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OBTAINING PROTEIN PREPARATIONS FROM POTATO JUICE WATERS, AND THEIR CHARACTERISTICS

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Key words: protein preparations, potato juice waters, physicochemical properties of protein.

Attempts were made to recover proteins from the potato juice waters. Centrifuging, ultafiltration or thermal coagulation methods were used. Proteins solubility, their lipophilic and aerating properties, wettablity and the buffer capacity of the protein preparations obtained, were compared.

INTRODUCTION

Attempts were made, in recent years, to utilise the protein-rich wastes and effluents from the processing of plant and animal raw materials. Correct utilisation of wastes in the food industry reduced the pollution of envirenment leading, at the same time, to the recovery of valuable components such as proteins, sugars, vitamins, etc.

The content of protein (in terms of dry substance) in the juice waters left after the production of starch varies from 27 to 30%, and BZT_5 for the 0.5% content of dry substance in the starch production plant effluents varies from 3000 to 6000 mg O_2/l. Presently the most efficient methods that would reduce the noxiousness of starch plant effluents are being sought. Membrane processes such as ultrafiltration (UF) and reversed osmosis (OR) belong to the suggested methods of the recovery of proteins from the juice waters. The employment of these processes enables the concentration and fractionation of solutions to the required content of protein in the final product [5, 9, 14]. Investigations are also carried out into the recovery of protein from the juice waters by the coagulation methods [11, 12], and the ion exchange methods [13].

Depending on the process used and the degree of concentration, protein preparations of different physico-chemical properties deciding about their usability in various branches of the food industry, can be obtained [14].

With this purpose in mind, attempts have been made to recover proteins from the potato juice waters and to investigate the physico-chemical properties of the concentrated and dried protein preparations.

MATERIALS AND METHODS

The potato juice waters left from the production of starch were centrifuged in a pulp centrifuge of Alfa-Laval to the content of dry substance of approximately 5%, and then were pasteurised at 60°C for 15 minutes, cooled to 8°C and concentrated by the ultrafiltration method in an apparatus of DDS Laboratory Modules (20-0, 36-LAB). Ultrafiltration time was 5 to 20 h. Membrane concentration was carried out in three ranges: 1:5, 1:10 and 1:15. Coagulation of precipitable components from the potato juice waters was also carried out at a temperature of 95°C. The concentrated preparations and coagulates were dried in an spry-drier Anhydro Laboratory S1. The air inlet temperature was 105°C, outlet temperature — 60°C.

The following analyses were carried out, to obtain the characteristcs of the juice water prior to and after concentration:

— nitrogen substances, by Kjeldahl's method [1],

— nitrogen substances precipitable with 12% trichloracetic acid [1],

— organic substances as a loss during incineration at 550°C,

— mineral substances as a post-incineration residue [1], and the selected physico-chemical properties of the preparations obtained were observed, including:

— lipophilic properties [10, 8]; in this case the amount of protein in test samples was 100 mg,

— solubility of proteins, swelling of preparations [6],

— wettability [6], aeration properties [2]; protein cencentration in test samples was 1%,

— buffer capacity [2],

— titration curves for 0.5% protein solutions were plotted using 0.1 HCl or 0.1 N NaOH [7].

The titration curve characterises the molecule aggregation and disaggregation degree, the accessibility of functional groups and qualitative changes occurring in proteins during the process. Titration curves were obtained by summing up the quantity of millilitres of 0.1 N HCl or 0.1 N NaOH used for the titration of proteins within pH ranges from 3 to 5 and from 5 to 10. The α coefficient value was calculated as the ratio of the

field contained between the titration curves to the field determined by the extreme points on the axes of co-ordinates (pH range on the X-axis and the number of millilitres of 0.1 N HCl or 0.1 N NaOH — on the Y-axis).

