"HENRI COANDA"
AIR FORCE ACADEMY
ROMANIA

GERMANY

"GENERAL M.R. STEFANIK"
ARMED FORCES ACADEMY
SLOVAK REPUBLIC

INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2011
Brasov, 26-28 May 2011

ELECTROPHYSICAL TREATMENT OF THE SECONDARY MILK PRODUCTS

Mircea BOLOGA, Elvira SPRINCEAN (Vrabie), Alexandru BOLOGA, Tatiana STEPURINA, Albert POLIKARPOV

Institute of Applied Physics of the Academy of Sciences of Moldova

Abstract*.The analyses of the secondary milk products thermal and electric parameters during the treatment by electrophysical method are presented. The arguments are adduced that it is necessary to control temperature and its effect on the final product quality. Energy consumption and optimal time for protein extraction are presented. The results could be used at the designing and elaboration of membrane electrolyzers and thermostabilizing systems, utilized in technological processes.*

Keywords*: electrophysical technology, protein extraction, secondary milk products, membrane electrolyyers, quality*

1. INTRODUCTION

As it was noted in the documents of the International Dairy Federation, a complete and wasteless milk processing is one of the important problems of dairy industry [1]. Its importance has increased during the last 10-15 years owing to the expension of production volume of dairy products [2]. Whey contains such valuable milk components as proteins, carbohydrates, vitamins, mineral substances and virtually does not contain fats. Its biological value is very high, since the most valuable protein fraction of milk (soluble whey proteins) and almost all lactosa (71.7%) remain in whey; the energy value of whey (in calories) is minimal.

Various methods of whey processing are known allowing to produce protein concentrates used as various biologically active food additives. A special emphasis was placed in recent years to the development of various infant food formulations on the basis of whey protein concentrates [4]. A number of food and feeding stuffs are produced from demineralized whey. Since whey proteins possess high emulsifying properties, their use in confectionary industry allowed to develop new products including various pastes [5]. The methods of whey processing, which are developed and improved, possess both definite advantages and disadvantages compared one to another [6]. The thermal methods lead to denaturation at temparatures exceeding 55-60 ^{o}C; chemical methods introduce reagents in proteins; this lowers the biological value of the products and narrows the field of their application [7]. Using highly efficient, though expensive, diaphragm methods (ultrafiltration) allows to recover the maximal protein quantity. However, the less are the pore dimensions, the more expensive is application of such diaphragms. Moreover, these are methods of periodical action; this leads to decreasing in the efficiency of treatment [8]. The ion-exchange resins allow fractionation of whey proteins, though they refer to expensive materials, and long-lasting treatments for recovery of ion-exchange agents are needed [9]. When electrodialysis is used fro whey processing, a

regular regeneration of diaphragms and high energy expenditures are necessary [10].

Analysis of the state-of-the art in this field allows to conclude that the most effective methods for whey processing provide such technologies where combined methods are jointly used. The aim of the performed research was to optimize one of the electrophysical methods of whey treatment based on the electroactivation of liquid media, directed for a wasteless treatment of whey yielding high-quality products [11].

2. EXPERIMENTAL RESULTS

Electrophysical and biochemical data give evidence, that using these methods allows to recover about 60% of proteins of their total content in the initial whey (IW) in the form of protein-mineral concentrate (PMC) and to obtain a deproteinized whey (DW). It contains a major part of aminoacids, a rather high percentage of lactulose inverted from lactose during the processing as well as a residual lactose. To optimize the process, the current density, the flow rate of the liquid, the temperature, the type and the state of the diaphragm were varied.

While investigating the thermal and electrophysical parameters of the method we have found that the content of the recovered protein increased from 30 to 60% with the increase in the current density from 0.013 to 0.021 A/cm^2 , Figure 1.

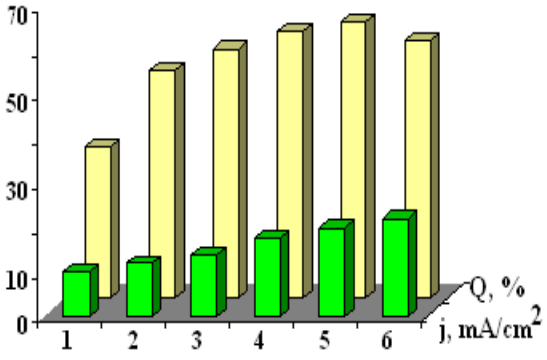


Fig. 1. Protein extraction characteristic. Protein recovery in PMC at the different values of the current density: 1 – 8; 2 – 10; 3 – 14; 4 – 18; 5 – 20; 6 – 22 mA/cm2.

