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A Modern Approach to Teaching Agri-Food Sciences in the Context of Sustainability and Climate Change Issues

Abstract. In this article we propose an approach to developing interdisciplinary teaching modules (ITeM) for sustainable management in agri-food systems, based on our experiences as academic teachers and researchers involved in agri-food disciplines. Each teaching module consists of a series of lectures either for 1st level (bachelor) or 2nd level (master) students. A model of the course is presented and recommended for teaching programmes in the area of Food Science and Technology, Agricultural Science, Food Engineering, Environmental Engineering, Food and environmental Biotechnology.

Keywords: food, agriculture, food quality and safety, climate change, law and regulations

1. Introduction

Nowadays academic teaching needs to focus much more attention on environmental issues related to agri-food system sustainability in a changing world. Apart from the basics of chemistry, biochemistry, biology and engineering, students are not sufficiently aware of how the water, soil, energy saving, and "zero waste strategies" for food industries might benefit both the production and distribution costs, so giving an important contribution to the mitigation of climate change.

Many basic processes in industry demand high quantities of water and energy (heating, cooling, particle size reduction, mass transfer, etc.) and apart from be-

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ing the basis for manufacturing are also needed for increasing safety and quality of the products. A tremendous amount of energy (and money) delivered to such processes contributes to the influence on climate changes by human activities. There is increasing interest from all involved stakeholders (e.g. producers, distributors, consumers, policy makers etc.) in the reduction of both economic and environmental costs. To achieve this goal, the understanding of all factors that may have an impact on certain processes is essential.

The revision of production and consumption patterns in the agri-food system needs to start from educational programmes, and both teaching programmes and methods should be revised and devised with this objective. This is work for academic teachers. The higher education system should built new bridges between science and industry. Universities are the most appropriate place to merge knowledge from basic science like biology, microbiology, chemistry, food technology and law to present new approaches to teaching, implied as a balance between consumer expectations, capabilities of producers and distributors and environment protection.

As academic teachers and researchers involved in agri-food sector disciplines, our goal is to propose novel interdisciplinary teaching modules (ITeM) in sustainable management of agri-food systems, consisting and based on aims listed in chapters as follows: Food processing, Food quality, Food safety, Recycling and valorization, Regulations.

The teacher/scientist involved in all the above-mentioned fields should combine their knowledge to build teaching modules (single subjects) where every branch will be led by a different teacher (according to their knowledge) ant implemented by other teachers of the module to edify the highest quality of interdisciplinary teaching. Table 1 resumes the organization of ITeM, which will be explained in detail in the following chapter related to the five modules.

Table 1. Resuming scheme with the main characteristic of the proposed ITeM

Interdisciplinary course characteristics			
Suggested for	Food Science and Technology, Agricultural Science, Food Engineering, Environmental Engineering, Food and environmental Biotechnology		
Implemented disciplines	Food and environmental Microbiology, Food Chemistry, Food and Environmental Biotechnology, Legislation		
Modules	1– food processing, 2 – food quality, 3 – food safety, 4 – recycling and valorization, 5 – legal regulations		
Academic level	Vocational school/college	Bachelor	Master
Teaching methods	Lecturing, exercises, teacher-led team working	Lecturing, exercises, student-led team working, brain storming	Lecturing, exercises, brain storming, problem solving, student reporting

Source: own elaboration.

2. Module 1: Food processing

The agri-food system is characterized by a complex and dynamic interaction that starts with the use of the natural resources (land, water, solar radiation, biological diversity, etc.) and has confluence with the food processing procedures. Food industries are connected to the agriculture system, that supplies vegetal- and animal origin raw materials, and the distribution chain and final consumers, with expectations about quality, safety, costs, but also emerging ones related to hedonistic consumption, health benefits, different dietary attitudes, attention to the environment (e.g. organic food) and other. Thus, food processing procedures are already under great transformation and all steps involved in food production must constantly develop according to the expectations of the market, so as rapid changes in law and regulations that deals with health and safety along with environment protection.

An interdisciplinary teaching approach ought to be designed with food processing, as a key step that receives all the input from external factors and needs to comply with old and new issues, including saving of natural resources, climate change effects on quality and safety of final products, and new regulations at national and international level.

