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Review of transformation processes, identification of critical points and proposed selection method.

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ALiSSE:	Advanced Life Support System Evaluator
ESM balance	Equivalent System Mass
MTBF:	Meantime Between failures
FPWG:	Food Processing Working Group

Reference documents

Annex to TN98.1.1 - Nutritional requirements for Space flights for Moon and Mars travels

1 Introduction

The aim of this technology selection step is to propose a methodology for the selection of the food processing techniques to be used to process the 4 crops selected for the Food Characterization project.
The selected processes should combine minimum losses in nutritional quality, minimum mass and energy needs and safe operation, given the constraints of future human space exploration missions. A qualitative trade-off approach not limited to the above criteria was established. Building further on first results, the approach will evolve towards more quantitative assessments in subsequent phases of the project.

A first selection approach will only concentrate on available technology functioning under earth (gravity) conditions. This will lead to first indications on efficiency and applicability of the selected processes ; they may lead either to semi finished products or to finished products, ready to prepare a meal.
The to be used processes must comply with ALiSSE criteria; their impact on the nutritional quality of the proposed meals must also be analyzed, based on previously defined requirements. Other criteria, such as acceptability or versatility of use, may also be important.
In order to take into account the different constraints and to select a number of technologies well suited to the Food Characterization research program, a selection methodology is proposed. A multicriteria evaluation logic will be the basis of this methodology.

This methodology will be used to select and plan processing tests on a limited number of pre-selected cultivars of the 4 FC crops.

- The selected processes will be analyzed in this TN and will help to identify a list of critical points to be improved during future developments of these processes or other complementary processes.
- The critical points identification is very important for the future Food Processing Characterization Unit. It may be completed after the in depth analysis of the selected processes which will be done during following TN of this phase.

Part 1 of this TN, will target the criteria on which an evaluation of the processes may be done. The logic of future selection of processes will be proposed.
In part 2, we will characterize the selected processes and identify potential complementary critical points.

NB : The scope of selected processes in this document is based on a first list of established processes from a European consumer viewpoint : Additional processes are to be considered in subsequent selection stages using the same methodology framework.
In this first methodology description document, selection of fermentation processes is limited to bread preparation. Less characterised fermentation processes raise issues of characterisation of (the stability of) the involved bacterial, fungal or yeast strains, as well as concerns of odour and taste acceptance among consumers, topics which need extended assessment and associated optimisation work in subsequent phases of the project.

2 Methodology and criteria for a trade-off of processing systems

In order to select the most adapted processes for "resource-efficient" crop harvest conversion to food, a list of criteria is considered, including specific nutritional criteria and ALiSSE criteria (Advanced Life Support System Evaluator).
For each of the criteria, the content and the specific aspects of food processing are described.

In the present phase, to select the products and corresponding processes to be studied, a simplified and qualitative approach is chosen: for each product each criterion (Alisse and nutritional) is scored from 1 to 5 (1 for negative to 5 for positive).

2.1 Food quality criteria

The aim is to feed the crew: therefore three criteria concerning the food processes are selected targeting the nutritional objective.

2.1.1 Nutritional criteria

This will target

- Energy and Macronutrients (carbohydrates, lipids, proteins) which are available (preserved by the different processing steps and digestible for humans)

as well as

- Micronutrients (minerals, vitamins…).

(Micronutrients will be considered even if their weight is very low compared to the global food mass. There are indications that the nutritional efficiency (bioavailability) of micronutrients is lower and that a risk of carcinogenicity exists when supplemented from a stock supplied from earth).

- Nasty components production:

They are mentioned when a specific risk is identified. As an example, production of toxic compounds during the processes of transformation of soybean is not mentioned in the literature. (even if,during thermal treatments, lipoxygenase, an enzyme naturally present in soybeans, mediates the conversion of polyunsaturated fatty acids to hydroperoxides and the subsequent degradation products are responsible for the off-flavours generated). It's possible to hide off-flavours in soymilk by adding vanilla.

The indicators proposed for this criterion are:

- *Nutritional preservation: percentage of nutrient content which is preserved by the process, for main nutrients (100% being the content in the raw crop, immediately after harvest).*
- *Nutrient preservation criteria will be considered per crop only for specific, abundant micronutrients for which the analysis in the raw crop was successful, according to the measuring protocols defined in TN98.4.1, which apply to both raw crop and processed product.*

- *Nasty components production: possible presence of any dangerous component will be crucial criteria.*

2.1.2 Food acceptability

This criterion applies to the end product, ready to eat; it may focus mainly on:
- *Sensory acceptability of the meal*
- *Lassitude effect/ versatility of the possible applications of the processed product, possible combinations with other meals*

Many questions are raised by these acceptability parameters, cultural (European viewpoint on food habits), environmental (microgravity influence on parameters to be considered at later stages).
In the present case of a first general scenario, targeting the process choice for each crop, the general acceptability of the processed product by an European consumer (without taking into account impact of the recipe choices) and versatility of use (incorporation in multiple different meals) is concluded to be of first importance.

Indicators: to be defined for future use in a further extended selection methodology. At the present FC Phase 1 level, we propose to consider the acceptability of the different possible products from a European consumer viewpoint, with a limited sensory test.(this will be established in the first food processing plan TN 98.5.1
This approach will be subjective and the above proposed first assessment of the food acceptability criteria suffers severe limits; extended selection methodology including food acceptability indicators to be further elaborated in Food Processing phase 2.

2.2 ALiSSE criteria

2.2.1 Mass criteria

Mass shall include:
- Dry mass of equipment
- Mass of fluids: water consumption and other required fluids for equipment functioning (e.g. cooling fluids, oil)
- All necessary secondary resources: consumables such as filters or grinding stones.
- Spare parts required for the whole mission duration, mass of tools (taking into account that some tools may be used for several purposes, applicable for more than one crop or allow different processing steps to be carried out),

The indicators proposed for these criteria could at first be based on existing processes
- If possible at this stage, total system mass of a processing unit in kg / total Kcal of the end product to be produced in one year, (based on average menu composition –

quantities to be evaluated based on preliminary menu elaborations see TN98.1.1 annexes)

- Total system mass in kg (as detailed above) / Kcal content of end product which can be produced per hour (production capacity in Kcal/h which is a parameter which can be measured). It is possible to estimate this indicator with existing equipment.
- Amount of waste water produced per kg of end product
- Other organic waste production (skin, and other organic wastes produced during the treatment, as well as roots, leaves (if not yet taken into account in crop yield).
- Other consumables needed for the processing

2.2.2 Crew time

It shall include:

- Base crew time for nominal system management (food preparation, processing, cleaning and preventive maintenance)
- Potential crew time (corrective maintenance, human or hardware failure management) which exists only in case of an error or a failure in the system. Thereby factors such as the Meantime Between Failure (MTBF) must be taken into account.
- If possible at this stage, a preliminary crew time expressed in working seconds/ end product Kcal to be produced (average for one year).

2.2.3 Energy (power) criteria

After discussion with SHERPA, it was decided to just consider available data concerning the following key indicators:

- Energy consumption per kilo of processed product
- Information concerning power peaks or Installed power

2.2.4 Efficiency

- The aim of the FC Project is to produce food corresponding to at least 40 % dry weight of the nutritional needs of the crew. A more direct reflection of the crew nutritional needs is the amount of energy: it could be advantageous to first consider the calories (Kcal) that need to be produced instead of weight (given the difference in energy density between carbohydrate, protein versus lipid, and the composition characteristics of the selected starting crops).

  For process engineering in general, and mass balance control in particular, dry mass is the relevant indicator. But both indicators are closely linked one to the other ([1]) and

[1] Taking the hypothesis of a nutritionally equilibrated diet, mainly for macronutrients: therefore the share of proteins, sugars and lipids is fixed and the targeted nutritional energy produced reflects the targeted mass produced: we cannot replace 2g of proteins from earth containing 8 cals by 8 calories coming from 1 g lipids produced in space. However a nutritional basis may be preferred, as it may theoretically be considered to process 1 g of lipids from Earth to produce 2 grams of proteins...

have to be used in the future. During last optimization steps, this will help to select the best way for supplying a full diet to the crew with a global minimum mass (food and equipment) coming from Earth.
- This nutritional criterion cannot be taken into account for the first selection of processes. An indicator targeting the energetic yield of the process would be very similar to the above chosen nutritional indicators which characterize how much valuable food (on a per nutrient basis) is produced per unit of biomass produced by the other compartments (higher plant and algal based). However, it may be completed by a dry mass yield indicator.

To be considered for future work: recycling of processing water (with possible valuable nutrient content) for use in other processes, or possible valorization of wastes generated by the selected processes.

2.2.5 Reliability

In the case of a first evaluation of food processes, this may include:
- Flexibility of the process concerning the raw material (composition, texture) and possible variations in the processed product (and intermediate products where relevant)
- Risk of processing tools breakdown:
- If any, risk or requirements concerning storage (raw or processed products).

2.2.6 Volume and possible impact on space adaptation requirements

- At the moment, the needed equipment volume is very difficult to estimate, but the basic dimensions of the equipment can be used as a starting point
- Considerations concerning the ratio *Volume/production capacity* can be mentioned.

2.2.7 Risk to human

Risks for humans to be mentioned:
- Physical (burning, cutting, electric shock.)
- Chemical (including risks of contamination/alteration of the processed products)
- Biological (including risks linked to processed product quality: e.g. bacteriological, viral, fungal)
- Environment contaminants (e.g. dust emission, microwaves, vibrations)

The different products and processes are quoted.

2.3 Other possible criteria linked to space adaptability

Moreover, there are other factors which can direct the choice towards processes better suited to space conditions.

A general check list from SHERPA is presented in the annex (some of these criteria are classified in the above ALiSSE criteria list under 1.2.7), which may help to identify the risk of some processes potentially not being adaptable or safe (in their current status) for their future intended space-based use.

2.4 Proposed methodology to select the transformation processes

The detailed method is not fully defined in the present document.
However we can introduce the logic of the selection process which would be developed during future steps.
The logic will be based on a progressive optimization of the ESM balance (Mass Equivalent of the System to be launched from earth, including all necessary inputs –after conversion in mass equivalent- of one process); this will include:

- At first, selection of individual processes and products, and optimization at a product level,
- Then, including menu elaboration and optimization at a menu level,
- Then including crop production with optimization at a global production and processing level.

The following scheme tries to summarize the different steps and adjustments of this optimization process.

