ABSTRACT AND REFERENCES

TECHNOLOGY AND EQUIPMENT OF FOOD PRODUCTION

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IMPROVEMENT OF A SCRAPER HEAT EXCHANGER FOR PRE-HEATING PLANT-BASED RAW MATERIALS BEFORE CONCENTRATION (p. 6–12)

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When heating liquid and paste-type products, enterprises in the food industry commonly use scraper heat exchangers, which, given their high heat treatment intensity, make it possible to retain the original properties of the treated raw materials. Most heat exchangers demonstrate an unstable stabilizing effect: the vapor pressure – the temperature that leads to damage to raw materials, under conditions of significant energy- and metal capacity. It is possible to eliminate these drawbacks by using a temperature-stable flexible film resistive electric heater of the radiating type as a heater in an improved scraper heat exchanger. We have proposed applying a hinged blade with a cutting edge (with a reflective heating surface) as a stirring element of the heat exchanger to obtain the uniform distribution of a product layer thickness at the working surface and to additionally heat by the blade's reflective surface. The heat exchanger can be supplemented with a cooling shell with ring channels to pass the refrigerant, which is placed on the outer surface of the non-thermally insulated flexible electric heater. Such a solution provides the possibility of cooling to –15 °C and it simultaneously serves the additional air thermal insulation in the absence of the carrier in it.

We have determined the uniformity of heat flow distribution over the heating surface of the model design of the improved unit (60.3...60.5 °C) and at the reflective surface of the hinged blade with a cutting edge (60.0...60.3 °C). The total thickness of a liquid layer has been established depending on the shaft rotation frequency of the proposed hinged blade with a cutting edge: at 50 min^{-1} – 1–2.65 mm, at 350 min^{-1} – 1.5 mm, compared with a standard hinge blade (a layer thickness is from 5.0 mm to 1.5 mm), in terms of product consumption W=50 l/h. The improved scraper heat exchanger is characterized by a 1.48-time decrease in the specific energy consumption (170.4 kJ/kg), used to heat a product volume unit, compared to the heater with a steam shell – 252.6 kJ/kg. The research result is the confirmed efficiency of using the improved scraper heat exchanger, as well as its proposed structural scheme.

Keywords: heating, scraper heat exchanger, cutting blade, heat removal, flexible film resistive electric heater of the radiating type.

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THE APPLICATION OF OSMOTIC DEHYDRATION IN THE TECHNOLOGY OF PRODUCING CANDIED ROOT VEGETABLES (p. 13–20)

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The improved technology of the production of candied table and sugar beet, carrot, parsnip, root celery, and rutabaga was offered. The technology is based on increasing the osmotic pressure in the

cells of plant raw materials by increasing the concentration of solids. The advanced technology involves the use of the process of osmotic dehydration in 70 % sugar solution of the temperature of 50 °C as an alternative to the process of blanching. This ensures the reduction of drying time up to 1 hour due to the partial transition of water from root cells into the sugar solution. Inactivation of enzymes, which occurs during dehydration, positively influences the organoleptic quality indicators of candied vegetables. Candied vegetables have a good smell, characteristic natural color, and can be used as a ready-made dessert dish and fillers in the production of fermented milk products and confectionery.

The influence of the traditional methods for processing plant raw materials on its nutritional and biological value was analyzed. The methods of making candied vegetables were studied and the shortcomings of these methods were revealed. A dataset on the modes of maintenance of dehydration and drying processes was obtained. The technology which includes: crushing raw material, osmotic dehydration, drying in vacuum drying chambers was proposed. The technology involves crushing raw material into cubes with the dimensions of 5/5/5 mm. Osmotic dehydration of raw materials occurs in the oversaturated sugar solution for 2.5 hours at the temperature of 50 °C with subsequent drying in vacuum drying chambers for 1 hour at 50 °C.

The design of the apparatus for osmotic dehydration, which ensures maintenance of the assigned temperature mode, preparation, and stirring the sugar solution, constant stirring of raw materials with the purpose of mass exchange intensification was developed.

The organoleptic (appearance, consistency, taste, smell, color) and physical and chemical quality indicators (mass fraction of sucrose, moisture, total ash) of candied table beets manufactured according to the improved technology were analyzed. Their compliance with the requirements of DSTU 6075:2009 was established.

Keywords: osmotic dehydration, vacuum drying chambers, candied table beets, root vegetables, mass fraction of sucrose.

