M ELiSSA

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UNIVERSITEIT GENT

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MELiSSA FOOD CHARACTERIZATION: PHASE 1

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PRELIMINARY TRADE-OFF OF FOOD PROCESSING TECHNOLOGIES: TEST RESULTS EVALUATION

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List of Abbreviations

ETH Zürich	Eidgenössische Technische Hochschule Zürich
HZPC	Company specialized in breeding and selecting potato cultivars. www.hzpc.nl
MFC1	MELiSSA Food Characterisation Phase 1

1 Presentation

TN98.5.2 gathered the different results obtained by processing the various crops.
Here are some conclusions concerning the different processes, which have been analysed according to some selected criteria:

- Nutrient preservation
- Sensory analysis
- Energy consumption
- Room and weight of equipment
- Risks to human.

2 Potato processing

2.1 Introduction

The majority of hydroponic potatoes are quite small and the largest potatoes are only about 40-50 g per piece. Many small potatoes were present in the harvest. Due to their size, it was not possible to include them in test preparations. Nevertheless, these small potatoes may eventually be used in other potato preparations such as mashed potatoes or for ingredients (e.g. starch extraction).
In MFC1 experiments, only two techniques have been used. Indeed, given the lack of raw material it was not possible to test all the cooking techniques initially proposed. Also due to the size and the amount of potatoes, we limit the number of tests.
As the size of the potatoes is very small, it is important to consider the consumption of potatoes with the skin. However, this consumption is not common in Europe and apart from a few preparation methods for potatoes with peel, most consumers prefer to peel the potatoes. The question is: is it an asset to leave on ? Indeed, it is interesting from a nutritional point of view to keep the skin because it contains a significant amount of nutrients (vitamins, fibres ...). On the other hand, the texture can sometimes upset some consumers. It is also interesting to use the skin to limit the peeling time, the weight of waste ... Due to the small size of the potatoes, the skin is about 30% of the weight of the potato. The use of an industrial abrasive peeler may reduce this amount. A lot of potatoes did not support a long storage. In fact, we observed during storage many varieties had developed sprouts. This can reduce the time of storage, have an impact on the gross weight and can alter the taste.

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2.2 Macronutrients preservation

2.2.1 For microwave cooked potatoes:

We see a direct loss of weight during cooking in the order of 30%. This loss is caused by dehydration, a well-known phenomenon for this type of cooking. Moreover, the small size will increase proportionally the effects of water loss. This will directly increase the concentration of nutrients and energy.

2.2.2 For boiled potatoes:

In all cases, except the potatoes cut into small cubes (1 cm^3), the potatoes have lost 1-3% of water. This causes a slight increase in levels of macronutrients and energy.
On the other hand, diced potatoes have absorbed water (2%) certainly by increasing the contact area.

2.3 Micronutrient preservation

In this, phase, we had no chemical analyses on water losses and wastes. But we have information on raw and cooked potatoes, so we can extrapolate differences.
Because of misinterpretation, phosphorus was not viewed as part of the basis set of analysis on the first samples

2.3.1 For microwave cooked potatoes:

For undetermined reasons, we find a lower calcium and iron content in potatoes after cooking. It will be interesting to further analyze potential losses of vitamins. In fact, some vitamins can be sensitive to high temperature, but there are less losses for water-soluble vitamins.

2.3.2 For boiled potatoes:

As expected the cooked, diced, peeled potatoes nutrient losses are more important than peeled potatoes and potatoes with skin. Except for phosphorus, where we see a significant increase in phosphorus and zinc. This could be caused by the composition of the cooking water. In all cases the water was a tap water quality standard without the use of softener. For cooking, this series of tests, the water was not salty. This could have an impact on reducing losses and increasing mineral concentration of sodium in the finished product.
There is no value for sodium due to an analytical problem.

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2.4 Sensory analysis

Initial evaluations were done internally but directly demonstrated a very unpleasant taste of all the potatoes tested.
According to HZPC, it could be the taste of a characteristic phenolic compound. In Phase 2 it will be important to test the taste and conduct further experiments in the presence of this taste.
Cooking in the microwave makes the skin of potatoes dryer and less pleasant.
For the skin, color of the skin and the flesh, hydroponic potatoes seems to be very close to commercial products.

2.5 Energy consumption evaluation per Kcal obtained end product

For 100 kcal, we can extrapolate the energy requirement to 0,044 kwh for microwaved potatoes
It has not been possible to measure energy consumption for boiled potatoes.

2.6 Necessary room and laboratory equipment weight

The weight of the equipment is very low. It will depend on the amount of processed products needed. If we expect to have large harvests (e.g. 3-4 times during the mission) the size of the equipment will be larger. In the case of continuous harvest, equipment can be very similar to a home kitchen.

