabbit, to which NaCl was added in concentrations from 8 to 12 % and 2 g of citric acid, viburnum juice, in concentrations from 10 to 40 %, dry spicy-aromatic plants (thyme – 0.1 %, motherwort – 0.1 %, rosemary – 0.1 %, basil – 0.1 %), and a marinade based on sea buckthorn puree (MB) (back-lumbar part of a rabbit to

which NaCl was added in concentrations from 8 to 12 % and 2 g of citric acid, sea buckthorn puree in concentrations from 10 to 40 %, dry spicy-aromatic plants (thyme – 0.1 %, motherwort – 0.1 %, rosemary – 0.1 %, basil – 0.1 %).

The influence of viburnum juice and sea buckthorn puree in marinades on changes in organoleptic parameters was studied based on a sensory analysis. The experimental samples of ready-made semi-finished products from rabbit meat aged in marinades with viburnum juice and sea buckthorn puree in the amounts from 10 to 40 % were evaluated using the following parameters: appearance, consistency, smell, aroma, taste, juiciness of the experimental samples after heat treatment. The tasting commission comprised seven members of the Department of Technology of Meat, Oil and Fat Products of the Stepan Gzhytskyi National University of Veterinary Medicine and Biotechnologies Lviv members.

Organoleptic tests were performed before and after heat treatment. Heat treatment of semi-finished products from rabbit meat in the "Agro-term" oven: they were baked at a temperature of 110 ± 1 °C for 90 minutes until the temperature in the center of the products reached 76 ± 1 °C. It was cooled with cold air to a temperature of 8 °C.

The viburnum juice-based marinade was prepared as follows: The berries were freed from the bunch and frozen at a temperature of 18 °C to remove saponin glycosides that affect the taste. Next, the raw material was thawed at 20 °C and pressed (the pressure of 25 kPa, the thickness of the berry layer equal to 50 mm). The marinade was prepared on a water basis, and 20 % viburnum juice was added. The marinade contained also salt, sugar, peppermint leaves, cardamom, dried ground onion, spices (black pepper – 0.1 %, cinnamon – 0.1 %, sweet paprika – 0.1 %), dry spicy-aromatic plants (thyme – 0.1 %, motherwort – 0.1 %, rosemary – 0.1 %, basil – 0.1 %), citric acid was added as a preservative. After mixing the marinade components, they were pasteurized at a temperature of 80 °C for 10 minutes.

The marinade based on sea buckthorn puree was prepared from a water-based frozen semi-finished product. As was the case with the first marinade, 30 % of thawed sea buckthorn puree, salt, sugar, lemon balm herb, spices and spicy-aromatic plants were added to water.

Viburnum is grown and harvested in the Lviv region, Lviv district, Velyka Kalynka village. Frozen sea buckthorn puree was purchased from Fruityland LLC Mint leaves and lemon balm herbs were purchased from "Liktravy". The relevant documents for the products confirm the quality and safety of the raw materials and meet the requirements of regulatory documents regarding the content of toxic elements and radionuclides; according to microbiological indicators, it does not exceed permissible levels.

Purified water was used to prepare the marinades, rock salt, white crystalline sugar, citric acid, ground black pepper, ground red pepper, sweet paprika, basil, oregano, onion, garlic dried, ground, rosemary, cloves, cinnamon, cardamom.

The mass fraction of salt was determined using the Mohr's method. To do this, 5 g of the test sample was transferred to a 250 cm^3 volumetric flask, 100 cm^3 of distilled water was added, heated to 40 °C for 45 minutes, and cooled to a temperature of 20 °C. A 5 ÷ 10 cm^3 filtrate was put into a 150 cm^3 flask, to which a 0.5 cm^3 portion of potassium chromic acid solution was added, and titration was carried out with silver nitrate solution. The mass fraction of salt was calculated using the formula:

$$X = \frac{0.00292 \times К \times V1 \times 100 \times 100}{V \times m} \ [\%]$$

where 0.00292 – the amount of sodium chloride equivalent to 1 cm^3 of 0.05 mol/dm^3 of silver nitrate solution, g/cm^3; *K* is the correction factor to the titer of 0.05 mol/dm^3 of silver nitrate solution; 100 – the volume to which the test sample is diluted, cm^3; 100 is a percentage conversion factor; *V1* – volume of filtrate taken for titration, cm^3; *V* is the volume of 0.05 mol/dm^3 silver nitrate solution used for the titration of the test sample, cm^3; m – mass of the studied sample, g.

The hydrogen index in raw materials and products was determined using the standard method. Approximately 5 g of homogenized sample was used to directly measure pH. The pH was measured with a pH meter (Edge HI2020, Hanna Instruments, Germany).

