6:1

Effect of time of salt addition on water binding properties of hot-boned beef from non-stimulated and electrically stimulated carcasses

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Hot processing systems designed to maintain the functional advantages of pre-rigor meat during storage require special handling procedures like the addition of salt to the coarsly ground muscle. In such systems the time course of rigor mortis and thus the time available for boning, grinding and blending becomes of great practical importance.

In the present study pre-rigor meat was excised from the thoracic limb of non-stimulated (NES, n=5) and electrically stimulated (ES, n=3) cow carcasses, coarsly ground and mixed thoroughly within appr. 1.5 h of stunning. Portions of NES meat were blended with 2% salt (NaCl) (added as 20% ice cold solution) at 2, 4, 8, 12 and 28 h p.m., while ES samples were treated likewise at 2 and 28 h p.m.

Recording of shrinkage of cooked, smoked sausages during production at 48, 72 and 144 h p.m. revealed a nearly linear reduction in water holding properties of NES meat when time of blending with salt was extended from 2 to 8 h, after which no further increase in weight losses were observed. Production from ES meat revealed shrinkage levels similar to those obtained for NES samples blended at 2 and 28 h. Frying losses of patties produced from the same raw material categories confirmed this pattern of reduction in water holding capacity with delay of salting time for both NES and ES samples.

The time course of pH in the raw materials before and after the addition of salt indicate that the pre-rigor properties of NES and ES meat might be partly preserved by blending with salt up to appr. 6 and 3 h p.m., respectively.

Microbiological and sensory evaluations indicate that the preblended samples, as opposed to non-salted controls, retained acceptable hygienic quality up to 6 days after slaughter, despite the fact that no specific hygienic precautions were taken during cutting and processing.

6:2

Mechanisms involved in nitrite inhibition of warmed-over flavor development in cooked meat.

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Mechanisms involved in the nitrite inhibition of warmed-over flavor (WOF) development in cooked meat were studied using ground beef (M) and meat pigment extracts (MPE). Addition of nitrite (156 mg/kg), L-ascorbate (250 mg/kg), sodium tripolyphosphate (0.5%), ADP (213.6 mg/kg), and EDTA (2%) to either the M or MPE individually or in various treatment combinations was carried out, after which the samples were heated and stored at various time periods at 4°C. Lipid oxidation was assessed by TBA numbers, while changes in the non-heme iron content before and after cooking were followed. Results indicate that nitrite prevents WOF development by three mechanisms: (1) as a metal chelator - sequestrant; (2) by stabilizing the unsaturated lipids within the membranes; and (3) through forming a strong complex with the heme pigments thereby preventing the release of non-heme iron by cooking. Although all three mechanisms appear to be involved in preventing WOF in meat, data show that nitrite inhibition of oxidation is primarily due to its stabilization of the porphyrin ring, which effectively blocks the release of non-heme iron on cooking and prevents its catalytic effect on oxidation.

6:3

The effect of blade tenderization on the cure and sensory characteristics of dry cured hams

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Application of cure adjuncts such as salt and sodium nitrate to fresh pork hams is done by the dry rub method with subsequent storage through dry cure application, cure removal and cure equalization. This process is followed by aging for the characteristic country cured flavor development. Although dry-cured hams have a unique flavor, the process is time consuming and dehydration from the curing process can reduce product tenderness.

Hams from the right side of 18 pork carcasses were removed, trimmed and tenderized with a Ross Industries Blade Tenderizer. Those hams from the left side of the same carcasses were handled the same way except they served as control samples by not being tenderized. All hams were dry cured for 40, 56 or 70 days to determine if blade tenderizing enhanced product taste attributes and/or accelerated the dry cure process. Treated hams and control samples were subjectively evaluated for visual color, before and after cooking, cure penetration, tenderness, juiciness and flavor. Objective measurements included percentage moisture, percentage salt, nitrite content (ppm), total plate count (TPC), anaerobic count (AC), psychrotrophic count (PC) and Kramer Shear Force.

Blade penetration had no effect ($P>0.05$) on visual color, cure penetration rate, percentage weight loss before curing, percentage moisture at various cure intervals, percentage salt at 40 and 56 d, nitrite level, microbial load (TPC, AC and PC), objective and subjective tenderness measurements, juiciness scores or flavor scores. Cure time had no effect ($P>0.05$) on percentage moisture, percentage salt, nitrite level, Kramer Shear force, and juiciness scores. Results from this research revealed that effects of blade penetration on all traits related to dry curing are minimal and that this operation will not accelerate the dry curing process or enhance product acceptability. Additional observations suggested that cure time should not be less than 70d if color stability during cooking is desired.

6:4

The coefficient "effectiveness grade" as a quality parameter for a complex process of food technology (explained for the example of cooking meat)

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If the material to be processed is one of a complex nature, for example meat, several characteristics change at the same time. There are desirable modifications (e.g. plastication of collagenous binding tissue) as well as undesirable modifications (e.g. destruction of vitamins). Furthermore, process-specific parameters, for instance, energy consumption which increases steadily with time, have to be taken into consideration. At this point, the question of comparability of results arises. For this purpose the term "effectiveness grade" (symbol: EG) is introduced. The practical utility of this term can only result from formulation of a reliable mathematical expression.

For a complex situation the following equation is proposed:

$$EG = -1 + \prod_{i=1}^{n} \text{flag } i + \frac{1}{n} \sum_{i=1}^{n} (\text{lev } m_i)^{w_i} \longrightarrow +1$$

The range of values is $-1 \leqslant EG \leqslant +1$. The values m_i are time dependent anyway, but there are further influencing factors.

The analysis includes the following parameters:
- core temperature of meat pieces (m_1)
- pasteurization effect within the core (m_2)
- texture effect (m_3)
- mass defect (m_4)
- total energy efficiency (m_5)

In the interests of microbiological safety, heating of meat to a core temperature of 75°C is usually required. From the microbial point of view, it is not useful to exceed this value. The aim might be to reduce the calculated number of vegetative microorganisms within the core by six powers of ten. This corresponds to a pasteurization effect of $L = 6$. $D_{65.5}$ ($D_{65.5}$ is the "decimal reduction time" at a temperature of 65.5°C).

