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# HISTOLOGICAL STRUCTURE OF COOKED COMMINUTED SAUSAGES WITH ADDITION OF EMULSIFIERS

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The addition of emulsifiers to meat mixtures affects the microscopic structure of comminuted sausages. The effect is statistically significant in fat emulsification. Emulsifiers must be selected according to the state of meat (post mortem time and temperature), conditions of comminution and cooking temperature.

## INTRODUCTION

One of the characteristic technological features of cooked comminuted sausages production is very fine disintegration and even dispersion of all components as a result of comminution with water. Comminution thus brings about a new physical arrangement of raw material components which to a large extent disturbs the original physical structure of all the comminuted raw materials, most importantly of meat proteins, fat raw material and water [4, 8]. The quality of cooked comminuted sausages depends vitally on the stability of the technologically produced spatial arrangement of these components. Comminution liberates from the myofibrils structure mainly myofibrilar proteins, i.e. actin and myosin, which form a coat around fat particles. After heat coagulation this coat becomes an elastic web holding together the spatial dispersion of fat that emerged during comminution. This process is accompanied by changes in rheological properties of the processed raw material mass. As a result of heat treatment the plastic stuffing becomes elastic sausage. In the structure of this system fat is the component which destroys the spatial arrangement of comminuted sausage most often and with the greatest ease. The stability of the spatial arrangement of raw material components of comminuted sausage stuffing depends primarily on the protein fraction. The role of proteins in shaping properties of such stuffing depends also on fat and water content and on technology of comminution. The amount of protein which is to serve as emulsifier and, after denaturation, as mechanical stabilizer of fat emulsion, increases with the increase of fat content and of the degree of its disintegration in the comminuted raw material mass. Accordingly, protein serves its function when it is soluble and when its amount is such that suffices at least to form a sufficiently thick coat around fat concentrations. This function is performed mainly by sarcoplasmatic proteins, and to a lesser extent by proteins of meat substitutes. According to literature, the latter proteins display a greater capacity to emulsify fat than to preserve its dispersion [12], this being due to the fact that they coagulate at higher temperatures than meat proteins. Certain proteins of some meat substitutes, e.g. some fractions of milk casein, coagulate at elevated temperatures that are, as a rule, never attained in heating meat products.

There were also relatively few studies of the effect of emulsifiers (other than proteins) on emulsifying capacity of fat in meat products. The results indicate that the role of emulsifiers consists in shaping rheological properties and sensory attractiveness of the finished products [2, 5, 7, 11].

The emulsifiers used till now in meat processing are gliceride emulsifiers, lecithin, proteins (of muscular tissues as well as of meat substitutes) and sodium diphosphate, pH = 7.3 * [2].

The technological effectiveness of emulsifiers in shaping the quality of cooked comminuted sausages varies considerably [10]. Emulsifiers added to cooked sausages filling have no direct bearing on the improvement of the sensory attractiveness of the sausages. They bring about a better emulsification of fat and its better integration with the structure of the finished product. These are qualitative features which enhance the sensory attractiveness of comminuted sausages, and one may thus speak of an indirect effect of emulsifiers on the sensory, attractiveness of products of this kind.

The available literature makes almost no mention of the effect of various kinds of emulsifiers on the histological structure of cooked comminuted sausages. The present research was intended to fill this gap by investigating the degree of simultaneous effect of seven different emulsifiers on the histological structure of comminuted sausages.

* Sodium diphosphate is not an emulsifier from the point of view of the theory of surface-active compounds and emulsions. It displays properties characteristic of emulsifiers only in association with muscular tissue proteins.

