NEW FOOD PREMISES FOR TRAINING AND RESEARCH PURPOSES

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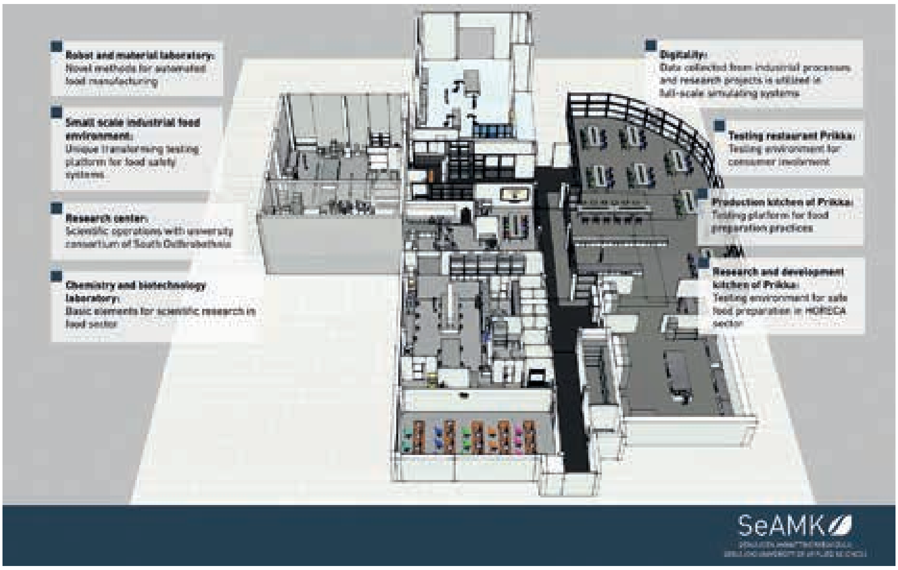
1 INTRODUCTION

Laboratory-based training is the most effective way to learn new science-based methods using experimentally testing of new hypotheses. According to constructive learning, meaningful learning takes place as the learner itself creates new knowledge structures through brainwork. Training in laboratories at university level enables meaningful learning. The learning situation involves the students' personal activity, co-operation, interactivity, purposefulness and self-direction. The laboratory-based training is expensive. Universities around the world have therefore reduced practical training in laboratories. In Finland, training in food technology has also decreased, which can be seen e.g. in reduced training opportunities within meat technology. In Finland, master level food sciences studies can be performed at the University of Helsinki, which has been a unifying force in Finnish food science education. Education in food sciences at bachelor level can be obtained only at the universities in applied sciences in Hämeenlinna and Seinäjoki. Due to traditions, dairy technology has been the focus area in Hämeenlinna and meat technology in Seinäjoki.

Southern Ostrobothnia is considered the food region in Finland. This is the reason why the region has invested in food technology training. At Seinäjoki University of Applied Sciences (SeAMK), School of Food and Agriculture special efforts have therefore been taken to increase practical training systematically in both biotechnology and food technology. The meat pilot plant in Seinäjoki is at the forefront in Finland. Test batches of manufactured products are produced at the meat pilot plant. The students can perform laboratory studies in the Frami Food Lab (FFL), SeAMK's new food premises, where SeAMK with partners enable training in an innovation environment at top level. SeAMK is building up the meat technology teaching in cooperation with the University of Helsinki.

2 BUILDING OF NEW FOOD TRAINING FACILITIES

A built pilot production environment (Picture 1) is the most effective way in technology training, but difficult to implement at large scale, if all food processes must be covered. Furthermore, high costs for raw materials of animal origin, e.g. meat and milk, limit laboratory training. Other limiting factors in FFL are expensive instruments and costs for reagents needed in chemical and microbial analyses. Despite this, the amount of laboratory-based training throughout the food chain must increase in the future, keeping in mind that the unit costs must be decreased. Moreover, new actions together with regional innovation and industrial actors must be sought. (European Hygienic Engineering & Design Group (EHEDG) 2014.)



