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Possibility of application of collagen preparation in egg white cream manufacturing technology

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Abstract

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The purpose of the research was to study the applicability of a collagen preparation in the egg white cream manufacturing technology. The manufacturing technology of a collagen preparation was developed. As a raw material second category by-products (lips and ears of cattle) and Protepsin enzyme preparation were used. We have studied the effect of the obtained collagen preparation on functional and technological properties of egg whites (foaming capacity and foaming stability). We also took ready dried protein-containing products to compare functional and technological properties of fresh egg whites with the added collagen preparation. Egg whites with 5% added collagen preparation proved to have high functional and technological properties. The foaming capacity was 97%; the foaming stability was 90% in the first minutes, and 80% in the next 15 minutes. The resulting cream with the addition of 5% collagen preparation from the mass of egg whites did not differ in organoleptic characteristics from the traditional formula of egg white cream.

Keywords: collagen preparation; egg whites; egg white cream; manufacturing technology; food biotechnology

Introduction

Egg-processing industry supplies the market with a variety of dried egg products: egg white powder, egg yolk powder, dried whole eggs, with or without various additives. This opens up an opportunity for manufacturers using egg products as a raw material to improve manufacturing technologies, changing the ratio of egg white and yolk in the formula and developing new types of products (Stadelman et al., 1995).

Successful application of dried egg products depends on their functional properties. It is established that the use of dried egg products instead of natural ones increases the consumer characteristics of the finished product.

One of the most important advantages of dried egg products is their high microbiological safety, since most of the bacteria die during pasteurization and drying (Wierenga et al., 2009). The main areas for improving quality of dried egg products are ensuring microbiological purity, obtaining the desired chemical composition, increasing solubility, emulsifying and foaming capacity of egg whites (Eckert et al., 2013). Drying is one of the most effective preserving methods. Powdered egg products are highly nutritious and find a variety of applications in food industry, cooking, synthetic textiles production, as well as in leather, printing and paint industries. Due to the development of these industries, manufacturers – suppliers of dried egg products – are faced with strict requirements concerning extension of production capacities, increased production, quality improvement and longer shelf life.

The available range of protein-based foaming agents for food industry is limited to egg whites or egg-milk protein mixtures. However, the stability of products on their basis is low unless stabilizing additives are added. Expensive struc-

ture-forming agents, such as agar-agar, starches, pectins, furcellaran, gelatine are used as foam stabilizers (Dickinson, 2012). The manufacturing technology of egg white-based whipped products is complex and multistage due to the low thermal stability of egg whites. There are known methods for producing protein whipped mass based on dry milk, but caseinates do not possess a high foaming capacity and require additional foaming agents, their foams are unstable and require a stabilizer (Dickinson, 1998). In order to save egg whites, protein supplements are used, such as dried whey, but such compositions need structure-forming agents, which stabilize the resulting whipped mass, for example modified starch (Behnke et al., 1986).

There is a method for the preparation of protein gelling whipped mass with gelatin in the composition, which is used as a foaming agent and structure stabilizer. The main drawback of this method is the narrow scope of its application. Gelatin has a very low foaming capacity and can only be used in compositions with egg white to produce products of fluffy consistency (Dickinson, 2010). In addition, the process of gelatin swelling and its subsequent dispersion in a high-viscosity environment is long and practically uncontrollable. This cannot but affect the quality of the finished product, which largely depends on the uniformity of distribution of a foaming agent in the aerated mass (Mine, 1995).

The objective of the research was to create a new protein foaming agent, easily dispersed in viscous aqueous systems. The goal was achieved by using a collagen preparation obtained by enzymatic hydrolysis as a protein foaming agent.

Materials and Methods

The materials of the research were the following:

– second category cattle by-products with a high content of connective tissue (lips and ears);

– Protepsin enzyme preparation (with standard proteolytic activity of 100 units/g), manufactured by ZAO Endocrine Enzymes Plant in Rzhavki, Solnechnogorsk district, Moscow region;

– egg white powder of various manufacturers;

– fresh egg whites with the addition of a collagen preparation.