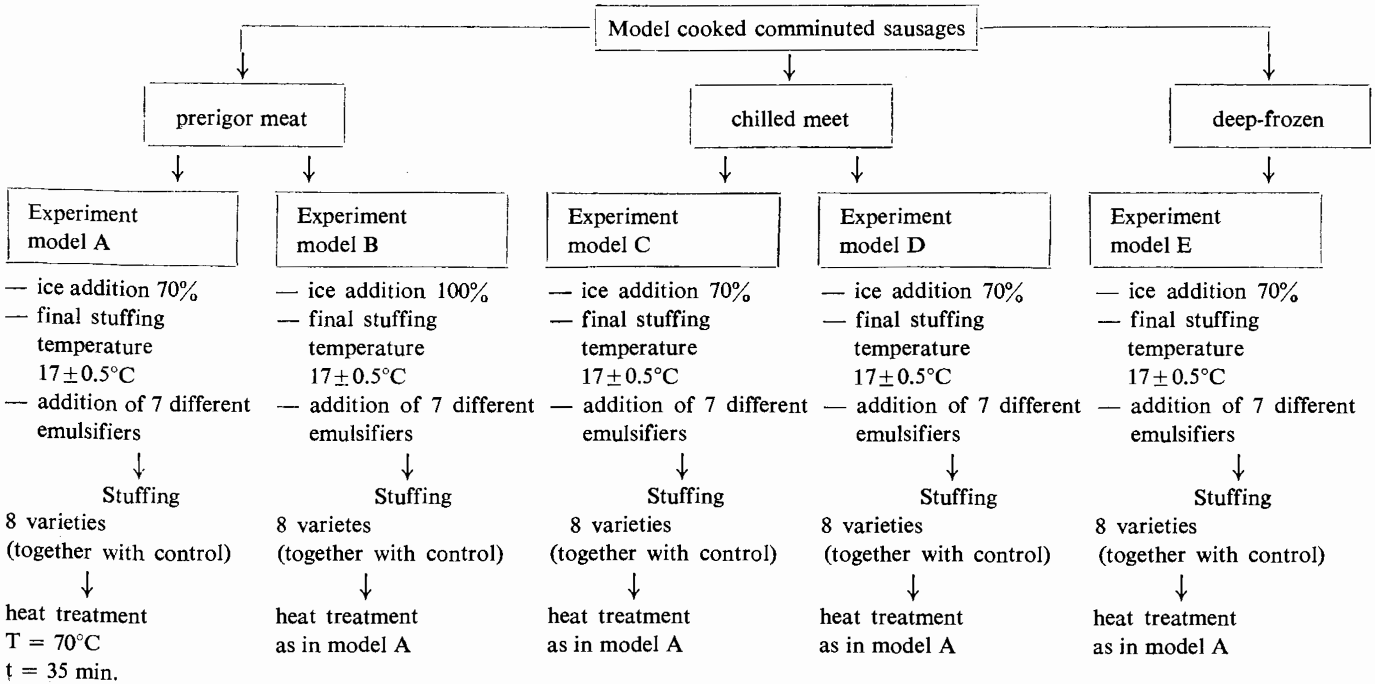



Fig. 1. Scheme of experiment organization

## EXPERIMENTAL

### MATERIAL

The technological evaluation of selected emulsifiers was based on analyses of model cooked comminuted sausages made of 65% first class tendonless beef round top and 35% pork back fat. Ice or water additions during sausage stuffing comminution amounted to 70 or 100% of lean meat mass. In all, five batches of experimental cooked comminuted sausages were produced Fig. 1 from meat stored for various periods and at various temperature conditions, namely

— pre rigor meat used in production about one hour after bleeding,

— chilled meat, subsequently refrigerated ($96 \leqslant t \leqslant 120$ h, $4 \leqslant T \leqslant 7°C$),

— deep-frozen meat which was chilled after slaughter ($t = 24$ h, $4 \leqslant T \leqslant 7°C$) and the frozen ($T = -30°C$) and stored in frozen state ($t = 8$ monts, $T = -20°C$).

The experimental sausages were produced from frozen meat; the defreezing phase was omitted.

The technological factor altering the properties of stuffings and of the subsequent sausages was the addition of seven different emulsifiers into the meat mass. Eight varieties of stuffing and sausages made therewith, differing as to the added emulsifier, were produced within each of the five experimental models. The obtained experimental sausages were numbered as follows:

No. 1 — reference (without emulsifier)
No. 2 — with 0.5% addition * of mono- and digliceride (Kirnol S)
No. 3 — with 0.5% monogliceride (Kirnol Super S)
No. 4 — with 0.5% of mono- and digliceride lactic acid ester (WK-102)
No. 5 — with 0.5% monogliceride citric acid ester (WK-135)
No. 6 — with 0.5% raw lecithin **
No. 7 — with 0.3% sodium diphosphate (pH = 7.3)
No. 8 — with 2.0% powdered blood plasma protein

The above eight kinds of model sausage stuffings were subjected to heat treatment in 200 g metal tins (measuring 99/93).*** The samples were heated at 70°C for 35 min. The experimental sausages were studied 24 h after production, and all results of observations were subjected to variance analysis [13].

