CHEM 9: CHEMISTRY OF COOKING

Foothill College Course Outline of Record

Heading	Value
Effective Term:	Summer 2021
Units:	5
Hours:	4 lecture, 3 laboratory per week (84 total per quarter)
Prerequisite:	Elementary Algebra or equivalent.
Degree & Credit Status:	Degree-Applicable Credit Course
Foothill GE:	Area III: Natural Sciences
Transferable:	CSU/UC
Grade Type:	Letter Grade (Request for Pass/No Pass)
Repeatability:	Not Repeatable

Student Learning Outcomes

- Collect data and interpret real-world physical phenomena using scientific models
- The students will be able to identify physical and chemical properties and change

Description

This course will use kitchen science and cooking to introduce fundamental principles of chemistry. Concepts include atomic theory; stoichiometry; acid-base reactions; the molecular structure of food compounds; heat transfer and cooking methods; egg foams, protein structure and denaturation; gas laws; pressure cooking and the Maillard reaction for meats; the molecular basis of aroma and flavor; sauces and viscosity; chemical reactions involved in baking; caramelization of sugars and crystallization in chocolate. Laboratory experiments will utilize both common chemistry instrumentation and kitchen equipment.

Course Objectives

The student will be able to:
A. Apply the scientific method and distinguish between hypotheses and scientific laws
B. Recognize periodic trends and apply them to common food molecules
C. Identify the different types of bonding (covalent, ionic and intermolecular) and understand the energy associated with each
D. Draw Lewis structures, determine molecular polarity, and analyze for intermolecular forces
E. Recognize, draw and name basic organic molecules
F. Recognize and draw carbohydrates, fatty acids and amino acids
G. Analyze molecular structure and how it affects physical properties
H. Write balanced equations to show basic chemical reactions
I. Use the concept of the mole and Avogadro's number in stoichiometry
J. Calculate and prepare aqueous solutions of specific concentrations
K. Identify how the basic methods of cooking differ and their relation to heat transfer and electromagnetic radiation
L. Analyze phase diagrams and quantify the energetics of phase transitions
M. Explain how pressure affects boiling point and cooking methods
N. Explain the molecular effects of acids and other chemicals on egg protein structure
O. Calculate gas formation from chemical reactions
P. Discuss the molecular basis of the Maillard reaction
Q. Recognize how molecular structure affects solubility, volatility and flavor
R. Discuss how gluten and starch content affect flour-based materials
S. Predict the products of chemical reactions with leavening agents
T. Recognize reducing sugars and glycosidic bonds and their application in caramelization
U. Explain how concentration, solubility and temperature mediate crystallization and the properties of chocolate

Course Content

A. Basic Concepts of Chemical Bonding (Lec, Lab)
1. Matter
a. Periodic table of elements
b. Atomic structure
2. Chemical bonding
a. Valence electrons
b. The octet rule
c. Polarity and electronegativity
d. Intramolecular bonding (ionic and covalent)
e. Intermolecular bonding (e.g., hydrogen bonding, van der Waals forces)
3. Lewis structures
a. Nomenclature
b. Formal charge
B. Organic Molecule Structure (Lec)
1. Structural formulas
a. Common functional groups (e.g., alkanes, alkenes, carboxylic acids)
b. Common names
c. Basic IUPAC rules
d. Branched hydrocarbons
2. Molecular geometry
a. Molecular shape
b. Polarity of common functional groups
c. Effects on boiling point, melting point and solubility
d. Cis/Trans isomerism
C. Molecules of Food (Lec, Lab)
1. Carbohydrates
a. Monosaccharides, disaccharides and polysaccharides
b. Glycosidic bonds
c. Reducing and non-reducing sugars
d. Linear and branched polymers (amylose, amylopectin and starch)
2. Lipids
a. Hydrophobic tail and hydrophilic head
b. Triglycerides
c. Saturated and unsaturated fatty acids
d. Structural effects on melting point
3. Proteins
a. Basic structure of amino acids
b. Side chain hydrophobicity and hydrophilicity
c. Peptide bond formation
d. Primary, secondary, tertiary and quaternary structure
e. Alpha helices and beta sheets
f. Folding and denaturation
D. Aqueous Solutions and Chemical Reactions (Lec, Lab)
1. The Mole
a. Avogadro's number
b. Molar mass
c. Molarity and concentration
2. Chemical reactions
a. Reaction types

