Studies on the optimum parameters of concentrating blood plasma by ultrafiltration

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Blood plasma is a product rich in protein, and accordingly it contains essential amino acids. Its introduction into meat products results in an improvement in yield and the water-holding capacity of ground meat, and also in the improvement of the flavour and the biological qualities of sausages and canned meats.
Blood plasma drying in spray driers is at present one of the best methods of the long term preservation of its qualities. However, it is worth noting that blood plasma has a high moisture content (91%), which is responsible for the inefficiency of its drying. Obviously, it is necessary to effect a preliminary concentration of the product which is hard to accomplish by heating without an injury to the biological qualities of the raw material.
In view of solving that problem, we studied the possibility to concentrate blood plasma by ultrafiltration, a method in which there is the least risk of protein denaturation.

Materials and Methods

Pig blood was used by us as initial raw material to obtain plasma. The blood obtained under hygienic conditions was stabilized using a 10% sodium citrate solution (0,25 ml/dm^3). After veterinary and sanitary inspection and the determination of the fitness of the blood, the latter was separated in an Alfa Laval separator with an average yield of blood plasma of 60%.
Ultrafiltration was conducted using a pilot plant, UF 36-18, supplied by the Danish company DDS. The module consists of 3 sections each of which has 40 type GR61PP flat membranes mounted in it, of a surface area of 6 m^2. The total membrane surface area constitutes 18 m^2. The size of openings is calculated to withhold molecules of a weight of over 20 thousand kg/kmol.
Plasma temperature is controlled by a thermoregulator, and cooling is effected in a tubular heat-exchanger (cooling liquid, tap water).
Pressure and transmissive capacity at a definite temperature were registered at constant time intervals by measuring the amount of permeating material per minute.
We included into the programme of the experiments the following:
- an analysis of the effects of temperature and pressure on the capacity of the plant;
- an analysis of changes in pressure, permeating material, dry matter and proteins in the concentrate and the permeating material in the course of the process.

The samples were analysed according to the folowing indices:
- protein content, by Kjeldal's method: in accordance with Bulgarian State Standard 9374-74, "Meat and meat products. Determination of protein content";
- moisture content: after Bulgarian State Standard 5712-74, "Meat and meat products. Determination of moisture content";
- ash content: after Bulgarian State Standard 9373-80.

Results and Discussion

The experiments to determine the effects of temperature and pressure on transmissive capacity with constant concentration and circulation flow were conducted by us by recirculating the permeating material and the concentrate in a receiver tank. We changed operational pressure in the range from 0,4 to 0,8 MPa; temperature, from 25 to 40°C. The values of transmissive capacity in terms of l/h.m^2, are shown in Table 1 and in the graph of Fig. 1.
From the data in the table it is obvious that, upon the consecutive change of pressure from 0,4 to 0,8 MPa at each 0,1 MPa, the increase in transmissive capacity within that range is insignificant:
- at a temperature of 25°C, 4,7-12,5%;
- at a temperature of 30°C, 5,9-10,0%;
- at a temperature of 40°C, 8,6-11,9%.

However, upon a saltatory change of pressure from 0,4 to 0,8 MPa, the increase in transmissive capacity becomes significant. Thus, for instance, at temperatures of 25, 30, and 40°C, it increases to 38,7, 36,2, and 49,1%, respectively.
The comparison of transmissive capacity in the 'mild' ultrafiltration treatment: pressure, 0,4 MPa, and temperature, 25°C; and in the 'severe' treatment: pressure, 0,8 MPa, and temperature, 40°C, demonstrates great possibilities of improving transmissive capacity by way of appropriate alterations of those two parameters.
Taking into consideration the results obtained in the experiment at constant concentration, it is possible to maintain that it is expedient to effect blood plasma ultrafiltration at the highest possible temperature and pressure.
Changes in ultrafiltration parameters and the chemical composition of the concentrate are directly dependent on the duration of the process. This is shown in Table 2 and Fig. 2. From the data shown it is obvious that, during the process, as a result of the increase in the viscosity of the concentrate, an increase in pressure occurs, from 0,5 MPa in the beginning to 0,63 MPa in the end of the process. At the same time, the pressure of the feeding pump and on the exit of the module remains unchanged: 0,20 and 0,28 MPa, respectively.
With an initial amount of blood plasma of 274 dm^3, 180 dm^3 of permeating material is obtained ultimately, which points to a volume concentration of 2,91 having been achieved.
Concentration factors of proteins and dry matter constitute 2,36 and 2,25.
Fig. 3 shows the change in transmissive capacity during the process. The curve of the graph indicates that right after the start of the plant a gradual decrease is found in the transmissive capacity of the membranes. Thus, if initially we have a high transmissive capacity: 14,3 l/h.m^2, within 15 minutes it is reduced by 28%, and within 40 minutes it is lower than the initial one by 50%.

Table 1. Dependence of the transmissive capacity of the membranes on the temperature and the pressure of the plasma treated

Pressure, MPa	Temperature, °C		
	25	30	40
0,4	12,9	16,0	17,7
0,5	13,8	17,0	19,8
0,6	15,2	18,7	22,0
0,7	17,1	19,8	24,3
0,8	17,9	21,8	26,4

Table 2. Changes in the chemical composition of the permeating material and the concentrate in the different phases and experiments on ultrafiltration