RESULTS

After the concentration of the juice waters (formerly centrifuged in a pulp centrifuge), by the ultrafiltration (UF) method to 1:15, the content of dry substance increased from 5.64% to 18.90%. Thus, the preparations dried by the spry method contained 79.0% of protein of dry substance, at a membrane concentration degree of 1:15; 64.2% of protein in dry substance at the concentration degree of 1:10 and 38% at a concentration rate of 1:5. The preparation obtained by thermal coagulation contained 31.01% protein of dry substance. Table 1 gives a detailed characteristic of the concentrated juice waters and of the dried protein preparations.

Depending on the degree of concentration and the protein recovery method, the preparations obtained had different physico-chemical properties. Satisfactory swelling of 0.49 ml water/g preparation was obtained at the 1:15 concentration rate. A similarly high (0.15 ml water/g preparation) swelling degree characterised the preparation obtained by the thermal coagulation technique. Table 2 shows difference in the swelling degree for the preparations obtained.

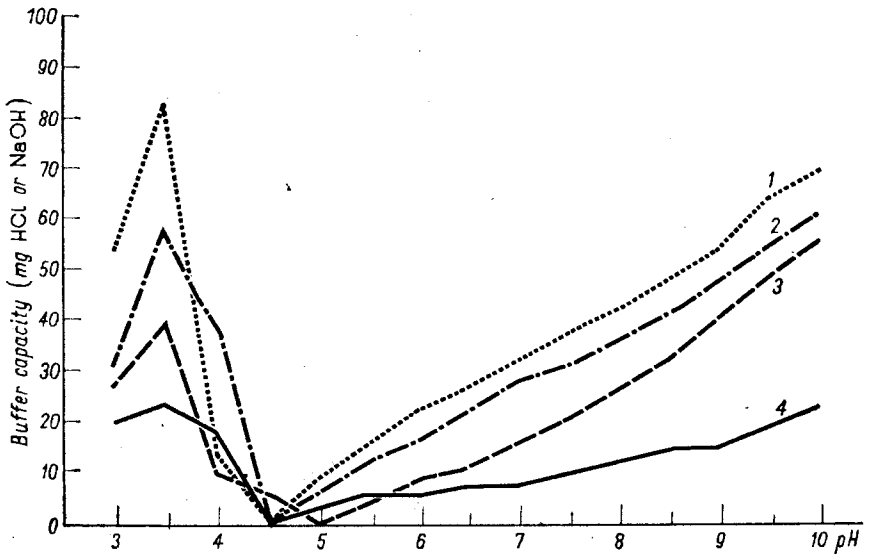

Fig. 1. Buffering capacity of protein preparations obtained; 1 — dried coagulate, 2 — dried product after UF condensation degree 1:15, 3 — dried product after UF condensation degree 1:10, 4 — dried product after UF condensation degree 1:10

Table 1. Chemical composition of concentrated and dried protein preparations

Kind of sample	Concentration degree	Dry substances %	Organic substances		Mineral substances		Nitric substances				
			in %	in d.s. %	in %	in d.s. %	N total in %	N total × 6.25		N prec. in 12% KTO	
								in %	in d.s. %	in %	in d.s. %
Potato juice waters		5.64	4.83	85.65	0.80	14.32	0.26	1.63	29.03	0.16	2.90
UF concentrate*)	1:5	6.25	5.58	89.42	0.66	10.57	0.38	2.37	38.00	0.23	3.80
Post-UF wash	1:5	1.71	1.32	76.85	0.39	23.20	0.18	1.16	67.98	—	—
Post-UF drying prep.	1:5	86.53	69.23	80.00	17.30	19.99	7.4	46.66	53.92	5.18	5.95
Post-UF concentrate	1:10	13.06	11.94	91.46	1.11	8.54	1.43	8.99	68.81	1.18	9.03
Post-UF wash	1:10	1.87	1.27	67.87	0.60	32.15	0.11	0.73	39.50	—	—
Post-UF drying prepar.	1:10	90.44	75.28	83.23	15.16	10.77	9.28	58.03	64.16	8.15	8.98
Post-UF concentrate	1:15	18.90	18.91	96.37	0.68	3.63	2.60	16.27	86.11	2.38	12.64
Post-UF wash	1:15	1.91	1.39	72.89	0.51	27.11	0.089	0.55	29.19	—	—
Post-UF-drying prep.	1:15	93.91	85.25	90.78	8.65	9.21	11.87	74.23	79.04	8.60	9.16
Coagulate		6.03	5.65	93.66	0.38	6.34	0.75	4.69	77.70	0.46	7.70
Post-coagulate wash		2.42	79.31	0.50	20.77	20.77	0.13	0.85	35.38	not made	
Post-coagulate fodder prep.		95.54	88.41	92.53	7.13	7.46	7.74	29.63	31.01	4.43	4.64