Students who are completing their study programmes should be aware of how basic production processes may impact on the environment (climate, natural resources) but also on the economic aspect of production. During their studies, it should be highlighted that basic processes (e.g. reducing in particle size, heating, cooling) that are water and energy demanding can be conducted in a more environmentally-friendly way.

From incremental innovation the goal for modern food technologies is the rebuilding and redesigning of the technological line to use heat transfer more efficiently. In the proposed teaching module, those issues are highlighted during every process description such as the dependency of conditions surrounding the new design. To do this, the teaching module starts with the description of the most common steps in food process lines highlighting critical points in which energy and water consumption can be oriented in a different way, to comply with the new issues of sustainability, environment protection and emission reduction. Food technologies rely on basic equipment and machinery that is shared by different productions (e.g. washing and sorting, fermenters, autoclaves, ovens, dryers, cooling systems, etc.). The teaching module will schematically report all their principles of working, highlight all parts that can be redesigned. Students will be actively involved in brainstorming and group work sessions to develop possible change and adaptation of the original design to follow scenarios of low energy and water consumption, use of alternative technologies (e.g. high pressures, microwave etc.) that may increase the efficiency of the process.

3. Module 2: Food quality

Currently food production processes are aimed at preserving the maximum output of product quality parameters. Maintenance of the highest quality attributes of food is often linked to minimizing the food processing. Some of the main factors that may negatively affect the product quality are high temperature and light. It should be emphasized that at the same time heat treatment process cannot be completely excluded from processing operations in order to stabilize and ensure the safety of the final product. Currently, processes requiring heat treatment of the product are carried out in minimum time with minimum temperature necessary to comply with food safety. The reformulation of the processes should allow the improvement of the performance of their application looking at both economic gain and environmental protection. The role of the module teacher is not only in showing the needs of each process, but also their implications for the technological line, affecting company finances and environmentalimpact.

Moreover, the climate change effects on some food crops is already forcing food industries to change the processing procedures in order to keep the final product's added compounds value, such as facing major changes in basic constituents. Wine industries are currently facing problems of higher temperatures during grape ripening and wine fermentation, with consequent unwanted higher ethanol content in final products and less stability of secondary compounds related to the wine taste [Mozell & Thach 2014: 81-89]. Level of vitamins, antioxidants etc. might be influenced by the increase of the seasonal variation of temperatures, rainfall regime, emerging new plant and animal pathogens in previously safe climate zones etc. thus forcing food industries to counterbalance this variability [Mattheis & Fellman 1999: 227-232; Stanley & Kays 1999: 233-247; Seung & Kader 2000: 207-220; Altunkaya & Gokmen 2008: 1173-1179]. In the food quality module, after the presentation of some case-studies in that field, student will be actively involved in the discussion of possible new strategies for increasing or maintaining the quality level of food products, by facing the new issues of sustainability and climate changing.

4. Module 3: Food safety

At present, microbiological safety of food is mainly based on the use of high temperature treatment or sanitizers (like chloride in the washing steps of raw materials), that are effective against pathogenic microorganisms. Other treatments are often coupled to temperature treatment to increase both the safety and the shelf life, like the use of salt, nitrates, sulfites, and other preservatives with bacteriostatic effect. The time-temperature level treatments are determined on the basis of the product characteristics (e.g. physical status, thermal stability of sensory and functional compounds, form, type and size of packaging etc.). From a water and energy saving perspective, food technologies can be consistently revised in order to increase the efficacy of the "killing steps" treatment coupling to reduction in water, chemicals and thermal energy use. The ITeM will be focused on the description of case studies in which food industries improved the treatment effectiveness together with consistent reduction of water use and time-temperature treatments. Moreover, a detailed description of how the faster and more reliable diagnostic methods for detecting biological and chemical hazards in food, starting from the raw materials, can consistently reduce the need of high energy and water consuming treatments, by increasing prevention of contamination episodes in the food chain.

Climate change may have both direct and indirect impact on the occurrence of food safety hazards at various stages of the food chain. Emerging hazards in primary production could influence the design of the safety management systems required to effectively control those hazards and ensure the safety of the final product. Furthermore, increasing average temperatures such as increased frequency of heavy precipitation events and extended dry periods could increase hygiene risks associated with storage and distribution of food commodities [FAO 2008].

