Composite sausages based on mustard seeds and its processing products: technological aspects of production

A L Alekseev¹, M I Slozhenkina², G V Fedotova², O A Knyazhechenko²,³, A A Slozhenkina² and A B Slozhenkin²

¹ Don State Agrarian University, Rostov region, Russia
² Volga Region Research Institute of Manufacture and Processing of Meat-and-Milk Production, Volgograd, Russia
³ E-mail: knyazhechenko71@gmail.com

Abstract. The greater part of protein-containing technological preparations on the Russian market is represented by products of foreign manufacturers, however, the Russian Federation possesses extensive resources of protein-containing raw materials of plant origin that are used in the meat product technology limitedly due to the lack of recommendations for their use. The issue of enriching meat products with non-traditional protein plant ingredients involves opportunity to use mustard seeds and products of its processing for this purpose. Despite valuable properties of this crop, the functional and technological characteristics of mustard seeds have not been sufficiently studied. The purpose of the research was to assess the functional and technological characteristics of a mustard-based protein supplement with the prospect of using it in sausage production technology. The study was conducted at the Food Technology Department of the Don State Agrarian University and in the conditions of LLC “Myasokombinat,” in Razvilnoe, Peschanokopsky district, Rostov region. High functional and technological properties and nutritional value of mustard flour allowed recommending it as a domestic functional supplement of vegetable origin for the technology of meat and vegetable sausages of a wide range.

1. Introduction
Carbohydrate food dominates in the dietary structure of the population in our country. There is an acute deficiency of protein, in particular of animal origin, and essential amino acids. Only half of the Russian population is provided with the minimum required dietary protein intake. One of the promising directions in reducing protein deficiency today is the efficient use of plant materials and creation of various forms of food protein on its basis [2, 11, 12].

Plant proteins based products are considered healthy foods with an improved nutrient balance compared to traditional foods. The predominant share of plant-based protein supplements on the Russian market is represented by products of foreign companies. The Russian Federation has extensive resources of protein-containing raw materials of plant origin, but they are limitedly used in the meat product technology due to the lack of scientifically based recommendations for their use [1, 8, 10].

In this regard, the issue of enriching meat products with non-traditional protein plants ingredients that involves opportunity to use mustard seeds and products of its processing for this purpose is of great interest. Despite valuable properties of this crop, functional and technological characteristics of mustard seeds have not been sufficiently studied [9, 13].
The purpose of the work was to assess the functional and technological characteristics of a mustard-based protein supplement with the prospect of using it in sausage production technology.

2. Research methods
The study was conducted at the Food Technologies Department of the Don State Agrarian University and in the conditions of LLC “Myasokombinat,” in Razvilnoe, Peschanokopsky district, Rostov region.

The objects of the research were raw meat—trimmed beef first grade and trimmed semi-fat pork, mustard flour (manufactured by LLC “Transagrosbyt,” Voronezh, Voronezh region, Russia), and other ingredients according to the recipe.

Modern functional and technological, biochemical, physicochemical, structural, mechanical, microbiological, and sensory research methods were applied according to GOSTs [3, 4, 5, 6, 7] in the experimental research study.

3. Results and discussion
Mustard seed processing product—mustard flour—is of considerable interest for sausage production. It is obtained by processing mustard cake left over after pressing oil. In its composition, mustard flour is similar to soy flour and contains a lot of protein, so it can be used as a protein supplement in sausages. The nutritional value of mustard flour is presented in table 1.

| Nutritional value | Content (per 100 g) |
|-------------------|---------------------|
| Calorie content   | 378 kkal             |
| Protein           | 37.1 g               |
| Fat               | 11.1 g               |
| Carbohydrates     | 32.6 g               |
| Water             | 7.3 g                |
| Fiber             | 5.9 g                |

If we compare the data on the quantitative protein content of 14-21% in meat and protein content of about 37% in mustard powder, we can assume that the mustard powder added into meat systems in any technologically feasible quantities will not cause a decrease in the weight fraction of protein in the finished product.

The study of functional and technological properties made it possible to objectively evaluate the options for the most rational use of mustard powder and flour, both individually and in combination with other protein-containing components of plant and animal origins (table 2).

| Ingredient        | Water retention capacity, g/g of preparation in water solution | Fat holding capacity, g/g of preparation |
|-------------------|---------------------------------------------------------------|-----------------------------------------|
| Mustard powder    | 4.64                                                          | 1.52                                     |

Analyzing the chemical composition of mustard powder and data on its functional and technological properties, we can assume possible options of the investigated preparation being applied in the formulations of emulsified meat products due to the capability of mustard powder to exhibit good water retention, fat holding, and gel forming properties.

