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PECULARITIES OF STRUCTURE FORMATION OF GELATIN IN THE PRESENCE OF MELON PULP

An attempt was made to obtain jellies in the gelatin-melon pulp system. Data on the ratio of electrostatic, hydrophobic interactions and hydrogen bonds upon structure-formation in mixture was obtained by regulating pH, ionic strength of the medium and introduction of urea into it. The dominating role of hydrogen bonds upon formation of gelatin jellies with melon pulp and sugar was determined.

Introduction

Intense interest in investigation of biological polymers is due to the possibility of their use in agriculture for the preparation of protein high-fodder; in medicine for preparation of medical forms; as well as in the production of make up preparations, detergents etc. Another perspective field of application of biopolymers is food industry [1-3]. In present, production of confectionery abounds in different jelly products on the basis of agaroid, gelatin, starch. Meanwhile in this case could be used also natural products which characterize with nutritive value, low prices and also with absence of by-effect to organism. However for successful application of natural products it is necessary to know pathways of regulation of them gelatinization properties. In this connection the aim of this work is determination of structurization mechanism of gelatin-melon pulp system.

Experimental

In this work used food gelatin from Novosibirsk's factory of biopreparations, government standard # 11293-89.

The pulps of summer melons were used as natural supplements to gelatin. Chemical composition and food value of melon pulp were determined by methods [4].

The determination of jelly stability P_K was carried out on Weiler-Rebinder apparatus using the tangentially removal plate method. The concept of the method is in measuring the effort, necessary to shift the plate, immersed into a structured system [5].

The mixture of solutions of gelatin with natural supplement was sustained during 24 hours at temperature 298K for formation of jellies.

The pH values of gelatin solutions before gel formation were determined using I-130 ionometer,

the accuracy of pH measurement was ±0.05 pH units. HCl and NaOH solutions were used to regulate pH values.

Infra red spektra of gelatin, melon pulp and its mixtures were obtained in spectrophotemeter 'Avator – 370 CsJ' with Furie – converter [6].

Results and Discussion

Confectioneries with jelly-like structure are obtained when gelling agents or pectin-containing fruit raw materials are used as the structure-forming agent [3]. In this work gelatin was used as the gelling agent, and melon pulp and sugar were used to impart flavour properties to the product. The comparison of structure-forming ability of gelatin and melon pulp showed that gelatin at concentrations as low as 2% after 24 hours forms rather stable structures with P_K of $5 \cdot 10^3$ dyne/cm^2, whereas melon pulp does not form stable structures under these conditions.

Gelatin is the product of collagen treatment consisting of long amino acid chains bound to each other by peptide bonds [8]. The presence in its macromolecules of polar amine and acidic functional groups, as well as hydrophobic hydrocarbonic sites imparts high activity to gelatin upon formation of bulk structures. Therefore, high stability of gelatin jellies is due to electrostatic interaction of oppositely charged amine and carboxylic groups, formation of hydrogen bond network and hydrophobic interactions between non-polar sites of polymer.

The main jointing material in cells of fruits and vegetables are pectin substances which are present together with arabanes, galactanes and other polysacharides. Pectins are linear polymers of galacturonic acid, in which carboxylic groups are partially substituted by methanol [9]. Consequently, the main type of interactions in melon pulp should be hydrogen bonds between hydrogen and oxygen atoms of adjacent units of pectin chains. Absence of structure-formation in melon pulp itself may be accounted for high water content, which is 82.60 % (Table 1).

Table 1. **Chemical composition of melon pulp**

Chemical structure	%	Vitamins	mg, %
Water	82.60	B-carotene	0.17
Lipids	0.10		
Carbohydrates	16.48	E	0.06
Proteins	0.42	PP	0.23
Ashes	0.40	F	14.5
Food value, kcal/100 g	68.00		

Introduction of melon pulp into gelatin substantially decreases P_K of jellies, increasing the critical concentration of gelatine structure-formation from 1,0% to 1.25 % (Curve 2 Figure 1). However, the presence of sugar in the mixture makes for structure-formation of the gelatin-melon pulp system, increase in structure stability being proportional to gelatin content. Although this mixture is less stable than gelatin, its P_K value is sufficient for preparing confectioneries of stable form.