The method employed to determine the moisture-retaining capacity of meat consists in preparing a 300 mg meat sample weighed on an analytical balance with accuracy to the third digit. The weight was placed on a pre-weighed circle made of polyethylene film and transferred to an ashless paper filter so that the sample lay on the filter. The filter with the sample was placed between two Plexiglas plates. A weight of 1 kg was placed on the surface of the plate. The duration of pressing was 10 minutes. After the specified time, the upper plate was replaced with a heavy one, and on the filter, the contour of the stain around the pressed meat and the contour of the general stain along the limit of moisture distribution were traced with a pencil. The areas of both wet spots were determined with a planimeter at least three times, and the average values were used to reduce a statistical error. Next, the high-quality meat was calculated using the formula:

$$MRC = \frac{(A - 8.4 \times S)}{M} \times 100 \ [\%]$$

where MRC is the moisture-retaining capacity of meat in percent; *A* – total amount of moisture in the meat sample in mg: $A = \frac{300 \times B}{100}$; *B* – 100 mass fraction of moisture in meat in percent, the value of which is obtained independently according to chemical analysis data with 30 high accuracy – up to 0.01 %); 8.4 is a constant obtained experi-

mentally, it means the amount of moisture retained in 1 cm^3 of the filter; S – wet spot area in cm^2; M is the mass of meat in the sample (300 mg with an accuracy of 1 mg).

The mass fraction of moisture was determined using the method of drying in a drying cabinet at a temperature of 100 ÷ 105 °C. In a pre-weighed box, a crushed portion of the product under study weighing 3 ÷ 5 g was placed and dried in an oven at 100 ÷ 105 °C. Drying was stopped when the difference between the last two weighings did not exceed 0.001 g. The final result was the arithmetic mean of 2 ÷ 3 parallel determinations. Calculations were made using the formula:

$$X = \frac{m1-m2}{m0} \times 100\ [\%]$$

where X – mass fraction of moisture, %; m_1 – mass of the sample before drying; m_2 – mass of the sample after drying; m_0 is the weight of the weight.

To determine the absorption of the marinade by the meat, the test samples were immersed in the marinade and kept for 3 to 15 days. Each test sample was weighed before and after pickling. After keeping the samples in the marinade, they were taken out and kept for 10 min to remove excess marinade. The absorption of the marinade was calculated according to the formula:

$$X = \frac{m1-m0}{m0} \times 100\ [\%]$$

where m_1 – a mass of the sample in the marinade; m_0 is the mass of the sample before pickling.

A mass loss after the formula determined heat treatment:

$$X = \frac{m1-m0}{m1} \times 100\ [\%]$$

where m_1 is the mass of the sample in the marinade; m_0 is the mass of the sample in the marinade after heat treatment.

To determine the number of mesophilic aerobic and facultatively anaerobic microorganisms, each meat sample selected for research is freed from visible fat and connective tissue and brought for 2 ÷ 3 minutes in ethyl alcohol and burned from the surface. Using sterile scissors, 2 × 1.5 × 2.5 cm pieces are cut and carefully ground together to produce an average sample. Next, a 1.0 ÷ 2.0 g crushed sample is weighed and 9.0 ÷ 8.0 cm^3 isotonic sodium chloride solution is poured and homogenized with an electric homogenizer or ground in a sterile mortar with sterile sand., A 0.5 cm^3 portion is taken from the resulting meat suspension with a sterile pipette and placed in a test tube with 9.5 cm^3 of an isotonic sodium chloride solution (at the same time, a 1:10 dilution is obtained). A 0.5 cm^3 suspension is placed in sterile Petri dishes: in the first dish – undiluted, and in the second one – a suspension diluted in a ratio of 1:10. Subsequently, following the generally accepted method, 10 ÷ 15 cm^3 of meat peptone agar

(MPA) melted and cooled to 45 ^{o}C is poured into Petri dishes, mixed by gently shaking the dish and placed on a flat surface for solidification. After that, 4 ÷ 5 cm^3 of cold agar is poured onto the surface of the solidified MPA medium. The crops are placed in a thermostat for 72 hours at a temperature of 30 ^{o}C and the number of colonies that have grown on the medium is counted. The number of mesophilic aerobic and facultatively anaerobic microorganisms in 1 g of meat is determined by multiplying the number of colonies by 36 dilutions. The final result is taken as the arithmetic mean obtained in all Petri dishes.

The statistical processing of data was carried out using the ANOVA module, as well as correlation-regression analysis methods. The research was carried out in five repetitions. The models obtained and their coefficients were assessed for reliability using the Fisher's and Student's statistical criteria: with the help of Fisher's F-criterion, the adequacy of the regression model to the initial data was checked; parameters were evaluated for statistical probability using the Student's criterion.

Results and their discussion

During the research, we prepared marinades with a salt concentration of 8 %, 10 % and 12 % to determine their optimal amount, which does not affect the quality deterioration during storage and ensures the appropriate organoleptic indicators of finished products. In addition, NaCl suppresses the growth of microorganisms while storing meat products and regulates water activity, osmotic pressure and electrolyte balance [6]. According to Halenur et al. [13], NaCl is an essential additive in meat processing, and salt is added from 1.1 g salt/100 g in sausages to 4.6 g salt/100 g in such sausage products as salami [13]. The dependence of the NaCl content in experimental samples of rabbit meat depending on concentration of the solution NaCl in the marinade (ωNaCl) is presented in the figure (Fig. 1).