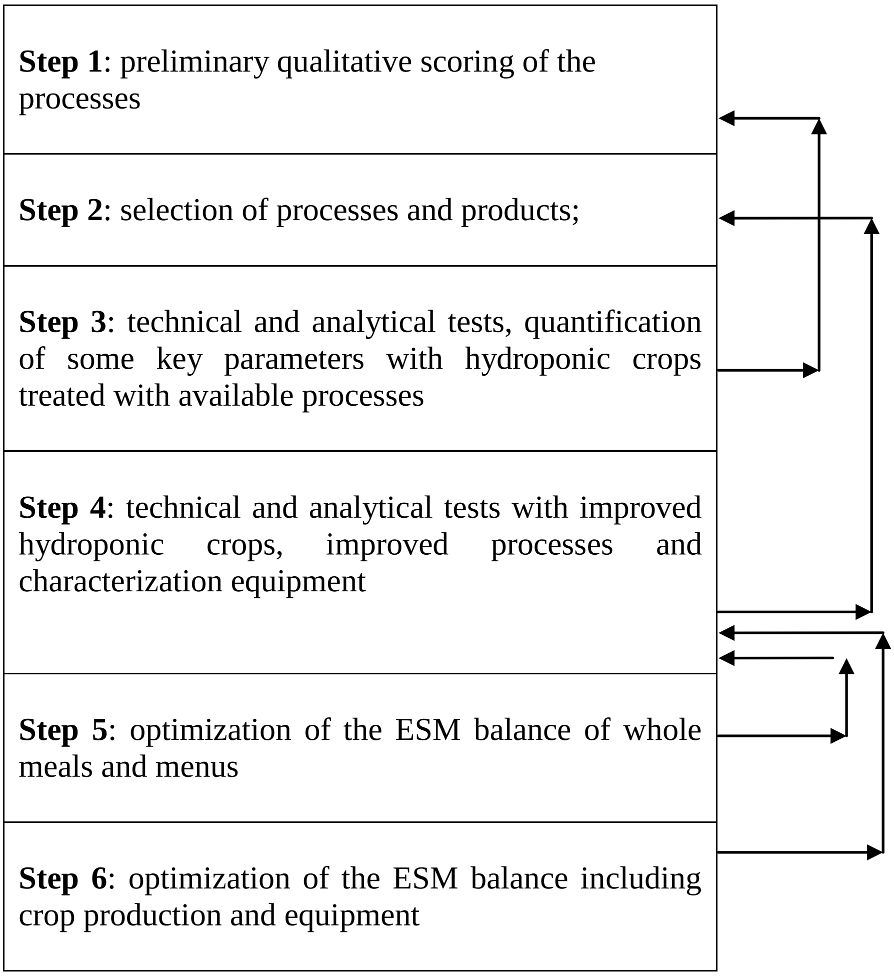


Fig. 1 Proposed methodology to select the transformation processes

2.5 Preliminary qualitative scoring of the processes

Except for the case of wheat, we considered the following scoring method for the different products:

- For each criterion a maximum of 5 points are attributed.
- Optimal result (as compared to other processes and literature references) corresponds to a 5 score.
- A very poor result corresponds to a 1 score .
- For each processed products, all the criteria have been scored.
- A total is done for each product, including all different criteria.

Taking the example of potato processing, the quotation has been done:

- Macronutrient preservation, (5 represents: no loss of macronutrients, under 2.5 loss of important amount of essential macronutrients)
- Micronutrient preservation, (5 represents: no loss of micronutrients, under 2.5 loss of important amount of essential micronutrients)
- Sensory acceptability (5 represents: good acceptability of consumers. This will be based on sensory analyses, under 2.5 more than 50% of the panel estimated that this product is not acceptable)
- Versatility of uses (5 represents: large versatility of uses in different recipes or end-products; under 2,5 limited versatility of uses)
- Mass criteria : (5 represents: uses few kitchen utensils, little water needed and small waste production; Under 2.5: the number of utensils is higher and higher waste production)
- Crew time : (5 represents: short preparation time (cooking, and serving); under 2.5: the total crew time is substantial)
- Energy (kwh/end product calories) (5 represents: low energy consumption (estimated by wattmeter); under 2.5: high energy consumption). Remark: a level for each quotation has to be determined.
- Energy (power peaks): (5 represents: low energy consumption (estimated by wattmeter) ; under 2.5: high energy consumption). Remark: a level for each quotation has to be determined.
- Reliability (5 represents: few risks of processing tools breakdown and high flexibility of the process; under 2.5 : the flexibility of the process is reduced or critical if processing tools breakdown)
- Human risk (5 represents: no risk for human (burn, contaminations, …); under 2.5 : increased risk)

All items are relevant. But it is necessary to consider that with a quotation under 2 for one criterion, the product or process needs to be adapted. In this first step, a process needs a minimum of 27,5 points on a total of 55 points to be eligible. If it is not possible to improve the total of this product/process, it will not be integrated in the MELiSSA list.
But, most of all, this is a ranking method to help choosing the adapted processes.

2.6 The limits of this preliminary trade-off methodology

It is obvious that the preliminary process selection based on a list of individual criteria is simple to handle but suffers different limits.

- Some criteria may eliminate a process which doesn't comply : eg security criteria
- More generally speaking, all criteria do not have the same importance
- The criteria are not independent the one from the others: equipment weight and energy consumption are clearly part of the ESM global cost of a process; in the same way, a low nutritional yield of a process may be compensated by its lower energy consumption…

- More globally, the choice of the selected processes will need a final optimization of the whole considered system.
- Eventually, it must be stressed that all the considered processes may be optimized to improve their performance or to comply with specific constraints.

Therefore, the criteria must be considered as indicators designed to help one's choice, or to optimize each individual process, considering the scoring as an easy to handle tool, with a rather wide scope; but the criteria must be completed by a qualitative analysis of what may be improved or not, and what can be the non-direct impact of each choice.
These criteria, and the way to optimize them for one specific process, are a good basis for the identification of the critical points of each process.

3 Process systems evaluation

In this second chapter we will score the different processes which are available to process the different crops.
The aim is :

- to check the possible use of these processes
- and to make a first evaluation of the performances of these processes.

3.1 Potato processing

3.1.1 Review of potato products and processes

The seven following main general established end products (Fig. 2) can be considered:

3.1.1.1 Fresh potato cooked in water

Freshly cooked potatoes can be consumed in several ways. All represent different energy costs and shelf-lifes:

- Peeled
- Unpeeled
- Cold (cooled after cooking)
- Hot (either still hot or reheated)

Peeled and Unpeeled potatoes can be preserved for 3 days at 7°C, 21 days at 7°C if under vacuum or 3 months at -18°C.The stored potatoes can then either be consumed cold or reheated.

3.1.1.2 Oven cooked or microwave or vapor cooked potato

- Peeled
- Unpeeled
- Cold (cooled after cooking)
- Hot (either still hot or reheated)

As for water cooked potatoes, cold or hot consumption is possible. The shelf life does not differ from water cooked potatoes.

Here are in fact 3 processes (oven cooked or microwave or vapor cooked potato) which are not using water immersion to transfer cooking calories: we do not consider the use of water in the cooking process -there is steam from potato water in an oven or in a microwave oven cooking process- but the immersion or not of the food in a water based liquid (water, wine, milk, ..). In terms of impact on the final product and nutritional aspects, differences may exist. Indeed, the cooking water immersion means that the temperature is limited to 100 ° C at atmospheric pressure so no risk of occurrence of compounds like caramelization or Maillard reactions. On the other side some losses on water-soluble macro and micronutrients are more important. So considering nutritional aspects, vapor cooking, microwave or oven cooking methods are rather close.

3.1.1.3 Mashed potatoes

The following cases are distinguished:

- Mashed hot or cold cooked potato: for immediate consumption or processing
- Mashed and frozen, to be stored and then reheated for consumption

3.1.1.4 Croquettes

- Mashed potatoes, coated (with dried bread crumbs) and cooked in oven or deep fried in croquettes
- Coated and frozen to be stored, to make croquettes to be cooked in oven or deep fried.

3.1.1.5 Sterilized potatoes

After blanching, they are packed and sterilized in their pack (vapor or water sterilization under pressure) and they can be stored in their packaging for longer term (at 7°C during 3 weeks to 3 months and more, depending from added preservatives and cooking temperature for plastic bags, and years for cans) and then prepared as if they were freshly cooked.

- Plastic bag, to be reheated for consumption
- Canned, to be reheated for consumption

The exact process is not determined at this time. Two main processes exists by vapor or by immersion in a hot liquid. It will depend on the quantity to sterilize. The nutritional impact will depend on the time of sterilization.

These parameters are part of those to be pointed out as critical points on comment 3 answer: critical points to be solved in following phases.

3.1.1.6 Dried mashed potatoes to produce flakes to be stored and rehydrated

- For puree
- For croquettes or others.

3.1.1.7 Deep fried potatoes

- Fried fresh, for direct consumption
- Cut and frozen to be stored and then fried.

NB: potato starch production was not included, This process doesn't lead to a specific meal but may only contribute as an ingredient, in various preparations (soups…), which in general will have a rather low potato starch content.

This review leads to many different processes, or combinations of various operations, to make a ready to eat potato meal, linked to seven main processing solutions (Fig. 3).

3.1.2 Description of the processes

On Fig. 2, one can see the different possible processed products.

The term "raw potatoes" means potatoes that were just harvested. While "ready to cook potatoes" means that the potatoes have been selected, graded, cleaned, possibly peeled and then can immediately go into a recipe or cooking process.

