Development of combined semi-finished products from poultry and vegetables with prolonged shelf life

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Abstract. Ionizing radiation in combination with vacuuming is a perspective method for shelf life prolongation of a wide range of food products. It is known that ionizing radiation can notably decrease the quantity of pathogenic microorganisms in food products along with preserving or improving of sensory characteristics of the products. The research on influence of ionizing radiation on food products quality and safety was carried out on semi-finished products from poultry meat (chicken) with vegetable stuffing composed from pumpkin, carrots and cedar nuts oilcake. The samples of stuffing and semi-finished products were packed into LDPE bags, vacuumed, and then exposed to ionizing radiation with high-energy electron beams of 3, 4, 5, and 7 kGy doses. The samples were evaluated by sensory characteristics, dry matters, vitamin C and mesophilic aerobes and facultative anaerobes content. It was determined that ionizing radiation has a positive effect on moisture-retaining capacity of stuffing and semi-finished products samples and presumes their shelf life prolongation. However, vitamin C content decreases during shelf life of samples regardless of radiation dose. The dose of 4 kGy doesn’t have negative effect on sensory characteristics of samples and can be considered as optimal. Therefore, practical implementation of developed technology will make possible the prolongation of food products shelf life, reduce storage costs at public catering enterprises and allows its integration into the HACCP system.

1. Introduction

Dairy and meat products (especially poultry meat and beef) are leaders among food products which cause various toxicoinfections. Fish and eggs causing salmonellosis are on the second place. The third place belongs to fruits and leafy vegetables. It is not possible to establish the causes of 45% of food poisonings, and independent experts claim that data on toxicoinfections submitted to WHO is reduced approximately 2.5…3 times [1–3].

Ionizing radiation causes physical and chemical changes in microorganisms which can destroy or inactivate them. Most radiation doses are not enough to kill all available microorganisms, but their quantity and species notably decrease after irradiation. Doses from 2 to 7 kGy lead to an intensive destruction of all microorganisms in food products, including such pathogen microorganisms as salmonellas [3–12]. Thus, the shelf life of food production can be increased and the threat of disease from pathogenic microorganisms can be either prevented or significantly reduced.

It is advisable to combine food production irradiation with its vacuuming. Isolation of products from oxygen doesn’t only prevent microorganisms’ growth, but also makes possible preserving and improving their sensory and nutritional properties. Moreover, food products can absorb unpleasant smells during transportation or storage processes, while vacuum packages fully exclude the
undesirable feature. Consisting of specialized multi-layer film, the packages also prevent water evaporation from products [5, 13–16].

The purpose of the research is the development of combined semi-finished products from poultry meat (chicken) and vegetables with prolonged shelf life with using of ionizing radiation.

2. Materials and methods

The experimental studies were carried out at Technology and Organization of Food Industries Department of Novosibirsk State Technical University and BioTechnopark Koltsovo, Novosibirsk region.

For obtaining vegetable stuffing of semi-finished products, the carrots and pumpkins as main ingredients were used. Carrots were chosen because they are widely spread all year round on Russian consumer market. Pumpkins were chosen because they are one of the most popular seasonal vegetables in Russia. Besides that, it is known that extractive substances from pumpkin fruits and leaves can inhibit lipid oxidation and discoloration and thus can prolong the shelf life of meat products [17].

The properties of cedar nut oilcake as a water-retaining agent and a thickener were also studied and used in the research. The nut oilcake is included in semi-finished products formulation based on its chemical composition, which is close to the cedar nut kernels composition. Thus, it can be a valuable source of:

- indispensable amino acids: valine, isoleucine, lysine, methionine, threonine, tryptophan, and phenylalanine;
- dispensable amino acids: alanine, arginine, aspartic acid, histidine, glycine, glutamic acid, proline, serine, tyrosine, and cysteine;
- glucose and fructose;
- mineral substances: I, Fe, Cu, P, Si;
- vitamins A, B₁, B₂, B₃, C, E, PP;
- dietary fibers;
- starch [18–21].

In addition, sugar was used in the formulations as a natural preservative and flavor additive.

According to the research topic, the formulations of semi-finished products from poultry with vegetable stuffing were developed. Based on previous sensory evaluation experiments, the best samples of semi-finished products were chosen.

It is known that semi-finished products and dishes from meat and poultry can be stored for a short term (up to 48 h and up to 72 h accordingly). Therefore, the technology of prolongation of their shelf-life can be applied. This technology can be carried out using ionizing radiation.

Pumpkins and carrots were peeled and cooked until tender. After that, sugar and cedar nut oilcake were added, and their mixture was blended.

The samples were packed in LDPE bags, vacuumed, and then exposed to ionizing radiation of high-energy electron beams of 3, 4, 5, and 7 kGy doses.

The semi-finished product samples were obtained from white and red chicken meat. For this, frozen chicken carcasses were used as an initial raw material. They were defrosted at a temperature of (4±2) °C, then deboned, skinned, chopped into small cubes with edges 3 cm and vacuumed into LDPE bags in portions of 50 g.

The following characteristics of semi-finished products and stuffing samples were determined.

Sensory evaluation of samples was carried out according to Russian national standard GOST 31986-2012 “Public catering service. Method of sensory evaluation of catering products” for the following characteristics:

- taste;
- color;
- aroma
- consistency.
Every indicator was evaluated on the 5-point scale (5 indicates the best and 1 implies the worst) by 4 semi-trained panelists. As a result of the evaluation, the average points for each characteristic were obtained.

