NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

COURSE CONTENT

Academic Year	2023/2024	**Semester**	1
Course Coordinator	Professor Chen Wei Ning, William		
Course Code	CH5222		
Course Title	Future Foods – Introduction to Advanced Meat Alternatives		
Pre-requisites	Study Year 3 or 4		
No of AUs	3		
Contact Hours	39 (26 hours of lectures, 13 hours of e-learning)		
Proposal Date	Aug 2021		

Course Aims

The course aims to equip you with knowledge of the rapidly growing and innovative field of alternative proteins which is developing advanced replacements for traditional meat products. You will gain an understanding of the core scientific principles and three main technologies in the field – cultivated meat, plant-based meat and fermentation. As part of the course, you will develop a research proposal to address a real-world challenge facing the industry. This course is designed for students with a background in biochemistry who are interested in this emerging, fast-growing industry that aims to mitigate issues of climate change, food safety, health and welfare challenges currently facing humanity.

Intended Learning Outcomes (ILO)

By the end of this course, you (as a student) would be able to:

1. Explain the scientific principles, methodology and applications of cultivated meat, plant-based meat and fermentation technologies as replacements for animal-derived food products.
2. Develop a research proposal to address scientific or engineering challenges currently facing the alternative protein sector.
3. Summarize the market opportunities and challenges for researchers, professionals and businesses in the alternative protein sector.
4. Describe and evaluate the textural, nutritional and sensory characteristics required for alternative protein food products to meet consumer expectations.
5. Describe the regulatory environment, government position and unique opportunities for alternative proteins in Singapore.

Course Content

This course includes the study of:

Introduction to cultivated meat

Introduction to plant-based meat

Introduction to fermentation

Cultivated meat - cells and cell differentiation

Cultivated meat – cell culture and measurement tools

Cultivated meat – tissue engineering

Cultivated meat - tissue engineering part two

Meat composition and structure

Raw materials in plant-based meat and association plant processing technologies

Plant based meat product development and texturization technologies.

Plant-based meat texture and nutrition optimization, regulations & white space opportunities

Fermentation process and applications for alternative proteins

Invited lectures from industry professionals and entrepreneurs in Singapore and globally (three guest lecture, 1 hour each)

Alternative protein market and opportunities (GFI guest lecture)

Alternative protein industry in Singapore – regulation, IP, and entrepreneurship.

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/Individual	Assessment Rubrics
Continuous Assessment					
1. Assignment 1– Literature review and summary – review articles	1, 2, 3, 4	A, B, C, D, I, L (see Appendix 2)	20%	Pair	Refer to Appendix 1
2. Assignment 2 – Literature review and summary – regular articles	1, 2, 3, 4	A, B, C, D, I, L (see Appendix 2)	20%	Pair	Refer to Appendix 1
3. Major Project	1, 2, 3, 4, 5	A, B, C, D, G, I, L (see Appendix 2)	60%	Pair	Refer to Appendix 1
Total			100%		

Formative feedback

Describe how you would be giving feedback to students on how they are learning in this course.

1. Pair assignment reports will give general comments on assignment performance and highlight those areas well answered and those that were poorly answered and how they can be improved for subsequent learning and assessments. One-on-one or group meetings will be offered to students who wish to discuss their feedback in more detail.
2. Attendance at lectures will be monitored and students that do not regularly attend lectures and adequately contribute to post-lecture discussions will be contacted. Students that do not improve from this initial contact will have a one-on-one meeting set-up to discuss the lack of lecture engagement.
3. Final project reports will give general comments on assignment performance and highlight those areas that were well answered and those that were poorly answered. One-on-one meetings will be offered to students who wish to discuss their feedback in more detail.

4. A discussion group will be set up for students to communicate between themselves and with the instructor regarding any lecture material and the above assessments. Any emails received from students to the instructor will be directed here and discussed, unless confidential in nature.

All feedback modes relate to all learning outcomes.

