THE UTILIZATION OF SOME PROTEIN ADDITIVES AND PHOSPHATES TO IMPROVE THE TECHNOLOGY FOR CANNED COMMINUTED MEATS

The available technology for canned emulsion meats is complicated, and keeping to it depends on a much greater number of factors as compared to sausage production, as during sterilization the comminuted meat is exposed to more severe heating than sausage cooking; this may cause the separation of the liquid phase (bouillon) due to the absence of moisture exchange between the product, hermetically sealed in cans, and the environment.

In this connection, the operating technology provides for prolonged (up to 72 hrs) meat curing prior to comminution in a cutter in order to immobilize a required amount of soluble proteins to stabilize fat emulsion resulting from cutting. At the same time, during cutting 5% of water and ice (of the raw materials) are added, this restricting the improvement of forcemeat quality during comminution in a cutter.

Meat holding in cure before its processing in machines creates difficulties for continuous preparation of emulsion, requires great production space and much labour.

Besides, the available technology does not bring into effect the useful property of finely comminuted meat to reconstitute its coagulation structure, which is partially broken during portioning, due to emulsion holding in cans before sterilization, as a result of gradual thixotropic appearance of new coagulation bonds among disperse particles.

A technological possibility of ready emulsion holding prior to sterilization and of its combination with meat holding in cure was studied, this rendering it possible to mechanize the whole process and to make it continuous. The defficiency of solubilized muscle proteins for emulsion stabilization is offset with the addition of non-muscle proteins (milk, blood, soya) during cutting.

The main object of the study was to develop a technology for continuous production of canned meat emulsion products. The following tasks have been set:

1. To determine the effect of added milk, blood and soya proteins on product chemical composition, organoleptical qualities, on changes in its amino acid composition, and to evaluate the efficiency of the above proteins as stabilizers of fat emulsion as applied to the technology of canned emulsion meats;

2. To study the possibility of finely comminuted meat curing with its subsequent holding in cure under anaerobic conditions in sealed cans; this will increase the concentration of solubilized proteins, strengthen emulsion structure due to the thixotropic reconstitution of coagulation bonds and yield a significant technological and economic effect at the commercial scale;

3. To find changes in some properties of the emulsion (pH, water- and salt-soluble protein contents, water-holding capacity, structural and mechanical properties) with sodium caseinate, blood serum and soya proteins added, during emulsion holding in cure, and to determine the optimum curing time;

4. To develop a technology of canned emulsion meats with the use of milk proteins, blood and soya proteins, and on its basis to make up a technological scheme, a draft technological instruction and technological specifications for the development of a continuous mechanized line for canned emulsion meats.

To prepare the emulsion, chilled beef and pork were used. Beef (5-6-year-old cows) and pig (12-month-old) carcasses were processed according to the operating technological instruction. L. dorsi muscles were removed from fresh-warm carcasses, wrapped into cellophane and held at $275 \pm 0.5^{\circ}K$ for 7 days.

As binders, home-made potato starch, sodium caseinate №2-64 (Bulgaria), soya protein Promine-D (USA), blood serum (prepared at the Moscow Meat Packing Plant) and home-made phosphates (trisodium-pyrophosphate$\cdot 9H_2O$) were tested.

Emulsions were prepared in a cutter according to the operating technology.

The formulations of canned products and the amount of proteins and phosphates added are given in Table 1.

Canned emulsion products, like the emulsion for cooked sausage, can be reasonably considered as a complex structured disperse system - a concentrated protein-fat-water one, its disperse phase being finely dispersed particles of muscle tissue and fat and a dispersion medium - the solution of protein and electrolytes.

The stability of emulsion structure during technological processing is determined by the resistance of protein membranes around dispersed fat particles and by the capacity of protein molecules to hold (or, in case of sterilization, to retain)water. During heating of the emulsion with an increased content of soluble proteins, no visible separation of water and fat is observed due to a sufficient strength of the protein membranes and to the formation of the structural protein carcass. Emulsions with a higher content of soluble proteins usually yield a denser and a more elastic structure. Thus, the use of the components which contains, mainly, soluble proteins and are able to stabilize emulsions of a direct type (fat in water) is theoretically feasible for the manufacture of canned comminuted products.