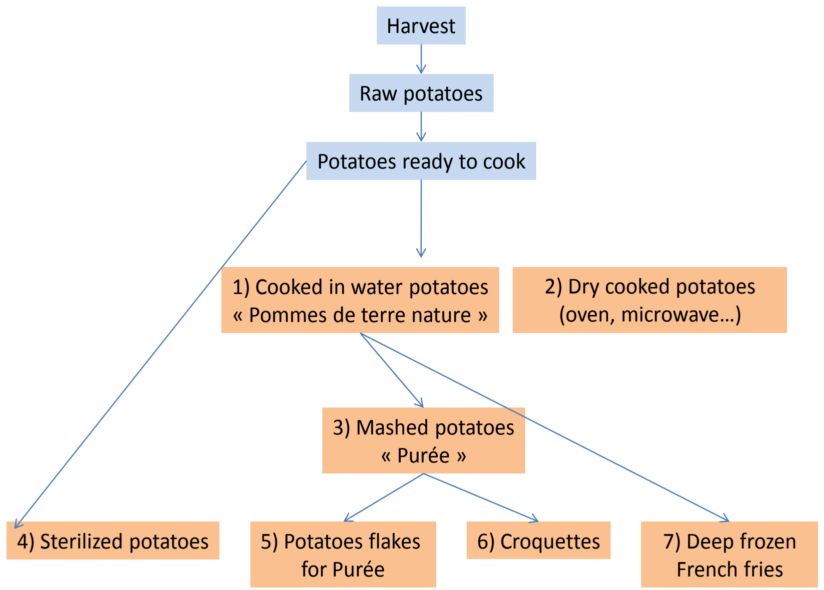
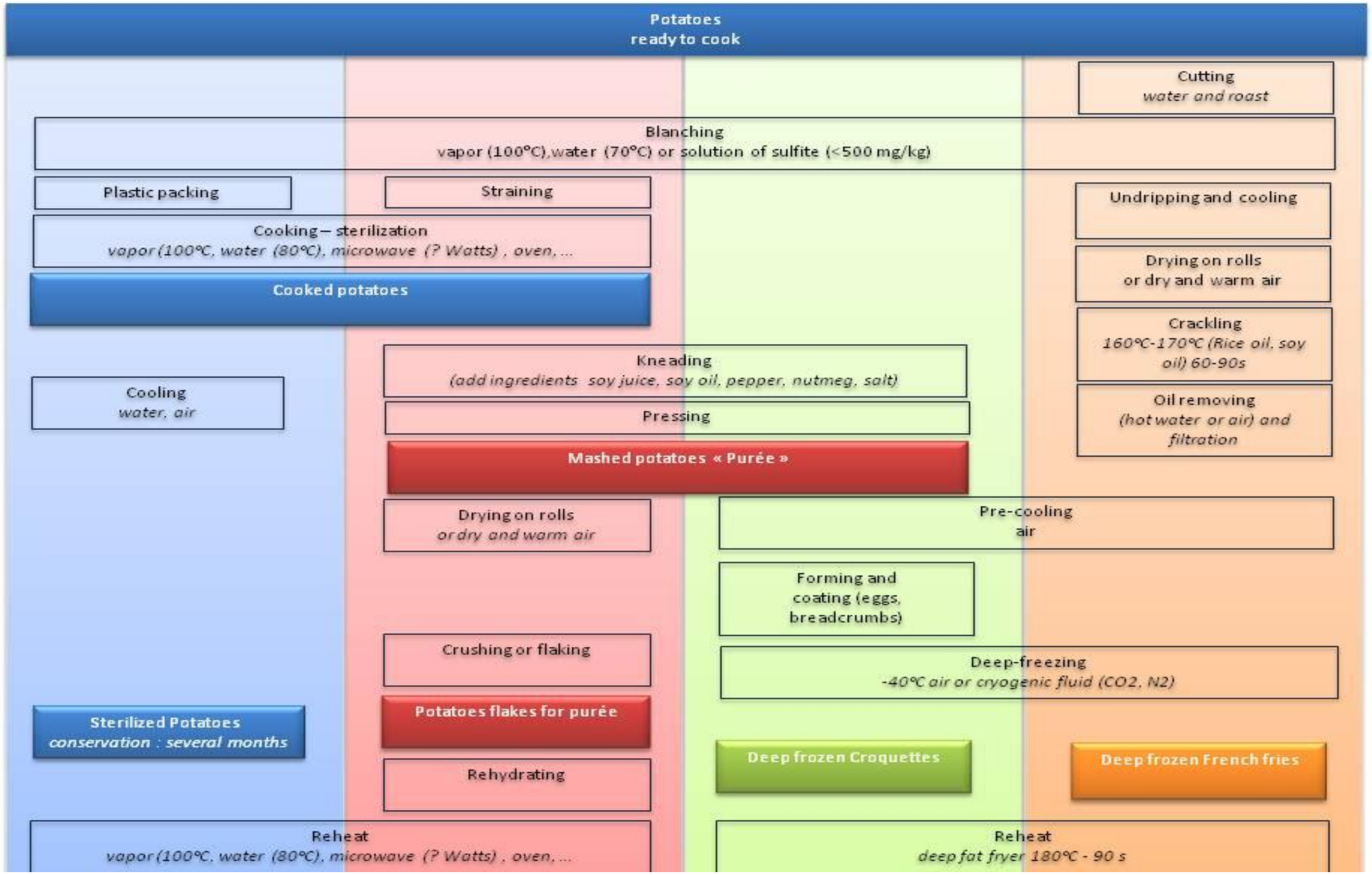


Fig. 2 The seven main end products for potato

Concerning Fig. 3 on next page, the different processing operations are presented. It must be stressed that cooked potatoes include "dry cooked" as well as "cooked in water" products which may have different yields. Concerning waste production, if a preliminary peeling has been done, this will generate potato skin waste. The cooking process will also generate cooking water waste (water with soluble sugars and proteins).

Fig. 3 Potato processes


Potatoes
ready to cook
Cutting
water and roast
Blanching
vapor (100°C),water (70°C) or solution of sulfite (<500 mg/kg)
Plastic packing
Straining
Undripping and cooling
Cooking – sterilization
vapor (100°C, water (80°C), microwave (? Watts) , oven, ...
Drying on rolls
or dry and warm air
Cooked potatoes
Crackling
160°C-170°C (Rice oil, soy oil) 60-90s
Kneading
(add ingredients soy juice, soy oil, pepper, nutmeg, salt)
Cooling
water, air
Pressing
Oil removing
(hot water or air) and filtration
Mashed potatoes « Purée »
Drying on rolls
or dry and warm air
Pre-cooling
air
Forming and coating (eggs, breadcrumbs)
Crushing or flaking
Deep-freezing
-40°C air or cryogenic fluid (CO2, N2)
Sterilized Potatoes
conservation : several months
Potatoes flakes for purée
Deep frozen Croquettes
Deep frozen French fries
Rehydrating
Reheat
vapor (100°C, water (80°C), microwave (? Watts) , oven, ...
Reheat
deep fat fryer 180°C - 90 s

3.1.3 Potato processes evaluation: quotation of the different selected products

Tab. 1 Evaluation of nutritional criteria for potato processes

Product	**Macronutrients preservation**	Score	**Micronutrients preservation**	Score
Specific considerations	*Skin will be thin in hydroponic culture. Not necessary to peel; Few losses with skin; if peeled: 10-20% of biomass*		*(no peeling)*	
PRODUCT 1 Water cooked potatoes	High content in starch, high digestibility. If cooked with skin higher content in fibers. Lower loss of nutrients in cooking water when skin is not peeled.	4,5	According to cooking method and time, loss of water-soluble elements and thermo-sensitive vitamins	4
PRODUCT 1bis: vapor, microwave or oven cooked potatoes	No water-soluble sugar losses in water.	5	loss of thermo sensitive vitamins	4,5
PRODUCT 2 Sterilized potatoes	High content in starch, high digestibility. If cooked with skin higher content in fibers	4,5	According to cooking method and time, loss of water-soluble elements and thermo-sensitive vitamins. Loss during long duration storage	3,5
PRODUCT 3 Mashed potatoes	High content in starch, high digestibility.	4.5	According to cooking method and time, loss of water-soluble elements and thermo-sensitive vitamins	4
PRODUCT 4 Flakes for mashed potatoes	High content in starch, high digestibility.	4	According to cooking method and time, loss of water-soluble elements and higher losses of thermo-sensitive vitamins	3,5
PRODUCT 5 Croquettes	Higher content in fat.	3	No water-soluble vitamins losses. Higher impact on thermo-sensitive vitamins	3,5
PRODUCT 6 French fries	Higher content in fat.	3	No water-soluble vitamins losses. Higher impact on thermo-sensitive vitamins	3,5

For Sterilized potatoes the first step is a blanching process in vapor or water immersion. After this step, potatoes are placed in vacuum plastic bag. A heat process is needed to sterilize the potatoes. The couple time/temperature will determine the level of sterilization and the time of storage. It is possible to obtain semi-cooked or cooked potatoes. In all cases the couple time/temperature will have an impact on vitamin losses. Moreover the storage will influence the vitamin content.

Tab. 2 Evaluation of food acceptability criteria for potato processes

Product	**Sensory acceptability**	Q*	**Versatility of uses**	Q*
PRODUCT 1 Water cooked potatoes	High. Taste differs with potato variety. Skin presence can have an influence. Better with strong flesh (20-22% starch) potato	5	High versatility	5

PRODUCT 1bis: vapor, microwave or oven cooked potato	id	5	id	5
PRODUCT 2 Sterilized potatoes	Taste can be a little bit different	4	High versatility	5
PRODUCT 3 Mashed potatoes	High. Taste will differ in function of potato variety, better with tender flesh (16-18% starch)	5	lower versatility	4
PRODUCT 4 Flakes for mashed potatoes	Depends on the rehydration properties	4	lower versatility	4
PRODUCT 5 Croquettes	High	5	Low. Due to high content of fat, recommendation is to consume it only once every second weeks	2
PRODUCT 6 French fries	High if not too fatty	5	Low. Due to high content of fat, recommendation is to consume it only every second weeks	2

Tab. 3 Evaluation of ALISSE criteria for potato processes

Product	**Mass criteria**	Q*	**Crew time**	Q*
Specification	*Equipment mass and water per kg/h producing capacity*		*Per kg/h producing capacity*	
PRODUCT 1 Water cooked potatoes	cooking container (about 0,5kg water for 1kg potatoes 100 times a year)	5		5
PRODUCT 1bis: vapor, microwave or oven cooked potato		4		5
PRODUCT 2 Sterilized potatoes	Cooked under pressure	2	reheat	4
PRODUCT 3 Mashed potatoes		4		4
PRODUCT 4 Flakes for mashed potatoes	Dried	1	Rehydration and reheat	3
PRODUCT 5 Croquettes		2	More processes	3
PRODUCT 6 French fries		3	More processes	2

Product	**Energy**	Q*	**Energy**	Q*
Specification	***kWh/end product calories***		***Power peaks***	
PRODUCT 1 Water cooked potatoes	medium (Depends on cooking method)	4	Depends on cooking method	5
PRODUCT 1bis: vapor, microwave or	medium (Depends on cooking method)	4	Depends on cooking method	5

oven cooked potato				
PRODUCT 2 Sterilized potatoes	rather high (Depends on cooking method)	3	sterilization	3
PRODUCT 3 Mashed potatoes	medium (Depends on cooking method)	4	Depends on cooking method	5
PRODUCT 4 Flakes for mashed potatoes	high (drying)	1	Drying	2
PRODUCT 5 Croquettes	high (freezing, storing and reheating)	2	Deep fat frying needs more energy for freezing and storage at -18°C	2
PRODUCT 6 French fries	high, if from frozen (freezing, storing, frying) lower if from fresh	3	Deep fat frying needs more energy for freezing and storage at -18°C	3
OTHERS…				

Product	**Reliability**	Q*	Volume	Q*	**Human Risk**	Q*
Specification			Describe possible specific impacts on the station			
PRODUCT 1 Water cooked potatoes	High (very simple process)	5			Not high Temperature, Low microbiological risk	3
PRODUCT 1bis: vapor, microwave or oven cooked potato	High (very simple process)	5			Not high Temperature, Low microbiological risk	3
PRODUCT 2 Sterilized potatoes	High	4,5	Storage		lower microbial risk, but higher for sterilization process	2
PRODUCT 3 Mashed potatoes	High	5			Temperature, Microbiological	3
PRODUCT 4 Flakes for mashed potatoes	High and flakes are easy to store	4	Less volume for storage		Increased Temperature risk (drying), low microbiological	2,5
PRODUCT 5 Croquettes	More losses in function of the quality of process	3	Needs larger freezer		Temperature (frying), Microbiological (higher with risk of breaking cool chain)	2
PRODUCT 6 French fries	High	3	Needs larger freezer		Temperature (frying), Microbiological (higher with risk of breaking cool chain)	2

3.1.4 Potato processed products selection

We select here the processed products on which the FPWG will realize a detailed evaluation of all the criteria. This selection takes into account the results of the first evaluation of all criteria including minimization of the risks to human.

Global scoring table gives the following cumulated results:

	Product 1	Product 1 bis	Product 2	Product 3	Product 4	Product 5	Product 6
Macronutrient preservation	4,5	5	4,5	4,5	4	3	3
micronutrient preservation	4	4,5	3,5	4	3,5	3,5	3,5
Sensory acceptability	5	5	4	5	4	5	5
Versatility of uses	5	5	5	4	4	2	2
Mass criteria	5	4	2	4	1	2	3
Crew time	5	5	4	4	3	3	2
Energy/calories	4	4	3	4	1	2	2
Energy	5	5	3	5	2	2	3
Reliabillity	5	5	4,5	5	4	3	3
Volume							
Human risk	3	3	2	3	2,5	2	2
TOTAL	**45,5**	**45,5**	**35,5**	**42,5**	**29**	**27,5**	**28,5**

NB: Volumes of equipment has not been estimated and are not scored

The processes to be selected will be analyzed in detail, including measures or biochemical analysis, which will allow quantifying all criteria much more precisely.