Dry matters content was determined according to GOST 28561-90 “Fruit and vegetable products. Methods for determination of total solids or moisture” for vegetable stuffing samples and GOST 9793-2016 “Meat and meat products. Methods for determination of moisture content” for semi-finished products samples”. The research was carried out for studying the influence of ionizing radiation on water-retaining properties of the products.

Vitamin C content was determined according to GOST 24556-89 “Products of fruits and vegetables processing. Methods for determination of vitamin C”. The research was carried out for studying the influence of ionizing radiation on vitamin C, because this vitamin is easily destroyed under mechanical, thermal and chemical treatment.

The microbiological indicators were determined in Novosibirsk Interregional Veterinary Laboratory according to GOST 10444.15-94 “Food products. Methods for determination of quantity of mesophilic aerobes and facultative anaerobes” and requirements of “Technical regulation of Customs union on the safety of food production” (TR TS 021/2011).

3. Results and discussion
The results of the sensory evaluation of vegetable stuffing samples on the 4th day of shelf life are presented in table 1.

| Characteristics | 0 (control sample) | 3 | 4 | 5 | 7 |
|-----------------|--------------------|---|---|---|---|
| Taste           | 4.8±0.2            | 4.8±0.1 | 4.7±0.1 | 3.2±0.2 | 2.1±0.2 |
| Color           | 4.9±0.1            | 4.9±0.1 | 4.8±0.1 | 3.3±0.2 | 3.2±0.2 |
| Aroma           | 4.9±0.1            | 4.9±0.1 | 4.8±0.2 | 3.2±0.2 | 2.3±0.2 |
| Consistency     | 4.9±0.1            | 4.8±0.2 | 4.8±0.2 | 4.7±0.2 | 4.7±0.1 |

During shelf life of vegetable stuffing samples, the changes in their taste, color and aroma were revealed. When the radiation dose was higher than 4 kGy, non-typical taste and aroma of samples were detected. It can be supposed that these radiation doses influence on carotenoids, which are contained in vegetables, and thus reducing their color intensity. However, radiation up to 4 kGy does not have any negative effects on sensory characteristics of vegetable stuffing samples.

Results of sensory evaluation of semi-finished products samples smell are shown in figure 1.

![Figure 1. Sensory evaluation of semi-finished products samples smell](image-url)
It was found that all samples exposed to ionizing radiation higher than 4 kGy had a clear specific technical smell mixed with sulphur smell. During shelf life, the sulphur smell in samples only increased.

Results of evaluation of dry matters content in vegetable stuffing samples are shown in figure 2.

![Figure 2. Dry matters content in vegetable stuffing samples](image)

According to the graph, the dry matters content in sample treated by ionizing radiation of 4kGy is lower than its content in the control sample. The maximum difference between them is 2%. Based on this data it can be concluded that ionizing radiation influences on water-retaining properties of vegetable raw materials.

Results of evaluation of dry matters content in semi-finished products samples are shown in figure 3.

![Figure 3. Dry matters content in semi-finished product samples](image)

According to the graph, the moisture in semi-finished products samples exposed to different radiation doses changes insufficiently during the first 3 weeks of storage and can be compared with the moisture of the control sample. At the end of the 4th week reduction in moisture of all samples can be observed but the experimental samples demonstrate a less noticeable decrease in moisture than control sample.
Thus we can conclude that ionizing radiation has a positive effect on the moisture-retaining capacity of stuffing and semi-finished products samples. Thus, the food products after irradiation preserve better on molecular and cellular levels.

Results of evaluation of vitamin C content in vegetable stuffing samples are shown in figure 4.

![Figure 4. Vitamin C content in vegetable stuffing samples](image)

According to the graph, after radiation the vitamin C content in all samples decreases, and after 27 days of shelf life it is equal. Therefore, ionizing radiation doesn’t have significant effect on vitamin C content in samples after more than 1 month of their shelf life.

The dynamics of QMAFAnM growth in vegetable stuffing and semi-finished products samples are presented in tables 2 and 3 accordingly.

| Dose of irradiation, kGy | QMAFAnM, CFU/g |
|--------------------------|----------------|
|                          | 2 days  | 8 days  | 20 days | 27 days |
| 0                        | 4.3×10³ | 7.5×10³ | 1.9×10⁴ | 1.1×10⁵ |
| 4                        | less than 10 | less than 10 | less than 10 | less than 10 |

The quantity of microorganisms in experimental sample does not change during a month while the quantity of microorganisms in the control sample gradually increases.

| Dose of irradiation, kGy | QMAFAnM, CFU/g |
|--------------------------|----------------|
|                          | 0 days  | 7 days  | 19 days | 26 days |
| 0                        | 3.0×10³ | 3.8×10³ | 1.2×10⁶ | 4.8×10⁶ |
| 3                        | 3.8×10³ | 7.2×10⁵ | 1.4×10⁶ | 6.4×10⁶ |

The quantity of microorganisms in experimental sample has got negative dynamics during first 3 weeks. However, by the end of the 4th week its dynamics practically reaches the level of the control sample.
4. Conclusion
Ionizing radiation presumes the extension of combined vacuumed poultry meat semi-finished products and vegetable raw materials shelf life. However, vitamin C content decreases regardless of radiation dose. The dose of 4 kGy doesn’t have negative effect on sensory characteristics of samples.

The introduction of new technologies of culinary production will make possible the increase of product shelf life and reduce storage costs while planning production at public catering enterprises.

In general context of the HACCP system, ionizing radiation should be treated as a way of reducing the danger caused by pests and microorganisms’ contamination of food products and can be used as a method of contamination decreasing.

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