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Project-based Learning (1 AU)	Course assignments and the major project were designed to help students learn through project-based learning. This approach encourages self-learning with guidance by the course staff, and includes literature review and summary, ideation and developing scientific writing skills. Assignment 1 requires reading and summarizing papers and a book chapter that were collected for the students based on their technology of choice and to suggest 1-3 project ideas. After input from the course staff, in assignment 2, students require to perform a short literature review on their project idea of choice and to suggest relevant experiments based on experiments seen in the literature review. Finally, in the final projects, students need to gather the information and write a short research proposal. This will help students build reading, writing, ideation and experimental design skills.
Group assignments	This will provide opportunity for you to learn from one another and to become active participants in their learning. With group-based work helps students will develop skills valued by employers (such as problem solving, negotiation, conflict resolution, leadership, critical thinking and time management)
Lectures (2 AU)	The lectures are the critical vehicle to communicate the key points of a large body of knowledge regarding various aspects of alternative proteins. Acquiring the information presented in the lectures will provide the intellectual framework to achieve the Intended Learning Outcomes. A typical lecture will include basics followed by examples/ case studies to enhance learning. Lecture content is updated yearly based on recent publications and advancements in the field.

Reading and References

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OPTIONAL

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* Dey, Tania. Fennema's Food Chemistry, Fourth Edition, Edited by Srinivasan Damodaran, Kirk L. Parkin and Owen R. Fennema. Journal of Dispersion Science and Technology - J DISPER SCI TECH. 10.1080/01932691.2011.584482. (2011)
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* Yin, H., Price, F. & Rudnicki, M. A. Satellite cells and the muscle stem cell niche. Physiol. Rev. 93, 23–67 (2013).
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*Hadnadjev, Miroslav & Dapčević Hadnađev, Tamara & Pojić, Milica & Šarić, Bojana & Mišan, Aleksandra & Jovanov, Pavle & Sakač, Marijana. Progress in vegetable proteins isolation techniques: A review. Food and Feed Research. 44. 11-21. 10.5937/FFR1701011H. 2017

Course Policies and Student Responsibilities

(1) General

Students are expected to complete all assigned pre-class readings and activities and attend all seminar classes punctually. Students are expected to take responsibility to follow up with course notes, assignments and course related announcements for seminar sessions they have missed. Students are expected to participate in all seminar discussions and activities.

(2) Online Compulsory Assignments

You are required to submit online compulsory assignments on due dates. Late submission without a valid reason will affect your assessment grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

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Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Course introduction and introduction to cultivated meat	1, 2, 3, 4	Primary scientific literature and online video/seminar.
2	Introduction to plant-based meat, Introduction to fermentation	1, 2, 3, 4, 5	Primary scientific literature and online video/seminar.
3	Cells and Cell Differentiation	1, 2, 3	Primary scientific literature and online video/seminar.
4	Cell culture and measurement tools	1, 2, 3	Primary scientific literature and online video/seminar.
5	Tissue Engineering Guest lecture (number 1)	1, 2, 3	Primary scientific literature and online video/seminar.
6	Tissue Engineering (continued)	1, 2, 3, 4	Primary scientific literature and online video/seminar.
7	Meat composition and structure Alternative protein market and opportunities (GFI guest lecture)	1, 2, 3, 4, 5	Primary scientific literature and online video/seminar.
Recess Week			
8	Raw materials in plant-based meat and associated plant processing technologies	1, 2, 3, 4	Primary scientific literature and online video/seminar.
9	Development of plant-based meat products and associated texturization technologies	1, 2, 3, 4	Primary scientific literature and online video/seminar.
10	Plant based meat texture and nutrition. Guest lecture (number 2)	1, 2, 3, 4	Primary scientific literature and online video/seminar.
11	Fermentation techniques and challenges for alternative proteins	1, 2, 3, 4	Primary scientific literature and online video/seminar.
12	Fermentation for alternative proteins part two	1, 2, 3	Primary scientific literature and online video/seminar.
13	Alternative protein industry in Singapore Guest lecture (number 4)	1, 2, 3, 5	Primary scientific literature and online video/seminar.

Appendix 1: Assessment Rubrics

Please note that partner assessment will form a part of your mark for Assignment 1 and 2 and the Major Project as detailed below. However, if there is evidence that you have significantly neglected to contribute to your teammate's work throughout the course your score may vary further. Please see the partner assessment rubric at the end of Appendix 1 for more information.