It is clear, therefore, that by some technological properties the emulsions with either sodium caseinate, blood serum or soya protein (Fig. 1) added are superior to those prepared by the conventional technology in that the former emulsions contain more water-soluble (Fig. 2) and salt-soluble (Fig. 3) proteins, are of high water-binding capacity (Fig. 4), are characterized with greater stickiness (Fig. 5) and lower plastic viscosity (Fig. 6).

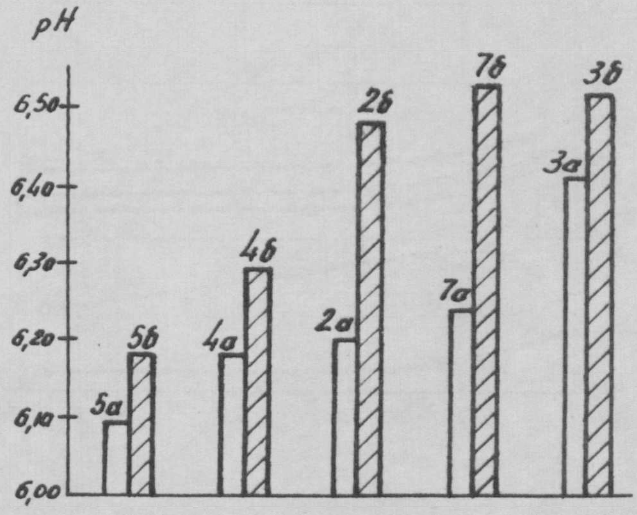

Fig. 1. The effect of sodium caseinate, blood serum, soya protein, phosphates and starch on emulsion pH (a - raw, b - sterilized).
Here and in Figs2-7 : 2 - emulsion with sodium caseinate added;
3 - " " blood serum " ;
4 - " " soya protein " ;
5 - " " starch " ;
7 - " " phosphates "

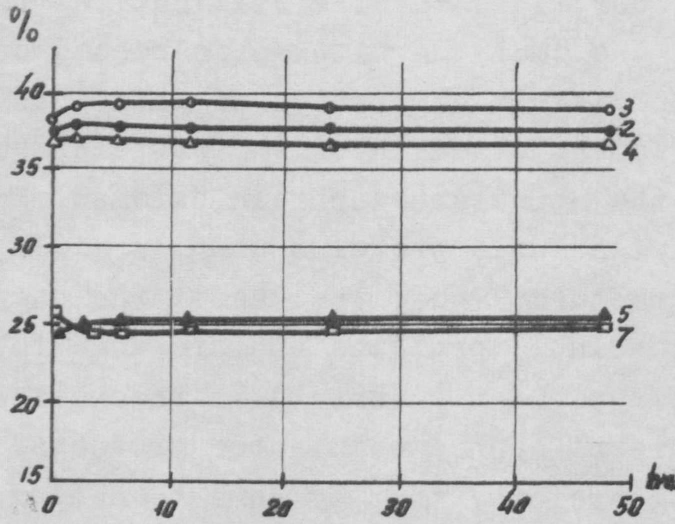

Fig. 2. Water-extractable proteins (% of the total nitrogen) in a raw emulsion during its holding in cure