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VALIDATION OF EMULSIFYING PROPERTIES OF SEMI-FINISHED PRODUCT BASED ON LOW-LACTOSE MILK WHEY (p. 21–29)

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This paper presents rheological and organoleptic studies of emulsion systems using a semi-finished product based on condensed low-lactose whey and fermented pumpkin pulp puree (SPCLLW). The positive influence of SPCLLW on the structure of emulsion systems was found, which was confirmed by expert sensory evaluation. The research confirms the component compatibility of SPCLLW and vegetable oil as a part of emulsion systems. This paper scientifically proves the influence of technological factors on the parameters of emulsification of a semi-finished product based on condensed low-lactose whey and fermented pumpkin pulp to ensure its target properties as an emulsifier and stabilizer in the technology of emulsion sauces. The experiments revealed the change in the quantitative values of the determinants of emulsion systems, such as viscosity and inversion stability, depending on the values of the pH of the medium, the emulsification temperature, the rate of oil dripping and the rotation of the working body of the mixer. It was proved that the acidification of the medium increases the viscosity of the emulsion system, therefore it is advisable to use SPCLLW in the composition of salty sauces of the emulsion type. There is a direct relationship between the manifestations of inversion instability and the increase in temperature of the emulsification process. The research reveals the inversely proportional effect of the rotation speed of the working body of the mixer on the increase in viscosity of the studied systems. Mathematical optimization is carried out for certain ranges of numerical values of parameters of separate indicators of the technological process. Rational parameters of the emulsification process are determined: temperature index – 18 °C, emulsification rate – 0.09...0.11 ml/s, pH from 5.0 to 5.5, rotation speed of the working organism of the mixer – 500 rpm. The research confirms the possibility of using SPCLLW as a part of emulsion systems, in particular sauces of emulsion type.

Keywords: low-lactose condensed semi-finished product, emulsifying properties, effective viscosity, inversion resistance.

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SURVEY OF COMPLEX INFLUENCE OF PHYSICO-CHEMICAL AND TECHNOLOGICAL PARAMETERS ON THE PROCESS OF MILK-EGG CO-PRECIPITATE OBTAINING (p. 30–37)

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The comprehensive influence of the medium pH and the concentration of sugar or sodium chloride on the process of coagulation of egg proteins has been established and analyzed.

It has been determined that sodium chloride in low concentrations reduces the viscosity of the colloidal solution of egg mass and increases the heat resistance of egg proteins by 6...8 degrees. It has been established that when the active acidity is shifted to the acid side, the egg coagulation temperature shifts by 10...12 degrees above the egg protein-coagulation temperature in a neutral medium. A pH shift towards neutral values reduces the temperature of coagulation and the formation of a protein clot by 5...8 degrees.

It has been established that the combined use of sodium chloride and medium pH leads to a synergistic effect on the heat resistance of egg proteins while the magnitude of the temperature of visible coagulation depends on the concentration of egg mass in the model systems. A 15 % concentration of egg mass in the system with the content of 1.0...1.5 % of sodium chloride and the system's pH of 4.2...4.3 was found to be the most rational.

It has been determined that the introduction of sugar stabilizes the system increasing the coagulation temperature of egg proteins and affects the sensory assessment of the homogeneity of the studied model systems after heating them to 100 °C.

It has been proven that the stabilizing effect of sucrose at pH 4.8 is more pronounced compared to a neutral medium. With an increase in the active acidity of the studied model systems, the stabilizing effect of the comprehensive influence of the medium pH and the concentration of sucrose on the coagulation of egg mass proteins is enhanced.

Based on the above results, the content of 15...20 % of egg mass and 20...25 % of sugar in the system was determined to be the most rational for milk and egg-protein concentrates, which allows the pasteurization of the mixture at 85...90 °C without stratification.

Keywords: milk and egg concentrate, viscosity of food system, sucrose, sodium chloride, active acidity.

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THE EFFICIENCY OF STABILIZING THE OXIDATIVE SPOILAGE OF MEAT-CONTAINING PRODUCTS WITH A BALANCED FAT-ACID COMPOSITION (p. 38–45)

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This paper reports a study of the fatty acid composition of a meat-containing semi-smoked sausage with Peking duck meat that established the biological effectiveness of the product's fat. The rosemary extract application efficiency has been investigated for the course of oxidation processes in a semi-smoked sausage with a high content of unsaturated fatty acids.

The high content of the monounsaturated FA C18:1 ω-9 (oleic) has been determined experimentally, 40.37 g/100 g fat. The content of the PUFA ω-3 in a meat-containing semi-smoked sausage made from the meat of Peking duck is 1.22 g/100 g of fat, which satisfies the daily recommended need in essential FA by 27 %. The ratio between the families of the FA ω-3/ω-6 in the developed products is at least 1:11 at the recommended physiological norms of the perfect fat composition in a meat product of 1:10.