Picture 1. Frami Food Lab including Analysis, Simulation and Sensory labs and Prikka restaurant with kitchen (Picture: Karri Kallio and Jarmo Alarinta).

2.1 Hygienic plant and equipment design in the FFL-facilities

All involved i.e. equipment designers and manufacturers, food processors as well as maintenance and cleaning service producers are never to put food safety at risk. It is a complex task to balance costs, safety regulations and user requirements. If requirements of hygienic design are in conflict with functionality or costs, the safety is to be put first. Furthermore, the hygienic design must be a purchase criterion, when new equipment is bought. With hygienically designed equipment, it is also easier to control critical factors in the food production. In planning, designing and building the FFL-facilities (Picture 2) we used the above-mentioned facts to ensure safe food processing in training and education (Text box 1). (Lelieveld, Gabrić & Holah 2016.)

Picture 2. Frami Food Lab with some basic equipment (Photos: Gun Wirtanen).

Text box 1. The FFL-facilities were designed based on hygienic design principles.

- provide defence against both external and internal hazards,
- ensure correct internal flows of personnel/students and material/equipment with minimized cross-contamination and/ or deliberated contamination,
- help to maintain the hygienic conditions during processing, service and cleaning phases and last but not least
- provide students with information about the importance of proper facilities and equipment.

Both poor hygienic design and inappropriate Good Manufacturing Practices (GMP) procedures lead to defects on surfaces e.g. visible corrosion, traces of lubricants and dirt accumulation on both food contact and non-contact surfaces. We have followed the hygienic engineering rules given in standards published by international standardisation organisations and in guidelines published by EHEDG, European Hygienic Engineering & Design Group (2014) (Text box 2).

Text box 2. In the EHEDG guideline No. 44 there is information on:

- construction and layout of premises and workspaces including facilities for personnel hygiene,
- availability of utilities e.g. energy, water and air,
- waste and pest control,
- suitability of equipment including service e.g. cleaning and maintenance,
- warehousing and flows of personnel and material and
- cross-contamination control.

2.2 FFL as food production establishment

Validation and verification are both vital parts in the food safety systems. The food produced can despite that many food processes contains heat treatment be post-process contaminated through e.g. surfaces, air or water. Physical, chemical and biological control points (CPs) are to be kept under proper control to ensure the safety in the process. We can obtain validation proof e.g. through mathematical modelling and/or from peer-reviewed scientific literature. In the FFL, we can implement in-house challenge tests and/or shelf life testing in new food processes. When validating a procedure, we can also include worst-case scenarios, data collection from process runs and validation of product run data. The reports will include information on raw material, equipment as well as process and environment facts. The reports will be established in the FFL-procedures. (Lelieveld et al. 2016.)

2.3 Verification procedures

Our aim is to provide evidence that produced products comply with current legislation. The CPs and CCPs in the HACCP plan belong to the verification material. This verification material e.g. reviews of food safety documents and internal audits with testing and confirmation will ensure the quality of process performed in the FFL-facilities (Text box 3). Once verification of the validated facilities and processes is completed, it is important that results are both documented and communicated. Personnel involved is informed about the results to ensure that all clearly understand the food safety issues performed. The students must also understand this process. Furthermore, the food safety program identifies updates needed in new processes. (Brackett et al. 2014.)

Text box 3. The "To Do" -list with steps in validation and verification:

- validation and verification are kept as separate tasks,
  - validation based on scientific proof of possible hazards in the processes,
  - verification based on science-based information to support the validation,
- lessons learnt have and will be used to improve both validation and verification,
- managers will be involved in both tasks.

2.4 FFL-activities

The FFL is a good framework for both traditional and novel production of meat, dairy, vegetable, cereal and berry products (Bradfors-Knox & Neighbour 2017). Cleaning of both premises and equipment between different processes is of utmost importance. Processes familiar from the food industry are utilised. The FFL with various equipment systems have been used in RDI projects. Each process is performed as planned with hygiene practices included. In FFL, we have already produced various meat products, sausages, bread, cakes, biscuits, cheeses, ice cream, beer, juice, seitan and vegetable patties. In the PIKI project, the equipment is used to determine protein properties in e.g. various vegetable protein isolates and concentrates, a commercial chicken meat product and a by-product stream of cottage cheese. The project aims to find new product concepts and substrates to be used e.g. as protein additives and enhancers, in modifying textures, in emulsifying, in new products to be used as such or in combined products.

