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STUDY INTO COLLAGEN HYDROLYZATE APPLICABILITY AS A STRUCTURE FORMING AGENT

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Досліджено динаміки піноутворення гідролізату колагену (ГК) в залежності від температури, часу збивання і концентрації. Отримані раціональні технологічні параметри його використання в якості піноутворювача для харчових рідких систем (t=8–10 °С, час збивання 3 хвилини з концентрацією 5 %). Найвища піноутворююча здатність (520 %) ГК досягається при його концентрації в розчині 5 %

Ключові слова: гідролізат колагену, глютин, харчові пінні системи, піноутворення, стабілізатори харчових систем

Исследованы динамики пенообразования гидролизата коллагена (ГК) в зависимости от температуры, времени взбивания и концентрации. Получены рациональные технологические параметры его использования в качестве пенообразователя для пищевых жидких систем (t=8–10 °С, время сбивания 3 минуты с концентрацией 5 %). Наивысшая пенообразующая способность (520 %) ГК достигается при его концентрации в растворе 5 %

Ключевые слова: гидролизат коллагена, глютин, пищевые пенные системы, пенообразование, стабилизаторы пищевых систем

1. Introduction

Quality of food products on the world market has improved significantly over recent years. The present-day people have also changed their diet preferring healthy rational nutrition. Rapid development of innovative technologies in the food industry gave impetus to the development of new products and technologies but a problem of inadequate raw materials and instability of the manufacturing process control has emerged at the same time. Quality management of most products is related to rheological indicators.

One of the most important challenges that the food companies are facing at present is development of diets and products with a high biological value, enriched with essential substances. To expand range of such products, non-traditional plant and animal raw materials are widely used. Protein raw materials attract special interest of scientists because of their structural and physiological significance for the human body. One of the lines of use of protein raw materials is development of a technology for preparation of drinks with a foamed structure. However, use of a liquid base for aerated drinks does not permit obtaining of a high-quality foam structure.

Manufacturing of products with an aerated structure is associated with a problem of improving their foaming properties since absence of a fat phase leads to a significant reduction in viscosity and a tendency to the system's syneresis. Thereupon, the main requirement in production of aerated products is a proper choice of an efficient structure forming agent.

Collagen hydrolyzate (CH) can be used as such structure forming agent. Oxidized forms of lysine and proline which are part of CH composition rapidly incorporate into the biological mechanism of formation of connective tissues in the human body which prevents development of cartilage, skin and bone diseases.

In this connection, development of compositions and technologies for production of drinks with the use of CH is a topical problem. The use of CH will enable creation of drinks with an aerated structure, improve management of the resulting product quality and expand the range of medio-prophylactic products.

2. Literature review and problem statement

What is of a particular relevance in the development of products with a higher biological value is selection of components for food products possessing functional properties and providing the body with adequate proteins, vitamins and macro- and microelements.

Today, parameters of the human nutrition system are determined by nutritiology because food provides each cell

of the body with all vital substances [1, 2]. The process of renewal of subcellular systems and cells of various organs and tissues of the human body depends on nutrition and constitutes a permanent and almost constant parameter depending on age, sex, body weight [3]. Physiological requirement of energy and nutrients is a combination of alimentary factors and is aimed at preservation of vital activity and reproduction of species and support of the adaptation potential [4–6].

Protein substances occupy dominant positions in the technology of structured products while the modern range of protein substances and sources of their production has been considerably expanded. The ability of protein structure formation is associated with hydrophilic and lipophilic properties and therefore an important technological characteristic for proteins is hydration and dissolution which depend on pH, ionic strength and temperature.

Protein is considered to be an essential nutrient due to its biochemical and physiological functions. Nutritional proteins have an important protective role: they strengthen the body's resistance to the effects of various infectious, toxic agents as well as mental stresses, stressful situations. At its sufficient level in diet, biological properties of other nutrients (fats, vitamins, mineral elements) manifest themselves most fully.

Along with traditional structure forming agents, functional compositions including several components, e. g. specially selected functional substances acting as emulsifiers, stabilizers and thickeners find an increasingly wider use.

It should be noted that one and the same recipe component performs both the role of a structure forming agent and a stabilizer in many structured products.

All important protein properties are determined by the spatial structure. The possibility of an optimal use of hydrogen and sulfhydryl bonds to stabilize milk foams is determined by the gradation of amino acids in the protein molecule. Their difilinity and surface activity depend on the protein structure features. These properties determine foaming capacity of the milk proteins used in food industry for production of products with a porous structure such as ice cream, whipped milk desserts, etc. [7–9].

The properties of an oil-water emulsion stabilized with milk protein which are determined by the surface structure and rheology of the layer adsorbed at a water-water boundary were studied. Systematic studies of stability and rheology of model emulsion systems have shown that they are especially influenced by pH, temperature, calcium ion concentration and protein content in solution [10].