According to experimental investigations studying the rheological aspects, a cooking time of 36 minutes may be considered as the optimum under the given conditions if the rest-over effect during the cooling-off phase is neglected.

The definition of mass defect may be considered principally as a damage function. EG reaches its maximum value after 36 min; then it decreases again due to the increasing influence of damaging factors.

6:5

Note on near infrared reflectance for in-line measurement of fat and moisture in commercial minced beef

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Recent work at the AFRC National Institute of Agricultural Engineering led to the development of the Silsoe Moisture Meter which aims to provide a robust, non-contact method for measuring the moisture content of cut or chopped material passing on a conveyor close to a sensing head. The device is designed to measure surface reflectance at four pre-specified wavelengths (670, 940, 1300 and 1450 nm). The purpose of this work was to assess the potential of the instrument for in-line monitoring of fat and moisture contents of commercial minced beef.

In order to model a conveyor system, samples were placed on a turntable rotating at 1 rpm and the front face of the sensing head was placed at a distance of 2 cm from the surface of the sample. Readings were averaged over 1 minute in a circle approximately 3.5 cm diameter and compared with data from a standard 'white' surface. Apparent reflectances and reflectance ratios at two wavelengths were examined for correlation with % moisture and % extractable fat obtained by freeze drying followed by vacuum drying, and Foss-let analysis respectively.

At all wavelengths, there were positive correlations between apparent reflectances and fat percentages, and negative correlations between apparent reflectances and moisture contents. Of the four wavelengths studied the apparent reflectance at 1450 nm was the best predictor of % extractable fat ($r = 0.88$, RSD = 2.98%) and % moisture ($r = 0.84$, RSD = 2.67%). The precision of the prediction of % moisture was significantly improved by a multiple regression of the reflectance at 1450 nm with that at 1300 nm (RSD = 2.55%) but reflectance measurements at other wavelengths did not significantly improve the precision of prediction of % extractable fat based on measurement at 1450 nm alone.

The results indicate that measurement of near infrared reflectance at one or more pre-determined wavelengths has potential for in-line composition analysis in industrial meat processing. However the standard Silsoe Moisture Meter tested in this experiment was not designed for use with meat and before its full potential could be realised in the meat industry it would be necessary to modify instrumental factors in order to increase the sensitivity and repeatability on low reflectance materials.

6:6

The measurement of fat content in mince by Video Image Analysis

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The use of Video Image Analysis (VIA) in the meat industry is expanding particularly in the area of process and quality control of meat products. However, its use measuring fat in particulate meats such as mince has been severely restricted by limitations in particle resolution and sample presentation.

This work describes how the problems of fat smear and discoloration due to drip taint, causing an over- and under-estimation of fat respectively have been eliminated by controlling the conditions of mince production. Tempering of the meat to between 0C and -5C was most effective. Above 5C problems of drip and smear steadily increased; below -5C the meat became too brittle and shattered when minced.

Particle resolution has been greatly improved by incorporating an improved optical system and illuminating with limited wavelength ultra violet light. This causes the fat and connective tissue to fluoresce making their separation from lean straightforward. In practice, fluorescing connective tissue was easily distinguished from the fat by the image analyser.

There was no noticeable change in level of fat detection during the first 15 minutes after mincing. Thereafter levels fell slowly reaching 50% of starting values after 2 hours. Earlier work has shown that with commercial quantities of meat, there is considerable sample variability. A 50% reduction in the sample size, caused by magnifying the field of view (in order to resolve 4 mm and 6 mm mince), did not adversely affect the results as application of the lipid prediction equation, (derived from earlier work), to the video data produced results in very good agreement to those obtained by chemical methods. This method may also be useful in measuring connective tissue content, and this is currently under investigation.

Application of video image analysis technology can now be effectively extended to areas of meat product manufacture using mince as an ingredient.

6:7

Lactobacillus plantarum and nitrite levels in pork as influenced by tumbling and temperature treatments

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The effect of intermittent tumbling (15 min on and 45 min off each hr for 18 hr) was compared to a non-tumbling treatment at processing temperatures of 3°C and 23°C on cured pork tissue inoculated with L. plantarum. Samples for investigating microbiological numbers of L. plantarum were taken at processing times of 0, 12, 15, 18 hr and after cooking to an internal temperature of 68°C, from surface (0 to 0.5 cm) and subsurface meat (0.5 to 1.0 cm) and from nontumbled exudate at each sampling period. The portions of the surface and subsurface samples remaining after the microbiological analysis was obtained were mixed in equal quantities for analysis of nitrite.

The analysis of variance indicated that tumbling was significant ($P<0.05$) and that linear time and location were highly significant ($P<0.01$) for microbial plate count for L. plantarum. The major differences for microbial numbers were attributed to location with numbers significantly decreasing from exudate to surface to internal samples at both 3°C and 23°C. Tumbling resulted in higher numbers of L. plantarum particularly in the internal tissue of product tumbled 18 hr at 23°C. Cooking to 68°C reduced L. plantarum to a nondetectable level.

The analysis of variance of residual nitrite during tumbling and nontumbling processing at 3°C and 23°C indicated that tumbling time and tumbling temperature interactions were highly significant ($P<0.01$). After 12 hr of treatment the tumbling at 23°C resulted in lower nitrite levels than the other 3 treatments. The nontumbled tissue processed at 23°C had significantly higher residual nitrite than the other 3 treatments after 15 and 18 hrs of processing and after processing and cooking. The cooking procedure resulted in a highly significant ($P<0.01$) reduction in residual nitrite.

6:8

Intensification of production of raw-dried pork meat products using starter cultures
I. Changes in the structural-mechanical properties of the meat products

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The possibility to intensify the production of raw-dried leg of pork was studied using mixed bacterial culture from strains 136 and 167.

Hind quarters from chilled pork injected with brine, containing 10^8 - 10^9 microbial cells/g of raw material were used.

The changes in the structural-mechanical properties were studied by varying the parameters: structural strength, plastic strength and tenderness. It was established that the applicable starter culture accelerates the moisture loss and contributes to the faster improvement of the structural-mechanical properties of the meat products.

