MUSSELPRO

Grant agreement number. 863681

D 2.8 Defining MUSSELPRO adjustments for its scale-up

Project Information	
ACRONYM	MUSSELPRO
Title	Demonstration of an IoT 4.0 mussel processing system for an advanced seafood canning industry.
Project coordinator	TEINCO (AUTOMATISMOS TEINCO SL)
GRANT AGREEMENT NUMBER	863681
Call-Topic	EMFF-BlueEconomy-2018
Document Type (R/DEM/DEC/OTHER)	R
Dissemination Level (PU/CO/CI)	PU
Date	29.05.2020

Document History	
Version and date	Changes
Final Version 29.05.2020	

Authors:

- **TEINCO:** Jose Luis Meniño, David Brunet, Pablo Alfaya, Daniel Rivero, Carlos Moa, Manuel Nogueira, Raul Pena,
- **JEALSA**: Salvador Duran, German Mosquera, Miguel Vidal, Jose Carlos López, Margarita Hermo

Content

Executive summary

The report **D2.8 "Defining MUSSELPRO adjustments for its scale-up**" led by TEINCO, belongs to the WP2 - Scaling of MUSSELPRO to its industrial unit DEMO [Months: 1-20].

In this report, we described the main results related to TASKS:

- Task 2.1 Definition of the scaling-up specifications (Deliverable 2.1)
- Task 2.2 Def. of the hyper spectral system adjustment for its scale-up
- Task 2.3 Definition of the vacuum cooker adjustment for its scaling-up
- Task 2.4 Definition of the smart autoclave adjustment for its scaling-up

1 INTRODUCTION

The deliverable **D 2.8 "Defining MUSSELPRO adjustments for its scale-up"**" aims to describe the main public results achieved so far in the project according to the implemented task (Task 2.1, Task 2.2, Task 2.3 and Task 2.4). The partial results obtained so far in the MUSSELPRO project have been kept under industrial confidentiality. The industrial secret will be maintained until the tests and validation of the MUSSELPRO system at industrial level are made in the facilities of JEALSA. Therefore, the results that the MUSSELPRO consortium considers public at this moment will be shown below.

The results of this report are linked to the following tasks:

- Task 2.1 "Definition of the scaling up specifications" (M1-M3).
- Task 2.2 "Definition of the hyperspectral system adjustment for its scale-up (M1-M7)
- Task 2.3 "Definition of the vacuum cooker adjustments for its scale-up" (M1-M7).
- Task 2.4 "Smart autoclave design" (M1-M7).

All these tasks belong to the WP2 "Scaling of MUSSELPRO to its industrial unit DEMO [Months: 1-20].

Task 2.1 "**Definition of the scaling-up specifications**" consists on the design of each of the MUSSELPRO components (hyperspectral equipment, vacuum cooker and smart autoclave). The integrated system must comply with food safety requirements, existing market regulations (e.g. CE markings), occupational safety regulations as well as operative specifications concerning e.g. maintenance and equipment cleaning.

Task 2.2 "**Definition of the hyperspectral system adjustment for its scale-up".** This task includes the definition and design of the adjustments to be done over the hyperspectral system to:

- operate on an industrial level, in an integrated manner into the workflow of the canning process.
- provide accurate information on the characteristics of the raw matter processed (mainly fat content and moisture level).
- allows easy modification and implementation depending on the needs of individual clients

Task 2.3 "**Definition of the vacuum cooker adjustments for its scale-up** ". Under this task, we defined the adjustments to be done over the current pilot plant of the vacuum cooker for its scale-up. This is, to shift from an equipment of length 1 m, ø 550 mm and capacity of 50 kg/cycle to and equipment of industrial dimensions. This task included the following:

- definition of the adjustments to be done over the hardware components, especially for the system for temperature optimization and homogenization (which includes the steam injection system and the vacuum pumps).
- definition of the upgrades to be done over the control system and its algorithm to work on and industrial scale.

Task 2.4 "**Definition of the smart autoclave adjustments for its scale-up"** . This task consists on:

- the definition of the adjustments to be done over the hardware components, especially over the steam injection system.
- definition of the upgrades to be done over the control system and its algorithm to work on and industrial scale.

Hence, the **objective of this deliverable** is to show the designs of the MusselPro demonstration system. Before going into detail about the different activities carried out, an overview of the mussel canning industry will be explained. The main challenges and needs of the mussel canning industry will be described and the reasons for developing the MUSSELPRO system as a business opportunity that will bring not only economic benefits, but this innovation will contribute to the transition of the EU seafood canning sector by introducing the advanced technology needed to improve the competitiveness of the sector. This system will also support European "coastal" communities in terms of job creation, and will have a positive impact on the environment by significantly reducing CO_2 emissions relative to the state of the art of today's canning industries.

2 GENERAL BACKGROUND

2.1 THE MUSSELPRO´ CONSORTIUM

The consortium of MUSSELPRO is formed by AUTOMATISMOS TEINCO the project coordinator, and JEALSA (project beneficiary). TEINCO will provide industrial innovation expertise focused on thermal processes in canning industry mainly specialised in designing, manufacturing and market advanced equipment for the food processing industry and 4.0 technologies. TEINCO will be responsible of the know-how of MUSSELPRO system. JEALSA, is the top manufacturer of canned seafood and fish in Spain and second in Europe with more than 4000 employees globally. Currently JEALSA is processing 130.000 annual tonnes of canned seafood and fish in the factory placed in Boiro (Galicia). JEALSA will be the technology validator providing, through several tests at its premises, crucial feedback for the MUSSELPRO optimisation, the fine tuning and demonstration of the system.

