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Article

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ASSESSMENT OF FUNCTION-TECHNOLOGICAL AND RHEOLOGICAL PARAMETERS OF CONSISTENCY STABILISERS FOR DAIRY PROTEIN-FAT SYSTEMS FOR THE PRODUCTION OF SEMI-SMOKED SAUSAGES

During the past few years, the world community has faced a number of problems related to the delivery and storage of milk and milk products. In particular, the situation provoked by quarantine restrictions in various countries of the world forces to look for solutions regarding the use of non-traditional raw materials for the production of classic or similar food products. As a result, it is quite promising to use dairy products with extended shelf life, in particular, dry milk concentrates as the main protein carriers for the production of stable protein-fat systems. The use of dry milk proteins makes it possible to manufacture restored structural products that can be used as an alternative to classic ones. Therefore, the object of research is food components of various origins, in particular food modified starches, food fibers and their modifications, hydrocolloids.

Characteristic indicators of viscosity with increasing shear stress were determined for 5 % solutions of modified starches of various types after brewing at a temperature of 80 °C. It was found that when the shear stress increases to a value of 200 Pa, there is a significant decrease in viscosity, which generally characterizes them as structural systems. The functional and technological indicators of wheat (VF-200), bamboo (BAF-200) food fibers (fiber length 200 microns) and carboxyl methyl cellulose (CMC) were studied. Increased functional and technological capabilities of CMC compared to dietary fibers were revealed. The kinetics of swelling of dietary fibers and CMC were studied, while the period of maximum intensification of the process, which is between 5 and 15 minutes, was determined. The maximum value of the swelling coefficient is characteristic for CMC 4.4±0.04, for wheat fiber 4.01±0.06, for bamboo fiber 3.81±0.05. Using the method of mathematical and statistical processing of experimental data, optimization of concentration and technological modes was carried out to achieve maximum hydration and strength of iota-carrageenan gel. It was determined that at a concentration of 1 % during brewing at 80 °C and a time of 5 min. high enough gel strength can be achieved for optimum consistency in the overall system.

The result of the work is a comprehensive study of the functional technological characteristics of food additives that will form the consistency of a structural protein-fat product of the cheese type, which can be used in sausage products as a filler, with the aim of improving the organoleptic, structural-mechanical and nutritional values of the finished products.

Keywords: *recipe of semi-smoked sausages, modified starch, carboxyl methyl cellulose, food fibers, iota-carrageenan, milk proteins.*

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1. Introduction

The use of dairy components in the recipes of sausage products allows to improve a number of indicators related to the nutritional and structural-mechanical properties of finished products [1]. At the same time, replacing liquid or condensed dairy products with dry ones has several actual advantages [2]:

– preservation of shelf life: dry milk products such as skimmed milk powder, enriched milk powder or milk protein powder have a longer shelf life compared to raw milk. This allows the product to be stored for a long period of time without the risk of spoilage [3];

– convenience of storage and transportation: dry milk products take up less space and are easier to transport compared to fresh milk. They can be conveniently packaged and stored without the need for refrigeration, making them easier to transport and use [4];

– reducing the risk of pathogens: dry dairy products undergo heat treatment during production, which reduces the risk of the spread of harmful bacteria, viruses and parasites. This is especially important in the context of health and food safety [5];

– higher nutrient retention: dry dairy products can contain enriched forms of nutrients such as vitamins and minerals. During the production process, additional components can be added to improve the nutritional value of the product [6].

The use of milk proteins in the recipes of meat products allows improving the quality and functional properties of meat products. Milk proteins, such as whey protein, sodium caseinate and others, have a high biological value and expand the amino acid composition of the product, providing a complete amino acid composition for the body [7]. They also affect the texture, taste and structure of meat products. Milk proteins also have emulsifying and stable properties, which allows improving the structural properties of the product, ensuring the homogeneity of mixtures and preventing the breakdown of emulsion systems [8]. In addition, the use of milk proteins can contribute to increasing the yield of the product, both during production and during storage and sale. In general, the use of milk proteins in the recipes of meat products opens up wide opportunities for improving the quality, taste characteristics and nutritional value of these products.

In order to expand the potential of using milk proteins in the recipes of meat products, there is a possibility of their integration into structural systems based on consistency stabilizers and hydrocolloids. At the same time, the possibilities of adding additional milk proteins to the recipes of sausage products are expanding significantly [9].

Modified food starches, gums, carrageenan, food fibers and their derivatives are the main food additives used to form various stable food systems [10]. Individually or in mixtures, these components have a high moisture-binding capacity and create a gel-like strong structure. They help stabilize the product by maintaining its shape and consistency during manufacturing and storage. In addition, they have emulsifying properties and can improve the distribution of fats in the product to prevent their separation, which is important to ensure the uniformity and stability of the product [11, 12].