*) UF — ultrafiltration

Table 2. Characteristic of functional properties of protein after drying

Kind of preparation	Protein swelling, cm^3 H_2O/g preparation						Solubility %	Wettability cm^3 H_2O/g protein
	5 min	10 min	15 min	20 min	25 min	30 min		
Dried after post-UF product concentration deg. 1:5	0.04	0.03	0.04	0.02	0.04	0	53.60	0.730
Dried after post-UF product concentration deg. 1:10	0.20	0.14	0.08	0.04	0.06	0.03	72.41	0.573
Dried after post-UF product concentration deg. 1:15	0.49	0.09	0.08	0.06	0.07	0.04	22.06	0.380
Dried after post-coagulation product	0.50	0.10	0.03	0.04	0.04	0.04	24.61	0.426

The water absorption (wettability) at the air relative humidity of 83%, is as follows: 0.73 ml water/g protein in the preparation obtained by the ultrafiltration method at the concentration ratio 1:5; 0.57 ml water/g protein at the concentration ratio of 1:10, and 0.38 ml water/g protein at the concentration ratio of 1:15 (Table 2).

The solubility of proteins in the preparations was found to be dependent on the concentration degree during ultrafiltration. For the concentration ratio of 1:15 the NSI was 22.06%, at the ratio of 1:10 the protein solubility amounted to 72.4%, and it reached 24.61% for the coagulate. The α coefficients characteristic of the changes in proteins, calculated for the titration curves in pH interval from 3 to 5 and