The increase in the current density is accompanied by an intensive heating of the treated whey in the cathode camera, Fig. 2. The end temperature in the camera amounts to 42 °C for j = 0.021 A/cm^2; for j = 0.023 A/cm^2 the temperature increases to 60 °C and reaches the denaturation limit for protein macromolecules. Therefore, it is not possible to optimize the process over the current density only.

To optimize the method, an additional selective supply with calcium ions is appropriate not only to increase the percentage of the recovered protein in the PMC, but also

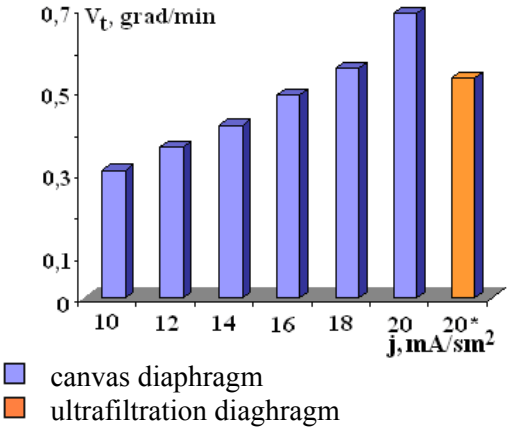


Fig. 2. Increase in the whey temparature versus the current density

to decrease the voltage and the energy expenditures, respectively Fig. 3.

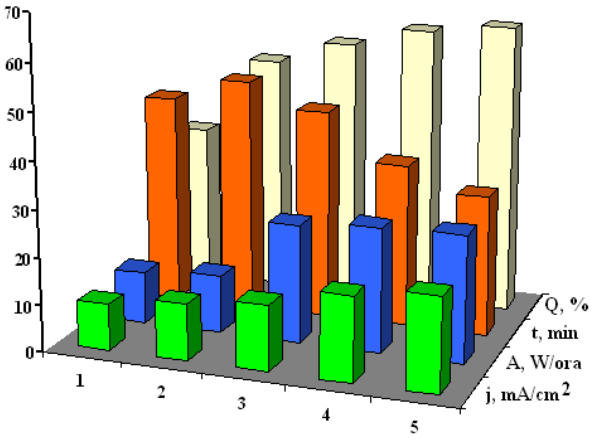
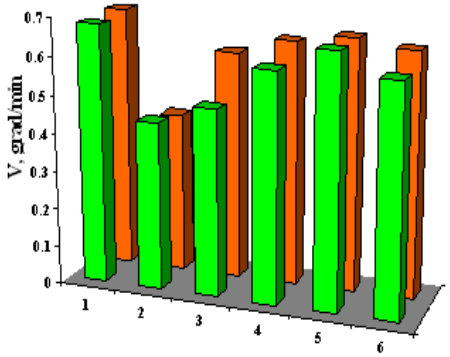


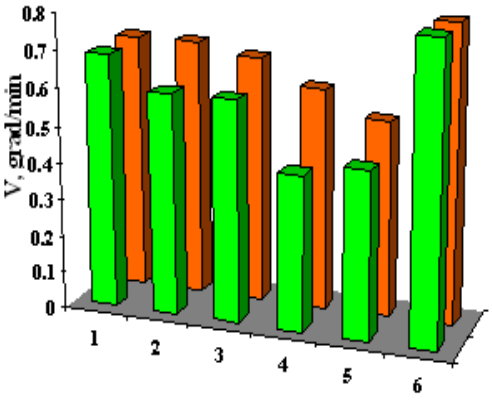
Figure 3. Qualitative dependence of the j, A, t, Q parameters from maximum values of the proteins extraction. j – current density (1 – 8; 2 – 10; 3 – 14,4 – 18; 5 – 20), mA/cm2,A– energy consumption, W/h;t – time, min;Q – recovered protein quantity, maximum value, %.