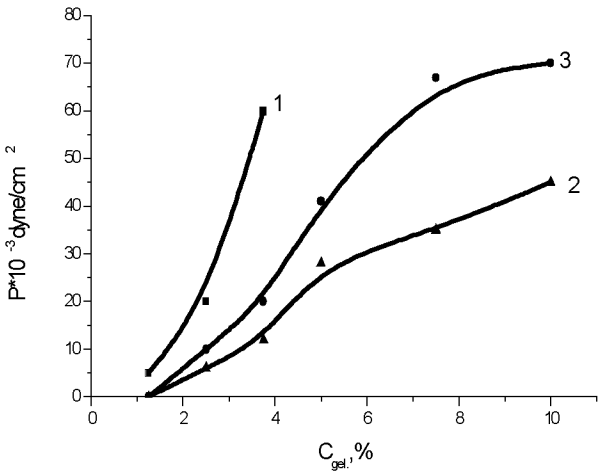

Fig. 1. Dependence of stability of gelatin (1), gelatin-melon pulp (2) and gelatin-melon pulp-sugar (3) jelly on gelatin concentration. $C_{melon\ pulp}$ = 50 %; C_{sugar} = 16,7 %

At IR spectra of gelatin it was found narrow absorption band at 1644 cm^{-1} which is C=O valence oscillation. The contribution of deformation component of NH group oscillation also could take place at this adsorption band.

At melon pulp IR spectra this band was moved to the left to 1624,5 cm^{-1} and has low intensity than gelatin [7].

In gelatin-melon pulp mixture were observed low-frequency displacement of this band (1635 cm^{-1}) which can be explained with deformation oscillations of NH groups. The absence of characteristic bands of C=O groups can be connected with participation of galacturonic acid molecules in formation of hydrogen bonds with carboxylic groups of gelatin.

Determination of strength of structures was carried out at various pH values to obtain data on the interaction mechanism in the gelatin-melon pulp-sugar system (Figure 3).

It was estimated that both gelatin and its mixture with melon pulp and sugar have maximum strength at the isoelectric point of gelatin (pH~5), structu-

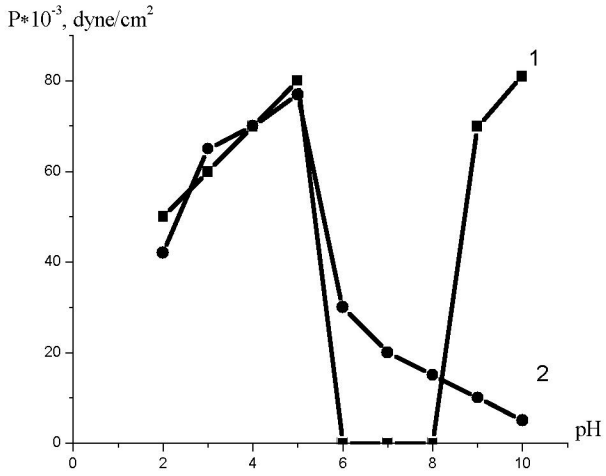

Fig. 2. IR spectra of gelatin (1), melon pulp (2) and gelatin-melon pulp mixture (3)

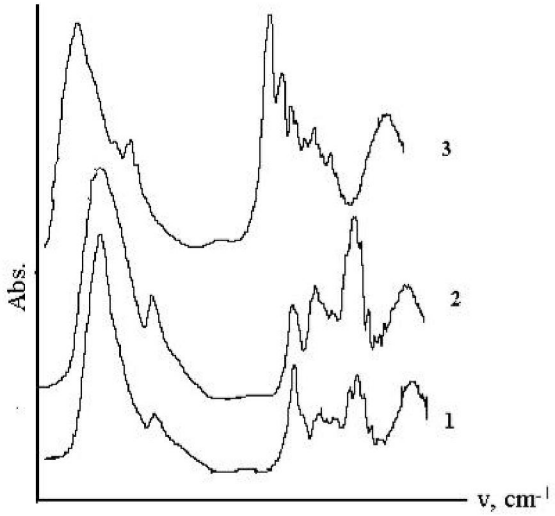

Fig. 3. Dependence of strength of gelatin (1), gelatin-melon pulp-sugar (2) jelly on pH value of medium. $C_{gelatin}$=10%, C_{sugar}=16.7%