In recent decades, a fundamentally new line of a drink-breakfast which is both a drink and a fast breakfast has emerged. For example, popular Switzerland drink-breakfasts contain 20 % fat-free sour milk and 52 % fruit juice (TM Coop Betty Bossi). In the Netherlands, drink-breakfasts based on a low-fat yogurt with some sugar and 60 % plain lime or peach juice (TM Sisi Frutmania) are widespread. Products with soy extract and high content of fruit pieces (TM Tom Soya) or with plain carrot juice (TM Innocent) are preferred in UK. In Ireland, drinks with more than 50 % fruit pieces are combined with non-fat yogurt (TM Tropicana Smoothies) [11–13].

In studies [14], availability of a milk substitute (MS) in products with an aerated structure based on fermented dairy products was analyzed. The obtained data indicate that the system of a reconstituted MS has a higher (48.7 %) foaming capacity compared to the reconstituted whole milk.

A technology of making foamy dishes and products with emulsifying properties was developed. Regularity of milk aeration depending on the conditions of foam formation was studied. Comparative estimation of methods for obtaining milk disperse systems depending on technological factors was made and a technology of foamed-milk and milk-vegetable products was developed [15].

The obtained data showed that a 3.2 times foam density growth is obtained when gas is saturated in a skim milk with a concentrated juice of berries. With gas saturation in the presence of a stabilization system, foam density is increased by 2.4 times. Thus, the MS as a stabilization system has shown a lower foam formation capacity compared to the control sample with the use of concentrated juices.

The paper [16] was devoted to the study of the features inherent to formation of foamy masses based on a cottage cheese whey and MS (skim milk). In this work, an algorithm for calculating interphase surface based on the amount and size of particles of the disperse phase was formulated. The developed classification of foamy milk masses and the technology of whipped milk products on the basis of established regularities were given. It has been proved that the maximum increase in foaming capacity of cottage cheese and skim milk is achieved in the temperature range (40–45) °C and (3–6) °C, respectively. Pectin, agar, gelatin and hamulsion were used as stabilizers of the food system. Pectin and agar have demonstrated high technological properties in stabilization of whey foams at a concentration of 1.5 %. For foams based on skim milk, the best stabilization indices were obtained with gelatin (2.25 %), Hamulsion QVB (1.2 %) and pectin (2 %).

Analysis of protein and saponin abilities in foaming and emulsifying has been carried out and physicochemical principles of designing multicomponent food systems have been worked out [17, 18].

A method for production of food additives from sugar beet roots and soybeans which have a high nutritional value and pronounced foaming and emulsifying properties was developed. Recipes and technologies of protein-whipped, biscuit, flour and cereal semi-finished products, mayonnaises, sweet dishes with the use of saponin containing additives prepared from sugar and table beets, soy, oatmeal and peas were presented [17].

Formation of an inhomogeneous structure of whey-based milk drinks in the process of their storage raises interest to the methods for stabilizing aggregate state of casein. Scientists have conducted studies on the effect of calcium ions and pH on stability of the dairy system. Low (2.5) pH was achieved by introduction of 85 % phosphoric acid. The obtained data showed that the level of aggregation can be reduced by reducing electrostatic interaction between acid glycosides and positively charged amino acids [19].

Introduction of mixtures of milk protein, gelatin and gum arabic as structure stabilizers to candy masses was investigated [20].

It has been proved that a high stabilizing effect on the food system is exerted due to reduction of surface tension and creation of aggregately stable layers of a dispersion medium. The research results have shown foaming capacity of 420 % for egg protein and 400 % for casein and that an increase in concentration of casein in suspension resulted in a weakening of foam formation. In optimizing the content of irreplaceable amino acids, egg protein and casein were used in a ratio of 506:50, foam formation was 34.4 % and foam sta-

bility was 77 % in an hour of exposure. A mixture of gelatin and gum arabic which was used to stabilize the foam structure contributed to an increase in foam stability to 98–99 % (within one hour of exposure).

Influence of a xanthan-milk mixture on stability of mayonnaise sauce structure was studied. The data have shown that addition of milk with xanthan to mayonnaise protects it from phase separation as compared to the control sample in which hen's egg was used as a structure forming agent. The obtained data have also shown that the food system achieves stability higher than 99 % with introduction of xanthan at a concentration of 0.2 % [21]. However, a casein-xanthan stabilizing system was used in this study to stabilize the structure. This protein-carbohydrate system can only be used in limited food systems such as dairy products and milk sauces.

Thus, milk protein is mainly used for structure formation in food systems. However, casein is badly assimilated by the human body, it can cause allergic reactions, does not impart good technological properties to foams and requires an additional introduction of structure stabilizers. The use of expensive stabilizers such as pectin, agar, xanthan, gum arabic leads to an increase in the cost of products.

Considering collagen-containing raw materials as a source of production of a stabilizer for food systems, special attention is attracted by fish secondary raw materials. The positive properties of fish collagen are its hypoallergenic function and the identity to human collagen contributing to its maximum assimilation.

