POSSIBILITY OF BLOOD PLASMA CONCENTRATION BY ULTRAFILTRATION

PETROVIĆ Lj., REDE R., DŽINIĆ N., UZELAC B.

Faculty of Technology, University of Novi Sad, Yugoslavia

W-6A.06

SUMMARY

The possibility of blood plasma concentration was investigated applying the ultrafiltration (UF) on a laboratory device (APV Pasilac, DDS-lab module with 20 membranes, type GR 61 PP).

UF was performed at 35C and 45C, inlet pressure 7-8 bar and outlet pressure 2.4 to 0.3 bar.

It was found that temperature affects significantly the flux, concentration degree and time of UF. The increase of UF temperature from 35C to 45C, the flux values increased from 3.75 l\m^2 to 36.37 l\m^2, that is the concentration from F_c 2.0 to F_c 2.7. In the same time, the time of the process was shortened, from 5 hours to 50 min. The increase of concentration degree is followed by the increase of protein content> 6.9% (plasma), 14.42% (Retentate I, 35C) and 17.70% (Retentate II, 45C).

Blood plasma and the obtained retentates were used as emulsifiers for the production of fat-emulsifier-water dispersive systems. It was confirmed that the functional characteristics of the proteins in the concentrated plasma were not changed by the applied process. However, only in case of 6>1>6 and higher ratios, the separation of fat after the thermic treatment was observed in model systems, which were firm-hard.

Introduction

The collecting and processing of blood for technical or nutritional purposes is a better technological and economical solution than the complex and expensive procedure of waste water treatment, in case blood is not collected.

The blood collecting and processing by drying of @full# blood or plasma is being applied for a longer period of time. Due to high nutritional value and good functional characteristics, the utilisation of additives obtained from plasma has increased significantly in meat processing (Dolatowski, 1986, 1988< Okanovi' et al., 1982< Petrovi' Ljiljana et al., 1992).

However, preservation of blood and plasma by drying is energetically not rational and, in the same time, the nutritional and technological value of the additives obtained is decreased. The energy necessary to reach the same concentration ldegree by ultrafiltration (UF) is 2 to 4 times lower compared to the classical drying (Pepper, 1981a< b). Furthermore, data on functional characteristics of the concentrates obtained are lacking. These were the starting points for our investigations.

Materials and methods

Pig blood plasma (BP) produced by blood separation was obtained from an industrial slaughter house (DD #29#, Subotica). The investigations of UF parameters and change of retentate composition were performed on a laboratory UF device (plate anf frame type, APV Pasilac DDS-lab module with 20 membranes, type GR 61 PP with polysulphone membranes of the second generation, surface 0.32 m^2). The retentate (R) was rejected to the feeding vessel, while the permeate (P) was continually removed.

The blood plasma temperature was maintained by thermostate at 35C i.e. 45C for the I and II experiment, respectively.

The inlet pressure of ultrafiltration was 7 to 8 bar, and the outlet pressure was 2.4 to 0.3 bar.

The flow (flux) was defined by the permeate amount per membrane surface unit per hour (l\m^{2}h).

The chemical composition of plasma, protein concentrate of plasma retentate (I and II) and permeate (I and II) was determined by>

- determination of water content, by drying at 105C,
- determination of total protein content by micro Kjeldahl method
- determination of ash content, by AOAC method (1980) at 520C.

Plasma and Retentate I and II were used for the preparation of fat-water dispersive systems, as emulsifiers (lard was chosen as the fatty phase). Dispersive systems lard>emulsifier>water in ratios 4>1>4, 5>1>5, 6>1>6 and 7>1>7 were prepared.

The dispersed systems lard-plasma (retentate)-water were prepared in the following way> Certain amount of plasma or retentate was gradually added to the weighed amount of lard, previously heated to 40C. Water heated to the same temperature was added til the achieving of the desired ratio, while stirring the mass with Ultra-Turrax, Janke u. Kunkel, for 5 min. at 6000 r\min.

Thermostability of the dispersed system was determined at pasteurization temperature. The dispersed systems in covered glasses were placed in water bath equipped with thermostat at 80C during 1 hour. After the thermal treatment and cooling of the model systems, the percentage of the separated fat and liquid was determined.