Powdered mustard cake considerably surpasses soy flour in terms of the fat and water retention, which is explained by the specific composition of its proteins that play an important role in the formation and stabilization of meat emulsions, since they dissolve in the aqueous emulsion phase and perform the function of surfactants that facilitate the emulsification process. In powdered mustard cake, there are
substantially more water-soluble proteins than in soy protein isolate, which is especially important when creating functional meat products.

High functional and technological properties and nutritional value of mustard flour allowed recommending it as a domestic functional supplement of plant origin for use in the technology of meat and vegetable sausages of a wide range.

The restrictions on the quantitative level of the mustard powder added into a product are mainly related to its specific sensory characteristics. In technological practice, protein-containing preparations and food supplements are usually applied either in dry or hydrated form, so in our experimental study the efficiency of mustard powder was evaluated in a hydrated form in a ratio of 1:3.

In order to establish the effect of the mustard flour protein supplement on the functional and technological properties of model minced meat and the limits of the mustard powder added to the recipes of cooked sausages, a portion of model minced meat was produced instead of an adequate amount of raw meat in the production conditions of LLC “Myasokombinat.” The sausage cooked according to the recipe “Stolovaya” (category B) was considered a Control sample; in Test samples, from 3 to 10% of trimmed beef grade 1 was replaced with mustard powder (table 3).

Table 3. Recipes of Test model minced meat systems.

| Ingredients                        | Control | Substitute 3% | Substitute 5% | Substitute 7% | Substitute 10% |
|------------------------------------|---------|---------------|---------------|---------------|---------------|
| Unsalted raw material, kg (per 100 kg of raw material) |          |               |               |               |               |
| Beef trimmed, 1 grade              | 40.0    | 38.8          | 38.0          | 37.2          | 36.0          |
| Pork trimmed semi-fat              | 59.0    | 53.0          | 47.0          | 41.0          | 41.0          |
| Cow's milk, powdered, whole or skimmed | 1.0     | 1.0           | 1.0           | 1.0           | 1.0           |
| Mustard powder hydrated            | 0.0     | 1.2           | 2.0           | 2.8           | 4.0           |
| Total                              | 100.0   | 100.0         | 100.0         | 100.0         | 100.0         |

The data on the effect of the hydrated mustard flour protein supplement on the moisture binding and emulsifying capabilities of minced meat systems are presented in Figures 1 and 2.

Figure 1. The effect of hydrated mustard flour on the moisture binding capacity of minced meat.

Figure 2. The effect of hydrated mustard flour on the emulsifying ability of minced meat.

An increase in the dosage of hydrated mustard flour introduced into minced meat caused an increase in its moisture-binding and emulsifying capacity, which was one of the important factors in the cooked sausage technology and contributed to an increase in the output of finished products and prolongation of the shelf life.
The hydrated mustard flour (1: 3) added into minced meat instead of the main raw material allowed improving the structural and mechanical characteristics of the finished product without considerable changes in the general chemical composition, yield, and sensory characteristics.

To confirm the effect of hydrated mustard flour as a protein supplement of vegetable origin and a substitute for a part of the main raw material, prototypes were developed based on the recipe for the sausage “Stolovaya” (category B) GOST 33673-2015 “Cooked sausages. General specifications.” In Test samples, from 3 to 10% of trimmed beef grade 1 was replaced with mustard powder (table 4).

**Table 4.** Recipe of Test samples of cooked sausages with different contents of mustard flour, replacing raw meat.

| Ingredients                                      | Control | Substitute 3% | Substitute 5% | Substitute 7% | Substitute 10% |
|--------------------------------------------------|---------|---------------|---------------|---------------|---------------|
| Unsalted raw material, kg (per 100 kg of raw material) | 100.0   | 100.0         | 100.0         | 100.0         | 100.0         |
| Beef trimmed, 1 grade                            | 40.0    | 38.8          | 38.0          | 37.2          | 36.0          |
| Pork trimmed semi-fat                            | 59.0    | 53.0          | 47.0          | 41.0          | 41.0          |
| Cow's milk, powdered, whole or skimmed           | 1.0     | 1.0           | 1.0           | 1.0           | 1.0           |
| Mustard powder hydrated                          | -       | 1.2           | 2.0           | 2.8           | 4.0           |
| Total                                           | 100.0   | 100.0         | 100.0         | 100.0         | 100.0         |