Problematic feature of modern scientific researches consists in absence of a comprehensive technological approach to studying foaming properties of structure forming agents. Technological parameters of the system such as pH, foam formation temperature, time of exposure to the system, concentration of the structure forming agent are not taken into account.

Therefore, it is necessary to conduct a comprehensive study of the influence of technological parameters on CH structure formation in aerated products and drinks for functional purposes.

3. The aim and objectives of the study

This work objective was to assess availability of using collagen hydrolyzate as a foam forming agent in production of aerated drinks.

To achieve this goal, the following tasks were set:

– study the influence of technological parameters on CH foaming capacity;

– study the influence of technological parameters of CH hydration;

– explore availability of using CH in production of whey based drinks.

4. Materials and methods used in investigating availability of using collagen hydrolyzate as a structure forming agent

The objects of the study:

– collagen hydrolyzate obtained by alkaline hydrolysis of collagen-containing fish raw materials (Fig. 1);

– milk whey;

– agar (Ukraine);

– apple pectin (Ukraine).

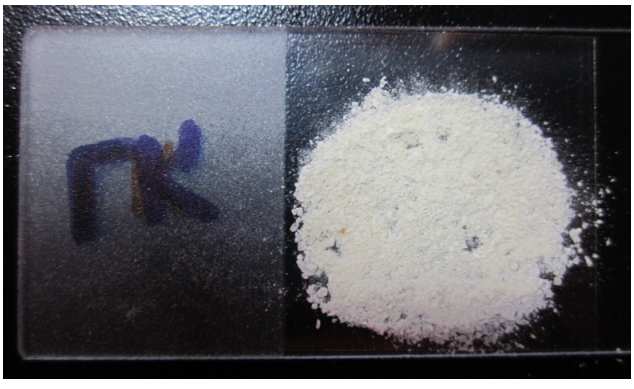

Fig. 1. Dry collagen hydrolyzate

The degree of collagen swelling was estimated as the product volume increment in relation to its initial volume and was calculated in percentage by the formula:

$$П = \frac{H}{H_0} \cdot 100\ \%, \quad (1)$$

where H is the product volume increment, cm^3; H_0 is the initial product volume, cm^3.

In order to conduct studies, the CH was ground to homogeneous particles. A 25 g weighed portion was taken to a 500 cm^3 cylinder and water was poured (water volume was 5 times more than the product volume). The product volume variation was measurement every hour during 7 hours.

Blender (Philips HR-1633/80, China) was used to obtain foam.

The protein foaming capacity was calculated by the formula:

$$C = \frac{B_n}{B_{p.b.}} \cdot 100\ \%, \quad (2)$$

where C is the protein foaming capacity, %; B_n is height of foam above the liquid level, cm^3; $B_{p.b.}$ is height of protein solution before foaming, cm^3.

Foam stability was estimated in terms of its height after exposure for (1...20)×60^2 in a calm condition and calculated from the formula:

$$C = \frac{B_n}{B_{n.b.}} \cdot 100\ \%, \quad (3)$$

where C is foam stability, %; B_n is initial foam height, mm; $B_{n.b.}$ is foam height after exposure for 15 minutes, mm.

Microscopy of samples was performed to determine average CH particle size using the Biolam P15 microscope (Lomo, Russia) with a ScopeTek DCM-130 E 1.3 Mp digital camera (Hangzhou Scopetek Opto-Electric Co., China).

The IR absorption spectra were recorded with the help of FTIR-8400S infrared spectrophotometer (Shimadzu, Japan) in a range of 4000...400 cm^{-1}. Pellets prepared by compression method with excess of KBr were used for analysis. The filler and test sample weights were 150 mg and 1.5 mg respectively. The resulting mixture was pulverized with a Von Ardenne vibrator (Germany) for 4 minutes. The resulting powdery mass (100 mg) was used to prepare a pellet. Subsequently, the specimen was vacuumed in a die at a pressure of 150 kg/cm^2.

The dry matter content in the solution was determined using RL-3 refractometer (Poland).

5. The results obtained in the study of foaming and hydration of glutin

The scheme of CH preparation from a secondary fish raw material consists of the following main stages: a three-stage treatment with alkali solutions, neutralization with a 2 % solution of acetic acid to pH=7.0. The obtained CH was dried in a drum drying machine at a temperature of (70±5) °C until it reaches a mass moisture fraction of 6.5 % and then crushed in a crusher to a particle size of 0.8–1 μm (Fig. 2). The CH was stored for 6 months at a relative humidity of 60...70 % and temperature of 18...20 °C [22].