6:9

Synthesis of dinitrosyl ferrohemochrome and its characteristics

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Attempts have been made to develop alternative meat-curing systems. As a first step, it is necessary to reproduce the colour of nitrite-cured meats. We have prepared the cooked cured-meat pigment, dinitrosyl ferrohemochrome (DNFH), in good yield and purity (>97%) from the reaction of hemin, an iron III porphyrin prepared from beef red blood cells and nitric oxide in buffered solutions, under conditions which will be described.

$$\text{Red Blood Cells} \longrightarrow \text{Hemin} \xrightarrow[\text{Reductant}]{[NO],\text{Base}} \text{Dinitrosyl Ferrohemochrome (DNFH)}$$

The pigment thus produced is stable in the absence of light and oxygen, or in the presence of light and absence of oxygen. However, oxygen with or without light, brings about rapid deterioration of DNFH. Application of dinitrosyl ferrohemochrome to comminuted meat imparts a clean pink colour indistinguishable from that of nitrite-cured meat.

Hemin was solubilized in water using a sodium carbonate solution. Reduction of the hemin iron to its ferrous state was carried out employing ascorbic acid, isoascorbic acid, their sodium salts, or sodium dithionite. Two molecules of nitric oxide add on to this reduced hemin to produce DNFH.

6:10

Effect of adding different proteins and their application procedure on some quality properties of canned whole meat cuts

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Development of application and functional properties of non-meat proteins enabled such proteins to be used even in first-quality products, such as whole meat cuts (ham, roast beef, steaks). In the present paper the effects of two different techniques of applying brine which, in addition to the usual ingredients, contained one of five examined non-meat proteins (soy isolates PP 500E, SP_6, U_4-111, then functional soy concentrate Sta-Pro 3000, as well as dried blood plasma and defatted soy flour mixture).

The first series of experiments comprised the normal injection-massaging technique in which brine composed of the usual ingredients was injected into lean boneless hams by a pickle injector followed by addition of a prepared dispersion of each of the above proteins to the massager. The whole meat cuts alternatively move horizontally and stay in the massager for 20 hours. In the second series of experiments vacuum-injection of brine containing all the ingredients was performed on an automatic Langen-line B-120/4-N in which the whole meat cuts are vertically tumbled under vacuum and alternatively stopped for 20 hours. In each of five experimental batches (of both series), 90 kg of brine with all the ingredients used was added to 200 kg of meat. Brine without added proteins was used for two control batches. The whole meat cuts were stuffed into flat 14 lbs cans and heated by a usual pasteurization procedure. After 15 days, the final experimental and control products were sampled for sensory evaluation as well as for examination of chemical composition.

It was found that the final products manufactured on automatic Langen-line were of high and even very high sensory properties, much more so than the products manufactured by the usual injection-massaging procedure. Among the five non-meat proteins, the most favourable effects on the sensory properties of the final products was exerted by the mixture of blood plasma and soy flour, followed by the soy isolates PP 500E and U_4-111 (with high NSI). The average increase in the protein content in the final products was 1.68% when the 2% soy isolates were added, whereas by adding 2% of the soy concentrate and mixture, it was 1.26%. Such results indicate that the effect of the applied technique on the quality of the final products was more dominant than the effect of simply adding the individual non-meat proteins.

6:11

Microbiology and technology of Chinese meat products

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Chinese meat products, although known from time immemorial, apparently became a subject of meat science only recently. LIN et al. (1980, 1981) as well as Ockerman and Kuo (1982) investigated the manufacturing of these meats. Our laboratory studied the microbiological stability of Chinese dried meats (Shin et al., 1982, 1983; Leistner, 1983; Shin, 1984) and Chinese sausage (Lin and Leistner, 1984).

Chinese dried meats: In China, these meat products are highly esteemed for their taste and nutritional value. They are prepared preferably from hot-boned meat, do not need much energy, and require only simple equipment for processing. Depending upon the particular meat species (pork, beef, poultry), and the type of spices added, about 30 different types of such meats are distinguishable, for which basically three different technologies are employed. In general, these products contain 15 - 35% sucrose, 3 - 5% NaCl, 10 - 20% moisture, and not more than 10^2 - 10^3 microorganisms per gram. We demonstrated that food-poisoning organisms either do not survive the processing of such meats or are unable to multiply in the finished products. If staphylococci or salmonellae recontaminate these products after processing, they vanish during storage. Products with an $a_w \leq 0.69$ are stable for at least one month without refrigeration and packaging; they are not even spoiled by xerotolerant moulds. Therefore, Chinese dried meats if properly processed are indeed safe foods.

Chinese sausage: To this product about 10% sucrose and 2% NaCl are added and it is stuffed into thin pork casings (25 mm in diameter). The sausage is dried for about 5 - 6 hours at 40 - 50°C and 80% RH (decreasing to 60% RH), and afterward is stored for one week at about 15°C and 80% RH, or at room temperature. Lactic acid bacteria become the predominant flora in the product. Since the sausage already has an $a_w < 0.94$ after the drying process, salmonellae do not multiply, but as toxigenic staphylococci could be troublesome, even Chinese sausage is heated before consumption.

Once the microbiological stability of traditional Chinese meat products is better understood and optimized, these meats should be recommended for general use in developing countries; they could also be of interest for food designers in industrialized countries as well. However, for people who are not used to sweet meat products, the sweetish taste of Chinese meats might be unpleasant. Taking this into account, it would be desirable to replace sugar by humectants with a neutral taste in meat products for consumption outside Asia.

6:12

The effect of starter cultures on stoichiometry and kinetics of dry sausage metabolism.