### METHODS AND OBJECTIVIZATION OF RESULTS

The histological structure of the cooked comminuted sausages was determined using a contrast microscope, and photographed [1]. Preliminary

* Emulsifier addition expressed as per cent of muscular and fat tissue mass.

** The lecithin preparation contained 40% impurities.

*** Hermetic tins were employed to ensure that the heat effluent does not diffuse out of the studied system.

analysis showed that some of the fat occurs in the form of large concentrations which are not surrounded by protein, and the remaining fat forms small concentrations embedded in protein. The former fat was considered unemulsified, and the latter as emulsified.

Evaluations of experimental sausages quality was verified by planimetry of fat concentrations which did not undergo emulsification during the production process. The failure to emulsify is indicated by the absence of protein coat surrounding fat concentrations as well as by the variegated form and usually large dimensions thereof. For technical reasons there were considered only those particles of unemulsified fat which on the photographs had an area of no less than 1 $mm^2$. Using this method the so called coefficients of fat dispersion effectiveness were determined from the following dependence:

$$Q = P_1/P_2$$

where Q — coefficient of fat dispersion effectiveness, $P_1$ — area of unemulsified fat, and $P_2$ — total area. The value of this coefficient increases ($Q \rightarrow 1$) with the increase of the number (area) of unemulsified fat concentrations in the sausage structure. Such increases accompany the worsening quality of the finished product, whereas the lower the value of Q ($Q \rightarrow 0$) the better is the quality of sausages in view of the better emulsification of fat.

## RESULTS AND DISCUSSION

Emulsifiers added to sausage stuffing alter the microscopic structure of cooked comminuted sausages considerably and variously. There were particularly large differences in the degree of fat emulsification. These are apparent, for example, in the histological structure of sausages produced according to the experimental model C (Fig. 2).

Depending on the manufacturing technology, the area of unemulsified fat in the structure of experimental sausages gives Q values ranging from 0.018 to 0.755 (Tab. 1). The differences are conditioned by the combined action of the investigated variance factors, i.e. quality of meat raw material, the technology of its storage prior to processing, and the technology of comminution of sausage stuffing (final temperature, ice or water addition, emulsifier). The differences in effectiveness of all these factors is highly significant statistically (Tab. 2). The factor affecting the degree of fat emulsification in the sausage mass most significantly is the kind of emulsifier added to the stuffing during comminution.

Among all the eight technological variants of experimental sausages, the best emulsification of fat and its most uniform dispersion were in sausages emulsified with powdered blood plasma protein and sodium

