A study of recovery rheological properties of egg yolk after freezing in making table salt

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Abstract. We studied the effect of salt on the quality indicators of egg yolk at various storage temperatures (−6, −12 and −18 °C) in order to determine the optimal storage parameters with minimal violation of its rheological properties. The object of study was an egg yolk made from standard five-day eggs of the first category, produced at the poultry farm in the Leningrad Region, and intended for the meat processing industry. The used salt met the requirements in accordance with GOST R 51574-2000. The yolk was frozen using shock freezing at a temperature of −35 °C and an air velocity of 15 m/sec. It was stored in refrigerators at the temperatures of −6, −12 °C for 10 months, and at −18 °C for 12 months. After thawing, the viscosity of the yolk was determined on the Engler viscometer; using a laboratory pH meter, organoleptic indicators for compliance with the requirements specified in GOST 30363-2013 "Liquid and dry egg products. Technical conditions”. Tests were conducted in accordance with TR TS 021/2011 “On food safety”.

1. Introduction

Currently, chicken eggs are being used less and less in food production, semi-finished products are being replaced - egg melange and egg yolk, in liquid or dry form, with or without additives. This significantly reduces the energy consumption of food production, due to the lack of additional technological operations - sorting, washing, and breaking eggs, separation into protein and yolk, if necessary. It is much more convenient to use liquid egg products, packed in aseptic bags with lids, which allow you to dose the product and take up significantly less storage space [1,2].

For producers of egg products, the question arises of preserving the value of products throughout the year, avoiding the mismatch of the seasons for the supply of raw materials and demand for the product. One way is to freeze egg melange in spring and summer during the season of laying chickens and use this semi-finished product in autumn and winter, during the period of demand for products and high prices for an egg. But when using this technology, it should be taken into account that the egg yolk, when processed at a temperature lower than −6 °C, is irreversibly gelled and delaminated, which complicates its further use after defrosting [3,4].

Studies on the freezing of egg products were intensively carried out in the 1970s and 1980s, which was associated with the plan for the development of the national economy, namely, with an increase in egg production. The data published in domestic and foreign literature on storage conditions, thawing and the study of the physicochemical and organoleptic properties of frozen egg products are very
limited and contradictory. Irreversible changes in the rheological properties of egg products during freezing and cold storage were revealed, the restoration of which at that time was not possible [5].

The purpose of this work is to investigate the restoration of the rheological properties of the yolk after freezing by adding table salt.

The yolk considered in this paper is used for the production of mayonnaise. The use of salt in this case is due to the fact that it plays the role of a natural preservative, and also positively affects the rheological properties of the yolk. The salt concentration was selected empirically, the effect of various concentrations on the rheological properties of the yolk at various negative storage temperatures was studied. The concentration used was discussed with customers to adjust their formulation of the finished product.

As you know, the quality of the yolk depends not only on the conditions of its freezing, but also on storage conditions [5]. In accordance with the GOST 30363-2013 "Liquid and dry egg products. Technical conditions" [6], egg products should be stored at a temperature not exceeding -18 °C for not more than 15 months, at a temperature not exceeding -12 °C - not more than 10 months.

The research objectives were to develop a new product - salted egg yolk, which has the ability to restore rheological properties after thawing. In particular, we studied the effect of different storage temperatures (-6, -12, -18 °C) of yolk with and without added salt on quality indicators in order to determine the optimal salt concentration in the product and the optimal storage parameters of the frozen yolk with minimal violation of its rheological properties. Temperatures –12 and –18 °C were selected based on the data of GOST 30363-2013 "Liquid and dry egg products. Technical conditions". At a temperature of –6 °C, according to foreign studies [7-9], irreversible changes occur in the yolk.

2. Materials and methods

For experiments, we took a yolk prepared from standard five-day eggs of the first category. The selection of raw materials and technological operations for the production of yolk was carried out in accordance with the current technological instructions for the production of frozen egg products.

Freezing was carried out in the Criodor heat chamber using shock freezing at a temperature of –35 °C and an air velocity of 15 m/ sec.

The yolk with an initial temperature of 4 °C was packed in packages of a polymer barrier film with a thickness of 60 μm, with dimensions of 320x150 mm and a capacity of 5 kg. The thickness of the product was 80 mm. They were stored in refrigerators at a temperature of –6, –12 °C for 10 months, at –18 °C for 12 months. They were thawed without opening the package [10] in air at + 18–20 °C and air velocity of 7 m/ sec.

The quality and property of the yolk after thawing and storage was evaluated by indicators characterizing the changes in its main components: by viscosity, pH, organoleptic, and microbiological indicators [11].

Viscosity was determined on an Engler viscometer in degrees Engler (°E) of conditional viscosity.

pH was measured using a laboratory pH meter, pH-150MI. Test procedure was conducting according to the GOST 31469-2012 “Food products of processing of eggs of poultry. Methods of physico-chemical analysis”.

The requirements for organoleptic indicators are given in the GOST 30363-2013 “Liquid and dry egg products. Technical conditions”. The tests were carried out in a production laboratory.

Microbiological analyses were carried out by a third-party accredited laboratory - Branch of the Center for Hygiene and Epidemiology in the Leningrad Region in the Vsevolozhsk Region. Tests were conducted in accordance with the TR TS 021/2011 "On food safety".

Salt was added to the yolk before pasteurization and thoroughly mixed with a stirrer for 30 minutes. The salt concentration was selected as 6, 9 and 12%. Dosage was carried out using attorney scales.