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Starter cultures may affect dry sausage characteristics and change metabolism. We have studied the effect of a starter sausage mix (S1) and a lyophilyzed starter culture on lactose (Hansen's CS123) (S2) on sausage quality and metabolism, as compared to a control (C) without added cultures. The basic sausage batter contained (% w/w) frozen S. American beef (37.9), frozen pork (31.6), frozen lard (25.3), salt (2.8) containing $NaNO_2$ (0.4) and KNO_3 (0.2), sodium caseinate (1.4), lactose (0.37), white pepper (0.28), glucose (0.33) and sodium-ascorbate (0.02). Materials were mixed in the cutter in the sequence beef, starter, pepper and additives, pork, lard and salt. Sausages were filled into Naturin casings (7 cm, 800-1000 g), fermented and dried under industrial conditions. A control series was compared to a series with added S1 (0.06%) or S2 (0.05%). At several intervals during fermentation and drying, texture (hardness and cohesiveness), pH, total carbohydrate, lactate, ammonia, free amino N, acetate and carbonyl compounds were determined. The final products were evaluated by a non-trained taste panel, in preference tests for colour, firmness, acid taste and general acceptability. Drying, texture development and metabolism were incorporated into a simple kinetic exponential model:
$y = a + b\,(1 - e^{-ct})$, allowing characterisation of kinetics in terms of lag time (a) and rate of change (c). Relative contribution of protein and carbohydrate as substrates, and of fermentation and oxidation as pathways in metabolism, was evaluated using a stoichiometric model.

Results:
Initial logarithmic counts for Lactobacilli and Micrococci (log/g) were : ∠ 3.3 & 3.6 (C); ∠ 3.3 & 4.2 (S1) and 5.4 & 6.4 (S2).
Sensory analysis of final products showed preference of S1 over C for firmness, and of S2 over S1 and C for firmness, acid taste and general acceptability.
Rates of drying, pH fall and texture development were increased by S1 and, to a less extent, by S2. Lag times were shortened by both S1 and S2.
S1 accelerates carbohydrate disappearance, lactate formation, proteolysis and ammonia formation compared to C. S2 has similar but less outspoken effects.
S1 does not change amount of substrate metabolized, nor pattern of metabolism. S2 increases amount of substrate metabolized by about 5%, shifts metabolism towards less proteolysis and heterofermentation and decreases the contribution of oxidation in overall metabolism.
Carbonyl compound concentration was lower in S1 than in C or S2.

6:13

Technological features of cooked sausage production as affected by the method of hydration of soy isolate

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Results are presented of a study into the effects on the physico-chemical and processing characteristics of varying the methods of hydration and addition of soy isolate to comminuted meat used for cooked sausage production. Four procedures for sausage emulsion preparation were used:-

1. preliminary preparation of soy protein isolate gel and blending with the meat ingredients during emulsion preparation;
2. soy isolate hydration with water in the bowl chopper at the initial stage of emulsion preparation;
3. soy isolate hydration with blood plasma in the bowl chopper at the initial stage of emulsion preparation;
4. same as in 3, followed with destabilization with the aqueous solution of calcium chloride.

It was found that methods of soy isolate hydration influence considerably emulsion pH's, structuro-mechanical characteristics, cooking losses, yield and the organoleptic qualities of the finished sausages, as well as isolate comsumption per unit finished product. Conditions are chosen which contribute to the maximum positive effect.

6:14

Investigation of the influence of a bacterial proteolytic enzyme preparation "Mesenterin 11-11" on the hydrophilic properties of cattle meat.

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An investigation was carried out of the changes in the hydrophilic properties of veal treated with "Mesenterin 11-11" - a proteolytic enzyme preparation obtained from Bacillus Mesentericus. M. Longissimus dorsi from veal carcasses in hot (2 h after slaughter) and in chilled condition (48 h after slaughter) was used. It was established that the proteolytic enzyme preparation "Mesenterin 11-11" increases the water-absorption capacity of M. Longissimus dorsi and improves its juiciness. The most effective concentration of the "Mesenterin 11-11" preparation was 0.2 - 0.3% enzyme solution, corresponding to 156 to 330 PU/kg of meat.

6:15

Hotsmoking - health - and environment protection

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In the Federal Republic of Germany the concentration of benzo-a-pyrene (B-a-P) in smoked meat products is limited to 1 ppb. For reasons of environment protection the emission of smoke from smokehouse is also limited. If the limits are exceeded the smoke must be cleaned after smoking in the meat processing industry. Nowadays smokehouses with smoldering smoke in closed and open systems are used together with friction smoke- and steam smoke-generators in open systems. In a closed system smoke is not generated with air from the environment of the smoking-chamber but with air/smoke from within the smoking-chamber. By means of that smoke is circulated between the smoke-generator and smoking-chamber. We studied how these smoke generation-methods meet the emission limits. For this purpose we investigated for each generator, at which temperature smoke is effectively generated. Then frankfurters were smoked in the different systems with defined temperatures of smoke under varied curing, drying and smoking conditions. The sausages were analyzed for the B-a-P and phenol content and evaluated sensorically. We measured concentration and throughput of organically bound total carbon immediately after smoke generation, at the outlet of the smoking-chamber and after thermal afterburning. The same studies were carried out in a smoke-generator for smoldering smoke in a closed system.
In all smoke-generators investigated, the German regulations, with less than 1 ppb B-a-P in the frankfurters, could be met. This is achieved by an average smoke generation temperatures of below 750°C and the length of the pipes from generator to smokehouse which must be at least 5 m. We could show that in pipes of this length the high boiling B-a-P condenses. On adapting proper smoking conditions to the different smoke-generators the typical smoking flavour could be achieved with all smoking-methods. The flavour varied only slightly between different smoking systems.
The smoldering-smoke and friction-smoke generators in the open system in an one-cart-smokehouse is adjustable to a throughput of less than 0,05 kg/h of organically bound total carbon. That is below the upper limits of the German regulations. In the steam smoke-generator in the open system these limits are always exceeded, demanding a cleaning before emission. Steam smoke can be condensed in smoke washers. The effectivity of cleaning in thermic afterburners depends on the total carbon concentration and the temperature of the burner. With the smoldering smoke and friction smoke-generators in open systems temperatures above 600°C are needed in the afterburner. In the steam smoke-generator - open system - even higher temperatures are necessary to stay below 50 mg total carbon /m³ which is the limit for afterburned smoke emission.
The smoking systems with smoldering smoke-generators in closed systems are superior to all open smoking systems with regard to low smoke emission.

6:16

Effect of technological treatment on the contents of vitamins B_1 and B_2 in meat products

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The nutritive value of meat and meat products is determined by the contents of fats, carbohydrates, proteins, vitamins and mineral substances.