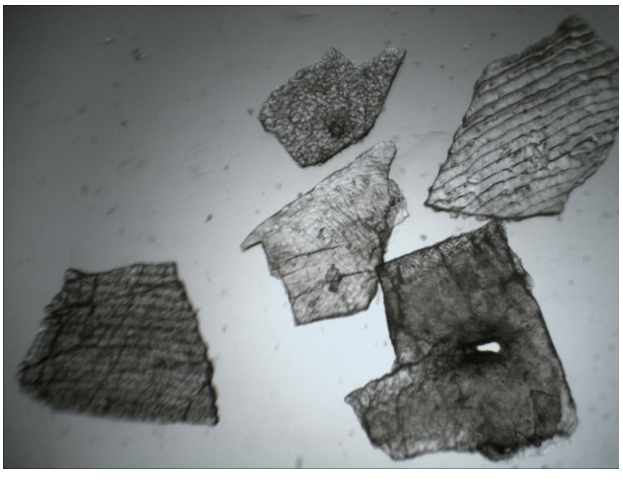

Fig. 2. Micrograph of collagen hydrolyzate

Previously, a study of mass-molecular composition of the CH protein components was conducted. The study has shown that the CH contained both high molecular protein components with molecular weight of up to 2000 kDa (0.33 %); 660.5 kDa (0.14 %) and 440 kDa (0.76 %); about (1.2...1.3) % and low molecular fractions up to (40.0...42.0) % of the total quantity. The share of average molecular fractions accounted for almost (56.7...58.8) % [23].

The obtained CH was white, it had a light smell of whole milk and no taste which makes it useable as a biologically active supplement to various foods.

Important factors influencing quality of aerated drinks include heat treatment conditions, pH, foaming agent (CH) concentration and whipping time.

To determine CH foaming capacity (FC), a study of FC variation dynamics from the time of heat treatment was conducted (Fig. 3). The obtained dynamics indicated that the CH had a higher FC (410 %) after heat treatment (95 °C) for 180 minutes in a neutral medium.

During this time, collagen fibers softened and partially hydrolyzed to form glutin. Prolongation of heat treatment is not feasible because the FC decreases (405 % and 404 %, during heat treatment for 210 and 240 minutes, respectively). Further treatment also results in accumulation of protein components of a low molecular weight with no foam capacity.

Absence of proteins or their insignificant amount in the base for aerated drinks is explained by the need for foaming without formation of interphase adsorption layers of a high mechanical strength. Therefore, the choice of a rational content of glutin should be based on a condition of providing maximum foaming.

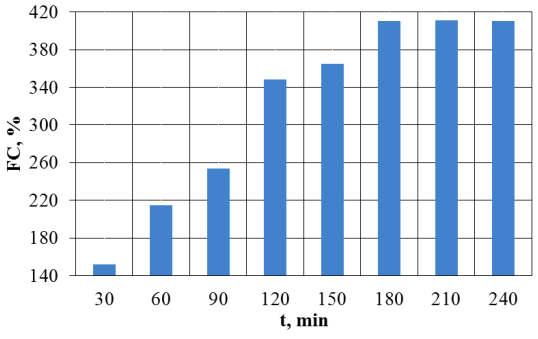

Fig. 3. Dynamics of CH foam forming capacity variation depending on heat treatment time

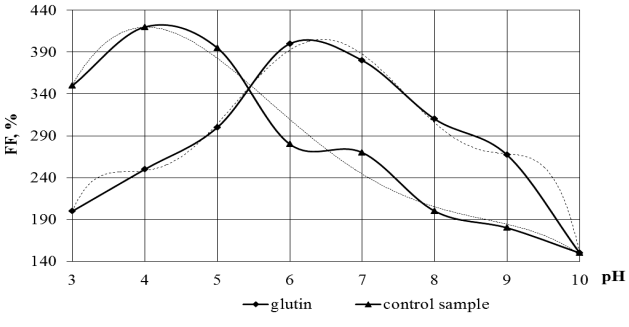

Fig. 4. Influence of pH on foam formation (concentration of protein structure forming agents 5 %, t=20 °C)

The dynamics of the foam formation dependence on pH can be described by polynomial approximation:

– Glutin:

$y=-0.4479x^6+17.19x^5-265.73x^4+2109.8x^3-$
$-9055.6x^2+19959^x-17469;$

$R^2=0.9968;$

– Control sample:

$y=-1.0748x^4+30.963x^3-320.16x^2+$
$+1352.2x-1573.2;$

$R^2=0.9756.$

Determination of FF dependence on the whipping temperature has shown that the hen's egg protein reached maximum (480 %) at 6 °C and glutin (503 %) at 8 °C. (Fig. 5).

