1. **FST 3204 FOOD BIOTECHNOLOGY**
2. **COURSE INSTRUCTOR:** Mr. Julius Wambete (B Sc. Food Technology and Nutrition, Nairobi 1985, M Sc Food and Agricultural Biotechnology, Reading 1990)
3. **COURSE TYPE:**

Core course for Year 3 B Sc. Food Science & Technology

Prerequisite knowledge: Food Microbiology I & II, Food Chemistry I & II, Biochemistry I & II, Food Engineering I & II, Food Processing and Preservation, Pilot Plant Processing Skills.

1. **COURSE STRUCTURE:**

Course is 3 credit units (3 CU): 2 lecture hours and 2 practical hours per week for 15 study weeks; [i.e. 30 lecture hours & 30 practical hours, equivalent to 45 contact hours].

1. **COURSE DESCRIPTION**

The course discusses the microbiological and technological principles of industrial application of microorganisms and enzymes in food production and processing systems to provide useful products and services. Lectures cover basic properties, characteristics, structures and functions of living cells (microbial) and enzymes; metabolic pathways and how these are harnessed, manipulated and applied through natural selection, genetic engineering, optimized reactor and environmental designs and controls to increase productivity. Major fermented food product technologies are also discussed with specific references to alcoholic beverages, dairy products, biomass, solvents, organic acids, traditional fermented products and biodegradation of waste into biogas and other useful products. The practical component of the course will include pilot plant alcoholic fermentation (wine), sauerkraut and yoghurt processing. A field trip to a commercial brewery will be arranged to enhance the learning experience.

1. **COURSE OBJECTIVES**

**General Objective:**

To furnish a student with knowledge and understanding of the basic biological and chemical processes of living cells and enzymes and how these are harnessed into industrial processes and technologies for the production, processing and preservation of food and related products

**Specific Objectives**

1. Appreciate the positive role and benefits of microorganisms and enzymes in food production, processing, and preservation.
2. Understand basic biological and chemical processes of living cells, enzymes, and microbial nutrition in relation to fermentation processes
3. Understand principles of inoculum /starter culture development for industrial fermentations and fermentor /reactor design, control and operation
4. Understand both upstream and downstream unit operations and technologies used for substrate preparation and recovery and purification of fermentation products
5. Know and flowchart unit operations in the processing and production a number of fermented products such as wine, beer, cheese, yoghurt and others with examples available in Uganda.
6. Know about effluent treatment and conversion of food and agricultural waste
7. CONTENT AND ORGENIZATION

The course is organized into 4 complementary sections:

* 1. Section one introduces and deals with the relationship between biotechnology, food production, food processing, and the nutritional quality of foods, highlighting the positive role and benefits of microorganisms and enzymes in food production, processing, and preservation.
  2. Section two reviews the fundamentals of microbial cell metabolism, nutrition, ecology and growth; microbial cultivation processes including growth characteristics, kinetics, models, fermentor design and operation, starter culture development; enzymes kinetics and enzyme reactors.
  3. Section three focuses on examples of applications of microorganisms and enzymes in fermentations, bioconversions and other bioprocesses for the production of food products and ingredients including cheese, yoghurt, beer, wine.
  4. Section four centres on the applications of biotechnological processes in conversion and stabilization of food wastes into safe and value-added products.

1. RECOMMENDED REFERENCES

**Core Reading**

1. **Doelle, Horst W**, Microbial Metabolism and Biotechnology (e-copy)
2. **Hutkins, Robert W**, Microbiology and Technology of Fermented Foods, ©2006 Blackwell Publishing(e-copy)
3. **Henry C. Vogel and Celeste L. Todaro, Eds**, Fermentation and Biochemical Engineering Handbook. © 1997 by Noyes Publications (e-copy)
4. **Stanbury, P.F, S Whitake, A.** (1984). Principles of Fermentation Technology. Pergamon Press: Oxford

**Background Reading**

1. **Micheal L. Shuler & Fikret Kargi,** Bioprocess Engineering; Basic Concepts . (2006). Prentice Hall
2. **Biochemical Engineering; James M. Lee** (1992). Prentice Hall International Series
3. **Bell, G.H, Smith D. E and Paterson, C. R** (1976). Text book of Physiology and Biochemistry. 9th Edition. Churchill Livingstone, London
4. **Conn, E.E and Stumpf, P.K** (1976). 45th Edition. John Wiley & sons Inc.
5. **Lehninger, A. L** (1982). Principles of Biochemistry. Worth publishers, Inc. New York
6. **Stryer, L**. (1981). Biochemistry. 2nd Edition. W. H. Freeman and Company. New York
7. **Christopher, K.M and van Holde, K.E,** (1990). Biochemistry, The Benjamin/Cummings Publishing Company, Inc. New York
8. **Murray Moo Young,** Comprehensive Biotechnology Vol-4,
9. **Rehm and Reid**, Biotechnology-
10. **R. M. Maier, I. L. Pepper & G. P. Gerba**: Environmental Microbiology*.*
11. **COURSE CONTENT, METHODS OF INSTRUCTION, TOOLS AND EQUIPMENT REQUIRED**

