Effect of subcryoscopic storage temperature on shelf life of chilled broiler meat

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Abstract. Limited shelf life of chilled poultry meat hinders its transportation over long distances to remote areas of consumption. In this regard, it is necessary to develop a storage technology for chilled poultry meat with prolonged shelf life. The study was carried out on meat samples of broiler chickens produced in accordance with GOST 31962-2013 and cooled by water evaporation. An IS 203.4 temperature recorder was used to measure meat temperature, and a TESTO 205 device was used to measure pH. The microbiological, physicochemical, and sensory characteristics of meat were determined according to standard methods. The shelf life of chilled meat was determined in accordance with MUK 4.2.1847-04 Sanitary and epidemiological assessment of justification for the shelf life and storage conditions of food products. The study showed that meat stored at −2.0 ± 1.0 ºС remains fresh for 20 days in terms of microbiological, physicochemical and organoleptic characteristics. It was found that meat can be transferred from a supercooled state to a chilled one in order to increase the shelf life to 15 days at a storage temperature of −2.0 ± 1.0 ºС.

1. Introduction

According to the international standard GOST 31962-2013, the recommended shelf life of chilled meat is 5 days for carcasses and no more than 2 days from the day of production at a temperature from −2 to +2 ºС for parts of carcasses [1]. This limitation of shelf life hinders meat transportation over long distances to remote areas of consumption. In this regard, it is relevant to develop a storage technology for chilled poultry meat with prolonged shelf life.

The development of a technology for storing chilled meat with prolonged shelf life will maintain the quality of poultry meat and enable its transportation over long distances, increase the time for industrial processing of meat, and reduce the number of refrigerating chambers for freezing meat. The effect of the near-cryoscopic storage temperature of −1.0 ºС on the shelf life of broiler meat has been established: 9 days for carcasses, 8 days for parts of carcasses [2]. An increase in the shelf life of meat while maintaining its quality can be achieved through the use of supercooling technology and storage at subcryoscopic temperature. Supercooling is a cooling process that lowers the temperature of meat by 1.0–2.0 ºС below the cryoscopic temperature [3].

The aim of the study is to determine the effect of subcryoscopic storage temperature on the shelf life of broiler meat.

2. Materials, equipment and methods

The object of the study is broiler chicken meat (thigh), hereinafter referred to as meat.
A SANYO MIR-253 refrigerated thermostat chamber with forced air circulation was used for storing samples. The meat temperature was determined using an IS 203.4 temperature recorder, which is designed to measure, record and construct a thermogram of temperature changes using computer technology. The pH value was determined using a TESTO 205 device.

Microbiological, physicochemical and organoleptic characteristics of meat were determined using standard methods [4–9]. The shelf life of chilled meat was determined in accordance with MUK 4.2.1847-04 [10]. Statistical processing of the results of a microbiological survey was carried out using the Excel and SPSS software packages, version 18.0.

3. Experimental part and results

Meat samples were packed into consumer packaging and placed in a refrigerator for cooling at –4 °C. The temperature was measured using an IS.203.4 recorder. The first sensor recorded the temperature at a depth of 5 mm, the second one recorded the temperature at deep layers of the samples.

Analysis of the thermogram on changes in meat temperature during cooling (Figure 1) shows that in the temperature range from –1 to –3 °C, meat exhibits three states:

- chilled (at near-cryoscopic temperature of –1 °C);
- supercooled (at subcryoscopic temperature of –1.7 °C);
- slightly frozen (at subcryoscopic temperature of –3 °C) at a depth of 5 mm.

After cooling, meat was stored at a subcryoscopic temperature of –2.0 ± 1.0 °C.

![Figure 1. Thermogram of changes in the temperature of cooling and storage of broiler meat](image)

When establishing the shelf life of chilled meat, the quantity of mesophilic aerobic and facultative anaerobic microorganisms (QMAFAnM), the presence of Salmonella and L. monocytogenes on the sample surface and in deep layers were determined. Microbiological characteristics of meat during storage at –2.0 ± 1.0 °C are presented in Table 1.

Table 1 shows that QMAFAnM in deep layers of meat was not more than 10 CFU/g when laying for storage. After 7 days of storage, it increased to (3.11±0.15)-10³, after 15 days it was (4.35±0.21)-10³, and after 20 days it was (7.21±0.32)-10³ CFU/g.