At the present level, this first selection methodology will take into account:

- the obtained score for each product,
- the objective of selecting processes which are rather different one from the other, in order to widen the scope of the different possibilities

Therefore, we observe that products 1, 1bis, 2 and 3 appear more adapted, but, at this stage, we keep with the seven products.

3.1.5 Prioritization of the criteria and suggestions to improve characterization and product performance

For each of the processes which have been analyzed, the following tables characterize:

- The weight to be given to each specific criterion in the choice of a process
- How to characterize the criteria with the existing equipment
- How to improve the characterization of the criterion: this could help in the FCPU future concept definition.
- How to improve the performance of the analyzed process on this criterion?

These elements will help to point out the characteristics of the operation (or process or equipment) which may have a strong impact on the performance of the process and to point out the limits of our characterization results : these are the critical points.

For example, is macronutrient preservation improved if we work with higher temperature and less cooking time ? or the contrary ? what are the operating parameters of each process (or equipment) which can be considered as critical ? This mainly requires that we improve the answers in the last column of each table and give details and explanations.
This will lead to priorities in the future Food processing characterization device.

We may also point out the parameters which **will not have a crucial impact** on the result, even if some optimization can be done : this will help us to prove that the main objective of this phasis keeps to select the products which have a good performance and (may be/I hope) that this selection will not be modified after technological improvements.

These elements will help selecting the critical points.

Tab. 4 Freshly oven cooked potato

CRITERIA	Weight of the criteria (To what extent will it be crucial for the selection of a process for this crop)	Possible test to characterize the criteria with the existing equipment (TN 5000)	Proposed future developments : ways to improve the characterization of the criteria	Proposed future developments : ways to improve the performance of each process on these criteria
Macronutrients preservation	Determinant	- Try with one cultivar. - Small sample - Cooking method : dried air oven - Chemical analysis (macro-nutrients)	- Try with each cultivar. - larger sample - Cooking method : dried air oven - Chemical analysis (macronutrients and amino acids, all carbohydrates)	Take into account the impact of the cooking method (fluid for heat transfer, time, temperature, pressure, on the nutritional content.
Micronutrients preservation	Determinant for some micronutrients (K, Vit C, …)	- Try with one cultivar. - Small amount - Cooking method : oven dry air - Chemical analysis (K, Na, Vit C)	- Try with each cultivar. - larger sample - Cooking method : oven dry air - Chemical analysis (All micronutrients)	Id..
Food acceptability	Determinant	Sensory analysis with internal test panel.	Sensory analysis with a greater test panel with experimented consumers with a scientific procedure of testing in a authorized laboratory.	Due to the results of the panel test propose modification of recipes.
Mass criteria		large professional oven	Use a environment with the possibility to change air pressure to be comparable to space station environment	Engineering of the oven
Crew time		List the timing for all procedures	Repeat with other operators to test recipes and timing	Make a standardization of procedure with different oven (power, volume, quantity of potatoes) and to determine the best ratio
Energy consumption		Only give the power of the oven and the time needed to cook	Use of a wattmeter	Optimization of heat transfer and equipment mass in relation to the quantity of potatoes to cook
Power peaks				Heat transfer
Reliability				

Volume (?)		large professional oven		Choose a more adapted oven in relation to the quantity of potatoes to cook
Risks to human		Microbial (pathogenic germ)	Microbial (pathogenic germ) extended	Determination of a HACCP procedure

Tab. 5 Boiled potatoes

CRITERIA	**Weight of the criteria (To what extent will it be crucial for the selection of a process for this crop)**	**Possible test to characterize the criteria with the existing equipment (TN 5000)**	**Proposed future developments : ways to improve the characterization of the criteria**	**Proposed future developments : ways to improve the performance of each process on these criteria**
Macronutrients preservation	Determinant	- Try with one cultivar. - Small sample - Cooking method : boiled potatoes in a pan - Chemical analysis (macro-nutrients)	- Try with each cultivar. - Greater sample - Cooking method : boiled potatoes in a pan, pressure pan, modification of air pressure, impact of time/temperature type of water and electrolytes - Chemical analysis (macronutrients and amino acids, all carbohydrates)	Take into account the impact of cooking method on the nutritional content.
Micronutrients preservation	Determinant for the most interesting micronutrients (e.g. for potato K, Vit C, …)	- Try with one cultivar. - Small amount - Cooking method : : boiled potatoes in a pan - Chemical analysis (K, Na, Vit C)	- Try with each cultivar. - Greater sample - Cooking method : boiled potatoes in a pan, pressure pan, modification of air pressure, impact of time/temperature type of water and electrolytes - Chemical analysis (All micronutrients)	Take into account the impact of cooking method on the nutritional content.

Food acceptability	Determinant	Sensory analysis with small test panel.	Sensory analysis with a great test panel with experimented consumers with a scientific procedure of testing in a authorized laboratory. Test different recipes	Due to the results of the panel test propose modification of recipes.
Mass criteria		normal pan with old electric cooker	Use equipment with the possibility to change air pressure	Choose a more adapted equipment in relation to the quantity of potatoes to cook
Crew time		List the timing for all procedures	Ask to other people to test recipes and measure timing	Make a standardization of procedure with different oven (power, volume, quantity of potatoes) and to determine the best ratio
Energy consumption		Only give the power of the electric cooker and the time needed to cooked	Use of a wattmeter, water consumption	Choose a more adapted oven in relation to the quantity of potatoes to cook
Power peaks				
Reliability		We have normal pan with old electric cooker		
Volume (?)				Choose a more adapted oven in relation to the quantity of potatoes to cook
Risks to human		Microbial (pathogenic germ)	Microbial (pathogenic germ)	Determination of a HACCP procedure

Tab. 6 Mashed potatoes

CRITERIA	**Weight of the criteria (To what extent will it be crucial for the selection of a process for this crop)**	**Possible test to characterize the criteria with the existing equipment (TN 5000)**	**Proposed future developments : ways to improve the characterization of the criteria**	**Proposed future developments : ways to improve the performance of each process on these criteria**
Macronutrients preservation	Determinant	- Try with one cultivar. - Small amount - Cooking method : boiled potatoes - Chemical analysis (macro-nutrients)	- Try with each cultivar. - Great amount - Cooking method : oven dry air, boiled potatoes, micro-wave - Chemical analysis (macronutrients and amino acids, all carbohydrates)	Take into account the impact of cooking method on the nutritional content.
Micronutrients preservation	Determinant for some micronutrients (K, Vit C, …)	- Try with one cultivar. - Small amount - Cooking method : oven dry air - Chemical analysis (K, Na, Vit C)	- Try with each cultivar. - Great amount - Cooking method : oven dry air - Chemical analysis (All micronutrients)	Take into account the impact of cooking method on the nutritional content.
Food acceptability	Determinant	Sensory analysis with small test panel.	Sensory analysis with a great test panel with experimented consumers with a scientific procedure of testing in a authorized laboratory.	Due to the results of the panel test propose modification of recipes.
Mass criteria		We have normal pan with old electric cooker	Use equipment with the possibility to change to air pressure similar to space station environment	Choose a more adapted oven in relation to the amount of potatoes to cook
Crew time		List the timing for all procedures	Ask to other people to test recipes and measure timing	Make a standardization of procedure with different oven (power, volume, amount of potatoes) and to determine the best ratio
Energy consumption		We have normal pan with old electric cooker. If electric mashing = energy consumption	Use of a wattmeter, water consumption,	Choose a more adapted electric cooker (induction?) in relation to the amount of potatoes to cook
Power peaks				
Reliability				
Volume (?)		We have normal pan		Choose a more adapted cooking method

				in relation to the amount of potatoes to cook
Risks to human		Microbial (pathogenic germ)	Microbial (pathogenic germ)	Determination of a HACCP procedure

Tab. 7 Sterilized potatoes

CRITERIA	Weight of the criteria (To what extent will it be crucial for the selection of a process for this crop)	Possible test to characterize the criteria with the existing equipment (TN 5000)	Proposed future developments : ways to improve the characterization of the criteria	Proposed future developments : ways to improve the performance of each process on these criteria
Macronutrients preservation	Determinant	- Try with one cultivar. - Small amount - Cooking method : oven dry air, low temperature - Chemical analysis (macro-nutrients)	- Try with each cultivar. - Great amount - Cooking method : oven dry air, low temperature - Chemical analysis (macronutrients and amino acids, all carbohydrates)	Take into account the impact of cooking method on the nutritional content.
Micronutrients preservation	Determinant for some micronutrients (K, Vit C, …)	- Try with one cultivar. - Small amount - Cooking method : oven dry air, low temperature - Chemical analysis (K, Na, Vit C)	- Try with each cultivar. - Great amount - Cooking method : oven dry air, low temperature - Chemical analysis (All micronutrients)	Take into account the impact of cooking method on the nutritional content.
Food acceptability	Determinant	Sensory analysis with small test panel.	Sensory analysis with a great test panel with experimented consumers with a scientific procedure of testing in a authorized laboratory.	Due to the results of the panel test propose modification of recipes.
Mass criteria	Determinant	We have only a great professional oven	Use a environment with the possibility to change air pression as compared in space station	Choose a more adapted oven in relation to the amount of potatoes to cook
Crew time		List the timing for all procedures	Ask to other people to test recipes and measure timing	Make a standardization of procedure with different oven (power, volume, amount of potatoes) and to determine the best ratio

Energy consumption		Only give the power of the oven and the time needed to cooked	Use of a wattmeter	Choose a more adapted oven in relation to the amount of potatoes to cook
Power peaks				
Reliability				
Volume (?)		We have only a great professional oven		Choose a more adapted oven in relation to the amount of potatoes to cook
Risks to human	Determinant	Microbial (pathogenic germ)	Microbial (pathogenic germ, fungi,)	Determination of a HACCP procedure

Tab. 8 Frozen French fries

CRITERIA	Weight of the criteria (To what extent will it be crucial for the selection of a process for this crop)	**Possible test to characterize the criteria with the existing equipment (TN 5000)**	**Proposed future developments : ways to improve the characterization of the criteria**	**Proposed future developments : ways to improve the performance of each process on these criteria**
Macronutrients preservation	Determinant (less)	- Try with one cultivar. - Small amount - Cooking method : oven dry air - Chemical analysis (macro-nutrients)	- Try with each cultivar. - Great amount - Cooking method : oven dry air - Chemical analysis (macronutrients and amino acids, all carbohydrates)	Take into account the impact of cooking method on the nutritional content.
Micronutrients preservation		- Try with one cultivar. - Small amount - Cooking method : oven dry air - Chemical analysis (K, Na, Vit C)	- Try with each cultivar. - Great amount - Cooking method : oven dry air - Chemical analysis (All micronutrients)	Take into account the impact of cooking method on the nutritional content.
Food acceptability	Determinant	Sensory analysis with small test panel.	Sensory analysis with a great test panel with experimented consumers with a scientific procedure of testing in a authorized laboratory.	Due to the results of the panel test propose modification of recipes.
Mass criteria		We have non professional freezer, deep fat fryer	Use a environment with the possibility to change air pression as compared in space station	Choose a more adapted deep fat fryer in relation to the amount of potatoes to cook
Crew time		List the timing for all procedures	Ask to other people to test recipes and measure timing	Make a standardization of procedure (power, volume, amount of potatoes) and determine

				the best ratio
Energy consumption	Determinant	Only give the power of the deep fat fryer and the time needed to cooked	Use of a wattmeter (freezer, deep fat fryer, …), amount of oil needed and waste (used oil)	Choose a more adapted freezer and deep fat fryer in relation to the amount of potatoes to cook
Power peaks				
Reliability				
Volume (?)		We have non professional freezer, deep fat fryer		Choose a more adapted freezer and deep fat fryer in relation to the amount of potatoes to cook
Risks to human	Determinant	Microbial (pathogenic germ)	Microbial (pathogenic germ)	Determination of a HACCP procedure

3.1.6 *Critical points of potato processing*

The "critical points" of a process are the points which are important for the optimization of this process, considering the different criteria.
These points will be specifically checked and investigated in order to improve the processes and the future FPCU will be conceived and built in order to explore these critical points.

