AN309

Topic areas in the oral part of state final exam for the master's study program Biotechnology and Food Science

I. Food Biotechnology and Microbiology (*compulsory*)

(in the context of study subjects Biotechnology in Food Industry, Food Microbiology, Risks in Biotechnologies, and Principles of Food Preservation this topic area is based on)

- Arrangement of food biotechnological process, basic raw materials as microbial substrates, process selection (batch, fed-batch, continuous), upstream and downstream operations.
- Production of ethanol for food, fuel and other industries; fermentation process, distillation, production of anhydrous ethanol for blending with gasoline, production of spirits and liqueurs.
- Food microbial biomass – baker's yeasts, feed biomass, edible mushroom cultivation, algae cultivation.
- Microbial production of organic acids in bioprocess – acetic acid (vinegar), citric acid, lactic acid. Production of amino acids by using bacteria.
- Wastewater treatment and solid waste treatment in food biotechnologies; production of biogas.
- Factors affecting the growth of microorganisms in foods and environment, including the proliferation of food borne pathogens and microorganisms causing food spoilage; microbial biofilm and its formation.
- Occurrence and classification of foodborne pathogens and spoilage causing microorganisms.
- Isolation and identification of target microorganisms using classical cultivation techniques and methods.
- Recent rapid methods for isolation and identification of target microorganisms.
- Sampling for microbiological analysis, principles, limits and applications of the methods for quantitative and qualitative analysis of microorganisms.
- Czech / European Union legislation and regulations for foodborne pathogens.
- Safety and organization of work in microbiological laboratories, Good Laboratory Practice, accreditation scheme, research and company QC and QA laboratories; risk groups of microorganisms.
- HACCP system in food industry/ biotechnology; analysis and control of microbial risks in raw materials, production process and during storage of products; process hygiene, CIP and SIP systems, disinfectants.
- GMP system in pharmaceutical industry, registration of drugs. Drugs versus food supplements.
- Genetically modified organisms in agriculture, pharmacy, medicine, and research. Contained use, release into the environment and placing on the market.
- Thermal food preservation – sterilization and pasteurization, the effect of heat on microorganisms, thermal process calculation.

- Non-thermal physical methods of food preservation – refrigeration and freezing, dehydration, irradiation, pulsed electrical field and high hydrostatic pressure.
- Chemical and biological methods of food preservation.
- Food packaging, functional properties of materials used for food packaging, packaging methods for food preservation
- The concept of hurdle technology – principles, applications, advantages and disadvantages.

II. Chemical Food Analysis and Safety (*compulsory*)

(in the context of study subjects Special Food Analysis, Isolation and Separation Methods, and Chemical Food Safety this topic area is based on)

- Application of analytical chemistry to foods – selection for a particular purpose, strategy of method validation, performance characteristics and their importance in the field of quality control and food safety.
- General principles of laboratory sample processing, extraction and separation methods in the analysis of food, criteria for their selection in targeted and non-targeted analysis.
- Main methods for the isolation of analytes from food samples for chromatographic analysis, issues of [expected] content and properties of the analyte and matrix composition.
- Chromatographic and electromigration methods – separation principles in the analysis of biomolecules (including polymeric substances) and applications in multidimensional separations of complex mixtures.
- Analysis of minor organic components of food (e.g. organic acids, phenolic substances, flavonoids, alkaloids) – selection of isolation, purification and detection method, options in the interpretation of the obtained data.
- Molecular spectrometry / spectroscopy methods (MS, IR, NMR): selection and comparison in terms of the type of information these provide, interpretation options.
- Spectrometric methods for elemental analysis (AAS, ICP-OES / MS) – their characteristics and application potential. Common methods in preparation of samples for elemental analysis in foods.
- Methods for the isolation of substances in gas phase (head space, purge & trap) and supercritical fluid extraction (SFE) method (principles, parameters, and application potential).
- Principles, parameters, and application potential of methods for isolation of substances in liquid and solid phase: (micro)liquid extraction (LLE, LSE, ASE, MASE), (micro)solid phase extraction (SPE, MEPS, SPME, SBSE), dispersed solid phase extraction (QuEChERS, MSPD)
- Preparative separation methods: adsorption chromatography (LSC), gel permeation chromatography (GPC), preparative chromatography (principles, parameters, application potential).