Food additives, spices, materials, g (per 100 kg of unsalted raw material)

| Ingredients                             | Control | Substitute 3% | Substitute 5% | Substitute 7% | Substitute 10% |
|-----------------------------------------|---------|---------------|---------------|---------------|---------------|
| Sugar                                   | 150     | 150           | 150           | 150           | 150           |
| Table salt                              | 2475.0  | 2475.0        | 2475.0        | 2475.0        | 2475.0        |
| Sodium nitrite                          | 7.4     | 7.4           | 7.4           | 7.4           | 7.4           |
| Black pepper                            | 100.0   | 100.0         | 100.0         | 100.0         | 100.0         |
| Allspice                                | 100.0   | 100.0         | 100.0         | 100.0         | 100.0         |
| Fresh garlic                            | 120.0   | 120.0         | 120.0         | 120.0         | 120.0         |

The research provided for tasting monitoring of sensory evaluation of cooked sausage prototypes with different contents of mustard flour, replacing raw meat, in points (table 5).

**Table 5.** General sensory evaluation of cooked sausage prototypes with different contents of mustard flour, replacing raw meat, in points.

| Batch of sausages, mustard powder added | General sensory evaluation, points |
|----------------------------------------|-----------------------------------|
| Control                                | 8.60                              |
| 3 % of a substitute                    | 8.60                              |
| 5 % of a substitute                    | 8.45                              |
| 7 % of a substitute                    | 8.42                              |
| 10 % of a substitute                   | 6.55                              |

Considering the totality of the indices, the products with a mustard powder content of up to 7% were preferred; a higher mustard powder content added to the product is inadmissible due to a pungent taste and grayish shade of sausage on the cut. The results of chemical and technological studies of cooked sausages of the control and test batches, containing mustard powder, are shown in table 6.

**Table 6.** Chemical and technological parameters of cooked sausages produced with mustard powder.

| Mustard powder added | Weight fraction, % | Output of finished products, % |
|----------------------|--------------------|-------------------------------|
|                      | moisture | fat  | protein |                      |                |
| Control              | 70.5     | 16.20| 12.60   | 118.0                |
| 3 % of a substitute  | 70.6     | 14.55| 13.30   | 118.9                |
| 5 % of a substitute  | 71.0     | 14.44| 14.05   | 119.5                |
| 7 % of a substitute  | 71.1     | 13.02| 14.85   | 119.9                |
| 10 % of a substitute | 71.3     | 12.50| 15.30   | 120.2                |
The analysis of the data suggested that the mustard powder in cooked sausage recipes as a substitute for a part of the main raw material caused minor changes in the total chemical composition of the finished product, with the mustard content of up to 7% ensuring consistently good sensory characteristics and an increase in protein content and a decrease in fat content.

4. Conclusion
The study of the functional and technological properties of a vegetable protein supplement – mustard flour – and their changes enabled substantiating the utility criteria for the investigated preparation in the formulations of emulsified meat products and optimizing the norms and conditions for the mustard powder used in cooked sausage technologies. The mustard powder as a substitute for part of the main raw material in cooked sausage recipes causes minor changes in the total chemical composition of the finished product, with the mustard content of up to 7% ensuring consistently good sensory characteristics and an increase in protein content and a decrease in fat content.

Acknowledgments
This work was carried out as part of a grant from the President of the Russian Federation НШ-2542.2020.11. Grant sponsors were not directly involved in the development, analysis, or writing of this article.

References
[1] Aslanova M A, Derevitskaya O K, Dydykin A S and Volovik E L 2010 Functional meat products enriched with vegetable raw materials Meat Industry 6 45-7
[2] Vasyukova A T and Rodina E V 2012 Research of functional properties of minced meat Food Industry Agro-industrial complex 6 13-8
[3] Zabodalova L A 2015 Scientific basis for creating products of functional purpose (St. Petersburg: ITMO University; IHiBT) p 32-7
[4] Kuznetsova E A, Alekseev A L and Serdyukova Ya P 2015 Prospects for the use of non-traditional protein ingredients in the technology of combined meat products Proc. Int. scientific and practical conference on Innovative technologies of food production (Persianovsky: DonSAU) p 76-9
[5] Lukin A A 2014 Technological features and prospects for the use of plant and animal proteins in the production of sausages Bulletin of the South Ural State University. Series: Food and Biotechnology 1 52-9
[6] Orlova G G 2016 The role of healthy and balanced nutrition in the prevention of the most common and socially significant diseases Rational nutrition, food additives and biostimulants 1 83-5
[7] Rogov I A, Oreshkin E N and Sergeev V N 2017 Medical and technological aspects of the development and production of functional food products Food industry 1 33-5
[8] Rusakova G G, Parakhnevich E D, Parakhnevich D V and Rusakova M M 2014 Chemical composition of mustard seeds and products of their processing Bulletin of the Nizhnevolsky agro-university complex: science and higher professional education 4 168-71