2.2 MUSSEL CANNING PRODUCTION

Mussels canning production takes place along a processing a line with multiple steps (Figure 1). Briefly, these are: (i) mussels washing and cleaning, (ii) mussels cooking in the cooker, (iii) meat removal from the shells, (iv) cans filling with the cooked mussels and the liquid medium (oil, water…), (v) cans sterilisation in the autoclave and (vi) labelling and dispatch.

The mussel canning process is characterized by high energy consumption. This is mainly due to the cooking and sterilisation steps. Indeed, these two steps alone consume **more than 70 % of the total energy** used in the sector (including transportation). High energy consumption cannot be avoided, but it can be optimized. The best approach to do so is by making an efficient use of the energy and by reducing processing times.

However, in the state-of-the-art, **energy is not efficiently used, and processing time lasts more than necessary**. Moreover, product quality is also negatively affected. The reasons behind these problems are:

- **Pre-fixed processing time**: depending on the characteristics of the raw matter (fat and humidity content), the processing time should be different. However, these characteristics are not assessed in the state-of-the-art, and so processing times are not selected accordingly.

- **Uneven heat distribution**: ideally, the temperature within the chamber of the cooker and the autoclave should be the same in all points. However, equipment currently available in the market is unable to do this. Consequently, cold spots are created. In order to compensate lower temperatures in the cold spots, the overall temperature of the chamber must be increased. This result in an **inefficient energy use** that could be avoided.

- **Overheating**: aligned with the previous point, compensating the lower temperatures in the cold spots by increasing the overall temperature, cause overheating in other spots. Since mussels (and fish products in general) are highly thermolabile, overheating ultimately results in **decrease product quality**, due to **excessive dehydration**, degradation of amino and fatty acids and oxidation of lipids.

2.3 MUSSEL CANNING INDUSTRY NEEDS

Based on the above analyses of the canning industry pain points, we highlight the following industry needs:

- **Reduce energy consumption**: through **minimisation of processing times and of processing inefficiencies at the stage of cooking and sterilisation**, allowing for better processing efficiency and profitability

- **Enhance final product quality**: through lessening the negative impact of processing on the product

2.4 MUSSELPRO SYSTEM INCREASES EFFICIENCY AND PRODUCT QUALITY

To answer the needs of the canning industry, MUSSELPRO is going to revolutionise the mussel canning sector solving its main pain points. MUSSELPRO system is an innovative technology-based solution that optimises and controls the conditions of mussel cooking and sterilisation, adjusting the processing times and temperature levels to the characteristics of each batch of mussels to be processed.

To do so, we have developed an **advanced vacuum cooker** and **smart autoclave.** Each one has:

- an **own-developed control system**, able to program the processing time and temperature according to the characteristics of the raw matter. To do so, a **hyperspectral equipment** specifically develop for the purpose of MUSSELPRO, measures the mussels' characteristics at the beginning of the processing.

- an **own-developed system for temperature optimization and homogenization.** It consists on a stem injection system and vacuum pumps (the later only for the vacuum cooker). Automatically managed by the control system, it avoids the creation of cold spots. Thus, uneven heat distribution and overheating issues are avoided.

Moreover, by leveraging the power of data, MUSSELPRO integrates an **IoT 4.0 platform**. It receives and process the data from the vacuum cooker, the smart autoclave and the hyperspectral system; enabling to offer further services: (i) real-time remote monitoring and tele-maintenance, (ii) augmented reality visualization and (iii) machine learning capabilities.

MUSSELPRO is highly versatile. On the one hand, the vacuum cooker and the smart autoclave are manufactured on-demand according to each client's needs. This way, the processing capacity of the vacuum cooker and the smart autoclave can be adjusted (from 400 to 600 kg/cycle for the vacuum cooker and from 10,000 to 30,000 cans/cycle for the smart autoclave). On the other hand, it can either be installed in already existing processing lines or in new processing lines. Moreover, if the client wants to, their regular and autoclave can be upgraded, by implementing the control systems and the system for temperature optimization and homogenization. This way, they do not have to purchase the whole equipment but only the upgrades that are a key differentiating factor.

Finally, it is possible to connect to the M2M network other equipment of the processing line (eg. the scale or the canning machine) so that the control systems can have a broader view of each batch and optimize even more the processing times and temperature.