Critical points for potatoes processing are:

- On raw potatoes : size, maturity, thickness of the skin, starch and water soluble sugars contents are essential critical points, able to modify main criteria of evaluation ; amount per harvest, contamination (physical, chemical, bacteriological), …may also deserve great attention.
- For the cooking process: Means and fluid for heat transfer is very important. cooking time and temperature and vapor pressure are important. Elements such as temperature homogeneity may play some part. Concerning the equipment, engineering parameters such as kitchen equipment weight and volume are essential.
- For storage : equipment, volume, amount per harvest, contamination (physical, chemical, bacteriological), shelf-life, …may have strong impact on the criteria.

Considering the different criteria, the critical points are:

Tab. 9 Critical points per criteria

CRITERIA	Critical points for each products
Macronutrients preservation	Temperature Cooking time Cooking process (mainly type of heat transfer and temperature)
Micronutrients preservation	Temperature Cooking time Cooking process (mainly type of heat transfer and temperature)
Food acceptability	Temperature Cooking time Cooking process (mainly type of heat transfer and temperature) Color, odor, seasoning (sensory analysis)
Mass criteria	Cooking process Amount / number of portions
Crew time	Cooking process (mainly type of heat transfer and temperature) Difficulty of the recipe Description of card recipe Amount / number of portions Automation
Energy consumption	Amount/ number of portions Temperature Cooking time Cooking process (mainly type of heat transfer and temperature)
Power peaks	Amount/ number of portions Temperature Cooking time Cooking process (mainly type of heat transfer and temperature)
Reliability	Cooking process (mainly type of heat transfer and temperature)
Volume	Amount of potatoes Cooking process Amount/ number of portions
Risks to human	Cooking process Automation

Note:
The "critical points" of a process are the points which are important for the optimization of this process, considering the different criteria.
These points will be specifically checked and investigated in order to improve the processes and the future FPCU will be conceived and built in order to explore these critical points.
The more a process or a piece of equipment is simple and clearly defined, the clearer are the critical points to work on. In the case of Melissa food processing, many items or hypothesis have not yet been defined: therefore the critical points may appear as heterogeneous or being addressed to very different levels, from raw material selection to unit operations choice or equipment conception.

3.2 Wheat and durum wheat processing

3.2.1 Wheat products and processes review

- To have a schematic view of the processes, we can consider the following possible end products usually starting from wheat:
    - Intermediate product: flour (long shelf life)
        - bread,(short shelf life)
        - not described here but using processes which are related to bread process: crackers and cakes, which include added sugar (long shelf life)
    - Intermediate product: germ (short shelf life)
        - Extruded germ (long shelf life)
        - Wheat sprout
        - Wheat bran to be added to flour to make cakes…
    - Direct making of:
        - Bulgur
        - Freekeh
        - Extruded cereals (long shelf life)
        - Flaked cereals (long shelf life)
        - Puffed cereals (long shelf life)
        - Not detailed here : Wheat milk

In case of basic problems (weight, vibration, noise, dust,…) with the conventional processing of the semi-finished flour and semolina, new wet processing approaches for the flour and/or semolina production could be activated ; however it would need some more detailed pre-developments steps to be done: at this stage we may thus still consider to select these processes.

- Usually starting from durum wheat, we can consider the following products
    - Intermediate product: semolina (various sizes)
        - Pasta (various shapes)
        - Couscous
        - Not detailed derived processes: fresh pasta

The main processes are schematically described here after (Fig. 4) (Fig. 5)

3.2.2 *Description of the wheat processes*

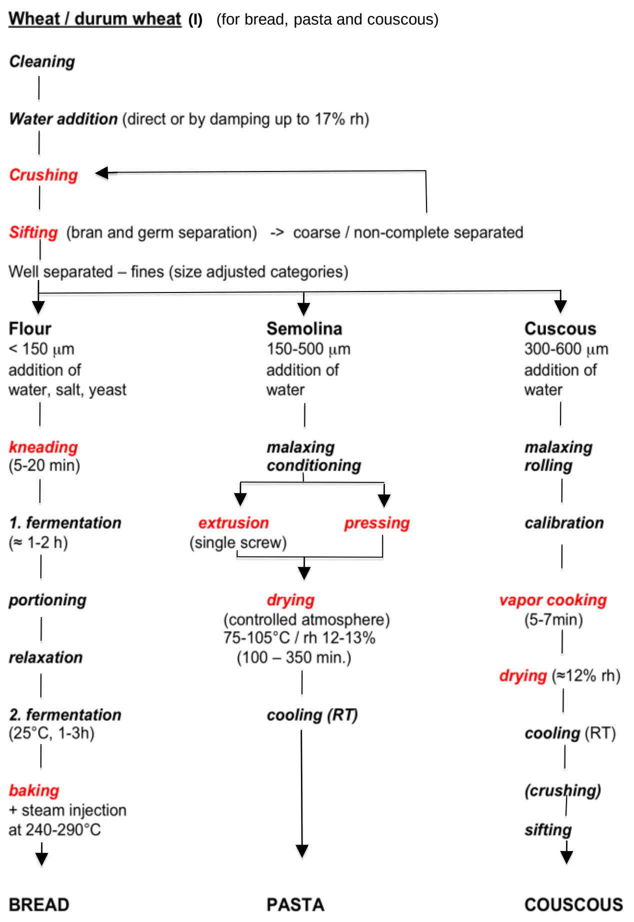


Fig. 4 Bread and pasta processes

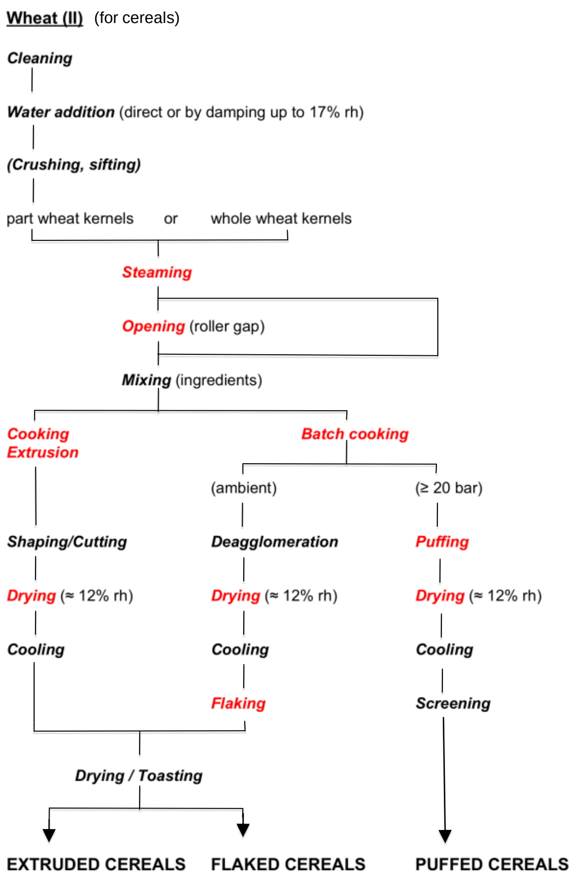


Fig. 5 Cereal processes

3.2.3 *Wheat and durum wheat processes evaluation*

Tab. 10 Quotation of the different selected products

Product	Processing step	Treatment	Nutritional impact	other Quality aspects	Risk factor
					Low, **M**oderate, **C**ritical
1. flour /semolina	***crushing***	mech. **breakage**	negligible	structure formation	mechanical forces, vibration, noise,dust (M)
	sifting	**separation** (bran, germ, endosperm) **classification** (endosperm particle size)	higher fraction of bran and germ increases protein, oil, tocopherol, sugar, B vitamin, soluble fibre, mineral and phenolic compound content (+) but also phytic acid (chelator) content (-).	sensorial quality in general reduced with increased bran or germ content	vibration, noise, dust, static electricity, explosiveness (dust explosion protection required) (C)
2. bread	***kneading***	stresses in shear / elongation flow **develop** the **gluten network** structure	pyridoxine and ferulic acid reduction; kneading time & -intensity reduction retains also Vit.E and carotenoids.	optimum viscoelastic gluten network properties with min. starch da-mage to be developed	mech. forces, water/humidity (M)
	1. fermentation	CO_2 generation and	riboflavin, thiamine and	bread volume	microorganism (yeast)

		bubble forming	phenolic comp. increase + compensation of folate loss + phytate reduction by yeast / fermentation		(L)
	portioning	structure **breakage**	negligible	-	
	relaxation	stress /strain **recovery**	none	bread volume & texture	
	2. fermentation	CO_2 generation and **bubble forming**	riboflavin, thiamine and phenolic comp. increase + compensation of folate loss + phytate reduction by yeast / fermentation	bread volume	microorganism (yeast) (L)
Product	Processing step	Treatment	Nutritional impact	other Quality aspects	Risk factor
	baking	starch gelatinization,protein denaturation, steam-bubble structure forming / **expansion & -stabilizing**. **aroma** (Maillard) **/ crust formation**	starch gelatinization & resistant starch formation (with baking temp. and time) reduce digestibility; folate loss evtl. slight increase in phenolic compounds in crust (Maillard)	bread volume, texture and crust (texture & aroma) development; impact on starch retrogradation (e.g. by partial baking)	high temperature, steam (M)
					Low, **M**oderate, **C**ritical
3. wheat	***crushing***	mech. breakage	negligible	structure formation	mechanical forces, vi-