The use of the listed food additives allows forming a product with a texture similar to hard cheese, with its characteristic appearance and characteristics.

The aim of research is to study the rheological properties of various food additives for the possibility of optimization modeling of the structural and mechanical indicators of individual components when they are used in the technology of semi-smoked sausages. The selected list of food components will have different functional indicators, while they will work in synergy to form a common system, to ensure the necessary indicators of emulsifying, moisture-binding and moisture-retaining ability. This will allow the use of food mixtures, based on selected components (in different ratios), in the manufacture of new protein, fat and protein-fat products, for use in various branches of the food industry.

2. Materials and Methods

The object of research is food components of various origins, in particular food modified starches, food fibers and their modifications, hydrocolloids.

A list of structure-forming additives was selected for further use as stabilizers for the manufacture of imitation cheese products. The following ingredients are selected as the basis of stabilizing functional components:

– Pasteurized modified corn starch of hot swelling (E1422, Clearam CH 20, France);
– Gelatinized modified starch obtained from waxy corn (E1424, National Starch and Chemica, Romania);
– Modified emulsifying starch (E1450, Paselli MC 150, Netherlands);
– Carboxyl methyl cellulose (CMC) (E466, Shandong Yulong Cellulose Technology Co, Ltd, China);
– Wheat fiber (Vitacel VF-200, Germany);
– Bamboo fiber (Vitacel VAF-200, Germany);
– Iota carrageenan refined (Richest Group, China).

A study of rheological and functional-technological properties of various types of structure-forming products was conducted; modified starches, food fibers, hydrocolloids, to determine parameters for achieving high functionality and suitability for manufacturing structural products based on them.

Rheological indicators were determined using a rotary viscometer Reotest-II [13].

3. Results and Discussion

The study of the chemical composition and hydrophilicity of modified starches provides important information about their potential use as thickeners-stabilizers to achieve the desired texture and structural-mechanical properties of food products. Selected starches, independently or in synergy, will allow creating stable matrices with moderate density, which will allow them to be used as a basis for the formation of low-fat, fatty, protein or protein-free products, which can be used as independent or semi-finished products for other food products, including meat clear.

Brewing temperature recommended by manufacturers for maximum hydration for selected starches is 80 °C. The concentration of the solutions was 5 %, the brewing temperature was 80 °C, and the holding time was 5 min.

Sample No. 1 – Pasteurized modified corn starch of hot swelling : Water (80 °C) – 5:95.

Sample No. 2 – Gelatinized modified starch obtained from waxy corn : Water (80 °C) – 5:95.

Sample No. 3 – Modified emulsifying starch : Water (80 °C) – 5:95.

Fig. 1 shows a graph of the dependence of viscosity on the shear stress of the investigated modified starches.

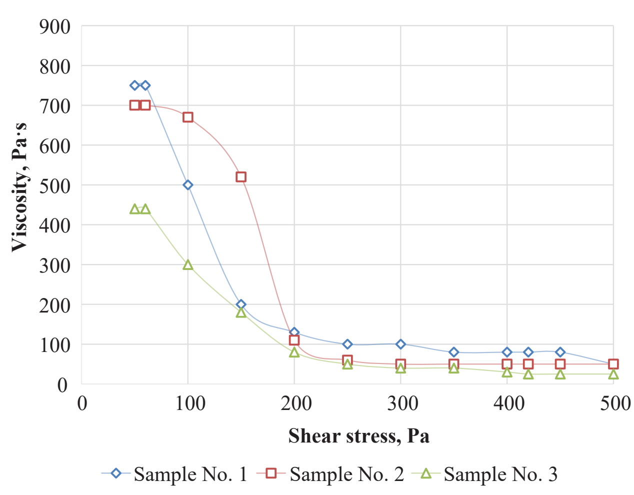


Fig. 1. Dependence of viscosity on shear stress

Based on the curves (Fig. 1), it can be concluded that all the studied objects are structured systems. When the load increases, the viscosity decreases. This is explained by the destruction of supramolecular structures in the system. Samples No. 1 and No. 2 have significantly higher viscosity indicators, compared to Sample No. 3, with the same parameters of preparation and mechanical impact. This is due to the properties of this sample, as it is characterized by additional emulsifying properties, while the gelling power and viscosity are lower. But it can be used additionally, as an emulsifier with Samples No. 1 and No. 2, in the starch : water : fat system.

To determine the functional and technological characteristics of CMC and food fibers, a study of the main functional characteristics was conducted. In particular, the moisture-binding (MBA), moisture-retaining (MRA), fat-retaining (FRA), emulsifying ability (EA) and emulsion stability (ES) were investigated. The results of the research are given in Table 1.