Below in Figure 1, we show a schematic representation of the mussel canning processing line with the MUSSELPRO system implemented (highlighted in orange) and a render of the hyperspectral system, the vacuum cooker, and the smart autoclave:

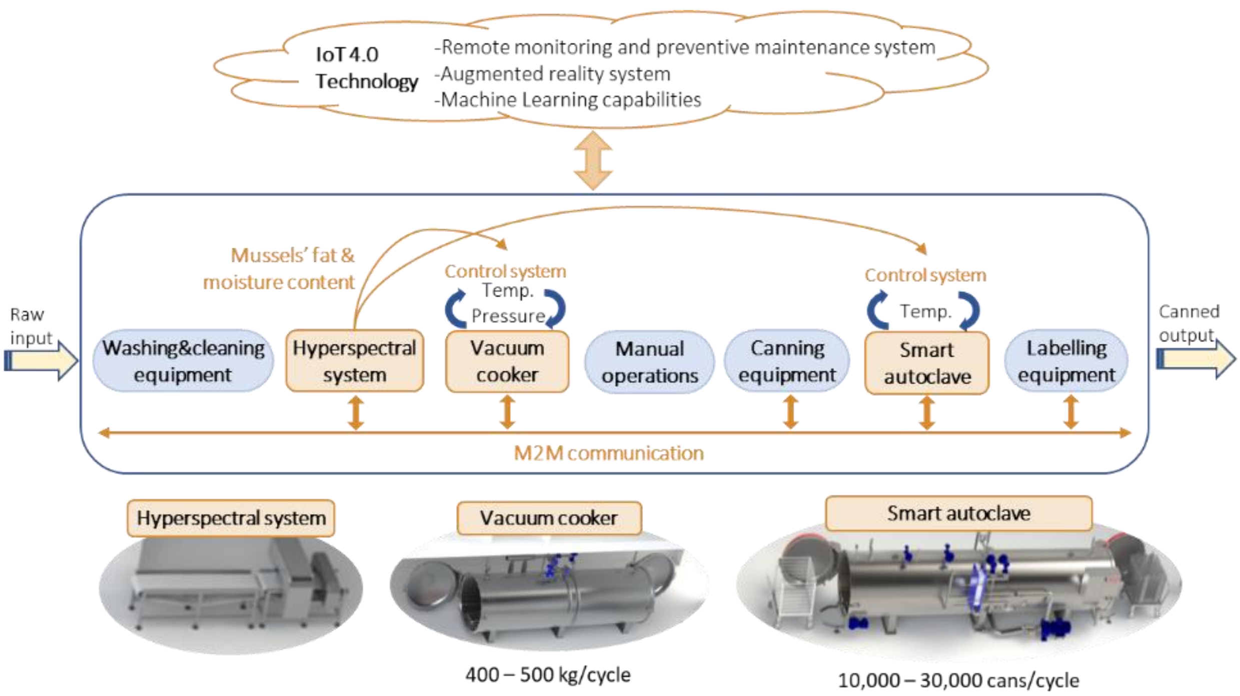


Figure 1. The MUSSELPRO system in the mussel canning process

The MUSSELPRO system allows for **full optimisation and control of the parameters** of mussel cooking and sterilisation, adjusting the temperature and processing time to the mussels' characteristics of each batch as well as enabling homogenous temperature conditions and better heat transmission to the inside of the processed product.

As a result, MUSSELPRO ensures the following revolutionary impacts for an average mussel cannery when compared with the state-of-the-art.

20% SHORTER PROCESSING CYCLES, which result in:

- **20 % higher processing output** allowing higher profit
- **15 % lower energy consumption per cycle**
- **50 % less water consumption and 15% lower green-house gas emissions per cycle**

AUTOMATICALLY OPTIMISED TEMPERATURE LEVELS AND HOMOGENEOUS HEAT DISTRIBUTION, which result in:

- **enhanced product quality**

3 DEFINITION OF THE MUSSELPRO DEMO SYSTEM ADJUSTMENTS FOR ITS SCALE-UP

The task 2.1 “definition of the scaling up specifications” has taken place during the first three months of the project (M1-M3). To carry out this activity, technical meetings have been held at the Jealsa´ facilities, studying and analysing the details that were considered appropriate for the mussel production line of **Jealsa, the technology validator.**

The objective of the deliverable D2.1 submitted in M3, was to define the constructive needs of the MusselPro equipment both at the construction and production design level together with the regulations and legislation required to comply with the food safety of the process.

This report contains the scaling up specifications of the 3 MUSSELPRO components that make up the MusselPro system as an industrial demonstration:

- Hyperspectral system for raw material control (task 2.2)
- Mussel cooking system= advance vacuum cooker (task 2.3)
- Sterilization system=smart autoclave (task 2.4)

Picture 1: Mussel production line at JEALSA

3.1 THE MUSSELPRO SYSTEM´ COMPONENTS

3.1.1 THE HYPERSPECTRAL SYSTEM

The first activity to carry out was the analysis of the scalability and possibility of implementation of the hyperspectral system in the production lines.