cereals					bration, noise,dust (M)
	sifting	separation (bran, germ, endosperm) classification (endosperm particle size)	higher fraction of bran and germ increases protein, oil, tocopherol, sugar, B vitamin, soluble fibre, mineral and phenolic compound content (+) but also phytic acid (chelator) content (-).	sensorial quality in general reduced with increased bran or germ content	vibration, noise, dust, static electricity, explosiveness (dust explosion protection required) (C)
	steaming	weakening of grain struc-ture by increase of tempe-rature and water content.	starting starch gelatinization, protein denaturation	structure / texture development	high temperature, steam/water/humidity (M)
	opening	cracking of grain structure	none	texture impact	mech. force, vibration (M)
	cooking extrus. / batch cooking	mech. + thermal stresses **develop gluten network** structure; starch gelatini-zation, protein denatura-tion, aroma development	starch gelatinization impacts on digestibility, folate, pyridoxine & ferulic acid loss expected; reduc-tion of mech./heat treatment re-tains Vit.E and carotenoids.	viscoelastic gluten net-work (denatured) filled with starch (gelatinized) to be developed opti-mal texture & stability.	high temperature (150°C), shear forces/torque and pressure (≥ 50 bar) (M)

	puffing	fast expansion, bubble forming / stabilizing	negligible	cereal volume & texture	high pressure (≥ 20 bar) (M)
	drying	water transfer and partial cereal structure collapse	folate loss; evtl. slight increase in phenolic compounds (Maillard)	cereal texture & aroma / taste	high temperature, vacuum (?)(M)
	flaking	cereal shape formation and structure compression	negligible (?)	cereal volume & texture	high temperature, steam, high mech. forces, vibration, noise (M)
Product	***Processing step***	Treatment	Nutritional impact	other Quality aspects	Risk factor
4. Bulgur	***cooking***	Gelatinization of whole wheat grain starch	starting starch gelatinization, protein denaturation	Generation of chewable texture and nut-like flavour	high temperature, steam/water/humidity (M)
	drying		evtl. slight increase in phenolic compounds (Maillard)	Adjustment to storage stability and microbiological safety	high temperature, vacuum (?); (M)
	bran separation	Crushing (e.g. roller mill) and sifting	higher fraction of bran and germ increases protein, oil, tocopherol, sugar, B vitamin, soluble fibre, mineral and phenolic compound content	Texture and (taste) improvement	vibration, noise, dust, static electricity, explosiveness (dust explosion protection evtl. required) (C)

	(cutting)	Tailoring of particle size	negligible		vibration (?)
5.Freekeh	***roasting***	High temperature heat treatment for pre-drying and aroma development	Deactivation of enzymes (germ) improving net protein utilization;	Aroma generation, (Maillard reaction) pre-drying	high temperature, steam, (M)
	cutting	Tailoring of particle size	negligible		
					vibration (?)
	drying	Adjustment of humidity for storage	evtl. slight increase in phenolic compounds (Maillard)		high temperature, vacuum (?); (M)
6. Extruded Germ	***Defatting***	Expeller pressing and / or solvent extraction	Loss of unsaturated fats	Reduction of rancidity sensitivity	Vibration, high energy consumption, solvents vapour (M)
	Extrusion	Mech. & thermal treatment for texturization, pasteuri-zation and shaping	reduction of mech./heat treatment retains Vitamins	Crisp texture formation	high temp. (150°C), shear forces/torque & pressure (≥ 50bar)(M)
	Drying	Water reduction (< 10%)	negligible	Increased Microb. Safety, texture	high temperature (M)

7. wheat sprouts	***Sprouting, then the whole wheat grain can be further processed either for bread (see 2.) or extruded cereals (see 3.)***	Wetting, controlled climate conditions and rinsing Further processes :See 2. and/or 3.			
8. wheat bran	***Wheat bran separated from conventional flour milling process (see 1.) can be added to bread (see 2.) or wheat cereals (see 3.)***	See 1, 2. and/or 3.			
Product	***Processing step***	Treatment	Nutritional impact	other Quality aspects	Risk factor
9. pasta	***malaxing***	mixing with water up to	starch hydration, gluten		mech. forces,

		31-32% moisture level	formation		water/humidity (M)
	extrusion	mechanical and thermal stresses develop gluten network structure; starch gelatinization, protein denaturation,	starch gelatinization impacts on its digestibility; protein denaturation	structure / texture development	shear forces/torque and pressure (L)
	drying	Water removal	Maillard reaction: reduction of protein digestibility at high temperature	finish product will be hard, retain its shape, and store without spoiling	high temperature (M)
10.couscous	***malaxing rolling***	mixing with water	starch hydration		mech. forces, water/humidity (M)
	vapour cooking		lost of thermolabile nutrient such as thiamine and riboflavin		high temperature, water/humidity (M)

3.2.4 Wheat and durum wheat processed products selection

On the basis of the available data, we propose to concentrate the analysis of the different criteria on the following products:

- Semi finished products or ingredients
    - **Flour:** the versatility of uses of flour is high but the Alisse criteria will probably not be easily satisfied: mass of equipment in generally high (especially for crushing) and sifting may cause critical vibrations and dust.
    - Semolina **:** same type of problems, perhaps a little less critical issue since product is coarser
    - **Bulgur :** it may be used in various preparations, and may be produced using wet processes, enzymatically supported , which can be very efficient. Bulgur is proposed for future analysis.

It must be noted that these processes (in particular the first two) are similar.

- End products, ready to eat, using the semi-finished products or directly obtained from the crop :

- Directly from wheat (green)
    - **Freekeh**, which will probably more easily satisfy the Alisse criteria as well as nutritional criteria (yield is probably higher – no waste products generated), to be cooked in water or to be fried and served hot,
    - Possibly : wheat flakes
    - **Wheat sprout** (short shelf life)

- From flour or semolina or bulgur
    - **Fresh pasta** made from semolina, to be cooked and served hot with a sauce.
    - **Biscuit or cookie**, made from flour, with long shelf life
    - It is possible to think about some bulgur based cake.

This selection allows studying products with long and short shelf life, and in-depth assessment of main wheat processing operations (bran separation…).
It could be worth to add cooking extrusion because it is a versatile process, but which needs today very large and heavy equipment.

Bulgur, Freekeh and wheat sprout will be priorized in TN 5000, the other products will be studied only on some relevant criteria, by testing or thanks to literature references.

3.2.5 Characterization of the criteria

Tab. 11 Freekeh characterization

CRITERIA	Weight of the criteria (To what extent will it be crucial for the selection of a process for this crop)	Possible test to characterize the criteria with the existing equipment (TN 5000)	Proposed future developments : ways to improve the characterization of the criteria	Proposed future developments : ways to improve the performance of each process on these criteria
Macronutrients preservation	high	protein (1) carbohydrate (2) moisture (3) dietary fibre (4) unsaturat. fat (5)	Spectroscopic method(s) e.g. NIR	controlled heating / roasting & de-hulling
Micronutrients preservation	high	Calcium (6) Copper (7) Iron (8) Potassium (9) Magnesium (10) Sodium (11) Zinc (12) Vitamins: A (13), B1 (14), B2 (15), C (16), E (17)		controlled heating / roasting & de-hulling
Food acceptability	medium	Sensory test		controlled heating / roasting & de-hulling
Mass criteria	medium	weighing		Equipment and process design
Crew time	medium	time check		id
Energy consumption	high	Calorimetry (18)		controlled heating / roasting & de-hulling
Power peaks	medium	Amperometry		
Reliability	medium			
Volume (?)	low			
Risks to human	medium			

ANALYTICAL METHODS : (1) Kjeldahl, (2) z.B Ewers, (3) drying cabinet, (4) Enzymatic-GLC/HPLC, (5) GC/MS after hexane extraction, (6-12) (F)AAS, (13-17) HPLC, (18) DSC

Tab. 12 Wheat sprouts characterization

CRITERIA	Weight of the criteria (To what extent will it be crucial for the selection of a process for this crop)	Possible test to characterize the criteria with the existing equipment (TN 5000)	Proposed future developments : ways to improve the characterization of the criteria	Proposed future developments : ways to improve the performance of each process on these criteria
Macronutrients preservation	high	protein (1) carbohydrate (2) moisture (3) dietary fibre (4) unsaturat. fat (5)	Spectroscopic method(s) e.g. NIR	controlled wetting & rinsing + climate control
Micronutrients preservation	high	Calcium (6) Copper (7) Iron (8) Potassium (9) Magnesium (10) Sodium (11) Zinc (12) Vitamins: A (13), B1 (14), B2 (15), C (16), E (17)		controlled wetting & rinsing + climate control
Food acceptability	medium	Sensory test		controlled wetting & rinsing + climate control
Mass criteria	low	weighting		Equipment and process design
Crew time	low	time check		id
Energy consumption	low	Calorimetry (18)		controlled wetting & rinsing + climate control
Power peaks	low	Amperometry		
Reliability	low			
Volume (?)	low			
Risks to human	low			

ANALYTICAL METHODS : (1) Kjeldahl, (2) z.B Ewers, (3) drying cabinet, (4) Enzymatic-GLC/HPLC, (5) GC/MS after hexane extraction, (6-12) (F)AAS, (13-17) HPLC, (18) DSC

Tab. 13 Bulgur characterization

CRITERIA	Weight of the criteria (To what extent will it be crucial for the selection of a process for this crop)	Possible test to characterize the criteria with the existing equipment (TN 5000)	Proposed future developments : ways to improve the characterization of the criteria	Proposed future developments : ways to improve the performance of each process on these criteria
Macronutrients preservation	high	protein (1) carbohydrate (2) moisture (3) dietary fibre (4) unsaturat. fat (5)	Spectroscopic method(s) e.g. NIR	Controlled low temp. vacuum cooking / drying
Micronutrients preservation	high	Calcium (6) Copper (7) Iron (8) Potassium (9) Magnesium (10) Sodium (11) Zinc (12) Vitamins: A (13), B1 (14), B2 (15), C (16), E (17)		Controlled low temp. vacuum cooking / drying
Food acceptability	medium	Sensory test		
Mass criteria	medium	weighting		Bran separation In wet state, With enzymes
Crew time	medium	time check		
Energy consumption	lmedium	Calorimetry (18)		Bran separation In wet state, enzymatically supported
Power peaks	medium	Amperometry		
Reliability	medium			
Volume (?)	medium			
Risks to human	medium			

ANALYTICAL METHODS : (1) Kjeldahl, (2) z.B Ewers, (3) drying cabinet, (4) Enzymatic-GLC/HPLC, (5) GC/MS after hexane extraction, (6-12) (F)AAS, (13-17) HPLC, (18) DSC

3.2.6 *Critical points*

The “critical points” of a process are the points which are important for the optimization of this process, considering the different criteria.
These points will be specifically checked and investigated in order to improve the processes and the future FPCU will be conceived and built in order to explore these critical points.

Critical points for wheat processing are:

- On raw grain: size of the grain, composition of the grain, variation in different crops are essential critical points.
- Concerning storage : shelf-life will be a key stake
- Concerning the different products, the critical points are often linked to the equipment to be developed - (see the following table)

Product	**Critical points**
Grain	Composition of the grain, (carbohydrates, proteins, lipids, micronutrients and ashes) and possible variations Phytic acid content
1. Flour	Mass of the equipment Reduction of vibrations, noise, dust, static electricity, dust explosion risks
2. Bread	Power needs (mechanical forces), high temperature, steam/water/humidity
	Presence of microorganisms (yeast)
	Shelf life
3. Bulgur	high temperature, steam/water/humidity, vibration, noise, dust, static electricity, explosiveness
4. Freekeh	controlled temperature, steam,
	Shelf life
5. wheat sprouts	Water for rinsing and waste water

Note:
The “critical points” of a process are the points which are important for the optimization of this process, considering the different criteria.
These points will be specifically checked and investigated in order to improve the processes and the future FPCU will be conceived and built in order to explore these critical points.
The more a process or a piece of equipment is simple and clearly defined, the clearer are the critical points to work on. In the case of Melissa food processing, many items or hypothesis have not yet been defined: therefore the critical points may appear as heterogeneous or being addressed to very different levels, from raw material selection to unit operations choice or equipment conception.