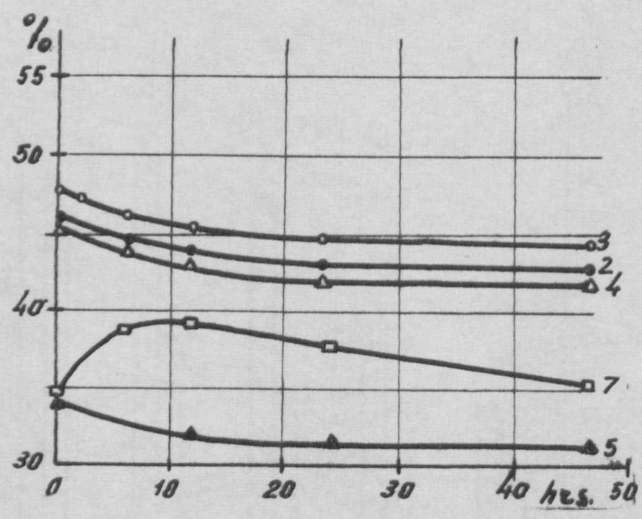

Fig. 3. Salt-soluble proteins in a raw emulsion during its holding in cure

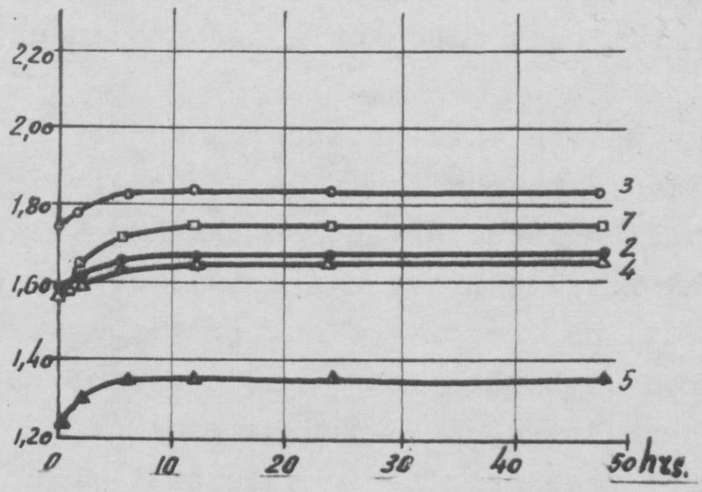

Fig. 4. Raw emulsion water-binding capacity during its holding in cure (bound water/dry residue ratio)

Sterilized emulsion with sodium caseinate, blood serum or soya protein added has a denser structure as compared to that with starch added.

Under our experimental conditions, when great amounts of water are added, emulsion technological properties are much affected with a better dispersion of meat and fat particles. As is known, water addition to meat, i.e. an increase in its water content, reduces the optimum cutting time. The formulation of canned "Sovetsky" frankfurter emulsion permits 5% added water (in the experiments 25% and more water were added). When a small quantity of cold water is added, one tries to increase the degree of dispersion by means of prolonging cutting time, the temperature exceeds a permissible level, this causing emulsion breakage.

Of notable influence upon finished product structure may be, as is observed by some researchers, stability of sodium caseinate, blood serum and soya proteins to coagulation and, hence, a higher strength of protein membranes, which stabilize fat particles during sterilization. Under our conditions, of the critical importance for emulsion structure stabilization is, however, the content of a great number of soluble muscle proteins.

Muscle proteins solubility is greatly related to the condition of meat.

F.Schtraub (on actomyosin solutions) and V.V.Palmin (on muscular tissue) established experimentally the capacity of phosphates to dissociate actomyosin into actin and myosin under certain conditions.

Actomyosin dissociation with phosphates under the conditions described is confirmed with raw emulsion viscosity and density decreasing and with cooked emulsion structure strengthening (Figs. 6 and 7).

Our experimental results prove a specific effect of polyphosphates on muscle proteins. Despite a comparatively small shift of emulsion pH, prepared with phosphates, it contains much more salt-soluble proteins than control emulsion samples (Fig. 3). It should be noted that at prolonged holding in cure salt-soluble proteins content in the emuslion with phosphates added is greatly reduced, whereas in all the other batches tested no considerable decrease occurs. This can be explained with polyphosphates decomposition as a result of hydrolysis and, as a consequence, with a reduced specific action of phosphates. The emulsion, cured with phosphates added, has a better water-binding capacity (Fig. 4), higher stickiness and lower viscosity as compared to controls. A sterilized emulsion with phosphates added has a stronger structure as compared to all the other tested batches.