Vitamins are organic substances which cannot be synthesized by the organism and should be introduced with food.

The different technological treatments of meat affect differently the contents of vitamins in the finished product. A modern technology to preserve the contents of vitamins B_1 and B_2, is freeze-drying.

The present work follows the contents of vitamins B_1 and B_2 in raw veal, poultry and veal liver, and their alterations upon cooking and upon freeze-drying.

Vitamin B_1 was determined by the thiochrome method.
Vitamin B_2 was determined by the lumiflavin method.

Vitamin B_1 loss upon cooking and freeze-drying in relation to the raw material amounts to 18.5 to 22.5 mg% for veal; 22.85 to 30 mg% for chicken, and 18.65 to 24 mg% for veal liver.

After cooking and freeze-drying, vitamin B_2 loss varies as follows: for veal 14-16 mg%; for chicken 24-26 mg% and for veal liver 16-18 mg%.

The studies indicate that the resulting losses in vitamins B_1 and B_2 are due to cooking, while upon freeze-drying, they are minimal. The products obtained can be used in dietetic nitrition.

6:17

A study into physico-chemical and structuro-mechanical changes during beef curing using electrical treatment

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The dynamics of the changes in pH-value, water-binding capacity and structuro-mechanical properties during the curing of hot beef by brine pumping were investigated. Samples were brine-pumped prior to or post-electro-massaging; controls were not subjected to electrical treatment. The muscle used in the study was longissimus dorsi. For the electrical treatment of the test samples, 50 cps, 220 V and 380 V current was used and applied intermittently for 600 s by means of an automatic interrupter which provided pulses of 0.4s duration with intervals of 0.6s between (220 V for 120s followed by 380 V for 180s).

It has been determined that when brine pumping was followed with electromassaging, pH was stabilized 2.5 times quicker and the meat had a higher water-binding capacity compared to the samples not treated electrically.

Comparative tests of the structuro-mechanical properties of the meat treated by the above conditions demonstrated the tenderizing effect of the electrical treatment on the muscles of the hot sides, this effect being greater in the case of massaging pre-pumped muscles with pulsed current.

6:18

Vacuumizing during curing in the production of cooked sausages from ground frozen meat blocks

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The applicability of vacuum-thawing of frozen ground meat for use in the manufacture of cooked sausages was studied at the stage of introduction of the curing ingredients. Ground block meat was thawed and mixed with the curing salts at the residual pressure of 1.94-2.20 kPa and at the environmental temperature of 17-19°C. Thawing time was 15-20 min depending upon the extent of grinding.

Ground meat vacuum-thawing combined with sodium chloride addition ensures a fast temperature increase of the frozen meat up to the desired levels; this accelerates salt/muscle protein interaction and prevents release of meat juice, thus enabling the preparation of a sausage meat mixture with a high water-binding capacity and giving a higher yield of cooked sausages with a better consistency in the finished product.

The addition of the curing ingredients under the reduced oxygen level during the vacuum-thawing conditions enhances the action of the nitrite-ion in the process of colour formation, affecting favourably the colour of the sausage and rendering it possible to decrease the residual nitrite in the finished product.

6:19

Changes in the chemical and physico-chemical features of horsemeat cured under vacuum-mechanical treatment

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Statistically analysed experimental data are presented, characterizing the levels of the basic components (protein, fat, water, sodium chloride, ash) in cured semi-prepared and finished products, which were cured according to the conventional technology (without mechanical treatment) or under vacuum-mechanical treatment at various pressure levels. Vacuumizing contributes to a higher moisture content in cured semi-prepared products, on average 1.5-2% compared to samples cured with mechanical treatment under normal atmospheric pressure. Finished products cured under mechanical treatment at various baric regimes are more moist (on average by 4.5-8.0%) than those cured without mechanical treatment. The application of the mechanical effect permits an improvement in protein and fat quality in the finished products by 0.67 and 0.34%, and in cured semi-prepared products by 0.82 and 0.33%. Vacuum-mechanical treatment at the residual pressure in the drum of $0.5 \cdot 10^5$ Pa increases protein and fat in the total solids of the finished product by 1.66 and 1.29% respectively and of the semi-prepared product by 1.38 and 0.55% respectively. The pattern of changes in pH depending on the residual pressure of the vacuum-mechanical treatment is demonstrated, pH being well correlated with the relation of WHC to the same parameters. The highest pH rise in the samples tested occurs at the stage of their vacuum-mechanical treatment, WHC being simultaneously improved by 20-22%. The analysis of the results suggests that the application of vacuum-mechanical treatment during curing of horsemeat influences the quality of cured semi-prepared and finished products favourably.

6:20

Specific features of microstructural changes in the muscular tissue during curing under electric current effect

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Comparative data on microstructural changes in hot l. dorsi muscle of young beef animals (140-150 kg liveweight), treated with electric current (220 V, 50 Hz, electric field intensity 220 V/m, for 420-720 s, intervals between pulses 0.5 s) before and after brine injection (brine density 1.18; nitrite content 0.1%, sugar content 2.5%, injection level 12% of the initial meat weight) are presented. It was found that in case of electric treatment after injection curing ingredients are distributed more evenly and penetrate into muscle fibres quicker, this being reflected in considerable swelling of the T-system; supercontracted areas and muscle fibres breakages are observed to a lower extent; muscle fibres are less deformed; fine-grained protein mass enters the interfibre space only slightly. The microstructure of the meat treated with electric current 24-48 hr after brine injection is similar to that of chilled meat held in cure for 10 days, as far as the extent of fibre swelling is concerned.

6:21

Improvement of calf and lamb rennets processing by means of an electroplasmolytic method

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The data presented reflect the results of experimental and analytical studies on electroplasmolytic processing of calf and lamb rennets.

The authors suggest a mathematical model of the behaviour of animal cells in the electrical field at various intensities. The effect of the electro-physical and structuro-mechanical characteristics of the raw material on the electroplasmolysis process is indicated. The selection of a power source and electroplasmolyzer instruments are discussed. A circuit diagram of the power source (a pulse generator) is given.