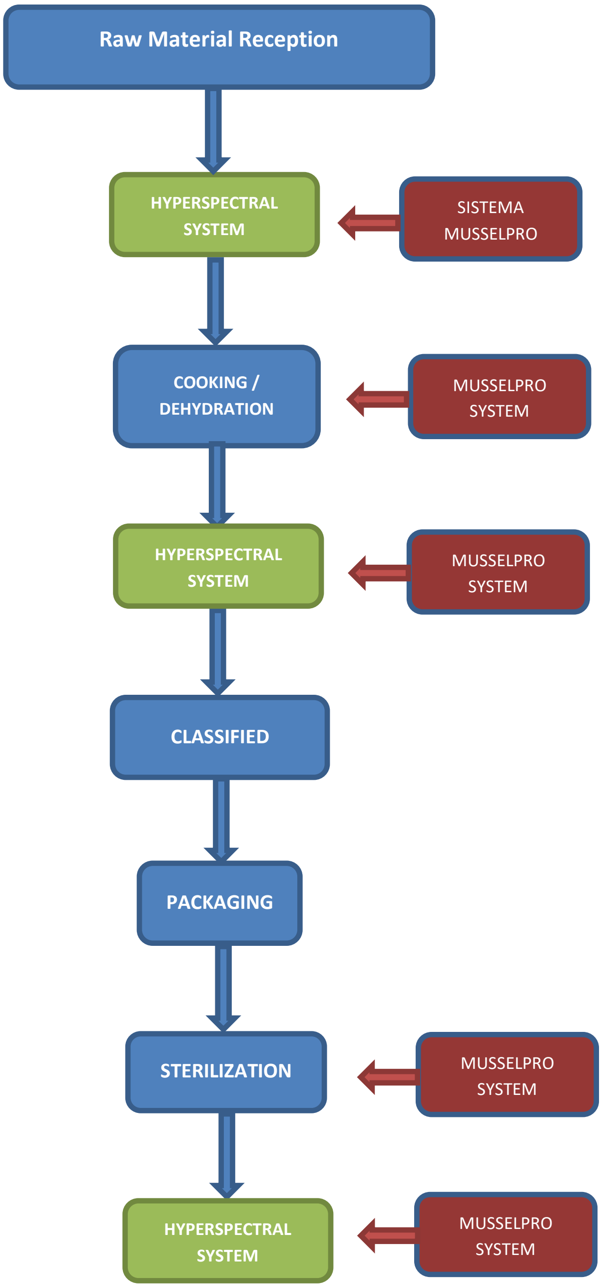


Figure 2. Stages of the process in which the hyperspectral system will be used.

A further analysis was conducted to find out the specific locations within the productive process where the raw material would be analysed. The tests showed that one of the most difficult challenges of the hyperspectral system scalability is the processing capacity of the raw material.

For this, the specifications of the system to be designed shall not exceed:

- 3 meters in length
- 1 meter wide

The hyperspectral system will have a data communication module to send the results of the evaluated parameters.

The objective of a machine vision system is to understand a scene (image) as well as human vision does, and to discriminate situations, looking for patterns. To convert a 3D real-world image to a 2D plane to produce information that can be processed by a computer. One difference from human vision is that it can also analyze in spectra other than the visible, such as infrared, X-ray and thermal imaging.

Most Machine Vision applications can be divided into

- Inspection: it refers to quality control, that is, to the qualitative testing of certain characteristics of the objects that go through a production chain, checking if their condition verifies the required standards so that they can be put on the market.

- Measurement and calibration: monitoring of measurements that are within the initial specifications.

- Classification: discrimination by color, size, geometry, etc. Recognition of predefined standards, adjustable within tolerances.

- Reading codes to identify elements, such as OCR systems (optical character recognition).

At an industrial level, artificial vision is normally applied as a complement to robotic systems whose purpose is to classify raw materials. For example, compliant or non-compliant raw material, depending on dimensional parameters (area, length, symmetry), physical-chemical parameters (colour, temperature...) or even the appearance of new spectral sensors, which means that we have applications where nutritional and microbiological parameters of the raw material are quantified .

Hyperstectral/NIR technology is one of the Advanced Sensors that is considered to have the greatest potential from the point of view of the processes carried out by the company Teinco. This technology has two well defined utilities: spectrochemistry and foreign body detection.

This technology allows to obtain the approximate chemical composition of the matter online providing very interesting information to the decision-making element so that it can parameterize the process to be carried out in the equipment. In addition, it is a non-destructive method that does not require contact with the raw material, which makes it very interesting from a hygienic-sanitary point of view.

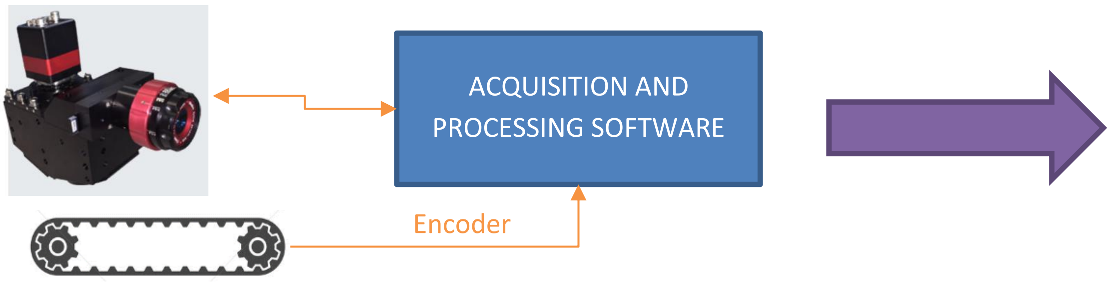


Figure 3: Hyperspectral Solution Scheme.

NIR technology is currently in full expansion within the industry, but it remains a difficult technology to implement especially if you want to work from a spectrochemical point of view. It requires very complex work to obtain the model.