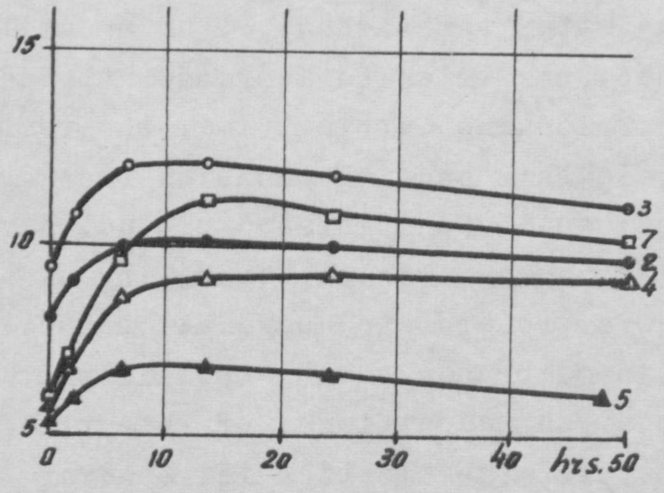

Fig.5. Raw emulsion stickiness during holding in cure

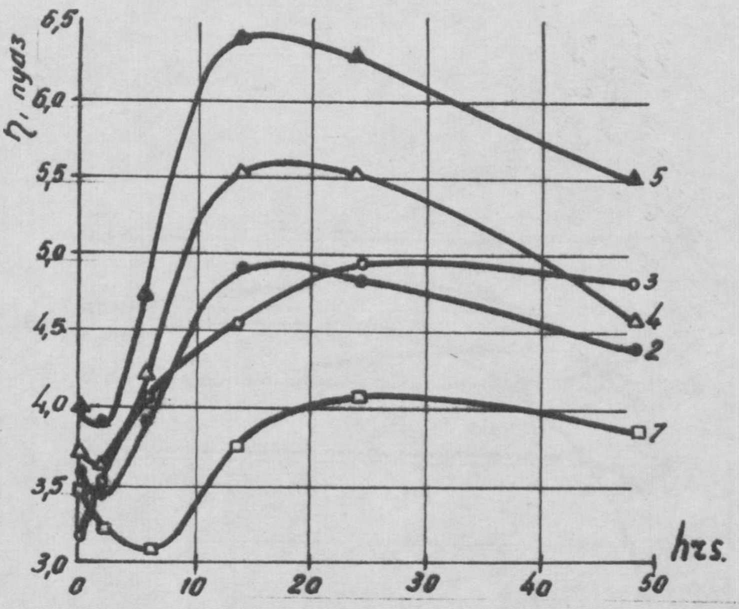

Fig. 6. Raw emulsion plastic viscosity during holding in cure

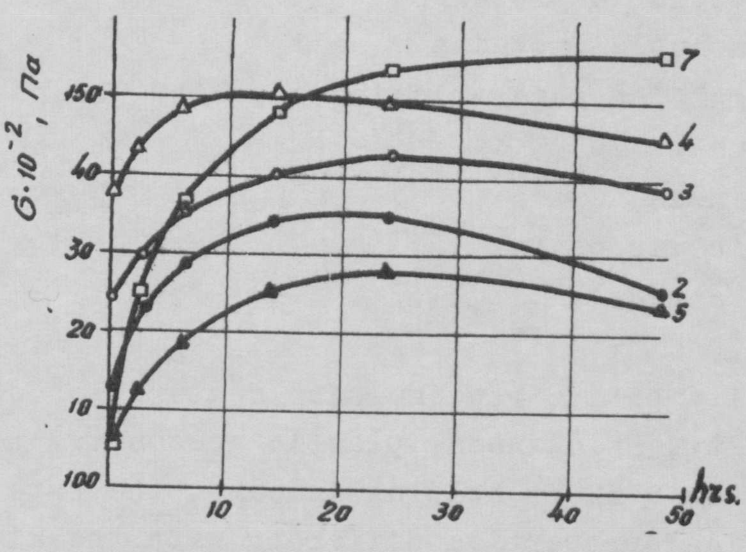

Fig. 7. Sterilized emulsion shear stress after holding in cure for various periods of time