The temperature characteristics independent of the composition of the anode liquid and the diaphragm type do not influence the protein yield, Figure 4, 5. However, a preliminary continuous cooling of the IW is necessary during the treatment to avoid approaching the denaturation limit. Therefore, the treatment temperature did not exceed 55-60 ^{o}C in all the experiments.



- over the total period of treatment;
- during 45 min of treatment

Fig. 4. Temperature increasing for various solutions of the anode liquid and treatment duration, canvas diaphragm: (1) initial whey, (2) 10% $CaCl_2$ solution in the DW, (3) 5% $CaCl_2$ solution in the IW, (4) 1% $CaCl_2$ solution in distilled water, (5) 1% $CaCl_2$ solution in the DW,(6) 1% $CaCl_2$ solution in the DW

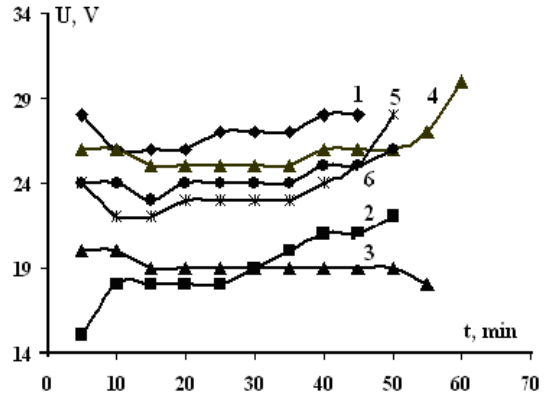


- over the total period of treatment;
- during 40 min of treatment

Fig. 5. Temperature increasing for various diaphragms, solutions of the anode liquid and treatment duration: (1) initial whey, canvas diaphragm, (2) 1% $CaCl_2$ solution in distilled water, canvas diaphragm; (3) 1% $CaCl_2$ solution in the DW, canvas

The optimization was performed according to two directions: by variation of the composition of the anode liquid with the aim to increase the protein yield and conserve the DPW to be suitable for further processing, as well as by variation in the diaphragm type to decrease the energy expenditures and to perform the process purposefully.

In the case of a canvas diaphragm and various compositions of the anode liquid, particularly when $CaCl_2$ solution in distilled water was used, a protein deposition on the diaphragm surface was not observed. The process was accompanied with an intensive foaming. Evidently, an intensive migration of calcium ions through the diaphragm facilitates the PMC formation. When an ion-exchange diaphragm MK-40 is used, a considerable voltage lowering, Figure 6, 7 and the increase



Fig, 6. Voltage variation for various composition of the anode liquid; canvas diaphragm: (1) initial whey, (2) 10% $CaCl_2$ solution in the DPW, (3) 5% $CaCl_2$ solution in the IW, (4) 1% $CaCl_2$ solution in distilled water, (5) 1% $CaCl_2$ solution in the DW,

(6) 1% $CaCl_2$ solution in the DW

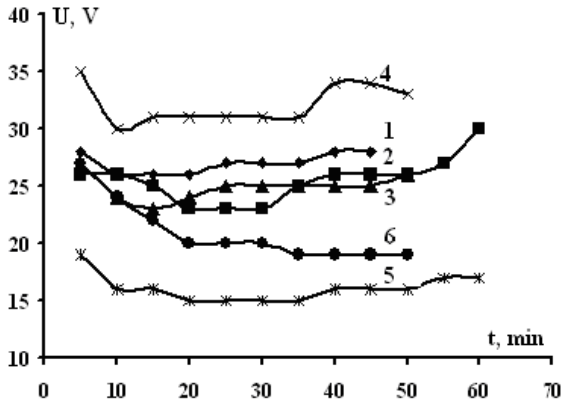


Fig. 7. Voltage variation for various diaphragms and compositions of the anode liquid: (1) initial whey, canvas diaphragm, (2) 1% $CaCl_2$ solution in distilled water; canvas diaphragm, (3) 1% $CaCl_2$ solution in the DW; canvas diaphragm, (4) IW, ultrafiltration diaphragm, (5) 2% $CaCl_2$ in distilled water; diaphragm MK-40, (6) 2% $CaCl_2$ solution in distilled water, diaphragm MK-40; (1) – (5) through regime is 5 ml/min; (6) stationary regime

in the protein percentage in the PMC (to 70% of the IW) were observed, Figure 8.