The processing of rennets in a special device between two flat electrodes by means of an electric pulse field having the intensity of $(2.8\text{-}3.2)\cdot10^5$ V/m, at the pulse frequency of 0.8 Hz and pulse duration of $(0.1\text{-}0.5)\cdot10^{-3}$s provides cell membrane destruction and guarantees a 10% increase in the yield of the finished product.

6:22

The quality of ham products prepared from bacon pork as effected with processing technology

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Smoked-and-cooked and smoked-and-baked cured meats, prepared from boneless bacon pork (with rind on) served as the object of the study. The raw meat is injected with a multicomponent flavoured brine (to 20-25% of its weight) containing salt, sugar, sodium nitrite, mustard, phosphates, sodium caseinate, flavouring VNIIZH-43M, and acetic and lactic acids in optimum portions.

The role of the brine components in imparting the required organoleptic characteristics to the finished products is demonstrated. After injection, the meat is subjected to mild massaging for 15 min. with 5-10% of the above brine added, followed by keeping in cure for up to 2 days at 2-4°C. The samples are then thermally processed according to the traditional regimes.

As the result of the study, it was found that the protein-fat ratio in the finished products prepared from bacon pork according to the developed technology is within 1:1, the amino acid profile (especially as far as the essential acids are concerned) being close to the physiological requirements of man; these products have high organoleptic parameters (consistency, colour, taste, aroma). The samples stored at 5-6°C for 15 days retained their quality, the peroxide number was 0.0015% I, and the acid number was the same as for fresh fat. When kept up to 21 days no coliforms, Proteus or anaerobes were found.

This study resulted in the development of the technology of smoked-and-cooked and smoked-and-baked products manufactured from bacon pork according to the following scheme: injection of a multicomponent flavoured brine, massaging, keeping in cure, thermal processing contributing to the mechanization of the process and providing high quality finished products.

6:23

Mathematical modelling in meat processing

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Processing meat into products frequently involves comminution and blending operations which may be followed by a heating stage to cook or stabilise the product. The variables which give individual products their distinctive character are numerous. Species, age of the animal, cut and composition of the meat, are to some extent controllable, as are addition of water, salt, polyphosphates, nitrite and spices, all of which have important roles in product quality. Factors less readily controllable are events associated with slaughter, chilling, conditioning and frozen storage, and those attributable to live animal stress causing gross differences in meat structure. Accurate prediction of the consequences of the events associated with carcass treatment and product composition could result in improvements in processing procedures and thus increase economic efficiency.

To study some of these interactions, the physical properties, colour, shear and cooking loss, of a meat product were used to create mathematical models based on Sheffé's mixture concept. A finely comminuted sausage whose composition was varied within the constraints of lean meat (60 to 90%), fat (0 to 30%) and water (10 to 40%) was used to derive the models. To study the effects of differences in meat structure on product quality, muscle was selected from normal and stress prone pigs and chilled at controlled rates. The derived models for colour were in agreement with the rationale of the Kubelka-Munk analysis of absorption and light scatter. The variance accounted for in the special cubic model for meat diluted by fat and water on the shear values of the cooked product was generally >90%. The coefficients for the terms in the models successfully described the effects of differences in the structure of the raw meat and the properties of cooked product. In addition, tripolyphosphate and salt (0 to 0.2% and 0 to 4.0% respectively) were varied in a central rotatable design to derive equations relating their interactive effects on the cooked meat:fat:water comminute.

6:24

Modelling and optimization of the amino acid profile of multicomponent meat systems

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Some aspects of modelling and optimizing the amino acid profile of multicomponent meat products are considered. For this, universally accepted methods of linear algebra are used. The basic equations to quantitatively evaluate the effect of altered ratios of protein components upon the amino acid composition of meat products are presented. The simplest principles of the optimization of the amino acid profile are formulated. Some difficulties arising in their implementation are discussed. The data are illustrated with several typical examples based on concrete practical experience. On the whole, the results of the work carried out allow:-

- modelling of the amino acid profile of the proteins of multicomponent combination meat products with respect to the kind and level of protein-containing raw materials in a composition;

- calculation of the amount of every ingredient in the formulation on the basis of the kind of the protein-containing raw materials and on the values of the conditional coefficients of the amino acid score of a combination meat product.

6:25

Water holding capacity (WHC) of meat - a possible parameter in heat process calculations?

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One of the important variables of the basic equations for the heat process calculations developed by Ball (Ball and Olson, 1957) is the temperature response factor f, i.e. the number of minutes required for the straight portion of the semilogarithmic time-temperature curve to traverse one log cycle. To prove the dependence of f on WHC (water holding capacity) eight experiments have been carried out with mixtures of ground beef or pork with curing ingredients (NaCl, polyphosphates) and various levels of added water heated in cylindrical cans (diameter 73, height 74 mm). DFD (dark, firm, dry), PSE (pale, soft, exudative) pork mixtures and pH adjusted ones have also been used for the f determination. Heat processing was carried out in a thermostatic water bath at 75°C or 80°C until 70°C was reached in the geometrical centre. Temperature was recorded by Ellab thermocouple at 5 minutes intervals. f values were calculated by the method of Ball and Olson (1957). Grau and Hamm (1972) filter paper press method was used to determine WHC. pH-meter Model 29 (Radiometer Copenhagen) with combined electrode was used for the pH measurements.

Experiments have shown that f is dependant on WHC of the mixtures of meat, curing ingredients and added water. Mixtures containing higher levels of added water have shown decreased f values. In most experiments this relationship has shown linear or nearly linear patterns. DFD pork mixtures have been heated at slower rates in comparison to the normal or the PSE ones, but even here the increased amounts of added water have caused a decrease of the f values. pH in the range 5.11 to 7.60 had no significant influence on f values. Ground beef (without additions) 3 hours post mortem showed the slowest temperature rise during heating (f =60 minutes), in contrast to the meat chilled for 48 hours (f = 54.6). Addition of a 0.5% polyphosphate preparation lowered the influence of the amounts of added water which decreased f values. The influence of percentage of added water on decreasing f values was also dependant on the post mortem time.

As the WHC determination used to consume more time, the authors are of the opinion that it is more convenient to correct the f values by operating with a percentage of added water because its amount nearly linearly decreases the f values.