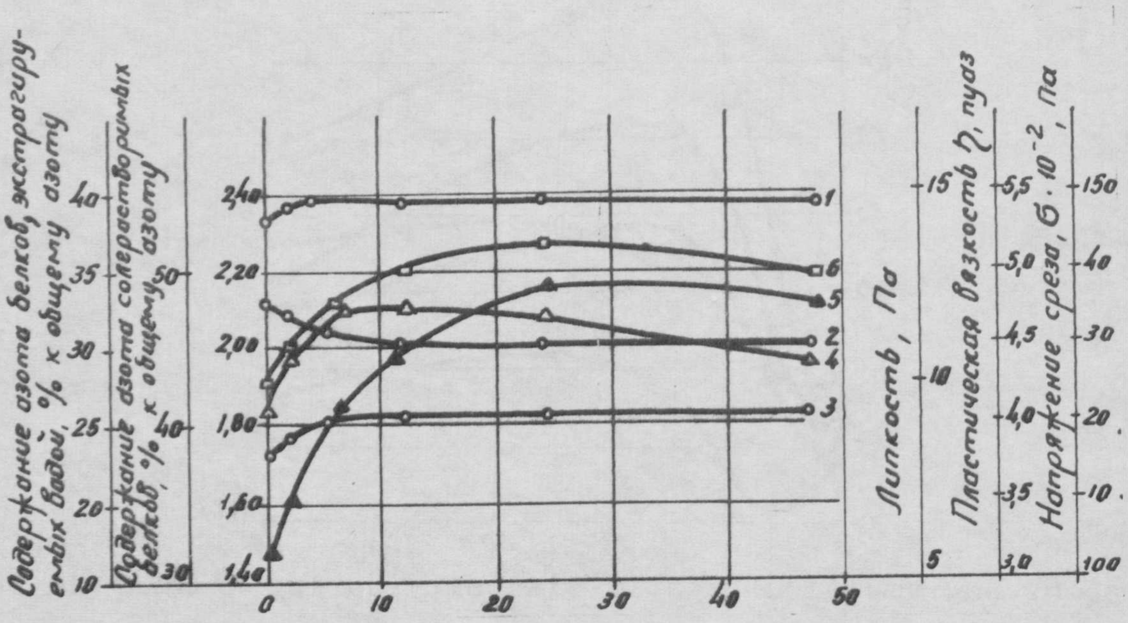

Fig. 8. Changes in the technological properties of emulsions with blood serum added during their preparation

1 - water-soluble proteins

2 - salt-soluble proteins

3 - raw emulsion water-binding capacity (bound water/dry residue ratio)

4 - stickiness

5 - plastic viscosity

6 - shear stress

The majority of the raw emulsion features studied (pH, water-binding capacity, stickiness, plastic viscosity) reach their optimum only after 6-12-hr holding in cure, the rate of changes in the technological properties differing with the kind of non-muscle protein added.

When adding blood serum to the emulsion (Fig. 8) within the first 6 hrs of holding in cure, water- and salt-soluble proteins, water-binding capacity, stickiness and shear stress of sterilized emulsion reach the extreme values (the difference between these indices for the emulsions held in cure for 6 and 12 hours is not statistically true). After 12-hr holding only plastic viscosity continues to grow.

Changes in the properties of the emulsion of other tested batches are approximately similar.

Thus, the quality of the finished canned products is determined with the following basic factors:

- with the chemical composition, and mainly, with protein/fat/water ratio;

- with the contents of soluble muscle proteins and collagen decomposition products;

- with the fineness of emulsion;

- with pH-value;

- with meat proteins capacity to bind water and to stabilize fat-in-water emulsions.

Many of these factors, being correlated (Table 2), manifest themselves more favourably in the manufacture of canned meats with milk proteins, blood, plant proteins or phosphates added.

The addition of sodium caseinate, blood serum or soya protein increases protein-fat-ratio up to 0.75; 0.83 and 0.74 respectively (Table 3), whereas it is equal to 0.61 in case of the conventional technology.

Soluble protein contents in canned emulsion meats with sodium caseinate, blood serum, soya protein or phosphates added and held in cure for 6 hours are 83.6; 86.2; 82.8; 64.7% (respectively) as compared to only 58.3% in the control.

The use of the above components in emulsions during comminution in a cutter allows greater amounts of added water (ice) as compared to the available technology. The estimations indicated that, when 20% ice of the emulsion weight are added, it is possible to supply to it about 1,500 kcal of mechanical energy per 100 kg during comminution, or by 1.7 times more, than in case of the traditional technology, without the risk of emuslion superheating (due to the latent heat of ice melting and water warming-up).

Besides, because of a higher water content of the test batches (from 1.67 to 1.93 - Table 2) as compared to the control one (1.35), the conditions of emulsion comminution in a cutter are improved.

The pH-value of the canned product, manufactured with sodium caseinate, blood serum, soya protein or phosphates, is much higher as compared to that of the control (Fig. 1.). It is characteristic of both raw and sterilized emulsions.

pH shift towards the alkaline field affects favourably water holding by the emulsion during sterilization. A high lability of proteins and emulsion pH of the test batches determine a greater water-binding capacity (Fig. 4).

Sodium caseinate, blood serum and soya protein are, probably, less effective stabilizers of emulsions than muscle proteins, though the replacement of up to 15% of beef with an equal amount (by protein content) of sodium caseinate or soya protein and curing with phosphates yield the finished canned emulsion meats of quite a satisfactory quality.

