Methods of storing rabbit meat to ensure functional nutrition

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Abstract. The aim of the study is to create a technology to increase the shelf life of dietary rabbit meat in a supercooled-frozen state while maintaining organoleptic properties using a stabilized cooling system.

At present, a new direction of nutrition science has been formed, namely the theory of functional nutrition, which suggests considering food as a means prevention and treatment of a number of diseases [1, 2, 3, 4].

Currently, the volume of rabbit meat production in Russia is more than 20 thousand tons. The analytical company BusinesStat predicts the growth of industrial production of rabbit products in Russia in 2022 to 40 thousand tons. In the EU countries at the moment, rabbit meat consumption is 2 kg per person per year, and in Russia about 100-180 g.

The growth rate of young animals is quite high and a two-month-old rabbit can have a weight of one and a half kilograms, respectively 85% of the animal’s carcass is meat. With age, the rabbit increases the amount of fat and, accordingly, calorie content. Rabbit meat is rich in vitamins: A, C, E, B1, B2, B6, B9, B12, PP. Also, in this meat there are such mineral elements as P, Fe, K, Ca, Zn, Cu, I, Mn. Chilled rabbit meat contains 19 amino acids. The calorie content of rabbit meat is estimated at 184 kcal per 100 g. Products prepared from it are absorbed by the body almost completely - by 90%.

Being on a diet, one can include only meat of rabbits who have not reached the age of three months. Subsequently, the accumulation of body fat occurs, respectively, the dietary value is reduced. Rabbit meat is rich in easily digestible proteins. Therefore, the product will be useful to people leading a healthy lifestyle, with an active way of doing sports, for people forced to work in places contaminated with radiation, in areas with a disturbed environmental situation. Regular consumption of rabbit meat helps not only reduce weight, but also improve metabolism in the body.

As a preventive nutrition, rabbit meat helps strengthen immunity, prevents wrinkles, develop insomnia, and ensures the health of teeth and gums, hair and skin. Dishes from a rabbit have a positive effect on vision, increase libido, prevent the development of the early aging process, protect against the negative effects of stress, colds, and strengthen immunity.

Especially the consumption of such a product is necessary for those suffering from such various diseases:

- cardiovascular system (normalizes blood pressure);
- impaired brain activity (improves memory and relieves headaches). Prevents the development of nervousness;
• gastrointestinal pathologies, digestive problems;
• diseases of the pancreas;
• diabetes.

Rabbit meat product is hypoallergenic. It can be safely used by pregnant and lactating mothers. It does not cause problems with the digestive system of the child.

When eating rabbits, there are contraindications. They must be taken into account when determining the possibility of using such meat.

Nitrogen compounds are present in rabbit meat, their quantity is small, but nevertheless the presence of such substances should be taken into account. Uric acid accumulates in the joints, which leads to a deterioration in their condition and can even cause the development of arthritis. For this reason, patients with gout are not recommended to use such a product.

One should not get carried away with rabbit meat to people with pathologies of the gallbladder. To avoid exacerbation of psoriasis, rabbit meat should also not be abused. Due to the high protein content, the product is not recommended for use with a low-protein diet and the detection of severe kidney pathologies.

It is recommended to include rabbit meat in the diet 2-3 times a week. The daily requirement for the male body is 180 g, women are recommended to use 150 g, and for children and the elderly no more than 100 g.

The preparation of dishes from rabbit meat depends on the method of canning. The most complete products can only be provided with refrigerated canning.

Traditional refrigeration processing of meat can be divided into the following processes:

• Cooling - during this period, the ripening of the meat occurs, after which it becomes soft and easy to digest. The cooling of carcasses is carried out at a temperature of up to 10 °C during the day. At the end of ripening, the carcasses are covered with a “drying crust”. Unripened carcasses should not be frozen, since the biological and taste properties of meat are impaired.
• Cooling - when the temperature in the middle of the muscles is from 0 to +4 °C. In this state, carcasses can be stored for up to 5 days.
• Freezing - the temperature in the thickness of the muscles should not exceed minus 8 °C.
• Storage in a frozen state, at a temperature of -18 °C, the recommended shelf life of rabbit meat is up to 10 months.

However, in industry, the well-known method of canning is practically not used, in a supercooled-frozen state [7, 9, 10].

The subcooled-frozen state can increase the shelf life of meat. Chilled-frozen meat can be stored and transported in piles at a temperature of –2 ± 0.5 °C for 15–20 days. Freeze fresh meat. In frozen meat, enzymatic processes slow down, but do not stop. On the first day of storage at –2 °C, biochemical processes occur intensively in meat due to a change in salt concentration caused by partial freezing of water. In the future, the main influence is exerted by storage at a low temperature, as a result of which the same enzymatic processes occur in muscle tissue as when storing chilled meat, but somewhat more slowly. The state of rigor mortis at 0 °C instead of 24 hours lasts 10-12 days, and the meat matures by the end of the shelf life, after 15-20 days. When storing rabbit meat in a supercooled-frozen state, the vital activity of microorganisms is significantly reduced.

During storage at –2 °C for 10-12 days the sorption capacity of meat decreases and the decrease in sorption capacity observed during this period coincides with the onset of rigor mortis. After the completion of rigor mortis, the sorption capacity increases and after 12-14 days of storage increases throughout the entire period of further storage.