Currently there are a variety of manufacturers who have equipment with this type of technology but many are not suitable for the industrial environment because they lack adequate IP[1] (Ingress Protection) rating. In addition, normally this type of camera is linear, requiring synchronized displacement to generate a 2D image.

The data captured by the hyperspectral camera requires a high level of processing in order to extract the useful information. This makes it necessary to use a very powerful PC dedicated to this task.

We decided to equip the hyperspectral system with a camera with the following characteristics:

- **Spectral Range: NIR (900-1700nm)**

We chose a camera that is manufactured according to a completely new optical design, based on a patented system of reflective concave mirrors with correction of image aberrations, which incorporate very high holographic efficiency coatings. These holographic coatings offer high distortion-free optical efficiency, excellent signal-to-noise ratio and very low stray-light compared to conventional transmitting systems, greatly improving image quality (both spatially and spectrally) with respect to conventional transmission systems.

We will work with a Software that is a hyperspectral image processing software to make hyperspectral image classification/processing models without programming or machine, with an easy and intuitive interface for the user. The solutions can be trained and used in different

[1] IP ratings for security cameras (as well as many other electronics) are used to define levels of Ingress Protection, or the level of effectiveness against intrusion from foreign bodies such as dust, water, moisture, tools and hardware

hypercubes. The results, classification/processing models, can be exported for real time post-processing.

Below Figure 4 shows an image for the hyperspectral system.

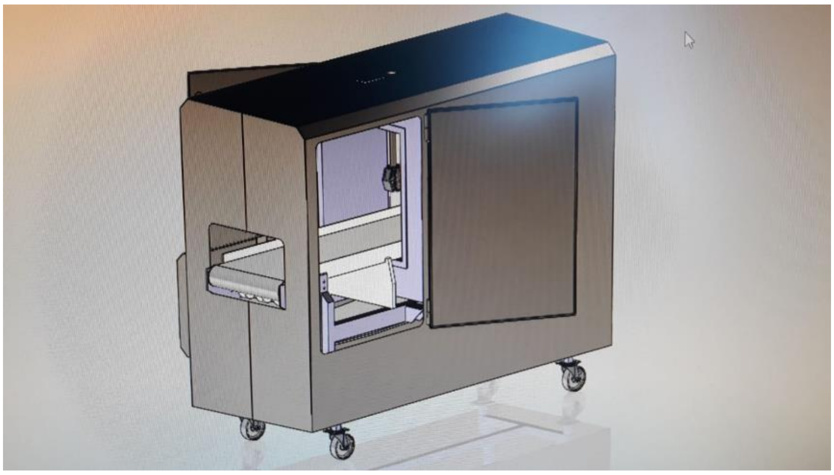


Figure 4: Hyperspectral system design

3.1.2 THE COOKING SYSTEM- ADVANCE VACUUM COOKER

There are different cooking systems and within each of these systems there are different control variables as well to optimize the cooking process. The following is a brief description of each of the systems used in the processing industry for fishery and aquaculture products.

Cooking in brine or brining: this process consists on soaking the fish meat in a salt-water solution at boiling temperatures (aprox. 99ºC). The cooking rafts are usually provided with a lid without an airtight seal, so that the temperature hardly exceeds 100ºC, but depending on the salt concentration, it can be higher. In this system the loss of humidity of the fish is caused by :

- the temperature

-the processes of osmosis (different concentration of salts between the fish and the brine).

Cooking in fresh water: this process consists on soaking the fish in a fresh water solution at boiling temperatures, usually 99°C. The cooking rafts are usually provided with a lid without an airtight seal, so that the temperature hardly exceeds 100ºC.

In both systems there is a loss of water and nutrients (such as protein, fat, etc.) that go to the cooking water.

Cooking in a steam tunnel: this process is carried out inside of a tunnel in which steam is injected until the desired temperature is reached; This cooking system implies a lower loss of nutrients compared to cooking in water and the discharges produced are considerably reduced, although the organic contamination is more concentrated. These discharges are a direct consequence of the condensations produced during cooking and cooling.

It also allows for subsequent cooling by applying internal vacuum in the cooker or cooking tunnel, achieving more or less rapid and effective drying and cooling of the fish. Cooking can be carried out at temperatures exceeding 100 ºC, generally at temperatures between 102 and 140ºC, being the most used in these cooking systems.

Most canning companies carry out cooking processes in brine, which present a series of problems associated with the high volume of cooking water, dragging of soluble nutrients and limited control of the degree of cooking.

Nowadays, both steam cooking and cooking in brine are performed. Theoretically, the optimum cooking process is *steam cooking* due to the fact that the volume of water from the cooking process is drastically reduced, although it is true that this will obviously be more concentrated than that from brine or immersion cooking. The migration of nutrients into the cooking medium is practically negligible; in contrast, in immersion cooking the loss of nutrients that migrate into the cooking water is considerably greater, with significant amounts of fat and proteins appearing in these waters, as well as suspended and sedimentary solids such as meat remains or skin (fish like tuna).

Because the coefficient of thermal conductivity of water is lower than that of saturated steam, cooking in a steam cooker is faster and also increases the final yield of the fish. This is because the temperature distribution within a steam cooker is more homogeneous and the rate of heat penetration into the fish is faster.

The Vacuum Cooker design for The MUSSELPRO is based on the premises of report D2.1 Scaling up specifications.