Sample No.	Process duration, min	Pressure, MPa			Concentrate temperature, °C	Permeating material				Concentrate		
		Circulating pump	Feeding pump in module	After the module		Transmissive capacity l/h	Transmissive capacity l/h.m²	Dry matter, %	Protein, %	Protein, %	Dry matter, %	Ash content, %
1.	0	0,19	0,5	0,28	30	257	14,3	1,77	0,16	6,96	8,62	0,72
2.	15	0,20	0,52	0,28	30	185	10,3	-	-	10,47	12,02	0,75
3.	45	0,20	0,52	0,28	30	139	7,7	-	-	13,62	15,97	0,76
4.	60	0,20	0,60	0,28	30	120	6,7	-	-	15,06	17,01	0,60
5.	75	0,20	0,62	0,28	30	86	4,8	-	-	16,05	18,35	0,61
6.	85	0,20	0,63	0,28	30	58	3,8	1,78	0,15	16,45	19,37	0,70

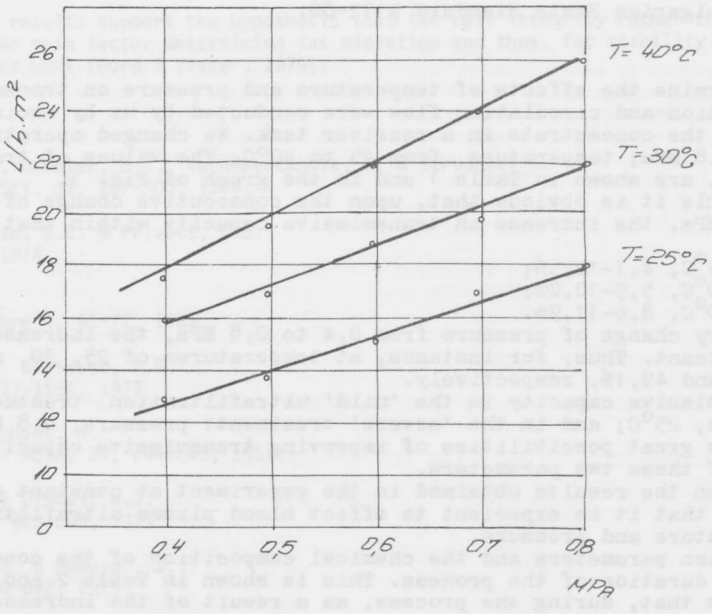

Fig. 1. Graphical presentation of the dependence of membrane transmissive capacity on temperature and pressure.

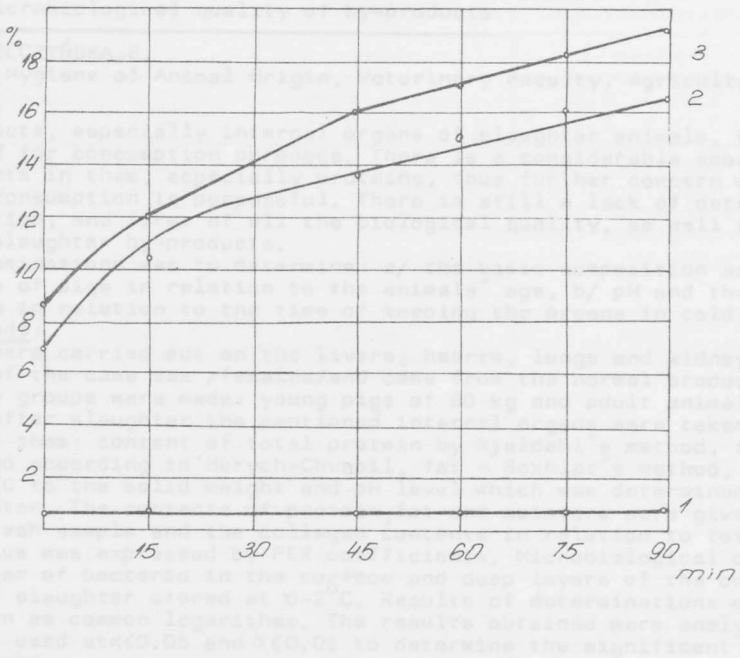

Fig. 2. Changes in the contents of ash, protein and dry matter in the concentrate
1. ash content; 2. protein; 3. dry matter.

Conclusions

1. Ultrafiltration is a suitable technology of concentrating blood plasma. In a short period of time concentration factors of proteins and dry matter increase to 2,36 and 2,25, respectively, and volume concentration reaches 2,91.
2. Transmissive capacity is directly dependent on temperature and pressure. From the point of view of preserving the operating qualities of the basic machinery and equipment, however, it is not recommended to operate at temperatures above 30°C and a pressure above 0,5 MPa.
3. Our experience shows that blood plasma ultrafiltration in 250 dm^3 batches is the most appropriate in view of avoiding a long standing of concentrate in the plant. This, in turn, contributes to the preservation of the microbiological status of the finished product within the range of standard requirements and to the quick regaining of the capacity of the plant after its washing.

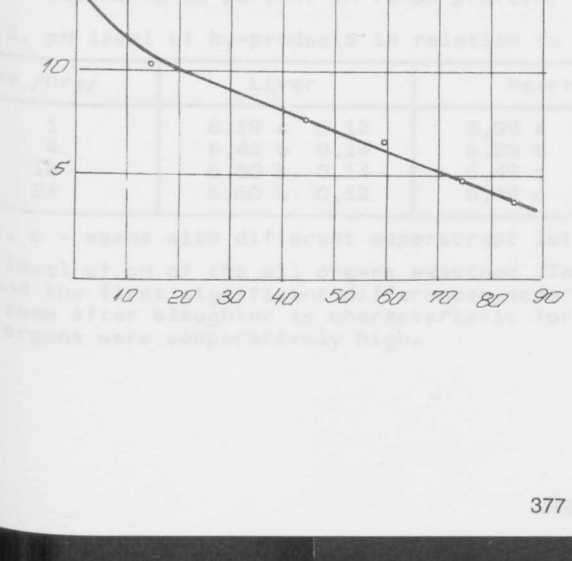

Fig. 3. Changes in the transmissive capacity of membranes in the course of the process.