When 8 % salt is added to the marinade, its mass fraction in the finished product is 1.9 %. There needs to be more than this amount, as this affects the taste indicator. When 10 % salt is added to the marinade, its mass fraction in the finished product increases to 2.2 %. At the same time, as determined by the tasting analysis, a pleasant, moderately salty taste is felt. When adding 12 % salt to the marinade, the product's mass fraction increases to 2.6 %. In terms of taste, the products have a noticeable aftertaste of salt and a less noticeable aftertaste of meat and spices. Therefore, the best amount of salt to use in the marinade is 10 %, and the mass fraction in the product is 2.2 %.

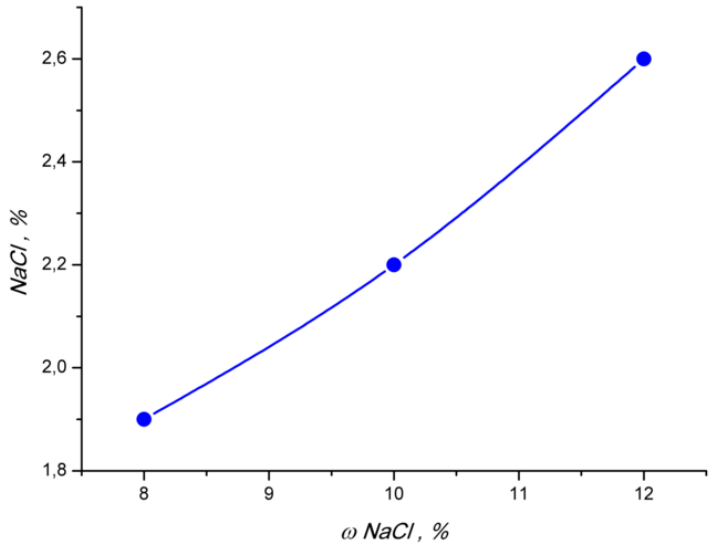

Figure 1. NaCl content in rabbit meat test samples depending on the concentration of the NaCl (ωNaCl) solution in the marinade

Rycina 1. Zawartość NaCl w próbkach mięsa króliczego w zależności od stężenia roztworu NaCl (ωNaCl) w marynacie

Salts, organic acids, fruit and vegetables, beverages (carbonated water, wine, etc.), enzymes, vinegar and combinations of these substances are usually used as marinades in pickling. Using viburnum juice and sea buckthorn puree in marinades and citric acid instead of vinegar makes it possible to obtain a finished product having a delicate consistency, in which all the food components that increase the biological and nutritional value of the product will be preserved. Meat quality is determined by several organoleptic parameters, including color, taste, juiciness and consistency [13], and various factors influence it.

The optimal concentration of viburnum juice and sea buckthorn puree in the marinade was determined by processing experimental samples of rabbit meat with the content of the proposed ingredients 10, 20, 30 and 40 % of the total weight of the marinade. The research results were based on the organoleptic indicators studied, namely, smell, aroma, taste and juiciness, which are the most important in determining the possibility of using raw fruit materials. The amount of viburnum juice and sea buckthorn puree was set based on the influence on organoleptic indicators, of which the smell, aroma, taste and juiciness of the products were selected as the most important. It was established that the products marinated in the viburnum juice-based marinade in the amount of 10 % had an insufficient smell and aroma, the taste was watery and not satu-

rated, there was a slight bitterness, the juiciness of the finished products was not sufficient, the meat was dry and, to some extent, hard (Fig. 2).

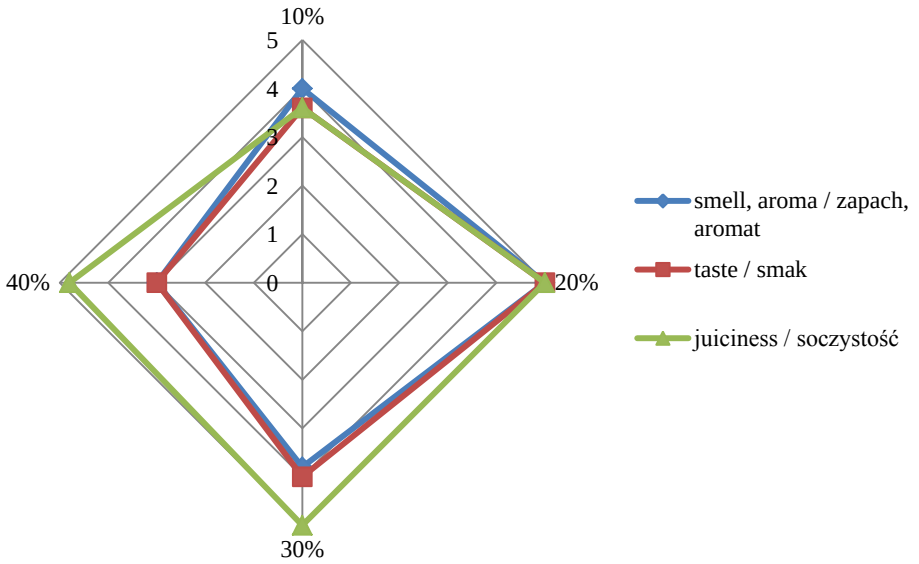

Figure 2. Profilogram of organoleptic indicators of rabbit meat with different contents of viburnum juice in marinades