Food producers are already facing challenges in food safety and risk assessment, like increased incidence of algal toxin in fish products, mycotoxins in food crops, an increased spread of emerging pathogens (e.g. *Vibrio vulnificus*, *Campylobacter* spp.), increased content heavy metals and micropolluttants in food matrices [Tirado et al. 2010: 1745-1765]. By consequence, law and regulations will introduce food safety requirements that will need rapid adaptation of regulatory and voluntary food safety management plans by industries.

The aim of the ITeM in this section is to focus the lectures and exercises in a blended course with chemistry and microbiology teachers, in which all the possible aspects of increased safety hazards will be evaluated and possible remediation strategies will be discussed with the students, by a problem solving approach.

One of the methods to prevent occurrences of threats is the widespread introduction of HACCP (Hazard Analysis and Critical Control Points). This system aims at minimizing the hazard through a well-developed system of supervision and control. However, for the system to work effectively it is necessary to make an in-depth analysis of all production processes. Benefits of the HACCP system are related not only to the safety of the product but environmental protection as well.

Records relating to the application of HACCP are contained not only in the legal regulations (EU) but also in Codex Alimentarius [Regulation No 852/2004, FAO Codex Alimentarius Standards].

Due to the emerging science, alternative ways to ensure the safety (and quality) should also be explained. The practice part of implementing Food Safety into the teaching module can rely on groups (2-4 student) working on the possible implementation of HACCP to the chosen part of technological lines of food production.

5. Module 4: Recycle and valorization

The food industry produces large fractions of the total amount of hazardous waste for the environment [Parfitt, Barthel & Macnaughton 2010: 3065-3081]. This is related to the high energy content of these products and their abundance in nutrients. Improper management of these wastes may result in serious consequences for the environment. Concerns are related to the possibility of pollution of water reservoirs and soil. The existing technologies (wastewater aerobic biological treatments, to anaerobic digestion of liquid and solid wastes, composting) often requires high amounts of energy that can be consistently saved with innovative processes. As an example, the oxygen demanding removal of excess ammonia-nitrogen from liquid and solid waste can now be achieved by novel microbiological processes at low oxygen level, like the "Anammox" process [van Dongen, Jetten & van Loosdrecht 2001: 153-160]. Moreover, strategies of Co-digestion of livestock manure and food waste in an integrated system [Banks, Salter, Heaven & Riley 2011: 71-79] could be a common solution to transform part of the residues of agri-food sector into biogas, with a potential recovery of the energy content of the organic waste, together with the reduction in greenhouse gas emission. The ITeM will present several case studies and then develop with the students a design of food processing that includes waste valorization and recycling (from the plant cultivar, to the packaging and logistic) as an essential part of the product and the process itself.

6. Module 5: Legal regulations

Cardinal points of each production are the regulations, which shape the nature, quality and product safety. Legal regulations on food in the EU countries are the basis for detailed regulations of each country. Regulations govern, among other things, the labeling of a food product, content of selected ingredients, food additives, aromas, enzymes, mineral components, determining food safety, and traditional specialty foods [Regulation (EC) No: 1924/2006, 178/2002, 852/2004, 509/2006, 510/2006, 1925/2006, 1332/2008, 1333/2008, 1334/2008]. These provisions, in addition to regulating issues based on generally understood principles of human and animal life, and the environment, ensure the fair exchange of goods protection.

Another key item is the voluntary labelling. Voluntary characters of application should be emphasized but not in the arbitrariness of their use. An entity choosing to implement them should follow in accordance with the appropriate provisions. An example of such regulations are "good practices" GMP (Good Manufacturing Practice), GHP (Good Hygiene Practice), GVP (Good Veterinary Practice), GTP (Good Trade Practice), GDP (Good Distribution Practice), GAP (Good Agricultural Practice), GLP (Good Laboratory Practice) [EudraLex 2015]. (Not all of them are voluntary regulations, some of them enter into enforced legislation.) Consumer's increasing awareness should influence on better understanding of labeling information with respect for products manufactured in accordance with certain principles (e.g. ecologically, traditionally, in the protection of the environment, animals, natural resources). In order to receive such a certificate (and therefore the labeling of the product) on analysis of the production processes should be carried out by an independent team of experts. Unfortunately, many certificates/characters are used freely and often the only requirement for labeling is a fee for the certifying company.