The sensory evaluation of the model systems was performed by a 5-member experienced panel. The descriptive method was used for the evaluation of the sensory characteristics (colour, consistency).

Results and discussion

The influence of temperature and time on flux and concentration degree Fc during UF of plasma is presented graphically (graph 1 - 35C and graph 2 - 45C).

Graph 1. Flux and Fc during UF of plasma at 35C in the function of time

Graph 2. Flux and Fc during UF of plasma at 45C in the function of time

At the beginning of the UF process, at 35C, the flux was 3.75 l\m^2, while after 5 hours it was 2.34 l\m^2.

After 5 hours the process was stopped, because the inlet pressure (p_i) was 7.1 and the outlet pressure (p_o) 2.4 bar.

The decrease of flux is the result of dry matter increase due to the concentration of proteins, in the first place. As a consequence of protein concentration, the viscosity and osmotic pressure are increaseing and, on the other hand, the proteins form an additional dynamic membrane on the surface of the real membrane, giving resistance to the flow of permeate. Under the described conditions, the concentration factor Fc of 2 was achieved.

At 45C (graph 2) the flux was several times higher - at the beginning of the filtration 36.37 \m^2, and after 50 minutes 23.51\m^2 (p_i 8 bar and p_o - 0.3 bar). The concentration factor reached 2.7.

Therefore, the higher the plasma temperature, the higher the flux values, due to the decrease of plasma viscosity and increase of diffusion coefficient. This influence is almost directly proportional.

The chemical composition of blood plasma, Retentate I and II and Permeate I and II is presented in Table 1.

Table 1. Chemical composition of plasma, Retentate I and II and Permeate I and II

Higher protein content was found in Retentate II - 17.70% compared to Retentate I - 14.42%. The chemical composition of Permeates I and II is very similar. The values for protein content range from 0.31 to 0.37% and for the ash content from 1.97 to 2.05%.

The obtained results of flux and concentration factor investigation are in agreement with the results of Zyrina et al. (1986) as well as of Kroll et al. (1986, 1988). Zyrina et al. applied ultrafiltration for the concentration of plasma. The process was performed at 40 to 48C and the plasma was concentrated til 18-24% of protein, at 0.3-0.4 MPa. Kroll et al. concentrated the plasma by UF process at 35 to 40C til the concentration factor 2.3 and 4 The concentration of proteins in the concentrate was 13.50, 19.00 and 24.00% respectively.

Somewhat lower blood plasma concentration achieved in our experiments is mostly the result of lower temperature of ultrafiltration. The increase of flux is significant at temperatures higher than 45C, however, at these temperatures, according to data available from literature, the native state of proteins is changed due to denaturation.

Our results confirme the occurrence of denaturation at 45C. Namely, fat and liquid separation was observed in model systems with the ratio of fat, emulsifier, water 6>1>6 and systems produced with plasma, Retentate I and Retentate II as emulsifier (Table 2). However, the amount of separated fat and liquid was the smallest in systems with the addition of plasma (8.46%), then is systems containing retentate I (15.20) and retentate II (20.85%). The same sequence, but with somewhat higher amount of separated fat and liquid was found in systems produced with higher ratio of fat and water (7>1>7).

Table 2. Amount of separated fat and liquid in model systems (%)

The dispersed systems with fat>emulsifier>water ratio 5>1>5 are stable (no separation of fat and liquid), neither with native plasma nor with UF plasma concentrate as emulsifier. Similar results were reported by Ani;i' et al. (1973), Turubatovi' et al. (1980) and Perovi' et al. (1980) applying native plasma for the dispersed systems. This points to the fact that the functional properties of plasma proteins are preserved during the UF concentration. The results of sensory colour analysis and consistency of the model systems are presented in Table 3.