6:26

Calculation of water activity in industrial sausage production

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It has been suggested that water activity (a_w) in dry sausage can be calculated following $a_w = 1.0014 - 0.6039$ [% NaCl/% H_2O + 0.0338] for $a_w \geq 0.895$ (Demeyer, 1979). This formula however was not based on experimental confirmation of the factor 0.0338, reflecting a concentration of NaCl equivalent to water soluble compounds other than NaCl, contributing to a_w. Also, no correction was used for the increasing contribution of such theoretical NaCl equivalents to a_w because of drying. We have determined the correction factor for our production conditions and have introduced a correction for drying. Values calculated using the corrected formula were compared with measured values.

Results:

a. Determination of correction factor; a_w was determined using two instruments, based on measurement of conductivity changes (Rotronic AG and Novasina, Zürich) on mixtures of meat (50/50 beef/pork) containing 10, 15, 20, 25, 30 and 40 % w/w lard. Irrespective of added additives (glucose, caseinate, ascorbate, spices and glutamate) a constant value for $a_w = 0.990 \pm 0.001$ (mean value ± SD, n = 42) was obtained. This allows calculation of a correction factor equal to 0.0189.

b. Based on the assumption that theoretical NaCl equivalents behave identical to NaCl during drying, the following formula, corrected for drying was developed:

$$a_w = 1.0014 - 0.6039 \cdot \frac{\% \text{ NaCl}}{\% H_2O} \left(1 + \frac{0.0189A}{B}\right) \quad (1)$$

With A = initial % H_2O in batter, B = initial % NaCl in batter. Values for a_w were measured using a Rotronic apparatus (a_{wm1}) and calculated following (1) (a_{wc}) for 7 different sausages at different drying stages with: $a_{wm1} = 1.0719\ a_{wc} - 0.0680$ $R^2 = 0.96$ RSD = 0.0042. Such accuracy of prediction is comparable to prediction of a_{wm1} by e.g. an isopiestic measurement (a_{wm2}) following $a_{wm1} = 0.9294\ a_{wm2} + 0.0666$ $R^2 = 0.95$ RSD = 0.0031 (n = 18).

Prediction of a_{wm1} by a_{wc} using estimates for A (50 %) and B (3 %) on 18 sausages was

$a_{wm1} = 1.3198\ a_{wc} - 0.3093$ $R^2 = 0.93$ RSD = 0.0038.

This systematic overestimation may be related to erroneous estimates of A and B and/or changes in the correction factor 0.0189.

Demeyer, D., Fleisw. 59, 973-974 (1979).

6:27

A study into the quality of young buffalo meat and its rational use in sausage production

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The morphology, chemical composition and the physico-chemical properties of the meat of young buffaloes grown at a feed-lot in the Azerbaidjan SSR were studied and compared with the characteristics of young beef derived from cattle of the local malokavkazskaya breed. It was found that, as far as the characteristics studied are concerned, the meat of well-fattened young buffaloes is not inferior to young beef: there are significant differences in higher yields of trimmed buffalo meat, a lower content of intramuscular fat, in a more intensive colour of the muscle tissue, and in a higher water-binding capacity; also the nitrogen level of the extractives is significantly higher.

The results obtained indicated the suitability of processing buffalo meat into various products similar to those prepared from beef.

6:28

EFFECT OF NITRATE LEVEL ON THE CHEMICAL AND MICROBIOLOGICAL PROPERTIES OF SAUSAGE DURING STORAGE

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Sodium nitrate is widely used during meat curing. In addition to its anticlostridial activity nitrate has been used in some meat products for acquirement of desirable colour and flavour. Nitrate is not so toxic as nitrite but it acts as a reservoir for nitrite via conversion reactions by reducing bacteria. On the other hand, nitrite can react with secondary and tertiary amines to form nitrosamines which were found to be toxic (carcinogenic, teratogenic and mutagentic). For this reason an attempt was carried out to minimize the amount of residual nitrite in sausage.

In this work the sausage prepared from conventional ingredients with additions of 10, 20 and 30 mg.$NaNo_3$/100 gm was stored at 4°C for one month and samples were with-drawn after 1,10,20 and 30 days and analyzed for moisture content, nitrite content, total volatile nitrogen , ammonia, TBA, total microbial count (TC) and organoleptic properties (color, aroma and taste) before and after cooking.

After 1 day storage the nitrite content was 8.2, 4.30, 87.1 and 127.3 mg/Kg. sausage; for samples prepared with additions of 1,10,20 and 30 mg. nitrate respectively.

Added NaCl and/or spices appeared to contain some nitrite. Only the sample prepared with 30 mg. nitrate had a very slightly higher residual nitrite than permitted by the Egyptian Food Regulation (maximum 125 ppm). After 10-30 days storage all samples, either fresh or cooked had lower amounts of nitrite than that permitted, owing to the progressive reduction of nitrate upon storage. At any given period of storage the higher the level of added nitrate; the lower the microbial load, total volatile nitrogen, ammonia and TBA.

Color, taste and aroma were improved by increasing quantity of added nitrate. Neverthless, no considerable differences were found in color, aroma and taste scores among samples prepared with 20 and 30 mg. nitrate.

A concentration of 20 mg. nitrate /100 gm. sausage was recommended for production of sausage with adequate organoleptic properties, high storage stability and a low residual nitrite.

6:29

Storage and processing characteristics of low-dose irradiated or frozen bovine muscles intended for cooked sausage production

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Sixty kg of beef raw materials were obtained from the hindquarters of four second-grade carcasses. All meat pieces (400-700 g each) were mixed together and distributed into 24 vacuum packages, each weighing 2.5 kg. The packages were randomly assigned to one of two treatments : (i) low-dose (300 krad) irradiation followed by storage at 0° ± 0.5°C; (ii) freezing and storage at -18°C.

Upon the completion of each storage period (7, 30 or 60 days), three packages of each treatment group were sampled for pH, water-binding and microbial determinations, and six sausage batters were prepared from the remaining beef raw materials plus post-rigor (24 h) pork and cooled pork back fat.