rization properties of sugar are sizeable at pH 6-8. However, in strongly basic region tendency to increase in strength was observed for gelatin, whereas decrease in stability when increasing pH was observed for mixture of gelatin with melon juice and sugar. Gelatin is known to have high strength at isoelectric point [8,10]. This is due to interaction of carboxylic and amine groups, stabilized by hydrophobic interactions and H-bonds. Although decrease of P_K are observed in acidic medium, stability values are rather high. Probably this may be accounted for the tendency of non-dissociated carboxylic groups to form hydrogen bonds. As regards the increase of gelatin stability in strongly basic medium, high concentration of OH^- groups is likely to contribute to the increase of ionic strength of medium, and as a result, to salting-out polymer macromolecules from solution. Formed polymer clots or aggregations serve, in a way, as new phase nuclei, which later on will condense owing to hydrophobic interactions. It seems that in gelatin-melon pulp-sugar mixture this effect presents moderate as molecules of sugar play role of "bridges" (connectors) between macromolecules of gelatin, galacturonic acid and water molecules.

One may judge the contribution ratio of electrostatic contacts and H-bonds according to structure-formation curves of gelatin-melon pulp-sugar mixture, obtained in solutions of NaCl and urea (Figure 4). The presence of salt in solution contributes to blocking of ionic groups, leading to the decrease in degree of electrostatic interaction between them, and urea is the compound that destroys hydrogen bonds. As it is seen in Figure 4, in the presence of NaCl of the concentration of 1 mole/l P_K of the mixture decreases from $72 \cdot 10^3$ dyne/cm^2 to $38 \cdot 10^3$ dyne/cm^2. When the same concentration of urea is used, P_K of the mixture is equal to $8 \cdot 10^3$ dyne/cm^2, and upon its increase up to 4 mole/l, structures disappear at all. Hence, hydrogen bonds play dominating role upon structure-formation in this system [11-13].

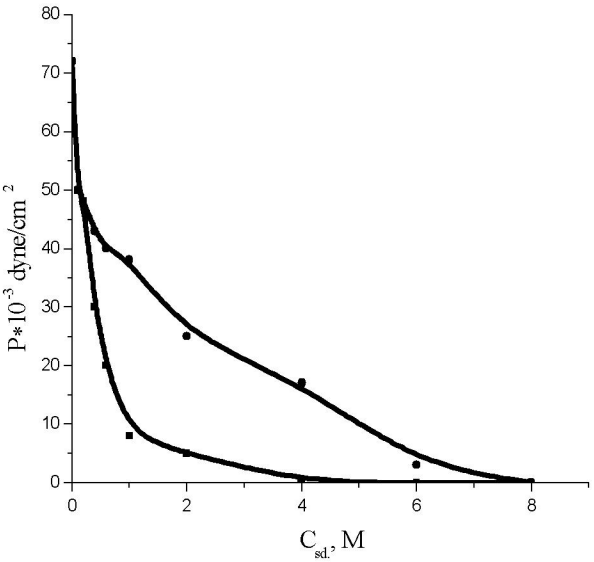

Fig.4. Structure-formation of the gelatin-melon pulp-sugar system in the medium of urea (1) and NaCl (2). pH= 4,1

The tendency of components of the mixture being studied to form hydrogen bonds and electrostatic contacts testifies to their high hydrating ability. In this connection, swelling of gelatin-melon pulp-sugar

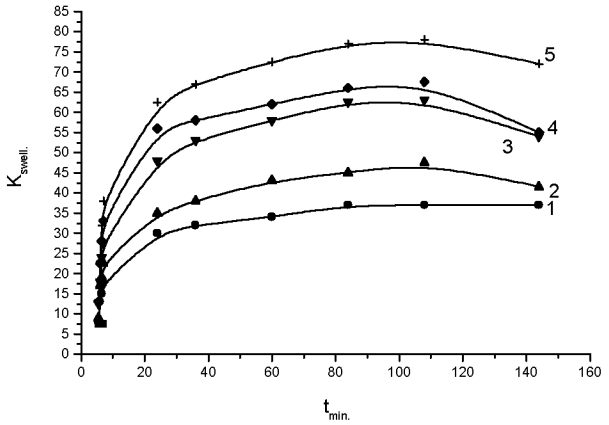

Fig. 5. Swelling curves of gels of gelatin with melon pulp in water. T=293 K. Gelatin concentration: 1 - 4.8%, 2 - 7.0%, 3 - 9.1%, 4 - 11.1%, 5 - 13.0%

structure samples with different content of gelatin were studied (Figure 5). All samples exhibit tendency to swelling; the common regularity in changes degree of swelling (K_{swel}) is in the existence of two sharp bends on kinetic curves. The first sharp bend may be accounted for saturation of gels with water, and the second one – for their destruction upon prolonged action of water (τ>100 h). Drying gels at temperatures of 318 K and 328 K (Figure 6) shows the presence on the curves of dependence of water loss on time of one sharp bend, corresponding by time to the region of first sharp bend on swelling curves. Apparently, in this time interval, evaporation of "free" water, not involved in hydration of gelatin and pectin macromolecules takes place.