- Gas chromatography (GC), two-dimensional gas chromatography (GC x GC; modulator function), matrix effects, injection techniques, chromatographic columns, temperature program, detectors (principles, parameters, and application potential).
- Liquid chromatography (LC) and supercritical fluid chromatography (SFC), column dimensions, stationary phases and separation mechanism, grain size of stationary phase, mobile phases and their flow rates, detectors (principles, parameters, and application potential).
- Mass spectrometry (MS) and ionization techniques – electron ionization (EI), chemical ionization (PCI, NCI), electrospray (ESI), chemical ionization at atmospheric pressure (APCI), photoionization (APPI), mass analyzers - quadrupole, time of flight, orbitrap (principles, parameters, and application potential).
- The main groups of chemical pollutants in food in the context of EU food legislation.
- Health risks related to dietary exposure to toxic and anti-nutritional substances, exposure monitoring strategies and prevention options.
- Food additives – main groups, their characteristics and conditions of use.
- Environmental and industrial contaminants – main groups and their characteristics in terms of properties and occurrence.
- Process contaminants – main groups, mechanisms of origin, and preventive measures.
- Natural toxins, mycotoxins – characteristics of main groups and preventive measures.
- Residues of pesticides and veterinary drugs – main groups and their characteristics in terms of properties and occurrence, ways to minimize contamination by the residues.

III. Bioengineering in Food Biotechnology (*compulsory*)

(in the context of study subjects Bioengineering I and Food and Biochemical Process Engineering this topic area is based on)

- Factors affecting the growth rate of producing microorganism (limitation by substrate, inhibition by product, process parameters), maintenance energy.
- Kinetics of cell growth (exponential growth phase, limited and unlimited growth). Kinetics of products formation (primary and secondary metabolites).
- Enzyme kinetics (Michaelis-Menten kinetics, equation, constants in and linearization of). Enzyme inhibition and types of reversible inhibition.
- Cell cultivation techniques (batch, fed-batch, semi-continuous), their characteristics and mass balance of biomass and substrate.
- Continuous cultivations and control systems – chemostat and turbidistat, characteristics and mass balance of biomass and substrate.
- Mixing in biological reactors, types of agitators, power number, homogenization time, shear force, gas dispersion.
- Aeration and oxygen transfer in bioreactors, measurement of dissolved oxygen, film theory, volumetric gas transfer rate, and factors affecting oxygen transfer rate.
- Bioreactor types, their construction elements and practical applications, and methods of regulation and control.

- Mass transfer, diffusion, extraction (principles, parameters, and application potential in food [bio]technology).
- Crystallization, nucleation, precipitation, crystal size distribution, granulometric analysis; milling and disintegration processes (principles, parameters, and application potential in food [bio]technology).
- Heat transfer, unsteady-state heat transfer, heating, cooling, vaporization, freeze and hot-air drying (principles, parameters, and application potential in food biotechnology).
- Physical properties of foods.
- Principles and parameters of membrane processes, electrodialysis, ion exchange, preparative chromatography, and adsorption and their application potential in biotechnology.
- Rheology and determination of food texture (basic model systems), rheological behavior of foods, non-Newtonian behavior, instrumental methods in food rheology.
- Principles and parameters of sedimentation, dispersion stabilization, centrifugation and their application in biotechnology and food industry.

VIa. Chemistry of Food and Natural Products (*compulsory-elective*)

(in the context of study subjects Reaction Mechanisms in Food Chemistry, Bioactive Natural Compounds, and Analysis of Bioactive Compounds this topic area is based on)

- Principles of reactions organic compounds in food – basic concepts of reaction thermodynamics and kinetics, molecular and supramolecular chemistry, chemical bonding and the description of steric structures.
- Reactions of lipids – key reactions in oleochemistry, reactions on the hydrocarbon chain of fatty acids, mechanism of autooxidation and other chemical lipid oxidations and types of lipid rancidity.
- Reactions of saccharides – reactivity of carbonyl and hemiacetal hydroxyl groups, redox and electrophilic reactions, enzymatic and non-enzymatic browning reactions, Maillard reaction, Strecker degradation of amino acids by sugars, melanoidins.
- Oxidation, isomerization, and elimination reactions of amino acids and proteins. Denaturation and hydrolysis of proteins. Reactions of amino acids and proteins with other food components.
- Reactions of vitamins caused by the treatment with heat, oxygen, metal ions, light and UV radiation, acidic and basic environments. Reactions of vitamins with other food constituents.
- Primary and secondary metabolism, relationships between main metabolic pathways, cellular and molecular targets of biological activity. Specific activities of proteins – lectins, proteases, protease inhibitors. Polysaccharides – structural types, functions and applications.
- Alkaloids – metabolic origin, main structural types, pharmacological activities, and biological sources.