The laboratory prototype that TEINCO currently has and that is to be scaled up to industrial size has the following characteristics:

- 1,000 mm Length
- 550 mm in diameter
- Capacity of 50 kg / cycle
- CE marking

To adapt the MUSSELPRO vacuum cooker to JEALSA´ productive capacity and to be able to draw representative results at an industrial level, the new cooker will be designed based on the following specifications:

The final length will be determined based on the physical space for installation and optimization of the final design:

- Diameter: 1,5 to 2 meters
- Vacuum generation capacity.
- Regulation and control system with data communication system

It is estimated that this equipment will allow at least a processing capacity of 1,500 - 2,000 kg/hour, which would allow us to process 12 to 16 Tons per shift.

3.1.3 STERILIZATION SYSTEM= THE SMART AUTOCLAVE

The final element of the MUSSELPRO system is the autoclave. In this case, the food preservation procedure is to pack the food in hermetic containers and to heat it to ensure inactivation or destruction of microorganisms and enzymes.

The heat treatment to be applied must be sufficient to destroy or inactivate the bacteria, which will be defined by specific time and temperature criteria, depending on the type of product and packaging being treated at any given time. These criteria must be established beforehand and must be strictly complied with in order to avoid health risks. In fact, this stage of the process in the preparation of canned fish and shellfish is considered a "critical control point" (according to the HACCP methodology or Hazard Analysis and Critical Control Points). This is so, since this is an essential stage to guarantee food safety in which it is possible to control the associated hazards (and their risks) through the establishment, control and monitoring of appropriate time / temperature scales.

These scales are estimated assuming that certain premises are met:

- Raw material in optimal hygienic conditions.
- Maintain the facilities and utensils in a correct state of cleanliness and hygienic conditions.
- Respect "good handling practices".
- Respect the "good manufacturing practices".

It is difficult to determine the initial microbial status of the product because fish product handling processes contribute to the increase of the microbial status. As they have a pH >4.6 and a water activity aw >0.85, canned fish and shellfish are classified in the category "low acid canned food". In this group, the most heat-resistant Pathogen microorganism taken as a reference when establishing sterilization processes is Clostridium botulinum, a sporulated bacteria with the capacity to generate a highly toxic toxin. Therefore, it is absolutely essential to count with studies that determine the minimum time necessary to guarantee the destruction of this highly pathogenic microorganism.

In recent years there have been several technical developments in sterilization systems (immersion systems, water showers with heat exchangers, development of counter-pressure processes, process automation, etc.). The quality technicians of the companies tend to overestimate the real sterilisation times applied in order to avoid problems of healthiness in the canned products; this is associated with greater energy consumption and GHG emissions that are greater than those theoretically necessary for the process. Therefore, if an optimum sterilisation system is achieved, the energy consumption and GHG emissions will be significantly reduced. The quality of the final product would also be improved.

Definition of the sterilization parameters : F0

The wet heat sterilization process is carried out in an autoclave by injecting steam or a mixture of steam and water at temperature and pressure, for a certain time, and then cooling the cans quickly. This guarantees the complete deactivation of all microorganisms that in the long term will produce the alteration of the food and/or could be harmful to the health of people.

The time at which the bacteria cells are thermally inactivated depends on several factors, the most important being the temperature and time of the sterilization process (time/temperature ratio).

In order to know these parameters, we carry out a series of tests in the autoclaves, introducing the type of container and the food to be sterilized. The heat is transmitted to the food by conduction from the outside to the inside and that is why the last point in reaching the adequate temperature for the destruction of the microorganisms is the centre of the can. This is the point at which the time/temperature binomial measurements must be made, to guarantee the correct sterilisation of the product: by measuring the temperature reached in the centre of the container, it can be guaranteed that the correct temperature has been reached at all points of the container.

We must measure the time it took to reach the temperature in the cold spot of the package, and this time will be the **minimum time of sterilization** of that product in that package.

This binomial between temperature and time to which a food is submitted is usually summarized in a mathematical expression known as **F0 value or equivalent mortality**. The F0 is used both to know if a treatment was sufficient to produce the correct sterilization, and to compare different types of processes with each other.

The F0 parameter is the result of a mathematical calculation that provides an approximate idea of the mortality of the microorganisms after heat processing. The mathematical expression is as follows:

$$F_0 = \int_0^t t.10^{\frac{T-T2}{z}}.dt$$

where:

- T: temperature in ºC, measured in the centre of the product
- T2: Reference temperature (ºC) 121.1ºC
- t: processing time (minutes)
- z: temperature coefficient of microbial destruction, which in general has a value of 10 if working with ºC, or 18 if working with ºF

The general method is based on the fact that each point on the heating and cooling curve of a container represents a lethal value for the organisms studied, from which the lethality curve is constructed. The exposure times required for the death of the organism (thermal death times) from which the test is performed are first determined, at various temperatures within the range of the process.

The lethal coefficient for a given temperature is reciprocal to the number of minutes required for the organism to die at that temperature.