The FFL-pasteurizer has been compiled as a Digital Twin, which allows simulation and testing of various pasteurization process and product parameters. When the pasteurization is run with real equipment, obtained data can be used to correct simulation errors and to improve simulations. The process optimization with various standardized settings can be used in both simulations and comparison to previous results. This system also allows students to do process simulations with information available from the industry. A fascinating study deals with playing music to cheeses during the ripening period. Representatives from various universities and a local dairy providing the cheeses are involved in this project. Music-cheeses have already been ripened and students have participated in the sensory evaluation of these cheeses.

3 FACILITIES FOR ANALYSING FOOD & FEED

The Analysis Lab at SeAMK must have as diverse base as possible of tools and equipment to serve different food projects (Picture 3). In the training, we focus on both raw materials and processing methods in food production, because processing affect structure, colour, shelf life, mouth feeling etc. of final products. Variations in both variety and season of raw materials also pose challenges to succeed in the production across the process lines. Various analyses enable fulfilling wishes of both industry and consumers. The students have to know the basics of various analyses. The laboratory analytics in the food industry is commonly based on rapid analysis methods, expensive specific analytics, and services from centralized laboratories. Without background knowledge, it is hard to develop new products based on such information. (Brackett et al. 2014.)

Picture 3. Preanalysis and Analysis labs is an entity in which the students perform both chemical and microbial analysis and report results (Photos: Gun Wirtanen).

3.1 Physical analysis

The raw materials significantly affect the properties of the final products. Therefore, the students learn how to measure particle size, size distribution, dry matter, water activity (a_w), water binding capacity, temperature, colour, specific gravity, viscosity, texture hardness/softness, adhesion etc. These can be analysed for both the raw materials and the food products. Important information about the product safety is provided by monitoring temperatures with holding times during heat treatments. (Fellows 2017). Furthermore, cereal can be analysed using e.g. Brabender's farino-, extenso- and/or amylographs as well as determining the falling number of the cereals (Kent & Evers 1994).

When we in the food product development want to evaluate the organoleptic product properties e.g. chewing more thoroughly, we have determined the structure with TA-XT2 Texture Analyser (Rosenthal 2015). In the Analysis Lab the structure properties have been used to determine products' physical properties and in improving the preservation of food product. The students have also thoroughly studied various food structure phenomenon e.g. tenderness of meat, crust formation in bread and potato ripeness (Kilcast 2010).

The organoleptic quality and shelf life of mushrooms, salads and meat have been measured with the colorimeter, which is available in the Analysis Lab. These observations are based on colour changes. In colour measurements, the goal is to convert for human eye visible colours into numeric values. Thus, small changes in colour can accurately be observed and changed into information about various products in students' work-based projects or project-based theses (Kilcast 2010).

3.2 Chemical analysis

The food chain studies include exercises in which chemical properties and quality of different raw materials and food products are analysed quantitatively. Titrimetric analyses are commonly used to quantitatively determine vitamin, mineral, and salt contents as well as levels of various acid e.g. acetic acid and lactic acid. These methods are both accurate and reproducible. In the Analysis Lab, we have also tools and equipment to determine the protein content using both the spectrophotometric method and the Kjeldahl method (Self 2005). In the Kjeldahl method the total protein, i.e. the crude protein, content in a product is achieved by multiplying the total nitrogen content of the sample with the conversion factor. In the spectrophotometric method the properties of a substance are determined by means of UV-Vis radiation. Spectrophotometry can be used to monitor e.g. the quality of food, the levels of additives, the protein content and some minerals. In addition, students determine the fat content in products using various extraction methods e.g. the Mojonnier method (Deibel & Deibel 2016). The extraction is a chemical separation method based on solubility properties of different compounds.