Another problem that should be considered during the teaching program is a need for the detailed verification of certificates/marks on packages, which are often confused with other signs, and done so intentionally. An example of such confusing marks can be CE *(Conformité Européenne)* and CE (China Export), in which the last one does not give us any information (Figures 1, 2).

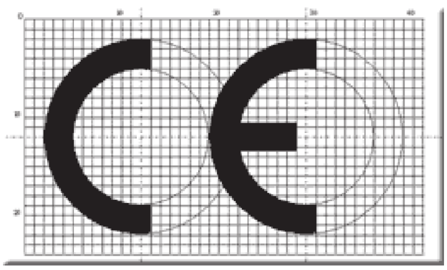

Figure 1. CE mark

Source: https://ec.europa.eu/growth/single-market/ce-marking_en [access: 14.12.2016].

Figure 2. China Export mark

Source: www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+WQ+P-2007-5938+0+DOC +XML+V0//EN [access:14.12.2016].

The benefits of presenting to students law regulations related to the production of food will contribute to increased awareness, better understanding of the complexity and the need for continuous training/track changes in the field of food law.

7. Implementation in educational programs

The ITeM in sustainable management of agri-food systems is intended as an integrative and intensive course that can be implemented in official teaching programs. In the case of bachelor degree level, it is suggested after the 3rd semester, when the students from the suggested courses are supposed to have already acquired proficiency in basic mathematics and physics, chemistry and biology. The purpose is to introduce sustainable management in all aspects of each subject by linking them in an interdisciplinary perspective. By a major use of lecturing, students will be introduced to the topics with examples and case studies, followed by student-centered teaching by means of work groups and problem solving exercises. For Master degree level, the ITeM will focus more on advanced processes and design, involving the students in the development of new processes for quality, safety and recycling, such as new regulations that fulfill the goal of sustainability and comply with climate change issues. Official teaching programs could benefit from an additional outcome for the students attending the ITeM, since they will increase their knowledge about how innovation and revenue increase in the agri-food sector revenue is consistent and not incompatible to sustainability. Paradigmatic is the need for adaptation and mitigation strategies that have to be put together to protect agriculture and food production from the negative effects of climate change.

The second step of our proposal is the ex-novo development of bachelor and master courses, such as intensive courses designed following the ITeM principles and application.

8. Conclusions

By combining several fields of study in one learning module our ITeM would provide an interdisciplinary knowledge to students that will be finalized towards combining the potential greater financial return for the company and protection of natural resources. So far, the containing and the adaptation to climate change, along with introduction of sustainability criteria in the agri-food system has always been considered as an additional obstacle, or an extra cost, for the food chain production and distribution. Our goal is to change the perspective into profitable innovation, in which energy and water saving processes, integration of reuse and valorization strategies, adaptive changes in processing lines, can increase the resilience of the agri-food system, together with economic benefits. The cross sectorial and cross scale level of knowledge of future tdxechnologists, engineers, nutritionists and agronomists, is a key challenge to design a better future for the agri-food system in a complex and dynamic changing world.

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Innowacje w programie nauczania w dziedzinach rolno-żywnościowych w aspekcie zmian klimatycznych

Streszczenie. Na podstawie doświadczenia autorów jako nauczycieli akademickich i naukowców w artykule zaproponowano interdyscyplinarny model tworzenia modułów dydaktycznych (ITeM) w zrównoważonym zarządzaniu w dziedzinach rolno-żywnościowych. Każdy moduł składa się z serii wykładów przeznaczonych dla studentów z I (licencjat) lub II poziomu (magister). Przedstawiony model może być stosowany w programach nauczania w zakresie: nauki i technologii żywności, nauk rolniczych, inżynierii żywności, inżynierii środowiska i biotechnologii środowiska.

Słowa kluczowe: żywność, rolnictwo, jakość i bezpieczeństwo żywności, zmiany klimatu, regulacje prawne