Module title[1]:	Quantitative Tools for Sustainable Food and Energy in the food chain		
Module code:	XXXX		
Module coordinator:	XXXX		
Other contributors:	Prof. Serafim Bakalis, Dr. Enda Cummins, Dr. Maria Gougouli, Ass. Prof. Almudena Hospido, Prof. Kostas Koutsoumanis, Dr. Estephania Lopez-Quiroga, Dr. Jeanne-Marie Membré , Mr. Ismael Martínez Lede, Dr. Vasilis P. Valdramidis, Prof. Jan Van Impe, Dr. Enda Cummins		
Semester:	2		
Credits:	5	Level:	4
Overview of module:	The specific objectives of this module are: (i) to develop each participants capacity to design and generate informative experimental data, (ii) to understand model structure development and selection to describe quantitatively chemical, microbiological and physical phenomena along the food chain and develop capabilities for quantifying accurately the sources of stochasticity, (iii) to make participants familiar with optimisation and risk assessment software tools, that can be exploited for developing mathematical models/quantitative risk assessments to aid decision-making for sustainable and safe food production . (iv) introduce participants to sustainability issues with the focus on environmental managements tools (e.g., LCA, carbon footprint) and energy optimization. Theoretical lectures will be alternated with problem-based learning (PBL). Theoretical lectures will cover the fundamentals and basic principles of predictive modelling and risk assessment. Additionally, PBL pedagogical tools will be used in which students will work in groups to solve realistic multifaceted problems with the use of computer		

	programming software. These problems will include the construction of experimental designs, model calibration, sensitivity analysis and safety risk scenarios.
Learning outcomes:	By the end of the programme students will: (i) have attained a fundamental understanding of the substantial body of applied modelling, statistics and recent developments in the field of Predictive Modelling and Quantitative Risk Assessment of foods, energy optimization and life cycle assessment (ii) have exercised personal responsibility and autonomous initiative in solving complex food safety and spoilage problems that are solved in a rigorous and sound approach, (iii) have engaged in critical dialogue and learned to criticise the broader implication of Applied Modelling approaches in Food Science, Technology and Engineering through interactive teaching, (iv) have the ability to analyze food production and processes from a broader sustainability perspective taking into account life cycle thinking, (v) have exploited available software packages and quantitative approaches for enriching current studies in the field in order to communicate results and innovations of research to peers.
Assessments:	Assessment will consist of a number of assignments, MCQs, group projects and continuous assessments. This is broken down as follows: 1. Student preparation activity- Poster presentation detailing research area and the role quantitative approaches have/can play in their research area. (All - 15%) 2. Static experimental design and model calibration - scientific computing subroutine submission (Valdramidis - 10%) 3. Dynamic experimental design and model calibration – scientific computing subroutine submission (Van Impe -

	10%) 4. MCQ on theoritical elements of risk assessment and the use of probability distributions (Cummins - 10%) 5. Quantitative risk assessment during food processes - spreadsheeet submission (Membré - 10%) 6. Quantitative risk assessment during food storage - spreadsheeet submission (Koutsoumanis - 10%) 7. Process modelling - spreadsheeet submission (Bakalis – 10%) 8. Preliminary definition of the scope of a life cycle analysis - spreadsheeet submission (Almudena – 10%) 9. Final project (All - 15%)
Workload	Hours Lectures 15 Computer laboratory 40 Learning activities (in class assignments) 25 Autonomous student learning 30 Total workload 110

Day, time	Major topics covered in lectures	Laboratory activity	Other activity	Assessment
Monday 23.03 9-9.20 am 9.20- 10.00 am 10.00 -12.30am 2-5.00pm	**Introduction (Dr. V. Valdramidis)** 1. Overview 2. Expectations 3. Reporting requirements **External speaker from industry** **Student preparation activity (All) (cont.)** 4. Poster presentation session **Lecture: Modelling in Bioscience and Food (Prof. J. Van Impe & Dr. V. Valdramidis)** 1. Predictive microbiology fundamentals 2. Multiscale mathematical modeling		Student poster presentations Designated student activity	Presentations graded by teachers (15%)

Tuesday 24.03 9-12.00 am 2-5.00pm	**Lecture: Modelling in Bioscience and Food (Prof. J. Van Impe & Dr. V. Valdramidis)** 3. Predictive microbiology : Microbial growth and inactivation, growth/ no growth **Computer lab work: Modelling in Bioscience and Food (Prof. J. Van Impe & Dr. V. Valdramidis)** 4. Introduction to (freeware) software for microbial growth and inactivation, growth/no growth	Computer laboratory, with in class tasks	Designated student activity	
Wednesday 25.03 9-12.00am	**Lecture: Modelling in Bioscience and Food (Prof. J. Van Impe & Dr. V. Valdramidis)** 5. Model calibration based on informative experiments : static and dynamic approaches		Designated student activity	