To assess the quality of the yolk during storage, the egg yolk parameters were taken as a base for comparison before freezing.
3. Results and discussion
The results of studies indicate that the process of freezing and storing the yolk without adding salt is accompanied by irreversible changes in the initial properties of the product. Table 1 shows the change in viscosity of the yolk during storage at different temperatures. As one can see, the viscosity increases from the very first days of freezing and then changes slightly. So, at −6 °C the viscosity of the frozen yolk in the first month increased 11 times.

Table 1. Change in viscosity of the yolk during storage at different temperatures

| Temperature, °C | Before freezing | The duration of the storage process, months | Samples removed from storage | Samples removed from storage |
|----------------|----------------|--------------------------------------------|-----------------------------|------------------------------|
| −6             | 0.22           | 2.39 2.43 2.43 2.43 2.43 2.43             |                             |                              |
| −12            | 0.22           | 2.67 2.67 2.68 2.68 2.68 2.68             |                             |                              |
| −18            | 0.24           | 2.89 2.89 2.89 2.89 2.89 2.89 2.90 2.90   |                             |                              |

Table 2 shows the change in viscosity of the yolk after adding salt at various concentrations during storage at different temperatures. The table shows that the viscosity of the yolk with the addition of salt at a concentration of 9% and 12% changes slightly at all studied temperatures.

During storage of egg yolk at a temperature of −6; −12 and −18 °C there is a slight pH shift to the alkaline region. As indicated in Table 3, at −18 °C, the changes are less pronounced, which is obviously associated with a slowdown in microbial and enzymatic processes that affect the pH of the product [12]. The addition of salt to the egg yolk shifts the pH to an acidic environment.

During storage, there is a decrease in carotenoids [13] which act as antioxidants in the oxidation of fats and substances that affect the color of the yolk. During storage, the color of the frozen yolk changes from bright orange to orange, especially at −6 °C. At this temperature, the color after defrosting the product practically does not recover. At −18 °C, the color of the frozen product changes with a lower intensity and is practically restored after defrosting. The addition of salt helps to fix the color, and the color of the yolk during storage does not change.

Table 2. Changing the viscosity of the yolk with the addition of salt in various concentrations during storage at different temperatures

| Temperature, °C | Concentration, % to mass | Before freezing | The duration of the storage process, months | Samples removed from storage | Samples removed from storage |
|----------------|--------------------------|----------------|--------------------------------------------|-----------------------------|------------------------------|
| −6             | 6                        | 0.23           | 0.48 0.51 0.59 0.68 0.79 0.85             |                             |                              |
| −12            | 9                        | 0.23           | 0.25 0.25 0.26 0.26 0.26 0.27 0.27         |                             |                              |
| −18            | 6                        | 0.24           | 0.24 0.24 0.24 0.24 0.25 0.25 0.25         |                             |                              |
| −12            | 12                       | 0.24           | 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24   |                             |                              |
| −18            | 6                        | 0.23           | 0.23 0.23 0.24 0.24 0.24 0.24 0.24         |                             |                              |
| −12            | 9                        | 0.23           | 0.23 0.23 0.23 0.23 0.23 0.23 0.24         |                             |                              |
| −18            | 12                       | 0.23           | 0.23 0.23 0.23 0.23 0.23 0.23 0.24 0.24   |                             |                              |
Table 3. Changing the pH of the yolk during storage at different temperatures

| Temperature, °C | Before freezing | pH | The duration of the storage process, months | Samples removed from storage |
|-----------------|-----------------|----|------------------------------------------|------------------------------|
|                 |                 |    | 1  | 6  | 7  | 8  | 9  | 10 | 11 | 12 |
| –6              | 5.92            | 5.95| 5.98| 5.99| 6.04| 6.12| 6.25 |     |
| –12             | 5.92            | 5.94| 5.97| 5.98| 5.99| 6.02| 6.19 |     |
| –18             | 5.92            | 5.93| 5.94| 5.95| 5.96| 5.97| 5.97| 5.98| 5.99|

In terms of organoleptic characteristics, consistency and taste, omelettes baked from a frozen yolk stored at various temperatures were no different. All samples showed a rubbery consistency, an unpleasant appearance and a specific taste.

Assessing the quality of the yolk during storage would be incomplete without taking into account the results of bacteriological studies, which led to the following conclusions. The limiting factor in assessing the quality of the yolk was the results of bacteriological laboratory tests. Coliforms remained normal - not detected in 0.1 g. However, during long-term storage at –6 and –12 °C, an increase in total viable count is observed, and the earlier it is, the higher the storage temperature is. So, in a product stored at –6 °C, total viable count growth began after 8 months of storage, at –12 °C - after 9 months of storage, at –18 °C for 12 months no growth was detected.

According to laboratory studies, the addition of salt helped to slow down the growth of total viable count during storage at various temperatures.

4. Conclusion

The study revealed a positive effect of salt on the restoration of the rheological properties of the yolk after thawing it.

A salt concentration of 6% does not have a sufficient effect on the change in the properties of the yolk. Concentrations of 9% and 12% lead to a positive effect, however, from an economic point of view, the optimal salt concentration of 9% was chosen at which the rheological properties of the yolk are restored after it is thawed and there is no increased salt consumption.

The optimum storage temperature of the frozen yolk –18 °C was determined, at which the change in viscosity is less pronounced, the color of the product is less intense, and the growth of KMAFAnM is not detected.

In the course of the research, a technological scheme was developed for the manufacture of salted egg yolk. As a result of the introduction of this product in the range of production of liquid egg products located in the Leningrad region, it was possible to increase sales of egg yolk by 13%.

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