The acidity affects the quality, appearance, shelf life and taste of foods. Acidity is measured using a pH meter. The chemistry studies in food quality may also include conductivity measurements, especially of water-soluble foods. The conductivity in an aqueous solution depends on the amount of dissolved ionic substances of salts, acids and bases. We can also produce various synthetic substances e.g. esters used as fragrances and flavours in small scale. These syntheses are based on reactions at certain conditions in which the starting agents are reacting forming new substances. These products can be purified through distillation or extraction. (Damodaran & Parkin 2017.)

The bachelor students are introduced how to use the HPLC equipment and in their intermediate studies they use it in analysing acids and sugars in food products (Guillarme & Veuthey 2011). Now, when the resources are increased in both project and exchange studies, conscientious students can deepen their knowledge in the method. In student works, it has been used to study e.g. the effect of different processing methods on the amount of benzoic acid in lingonberry juice and an entirely new method to determine value compounds of side streams in the food industry. The uHPLC, which enables very accurate analyses, has been used in co-operation projects with University of Turku to study the influence of various processes on amino acid compositions of e.g. fungi and potatoes. (Damodaran & Parkin 2017.)

3.3 Microbial analysis

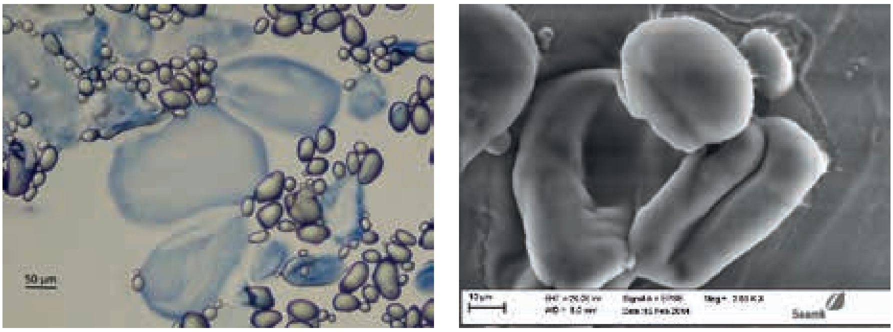
The Analysis Lab facilities are also utilised for studies in microbiology. These activities are divided into basics of microbiology, growth conditions in e.g. culturing and fermentation, surface hygiene and personal hygiene. Rapid methods are used e.g. in monitoring surface cleanliness. Microbes have been grown under both aerobic and anaerobic conditions. Both wanted and unwanted microbes in biotech and food environments are identified based on growth factors and biochemical reactions (Adams, Moss & McClure 2016).

Results are obtained through colony counting and with different microscopic techniques, i.e. light, stereo and electron microscopy, as well as using spectroscopy. For example, lactic acid bacterial strains have stepwise been inoculated from slant surface through culturing in a 4-position BiostatQ fermenter into experiments in larger fermentation vessels (Najafpour 2007). Growth of microbes in different nutrients under various environmental circumstances have also been studied in more detail using a Bioscreen C instrument with space for 2 x 100 growth curves at a time (Russell 2005). Various microbial research topics have been carried out in theses and project works in the Analysis Lab.

3.4 Microscopical techniques

Knowledge of food structures and interactions between structural elements in food can be examined with both light and electron microscopes. It is useful to combine information from both types of microscopes to understand various behaviours.

The bachelor's students have used the light microscope technique to identify microbes based on e.g. Gram and spore staining as well as yeast staining. They have also determined the cell density of both bacteria and yeasts using counting chambers during fermentation processes. The microbes or food examined can be stained to improve interpretation and visualization of images. Staining techniques have also been used to detect changes in food structures (Picture 4). The advantage of light microscopy is the images' colour perceptibility (Heertje 2014).



Picture 4. Potato starch at 60°C: photos of iodine stained starch in light microscopy (left) and in elecrone microscopy (right) (Photos: Merja Kyntäjä).

The scanning electron microscope at SeAMK is a Variable Pressure - Environmental Scanning Electron Microscope (VP-ESEM). The advantage of this method is that the samples do not need to be coated, thus the microbial or organic food samples examined remain in natural form and are not damaged. Structural changes due to processing, changes in the raw materials and localization of microbes growing in the samples can be observed using this technique. (Groves & Parker 2013.).