Protepsin is an enzyme preparation of animal origin, containing a complex of acidic proteinases, intended for use in the meat industry for processing raw meat. The enzyme composition of the preparation is developed so as to have a balanced effect on various proteins of meat and meat systems used in the technology of meat processing. Protepsin's action in the meat system is similar to intracellular enzymes (cathepsins). It produces a synergistic effect and has additional qualities that allow to apply it in a wider range of technological parameters, and also to influence those protein systems on which intracellular enzymes have an insignificant effect or do not have any effect at all (Ghaffari-Moghaddam et al., 2014).

The solubility of egg whites was determined according to the solubility index (express method) using a refractometer. The concentration of hydrogen ions (pH) was determined using an electronic pH meter. The mass fraction of fat was determined using a filtering funnel. The essence of the method consists in dissolving the bound and free fat of the analyzed sample with an extractive mixture of ethyl alcohol and chloroform, separating the fat solution from the rest of the sample by filtration through a glass filter, evaporating the extraction mixture and weighing the residue after drying.

The mass fraction of protein substances was determined using the Kjeldahl method. The essence of the method consists in determining the mass fraction of the total nitrogen contained in the analyzed sample by its mineralization (decomposition) with boiling concentrated sulfuric acid to form ammonium salts, converting ammonium to ammonia by alkalinizing the mineralized substance, distilling off ammonia with hot steam, and determining the amount of the distilled ammonia using the titration method. The mass fraction of nitrogen is recalculated to the mass fraction of protein using the coefficient 6.25.

The mass fraction of solids was determined by drying the egg white powder in an oven at the temperature of 105 ± 2°C to a constant mass.

The content of impurities was determined judging by the presence of shell fragments and other solid impurities larger than 1 mm in 100 g of reconstituted dried egg products. The essence of the method consists in filtering the analyzed sample diluted with water (dried egg products were preliminarily reconstituted with water) through a sieve with the size of a cell diameter of 1 mm, and a visual assessment of the presence or absence of a residue on the sieve.

The glucose content was determined by acid hydrolysis of carbohydrates. The method is based on the ability of reducing substances, formed during the acid hydrolysis of carbohydrates, to reduce ferricyanide (red prussiate of potash) to ferrocyanide (yellow prussiate of potash) in an alkaline medium. Reducing substances were determined by titration with a standard solution of invert sugar of an excess of ferricyanide remaining after its reaction with reducing substances. The mass fraction of sugar was defined as the difference in the results of measurements of the reducing substances before and after the acid hydrolysis of the sample. The mass fraction of total carbohydrates was determined by recalculating the results of determination of reducing substances to glucose after acid hydrolysis of the sample.

Foaming capacity. The sample weight containing 6 g of dry substance was placed in a beaker, 25 cm^3 of distilled water was added and thoroughly triturated with a glass spatula in a beaker until a homogeneous mass was obtained. Then the mass was transferred to a 500 ml measuring cylinder with a ground stopper, the remainder in the beaker was rinsed with distilled water, and the total volume of the liquid in the cylinder was brought up to 300 ml. Then, it was whipped using the electric stirrer for 10 minutes and after every minute the volume of the whipped mass was measured (Rouimi et al., 2005).

To determine the stability of the foam, the cylinders were left in a quiescent state for 15 minutes, after which the height of the remaining foam was measured and its resistance was calculated (Skurikhin and Tutelyan, 1998).

All measurements were carried out in three replications. Statistical analysis was performed using Microsoft Excel XP and Statistica 8.0 software package. The statistical error of the data did not exceed 5% (at 95% confidence level).