The current study has confirmed the high antioxidant activity of rosemary extract and the effective inhibition of the process of lipid oxidation in meat-containing sausages. Introducing a rosemary extract in the amount of 0.02–0.06 % slows down the hydrolytic oxidation of minced meat lipids by 29.13–35.00 %, inhibits the peroxidation of lipids in the meat-containing semi-smoked sausage, thereby reducing the number of peroxides by almost five times.

It has been confirmed that stabilizing the peroxidation of lipids in the meat-containing semi-smoked sausage made from Peking duck meat with a high concentration of unsaturated fatty acids should, as a consequence, reduce the concentration of secondary oxidation products. The number of aldehydes and ketones was least at the end of shelf-life of the finished products and was 0.38–0.80 mg MA/kg of the product, which is 2.54–3.94 times lower than that of control sample. The greatest stabilizing effect has been achieved when introducing a rosemary extract in the amount of 0.06 %, which makes it possible to reduce the indicators of oxidative spoilage of fat by more than twice.

Keywords: meat-containing semi-smoked sausage, duck meat, unsaturated fatty acids, rosemary extract.

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SUBSTANTIATING THE USE OF GERMINATED LEGUME FLOUR ENRICHED WITH IODINE AND SELENIUM IN THE PRODUCTION OF COOKED-SMOKED SAUSAGES (p. 46–54)

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The possibility of using flour from soybean and chickpea grains, which are germinated in solutions of mineral salts, has been considered. The feasibility of its use in the production of cooked-smoked sausages by reducing meat raw materials has been investigated. The obtained patterns will be used in the development of the technology of cooked-smoked sausage enriched with iodine and selenium, the deficit of which is observed in 17 % of the world's population.

The reported study has established that all experimental samples demonstrated an improvement in the structural and rheological characteristics compared with the control. It has been found that the use of legume flour, germinated in solutions of mineral salts, affects a change in the pH of minced meat. The samples containing them have a less pH, by 0.2; 0.4; 0.7 °T. The samples change color from dark red (control) to yellow-pink and yellow-gray. The content of the mass fraction of iodine and selenium in the samples containing the flour of legumes sprouted in the solutions of mineral salts of 5, 10, 15 %, was 13; 26; 39 μg by iodine, and 12.5; 25; 37.5 μg by selenium content. The content of essential amino acids increases by 1.609; 2.756; 4.012 mg/100 g compared with the samples where legume flour was used, sprouted in water; by 2.134; 5.594; 8.468 mg/100 g compared with the control sample. The total content of essential amino acids increases by 3.128; 6.254; 9.380 mg/100 g compared with the control sample, and by 1.054; 2.100; 3.150 mg/100 g in comparison with samples in which the legume flour sprouted in water was used.

The established patterns are the scientific basis for the development of the production technology of cooked smoked sausages en-

riched with iodine, selenium, and amino acids. The developed product could adjust the structure of people's nutrition, thereby eliminating significant deviations in the consumption of microelements.

Keywords: legume flour, cooked-smoked sausages, iodine deficiency, selenium deficiency, soybeans, chickpeas, amino acids.

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IMPROVING THE PROCESS OF HYDROTHERMAL TREATMENT AND DEHULLING OF DIFFERENT TRITICALE GRAIN FRACTIONS IN THE PRODUCTION OF GROATS (p. 55–65)

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The influence of hydrothermal treatment (grain moistening) and dehulling duration on the yield and quality of groats from different fractions of triticale grain was studied. Comparative analysis of groats yield and its culinary quality at different grain moisture, depending on its fractions, was performed. The degree of the influence of the studied factors on the yield and quality of triticale groats was determined. The influence of dehulling duration, the size of a triticale caryopsis and grain moisture content is reliable. These factors significantly influenced the groats yield and quality. In addition, the influence of the duration of grain dehulling was the highest. The highest groats yield was obtained at the dehulling duration of 20 s, the lowest – at dehulling for 180 s.

The social survey was conducted and the main priorities for buyers of cereal products were established. It was proved that while choosing food, consumers pay the most attention to culinary characteristics of the finished product.

It was established that it is optimal to dehull triticale grain for 100 s. The application of such parameters of treatment makes it possible to obtain the yield of whole groats of 88.8 % with the culinary quality of 6.7 points. The groats quality meets the requirements of DSTU 76992015 "Wheat Groats. Technical specifications".

Based on the research, it was established that the separation of the triticale grain into fractions that differ in their geometric properties, in particular, thickness, is effective. The peculiarities of groats yield, depending on the triticale grain fraction, were determined. Application of hydrothermal treatment of triticale grain (moistening up to 14.0 %) makes it possible to increase the groats yield up to 88.7 %. The treatment of the fractions with grain thickness less than 2.4 mm ensures the groats yield up to 87.8 %. The groats yield during dehulling the grain, which has a thickness of more than 2.4 mm, is from 88.8 to 89.1 %.