For theoretical purposes, to ensure the sterility of a product, the value calculated for *Clostridium botulinum*, a highly heat-resistant organism requiring an approximate value of F0=3, would be taken as the standard. In practice, this value is very low, since the contamination of the raw material, the variations in the heat treatment and the environmental conditions to which the preserves will be subjected are much more severe, so that the product would end up being altered quickly. In order to have a sufficient safety margin, F0 values between 6 and 14 are usually adopted, depending on the final destination of the canned food and the processing.

Definition of the sterilization phases

In order to make the new autoclave system compatible with existing requirements in terms of heating, temperature homogenisation and specific cooling needs, the new conditions needed to be defined. The standard design needed to be slightly modified in order to favour energy consumption. The designs that have been made should take into account the particular specifications for the different program phases.

The following diagram (Figure 5) shows a target curve established as a standard for the project. It is divided into different phases (heating, maintenance and cooling). The temperatures and times are representative, and they will be optimized once the MUSSELPRO system is installed.

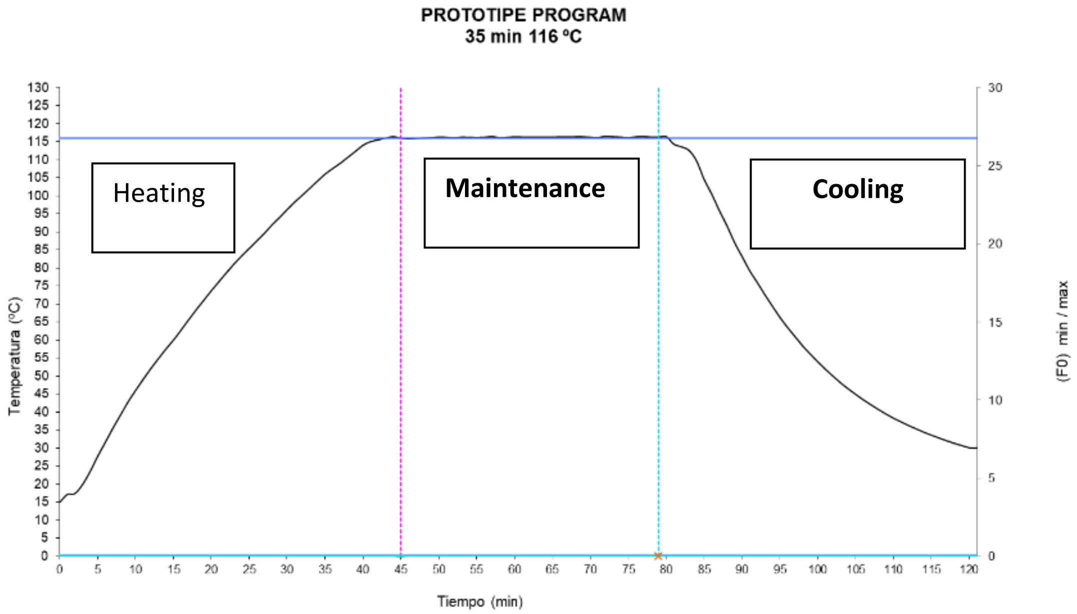


Figure 5. Sterilisation Curve established as a standard for the project

Sterilisation Program phases:

Heating: the phase is designed to reach the process temperature.

Maintenance: this is the main phase of the sterilization process; it starts after the CUT heating time, so the designs developed by MUSSELPRO have focused special attention in this aspect.

A properly established CUT time must ensure that the following points, which directly affect the commercial sterility of the product, are met without any nuisance:

- All places in the autoclave are above the established process temperature.
- The time programmed in the controller ensures at least the compliance with the time established as CUT time.

In order to avoid unnecessary organoleptic and nutritional degradation, it is essential that the design of the heat treatment system is carried out under the following conditions:

- After the CUT time (and if possible during the whole process) the difference in temperature between cold and hot points should be minimal. This prevents over-sterilization. This is an essential aspect of commercial competitiveness.

- The established heating time must ensure an efficient use of the maximum performance of the autoclave. This also favours the previous point, as well as the possibility of optimising the process times.

- It is convenient to use unified process times when dealing with an installation with more than one autoclave. Despite the fact that the design is treated individually in the project, this and other aspects are taken into account in order to facilitate subsequent industrial scaling.

Cooling: At the end of the time scheduled for the STERILIZED phase, the control system will close the steam circuit and allow water to pass through the exchanger in order to gradually lower the internal temperature of the autoclave to a safe value. It will also bring down the pressure until its value is matched to that of the outdoor environment.

Homogenisation parameters

Other aspects related to homogenization considered for the design of the autoclave are the following:

Even though all critical points concerning the commercial sterility of the product are covered, it is essential for achieving uniform sensory results that the autoclave works within acceptable homogenisation ranges. The opposite has implications for the reduction of quality and therefore a decrease in the commercial potential of the product that is difficult to quantify.

Despite the fact that there are different criteria for the temperature differential that an autoclave must work with, each canning producer must follow a criterion that is coherent with the type of product that they produce and the tolerance that it has to the heat treatment. It should be taken into account that the heat treatment carried out is already highly aggressive in terms of nutritional and organoleptic degradation, aspects especially considered in the MUSSELPRO project.

Those products that are less resistant to the severe sterilization conditions must be treated in autoclaves that avoid unnecessary over sterilization; otherwise the final quality of the product that reaches the consumer will be significantly reduced. This quality reduction depends on the position that the package occupies in the autoclave.