When stored in frozen meat, an intensive accumulation of free amino acids occurs, and the total content of free amino acids after 12 days of storage of meat at -2 °C reaches about the same level as in meat stored at +2 °C for 7 days. In addition to free amino acids, volatile aromatic substances are formed.
(higher alcohols, neols, sulfites, aldehydes, ketones, esters, fatty acids, amines and complex mixtures of these substances). However, the change in aromatic substances at $-2^\circ$ C occurs at a lower rate than at $+2^\circ$ C. When storing meat at low positive temperatures, the highest content of volatile aromatic substances is observed after 6-7 days, and at a temperature close to cryoscopic, after 14-16 days. The composition of aromatic substances in chilled and frozen meat is the same. The thickness of the frost-bitten layer should be no more than 2-2.5 cm.

The disadvantage of this method of canning is that frozen meat should be stored at a temperature of $-20^\circ$ C, while fluctuations are allowed no more than $\pm 0.5^\circ$ C. The use of conventional refrigeration systems is not able to provide specified technological conditions. The minimum temperature fluctuations that can be obtained with the traditional storage method is $\pm 1^\circ$ C.

When designing refrigeration equipment take into account the uneven load over time. The selection of equipment is carried out according to peak loads, which leads to the need to increase the productivity of refrigeration equipment by at least 20%. In figure 1 shows a thermogram of changes in air temperature when using an air cooler with direct boiling of the refrigerant.

![Diagram of the air temperature in the chamber at a differential of $\pm 1^\circ$ C.](image)

Due to the fact that the temperature difference between the refrigerant or refrigerant in the cooler and the air in the chamber is 7-8 $^\circ$ C, there is a need for thawing. When thawing the surface of the heat exchanger, significant fluctuations in the temperature of the air in the chamber are possible. Therefore, the necessity of developing such a temperature stabilization system that guarantees temperature fluctuations of not more than $\pm 0.5^\circ$ C has been identified.

Cooling systems "chiller air coolers" provide the most stable temperature maintenance. Cold batteries are used to stabilize the temperature at peak load values [8, 9]. The principle of operation of cold accumulators is as follows: before the peak load, the chiller is turned on at full power and liquid is cooled in the cold accumulators with the required phase transition temperature.

Thawing (melting) of a special liquid gives the necessary cooling capacity during peak periods. Due to the fact that it is necessary to accumulate cold at temperatures below $-9^\circ$ C, eutectic solutions of polyhydric alcohols, potassium chloride, sodium chloride, magnesium chloride, etc. can be used. In our
case, the Cristopia STD system proposed by CIAT, France, was acceptable. [8]. Accumulation of cold using capsules - placeholders.

![Figure 2. Appearance of STD capsule.](image)

This method consists in the fact that ice in the cold accumulator does not have direct contact with the coolant, but is formed in polyethylene storage capsules. The cold accumulator, which is a thermally insulated reservoir, is filled with such capsules. Capsules are molded under pressure from high density polyethylene and filled with a special liquid. Liquid coolant circulates in the battery (in our case, water and inside the aggregates. This ensures energy storage in the form of latent heat of crystallization during the phase transition from liquid to solid. The spherical shape of the capsules provides a large heat transfer area. We used IN10 capsules with a diameter of 77 mm with a phase transition temperature of -10.4 °C (figure 2). According to the company, capsule-fillers allow at least 10,000 cycles (freezing-thawing), service life - at least 20 years.

However, experience shows that in reality their service life is an order of magnitude shorter. In the coolant flow, the balls move, the plastic is easily abraded and at least after 2 years of intensive work require replacement.

A simplified hydraulic circuit (basic elements), according to which the principle of operation of STL cold accumulators can be traced, is shown in figure 3.

![Figure 3. Hydraulic diagram of a stabilized cooling system](image)

The circuit consists of two circuits - primary and secondary. The primary circuit serves to charge the cold accumulator. In this circuit, the coolant circulates at a constant flow rate and with varying...
temperature. In the secondary circuit, the coolant circulates at a constant temperature, but with a variable flow rate.

In the heat exchanger (evaporator), freon evaporates and in the water circuit of the heat exchanger lowers the temperature of the coolant.

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Pumps 4 and 5 circulate the fluid along the primary and secondary circuits. The adjustment of the coolant flow through the secondary circuit is carried out by a three-way valve 6.

Our experiments on the use of a stabilized cooling system for storing rabbit meat in a supercooled-frozen state chamber with two air coolers show that the second air cooler comes into operation when the frost on the surface of the first is thawed. The experimental results are presented in figure 4.

It can be seen from the results of the experiment, it was possible to stabilize the temperature of the air in the chamber regardless of the thawing process and from fluctuations in air temperature in the environment. The differential of temperature fluctuations was obtained less than stated according to the technical conditions, therefore we have achieved the goal of the study. It should be noted that the cost of the temperature stabilization system that we developed is higher than a conventional system with direct boiling air coolers, according to the presented technological solution, it significantly reduces the risks of threshold thermal values for storing rabbit meat in a supercooled-frozen state.

![Diagram of air temperature in a chamber with stabilization system](image)

**Figure 4.** Diagram of air temperature in a chamber with stabilization system.

If one needs short-term storage, it is preferable to use the developed system of stabilization of storage temperatures, which allows to extend the shelf life of meat in a refrigerated state up to three weeks and reduces the risks of fluctuations in thermal conditions to minimum values.

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