Prior to storage, low-dose irradiation reduced the number of microorganisms present in meat by at least 2 log cycles; after a 60-day storage at 0°C, however, viable microorganisms, mainly lactic acid bacteria, reached very high levels ($>10^7$). A concomitant decrease in pH, and the high juice loss rendered the irradiated beef raw materials unfit for further storage and processing. The microbial status of the frozen meat did not change significantly during the 60-day storage period.

Percentage shrinkage, residual nitrite, and the fat and moisture content of the finished sausages did not differ significantly ($P>0.05$) between treatments; products made from the irradiated raw materials, however, were assigned lower flavour and colour scores than those from the frozen meat (6.7 vs 8.0 and 6.3 vs 7.3, respectively). Storage for more than 30 days affected adversely the processing characteristics of both the irradiated and frozen beef raw materials.

It is concluded that irradiated and cooler stored beef raw materials have no advantages over the frozen ones when intended for cooked sausage manufacture. Preliminary results in favour of the low-dose irradiation of pre-rigor beef pre-blends for sausage production are also reported.

6:30

Modification of deboning of meat for sausage production

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For the sausage manufacturing technology which is currently in use, deboned meat must be accurately selected. As a result of such selection, 4 grades of pork and beef are obtained, each varying in the content of muscle, connective and adipose tissues. The cutting, deboning and selection activities are labour-consuming.

The need for an increased rate of production often causes improper grading, thus affecting the quality of the finished products. Modifications to the cutting and deboning operations were carried out. The order of the carcasses designated for sausage production on the cutting lines was changed, grading was simplified, and deboning was rationalized.

These modifications were accompanied by elaboration of the appropriate new recipes and the technology of the sausage production. The quality of the meat obtained from specified parts of carcasses was characterized. Deboned pork was divided into lean and fatty grades, and deboned beef into sinewy and non-sinewy grades.

As a result of the modifications to the deboning procedure, pronounced savings in labour were achieved.

6:31

Predicting the effect of fat thickness and distribution on the heating times of joints of rolled meat

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Most fundamental studies of heat and mass transfer during meat cooking have assumed that joints may be represented by spheres or infinite slabs or cylinders with homogeneous properties. In practice, the heating of joints can rarely be characterized by heat flow in a single direction and 1-dimensional approximations are invalid. Furthermore, meat joints usually consist of fat and lean, the thermal properties of which differ considerably over the temperature range experienced during cooking so that the assumption of homogeneity is also unjustified.

In the present studies, 2-dimensional finite difference approximations to the heat conduction equation were developed for a finite cylinder using a combination of the methods of Dusinberre and Newman. These approximations were used to study the effect on cooking time of fat layers of various thicknesses located at the surface or centre of lean cylinders of meat.

Since previous work has shown the need to account for the shrinkage of meat during cooking it was estimated experimentally by cooking whole cylinders (16cm long by 8cm diameter) of bovine *M. semitendinosus* or beef fat in a natural convection oven at 175°C. The length and diameter of each cylinder was determined before (X_1) and after (X_2) cooking and used to calculate a shrinkage ratio ($X_1 + X_2 / 2 X_1$) for fat and lean both radially and longitudinally. These factors were used to scale the initial dimensions used in the cylindrical models. Predictions for cooking cylinders in a natural convection oven at 175°C showed that cooking times, from a uniform temperature of 10°C to a centre of 74°C, were in all cases within the range 63 to 75 minutes. Joints with a fat layer on the outside cook slower than joints with an equivalent thickness of fat at the centre. Similarly with two joints of equal volume fractions of fat and lean, the joints with surface fat cook slower.

Substantial percentage differences, defined as [(predicted-experimental) x 100/predicted], of 8% and -38% for whole fat and lean cylinders respectively, were found between experimental and predicted results. A further model which enables thermal properties to vary with temperature and consequently location has also been developed. This model did not clearly reduce the difference between experimental and predicted cooking times which were 33% for whole fat and -37% for whole lean cylinders. The most likely causes of these differences are considered to be the assumptions made in the model and the use of inappropriate thermal properties and/or heat transfer coefficients.

6:32

Contact steam heating of mechanically separated poultry meat

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The cooking process of mechanically separated poultry meat was studied in a steam contact coagulator with distributed steam injection under conditions of continuous heating of the samples being tested. The heat capacity (c), heat conductivity (λ) and temperature conductivity (a) of mechanically separated chicken and duck meat differ because of differences in the chemical composition of the meats.

The expenditure of steam for the heating of mechanically separated chicken and duck meat in a thermal coagulator calculated using experimental values of c and λ, conformed closely to actual values of steam expenditure. The water content of steam heated meat is increased because of the steam condensation, and as a result the relative fat content is decreased. Fat and water content calculated values represent permissible errors from actual for industrial practice values.

Heating above 70°C leads to qualitative changes in the structure of mechanically separated meat, a suspension is formed for which the limits of fluidity or the utmost shear strain cannot be determined, i.e. the structure, in the normal sense of the word, is absent. The subsequent fine grinding of the structureless suspension leads to formation of minced meat with pronounced solid-like properties for which the numerical values of the maximum shear strain are a bit higher than for raw meat. Experimentally achieved thermophysical characteristics and reological data for mechanically separated meat can be used for calculation and prognosis of cooking processes.

Development of cooked products preserved by freeze-drying

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Experiments were conducted to develop cooked products preserved by freeze-drying.

To preserve nutrients to a maximum extent, product cooking was effected at a temperature of 90 - 100°C. In this way, protein hydrolyzation is prevented, and also the deamination of some amino acids, which occurs upon heating over 100°C. Three types of raw materials were used to develop the cooked products: veal, poultry meat and veal liver. The raw material structure of particle size of up to 20 mm proved the most suitable for both cooking and freeze-drying. During freeze-drying, comparatively mild treatments were applied: freezing, from -30 to -45°C; maximum heating, up to 70°C; final drying temperature, from 30 to 40°C.

Cooked products preserved by freeze-drying are characterized by the following chemical indices: water content, 1-3.17%; protein content, 68.59 - 84.88%; fat content, 6.89 - 11.89%; protein digestibility, 94.74 - 98.38%.

The reduced fat content and the low water content, and also the high protein digestibility and the high protein content of these products makes them extremely valuable for dietetic nutrition.