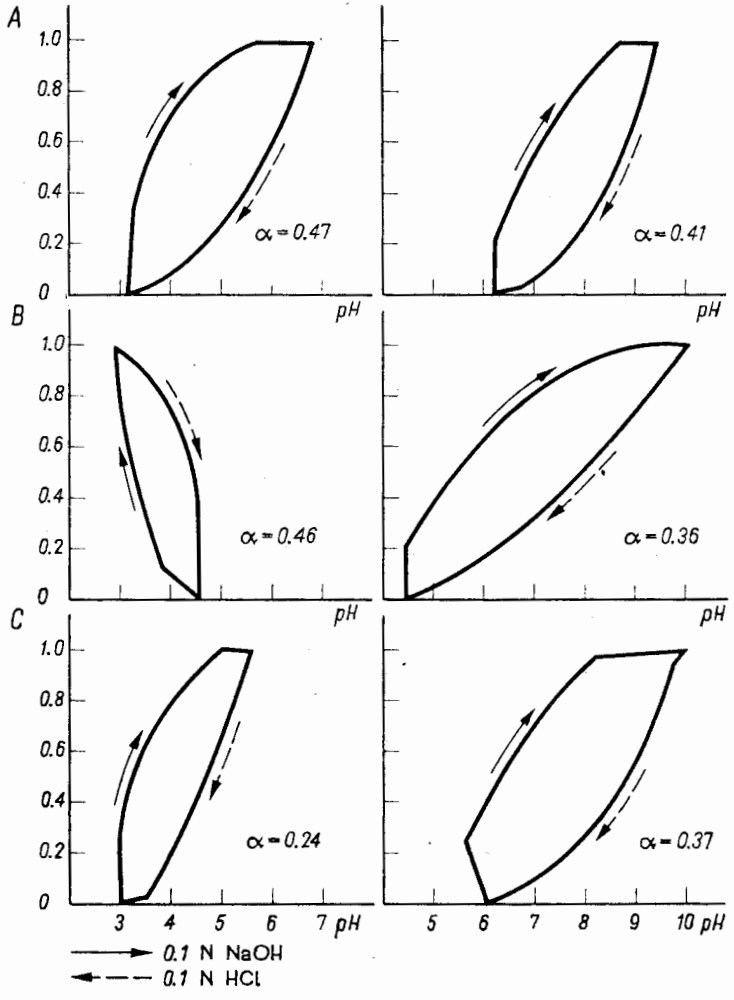

Fig. 2. A — hysteresis of potato juice thickened by the UF method to 1:15, B — hysteresis of coagulate, before drying, C — hysteresis of potato juice

compared to the coefficient for the potato juice titration curve, irrespective of the preparations concentration degree, grew from 0.24 to 0.27 for the concentration ratio of 1:15, to 0.42 and 0.43 for preparations obtained at the 1:10 and 1:5 concentration ratios, and 0.46 for the concentrate obtained by the coagulation method. After drying, the α coefficient increase was observed in the case of protein preparations obtained by thermal coagulation, and in the case of preparation obtained by the UF method at a concentration ratio of 1:15. Fig. 2 shows selected titration curves.

The characteristic of the emulsifying capacity indicates to the growth of this capacity in proteins after dryig.

The emulsifying activity for 100 mg of protein obtained by the UF method at the concentration ratio of 1:15 was 44.74%, to decrease to 40.02% after drying.

A higher emulsifying activity in the case of preparation obtained at the concentration ratio of 1:10 was displayed by the preparation before drying. The amount of oil not emulsified by the sample before drying was 25%, and after drying — 44.5%. The stability of emulsion (oil, water, protein preparations) amounted to 98.67% in the case of coagulate and 92.48% for the preparation after UF (Table 3). Heating of the emulsified protein samples at 80°C for 30 minutes had only a little effect on the stability of the emulsions of dried preparations concentrated by the UF method to the ratios of 1:10 and 1:15. The dried protein preparation

Table 3. Emulsifying properties of concentrated and dried protein perparations

Kind of preparation	Emulsyfying activity	Emulsion stability	Emulsifying capacity	
			% of emulsified oil phase	V 100+
Preparation after UF concentration degree 1:15	79.06	82.04	66.44	8.31
Dried product	69.94	95.08	76.47	139.42
Preparation after UF concentration degree 1:10	25.14	44.70	78.23	3.99
Dried product	44.54	48.20	81.09	147.88
Preparation after UF concentration degree 1:15	44.74	44.74	68.55	8.33
Dried product	40.02	92.48	75.00	81.30
Product after thermal coagulation	97.82	98.67	68.55	1.33
Dried product	62.44	98.58	39.75	45.59

+V 100 = the amount of oil emulsified by 100 mg protein

Table 4. Whipping properties of concentrated and dried protein preparations

Kind of sample	Whipping time min	Volume increase after whipping	The ratio of volume after whipping, in ml, to the whipped preparation weight after whipping, in g	Changes in whipped preparation structure in time, in %			
				20 min.	30 min.	60 min.	120 min.
Product after UF concentration degree 1:15	10	650	8.50	13.20	21.20	35.90	34.50
Dried product	10	650	7.94	9.89	22.90	33.70	35.00
Product after UF concentration degree 1:10	10	1000	10.80	14.60	20.80	30.20	40.10
Dried product	10	650	8.14	11.83	22.60	35.96	33.00
Product after UF concentration degree 1:15	10	1100	13.43	15.80	18.90	10.20	34.50
Dried product	10	525	25.18	18.30	17.24	28.79	20.00
Product after coagulation	10	does not become					
Dried product	10	whipped					

obtained by the UF method, at the concentration degree of 1:10, emulsified 147.88 ml oil/100 mg protein, whereas 100 mg of protein recovered by the thermal coagulation method emulsified only 45.59 ml oil (Table 3). The emulsifying properties of the preparation after ultrafiltration and condensation to 1:10 should be emphasised.