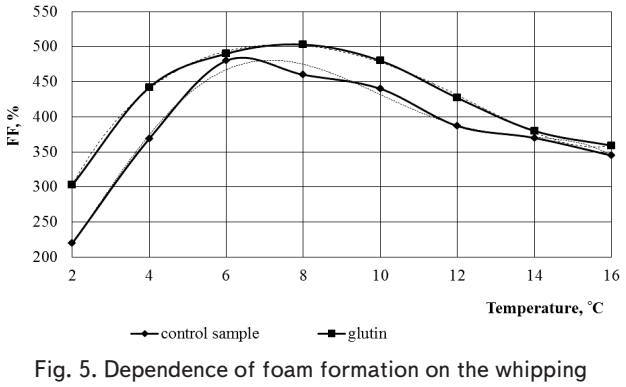

Fig. 5. Dependence of foam formation on the whipping temperature for glutin and the control sample

Dynamics of foam formation dependence on the whipping temperature can be described by polynomial approximation:

– Glutin:
$y=0.004x^5-0.1786x^4+3.2952x^3-$
$-34.953x^2+205.17x+9.25;$
$R^2=0.9987;$
– Control sample:
$y=-0.0103x^5+0.4547x^4-6.8705x^3+36.516x^2+$
$+1.6086x+117.75;$
$R^2=0.9896.$

The decrease of FF in a case of the whipping temperature growth is explained by a decrease in the strength of the foam films in correspondence with an increase in the surface tension which leads to a decrease in the mechanical stability of the surface layer of the films. In this connection, a rational range of whipping temperatures was chosen within 8 to 10 °C.

The data on dependence of FF on the whipping time have shown a rational time value of 3 minutes. With such duration of mechanical action, the value of glutin FF was 475 % compared to the control sample which has shown 347 % for the same time of whipping (Fig. 6).

Influence of glutin concentration on its FF at optimal conditions was studied (Fig. 7). Hen's egg protein was chosen for the control sample.

Polynomial equations were obtained. They describe the rate of FF curves with accuracy of 95.06 % and 89.86 % for the control sample and glutin, respectively.

It has been established that the highest level of glutin and hen's egg protein FF was maximal when their concentration in a solution was 4 % and 6 %, respectively. In this case, the values of glutin and hen's egg protein FF were 480 % and 490 %. When concentration of glutin in solution increased, its capacity of forming a foamy structure decreased because of an increase in the dry matter quantity in films and formation of less stable bonds in the liquid-gas system. So, with an increase in glutin concentration in the system up to 8 %, there was a decline in foam formation compared to an optimal concentration of 20 %. Thus, glutin can act as an effective foaming agent and can be used as a substitute for hen's egg protein in production of aerated food products.

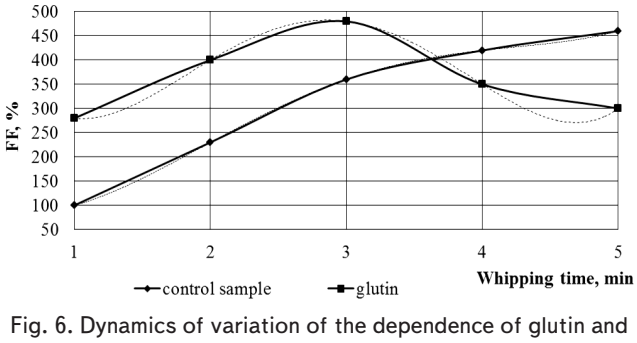

Fig. 6. Dynamics of variation of the dependence of glutin and the control sample FF on the whipping time (pH=6, t=9 °C)

The dynamics of dependence of foam formation on the whipping time can be described by polynomial approximation:
– Glutin:
$y=19.167x^4-220x^3+820.83x^2-1090x+750;$
$R^2=1;$
– Control sample:
$y=5x^4-61.667x^3+245x^2-248.33x+160;$
$R^2=1.$

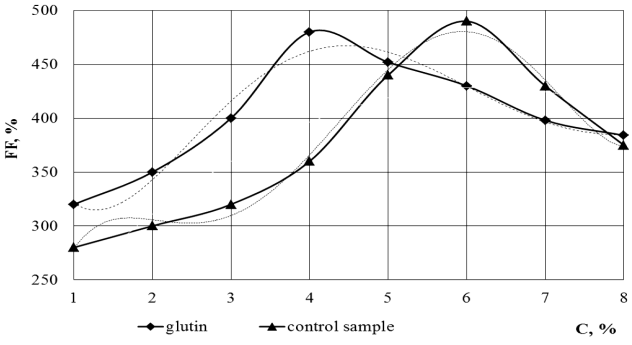

Fig. 7. Effect of the protein structure forming agent concentration on FF (pH=6, t=9 °C, whipping time: 3 minutes)

The dynamics of influence of the structure forming agent concentration can be described by polynomial approximation:
– Glutin:
$y=-0.1814x^5+5.1253x^4-52.44x^3+228.41x^2-$
$-367.67x+508;$
$R^2=0.9626;$
– Control sample:
$y=0.5657x^5-12.856x^4+104.33x^3-$
$-366.88x^2+572.46x-18.75;$
$R^2=0.9914.$

When studying dispersibility of the formed foams, it was found that the egg protein foam had a monodisperse structure with disperse particles of the same order. The average radius of the disperse particle in the foam formed from the egg protein was about 1.0 mm. The foam formed from CH was a polydisperse system featuring presence of dispersed particles with sizes of different orders. The average radius of the dispersed particle of the CH foam was 1.53 mm.