Rycina 2. Profilogram wskaźników organoleptycznych mięsa króliczego z różną zawartością soku kaliny w marynatach

When viburnum juice is used in the marinade in the amount of 20 %, the smell and aroma of meat improve significantly. This is manifested in the characteristic smell of rabbit meat disappearing and the meat being saturated with the smell characteristic of viburnum. The taste of meat is delicate, with a characteristic aftertaste of viburnum, which does not spoil the overall impression and does not adversely impact the inherent taste of meat. The juiciness of meat is high; it is tender and soft, with a pleasant appearance. When viburnum juice is added to a marinade at 30 %, there is a deterioration in smell, aroma and taste. The amount of viburnum significantly affects these indicators, causing the bitter taste and rich aroma of viburnum. However, meat is quite juicy and tender. When viburnum juice is used in a marinade at 40 %, the smell and aroma significantly deteriorate, and an aftertaste is not characteristic of meat. Therefore, as found through the organoleptic evaluation, the maximum viburnum juice in a marinade is 20 %.

The marinade's amount of sea buckthorn puree was also determined based on organoleptic indicators (Fig. 3).

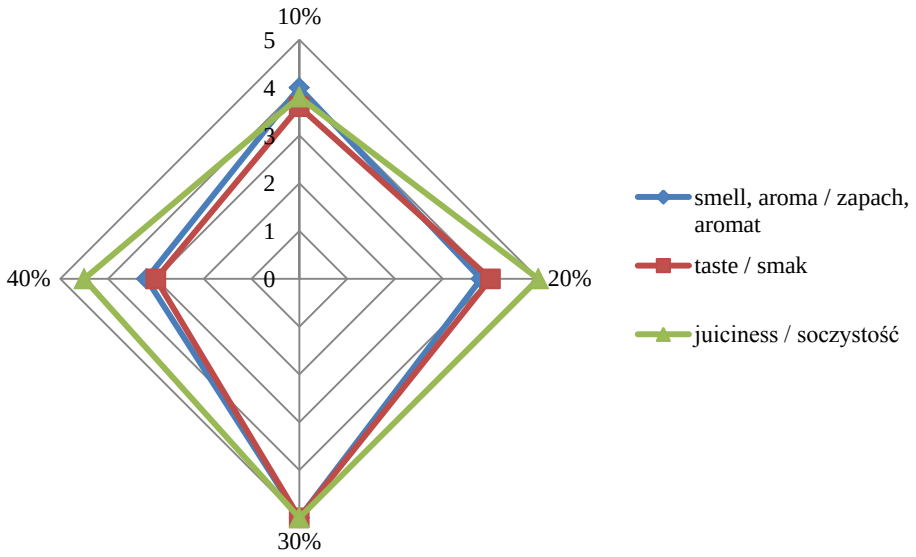

Figure 3. Profilogram of organoleptic indicators of rabbit meat with different contents of sea buckthorn puree in marinades

Rycina 3. Profilogram wskaźników organoleptycznych mięsa króliczego z różną zawartością przecieru rokitnikowego w marynatach

The use of sea buckthorn puree in a marinade in the amounts of 10 % and 20 % is insufficient since the smell and aroma of the finished product are not fully expressed, and the characteristic taste of rabbit meat is felt. However, using sea buckthorn puree in the amount of 20 % affects juiciness – meat is tender and soft. Using sea buckthorn puree at 30 % makes it possible to obtain a product that satisfies organoleptic indicators. The taste of sea buckthorn is practically not felt – the smell characteristic of rabbit meat disappears, which can cause unpleasant sensations in most consumers. The use of sea buckthorn puree in the amount of 40 % worsens the smell and aroma due to the intense feeling of the smell of sea buckthorn, affecting the deterioration of the taste and causing its acidity. Therefore, the optimal amount of sea buckthorn puree in marinades is 30 %.

Marinated semi-finished products from rabbit meat without heat treatment were characterized by their inherent appearance. The samples with viburnum-based marinade were rich red, and the samples based on sea buckthorn puree were orange. This is due to the presence of coloring substances in the fruits. Experimental samples of semi-finished products from rabbit meat before and after heat treatment are shown in Figs. 4 ÷ 9.