b. Balancing chemical equations
c. Stoichiometry
d. Heats of reaction
3. Acid-base reactions
a. Ionization
b. Strong versus weak acids
c. Common acids and bases
d. pH scale
E. Heat Transfer in Cooking (Lec, Lab)
1. Heat and temperature
a. Molecular motion
b. Units of energy
c. Boiling point
d. Melting point
2. Forms of heat transfer
a. Convection
b. Conduction
c. Radiation and the electromagnetic spectrum
3. Phase transitions
a. States of matter
b. Phase diagrams
c. Vapor condensation
d. Heat of fusion
e. Freezing point depression
4. Calorimetry
a. Specific heat capacity
b. Calorimeters
5. Thermal conductivity
a. Heat density of foods
b. Conductivity of cooking materials (e.g., ceramic, aluminum, copper)
c. Nonstick coatings (e.g., Teflon and silicone)
6. Sous vide
a. Lowered boiling point at reduced pressure
F. Eggs (Lec, Lab)
1. Egg structure and composition
a. Egg white (albumin) proteins and composition
b. Yolk proteins and composition
c. Fatty acids and cholesterol
2. Chemistry of egg cooking
a. Protein coagulation
b. Effects of heat
c. Effects of chemical additives (e.g., acid, sugar, salt, cream and fats)
d. Hydrogen sulfide production
3. Egg foams
a. Physics of foam formation (amino acids and air/water interface)
b. Stabilization by additives (i.e., carbohydrates)
c. Destabilization (i.e., disulfide bridges, acids, salt, sugar)
4. Soufflés
a. Behavior of gases
b. Charles' law
c. Gay-Lussac's law
d. Boyle's law
G. Meat (Lec, Lab)
1. Cooking of meat
a. Maillard reactions
b. Cooking oils and smoke point
c. Pressure cooking
d. Toxic byproducts (e.g., heterocyclic amines, polycyclic aromatics)
2. Brining and marinades
a. Acidity and protein denaturation
b. Osmosis
3. Freeze-drying
a. Sublimation
b. Freezer burn
H. Plants, Herbs and Spices (Lec, Lab)
1. Molecules of aroma and flavor
a. Classification of flavor molecules: terpenes and phenolics
b. Volatility
c. Spiciness and pungency (e.g., thiocyanates and alkylamides)
d. Solubility and structure
2. Tea
a. Green versus black tea
b. Browning enzymes
c. Molecules of astringency
d. Steeping and temperature control
3. Coffee
a. Roasting and the Maillard reaction
b. Flavor and astringent phenolics
c. Caffeine extraction methods
d. Brewing and grind surface area
I. Chemistry of Sauces (Lab)
1. Consistency
a. Viscosity
b. Gels and thickening agents
c. Emulsions
d. Foams
e. Jellies
J. Bread Structure and Baking Chemistry (Lec, Lab)
1. Basic structure of wheat flour
a. Gluten protein
b. Starch
c. Water and consistency
d. Dough versus batter
2. Gluten
a. Glutenin versus gliadin
b. Plasticity and elasticity
c. Chemical control of gluten strength
3. Leavening agents
a. Chemical agents and reactions
b. Yeast and fermentation
4. Dough and batter composition
a. Protein composition and baking application
b. Roles of shortening (fats)
5. Cookie ingredients and texture
a. Gluten content and texture
b. Sugar proportion and hardness
c. Fat content and moisture
K. Confections and Chocolate (Lec, Lab)
1. Synthetic sugar substitutes (e.g., Splenda, Nutrisweet, etc.)
a. Structure versus glucose, fructose and sucrose
b. Receptors and perceived sweetness
2. Caramelization
a. Glycosidic bond hydrolysis
b. Chemical products and flavor
c. Color
3. Crystallization
a. Supersaturation and solubility
b. "Seed crystals" and nucleation sites
c. Crystal size and temperature
4. Chocolate
a. Crystallization of cocoa butter
b. Polymorphism
c. Tempering and fat bloom