Table 3. Sensory evaluation of colour and consistency of model systems

The dispersed systems i.d. the model systems after thermal treatment and cooling, produced with plasma as emulsifier were light yellowish (systems with ratio 4>1>4 and 5>1>5) i.d. greyish-yellowish (systems with 6>1>6 and 7>1>7), while Retentate I and II affected the appearance of grey-pink colour.
The consistency of model systems containing plasma was firm-elastic (4>1>4, 5>1>5) i.d. firm (6>1>6, 7>1>7).
The model systems with Retentate I and II were firm (4>1>4, 5>1>5) i.d. firm-hard (6>1>6, 7>1>7).
The model systems produced with the addition of Retentate I and II are somewhat firmer, either as the result of higher separation of fat and liquid during the thermic treatment (Table 2), or the decrease of functional characteristics of concentrate proteins due to the denaturation at higher temperatures of UF. However, the change of functional characteristics is not significant as the ratio of fat>emulsifier>water at which the fat and liquid separation starts after thermal treatment has not been changed.

Conclusion

On the basis of the investigation of blood plasma UF parameters as well as of functional characteristics of native plasma and concentrates (retentates) obtained, it can be concluded that>
1. The UF temperature affects the flux, concentration degree and time of UF. Increasing the UF temperature from 35 to 45C, the flux value increases from 3.75 l\m^{2}h to 36.37l\m^{2}h, the concentration degree from 2 to 2.7, while the UF time is shorter, from 5 hours to 50 minutes.
2. The higher the concentration degree, the higher the protein content of the retentate> 6.9% (plasma) to 14.42% (Retentate I) and 17.70% (Retentate II).
3. The functional characteristics of the plasma proteins remain unchanged during UF concentration, that is, the emulsifying stability is somewhat lower, than of native plasma, but the decrease is not significant.

References

Ani;i', V., Milo[evski, V., "iri' M. and Kosti', M., (1973). Ispitivanje sposobnosti dodatih belan;evina kao emulgatora masnog tkiva. Tehnologija mesa, XIV, 5, 141.
AOAC (1980)., Official Methods of Analysis, 13thed Association of Official Analytical Chemists, Washington, DC
Dolatowski, J.Z., (1986). Influence of Blood Plasma on changes in the micro-structure of meat tissue during curing. Die Fleischwirt., 66, 7, 1177.
Dolatowski, J.Z., (1988). The influence of Blood plasma on the colour and colour stability of cooked hams. Die Fleischwirt., 68, 8, 1018.
Kroll, J., Peters, H. and Kleschewski, M., (1986). Fractionation of protein-containing solution by ultrafiltration and selected functional properties of fractions available. Lebensmittelindustrie, 33 (66), 257-260.
Kroll, J. and Peters, H., (1988). Use of membrane methods in the processing of blood plasma and curing solution. Fleisch., 42\7, 130-132.
Okanovi', Dj., Petrovi' Ljiljana, Beara Marija, Popov-Ralji' Jovanka and Mihajlovi', B., (1992). Ispitivanje mogu'nosti salamurenja mi[i'a buta svinja slabijeg kvaliteta. Tehnologija mesa, XXXIII, 5, 217-223.
Pepper, D., (1981 a). Whey concentration by reverse osmosis. Dairy Industries International, 46> 24-26.
Pepper, D., (1981 b). Reverse osmosis using multi-stage recycle designs. The Australian Journal of Dairy Technol., 18> 120-122.
Perovi', M., Turubatovi', L., Jakovljevi', M. and Sekis, S., (1980). Ispitivanje mogu'nosti primene me[avine belan;evinskih preparata na bazi pivskog kvasca i krvi stoke za klanje u model proizvodima od mesa. Tehnologija mesa, XXI, 2, 43.
Petrovi' Ljiljana, Petrovi', M., ?lender, B., Tubi', M. and Dupalo, Dj., (1992). Uticaj elektrostimulacije na brzinu promena senzornih svojstava toplo otko[tenog june'eg mesa tokom zrenja. Tehnologija mesa, XXXIII, 6, 273-277.
Turubatovi', L., Perovi', M., Jakovljevi', M. and Jefti', Lj., (1980). Mogu'nost primene me[avina belan;evinskih preparata razli;itog porekla u izolovanim sistemima. Tehnologija mesa, XXI, 2, 46.

Zyrina, K.L., Volnov, A.V., Avilov, V., Griskin, T.V. and Knusnetsov, V.D., (1986). Quality characteristics of blood plasma concentrated by ultrafiltration. Mysnaya Industriya SSSR, 8> 15-17.