Figure 4. Control before heat treatment
Rycina 4. Kontrola przed obróbką cieplną

Figure 5. Rabbit meat after aging in viburnum fruit juice marinade before heat treatment
Rycina 5. Mięso królicze dojrzewające w marynacie z soku kaliny przed obróbką cieplną

Figure 6. Rabbit meat after aging in a marinade based on sea buckthorn fruit puree before heat treatment
Rycina 6. Mięso królicze po dojrzewaniu w marynacie na bazie puree z owoców rokitnika przed obróbką cieplną

Figure 7. Control after heat treatment
Rycina 7. Kontrola po obróbce cieplnej

As a result of the organoleptic evaluation of rabbit meat after heat processing, it was established that viburnum juice in the amount of 20 % and sea buckthorn puree – 30 % are considered the most appropriate components in marinades since it is at this range that the maximum effect of a marinade is achieved, obtaining a delicate product without deterioration of organoleptic indicators.

Moisture retention capacity is one of the most essential technological characteristics that affect the quality and yield of meat and meat products. This indicator was studied on the sixth day since this is the average time of optimal aging of the test samples in marinades. Along with this indicator, we determined the salt content in the

Figure 8. Rabbit meat in viburnum fruit juice marinade after heat treatment
Rycina 8. Mięso królicze w marynacie z soku kaliny po obróbce cieplnej

Figure 9. Rabbit meat in marinade based on sea buckthorn fruit puree after heat treatment
Rycina 9. Mięso królicze w marynacie na bazie puree z owoców rokitnika po obróbce cieplnej

Table 1. Physico-chemical and functional and technological indicators of semi-finished products from rabbit meat (M ± sd, n = 5)
Tabela 1. Wskaźniki fizykochemiczne i funkcjonalno-technologiczne półproduktów z mięsa króliczego (M ± sd, n = 5)

Indicator [%] / Wskaźnik [%]	The name of the experimental sample / Nazwa próbki doświadczalnej		
	K	MV	MB
Mass fraction of moisture / Udział masowy wilgoci	72.5 ± 0.08	75.8 ± 0.09***	73.2 ± 0.1***
Mass fraction of salt / Udział masowy soli	2.4 ± 0.09	2.3±0.07	2.2 ± 0.07
Moisture-retaining capacity / Zdolność zatrzymywania wilgoci	57.18 ± 0.10	61.46 ± 0.07***	59.73 ± 0.09***

Explanatory notes / Objaśnienia:
K – control sample / próbka kontrolna; MV – experimental sample: marinade based on viburnum juice / próbka eksperymentalna: marynata na bazie soku kaliny; MB – experimental sample: marinade based on sea buckthorn puree / próbka eksperymentalna: marynata na bazie puree z rokitnika
Note: statistically significant differences were taken into account compared to the control group: * – $p < 0.05$; ** – $p < 0.01$; *** – $p < 0.001$. Samples were compared within one row /
Uwaga: uwzględniono różnice istotne statystycznie w porównaniu z grupą kontrolną: * – $p < 0.05$; ** – $p < 0.01$; *** – $p < 0.001$. Próbki porównywano w obrębie jednego rzędu

product. The results are presented in Table 1. The moisture-retaining capacity of the control sample is lower than that of the sample of semi-finished rabbit meat in a mari-

nade based on viburnum juice by 7.5 %, and semi-finished rabbit meat in a marinade based on sea buckthorn puree – 4.5 %.

Mass fraction, salt and moisture retention capacity are closely related. The mass fraction of moisture increases in the presence of salt, and the moisture-binding capacity increases due to the moisture content in the products. Salt affects rabbit meat's moisture-binding capacity by increasing myofibrillar proteins' solubility.

As expected, treatment with marinades based on viburnum juice and sea buckthorn puree using 10 % NaCl solution causes a significant increase in the moisture-binding capacity of experimental meat samples. These changes are explained by the contribution of table salt to a stronger dissociation of acid groups, in contrast to amino groups, which shift the isoelectric point of proteins towards lower pH values [2]. Adding 20 % viburnum juice and 30 % sea buckthorn puree to the marinade increased this indicator by 61.5 % and 59.8 % compared to the control sample. It should be noted that the pH value of meat is a determining factor of moisture-binding capacity [8].

The following studies aimed to establish the shelf life of semi-finished products in marinades. The test samples were stored refrigerated at a temperature of $+2 \div 4$ °C for 15 days. The following were determined: pH, absorption of marinade by meat and losses as a result of heat treatment. One of the food acids primarily used in marinating meat is acetic acid, characterized by antimicrobial and antioxidant properties [7]. However, acetic acid increases the marinade's acidity, affects the meat's texture during the marinating process and changes color. Hence, the marinating time of the meat is mostly $30 \div 180$ minutes at a temperature of $4 \div 8$ °C [25]. Our research offers semi-finished products from rabbit meat treated with viburnum and sea buckthorn fruit marinades containing organic acids. Acetic acid was replaced with citric acid to provide a gentler preservative effect.