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|  | **TOPIC** | **CONTENT** | **METHOD OF INSTRUCTION / Time allocated** | **TOOLS / EQUIPMENT NEEDED** |
| 1.1 | **Positive and Beneficial Role of Microorganisms and Enzymes in Food Processing** | Preservation, Generation of desirable flavours and aromas  Nutrient Enrichment, Enhancement of Digestibility and Bioavailability  Transformation and Modification, Production of Valuable Products,  Technical and Functional Roles | * Lecture (1 hr) * Group assignment & presentations (2hrs) | * Visual aids [LCD projector / white board & BB markers] * e-Handout |
| 2.1 | **Cell Biology** | Structures, Organization and Function | * Lecture (1hr) | * Visual aids [LCD projector/ white board & BB markers] * e-Handout |
| 2.2 | **Microbial Metabolism and Nutrition** | Basic Concepts of Metabolism, Carbohydrate Metabolism, Glycolysis and Other Metabolic Pathways, Fermentation, Principles of thermodynamics and Bioenergetics, Nutritional requirements, Nutritional types of microorganisms, Cellular transport by a prokaryotic cell, Types of media for cultivation of microbes  Cultivation of anaerobic organisms. | * Lecture (4hr) * Group assignment & presentations (2hrs) | * Visual aids [LCD projector/ white board & BB markers] * e-Handout |
| 2.3 | **Microbial Growth** | Phases of microbial growth, Effect of nutrient conditions, temperature, O/R potential, water activity, pressure, pH, light etc, on bacterial growth, Measurement of bacterial growth, Monod kinetics of bacterial reproduction, product formation, Batch Culture,  Continuous culture using Chemostat and Turbidostat and its kinetics.  Fed batch Culture | * Lectures (4 hrs) | * Visual aids [LCD projector/ white board & BB markers] * e-Handout |
| 2.4 | **Starter Culture Development** | Desirable properties of the “*Ideal Organism”,* Principles of Selection, Isolation, Preservation and Improvement of microbial culture | * Lectures (2 hrs) | * Visual aids [LCD projector/ white board & BB markers] * e-Handout |
| 2.5 | **Fermentor Design and Operation** | Design criteria: Productivity and operational requirements, media rheology, substrate supply and flow rates, materials of construction,  sterilization considerations, maintenance of aseptic conditions, heat and oxygen transfer requirements  Instrumentation | * Lectures (2 hrs) | * Visual aids [LCD projector/ white board & BB markers] * e-Handout |
| 2.6 | **The recovery and purification of fermentation products** | Intracellular and extracellular products, Foam separation, Precipitation, Filtration, Centrifugation, Cell Disruption :  Physical- mechanical methods, Chemical methods, Liquid – liquid extraction, Solvent Recovery, Chromatography , Ultra filtration, Drying, Crystallization | * Lecture (2hrs) * Group assignment & presentations (2hrs) | * Visual aids [LCD projector/ white board & BB markers]; * e-Handout |
| 2.7 | **Introduction to Enzyme Catalysis** | **Protein Structure:** Primary, secondary, tertiary and quaternary structure, techniques, **Enzyme classification:** IUB enzyme classification, **Enzyme Activity:** Principle and techniques of enzymatic analysis, factors affecting enzyme activity, **Sources of enzymes, their extraction and purification of enzyme:** Objectives and strategy, separation techniques, test of purity. | * Lecture (2hr) | * Visual aids [LCD projector/ white board & BB markers] * e-Handout |
| 2.8 | **Overview of Enzyme Catalysis and Kinetics:** | **Bioenergetics and Catalysis**: Single substrate kinetics: Equilibrium and Steady state kinetics, significance of Km, Vmax & Kcat, Pre-steady state and Relaxation kinetics  **Multisubstrate kinetics**: General rate equation, compulsory order, random order and pingpong mechanisms and their primary and secondary plots, **Enzyme inhibition and its kinetics:** Reversible and irreversible inhibition, competitive, non-competitive and uncompetitive, mixed, partial, substrate and allosteric inhibition  **Thermal kinetics:** Effect of temperature on reaction rate, enzyme stability, Arrhenius equation and activation energy, **Mechanism of Enzyme Action:** Enzyme activators, co-enzymes and co-factors in enzyme catalysis, Enzyme and substrate specificity, Investigation of active Centre, Factors affecting catalytic efficiency, Experimental approaches to determine enzyme mechanisms, **Enzyme mechanisms:** Lysozyme, Chymotrypsin, Carboxypeptidase, Restriction  endonuclease, Aspartate transcarbomylase, **Allosteric enzymes and sigmoidal kinetics:** Protein ligand binding, Co-operativity, MWC & KNF models, Regulation of enzyme activity. Control of metabolic pathways, **Enzyme engineering:** Chemical modification of enzymes: methods of modification of primary structure, catalytic and allosteric properties, use of group specific reagents. | * Lecture (4hr) * Group assignment & presentations   (2hrs) | * Visual aids [LCD projector/ white board & BB markers] * e-Handout |
| 3.1 | **Production fermented food products** | Production of Cheese, Beer Brewing, Wine Making, Sauerkraut Production, Yoghurt Production | * Lecture (6hr) * 3 fermentation and 1 malting Practical (12hrs) * 2 Field trips (6hrs) | * Visual aids [LCD projector/ white board & BB markers] * e-Handout * Assorted Pilot Plant Equipment , Raw materials and Ingredients * Transport |
| 4.1 | **Solid waste management** | Utilization of wastes for production of food, fuel and fertilizers, Integrated processes and strategies in food production and solid waste management. | * Lecture (2hr) * Group assignment & presentations (2hrs) | * Visual aids [LCD projector/ white board & BB markers] * e-Handout |

1. **SUMMARY OF TIME NEEDED**

Interactive lectures covering theory 30 hrs

Pilot Plant -based Practical 12 hrs

Group Assignments and Presentations 12 hrs

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| Field Trip 6hrs |

1. **OVERALL COURSE EVALUATION**

Continuous Assessment Test 10%

Pilot Plant Practical, 20%

Group Assignments and Presentations 10%

University Examination 60%