Lab Content

A. Spherification with Sodium Alginate
1. Measure and record mass and volume data
2. Perform simple dilutions and measure their effects on sphere formation
3. Make physical properties observations of products
B. Energy Content of a Snack Food
1. Experimentally quantify the amount of heat generated from combustion of a snack food by construction of a calorimeter
2. Calculate heat loss and compare experimental data to reported values
C. Egg Protein Denaturation
1. Evaluate the effects of heat and various chemical additives on egg protein structure
2. Provide explanations at the molecular level concerning both chemical and physical denaturation of egg proteins
D. The Effect of Cooking Methods on Vitamin C Content in a Green Pepper
1. Calculate the unknown ascorbic acid content extracted from a green pepper subjected to boiling, steaming, baking and microwave radiation
2. Introduction to titration as an analytic lab technique
3. Introduction to organic compound solubility and extraction
E. The Smell and Color of the Maillard Reaction
1. Perform qualitative analysis of Maillard reaction between glucose and a variety of amino acids in solution and on solid surfaces
2. Conduct library and internet research in order to identify compounds formed based on reactant structure, aroma and color
F. The Components of Coffee's Flavors
1. Use of common laboratory equipment to extract different organic compounds present in coffee grinds
2. Analysis and separation of extracted compounds by thin layer chromatography, with comparison to standard compounds using Rf values
G. The Color of Roux
1. Observe the effects of heat on the properties of flour and butter by making different time-dependent roux
2. Indirect quantification of roux viscosity through velocity measurements
H. Chemical Leavening Agents in Baking
1. Perform a series of gas forming chemical reactions utilizing different leavening agents to test their reactivity
2. Assess the effects of different leavening agent quantities in a biscuit recipe
3. Measure and calculate gas formation using stoichiometry and compare theoretical versus experimental yields
I. Crystallization and Chocolate Fat Bloom
1. Use of common laboratory equipment to introduce the concept of crystallization, seed crystals, and polymorphs
2. Synthesis of cocoa butter seed crystals through temperature control
3. Evaluate the formation of different polymorphs by analysis of melting point and sheen

Special Facilities and/or Equipment

Chemistry laboratory with fume hoods; hot plates; microwave; small ovens and freezers; standard laboratory glassware such as beakers, burets, flasks, graduated cylinders; analytical balances; thin layer chromatography plates.

Method(s) of Evaluation

Midterm exams utilizing both multiple choice and open-ended questions
Lecture quizzes: predominantly short answer
Laboratory quizzes: predominantly short answer
Written laboratory reports
Final cumulative examination: open-ended questions and multiple choice

Method(s) of Instruction

Lecture
Laboratory
Discussion
Group work

Representative Text(s) and Other Materials

Rodriguez-Velazquez, Sorangel. Chemistry of Cooking. 2016.

McMurry, J., M. Castellation, and D. Ballantine. Fundamentals of General, Organic and Biological Chemistry. 2016.

Timberlake, K.. Chemistry: An Introduction to General, Organic, and Biological Chemistry, 13th ed.. 2018.

Lab Manual: Tam, Victor, Ph.D. Chemistry of Cooking Laboratory Manual. 1st ed. 2014.

Types and/or Examples of Required Reading, Writing, and Outside of Class Assignments

A. Homework Assignments
1. Homework will include reading of the assigned texts and subsequent submission of short, thorough summaries of the readings.
2. Homework will include problem sets from the text for each of the main concepts covered in the course.
B. Laboratory Assignments
1. There are nine experiments performed in this course during the weekly three-hour laboratory session for which data and calculations and a post-laboratory assignment are submitted and assessed.
C. Additional Coursework
1. One or more projects and assignments will require library research or utilization of online resources such as scientific journals or texts, which will necessitate moderate time commitment outside of class.
2. Supplementary worksheets will be provided by the instructor as a resource for more challenging problems beyond those presented in the text.

Discipline(s)

Chemistry