There are image analysis programs, which can be used in analysing the microscopic images. The most widely used software programme is ImageJ, which is an open source solution. The microscope and camera manufacturers have their own software programmes. The software programme can be used in automatizing the image analysis. Approaches based on software programmes enable efficient processing of data from large numbers of images e.g. from timeline series. New samples can also be subjected to exactly the same analysis as the previous ones. Thus, the reproducibility rises to a new level. Furthermore, the clarity of the images can be improved. Thus, images can be interpreted easier, when information from the colour measurements and grayscale SEM images are combined (Rueden et al. 2017).

3.5 Sensory analysis

Due to the place of the Sensory Lab, it is easy to attract passing students, personnel and visitors to take part in sensory tests. There can be eight evaluators at a time. The white walls on the white table guarantee the product reviewers their own place and peace during the evaluation. A test panel of experts can also be trained for special analysis. In the research, products can be evaluated by combining the organoleptic evaluation with chemical, physical and microbial analyses including information from microscopy and imaging techniques. This type of comprehensive evaluation can be used in preservation research and for new products developed. (Kilcast 2010.) Our international students can take part in developing products for the international market.

4 FUTURE NEEDS

Development in the food sector, and in particular in technology, is strong. For these reasons, the FFL facilities will continuously be developed towards future needs. One of the most important areas for future development is the deepening of international co-operation in small-scale pilot and teaching activities. SeAMK aims strongly to be on the cutting edge of development and to work with industrial stakeholders, thus we can act as a credible partner in the business community. As a school educating food processors, we are responsible to implement validated activities complying with verified food safety. Furthermore, we are actively developing both our training syllabus and work commissioned to meet future needs. Due to the rising vegetarian, vegan and flexitarian booms, more equipment suitable for preparing vegetarian and vegan food will be acquired in the future. These will be at the top on the investment list. The renovated facilities will provide a good framework for operations for the coming decade. The equipment base will actively be renewed in cooperation with the business community, research institutes and other trainers.

5 SUMMARY

The Frami Food Lab project started based on needs to have new food laboratory facilities at Seinäjoki University of Applied Sciences (SeAMK) and to make the education in food more work oriented. The enterprises in Southern Ostrobothnia need the facilities as a showcase of food expertise i.e. the premises boost the visibility of the food sector. We have considered both training and research aspects, when designing the facilities. In use, these premises will provide opportunities for the students to develop their skills in food processing including attractive and demanding business ideas. The food laboratory entity will be used in project studies in co-operation with food and biotech companies. We designed the controlled food-processing laboratory to enable application in food establishments approved by the food authorities. The facilities are divided into various departments for e.g. the reception of raw materials, the pre-processing facility, the changing area with barriers e.g. washing and disinfection of hands, use of face masks and changing of clothes as well as shoes before the staff enters the food processing area. All analysis will be carried out in the Analysis

Lab. The accessibility and the possibility to arrange training in both chemistry and microbiology in the same facilities were also very important. This enables us to use the facilities more efficiently. It also supports the training in both food processing and biotechnology. These new facilities with hardware and state-of-the-art design create a framework for various activities. Some activities will also be placed in the Sensory Lab.

The ventilation system in the food facilities was by far the biggest structural challenge in building it into the already existing facilities. Two separate ventilation solutions are used. One was implemented with rails and is used in the fume cupboards and chemical storage. A system based on traditional ventilation is used in the rest of the FFL area. This area will serve training in a holistic way and provide researchers with a very good opportunity to carry out various types of research. Students studying agrology, biotechnology, food processing and hospitality management will all use the facilities. Some of the equipment used e.g. in grinding grains affects how the area is kept clean and free from dust. Then we also have ovens and stoves causing heat that affect the air conditioning. The area should be kept free of condense droplets. Due to this, the mills are place in a small, closed room and ovens are used at certain periods based on timing for the various processes. With a good implementation, the area serves both students and other stakeholders in performing RDI activities.

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