The aging of rabbit meat in marinades based on viburnum juice and sea buckthorn puree was carried out for 15 days. It was established that the pH of meat from 3 to 9 days increases from 5.38 to 5.8 – in sample No. 1, based on viburnum juice, and from 5.35 to 5.9 – in the sample based on sea buckthorn. On the 12^{th} day, the pH of the experimental samples increased to 6.81 and 6.92, respectively, which may indicate the beginning of the meat spoilage process (Table 2).

The pH value is an important parameter that affects meat's physico-chemical, biochemical, technological and microbiological characteristics and changes during storage. The pH value slightly increased throughout the marinating period in all meat samples due to the accumulation of alkaline nitrogenous compounds such as amines and ammonia resulting from enzymatic reactions and the action of microorganisms.

Rabbit meat marinated in the marinade based on viburnum juice showed the lowest pH values during the entire period – 7.23 ($p < 0{,}001$). The highest pH values were determined in the control sample, which was 7.98 (day 15). Several reasons cause the

pH of meat to change, such as microbial activity and an acidic marinade. A higher concentration of organic acids leads to a decrease in the pH of meat. During the treatment of meat with acid solutions, the product becomes more challenging due to the removal of broth [1].

Table 2. pH of test samples of semi-finished products from rabbit meat (M ± sd, n=5)
Tabela 2. pH badanych próbek półproduktów z mięsa króliczego (M ± sd, n=5)

Days of keeping meat semi-finished products in marinades / Dni przetrzymywania półproduktów mięsnych w marynatach	pH (control) / pH (kontrola)	pH (sample №1 MV) / pH (próbka nr 1 MV)	pH (sample №2 MB) / pH (próbka nr 2 MB)
0	5.11±0.08	4.76±0.1*	4.5±0.1**
3	5.92±0.1	5.38±0.08**	5.35±0.1**
6	6.23±0.09	5.44±0.1***	5.48±0.09***
9	6.82±0.1	5.8±0.08***	5.9±0.08***
12	7.34±0.1	6.81±0.08**	6.92±0.1*
15	7.98±0.1	7.23±0.07***	7.34±0.09**

Explanatory notes / Objaśnienia:
sample №1 MV – experimental sample: marinade based on viburnum juice / próbka eksperymentalna: marynata na bazie soku kaliny; sample №2 MB – experimental sample: marinade based on sea buckthorn puree / próbka eksperymentalna: marynata na bazie puree z rokitnika
Note: statistically significant differences were taken into account compared to the control group: * – $p < 0.05$; ** – $p < 0.01$; *** – $p < 0.001$. Samples were compared within one row / Uwaga: uwzględniono różnice istotne statystycznie w porównaniu z grupą kontrolną: * – $p < 0.05$; ** – $p < 0.01$; *** – $p < 0.001$. Próbki porównywano w obrębie jednego rzędu

The optimal time for keeping rabbit meat in a marinade based on viburnum juice and sea buckthorn puree is 12 days because, during this time, the effect of the marinade on the structure of the meat fibers is achieved, it becomes soft and tender, and spoilage processes do not begin. The reliability coefficient of the results is 0.94 (for the sample in the marinade based on viburnum juice) and 0.96 (for the sample in the marinade based on sea buckthorn puree).

The change in pH, the absorption of the marinade by meat and losses after cooking, as well as the development of microorganisms in the test samples are related to each other. After 3 days of marinating, the pH of the test samples was 5.38 (sample 1) and 5.35 (sample 2), at which time the absorption of the marinade was the greatest, compared to the control: sample 1 – 40.65, sample 2 – 44.83. Preserving experimental samples of rabbit meat in a marinade for more than 12 days leads to the development of microorganisms that can cause spoilage processes and pose a threat to the life and

health of consumers. Therefore, the optimal time for marinating rabbit meat is from 3 to 12 days.

Furthermore, research into rabbit meat in marinades was carried out according to microbiological indicators during the process of marinating at temperatures of 0 ÷ 2 °C for 0, 3, 9 and 12 days, in order to confirm its quality and safety. During this period, the development of the number of mesophilic aerobic and facultatively anaerobic microorganisms was observed.