3.3 Soybean processing

3.3.1 Soybean products and processes review

A lot of products may be made from soya and we present here some of the most frequently used products and processes.

Concerning end products, ready to eat :

- **Soya milk**: we will make the distinction between
  - industrial
  - and kitchen processes

  To be noted: two end products which can be made from soya milk are not described here :
  - It is possible to produce soya yoghurt (not described) by simple fermentation.
  - It is also possible to produce "tofu" (soya cheese) by coagulation with magnesium chloride (nigari)
- **Sprouts**: it is possible to get soya sprouts (to be eaten raw, commercial sprouts are generally produced from "green soya" or "mungo" seeds) to be eaten fresh.

  NB : Our seed are *Glycine max* and not *Vigna radiata* ("mung bean") but it is possible to produce and eat fresh yellow soy sprout (for example as salad). Several authors produced sprout from *Glycine max* and they studied their nutritional characteristics (Donangelo et al. (1995), Martín-Cabrejas et al. (2008), Fernandez-Orozco (2008), ….)
  - Industrial sprouts
  - Kitchen sprouts

Concerning semi-finished products :

- **Okara** (fibers and proteins from milk production):
  - Texturised okara
  - Dried okara

  It is also possible to make cookies with flour and okara (not described here).

- Oil:
  - Soy oil is industrially extracted. It may be a valuable source of oil. See Tab. 14 for comparison with simple mechanical extraction.
    Soy oil may be preserved when stored under adapted conditions.

- Isolated proteins**:**
  - Isolated proteins may be used to enrich the protein content of meals, as extra ingredients. They can be preserved after drying.
  - It is possible to study the processing of the defatted flakes to make a dried protein flakes flour, with rather long shelf-life and which can be used in the same way.

Soja milk, dried okara and soy sprouts are the selected products for the following phases.

Several other possibilities may be studied such as kinako (toasted soy flour) with which it is possible to make cookies (adding sugar and wheat flour).

3.3.2 Description of the processes

SOYMILK AND TEXTURED PRODUCT BY OKARA

Soybeans seeds

Cleaning

Washing

(Dehulling) — Heating at 105-110 °C
Craking of beans
Sifting

Soaking
(Water:bean ratio 8:1 / 10:1
Room temperature
Time ~ 12 h)

Wet grinding
(Water temperature:
room temperature or
80-90 °C)

Paste boiling
(~ 30 min)

Filtration — **OKARA**

SOYMILK

Sanitization

Okara

Moisture adjustment
(20 – 60 %)

Cooking extrusion
(Temperature 160-180°C
Pressure 20-200 Kg cm^{-2}
Velocity rotation 40-250 rpm)

Pushing trough a costricted exit
(Cooling: room
temperature – 0°C)

TEXTURED PRODUCT

Fig. 6 Soymilk and texturized by-product okara

Fig. 7 Soybean seed sprouts

Sanitization with sodium hypoclorite
(Sodium concentration: 0.07%
Beans:solution ratio= 1:5
Time: 30 min)

|

Washing with cold water

Soaking
(Water:bean ratio 5:1
Room temperature
Time ~ 5 h and 30 min)

Germination
(Temperature: 20-25°C
RH: 90-99%
Time: 2-6 days)

|

SPROUTS

|

Freeze-drying

Sprout process

Fig. 8 oil and isolated protein

Soybeans

Crushing

Sifting — Hull removing

Conditioning
(Temperature ~ 130°C
RH: 10-11%)

(**Cooking extrusion**)
(Temperature: 135-140°C)

Mechanical compression — **DEFATTED FLAKES**
(Pressure: 40-60 MPa)

OIL

Screening

Decantation

Defatted flakes

Mixing with extraction alkaline medium
(Sodium or calcium hydroxide
7.5<pH<9
Solid liquid ratio: 1:10 / 1:20
Temperature=80°C
Time=30-45 min)

Separation by screening or centrifugal clarification

Acid precipitation of protein
(HCl solution at pH=4.5)

Separation by screening or centrifugal clarification

Washing of curd

ISOLATED PROTEIN

Spray-drying

3.3.3 *Soybean processes evaluation*

Tab. 14 Quotation of the different selected products

PRODUCTS	PROCESSING STEP	TREATMENT	NUTRITIONAL IMPACT	OTHER QUALITY ASPECTS	RISK FACTOR
					Low, Moderate, Critical
1.a SOYMILK	***Optional dehulling***	Heating at 105-110 °C oven 30 min Beans mechanical rupture Hull removing by a gravity separator or an aspirator.	Loss of anti nutritional factors (+), Increase sensorial quality of the final product (+) More lipoxydase activity (-)	Slightly better flavour Better protein yield	High temperature Mechanical forces Vibration Noise Dust Explosiveness (dust explosion protection required) (C)
	Soaking	Water come in to the seeds: beans increases their volume.	Lost in soaking water of soluble nutrients: mineral salts (-), oligosaccharides (+)	It makes grinding possible	
	Wet grinding	Breaking of seeds structure	Hot water grinding improves isoflavones extraction (+)		High temperature Mechanical forces Vibration Noise (L)
	Paste boiling	Extraction of seeds components	Lost of thermolabile nutrient (-) Trypsin inhibitor inactivation (+)		High temperature (M)
	Sanitization	Reduction of microbial	Lost of thermolabile nutrient (-) Tripsin inhibitor inactivation (+)		High temperature (M)

PRODUCTS	PROCESSING STEP	TREATMENT	NUTRITIONAL IMPACT	OTHER QUALITY ASPECTS	RISK FACTOR
					Low, **M**oderate, **C**ritical
1.b KITCHEN PROCESSING FOR SOYMILK	***Soaking***	Water come in to the seeds: beans increases their volume.	Lost in soaking water of soluble nutrients: mineral salts (-), oligosaccharides (+)	It makes grinding possible	
	Wet grinding	Breaking of seeds structure	Hot water grinding improves isoflavones extraction (+)		High temperature Mechanical forces Vibration Noise (L)
	Paste boiling	Extraction of seeds components	Lost of thermolabile nutrient (-) Trypsin inhibitor inactivation (+)		High temperature (M)
	Sanitization	Reduction of microbial	Lost of thermolabile nutrient (-) Tripsin inhibitor inactivation (+)		High temperature (M)

PRODUCTS	PROCESSING STEP	TREATMENT	NUTRITIONAL IMPACT	OTHER QUALITY ASPECTS	RISK FACTOR
2. TEXURED PRODUCT BY OKARA	***Cooking extrusion***	Mechanical and thermal stress induces formation of a insoluble three-dimensional structure of proteins	Lost of thermolabile nutrient (-)		High temperature Shear forces Pressure Vibration (M)
	Pushing through a constricted exit	Forming and cooling			Shear forces Low temperature Vibration (L)

PRODUCTS	PROCESSING STEP	TREATMENT	NUTRITIONAL IMPACT	OTHER QUALITY ASPECTS	RISK FACTOR
3a. SPROUTS	***Sanitization with sodium hypoclorite***	Reduction of microbial contamination			Corrosiveness Irritant (M)
	Soaking	Water absorption in to the seeds: beans increase their volume.	Lost in soaking water of soluble nutrients: mineral salts (-), oligosaccharides (+)	Activate germination	
	Germination	With a complex metabolic process, the seed comes out of its latency stage and the reserved substances present in the cotyledons are broken down and used for the development and growth of the hypocotyls	Decrease in raffinose and in stachyose content (+) Decrease in total dietary fiber (-) Kunitz inhibitor degradation (+) Increasing in all vitamin (except thiamin) content (+) Trolox equivalent antioxidant capacity increasing (+) Total isoflavone increasing (+)		
	Freeze-drying	Water removal by sublimation	Negligible	It increases product stability	Low temperature Vacuum (L)

PRODUCTS	PROCESSING STEP	TREATMENT	NUTRITIONAL IMPACT	OTHER QUALITY ASPECTS	RISK FACTOR
3b. KITCHEN PROCESS FOR SPROUTS	***Sanitization with sodium hypoclorite***	Reduction of microbial			Corrosiveness Irritant (M)
	Soaking	Water come in to the seeds: beans increase their volume.	Lost in soaking water of soluble nutrients: mineral salts (-), oligosaccharides (+)	Activate germination	
	Germination	With a complex metabolic process, the seed comes out of its latency stage and the reserved substances present in the cotyledons are broken down and used for the development and growth of the hypocotyls	Decrease in raffinose and in stachyose content (+) Decrease in total dietary fiber (-) Kunitz inhibitor degradation (+) Increasing in all vitamin (except thiamin) content (+) Trolox equivalent antioxidant capacity increasing (+) Total isoflavone increasing (+)		

PRODUCTS	PROCESSING STEP	TREATMENT	NUTRITIONAL IMPACT	OTHER QUALITY ASPECTS	RISK FACTOR
4.OIL	***Crushing***	Mechanical breakage	More lipoxydase activity (-)		Mechanical forces Vibration Noise Dust (M)
	Sifting	Hull removing	Reduction of the oligosaccharides (+),		Vibration, Noise, Dust, Explosiveness (dust explosion protection required) (C)
	Optional cooking extrusion	It disrupts the tissues and releases hot oil within the matrix	Lost of thermolabile nutrients (high-temperature - short-duration treatment contributes greatly to retention of nutritional value)	Oil recovery increasing	High temperature Shear forces Pressure Vibration (M)
	Mechanical compression	It forces the oil out of matrix under pressure			Shear forces Pressure Vibration (L)

PRODUCTS	PROCESSING STEP	TREATMENT	NUTRITIONAL IMPACT	OTHER QUALITY ASPECTS	RISK FACTOR
5.ISOLATED PROTEIN	***Extraction with alkaline medium***	Protein solubilization	High pH values favour undesiderable chemical modification such as: Protein denaturation, Maillard reaction Destruction of cystine and formation of dehydroalanine Decreasing in total genistein content	Browning (-)	Corrosiveness Irritant (C)
	Separation by screening or centrifugal clarification	Removing of coarse foots			Vibration Noise (L)
	Acid precipitation	Protein precipitation at isoelectric point			Corrosiveness Irritant Toxicity (C)
	Separation by screening or centrifugal clarification	Removing of sludge			Vibration Noise (L)
	Spry-drying	Water removal by evaporation	Possible thermal degradation of protein	It increases product stability	High temperature Pressure (L)

3.3.4 *Soybean processed products selection*

Taking into account the performances of the different processes, a qualitative quotation of each product and criteria has been done.