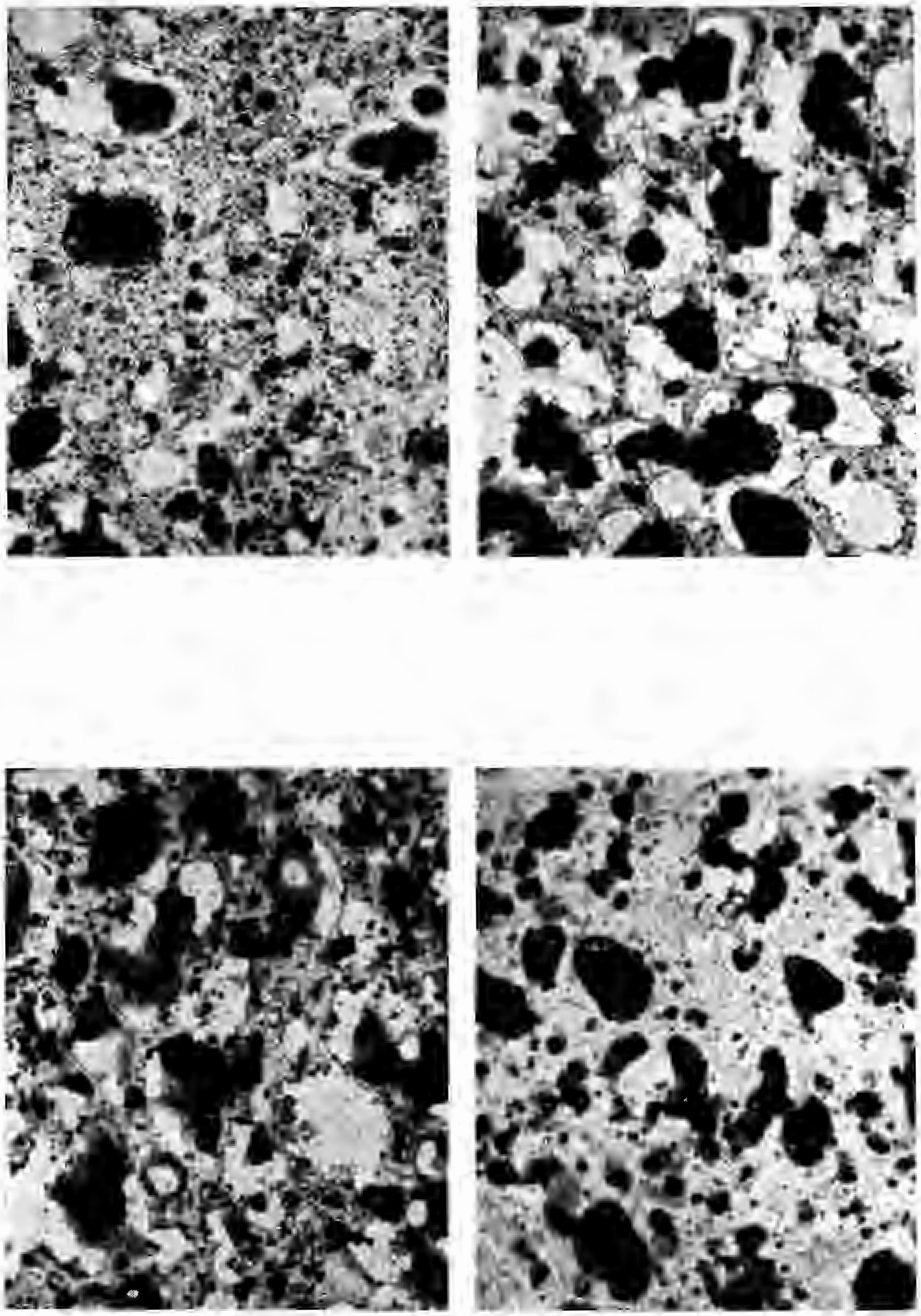
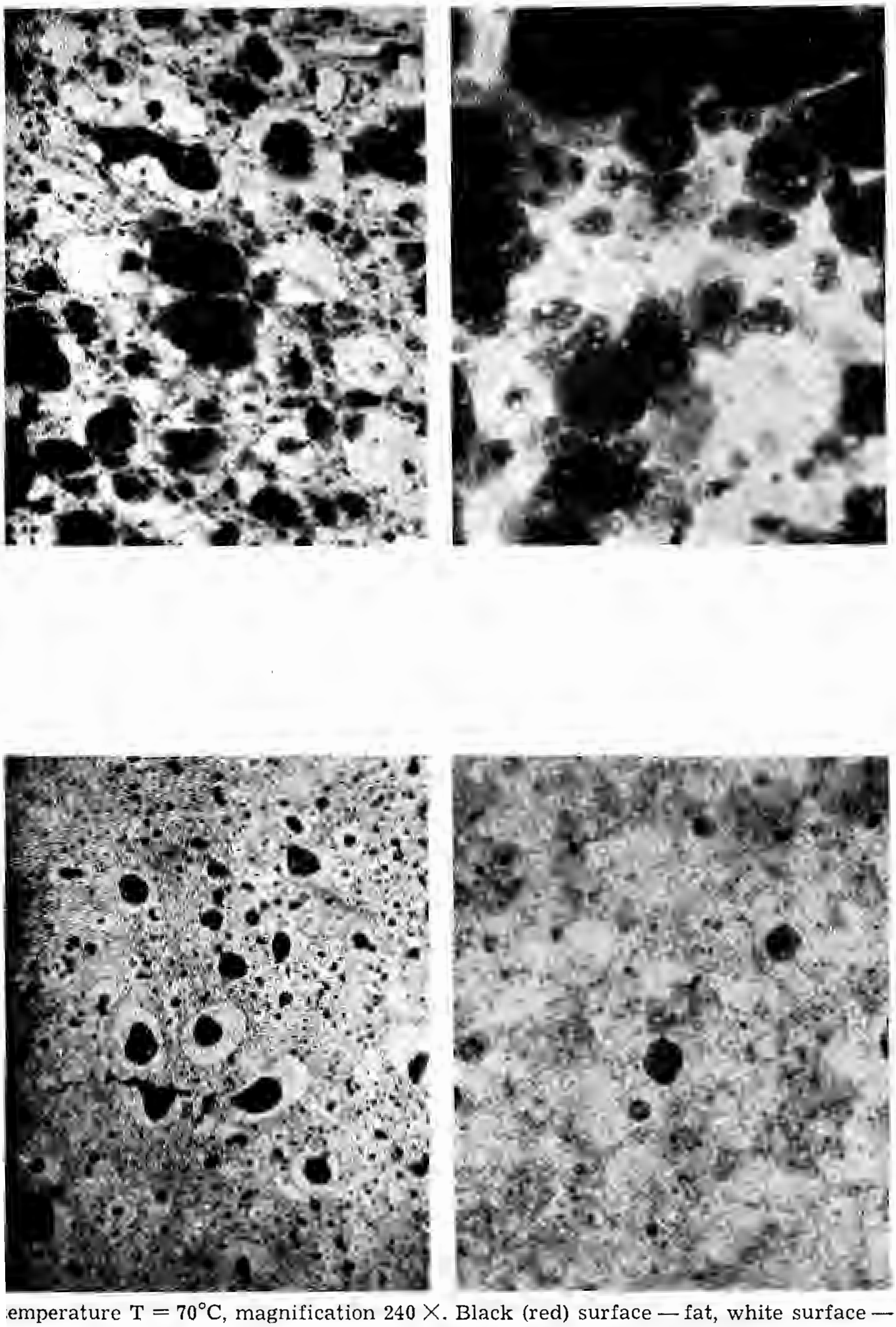