Drying gels at temperatures of 318 K and 328 K (Figure 6) shows the presence on the curves of dependence of water loss on time of one sharp bend, corresponding by time to the region of first sharp bend on swelling curves. Apparently, in this time interval, evaporation of "free" water, not involved in hydration of gelatin and pectin macromolecules takes place.

Conclusions

Thus, quite stable gelatin jellies, the stability of which may be regulated by changing structure-formation conditions, may be obtained in the presence of melon pulp. Optimal for structure formation of gelatin-melon pulp system is pH~5 - isoelectric point. Jelly formation properties of sugar at gelatin-melon pulp system take sizeable place at pH 6-8.

Also there were investigated influences of NaCl and carbamide on stability of jellies. It was established that at the presence of 4 mole/l carbamide there

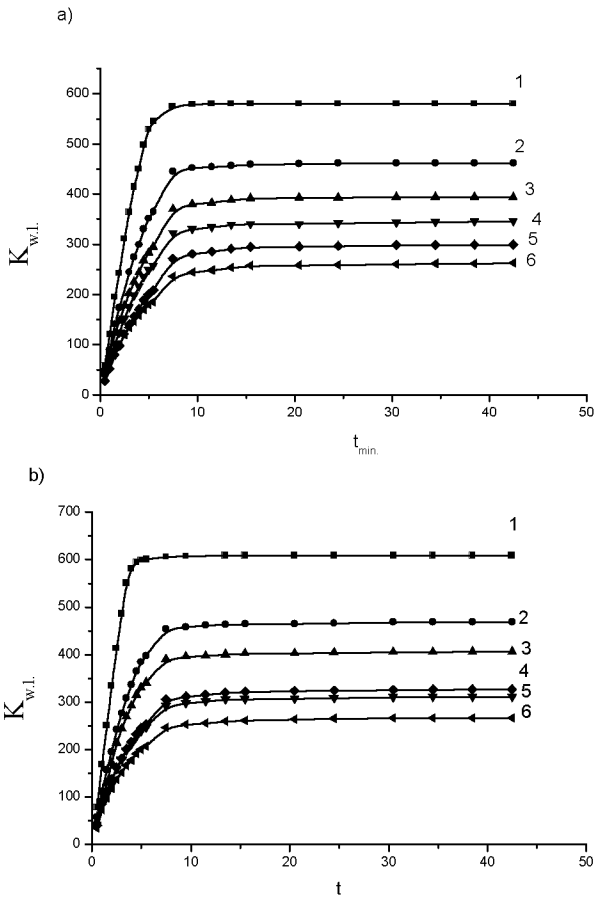

Fig. 6. Dependence of water loss on time at 318 K (a) and 328 K (b). Gelatin concentration: 1 - 2.4% ,2 - 4.8%, 3 - 7.0%, 4 - 9.1%, 5 - 11.1%, 6 - 13.0%

takes place destruction of structures, whereas at the same concentrations of NaCl this system stays without changes. On the basis of this facts was concluded that hydrogen bonds play dominant role at structureformation of investigated system.

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Резюме

Желатин, қауынның жұмсақ бөлігі және қант негізінде иркілдек құрылымдар алынды. Ортаның pH-ы мен иондық күшін реттеу арқылы бұл жүйенің құрылым түзілуінде электростатикалық, гидрофобтық әрекеттесулердің және сутектік байланыстардың үлестері туралы мәлімет алынды. Желатиннің қант пен қауын қатысында иркілдек құрылым түзуінде сутектік байланыстардың анықтаушы ролі көрсетілді.

Резюме

Изучено структурообразование желатина в присутствии дынной мякоти и сахара. Определен механизм структурообразования: путем регулирования pH, ионной силы среды и введения в нее мочевины получена информация о соотношении электростатических, гидрофобных взаимодействий и водородных связей при структурообразовании в системе. Установлена доминирующая роль водородных связей при образовании студней желатина с дынной мякотью и сахаром. Исследована кинетика набухания и дегидратации студней.

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