

Molecular gastronomy and food chemistry

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1. pH through illustrative examples, neutrality. Equilibrium dissociation, temperature effects on water pH. Food acids, food buffers, Henderson–Hasselbalch equation, zwitterions. Colour changes in drinks and their physical explanation, HOMO-LUMO. pH and food safety. Comparing baking powder, baking soda, and yeast for leavening. Proteins: structure, denaturation, curd and cheese. Further basics if needed: chemical bonds, polyatomic ions, Arrhenius law, physical background of Le Chatelier’s principle.
2. Saturation, precipitation. Eggshell, limescale, and antacids. Nucleation and growth in ice creams, chocolate (selective nucleation), and cheese. Phase separation, ouzo effect in drinks. Redox reactions: rusting, stainless steel, burning, fire extinguishers in the kitchen. Potato and lasagna batteries, Nernst equation. Enzymatic browning, antioxidants, vitamin C. Basics of stereochemistry: L and D sugars, R and S amino acids, volatiles, the thalidomide/Contergan tragedy. Coordination chemistry: tannins, chlorophyll, vitamin B12, and chelators. Food analytics: GC-MS, HPLC, FTIR, refractometry, thermogravimetry.
3. Colloids: emulsions and foams. Amphiphilic (amphipathic) surfactants/tensids, detergents, supramolecular complexes, CMC. Oil-in-water and water-in-oil emulsions, cream, butter, mayonnaise, and the origins of life. Stabilization: thickeners. Ice cream types and microstructure control. Plant milks, DLVO theory. Surface tension, Marangoni effect, tensids and foam strengtheners, whipped cream, and meringue. Osmosis, swelling, dehydration. Reverse osmosis: filtering, concentrating. Porous foods, instant coffee, and the Lucas–Washburn equation.
4. Kitchen physics. Electromagnetic waves, induction: microwave oven, induction heater, and IR thermometer. Viscosity, Newtonian and non-Newtonian flows. Cracking, T_g glass transition temperature. Pressure and vacuum: boiling point change, Clausius–Clapeyron equation. Pressure cooker, extruder, and rotary evaporator/distiller. Distillation diagrams, azeotropic point in water–ethanol systems. Steam and vacuum distillation. Extraction: simple, Soxhlet, and supercritical. Drying, sorption isotherms, freeze-drying, drying of fruits. Water activity, microbial stability. Clouding: dry ice and ultrasonic steamers. Freezing: supercooling, concentrating by freezing, ice wines. Pasteurization and sterilization: autoclave, HPP, gamma rays. Ultrasound in culinary science. Centrifuges in food science. Diffusion and its mathematics.
5. Carbohydrates. Simple sugars, reducing (linear) and sweet (ring) forms. Sugar alcohols and sweeteners. Maillard reactions and caramelization. Disaccharides, alpha and beta bonds. Polysaccharides. Starches: amylose, amylopectin. Microscopic structure, gelatinization, retrogradation. Iodine reaction, helical structure. Rice types and their nutritional content. Pasta, rice noodles, and rice paper. Dietary fibers and prebiotics. Metabolism: glycemic index of foods, diabetes. Glycosides and their importance in wine maturation.
6. Proteins. Amino acids, side chains, isoelectric point. Essential and non-essential amino acids. Protein types and proteins in foods. Enzymes: proteases (bromelain, rennet), amylase, lipase, pectinase. Cheese

and orda. Gluten network and factors affecting its strength, farinometry. Bubble retention and strudel sheets. Protein denaturation, gelation.

7. Lipids and lipoids. Triglycerides, saturated and unsaturated fats. Omega-3 and omega-6 fats, essential fatty acids. Melting range, Solid Fat Content curve, hysteresis. Smoke point. Oil pressing. Infusion and fat washing. Fat oxidation and rancidity: mechanisms and protection. Fat hydrolysis, lipases, soaps. Oil powders. Fat crystallization, chocolate tempering, aerated chocolate. Fats in meat baking. Fat metabolism: disassembly and assembly, olestra.

8. Hydrocolloids. Classification: origin, monomers (carbohydrates or amino acids). Bound and free water. Gelling mechanisms: ion-induced (alginate, tofu), cooling-induced (gelatin, agar, starch, pectin, carrageenan, gellan, konjac) gelation, cross-linking (chitosan, hams with transglutaminase), and others. Properties of various hydrogels, hydrogel variants, and their culinary use. The green *C. barbata* gel. Thickeners. Molecular gastronomy: normal and reverse spherification. Gel elasticity, Flory–Rehner equation.

9. Food microbiology. Tree of life, modern taxonomy, 16S metabarcoding. Spores, cell walls. Metabolism: redox processes, pathogen types. Carbon, electron, and energy sources: classification. Catabolism, nitrogen and phosphorus sources. Basics of fungal and plant metabolism. “Energy” molecules: NAD and ATP. Fermentation basics: glucose conversion, energetics, variants, handling H^- and NAD^+ regeneration. Lactic acid bacteria and alcoholic fermentation, acetic acid production. Dairy: yogurt, kefir, curdled milk, curd. Salty or pH-stabilized LAB: sauerkraut, kimchi, *com ruou*, *khanom chin*. Solid-state “fermentation” by molds: koji, tempeh, oncom. Soy sauce, natto, cocoa, and coffee. Specials: tea, noble rot. Alternative coffee fermentations: koji, tempeh, shell upcycling. Fermentation starting with amylase: beer, kuchikamizake, koji-shochu. Sourdough and bread. Amylolytic yeasts: tapai, *com ruou*. Fermentation of sugars: wines. Distilled spirits, liqueurs, kuro mirin, and bee pollen liqueurs. Acidic fermentations: kombucha, water kefir, nata de coco, acetic acid, and bacterial cellulose. Meat fermentation: nem chua and salami, kiviak (horror). Spoilage and antimicrobial agents.

10. Neuro and medical gastronomy, dietetics. Nervous system, spike propagation. Taste, smell, heat, and texture receptors, “tongue microscope,” miracle berry. Genetic variations. Sensory analysis: AB tests, star plots. Individual tests, focus groups, open and double-blind investigations. Caffeine, tea, antioxidants. Methanol and ethanol, toxins. Nanoplastics. Dietetics, obesity, vitamins, and minerals. E-numbers. Immunology, cheese reaction. Hygiene, cleaning/disinfecting agents.

11. Modern trends. Artificial meat. Fungal, microalgal, cyanobacterial, and algal proteins. Electronic tongue and nose, electric spoon, ultrasonic knife. New preservation methods. Novel packaging materials: active, smart, degradable. Nestlé hollow sugar. Personalized nutrition, epigenetics. Ultraprocessing issues. AI tools. Leading food science journals and information portals.