Table 1

Functional and technological characteristics of food fibers

Name	MBA (g water/g fiber)	MRA (g water/g fiber)	FRA (g oil/g fiber)	EA (%)	ES (%)
KMC	4.9±0.1	14.2±0.07	5.11±0.06	57.1±0.06	53.4±0.1
VF-200	4.45±0.09	12.1±0.12	4.56±0.1	54.3±0.05	52.3±0.06
BAF-200	4.34±0.09	6.6±0.05	5.54±0.12	53.9±0.06	51.1±0.02

Data in the Table 1 shows that the selected food fibers have a high emulsifying capacity and resistance to emulsions. The indicators of carboxyl methyl cellulose have slightly better values, which is characteristic, since the modification of cellulose has improved structural and mechanical indicators, which is characterized by its rather wide use in various branches of food and industrial production. The highest values of MBA and MRA are observed in KMC and wheat fibers, whereas FRA has a sample of bamboo fiber. These characteristics give an understanding that the use of dietary fibers in water : fat or water : protein : fat systems is expedient and promising.

A study of the swelling process of the studied KMCs and dietary fibers was conducted at a temperature of 20±2 °C in purified drinking water. The kinetics of swelling of dietary fibers and KMC is presented in Fig. 2.

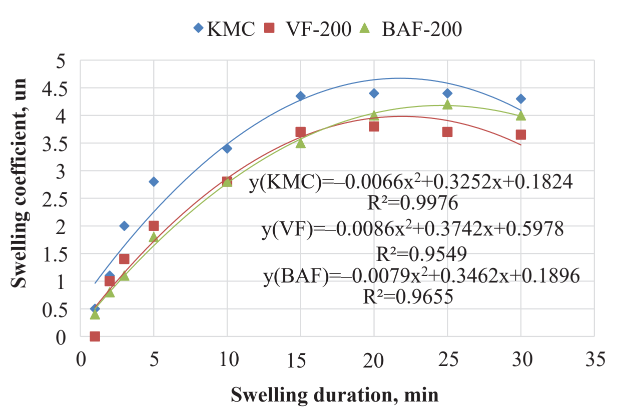


Fig. 2. Kinetics of KMC, VF-200, BAF-200 swelling

According to the graph (Fig. 2), the maximum intensification of swelling occurs within 5–15 min. The maximum value of the swelling coefficient is typical for KMC 4.4±0.04, while the maximum value is reached after 15 min swelling process. After 25 min. process, swelling slows down, probably as a result of an increase in the volume of dietary fiber, and accordingly, tension in the spatial grid. The maximum value of the swelling coefficient for the other two samples was 4.01±0.06 for BAF-200 at 25 min. swelling and 3.81±0.05 for VF-200 at 20 min. Characteristically, KMC requires less time for maximum hydration, while it has a higher coefficient, so when it is used in food mixtures, maximum functionality can be achieved with lower material costs associated with mechanical impact during swelling.

A study of the influence of the concentration and technological modes of preparation of iota-carrageenan in aqueous solutions on rheological parameters was carried out in order to assess the maximum realization of the technological potential of the hydrocolloid system. For the study, iota-carrageenan solutions of 0.5 %, 1.0 % and 1.5 % with the addition of 0.2 % KCI were prepared.

When preparing the samples, the amount of iota-carrageenan (X_3), brewing temperature (X_2) and duration of mixing (X_1) were varied.

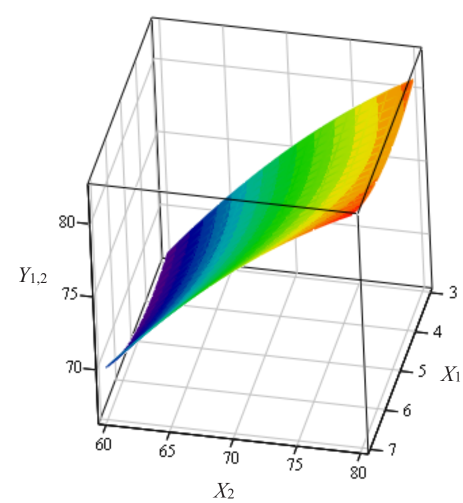
With the help of regression analysis, the regression equations and the response surface of the dependences of the iota-carrageenan gel strength on the specified factors and levels of variation were obtained (Fig. 3–5).

To assess the accuracy of equations (3)–(5), the mean square deviation of the initial and calculated values of the function was found, which are: $\delta Y_{1,2}=0.85$, $\delta Y_{2,3}=0.64$, $\delta Y_{1,3}=0.36$.

Analyzing the response surfaces (Fig. 3–5), it is possible to conclude that the parameters for achieving high gel strength are the mixing duration of 5 min for a temperature of 80 °C and a concentration of iota-carrageenan at the level of 1.0 %.