To produce the groats from triticale grain, it is advisable to use the grains that have a thickness of 2.8 mm or more. The optimum duration of dehulling is 100 s. To increase the overall culinary assessment by 1 point, it is recommended to increase the duration of dehulling a large grain up to 140 s. This method differs from the classical one by the fact that it uses a large grain fraction with the lower moisture content.

The developed recommendations can be used by grain processing enterprises during processing triticale with the view to intensifying the production.

Keywords: hydrothermal treatment, dehulling, grain fractions, triticale, groats yield, culinary assessment.

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DEVELOPMENT OF AMINO ACID BALANCED FOOD SYSTEMS BASED ON WHEAT FLOUR AND OILSEED MEAL (p. 66–76)

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The analysis of the main methods of increasing the nutritional and biological value of wheat flour has been conducted. Considerable attention is paid to the issue of adjusting the protein content in flour due to additives. The relevance of improving the amino acid composition of flour protein is emphasized. The feasibility of comprehensive studies for the development of food system formulations with a balanced amino acid composition based on wheat flour and oilseed meal is substantiated.

The amino acid content has been experimentally determined and the biological value of raw materials proteins for food systems which are sunflower and soybean meal has been calculated. The mixture composition of sunflower and soybean meal with an improved amino acid composition has been scientifically substantiated. It has been found that the protein composition of the meal mixture is maximally close to the reference in terms of the content of leucine, lysine and the amount of sulfur-containing amino acids (methionine, cystine). The score of isoleucine, tryptophan, phenylalanine and tyrosine in the protein composition of oilseed meal is 1.1–1.47 times higher than the reference.

The amino acid composition has been calculated and the biological value of the protein of food systems containing 80–90 % wheat flour and 10–20 % composition of soybean and sunflower meal with improved amino acid composition has been determined. It has been found that the formulation of the food system containing 20 % of the

composition of meal mixture and 80 % of wheat flour has the greatest biological value in comparison with wheat flour. In this food system, the limited amino acids – lysine and sulfur-containing (methionine and cystine) are the closest to the reference one and are 67.68 % and 70.12 %.

The fatty acid composition has been experimentally determined. The biological effectiveness of the fats of the developed food systems has been calculated. The closest to the fatty acid ratio recommended by nutritionists is the food system with a ratio of meal mixture: wheat flour of 20:80.

The resulting formulations of food systems will be useful in technologies of flour products with high biological value.

Keywords: wheat flour, sunflower meal, soybean meal, essential amino acids, amino acid score, fatty acids, food systems.

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BIOTECHNOLOGICAL ASPECTS OF OBTAINING FERMENTED SOYBEAN PRODUCTS WITH INCREASED PHYTOESTROGENIC ACTIVITY (p. 77–88)

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We have studied the proteolytic, α-galactosidase, and β-glucosidase activities of the consortia Lactobacillus acidophilus 317/402 with Bifidobacterium longum-Ya3 and Bifidobacterium adolescentis-C52 in the process of soy milk fermentation. It has been established that the studied cultures possess active enzyme apparatuses and help minimize those factors that limit the use of soy milk for the production of functional foods – the presence of indigestible oligosaccharides and a legume taste. In terms of the proteolytic activity, which was 30 mU in 6 hours, the consortium Lactobacillus acidophilus 317/402 with Bifidobacterium adolescentis-C52 was the leader. The largest α-galactosidase and β-glucosidase activities, 98 U/mg and 81 U/mg, respectively, were demonstrated by the consortium Lactobacillus acidophilus 317/402 with Bifidobacterium longum-Ya3. At the same time, the amount of daidzin, glycitin, and genistin decreased by 93 %, 75 %, and 99.6%, respectively, while the amount of relevant aglycones increased by 278 %, 153 %, and 338 %. The specified enzyme activities of Lactobacillus acidophilus 317/402 with Bifidobacterium adolescentis-C52 did not exceed 78 and 75 U/mg, respectively, while the biotransformation processes of isoflavones were less intensive. It has been shown that certain symbiotic relationships between the selected strains of Bifidobacterium and Lactobacillus acidophilus are formed in soybean milk, which makes it possible to obtain high titers of probiotic cultures in the finished product, with the predominance of Bifidobacterium. After 9 hours of fermentation, the average number of Bifidobacterium and lactobacillus cells for both consortia was (0.9–2)·108 CFU/cm3 and (0.8–4)·109 CFU/cm3, respectively. We have proven the increase in the probiotic and estrogenic activity of fermented drinks based on soy while reducing the amount of galactooligosaccharides by 50–70 % on average.

Keywords: fermentation, soy milk, Lactobacillus, Bifidobacterium, probiotics, oligosaccharides, isoflavones, α-galactosidase, β-glucosidase.

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