Thus, the utilization of milk proteins, blood and plant proteins in canned emulsion meats is theoretically substantiated as, due to high solubility of sodium caseinate, blood serum and soya protein, the concentration of protein in the liquid phase of the emulsion system and viscosity are increased the conditions of the ready canned emulsion structure formation, as well as of emulsion dispersion are improved, and the stability of the fat-water emulsion is raised.

Phosphates application not only improves the conditions for proteins extraction because of an increase in the ionic strength of the liquid phase, but results in actomyosin dissociation into actin and myosin due to the specific action of phosphates on actomyosin proteins and raises significantly muscle proteins solubility, increasing emulsion water-binding capacity and stability during heating.

Swelling and solubilization of high-molecular compounds is a process which develops with time, so, despite fine dispersion and uniform distribution of curing substances throughout the emulsion just after its preparation, muscle proteins extraction, water-binding and structure formation take some time. One can assume that in all the batches tested the process of structure formation is practically completed within the first six hours of curing, though slight alterations in the emulsion properties may be observed later - up to the 24th hour of holding in cure.

On the basis of the analysis of the experiment carried out and of the data in literature, a technology can be recommended for canned emulsion meats, which uses milk proteins, blood, plant proteins and phosphates (Fig. 9).

The recommended technology differs from the conventional one in that milk and plant proteins and blood are used as supplementary soluble proteins which are necessary during fine comminution in a cutter to stabilize the fat emulsion, this allowing to hold comminuted meat in cure prior to sterilization and strengthening emulsion coagulation structure. The emulsion is held anaerobically, sealed in cans. The elimination of meat curing prior to comminution makes the process of the production of canned comminuted meats a continuous one.