Table 3. Indicator of mesophilic aerobic and facultatively anaerobic microorganisms of rabbit meat in marinades, colonies of forming units (CFU) in 1 g

Tabela 3. Wskaźnik obecności mikroorganizmów mezofilnych tlenowych i fakultatywnie beztlenowych mięsa króliczego w marynatach, kolonie jednostek tworzących (CFU) w 1 g

Days of keeping meat semi-finished products in marinades / Dni przetrzymywania półproduktów mięsnych w marynatach	control / kontrola	sample №1 MV / próbka nr 1 MV	sample №2 MB / próbka nr 2 MB
0	1.2×10^2	1.5×10^2	1.4×10^2
3	2.8×10^2	2.8×10^2	2.9×10^2
9	4.1×10^3	7.6×10^2	6.9×10^2
12	8.1×10^3	3.3×10^3	3.5×10^3

Explanatory notes / Objaśnienia:
sample №1 MV – experimental sample: marinade based on viburnum juice / próbka eksperymentalna: marynata na bazie soku kaliny; sample №2 MB – experimental sample: marinade based on sea buckthorn puree / próbka eksperymentalna: marynata na bazie puree z rokitnika

The number of mesophilic aerobic and facultatively anaerobic microorganisms (NMAFAnM) in the control sample is 2.8×10^2 after 3 days of storage, 4.1×10^3 after 9 days and 8.1×10^3 CFU in 1 g of product after 12 days. The total bacterial insemination of experimental samples of semi-finished products from rabbit meat in a marinade based on viburnum juice and sea buckthorn puree is significantly smaller than in the control sample on the 3rd day – 2.8×10^2 and 2.9×10^2, on the 9th day – 7.6×10^2 and 6.9×10^2 and on the 12th day – 3.3×10^3 and 3.5×10^3 CFU in 1 g of product.

The results of our research are consistent with the results of Balmaceda et al. [4]. The development of microflora occurs most intensively in the control sample, compared to the experimental ones. This can be explained by the fact that raw materials used in the recipes of marinades contain phenolic compounds that have an inhibitory action on the growth of microorganisms. In addition, flavonoid compounds, including rutin, quercetin present in viburnum berries, exhibit antimicrobial activity against various strains of bacteria.

Organic acids in marinades allow more moisture to be absorbed during pickling and reduce losses during heat treatment [18]. Marinades based on viburnum juice and sea buckthorn puree do not cause excessive broth release during heat treatment, hence the finished products retain a delicate and soft structure.

The influence of the marinade type on the marinade's absorption by the meat and losses as a result of heat treatment of the experimental samples is shown in Fig. 10.

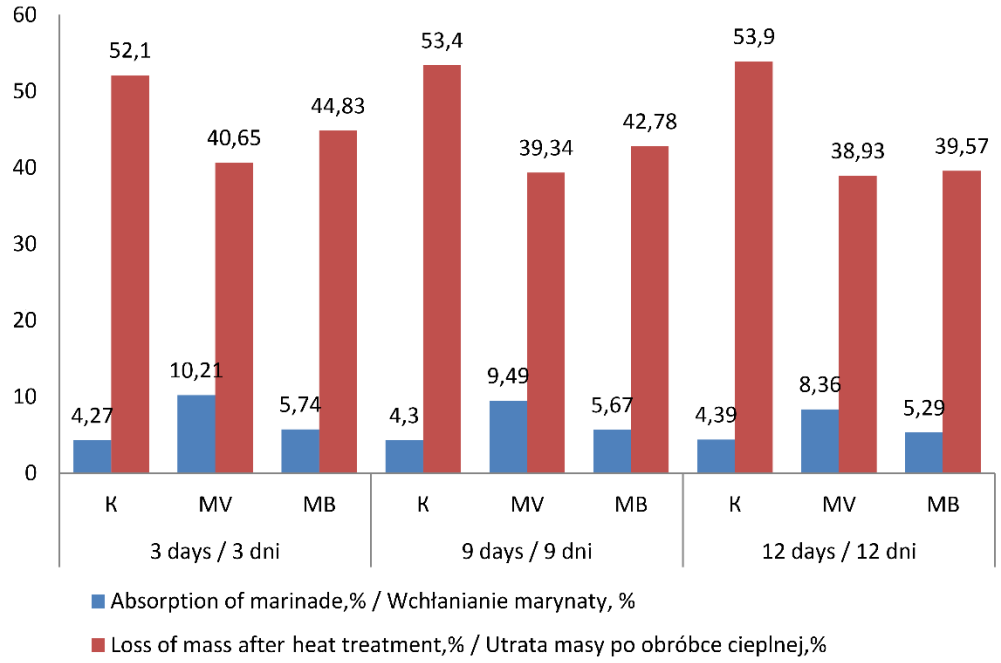

Fig. 10. Absorption of marinade by meat and losses as a result of heat treatment [%]
Rys. 10. Wchłanianie marynaty przez mięso i straty w wyniku obróbki cieplnej [%]
Explanatory notes / Objaśnienia:
K – control sample / próbka kontrolna; MV – experimental sample: marinade based on viburnum juice / próbka eksperymentalna: marynata na bazie soku kaliny; MB – experimental sample: marinade based on sea buckthorn puree / próbka eksperymentalna: marynata na bazie puree z rokitnika

Higher marinade absorption was observed for the sample processed with viburnum juice-based marinade at 10.2 %, while marinade absorption based on sea buckthorn puree was 5.7 %. On the 9th and 12th day, absorption by the meat sample of the marinade based on viburnum juice was 9.49 % and 8.36 %, and the samples in the marinade based on sea buckthorn puree were 5.7 % and 5.3 %. Such results also depend on the pH of a marinade, the one which is based on viburnum juice – 2.92 and sea

buckthorn – 2.32. When semi-finished rabbit meat is kept in marinade for 12 days, moisture is released, associated with weakening intermuscular fiber protein bonds.