The functional properties of glutin are understood as physical and chemical characteristics that determine its behavior in reprocessing into food products and ones that provide necessary structure, technological and consumer properties to the product. The most important functional properties include stability of the foam and its formation, ability to stabilize disperse systems (foams, emulsions, suspensions) and form gels, adhesion and rheological properties of the protein systems.

The obtained data on the influence of temperature and time on the foam "life" indicate that temperature significantly influences viscosity of the food system and increases rate of egress from the foam. For example, foam stability decreases by 19.3 % at 20 °C, by 30.8 % at 30 °C, by 46.1 % at 40 °C and by 60.5 % at 50 °C compared to the foam exposed for 20 minutes at 10 °C.

Analysis of the obtained IR spectra of glutin have shown a peak at 3500 cm^{-1} meaning that glutin is a product of collagen hydrolysis (amide A) and the peaks of 1670.24 cm^{-1} and 1550 cm^{-1} show presence of amide I and amide II. The presence of valence fluctuations of –C=I group of non-ionized and ionized acids is indicated by an absorption band at 1620 cm^{-1}.

A strong broad band with an absorption maximum at 3400 cm^{-1} was observed in the glutin spectrum. This band was shifted to the low-frequency region in comparison with the frequency of free OH– groups which indicates presence of hydroxyls in the system of hydrogen bonds. Absence of an absorption band at 3650 cm^{-1} shows that virtually all hydroxyl groups were included in the hydrogen bond. The presence of peaks at 600 cm^{-1} and 1050 cm^{-1} characterizes valence fluctuations in the structural skeleton of the molecule and indicates that hydrolysis has not been fully realized.

The data of IR spectroscopy have shown presence of free groups capable of binding water molecules.

Therefore, the next step was to study the effect of technological parameters on glutin hydration to predict its behavior in the food system as a structure stabilizer.

The study of glutin hydration was carried out at physiological pH values (2.3, 7.0, 10.1) and at various temperatures (Fig. 8–10).

The highest degree of swelling was observed after 3–3.5 hours of incubation at pH=7.0 and 2.5–3 hours at pH=2.3 (Fig. 8, 9). This can be explained by the smallest protein's ability to adsorb water at the isoelectric point (when the protein molecule charge is close to zero).

As the obtained data show, the smallest degree of glutin swelling was observed at pH=10.1 (Fig. 10).

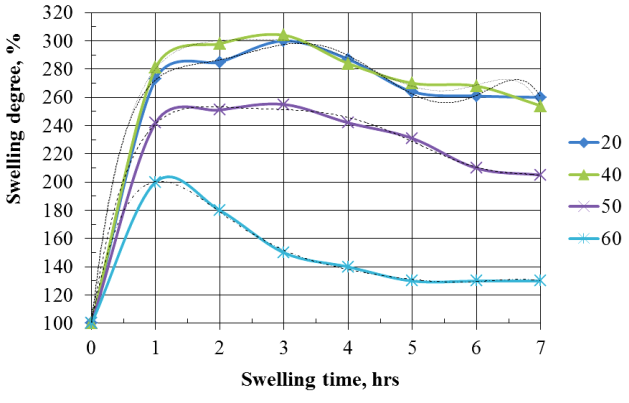

Fig. 8. Dynamics of CH hydration at pH=2.3

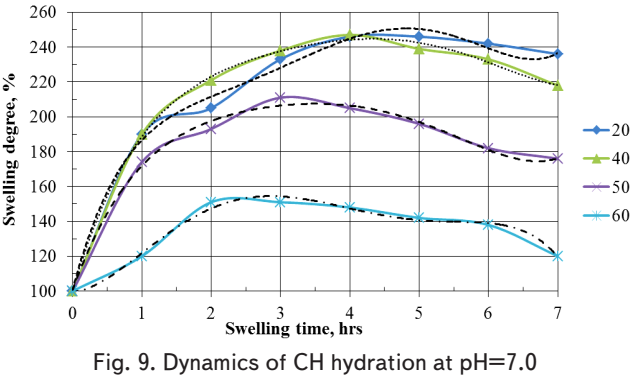

Fig. 9. Dynamics of CH hydration at pH=7.0

Thus, it can be asserted that the CH as a complex protein has an isoelectric point in an alkaline medium.

Decrease in pH results in dissociation of basic (NH–) and acidic (COOH–) protein groups, growth of the charge of the glutin protein molecule and intensification of its hydration. The hydrated (aqueous) envelope gives stability to protein solutions, prevents individual particles from their sticking together and precipitation (strong hydrate shells formed around them protect the protein molecules from gluing and precipitation).