In swabs from the meat surface when laying for storage, QMAFAnM was (3.57±0.17)-10³ CFU/cm³. During storage, QMAFAnM increased on the meat surface: after 7 days of storage it was (4.43 ± 1.19)-10³, after 15 days it was (1.27 ± 0.06)-10⁴, after 20 days of storage it was (1.27 ± 0.06)-10⁴ CFU/cm³.

Salmonella and L. monocytogenes were not recorded in the study.
Table 1. Microbiological characteristics of meat during storage at –2.0 ± 1.0 ºC

| Storage, days | Microbiological parameters | | | |
|---------------|-----------------------------|-----------------|-----------------|-----------------|
| | QMAF | FanM | Salmonella | L. monocytogenes |
| | swab from the surface, CFU/cm³ | deep layers, CFU/g | in 25 m³ of swab | in 25 g |
| 0 (background) | (3.57±0.17)·10³ | <10 | Not found | Not found |
| 7 | (4.43±1.19)·10³ | (3.11±0.15)·10⁴ | Not found | Not found |
| 15 | (8.11±36)·10⁴ | (4.35±0.21)·10⁴ | Not found | Not found |
| 20 | (1.27±0.06)·10⁴ | (7.21±0.32)·10⁴ | Not found | Not found |

During organoleptic survey of meat after storage for 20 days, the sample surface was dry, whitish-yellow with a pink tint, the subcutaneous and internal adipose tissue was yellow, the muscles in the cross section were pale pink, slightly moist, leaving no wet spots on the filter paper. During microscopy of smears-prints, there were isolated cocci and sticks, traces of muscle tissue were not found, the smell was specific, characteristic of fresh poultry meat. The cooked broth was transparent and fragrant.

The freshness of meat during storage was determined. The results are presented in Table 2.

Table 2. Physicochemical characteristics of meat (n=5)

| Storage, days | Hydrogen ion concentration, pH | Acid number of fat, mg KOH/g fat | Peroxide number, mmol (1/2 O₂)/kg | Mass fraction of volatile fatty acids, mg KOH/100 g |
|---------------|--------------------------------|-------------------------------|-------------------------------------|------------------------------------------|
| Background    | 6.0±0.23                       | 0.15±0.007                    | 1.82±0.08                           | 1.92±0.09                               |
| 7             | 6.4±0.21                       | 0.25±0.008                    | 2.64±0.13                           | 2.82±0.12                               |
| 15            | 6.6±0.25                       | 0.55±0.027                    | 3.25±0.14                           | 3.34±0.11                               |
| 20            | 6.8±0.31                       | 0.87±0.025                    | 3.82±0.15                           | 3.58±0.12                               |

As can be seen from Table 2, the hydrogen ion concentration in meat during storage was 6.0 ± 0.23 pH and increased to 6.8 ± 0.31 pH by the end of storage.

The acid number of fat at the beginning of storage was 0.15 ± 0.007, and after 20 days it increased to 0.87 ± 0.025 mg KOH/g. The peroxide number of meat during storage increased from 1.82 ± 0.08 at the beginning to 3.82 ± 0.15 mmol (1/2 O₂)/kg after 20 days of storage. A similar trend was observed when determining the mass fraction of volatile fatty acids, the background was 1.92 ± 0.09, and at the end of storage it was 3.58 ± 0.12 mg KOH/100 g.

Figure 2 presents the dynamics of changes in the acid number of fat, peroxide number and mass fraction of volatile fatty acids in meat during storage. Figure 2 shows an increase in the studied characteristics during storage of poultry meat, which at the end of storage did not exceed the standard.

Thus, physical and chemical characteristics of the samples corresponded to fresh meat within 20 days of storage.

Figure 3 shows a gradual increase in the concentration of hydrogen ions in meat during storage, which at the end of storage did not exceed the standard.

Figures 2 and 3 illustrate the dynamics of changes in the acid number of fat, peroxide number, mass fraction of volatile fatty acids, the concentration of hydrogen ions in meat during storage. The obtained results show that physicochemical characteristics of meat after 20 days of storage correspond to those of fresh meat.
4. Conclusion
The study showed that organoleptic, microbiological and physicochemical characteristics of meat stored at $-2.0 \pm 1.0$ °C for 20 days correspond to GOST 31962-2013.

It was experimentally established that meat of broiler chickens can be transferred from a supercooling state to a chilled one in order to increase the shelf life to 15 days at a storage temperature of $-2.0 \pm 1.0$ °C according to MUK 4.2.1847-04.
Aknowledgments
The study was carried out within the framework of the state assignment for R&D AAAA-A20-12001069002-3.

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