The protein preparations showed a higher whipped volume growth before drying. The proteins separated by coagulation showed no whipping ability (Table 4). The whip-generating properties of proteins from the potato juice were tested in our previous study from this subiect [14].

The buffer capacity of dried preparations, irrespective of the degree of concentration and the way of recovery, was high and it reached 80.15 mg HCl at pH 3.5 for protein obtained by the coagulation method, and 30.92 mg HCl at pH 3 for proteins obtained by ultrafiltration at a concentration ratio of 1:15 (Fig. 1).

DISCUSSION

The application of ultrafiltration (UF) made it possible to obtain a protein preparation of a higher content of nitrogen substances compared with the one obtained by thermal coagulation. A comparison of the physico-chemical properties of protein preparations obtained by the UF and thermal coagulation methods suggests a weaker effect of UF on the modification of structure and on protein properties. It is known that swelling and wettability of proteins depend on the size of the particles and on the number of the free functional groups [6]. Changes occurred most probably in the protein structures of II and III order during thermal coagulation, enabled the aggregation of these proteins [4].

These changes might have decided about the properties of swelling and wettability in the case of preparations obtained by the coagulation method.

From Hernansson's investigations it results that the swelling growth tendency accompanied by a reduction of protein solubility (NSI) depends on the temperature applied in the protein preparations production process [6].

Titration curves for 0.5% protein solutions were used to compare the degree of degradation of proteins concentrated by ultrafiltration and by thermal coagulation. In this way, a picture of changes occurring in protein during technological processess has been obtained. The α coefficients calculated for the titration curves seem to indicate to the liberation of functional groups in preparations concentrated by the UF method at the concentration degree of 1:15.

The emulsifying properties of potato protein preparations obtained

by the UF methods being better than the preparations obtained from soya beans or broad bean [10] deserve particular emphasis.

The investigations currently carried out by the authors of this study aim at mastering the technology of production of protein preparations from the potato juice on a semi-industrial scale, and at confirming their usefulness for the food industry.

CONCLUSIONS

1. The results of this study confirm that it is possible to produce protein preparations from potato juice by the ultrafiltration method.

2. The physico-chemical properties of preparations obtained in this way depend on the degree of protein recovery from the juice waters and, in the first place, from the protein coagulation degree and temperature.

3. The physico-chemical properties of protein preparations obtained by the ultrafiltration method suggest that it might be possible to use these preparations in the food industry as fat emulsifiers or and the whipping agents in the bakery industry.

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OTRZYMYWANIE I CHARAKTERYSTYKA PREPARATÓW BIAŁKOWYCH Z WÓD SOKOWYCH ZIEMNIAKA

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Streszczenie

Białka z wód sokowych ziemniaka odzyskiwano stosując odwirowanie i ultrafiltrację lub koagulację termiczną. W zależności od sposobu produkcji otrzymano preparaty białkowe, w których zawartość białka ogółem w s.s. wynosiła od 38,0% do 86,11%. Rozpuszczalność białek (NSI) wynosiła od 22,06% do 72,41%, natomiast zwilżalność preparatów sięgała od 0,350 ml wody/g białka do 0,730 ml wody/g białka. Wykazano, że 100 mg białka w suszonych preparatach emulgowało od 45,59 ml do 147,88 ml oleju.

Zadowalające pęcznienie białek w ilości 0,50 ml wody/g otrzymano w przypadku preparatów po zagęszczeniu soków metodą UF przy stopniu koncentracji 1:15 (tab. 2). Pojemność buforowa preparatów sięgała 80,15 mg HCl przy pH 3,5 i 68,2 mg przy pH 10 (rys. 1). Właściwości fizykochemiczne otrzymanych preparatów białkowych sugerują możliwość ich zastosowania w przemyśle piekarskim i cukierniczym.