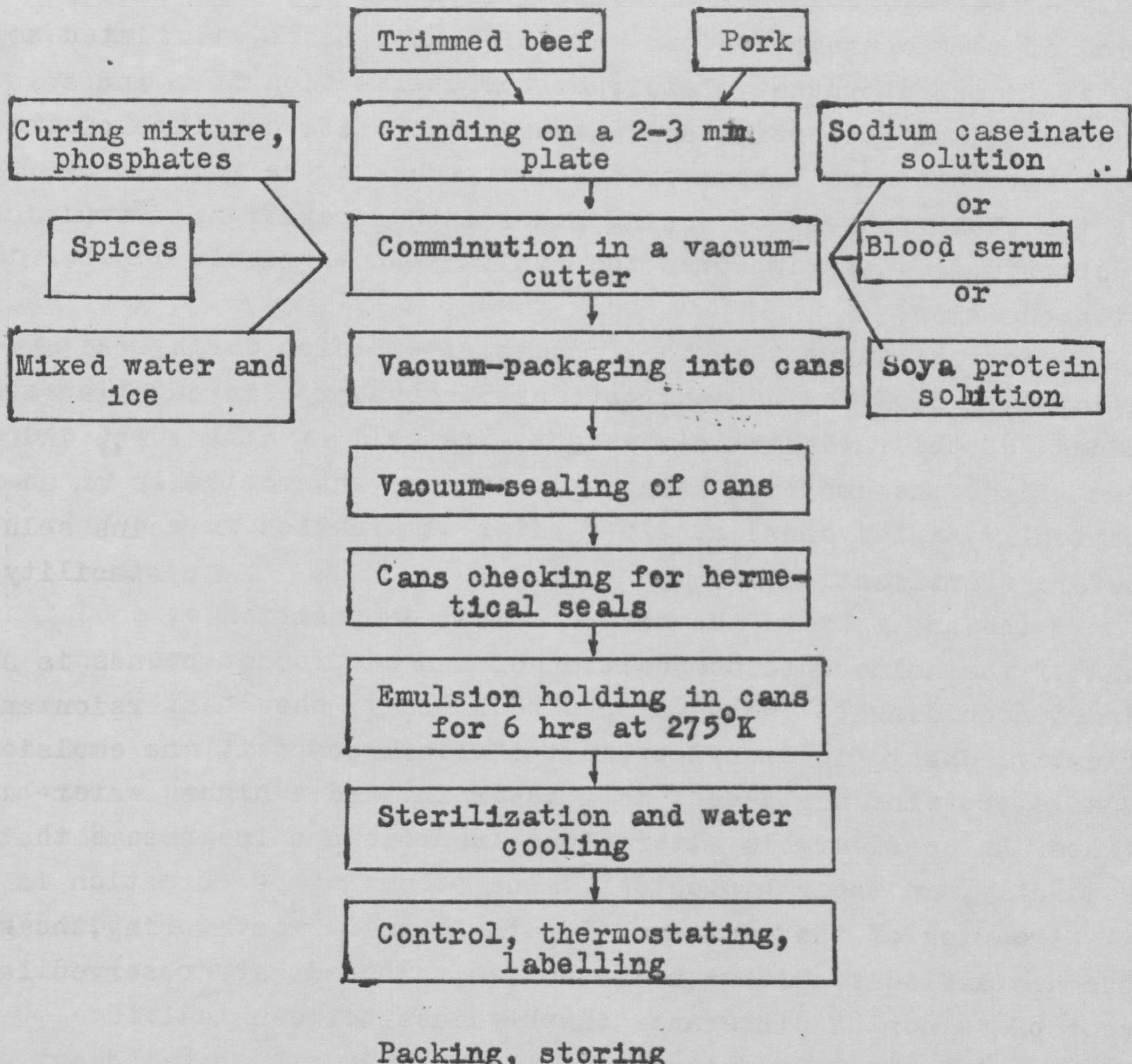

Fig. 9. A technological scheme for canned emulsion meats with milk proteins, blood and plant proteins added

Phosphates are added during comminution in a cutter, increasing their efficiency.

The advantages of the recommended technology are as follows: it allows to mechanize the process of curing, increases labour productivity and the reliability of the process, improves the quality of the finished product and the sanitary-and-hygienic conditions of production, increases the resources of the edible raw materials in the meat industry, saves production space, improves the yields of the finished product.

As a result of the studies carried out, a technology has been developed for canned emulsion meats with the use of milk and plant proteins and blood, which provides more complete utilization of edible raw materials for processing into meat products, a reduction of meat consumption per unit of canned meats, i.e. an increase of finished product yields; better utilization of emulsion technological properties and, consequently, its quality improvement; it increases labour productivity due to the mechanization of the whole process of curing and related operations, saves production space; and improves the sanitary-and-hygienic conditions of production;

- for the first time the process of emulsion curing was studied, with 3.5% sodium caseinate or 3% soya protein and 20% water added (of the raw materials weight), as well as with 30% blood serum added, the emulsion being held in cure anaerobically (in hermetically sealed cans) at 275°K after comminution in a cutter just before sterilization;

- the analyses of the main chemical composition of emulsions and of the amino acid composition of canned product proteins, produced according to the developed technology, show that the determinative change in canned product chemical composition, when non-muscle proteins are added, is a lower fat and a higher water contents. No considerable alterations in protein aminograms, and consequently, in their biological value occur;

- curing of the emulsions for the canned meats, produced by the new and conventional technologies, proceeds at greatly different pH-values (a difference in pH-values between individual batches reaches 0.24 unit).

- emulsions, prepared with sodium caseinate, blood serum or soya protein, contain water-extractable proteins by 11-14% more, as compared to the conventionally prepared emulsions with starch added. Salt-soluble proteins content is also much higher in the emulsions with sodium caseinate, blood serum or soya protein. At emulsion curing with phosphates added, salt-soluble proteins extractability has the distinct maximum - between 6 and 12 hours. Emulsion water-binding capacity is increased markedly during holding in cure. After 6-hour curing all the water is firmly retained by the emulsion and is not pressed out. This property is determined with the ratio of the components used, it is much higher in case of the emulsions with sodium caseinate, blood serum or soya protein, which retain water better during sterilization;

- during curing, the adhesion (stickiness) of a raw emulsion is increased, especially in case of phosphates addition. Raw emulsion plastic viscosity is changed markedly during holding in cure. Of the lowest viscosity is the emulsion cured with phosphates. Plastic viscosity, like stickiness, depends, to a great extent, on the ratio of emulsion components. Of the most dense texture is sterilized emulsion with soya protein added, as well as that cured with phosphates and held in cure not less than 6 hours.