Results and Discussion

Development of technology for collagen preparation manufacturing

The method for obtaining the collagen preparation involves the following stages of raw material processing:

1) the raw material was mechanically cleaned to remove related components;

2) the raw material was cut into fragments up to the size of 1x1 cm^2;

3) the raw material was washed to remove the impurities which reduce the shelf life of the target product (water-soluble proteins and lipids). First, the raw material was washed with water accompanied by vigorous mixing, water ratio 1:5. Then the raw material was washed with an alkaline salt solution containing up to 0.3% sodium hydroxide and 0.3% sodium chloride at pH 11-12, water ratio 1:10. The temperature is not determinative, it must be observed in the range from +4 to +23°C. At this stage, along with the removal of impurities, swelling and loosening of the derma, which is necessary for enzymatic processing, took place;

4) the prepared secondary collagen-containing raw material – lips and ears of cattle – taken in a ratio of 1:2 was ground in the meat mincing machine and then processed in the cutter. After adding water and 0.2 kg of the enzyme preparation to the minced raw material, the resulting mixture was heated to 40-45°C. Hydrolysis was carried out for 1.5-2 hours. In order to inactivate the enzyme preparation the mixture was heated to the temperature of 80-90°C for 15–20 minutes (Spohner et al., 2015).

5) the raw material was mechanically homogenized, not allowing the mass to be heated above +35°C. Then, while stirring, the homogenate was acidified to food pH limits with aqueous solutions of citric or acetic acid (Mandl, 2000). The acidified homogenate was forced through a sieve with a hole diameter of 1 mm to remove undissolved residue and other impurities.

Thus, we obtained a polyfunctional collagen preparation in the form of an aqueous dispersion with a solids content of 8-16%, the main distinguishing feature of which is that the particle size does not exceed 6-6.5 μm in diameter (which corresponds to the diameter of the collagen fibrils);

6) the aqueous dispersion of the collagen preparation was dried in a thin layer with active air circulation or in vacuum at the temperature of no higher than 30-35°C. A dry collagen preparation with residual moisture content of 5-12% was obtained in the form of a translucent film.

The dry collagen preparation is easily rehydrated, forming uniform dispersions in aqueous systems with a wide range of viscosity, depending on the concentration of solids, the pH of the medium and the temperature. It serves as an effective foaming agent at pH 3.0-6.0 (Kuzelov et al., 2002). Being a polydisperse system, the collagen preparation stabilizes the foaming process and intensifies the process of structure formation due to the partial denaturation of collagen molecules at the interface of liquid and gas phases under mechanical stirring (Krog, 1997). This is the basis of its action as a foam stabilizer.

The use of collagen dispersions makes it possible to significantly simplify the technology of producing whipped mass, such as egg white. Since it is more thermally stable, it can be added to other components of the mixture without their pre-cooling (Goralchuk et al., 2017).

Study of effect of collagen preparation on functional and technological properties of egg white

To determine the amount of the collagen preparation to be introduced, samples with a mass fraction of 1 to 6% were prepared, with the interval of 1%. The effect of the collagen preparation on the foaming capacity was investigated at different temperatures. Figure 1 shows the change in the foaming capacity in the presence of a collagen preparation.

As can be seen from Figure 1, the optimal amount of the collagen preparation to be introduced into the formula of whipped egg whites is 5% of their mass. The introduction of a bigger amount reduces the foaming capacity of egg whites due to the increase in the viscosity of the system. Figure 2 shows the effect of the collagen preparation on the foaming capacity of egg whites depending on the temperature.

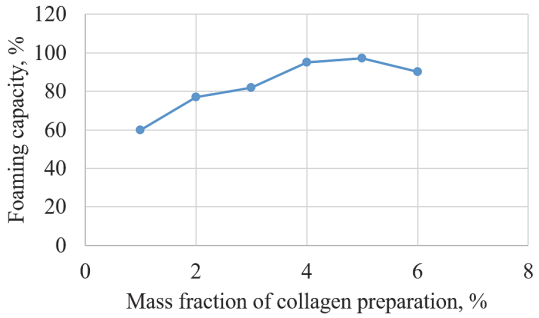

Fig. 1. Effect of collagen preparation on foaming capacity of egg whites

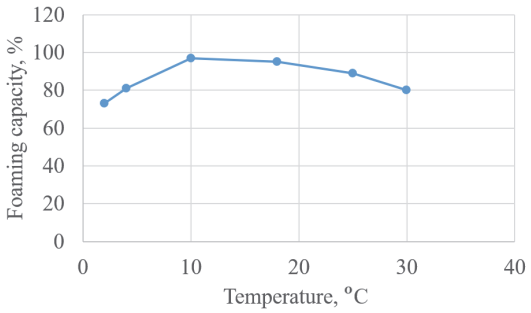

Fig. 2. Effect of collagen preparation on the foaming capacity of egg whites depending on the temperature