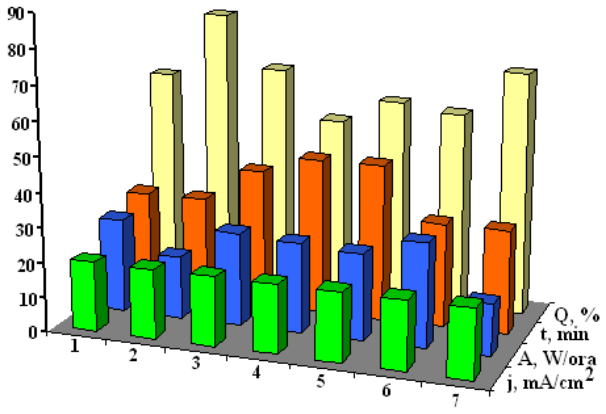


Fig. 8. Application of The Different Membranes And Liquid Anodic Solutions In Dependence of the Recovered Protein Maximum Quantity:1 - Iw, Prelate Membrane (Pm); 2.– 10% Sol. $Cacl_2$ In Dw, Pm; 3.- 5% Sol. $Cacl_2$ In Iw, Pm; 4. –1% Sol. $CaCl_2$ in Water (distilled), industry,PM; 5. –1% sol. $CaCl_2$ in Water (distilled), PM; 6. – IW, ultra filtration membrane; 7. - 2% sol. $CaCl_2$, ion selective membrane MK-40.

3. CONCLUSION

The study of thermal and electrophysical parameters of whey processing allows to analyze and substantiate the effective regimes for the recovery of valuable components, to optimize the combination of various parameters and treatment conditions with the aim to produce an ecologiclaly pure and of high quality protein-mineral concentrate and lactose-lactulose product to be used in the food and pharmaceutical

REFERENCES

1. Khramtsov A.G., Nesterenko P.G., Wastless *Technology in Dairy Industry*, M.: Agroptomizdat, 1989. – 279 p.
2. Khramtsov A.G., Suyunchev O.A., Rudakov A.S., Zhilina M.A., Batdyev Ch.M., *Using Deproteinized Cheese Whey*
3. Khramtsov A.G., *Whey*, M., Agropromizdat, 1990, 240 p.*for Production of Beverages*, Vestnik SevKavGTU, ser. Prodovol'stvie, no. 1 (7), 2004, http://www.ncstu.ru (Stavropol').
4. I*ntroduction to Dairy Science and Technology: Milk History, Consumption, Production, and Composition*, Agriculture and Agri-Food Canada, Canadian Dairy Information Center, www.dayryinfo.gc.ca
5. Lodygin A.D., Krainyukov D.N., Lomako E.V., Kazakova E.V., *Results of the Study of the Isomerization Process of Lactose into Lactulose in Concentrated Cheese Whey*, Sbornik trudov SevKavGTU, ser. Prodovol;stvie, 2005, no. 1, http://www.ncstu.ru (Stavropol).
6. Senkevich T., Ridel' K.L., *Whey: Processing and Using in Agroindustrial Complex,* M.: Agropromizdat, 1989.
7. Khramtsov A.G., Lafishev A.F., Cuyunchev O.A., *On the Production of Soft Cheese Using a Thermoacid Coagulation of Proteins*, Vestnik Sev.Kav. GTU, ser. Prodovol'stvie, no. 1 (6), 2003, http://www.ncstu.ru (Stavropol').
8. *Whey Membrane Filtration Applications* 2005, *Ionics Incorporated*, This page was

last updated on April 4, 2006. 22:42:47, www.ionics.com

9. Molochnikov V.V., Nesterenko P.G., Bogdanova N.A., Kovaleva O.G., Vodolazov L.I., Astakhov E.S., I*nfluence of the Ionite Mass and Process Duration on the Whey Demineralization Degree*, Tezisy dokladov Mejd. nauchno-practicheskoi konf. „Eneergosbere-ayushchie tekhnologii pererabotki sel'skokhozyaistvennogo syr'ya", Minsk, 1996.
10. Bruce T. Batchelder, *Electrodialysis Applications in Whey Processing, Ionics Incorporated* ,International Whey Confer., October 28, 1986, Chicago, Illinois, USA.
11. Bakhir V.M., *Elektrochemical Activation*, M., VNII Med. tehhniki,1992, vol.2, 657 p.