Fig. 2. Microscopic structure of experimental sausages. Experimental model C, cooking



emperature T = 70°C, magnification 240 ×. Black (red) surface — fat, white surface — air, grey fine-grained surface — protein (see page 322)

diphosphate with pH = 7.3 (Tab. 1, Fig. 2). The coefficients of fat dispersion effectiveness are in each case lower ($0.018 \leqslant Q \leqslant 0.197$), in a statistically significant manner, than in the other sausage varieties (kinds of emulsifiers), control samples included (Q values for the latter ranged from 0.246 to 0.433). The effect of the abovementioned emulsifiers was particularly advantageous in cooked comminuted sausages made of chilled meat (Tab. 1, experimental models C and D).

Table 1: Changes of fat dispersion effectiveness coefficient (Q) in experimental cooked sausages

| Sausage variety (kind of emulsifier) | Experimental model | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| 1 | 0,258 | 0,261 | 0.246 | 0.338 | 0.433 |
| 2 | 0.260 | 0.269 | 0.281 | 0.274 | 0.387 |
| 3 | 0.255 | 0.258 | 0.288 | 0.339 | 0.402 |
| 4 | 0.259 | 0.251 | 0.263 | 0.327 | 0.424 |
| 5 | 0.262 | 0.262 | 0.272 | 0.279 | 0.435 |
| 6 | 0.347 | 0.329 | 0.755 | 0.583 | 0.695 |
| 7 | 0.152 | 0.162 | 0.018 | 0.070 | 0.193 |
| 8 | 0.164 | 0.170 | 0.057 | 0.141 | 0.197 |

The histological structure of cooked comminuted sausages with lecithin differs from that of all the other ones, and compares unfavourably with them. The fat in these sausages is least emulsified and the Q coefficient is high (0.329—0.755). Compared with the control sausages produced without any emulsifier, the fat concentrations (globules) are several times larger. Lecithin is thus a technological agent which never improves the histological structure of the finished product. Quite the contrary in fact: it causes its considerable deterioration. This fact was already demonstrated in other quality tests of experimental cooked sausages [6, 10].

The usefulness of the remaining (gliceride) emulsifiers depends on the joint effect of conditions of meat raw material storage (temperature, time)

Table 2. Variance analysis of fat dispersion effectiveness in experimental cooked sausages

| Variance source | Degrees of freedom | F (calculated) | F (tabular) | | NIR 0.01 |
|---|---|---|---|---|---|
| | | | = 0.05 | = 0.01 | |
| Total variability | 39 | — | — | — | — |
| Experiment model | 4 | 4.288 | 2.71 | 4.07 | 0.013 |
| Kind of emulsifier | 7 | 13.288 | 2.36 | 3.36 | 0.016 |
| Error | 28 | 1.000 | — | — | — |

and on the technology of meat comminution. In model C experimental sausages, fat emulsification is statistically significantly worse and fat dispersion less uniform than in the control sausages ($Q > 0.246$; Tab. 1, Fig. 2). A positive effect on histological structure of gliceride emulsifiers added to the stuffing is observed in cooked comminuted sausages made of chilled meat (with the stuffing overheated during production) and of deep--frozen meat (Tab. 1, experiment models D and E). Additions of gliceride emulsifiers to the stuffing of cooked sausages made of pre rigor meat, well absorbing and binding water, are not justified. Sausages produced from this kind of raw material display proportionately good emulsification of fat, and fat dispersion in the sausage structure is uniform in a statistically significant manner and comparable to that in the control samples (Fig. 1, experiment models A and B).