Table 1

The formulations of the experimental batches of canned emulsion meats

Experiment №	Batch №	Emulsion components added into a cutter, kg							
		extra-grade trimmed beef	mixed water and ice	sodium caseinate	blood serum	soya protein	starch	salt	phosphates
I	1	40.0	25.0	-	-	-	-	2.5	-
	2	36.5	25.0	3.5	-	-	-	2.5	-
	3	40.0	-	-	30.0	-	-	2.5	-
	4	37.0	25.0	-	-	3.0	-	2.5	-
	5	36.5	5.0	-	-	-	3.5	2.5	-
	6	34.0	25.0	-	-	-	6.0	2.5	-
II	7	40.0	25.0	-	-	-	-	2.2	0.3
	8	36.5	25.0	3.5	-	-	-	2.2	0.3
	9	40.0	-	-	30.0	-	-	2.2	0.3
	10	37.0	25.0	-	-	3.0	-	2.2	0.3
	11	36.5	5.0	-	-	-	3.5	2.2	0.3
	12	34.5	25.0	-	-	-	6.0	2.2	0.3
III	13	25.0	36.5	3.5	-	-	-	2.5	-
	14	20.0	15.0	-	30.0	-	-	2.5	-
	15	25.0	37.0	-	-	3.0	-	2.5	-
IV	16	25.0	36.5	3.5	-	-	-	2.2	0.3
	17	20.0	15.0	-	30.0	-	-	2.2	0.3
	18	25.0	37.0	-	-	3.0	-	2.2	0.3

Note: the amount of fatty pork for all the experiments and for all the batches was 60 kg.

Table 2

Correlation coefficients among pH, salt- and water-soluble proteins, water-binding capacity, stickiness and plastic viscosity of raw emulsions and shear stress of sterilized emulsions

Indices	Water-soluble proteins	Salt-soluble proteins	Water-binding capacity	Stickiness	Plastic viscosity	pH	Sterilized emulsion shear stress
Water-soluble proteins		+0.918^{xx}	+0.637^{xx}	+0.412^{x}	-0.615^{x}	+0.423^{xx}	+0.612^{x}
Salt-soluble proteins	+0.918^{xx}	-	+0.827^{xx}	+0.714^{x}	-0.813^{xx}	+0.611^{x}	+0.817^{xx}
Water-binding capacity	+0.637^{x}	+0.827^{x}	-	+0.419^{x}	-0.493^{x}	+0.617^{x}	+0.718^{x}
Stickiness	+0.412^{x}	+0.714^{x}	+0.419^{x}	-	-0.395^{x}	+0.441^{x}	+0.412^{x}
Plastic viscosity	-0.615^{x}	-0.813^{x}	-0.493^{x}	-0.395^{x}		at n=18 p 0.05	at n=18 p 0.05
pH	+0.423^{x}	+0.611^{x}	+0.617^{x}	+0.411^{x}	at n=18 p 0.05	-	+0.511^{x}
Shear stress of sterilized emulsion	+0.612^{x}	+0.817^{x}	+0.718^{x}	+0.412^{x}	at n=18	+0.511^{x}	-

^{x} - P 0.05

^{xx} - P 0.01

T a b l e   3

The main chemical composition of canned emulsion meats with milk proteins, blood or plant proteins added

Batch №	Canned emulsion meats with the addition of:	Contents (as % of the sterilized emulsion) of:		
		protein	fat	water
1	C o n t r o l	13.4±0.2 x)	20.6±0.5	64.0±0.8
2	Sodium caseinate	15.3±0.1	20.5±0.3	62.6±1.0
3	Blood serum	15.2±0.3	18.2±0.4	64.5±1.5
4	Soya protein	15.0±0.3	20.3±0.3	62.4±0.7
5	Starch (3.5%)	14.9±0.2	24.6±0.3	57.5±0.6
6	Starch (6.0%)	12.9±0.2	21.1±0.2	63.8±0.5
13 xx)	Sodium caseinate	13.3±0.1	19.9±0.3	64.5±0.9
14	Blood serum	13.8±0.2	19.8±0.4	64.2±1.2
15	Soya protein	13.4±0.2	19.9±0.4	64.9±0.8

x)

0.05

xx)

Formulations of Batches 7-12 and 16-18 were not further studied as they are similar to those of Batches 1-6 and 13-15, except the curing composition (see Table 1).