Determination of temperature effect on the degree of swelling at various pH values has also shown that temperature significantly determines hydration tendency.

At all chosen pH values, a slight glutin swelling occurs in 1.5 hours at 60 °C (198 % at pH=2.3, 151 % at pH=7.0, 110 % at pH=10.1). With a decrease in temperature, the swelling degree increases significantly: glutin gradually hydrates and reaches the highest swelling degree (305 %) at 20 °C, pH=2.3 and t=3 hrs. Destruction of glutin and formation of gelatin take place at pH=10.1 and temperature of 60 °C.

Sweet milk whey or juices can be used as the base for aerated drinks. Therefore, it is necessary to determine behavior of glutin at their inherent pH values. The next step in the study of protein hydration was to determine temperature effect on glutin swelling in medium-acid media.

Studies have shown that when temperature increases, the degree of glutin hydration grows and then falls (Fig. 11). At a temperature of 60 °C, maximum swelling value was reached in incubation at 40 °C for 2 hrs. and at 50 °C for 3 hrs. (195 % and 204 %, respectively). The maximum (220 %) degree of swelling was reached after 3 hours of incubation at 20 °C. Further glutin incubation resulted in a fall of swelling degree.

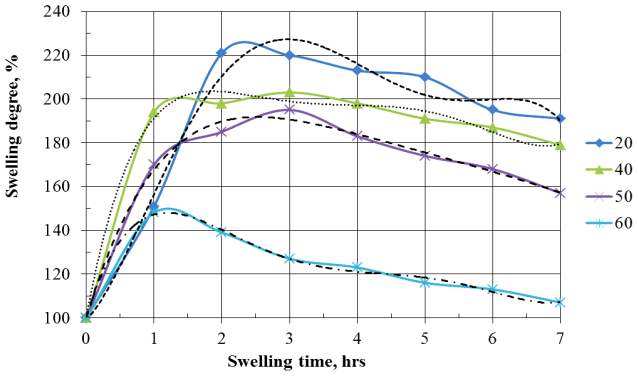

Fig. 10. Dynamics of CH hydration at pH=10.1

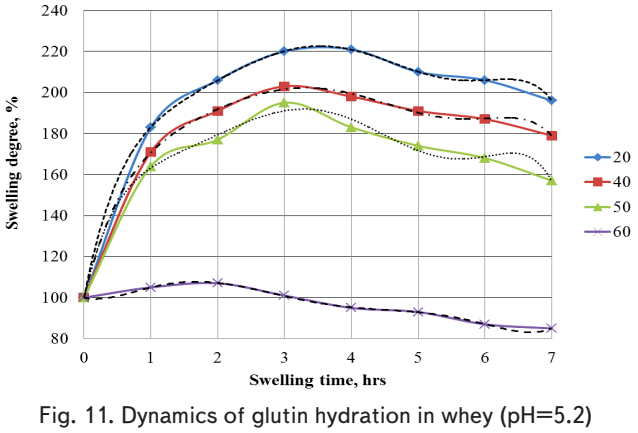

Fig. 11. Dynamics of glutin hydration in whey (pH=5.2)

To confirm the start time of glutin dissolution, a study was carried out on accumulation of dry matter in the liquid phase. The initial value of dry substances was taken equal to 100 %. With an increase in incubation time, the content of dry matter increases with respect to the initial concentration by 4.23 % at 20 °C, by 5.2 % at 40 °C, by 6.34 % at 50 °C and by 7.24 % at 60 °C.

To study the effect of stabilizers on glutin foam formation and investigate stabilization of interphase structures obtained by whipping, a series of experiments was carried out using the most common hydrocolloids. As stabilizers, natural phytogenic substances were used: apple pectin and agar.

It is known that colloidal solutions of these substances are capable to form foams which indicates their influence on surface tension, viscosity, density and other characteristics that influence formation of dispersions. Maximum foaming capacity of colloids is achieved in a certain range of concentrations of the structuring agent. Therefore, the

main purpose of the studies carried out at this stage was to determine rational concentrations of stabilizers which ensure obtaining of foams to be used under intensive hydromechanical influences.

Stability of the foam obtained by whipping the mixture with a 5 % mass fraction of glutin at a temperature of (8±1) °C in the presence of various stabilizers in various concentrations is presented in Fig. 12.

The obtained data (Fig. 12) show that when foam was exposed for 5 minutes at 20 °C, solutions with a 1.5 % concentration of agar and pectin (99.7 % and 94 %, respectively) had the highest foam stability.

Therefore, in the further experiments, precisely this concentration of stabilizers was used when determining dynamics of foam stability ("foam life") (Fig. 13). The experiments were performed at an exposure time of 25 minutes and temperature of 20 °C. As a control sample, a sample was selected with no stabilizers (agar and pectin).