2.7 Risks to human

During cooking the risks for astronauts are burns when handling or splashing. It should be noted that an increase in temperature of the room due to cooking is possible as well as risks linked to water steam.
With the microwave oven, the risk of burns is limited. The risks are more important concerning microwave emission in case of sealing problems.

2.8 General conclusion and future perspectives

So, at this time is not possible from our point of view to determine the best cultivar.
There are great differences among potatoes. Maybe the degree of maturity of potatoes is not the same. It will be interesting to analyse potatoes at different stages of maturity.
In phase 2, we expect to work on a standardized potato. Specifications will define the degree of maturity, the size, the weight, and some other aspects. Moreover it is important for us to harvest a higher amount to elaborate more tests and more recipes.
Water and wastes analyses were not including in this test. Only indications were obtained.

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Due to the very unpleasant taste, no sensory analyses were conducted. Sensory analysis is important for us, because astronauts have to consume the potatoes. Good taste is the first important aspect to feed human.
During this phase, energy consumption, type of equipment and risk to human were for us less important. In the phase 2, provided we will obtain standardized potatoes, we will be able to process more tests and recipes. This will indicate the best compromise among all cultivar and all criteria.

3 Wheat processing

3.1 Macronutrients preservation

Macronutrient preservation during the processes investigated (milling, baking) is not a real issue (no losses for whole grain product, fibre loss directly related to bran separation in case of non whole grain product), however the baking process does have an impact on digestibility / bioavailability of respective components. But has not been investigated here.
Concerning the macronutrient composition of hydroponic wheat, it was remarkable that the hydroponically grown samples provided an increased fraction of protein and a complementarily reduced fraction of carbohydrates in comparison to the respective field samples of the same cultivars.

3.2 Micronutrients preservation

Micronutrient composition of the non-processed and processed samples were measured by Prof. U. Feller (University of Bern) and included in his report.
As can be derived for the analytics done on the four cultivars of the hydroponic wheat samples, there was a strongly pronounced increase of the ash content as a result of smaller grains and most probably the mineral composition of the hydroponic media used.

3.3 Sensory analysis

The two processes (milling, baking) investigated for wheat bread production delivered good sensory quality of the produced bread as evaluated by a non-trained sensory panel at ETH Zürich. This result relates to the field samples of the Greina cultivar.
Two-fold aspect of milling impact on wheat starch and gluten protein. Mechanical wheat starch damage improves water holding capacity of the dough and thus impacts positively on freshness and slower development of aging effects.
It has to be noted that due to the small fractions of hydroponically grown bread wheat cultivars there was the only possibility to carry out the product processing using field cultivated samples. As a consequence sensory characteristics reflect only the field samples processed by

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the selected small scale processing units. We can expect that the higher ash content detected for the hydroponically grown cultivars will lead to altered sensory characteristics.

3.4 Energy consumption (process chain) evaluation per KJ obtained end product

For this lab scale study including milling and baking as described in detail in the report ≈ 0.125 KW/Kg.

3.5 Necessary room and laboratory equipment weight

1 m3 space and 80 kg.

3.6 Risks to human

High temperature (baking)

3.7 General conclusion and future perspectives

Until today the basic technological properties of the hydroponically grown bread wheat cultivars have been tested for the milling operation. It was confirmed that the milling behaviour compares to field grown samples of the same cultivars. The higher ash content of the hydroponically grown wheat has no negative impact on its milling performance. From a product quality characteristics perspective, the ash content in the hydroponically grown cultivars comes close to an acceptable limit concerning the use of the flour for standard bread making. It is expected that further optimization in the hydroponic growth conditions and refinement of the nutrient solutions applied, will allow for ash reduction.
Concerning the bread making properties, the experiments carried out were restricted to field grown cultivars, due to the lack of larger quantities for the hydroponic wheat. The good applicability of the experimental setups was confirmed. It can be assumed that the procedures will work equally well with the hydroponic wheat as soon as available in larger quantity (> ca. 1 kg / cultivar).
The physical and sensory analyses carried out so far reflect the situation described before, meaning that the applicability of the measuring procedures has been confirmed. This should also hold for the hydroponically grown cultivars.

Green wheat based products like freekeh will be focused as soon as green wheat in the milky state can be harvested from the field or, if it can additionally be made available from the hydroponic cultures.

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4 Soy processing

4.1 Introduction

Soybean is becoming an important crop worldwide because of the importance of its nutritional properties: it provides fat and good quality proteins and the health benefits of its products have been well documented. Soybean is a good source of dietary fiber and, for this reason, can have positive effect on diarrhoea, constipation, anti-infiammatory and anti-carcinogenic effects on the digestive system, can reduce the cholesterol level. Soybean seeds contain many phenolic compounds, isoflavones in particular, with biological activity: they present effects on cancer, vascular disease, osteoporosis and menopausal symptoms.