The smart autoclave‘ sizing has been carried out in such a way that it allows its correct and safe installation in JEALSA. In this way, analysing the available spaces, the following technical specifications were defined:

- Regulation and control system with data communication system.
- CE marking.

Regarding the productive capacity, this would increase more than 10,000% with respect to the TEINCO prototype system since we would be able to process around 15,000 cans/cycle compared to the 100 cans/cycle currently processed in the TEINCO´s prototype.

4 NEXT STEPS

Next we describe the tasks to be carried out during the next 6 months of the project. We will start with the manufacture (Task 2.6) and assembling (task 2.7) of:

Vacuum cooker: (chamber, valves, pipes, vacuum pumps, steam injection system…) according to the technical drawings defined in Task 2.3. A welder company for the assembling of the different pieces will be hired. This company will be legally authorized to assemble pressure equipment. Moreover, the control system of the vacuum cooker will be developed (assembling of the different pieces such as the electrical panel, touch screen,…) and programmed. TEINCO's personnel will also develop the algorithm of the control system, which calculates the optimal temperature and processing time of the vacuum cooker according to the values from the hyperspectral equipment and the conditions within the cooker.

Smart autoclave: (chamber, valves, pipes, steam injection system…) according to the technical drawings defined in Task 2.4. As with the vacuum cooker, an authorized welder company for the assembling of the different pieces will be hired.

Hyperspectral equipment: based on Task 2.2, we will focus on the development of the algorithm for the generation of the chemical images and the software for processing the hypercube and we will generate predictive models. We will also advance in the definition of the operating parameters of the hyperspectral system:

- definition of the needs of the algorithm to generate predictive models.
- definition of working conditions.

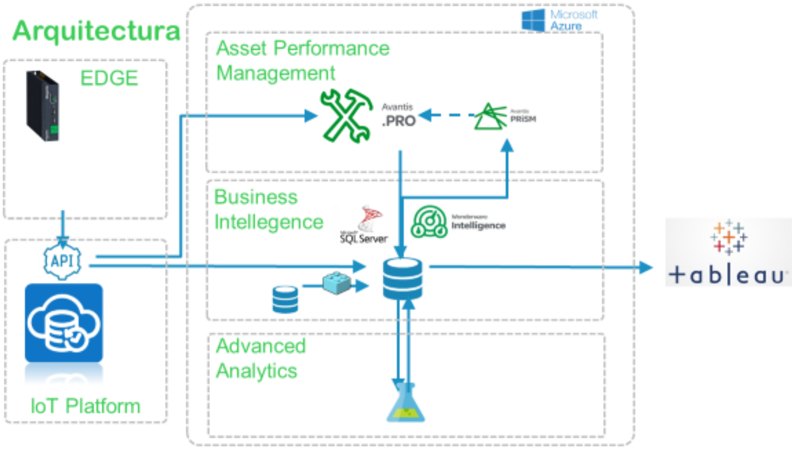
Regarding the control system of the smart autoclave, TEINCO personnel will develop and program it.

We will start the development of the IoT SYSTEM´s Task

The objective of this task is to create a solution that allows converting data into knowledge and knowledge into actions leading to competitive advantages. For this purpose, the intention is to create a cloud-base data architecture that allows:

- scale up and grow quickly
- incorporate new data sources, new visualizations and new Machine Learning models.
- access a single information repository

The project team has held several meetings to analyse and to propose a first architecture for the scale up of current systems at industrial levels. This first version may undergo changes during the project implementation.



5 CONCLUSIONS

This report describes the specifications for the proper scaling up of the MUSSELPRO system from a technical and regulatory perspective. The analysis shows that there are not obstacles for the industrial scaling up of the prototypes owned by TEINCO.

Although the present report indicates some measures for each of the components that make up the MUSSELPRO SYSTEM, these are estimates that serve as guidance to positively assess the scalability of the prototype. The real measures will be obtained once the design phase for the different systems and the integration of all of them in the productive line of JEALSA will finalised.

So far we studied the needs for the scalability of the laboratory hyperspectral system to an industrial system. The design of the whole hyperspectral system was also carried out.

The vacuum cooker‘ sizing has been carried out in such a way that it allows its correct and safe installation in JEALSA. In this way, analysing the available spaces, the following technical specifications were defined:

- Diameter: 1,5 to 2 meters
- Vacuum generation capacity.
- Regulation and control system with data communication system

It is estimated that this equipment will allow at least a processing capacity of 1,500 - 2,000 kg/hour, which would allow us to process 12 to 16 tons per shift.

The smart autoclave‘ sizing has been carried out in such a way that it allows its correct and safe installation in JEALSA. In this way, analysing the available spaces, the following technical specifications were defined:

- Regulation and control system with data communication system.
- CE marking.


Co-funded by the European Maritime and Fisheries Fund
MUSSELPRO 863681
DEMOSTRATION OF AN IoT 4.0 MUSSEL PROCESSING SYSTEM FOR AN ADVANCED SEAFOOD CANNING INDUSTRY
C2: Vacuum cooker
C1: Hyperspectral equipment
Canning zone
C4: IoT 4.0 Technology
C3: Smart autoclave
TEINCO
Tecnología alimentaria
Direction of the processed product
JEALSA