Module title1:	Quantitative Tools for Sustainable Food and Energy in the food chain		
Module code:	XXXX		
Module coordinator:	XXXX		
Other contributors:	Prof. Serafim Bakalis, Dr. Maria Gougouli, 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		
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 and develop capabilities for quantifying accurately the sources of stochasticity, (iii) to make participants familiar with optimisation software and model simulation in research, that can be exploited for developing decision-making and quantitative risk assessment tools. (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. 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- Brief presentation by students detailing research area and the role quantitative approaches have/can play in their research area. Coupled with this will be the requirement to submit a representative list of 10 relevant publications in their subject 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 14.03 09.00-09.15 09.15-09.45 09.45-10.30 10.30-11.15 11.30- 13.30 14.30-17.30	**Introduction (Dr. V. Valdramidis)** Reception Overview of Q-SAFE project **External speaker 1 from an EU Organisation: EFSA** **External speaker 2 from industry: ANFACO-CECOPESCA** **Student preparation activity (All)** 1. 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 15.03 09.00-12.30 12.30-13.30 & 14.30-15.15 & 15.30-17.30	**Lecture: Modelling in Bioscience and Food (Prof. J. Van Impe & Dr. V. Valdramidis)** 3. Predictive microbiology : Microbial growth and inactivation, growth/ no growth **Lecture: Modelling in Bioscience and Food (Prof. J. Van Impe & Dr. V. Valdramidis)** **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	Submission of spread sheet analysis (10%)
Wednesday 16.03 09.00-13.30	**Lecture: Modelling in Bioscience and Food (Prof. J. Van Impe & Dr. V. Valdramidis)** 5. Model calibration based on informative		Designated student	

	experiments : static and dynamic approaches		activity	
14.30-15.15	**Discussion time and preparation of final project**			
15.30-17.30	**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 17.03 09.00 -13.30	**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 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	

14.30-15.15 15.30-17.30	**Discussion time and preparation of final project** **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 laboratory to solve food safety problem using risk assessment tools		End of session MCQ (10%)
Friday 18.03 09.00-11.00 11.30 - 14.00	**Discussion time and preparation of final project** **Computer lab work. Quantitative Microbial Risk Assessment (QMRA) during food processing (Dr. J.-M. Membré)** 16. Introduction to case study: Bacillus cereus in cooked chilled products	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”)		

From 16.00	17. Practise on QMRA key process steps: heat treatment, partitioning and bacterial growth **Social event: tour + dinner.**	Raw material analysis, thermal reduction, thermal inactivation (spore lag time).		
Saturday 19.03	**Free time**			
Saturday 20.03	**Social event: trip to Finisterre**			

Monday 21.03 09.00-13.30	**Computer lab work. Quantitative Microbial Risk Assessment (QMRA) during food processing (Dr. J.-M. Membré)** 18. QMRA model development - check list before jumping on equations 19. Inputs: data fitting, selection of distributions 20. Model interpretation: sensitivity analysis 21. Outputs: Scenario analysis	Implementation of inputs: deterministic/ probabilistic, expert elicitation, data collection…. 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	Designated student activity Designated student activity	Submission of spread sheet anaysis (10%)

14.30-17.30	**Computer lab work: Quantitative Microbial Risk Assessment during Food Storage (Prof. K. Koutsoumanis & M. Gougouli)** 22. The use of Predictive Microbiology in Quantitative Microbial Risk Assessment during Food Storage 23. 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 24. A risk-based approach to evaluate the compliance of foods with the food safety criteria Case study for shelf-life determination	settings) for different product formulations (pH and aw)		

Tuesday 22.03 09.00-13.30 14.30-17.30	**Lecture: Quantitative Microbial Risk Assessment during Food Storage (Prof. K. Koutsoumanis & Dr. M. Gougouli)** 25. 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)** 26. Hand-on training on available software for predictive microbiology and risk assessment 27. Risk-based Shelf life assessment of foods **Lecture: Integrating process modelling approaches in Microbial Modelling (Dr. S. Bakalis & Dr. Estephania Lopez-Quiroga)** 28. Introduction to Food processing		Designated student activity Designated student activity	Submission of spread sheet anaysis (10%)

	29. Estimation of Energy expenditure 30. Process optimization			
Wednesday 23.03 09.00-11.00	**Computer lab work: Process modeling and Life Cycle Assessment. (Dr. S. Bakalis & Dr. Estephania Lopez-Quiroga)** 31. Hands-on food processing	Model development exercise	Designated student activity	Submission of spread sheet analysis (10%)
11.30 -13.30	**Lecture: Life Cycle Analysis (Prof. A. Hospido)** 32. Life Cycle thinking 33. Life Cycle assessment methodology	Model development exercise	Designated student activity	
14.30-17.30	**Computer lab work: Life cycle assessment and carbon footprint calculations (L. Roibás)** 34. Hands-on Life Cycle Analysis			Submission of spread sheet anaysis (10%)

Thursday 2.04 09.00-09.30 09.30-11.00 11.30-14.00 15.00-17.00 17.00-17.30	**Trip to Feiraco facilities** **Lecture: Life Cycle Analysis (Mr. Ismael Martínez Lede, Prof. A. Hospido)** 35. Life Cycle assessment in the industry **Visit to Feiraco's facilities (dairy factory)** **Visit to Feiraco's facilities (farm)** **Return to Santiago de Compostela**			
Friday 3.04 09.00-11.30 12.00-13.00	**Students Project presentation and final assessment** 36. Working example using knowledge from previous classes. Presentation of working example **Final conclusions**		Designated student activity	Submission of all projects (15%)