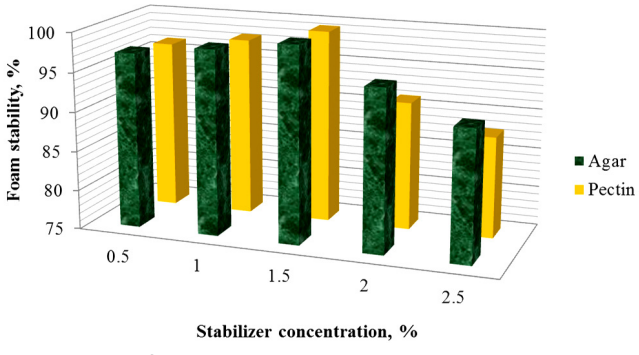

Fig. 12. Effect of stabilizer concentration on glutin foam stability

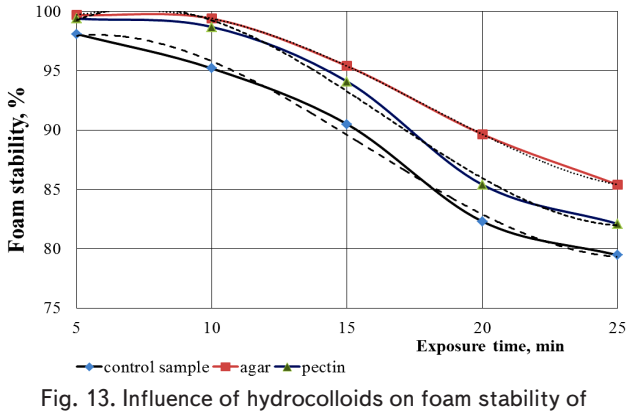

Fig. 13. Influence of hydrocolloids on foam stability of glutin solution

The obtained data show that agar used as a stabilizer was most effective. For example, foam stability decreased by 15 % after 25 minutes of exposure while the respective figure was 22.4 % when pectin was used.

6. Discussion of the results obtained in the studies of availability of using collagen hydrolyzate as a structure forming agent

The study of the effect of whipping temperature on CH foam formation has shown that stability of the formed film skeleton decreased because of growth of surface tension with temperature increase. When temperature increases, foam formation falls because desorption of glutin molecules intensifies and evaporation of moisture from foam films increases which in turn reduces viscosity of the system.

Foam forming capacity of glutin increases with pH growth up to 6.0 because the foam compounds which impart acidic nature to the product float into the interphase foam films. Reduced pH results in a dissociation of the basic (NH–) and acidic (COOH–) groups of protein, growth of the charge of the protein glutin molecule and an increase in its hydration. The hydrated (aqueous) envelope gives stability to the food system, prevents individual particles from sticking together and precipitation. The strong hydrate shells formed around these particles protect the protein molecules from gluing and precipitation.

An increase in glutin concentration in a solution contributes to the concentrated saturation which is characteristic of each surfactant. This is due to the fact that when concentration increases to a critical level, association of surfactant and polymer molecules is beginning. Thus, when the CH concentration increases, its activity decreases.

Preliminary heat treatment of CH promotes softening and partial hydrolysis while forming glutin. The most rational time of heat treatment is within 210–240 minutes. Collagen undergoes partial hydrolysis during this time. The final product of glutin contains a set of free amino acids and protein molecules of a medium molecular weight capable of foaming and stabilizing the food system.

The advantage of this work is the study of the complex effect of various technological parameters on foaming and hydration of glutin to predict its use and behavior in various food systems.

Since glutin has high foaming and hydration properties, it can act as a mono-hydrocolloid. The use of glutin will make it possible to replace expensive mixtures of hydrocolloids consisting of a structure forming agent and a structure stabilizer. The use of glutin will also make it possible to expand assortment of products with bioprotective properties which are recommended for people suffering from connective tissue diseases of the musculoskeletal system. The model studies in production of aerated milk drinks allow us to assert that glutin can be used both in industrial production and in restaurants.

7. Conclusions

1. The study of influence of technological parameters on collagen hydrolyzate foam formation has shown that it acquires hydrocolloid properties after a preliminary heat treatment at a temperature of 95 °C for 180 minutes in a neutral medium. Rational technological parameters of glutin foam formation have been established (pH=6, t=9 °C, whipping time 3 minutes).

2. The considered dynamics of variation of glutin hydration degree have shown that its exposure at various temperatures for more than 2.5–3 hours (for pH=2.3 and pH=10.1, respectively) and more than 4 hours at pH=7.0 leads to a fall of the hydration index which is explained by a partial transition of glutin into a soluble form. The ability of glutin to hydrate enables its use as a substance capable of binding free moisture in food systems thus preventing syneresis.

3. The data obtained in evaluating the use of glutin as a structure forming agent in production of milk drinks have shown the possibility of its use as an effective structure forming agent.

Optimum technological parameters of making aerated milk drinks with the use of glutin were obtained: pH=5.2, glutin concentration of 5 %, agar or apple pectin concentration of 1.5 %.

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