Tab. 15 Soya processing selection

Evaluation of **nutritional criteria** for soybean processes:

Product	Macronutrients preservation	Score	Micronutrients preservation	Score
PRODUCT 1a Soymilk (industrial process)	High content in protein and fat. Adding soymilk and okara macronutrient it's possible to obtain a very high energy recovery	5	Very good micronutrient content (vitamins, minerals and isoflavones)	5
PRODUCT 1bis: Soymilk (kitchen process)	High content in protein and fat. Adding soymilk and okara macronutrient it's possible to obtain a very high energy recovery	5	Very good micronutrient content (vitamins, minerals and isoflavones)	5
PRODUCT 2a Texured product by okara	High content in protein and fat. Adding soymilk and okara macronutrient it's possible to obtain a very high energy recovery	5	Fairly good micronutrient content	3
PRODUCT 2b Okara (ingredient for recipes)	High content in protein and fat. Adding soymilk and okara macronutrient it's possible to obtain a very high energy recovery	5	Fairly good micronutrient content	3
PRODUCT 3 Sprouts	Small decreases in total carbohydrates and a similar small increases in crude protein.	5	Increases in tot. isoflavones in early stages of germination	5
PRODUCT 4 Oil	Low oil recovery	2		5
PRODUCT 5 Isolated protein	Fairly good protein recovery	4		5

Evaluation of **food acceptability** criteria for soybean processes:

Product	Sensory acceptability	Q*	Versatility of uses	Q*
PRODUCT 1a Soymilk (industrial process)	It's possible to improve sensory acceptability adding sugar	5	Using soymilk for breakfast does not induces lassitude because, as it is in general accepted, this meal can be standardized	5
PRODUCT 1bis: Soymilk (kitchen process)	It's possible to improve sensory acceptability adding sugar	5	Using soymilk for breakfast does not induces lassitude because, as it is in general accepted, this meal can be standardized	5
PRODUCT 2a Texured product by okara	Several recipes possibilty	5	Several recipes possibilty	5
PRODUCT 2b Okara (ingredient	Several recipes possibilty	5	Several recipes possibilty	5

for recipes)				
PRODUCT 3 Sprouts	It's not a typical European product but its popularity among European consumers is increasing	5	Several recipes possibilty	5
PRODUCT 4 Oil	Possible bad taste	2	Better use "raw"	2,5
PRODUCT 5 Isolated protein	Several recipes possibilty	5	Several recipes possibilty	5

Evaluation of **ALISSE criteria** for soybean processes:

Product	Mass criteria	Q*	Crew time	Q*
PRODUCT 1a Soymilk (industrial process)		3		4
PRODUCT 1bis: Soymilk (kitchen process)	Uses few kitchen utensils	5	It's possible a total automatization	5
PRODUCT 2a Texured product by okara		2		2
PRODUCT 2b Okara (ingredient for recipes)	Uses few kitchen utensils	4	It's possible a total automatization	5
PRODUCT 3 Sprouts	No utensils	5	Need for human intervention just in sanitization and soaking steps	5
PRODUCT 4 Oil		2		1
PRODUCT 5 Isolated protein		2		3

Product	Energy	Q*
PRODUCT 1a Soymilk (industrial process)		3,5
PRODUCT 1bis: Soymilk (kitchen process)		4
PRODUCT 2a Texured product by okara	Great energy required for texurization	1
PRODUCT 2b Okara (ingredient for recipes)		4
PRODUCT 3 Sprouts	No energy required	5
PRODUCT 4 Oil	Great energy required for extrusion	1
PRODUCT 5 Isolated protein	Great energy required for extrusion	2

Product	Reliability	Q*	Volume	Q*	Human Risk	Q*
PRODUCT 1a Soymilk (industrial process)		4	Storage		Vibration , noise and dust in dehulling step	1
PRODUCT 1bis: Soymilk (kitchen process)		4	Storage		High temperature in boiling step	4
PRODUCT 2a Texured product by okara		2	Storage		Shear forces, pressure and vibration in texturing step	2
PRODUCT 2b Okara (ingredient for recipes)		4	Storage		High temperature in boiling step	4
PRODUCT 3 Sprouts		4	Less volume for storage		Corrosiveness, irritant (sodium hypoclorite in sanitization step)	4,5
PRODUCT 4 Oil		4	Needs larger tank		Vibration , noise, dust	1
PRODUCT 5 Isolated protein		3	Less volume for storage		Corrosiveness, irritant, toxicity	1

Product	**TOTAL Q**
PRODUCT 1a Soymilk (industrial process)	**35.5**
PRODUCT 1bis: Soymilk (kitchen process)	**42**
PRODUCT 2a Texured product by okara	**27**
PRODUCT 2b Okara (ingredient for recipes)	**39**
PRODUCT 3 Sprouts	**43.5**
PRODUCT 4 Oil	**20.5**
PRODUCT 5 Isolated protein	**30**

SOY MILK (kitchen scale) simultaneously produced with OKARA and SOY SPROUTS appear to be the most adapted products : they have good nutrient yield (soymilk and okara have very good energy recovery - 90.7% and the seeds germination has a nearly total energy recovery – 98.3%) and rather good acceptability (it’s possible to solve problems for soymilk sensory acceptability by sugar and vanilla adding); their production does not require great energy expenditures nor bulky and heavy equipment; After germination, new proteins and vitamins are synthesized which may be relevant for the overall nutritional balance.

Oil and isolated protein show low total scores values: macronutrient preservation is not satisfactory, processes are fairy complex (great energy required, big instruments and high risk to human).

The same for cooking extrusion equipment concerning Okara production.

3.3.5 *Characterization of the criteria*

The above tables present a prioritization and main characteristics of the criteria for the selected products

Tab. 16 Soymilk

CRITERIA	Weight of the criteria (To what extent will it be crucial for the selection of a process for this crop)	Possible test to characterize the criteria with the existing equipment (TN 5000)	Proposed future developments : ways to improve the characterization of the criteria	Proposed future developments : ways to improve the performance of each process on these criteria
Macronutrients preservation	determinant	Concentration of protein and fat		Check modification during processing and shelf life. Lipid oxidation, protein hydrolysis, extent of Maillard reaction
Micronutrients preservation	determinant	Concentration of isoflavones		Factors affecting isoflavones bioavailability
Food acceptability	determinant	Sensory analysis		Sensorial studies using a panel trained on soybean product
Mass criteria		Weight - 3.5kg*		
Crew time	medium			Development of rapid processing for milk and okara manufacturing
Energy consumption	lower	Available in 110 V, 60 Hz and 220-240V, 50 Hz*		
Power peaks		Max power - 800 W *		

Reliability	medium			
Volume (?)		Size - 7.4" x 9.2" x 13.6*		
Risks to human	lower	Evaluation of phytic acid content		

Tab. 17 Okara

CRITERIA	Weight of the criteria (To what extent will it be crucial for the selection of a process for this crop)	Possible test to characterize the criteria with the existing equipment (TN 5000)	Proposed future developments : ways to improve the characterization of the criteria	Proposed future developments : ways to improve the performance of each process on these criteria
Macronutrients preservation	determinant	Concentration of protein and fat		
Micronutrients preservation	medium	Concentration of isoflavones		
Food acceptability	determinant	Sensory analysis		Several recipes development
Mass criteria		Weight - 6.5 lbs*		
Crew time	lower			Total process automation
Energy consumption	lower	Available in 110 V, 60 Hz and 220-240V, 50 Hz*		
Power peaks		Max power - 800 W *		
Reliability	lower			
Volume (?)		Size - 7.4" x 9.2" x 13.6*		
Risks to human	lower	Evaluation of phytic acid content		

** Several automatic soymilk makers are available on the market: mass, energy consumption and volume data are well known. "SoyaJoy Soymilk Maker - Sanlinx Inc" characteristics (Capacity - 1.5 litres) are reported, for example.*

Tab. 18 Soy sprouts characterization

CRITERIA	Weight of the criteria (To what extent will it be crucial for the selection of a process for this crop)	Possible test to characterize the criteria with the existing equipment (TN 5000)	Proposed future developments : ways to improve the characterization of the criteria	Proposed future developments : ways to improve the performance of each process on these criteria
Macronutrients preservation	determinant	Concentration of proteins and fats		
Micronutrients preservation	determinant	Concentration of isoflavones , vitamins production		
Food acceptability	determinant	Sensory analysis		Several recipes development
Mass criteria	lower			
Crew time	medium			
Energy consumption	medium	No energy requirements for germination except controlled temperature		
Power peaks				
Reliability	determinant			
Volume (?)		No volume requirements in Kitchen spaces		
Risks to human	lower	Evaluation of phytic acid content		

3.3.6 Critical points

The “critical points” of a process are the points which are important for the optimization of this process, considering the different criteria.
These points will be specifically checked and investigated in order to improve the processes and the future FPCU will be conceived and built in order to explore these critical points.
Critical points for the selected soy processes are mainly focused on nutrition results:

- Raw soy composition.
- Concerning storage : as we have considered “kitchen processes” to be done for direct use, the shelf-life of the cropped grain and of the resulting products will be a key stake

- Concerning the different products, we could study the influence of transformation processes not only on the yield but also on the actual nutrient bioavailability .
- Acceptability, crew time and possible automation, appear to be also important.

The following table gathers the critical points for the selected products

Product	Critical points
Grain	Composition of the grain, (carbohydrates, proteins, lipids, micronutrients and ashes) and possible variations Phytic acid content Grain preservation
1. Soy milk	Yield, preservation of nutritional content, phytic acid , crew time reduction , shelf life
2. Okara	Yield, drying process, crew time reduction, acceptability and recipes, shelf life
3. Soy sprouts	Nutritional content, Crew time, acceptability and diversification of uses,

<u>Note:</u>
The "critical points" of a process are the points which are important for the optimization of this process, considering the different criteria.
These points will be specifically checked and investigated in order to improve the processes and the future FPCU will be conceived and built in order to explore these critical points.
The more a process or a piece of equipment is simple and clearly defined, the clearer are the critical points to work on. In the case of Melissa food processing, many items or hypothesis have not yet been defined: therefore the critical points may appear as heterogeneous or being addressed to very different levels, from raw material selection to unit operations choice or equipment conception.

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5 Annexes

5.1 Annex 1: Checklist of potential Risks

• Thermodynamic and fluidic
o Pressure (difference, high, low, vacuum)
o Temperature (difference, high, low)
o Heat transfer
o Fluid jet
o Thermal properties of materials
• Electrical and electromagnetic
o Voltage (high, medium, low)
o Static electricity
o Electric current (high, medium, low)
o Magnetic field (induced, external)
o Ionization
o Sparks
• Radiation
o Light (infrared, visible, ultraviolet, laser)
o Radioactivity (alpha, beta, gamma rays)
o Open fire
• Chemical
o Toxicity
o Corrosiveness
o Flammability
o Explosiveness
o Asphyxiant
o Irritant
• Mechanical
o Physical impact or mechanical energy
o Mechanical properties of materials (e.g. sharp, rough, slippery)
o Vibration
• Noise
o Frequency and intensity

• Biological
o Human waste
o Micro-organism
o Carcinogenic
• Psychological
• Physical
o Confined space
• Environment - space
o Zero gravity
o Vacuum
o Atmospheric composition
o Contaminants, pollutants
o Meteorite and space debris
o Temperature (difference, low, high)
o Radiation
o South Atlantic anomaly
• Environment - Earth
o Environmental extremes
o Natural disasters
o Lightning