The optimal temperature for whipping egg whites is 10-15°C. Further research involved ready dried protein-containing products to compare the functional and technological properties of fresh egg whites with the addition of the collagen preparation.

Physical and chemical properties of dried egg whites

Top-selling egg white containing powders were used to study physical and chemical properties:

– HW dried egg white albumin powder (supplied by Soyuzsnab);

– Parmovo egg white powder (produced in Italy);

– Igreca egg white powder (produced in France);

– Sanovo egg white powder (produced in Germany).

Comparative physical and chemical properties are presented in Table 1.

The obtained results show that the presented egg white powders of various manufacturers meet the regulatory requirements for physical and chemical properties and quality indicators.

Study of foaming stability and foaming capacity of egg white powder and egg whites with added collagen preparation

Figure 3 shows the results of determining the foaming capacity of egg white powders and egg whites with 5% added collagen preparation. As follows from Figure 3, all the egg white powders have a high FC, comparable to the FC of raw egg whites with 5% added collagen preparation. Figure 4 shows the foaming stability (FS) of egg white powders while the foam stands for 15 minutes after its formation. As can be seen from Figure 4, egg white powders produce sufficiently stable foam with a slightly lower FS than that of raw egg whites with 5% collagen preparation.

The FS of all the egg white powder samples drops rapidly during the first 5 minutes when the foam is left to stand, and then it slowly decreases during 15 minutes, which indicates the need for rapid processing of confectionery masses after whipping and reducing the periods of standing between operations (Allen et al., 2006).

Development of manufacturing technology of egg white cream with 5% collagen preparation

The formula of the egg white cream is given in Table 2. Pre-cooled egg whites were whipped in the whipping machine first at a low speed to a porous foam, and then at a rapid speed for 7 to 10 minutes to a stable dense white foam. 15-20% of the prescribed powdered sugar was added to the

Table 1
Comparative physical and chemical properties

Properties	HW dried egg white albumin powder (supplied by Soyuzsnab)	Parmovo egg white powder (produced in Italy)	Igreca egg white powder (produced in France)	Sanovo egg white powder (produced in Germany)
Solubility, %	91	93	92	93
Glucose content	none	none	none	none
Concentration of hydrogen ions, pH	5.9	6.1	6.9	6.3
Mass fraction of solids, %	93	95	92	96
Mass fraction of fat, %	0.3	0.1	0.2	0.2
Mass fraction of proteins, %	87	90	88	91
Content of impurities	none	none	none	none