The above observations justify the claim that measurements of the histological structure of cooked comminuted sausages may serve as a significant test of their quality. However, one must bear in mind that the microscopic structure of cooked sausages is chiefly modelled by changes of other physico-chemical parameters, mainly the mass of heat effluent of the water and fat fraction.

## CONCLUSIONS

1. Emulsifiers are only one of the factors responsible for the histological structure of cooked comminuted sausages, which is also affected by conditions of meat raw material storage (temperature, time) and by the technology of its comminution.

2. The kind of emulsifier must be selected in dependence on the strictly planned technology of cooked comminuted sausage production. The applied emulsifiers (except for lecithin) brought about a statistically significant ($\alpha = 0.01$) improvement of fat emulsification and led to a uniform fat dispersion in sausages made of deep-frozen meat, and also of chilled meat when the sausage stuffing was comminuted incorrectly (overheated).

3. The best statistically significant emulsification of fat is caused by emulsifying the stuffing of comminuted sausages with powdered blood plasma protein and sodium diphosphate with pH = 7.3. The most inferiour microscopic structure, i.e. the relatively highest coefficient of fat dispersion effectiveness (Q) was found in sausages manufactured with lecithin.

4. The proposed Q coefficient may be a useful element in programming the quality of cooked comminuted sausages. The reasons for uneven emulsification of fat in the sausage mass are yet to be explained.

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## STRUKTURA HISTOLOGICZNA KUTROWANYCH KIEŁBAS PARZONYCH PRODUKOWANYCH Z DODATKIEM EMULGATORÓW

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### Streszczenie

Wykonano pięć doświadczalnych produkcji kutrowanych kiełbas parzonych. Doświadczalne kiełbasy produkowano z mięsa, które było przechowywane w różnych warunkach temperaturowo-czasowych (niewychłodzone, wychłodzone oraz zamrożone). Do farszu tych kiełbas wprowadzono na początku procesu kutrowania siedem różnych emulgatorów (lecytynę, sproszkowane białko osocza krwi, dwufosforan sodu o pH = = 7,3 oraz cztery rodzaje emulgatorów glicerydowych). Modelowe farsze poddano obróbce cieplnej w opakowaniach blaszanych w następujących warunkach T = 70°C, 80°C, 100°C, 110°C ($F_c$ = 0,6 — 0,8); t = 35 min. Jakość doświadczalnych wędlin oceniono na podstawie zmian struktury histologicznej.

Emulgatory dodane do farszu w znaczny sposób różnicują strukturę mikroskopową kutrowanych kiełbas parzonych. Bardzo duże zróżnicowanie zaobserwowano w stopniu zemulgowania tłuszczu. Spośród zastosowanych emulgatorów najlepsze zemulgowanie tłuszczu i jego najbardziej wyrównaną dyspersję przestrzenną w masie wyrobu uzyskuje się stosując emulgator w postaci sproszkowanego białka osocza krwi oraz dwufosforanu sodu o pH = 7,3.

Struktura histologiczna doświadczalnych kiełbas, do których dodano lecytynę, różni się zawsze i to niekorzystnie od wszystkich pozostałych. Tłuszcz w tych kiełbasach jest najmniej zemulgowany. O przydatności technologicznej pozostałych emulgatorów, tj. glicerydów decyduje współdziałanie badanych czynników zmienności, a więc warunki temperaturowo-czasowe przechowywania mięsa, technologia kutrowania farszu oraz temperatura obróbki cieplnej. Efekt tego współdziałania jest zresztą różny. Emulgatory trzeba selektywnie dobierać w dostosowaniu do sytuacji technologicznej, głównie do jakości przetwarzanego mięsa.

Uzasadnienia technologicznego zastosowania emulgatorów w produkcji kutrowanych kiełbas należy doszukiwać się przede wszystkim w polepszeniu zdyspergowania tłuszczu i związania go ze strukturą gotowego wyrobu.