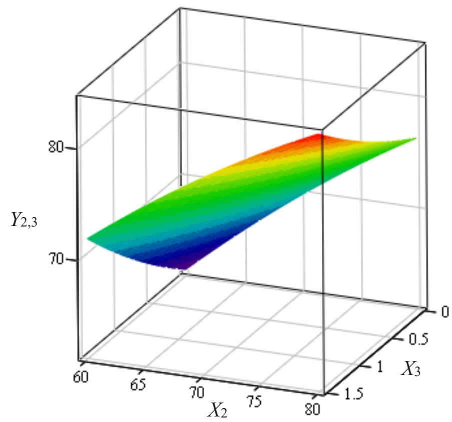
The specified parameters are the most advantageous from the point of view of iota-carrageenan brewing properties, process speed, material and technological costs.

Using the obtained results, it is possible to create stabilizing mixtures based on the studied components, while using specific concentrations and preparation modes to achieve the maximum effect.



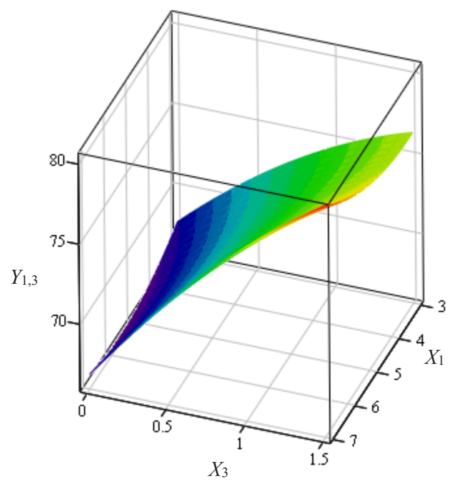
$$Y_{1,2} = -29.75 - 1.52 \cdot X_1 + 0.32 \cdot X_1^2 + $$
$$+ 2.41 \cdot X_2 - 0.01 \cdot X_2^2 - 0.02 \cdot X_1 \cdot X_2$$

Fig. 3. Response surface of the dependence of gel strength (Y) on the duration of mixing (X_1) and brewing temperature (X_2)



$$Y_{2,3} = -18.78 + 10.09 \cdot X_1 + 0.97 \cdot X_1^2 + $$
$$+1.79 \cdot X_2 - 0.01 \cdot X_2^2 - 0.08 \cdot X_1 \cdot X_2$$

Fig. 4. Response surface of the dependence of gel strength (Y) on brewing temperature (X_2) and solution concentration (X_3)



$$Y_{1,3} = 74.12 - 2.85 \cdot X_1 + 0.25 \cdot X_1^2 + $$
$$+6.09 \cdot X_2 - 1.88 \cdot X_2^2 + 0.83 \cdot X_1 \cdot X_2$$

Fig. 5. Response surface of the dependence of gel strength ($Y_{1,3}$) on mixing time (X_1) and solution concentration (X_3)

A limitation is that the obtained results refer to selected components of the respective manufacturers. Using components from other manufacturers, with the same or similar names and specifications, results may vary.

Despite the state of war in the country and the restrictions associated with it, this study was conducted in accordance with generally used methodological guidelines, on the laboratory equipment of the National University of Food Technologies (Kyiv, Ukraine).

Further research will be aimed at determining the characteristics and functional properties of various products using the investigated components as consistency stabilizers.

4. Conclusions

1. It was determined that solutions of modified starches (No. 1 and No. 2), at a concentration of 5 % and a welding temperature of 80 °C, form viscous structural systems and can be used as thickeners-stabilizers. At the same time, Sample No. 3 has lower viscosity indicators, but at the same time, it can act as an emulsifier, which is recommended by the manufacturer.

2. Evaluating the functional and technological characteristics of KMC and food fibers, it was found that KMC as a whole has higher moisture binding (MBA), moisture retention (MRA), fat retention (FRA), emulsifying ability (EA) and emulsion stability (ES), in comparison with dietary fibers. It was determined that the highest coefficient of swelling has a KMC of 4.4±0.04 units, while the maximum intensification of swelling occurs within 5–15 min. of stirring and after 15 min. reaches its peak.

3. Indicators of concentration, temperature and mixing time were calculated to achieve the maximum strength of the iota-carrageenan gel. It was established that the following indicators will be used to achieve optimal gel strength and economic efficiency: carrageenan concentration 1.0 %, mixing time 5 min. and a temperature of 80 °C.

4. The obtained results allow concluding that when forming strong protein-fat systems with the additional use of milk protein concentrates, it is possible to use stabilizing complexes based on modified starches, carboxyl methyl cellulose and iota-carrageenan in different ratios. At the same time, in order to achieve maximum strength of the product due to the functionality of food additives, the manufacturing process should include heating to 80 °C and holding for 5–10 minutes.

Conflict of interest

The authors declare that they have no conflict of interest in connection with this study, financial, personal, authorship, or otherwise, that could affect the study and its results presented in this article.

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The study was conducted without financial support.

Data availability

The manuscript has no associated data.

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