- Phenolics – shikimate and polyketide pathways, main structural types of phenolics including representative examples of pharmacologically active compounds.
- Isoprenoids – mevalonate pathway, isoprene rule; monoterpenoids and sesquiterpenoids (main principles of essential oils), diterpenoids (resins, toxic diterpenes, sensorically active diterpenes), triterpenoids; metabolic origin of steroids; carotenoids (biological functions, metabolic origin and main functions of retinoids).
- Bioactive glycosides – metabolic role of glycosyltransferases and glycosidases, cardiac glycosides, saponins, cyanogenic glycosides, and glucosinolates.
- General characteristics of analytical procedure for the analysis of biologically active compounds in natural products, performance characteristics and method validation (accuracy, precision, trueness, sensitivity, specificity, working range, linearity, rugedness, LOD, LOQ).
- Basic steps in the analysis of bioactive compounds (sampling, processing of the laboratory sample, extraction / fractionation, purification, instrumental analysis), differences in processing workflow as depending on physico-chemical characteristics of the analyte / matrix, differences in the analysis of macro- and micro-compounds.
- Chromatographic separation and detection of non-polar bioactive compounds (fatty acids, lipid species, fat-soluble vitamins, lipid accompanying compounds, fat-soluble contaminants, essential oils).
- Chromatographic separation and detection of middle-polar / polar bioactive compounds (amino acids, biogenic amines, organic acids, polyphenols, flavonoids, water-soluble vitamins, bioactive glycosides, alkaloids).
- Trends in trace analysis of specific groups of bioactive compounds (mycotoxins, pesticides, environmental contaminants).

IVb. Molecular Biology and Genetic Engineering (*compulsory-elective*)

(in the context of study subjects Molecular Biology and Genetic Engineering this topic area is based on)

- Organization of eukaryotic cell – cell surface organization, cell-cell, and cell-extracellular matrix interactions, cellular organelles and cytoskeleton, types of tissue (connective, epithelial, nervous, and muscle tissue) and their characteristics.
- Regulation of protein function – protein folding and molecular chaperon and chaperonins, protein degradation (ubiquitin-proteasome system), covalent and non-covalent modifications of proteins, molecular switches and G protein characteristic.
- Moving proteins into membranes and organelles – mechanisms of intracytoplasmic targeting proteins to mitochondria, targeting to peroxisomes, transport in and out of the nucleus.
- Vesicular trafficking, secretion, and endocytosis – intracytoplasmic targeting proteins to and across the ER membrane, protein quality control in ER; mechanism of vesicle budding and fusion, early and late stages of the secretory pathway, retrograde and anterograde transport, endocytosis and endosomal-lysosomal system.

- Cytoskeleton – organization, structure and functions of microfilaments, microtubules and intermediate filaments, movement connected with cytoskeleton components, protein motors.
- Signal transduction – principles and components of signal pathways, signal transduction molecules (receptors, ligands, second messengers, monomeric and trimeric G-proteins, protein-kinases and phosphatases, adaptor molecules).
- The eukaryotic cell cycle and its control – characteristics of individual stages of the cell cycle and its control points, regulatory role of cyclins, cyclin-dependent kinases, and ubiquitin-ligases, restriction point, RB protein.
- Programmed cell death – apoptotic pathways and their regulation, family of Bcl2 proteins and their characteristics, adapter proteins and apoptosome, caspase activation.
- Basic operations with DNA – DNA amplification, purification and cloning, restriction endonucleases, PCR and its applications.
- Introduction of DNA into the cells – vectors, transformation and transfection methods, selection of transformants and stable transfectants.
- Analysis of DNA – nucleotide sequencing methods, forensic DNA analysis, genomic and subtraction libraries, restriction analysis, nucleic acid labeling and probe utilization.
- Modulation of gene expression – site-directed mutagenesis, gene knockout and silencing of gene expression.
- Gene expression – microbial and tissue cells and cell-free expression systems, construction of transgenic organisms (principles and methods), purification of recombinant proteins, fusion tags for detection and affinity purification of proteins, gene therapies.
- Detection of gene expression products – microarrays, electrophoretic, fluorescent and immunochemical methods, metabolic labeling and immunoprecipitation.
- Analyzing protein interactions –principles and applications of methods used to examine mutual protein-protein and protein-nucleic acid interactions.