2-5.30 pm	**Computer lab work: Modelling in Bioscience and Food (Prof. J. Van Impe & Dr. V. Valdramidis)** 6. Construction of experimental designs, regression anaysis	Computer laboratory, with in class tasks		Submission of spread sheet anaysis (10%)
Thursday 26.03 9-12.00am	**Computer lab work: Risk Assessment (Dr. E. Cummins)** 7. Introduction 8. Overview, Risk management, risk communication, risk assessment 9. Stages in risk assessment 10. Why do a risk assessment **Introduction to @Risk (Dr. E. Cummins)** 11. Introduction to modelling tools – Introduction to @Risk 12. Deterministic vs stochastic 13. Distributions – uncertainty and variability 14. Monte Carlo simulation		Designated student activity Designated student activity	

2-5.00pm	**Discussion time and preparation of final project**			
Friday 27.03 9-12.00 am 2-5.00 pm	**Problem solving exercises (Dr. E. Cummins)** 15. Overview of binomial process and application of probability distributions (beta, binomial, negαtive-binomial) to solve food safety problems. **Computer Lab session: Quantitative Microbial Risk Assessment during Food Processing (Dr. J.-M. Membré)** 16. Introduction to the case study: Bacillus cereus in cooked chilled products (REPFEDs)	Computer laboratory to solve food safety problem using risk assessment tools Optimization of the thermal pasteurization settings (process criteria) to achieve a given PO (PO defined as “no outgrowth of injured spores at the manufacture product release”)		End of session MCQ (10%)

	17. Model conceptual framework **Computer Lab Session: Probabilistic modeling of heat treatment processes (Dr. J.-M. Membré)** 18. Model development – Data fitting – Distributions selection	Raw material analysis, thermal reduction, thermal inactivation (spore lag time). Implementation of inputs: deterministic/ probabilistic, expert elicitation, data collection….		
Saturday 28.03	**Free time**			
Saturday 29.03	**Free time**			

Monday 30.03 9-12.00am	**Computer lab work: Quantitative Microbial Risk Assessment during Food Processing (Dr. J.-M. Membré)** 19. Sensitivity analysis 20. Scenario analysis	Impact of variability and uncertainty associated with each input to the results, finalization of the QMRA model Presentation of results - optimization of process criteria (thermal pasteurization settings) for different product formulations (pH and aw)	Designated student activity	Submission of spread sheet anaysis (10%)

2-5.00pm	**Computer lab work: Quantitative Microbial Risk Assessment during Food Storage (Prof. K. Koutsoumanis & M. Gougouli)** 21. The use of Predictive Microbiology in Quantitative Microbial Risk Assessment during Food Storage 22. Hand-on on the existing predictive tools-data -Sources of variability in microbial growth -Stochastic models of microbial growth during distribution and storage of foods 23. A risk-based approach to evaluate the compliance of foods with the food safety criteria Case study for shelf-life determination		Designated student activity	

Tuesday 31.03 9-12.00 am 2-5.00 pm	**Lecture: Quantitative Microbial Risk Assessment during Food Storage (Prof. K. Koutsoumanis & Dr. M. Gougouli)** 24. A risk-based approach to evaluate the compliance of foods with the food safety criteria **Computer lab work: Quantitative Microbial Risk Assessment during Food Storage (Prof. K. Koutsoumanis & Dr. M. Gougouli)** 25. Hand-on training on available software for predictive microbiology and risk assessment 26. Risk-based Shelf life assessment of foods **Lecture: Integrating process modelling approaches in Microbial Modelling (Dr. S. Bakalis & Dr. Estephania Lopez-Quiroga)** 27. Introduction to Food processing 28. Estimation of Energy expenditure 29. Process optimization		Designated student activity Designated student activity	Submission of spread sheet anaysis (10%)

Wednesday 1.04 9-12.30am 2-3.00pm 3-5.00pm	**Lecture: Life Cycle Analysis (Ass. Prof. A. Hospido)** 30. Life Cycle thinking 31. Life Cycle assessment methodology **Lecture: Life Cycle Analysis (Mr. Ismael Martínez Lede, Prof. A. Hospido)** 32. Life Cycle assessment in the industry **Discussion time and work of final project**		Designated student activity Designated student activity	

Thursday 2.04 9-12.00am 2-5.00pm	**Computer lab work: Process modeling and Life Cycle Assessment. (Dr. S. Bakalis & Dr. Estephania Lopez-Quiroga)** 33. Hands-on food processing **Computer lab work: Process modeling and Life Cycle Assessment. (Prof. A. Hospido)** 34. Hands-on Life Cycle Assessment Soaftware	Model development exercise Model development exercise		Submission of spread sheet anaysis (10%) Submission of spread sheet analysis (10%)

Friday 3.04 9-12.00am 2-3.00pm	 **Students Project presentation and final assessment** 35. Working example using knowledge from previous classes. Presentation of working example **Final conclusions**		 Designated student activity	 Submission of all projects (15%)