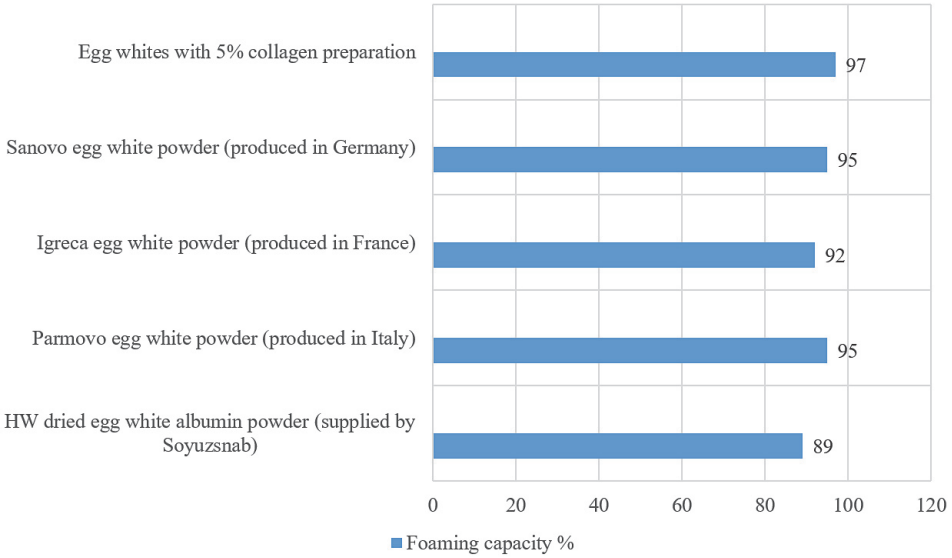

Fig. 3. Foaming capacity (FC) of egg white containing raw material

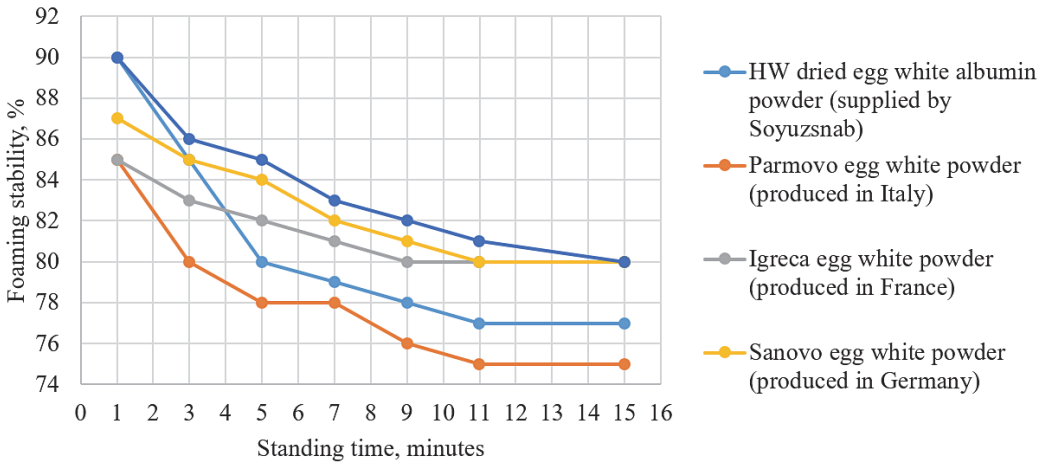

Fig. 4. Foaming stability (FS) of egg white powders and egg whites with the collagen preparation while the foam stands

Table 2
Formula of egg white cream

Raw material	Classic formula	Egg white cream with 5% collagen preparation
Egg whites	349	331.55
Powdered sugar	624.3	624.3
Citric acid	0.7	0.7
Vanilla powder	26	26
Collagen preparation	–	17.45
Total	1000	1000

whipped mass, and the mixture was whipped for another 10 minutes. For greater stability citric acid was added during whipping (Margander, 1995). Without stopping the whipping, vanilla powder, remaining powdered sugar and collagen preparation preliminary ground to powder were added in a thin trickle. The mixture was whipped to a glossy mass.

Conclusions

In the course of experimental studies, the manufacturing technology of the collagen preparation was developed, which includes the following stages: mechanical cleaning of the raw material from related components; cutting the raw material into fragments up to the size of 1x1 cm^2; washing off impurities; enzymatic hydrolysis; mechanical homogenization.

The optimal amount of the collagen preparation to be introduced into the formula of whipped egg whites is 5% of their mass. The introduction of a bigger amount of the collagen preparation reduces the foaming capacity of egg whites due to the increase in the viscosity of the system.

Egg whites with 5% added collagen preparation have high functional and technological properties. The foaming capacity is 97%; the foaming stability is 90% in the first minutes, and 80% in the next 15 minutes.

The manufacturing technology for egg white cream with the collagen preparation in an amount of 5% of the egg white mass was developed. The obtained cream did not differ in organoleptic characteristics from the traditional formula of egg white cream.

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