Assessment Criteria for Assignment 1 – Literature summary – review articles

(Total mark will be scaled to 20%)

Criteria	Requirement for a high mark	Mark %
Technology segment motivation and background	• Clearly summarise the motivation for development, and general background, of your technology of choice based on relevant review papers.	40
Research idea development	• Highlighted research gaps and potential project ideas are clearly summarised conveying a clear understanding of your technology of choice and some research gaps that could be addressed. • Answers clearly and coherently link research ideas to possible market applications.	10
Writing style	• Grammatically faultless • Arguments linked • Coherence of text throughout document • Text is completely original and based on clear student understanding and synthesis of information from multiple sources	10
Insight/interpretation	• Dynamic interpretation of competing theories or methods addressed	10
Accuracy of information	• Information flawlessly presented • Scientific and common names and terms used accurately	10
References	• Evidence of background reading beyond what was provided • Proper citation and reference list	10
Partner Assessment	• This mark will be based on students rating of their partner using the partner assessment rubric at the end of Appendix 1.	10
	Total	100

Assessment Criteria for Assignment 2 - **Literature review and summary – regular articles**

(Total mark will be scaled to 20%)

Criteria	Requirement for a high mark	Mark %
Research idea development	• Research project proposal topic is clearly defined and conveys a strong understanding of the chosen technology and research gaps • Experiments, protocols and data collection methods for the proposal are relevant and logically summarised • Dynamic interpretation of different potential methods that could be employed are addressed (if relevant)	50
Insight/interpretation	• Discussion of related research article(s) is highly relevant to the research proposal and its related concepts are clearly highlighted • Evidence of background reading beyond what was provided • Proper citation and reference list	20
Accuracy of information	• Information flawlessly presented • Scientific and common names and terms used accurately	10
Writing style	• Grammatically faultless • Arguments linked • Coherence of text throughout document	10
Partner Assessment	• This mark will be based on students rating of their partner using the partner assessment rubric at the end of Appendix 1.	10
	Total	100

Assessment Criteria for Major Project – Research Proposal

(Total mark will be scaled to 60%)

Criteria	Requirement for a high mark	Mark %
Concepts and goals	• Research idea is novel, addresses a gap in current knowledge and is linked to measurable results • Hypothesis and research goal(s) are clearly identified and logically address the research idea in a practical manner • The research proposal is clearly linked to an application in the alternative protein field.	35
Experiments and experimental design	• Overall experimental design is scientifically feasible, clearly tests the stated hypothesis and would achieve the research goals. • Appropriate individual experimental methods and data to be generated (i.e. what parameters will be varied, what measurement is to be quantified) are identified and modified where appropriate to best address each sub-task of the research plan.	25
Structure and logical presentation	• Research proposal progresses logically through each section • Introduction clearly introduces and defines all relevant aspects of the proposal and highlights relevant recent scientific developments and challenges	10

	• Research plan is separated into logical sub-tasks that clearly address the research proposal hypothesis	
Accuracy of information	• Information flawlessly presented • Scientific and common names and terms used accurately • Proper citation and reference list	5
Writing style	• Grammatically faultless • Arguments linked • Coherence of text throughout document	5
Partner Assessment	• This mark will be based on students rating of their partner using the below partner assessment	20
	Total	100

Partner Assessment Rubric

Please indicate your perceptions of other team member's contribution during the project development. Use the scale below for assessing each team member.

10-9	8-7	6-4	3-1	0
Demonstrate outstanding contributions and efforts during teamwork.	Exhibited appropriate effort in contributions during teamwork.	Made some contributions but greater effort could have been exhibited during teamwork.	Did not contribute much effort during teamwork.	Made no effort to contribute during teamwork.

Team member:											
Preparation for work accomplishment: completed readings.	10	9	8	7	6	5	4	3	2	1	0
Task-related collaborative behavior: task-focused, respectful of others, and cooperative.	10	9	8	7	6	5	4	3	2	1	0
Team adjustment behaviors: intra-team coaching, problem solving	10	9	8	7	6	5	4	3	2	1	0
Work behaviors: involved and participatory	10	9	8	7	6	5	4	3	2	1	0
Communication: information shared and exchanged, engaged in process, and made verbal contributions.	10	9	8	7	6	5	4	3	2	1	0

Appendix 2: The EAB (Engineering Accreditation Board) Accreditation SLOs (Student Learning Outcomes)

a) **Engineering knowledge**: Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.

b) **Problem Analysis**: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c) **Design/development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

d) **Investigation**: Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

e) **Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

f) **The engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

g) **Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for the sustainable development.

h) **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

i) Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.

j) **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

k) **Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

l) **Life-long Learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.