Loss of meat during heat treatment of baking is an essential organoleptic, technological and economic parameter. The leading cause of losses is a decrease in moisture [10]. As can be seen (Fig. 10), pickling semi-finished products using viburnum juice increased the ability of meat to bind water, which reduces losses while cooking. The control sample received the most significant losses during heat treatment – 52.1 %. In pickling, the structure of muscle fibers is weakened, and accordingly, the release of moisture increases. This can be observed on the control sample after heat treatment, which was kept in the marinade for 9 and 12 days.

Losses during heat treatment depend on the quality of raw meat, temperature and a cooking method. Mass losses after heat treatment in samples based on viburnum juice and sea buckthorn puree are 40.62 and 44.83 % (3^{rd} day), 39.34 and 42.78 % (9^{th} day), 38.97 and 39.57 % (12^{th} day).

The pickling process has different effects on the value of losses during the heat treatment of test samples. Our further research will determine the maximum shelf life of semi-finished products made of rabbit meat aged in marinades based on fruit raw materials. It also includes a study into the impact of methods and types of packaging on the compliance of semi-finished products with safety indicators following regulatory documents.

Conclusions

1. The most suitable amount of salt to be used in a marinade is 10 %. At the same time, the mass share of salt in products is 2.2 %, which will ensure the production of dietary meat products with a low salt content. When adding salt to a marinade, 8 % is insufficient and affects the taste indicator; products are not salted. Adding 12 % salt to a marinade leaves a noticeable taste of salt and a less noticeable taste of meat and spices.
2. As a result of conducting organoleptic studies on products after heat treatment, it was established that the most favorable for sensory sensations in marinades is theamount of viburnum juice at 20 %, sea buckthorn puree at 30 %, since it is in this range that the maximum effect of a marinade is achieved, obtaining a delicate product without deterioration of organoleptic indicators.
3. The optimal time for holding rabbit meat in a marinade based on viburnum juice and sea buckthorn puree is 12 days because, during this time, the marinade's effect on the meat fibers' structure is achieved; it becomes soft and tender. Marinating semi-finished rabbit meat in marinades based on viburnum juice and sea buckthorn puree increases the ability of the meat to bind water, which reduces losses during heat treatment. Such results are affected by using 10 % NaCl solution and organic

acids in fruit raw materials. Mass losses after heat treatment in experimental samples of semi-finished products from rabbit meat in marinades based on viburnum juice and sea buckthorn puree are 40.62 and 44.83 % (3rd day), 39.34 and 42.78 % (9th day), 38.97 and 39.57 % (12th day).

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WYKORZYSTANIE NOWYCH RODZAJÓW MARYNAT NA BAZIE SUROWCÓW OWOCOWYCH W TECHNOLOGII PÓŁPRODUKTÓW KRÓLICZYCH

S t r e s z c z e n i e

Wprowadzenie. Mięso królicze cieszy się dużym zainteresowaniem konsumentów na całym świecie ze względu na jego doskonałe właściwości odżywcze, dobrze zbilansowany skład aminokwasowy, wysoką zawartość składników mineralnych i witamin. Jednym z etapów technologicznego przetwarzania półproduktów z mięsa króliczego jest proces technologiczny marynowania, który zapewnia ukształtowanie niezbędnych właściwości technologicznych i konsumenckich surowców i produktów gotowych. Zastosowanie soku z kaliny i puree z rokitnika może być obiecującym źródłem surowców do marynowania półproduktów mięsnych.

Wyniki i wnioski. Wyprodukowano dwie próbki marynat: na bazie soku z kaliny i puree z rokitnika. Ustalono, że optymalna ilość soli stosowanej w marynacie wynosi 10 %, co zapewnia produkcję dietetycznych wyrobów mięsnych o niskiej zawartości soli wynoszącej 2,2 %. Najbardziej korzystna dla wrażeń sensorycznych w marynatach będzie zawartość soku z klina wynosząca 20 % i puree z rokitnika – 30 %. Optymalny czas przechowywania mięsa króliczego w marynacie na bazie soku kaliny i puree z rokitnika to 12 dni, gdyż w tym czasie marynata najlepiej oddziałuje na strukturę włókien mięsa, staje się ono

miękkie i delikatne. Marynowanie półproduktów króliczych w tych marynatach zwiększa zdolność mięsa do wiązania wody, co zmniejsza straty podczas obróbki cieplnej i wynoszą one 40,62 i 44,83 % (dzień 3), 39,34 i 42,78 % (dzień 9), 38,97 i 39,57 % (12 dzień).

Słowa kluczowe: marynaty, kalina, rokitnik zwyczajny, półprodukty, mięso króliczе