Despite several nutritional proprieties, the real nutritional value of soybean and soy meal is lower than expected: it is done to the presence of different compounds usually known as anti-nutritional factors that act as direct or indirect antagonists of nutrient availability. Phytic acid, in particular, is a strong chelator of important minerals such as calcium, magnesium, iron and zinc.

The use of soybeans as a food has also increased because there are several possibilities of processing.

4.2 Macronutrients preservation:

The process for soymilk and okara production is very effective because of absence of waste and high recovery of macronutrients. Fat and protein recoveries depend on cultivar but, in mean, it is possible obtain a quite total protein recovery (97%) and a very high fat recovery (67%). Highest percentage of proteins residues is in the pulp; fat in okara is lightly higher.

Concerning the varieties, CRESIR obtains the highest protein content, but adding soymilk and okara protein recovery we obtained, for this cultivar, the lowest value. REGIR soy milk and ATLANTIC okara have the highest protein yield.

There are not significant differences among varieties in term of fat content both in soybeans seeds and in soymilks. In okara samples ATLANTIC and REGIR show the highest values, PR91M10 and CRESIR the lowest ones.

The production of soya sprouts uses a very simple and economical technology. Germination process causes, in soybean seeds, hydrolysis of proteins and increase of free amino-acid; a small increase in crude protein is reported. Soybean seeds germination process leads to a slight decrease in the oil content (it could be probably ascribed to consumption of oil as energy and/or synthesis of certain structural constituents in the young seedling). With respect to the seeds a very little part of the macronutrients is lost but this can be considered a not very important weakness.

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4.3 Micronutrients preservation

The process for soymilk and okara production includes heat treatments and this causes isoflavones destruction: in mean, adding soymilk and okara recovery we obtained a 38% value. Nevertheless, total isoflavones concentration is higher in okara (37.6% recovery) than in soymilk (0.4% recovery): okara undergoes only one thermal treatment (while soymilk undergoes two thermal treatments) and isoflavones are not completely hydrophilic molecules (extraction for analysis was carried out with MetOH/H_2O 70/30).
Concerning the varieties, CRESIR presents the highest total isoflavones content in seeds and in okara; in soymilk there are not significant difference among CRESIR, REGIR and ATLANTIC while PR91M10 presents the lowest content.
For soya sprouts, germination causes a rapidly increase in total isoflavones content, during the early stage of germination.

4.4 Sensory analysis

Soymilk does not taste like dairy milk, but it presents a characteristic flavour of beans and for this reason is not always well accepted by European consumers; however it is increasingly used, for example by vegan people or cow's milk intolerant/allergic people.
Soymilk obtained with laboratory equipment with addition of vanilla sugar (2 g/lt) and salt (1.5 g/lt), is very close to a market soymilk sample (Italian market leader).
In the context of a space mission, soymilk can be drunk daily for breakfast and it has no give laxation effect.
Okara and sprouts are not typical European food but they are ingredient for several recipes (for example, different sprout salads or okara meatballs): in this way it's possible to hide the taste of soy and, without laxation effect, is possible to contribute to an appropriate menu cycle rotation.

4.5 Energy consumption evaluation per Kcal obtained end product

Thermal process for soymilk and okara production causes energy consumption: 2400 KJ /liter of soy milk.
Soybeans germination is a very economic technology. Energy consumption is, eventually, done to sprouts drying, but planning germination in the consumption function is not required drying.

4.6 Risk to human

The process for soymilk and okara production does not destroy phytic acid (it's heat-stable): the highest percentage goes in juice.

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Concerning the varieties, REGIR shows the lowest phytic acid in seeds, in soymilk and in okara but in okara samples there are not significant differences between REGIR and PR91M10.
A number of experts have observed a reduction in phytic acid during germination of different legume seeds apparently as a result of a large increase in phytase activity; in particular, in soybean, was observed a 17% reduction after five days of germination.

4.7 General conclusion and future perspectives

In this phase, many different parameters were evaluated on seeds and products. The conclusion is that the selection of the best cultivar depends on the importance given to each parameter.
CRESIR market samples show the highest protein and total isoflavones content whilst REGIR market samples present the lowest phytic acid concentration.
Anyhow, would be more appropriate to choice the best cultivars, evaluating the hydroponic performance and not the market samples. Among samples grown using hydroponic systems, if the production of protein rich meal is the priority PR91M10 is the best one, on the other hand if oil production is the main final destination REGIR variety reaches the top.
In the second phase, we expect to work on processing of hydroponic seeds. Seeds transformation processes, indeed, can affect not only macro and micronutrient concentration but also their bio-accessibility: future studies will address this point.
Taste is a very important factor and, for this reason, sensory analysis can be improved in phases 2 using a panel trained on soybean product. Different okara recipes can be tested and, in order to save crew time, rapid processing for milk and okara manufacturing can be developed.

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