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List of Abbreviations

AD:	Applicable Document
ADF:	Alain Ducasse Formation
AIL:	Action Item List
ALISSE:	Advanced Life Support System Evaluator
AOAC:	Association of Official Analytical Chemists
DDR:	Detailed Design Review
DO:	Dissolved Oxygen
ECLSS:	Environmental Closed Life Support System
ESA:	European Space Agency
ESR:	European Standard Rack
FPPS:	Food Production and Preparation system
FPU:	Food Preparation Unit
HAR:	Hardware Acceptance Review
IPL:	Institut Paul Lambin
ISS:	International Space Station
LEO:	Low Earth Orbit
LSS:	Life Support System
MELiSSA:	Micro Ecological Life Support System Alternative
NASA:	National Aeronautics and Space Administration
PCU:	Plant Characterisation Unit
PPU:	Plant Production Unit
P&ID:	Process and Implementation Diagram
PDR:	Preliminary Design Review
RD:	Reference Document
RH:	Relative Humidity
ROM:	Rough Order of Magnitude
SRR:	System Requirements Review

ST:	Sub-Task
TN:	Technical Note
UBP:	Université Blaise Pascal

1 Introduction

1.1 About the MELiSSA space research program

The acronym MELiSSA means 'Micro-Ecological Life Support Alternative' and is a development program of a microbiological and horticultural plant based ecosystem. The system is used for regenerative life support systems for long-term space missions to lunar bases or flights to Mars.

The basis of MELiSSA is the treatment, recovery and recycling of edible biomass, water and oxygen from human waste and carbon dioxide. The scale and advanced stage of technologies that have been developed to overcome the numerous technical challenges is substantial. Many of these solutions directly impact and present solutions to environmental issues on earth. Examples include: optimized water treatment systems, sewage systems, recycling of waste, controlled crop growth. And the list continues. All technology developed until now is described in Technical Notes.

1.2 About the Melissa Food Characterisation Phase 1 research program

Long term manned space missions require life support systems to sustain day-to-day life of the crew. Life Support technology used during short term missions today is inadequate (most of the consumables are just re-supplied to the ISS), and insufficient for long term missions (Lunar or Martian exploration). For such missions most of the consumables will have to be produced in situ and therefore, Life Support Systems must be designed regenerative.

Europe has built up expertise in the various Life Support areas and a considerable reservoir of competence is now available regarding air recycling, water recycling (grey, yellow, black), waste management, food production as well as associated quality control, including monitoring, detection and taking countermeasures. Technology development and associated characterization are rather well advanced for air, water and wastes treatment, however food system development remains an area where a big step with respect to: i) characterization, ii) understanding and iii) engineering has to be taken.

A food system is generally considered as the complete chain of production and preparation of the food. That is from the higher plant (vegetable crop) selection and production to the final edible food product elaboration, which will end up on the crew plate. By producing higher plant and elaborated edible food products, additional waste is generated (around 50% of the produced biomass is generally considered as non-edible), which will enter the ECLSS waste treatment system. Therefore, in order to maintain the performance of the recycling loop, the characterization of the produced biomass (edible and non edible) is a key issue towards a closed regenerative system.

With the aim to elaborate a roadmap for a food production and preparation strategy as well as associated process optimization, an AURORA study has been carried out and several critical points were identified. With regards to medical issues, a lack of clear nutritional specifications for elaboration of crew diet was reported. With regards to life support issues, the study demonstrated the lack of generic tools to evaluate the cost of a food system (with respect to mass, energy, crew time). In addition, a lack of appropriate food products data (i.e. nutritional composition, nutritional stability, shelf life…), including higher plants composition (edible and non edible), was demonstrated. This concerns as well information on evolution of plant nutritional properties versus cultivation as transformation conditions, which is a key point when designing crew diet and waste recycling loop (e.g. MELiSSA wastes management part).

Based on these conclusions, several parallel studies were initiated to obtain necessary knowledge:

- In the frame of a study, MEliSSA recipes were created and implemented in the Long Term Bed Rest in 2005. First of all, the study demonstrated the possibility to elaborate acceptable dishes with a limited number of selected plants meanwhile respecting the nutritional specifications given for the bed rest. In addition, this study confirmed the lack of appropriate nutritional data, which was previously identified. The current knowledge published in nutritional databases is generally limited to field crops without precision of variety/cultivar and environmental growth conditions as well as semi elaborated products for which the transformation conditions are not known

- In the frame of another study, the preliminary MELiSSA food database was developed to evaluate the cost of a Food Production and Preparation System (FPPS). This tool was conceived to include all data from the plant production system to the ultimate recipes preparation equipment and it proposes additional functionalities as for instance diet management system. Due to the need to close the ECLSS loop, and consequently the necessity to couple many processes together, the current leitmotiv for each technology developed is the understanding, modeling and control of every single unit. Today, if the MELiSSA compartments are now rather well defined for 4 chemical elements, namely C, H, N, and O, this limited level of definition is only a preliminary step of the characterization necessary for a complete understanding of the MELiSSA loop. Regarding food sources, mainly higher plants, this level of characterization is far from being complete and from allowing a good understanding and a proper modeling approach. Therefore, an Aurora activity and a GSTP activity were placed to get a preliminary understanding and basic modeling of the plant metabolism, as well as the preliminary design of a instrument required to study higher plant canopy.

For all the reasons mentioned above, and in front of the high quantity of work to be performed (i.e. the most frequently number of crops considered by space agencies is in the order of 32), it is today of major importance:

- to approach the food production and preparation at the system level, and to tackle the issue with a global approach,
- to progress on the understanding and characterization of food preparation processes,
- to progress in the characterization and modeling of higher plant (i.e. plant characterization) via the developments of a well defined generic facility (PCU),

For budgetary reasons, it has been decided to initiate this study with only 4 vegetable crops: wheat, durum wheat, potato and soybean. Those crops are the most important in the diet requirements fulfilment.

The study is divided in 2 phases:

Phase 1:

- Definition of the requirements for a food production and preparation system (FPPS)
- Definition of the FPPS sub-system requirements
- Review of the sub-system state of the art and identification of criticalities
- Preliminary trade-off of representative crop cultivars
- Preliminary trade-off of food preparation processes
- Elaboration of the requirements for a plant characterization unit
- Preliminary Design of the plant characterisation unit
- Critical sub-systems study and selection
- Detailed design of the plant characterisation unit, which will be a ground research facility,

Phase 2:

- Construction, installation and functional tests of the PCU
- Tests performance (overall 500 days test are minimum requirement on each crop)
- Further development of mathematical modeling (including chemical and nutritional evolution of plants versus environmental culture conditions)
- Results evaluation
- Roadmap for the development of a food production and preparation system (FPPS), which will be the future in space (i.e. microgravity and reduced gravity applications) facility for food production and preparation.

The present commercial evaluation concerns only the phase 1 of the activity. The technology is still at a very early stage which limits the perspective of this commercial evaluation.

Found within this commercial evaluation is an initial market survey and assessment of the possibilities for valorization of the developed knowledge. This task is associated with the workpackage MFC Phase1 Project Work package 9000 'Management and commercial evaluation' mentioned below, within the framework of the Food Characterisation phase 1 of the MELISSA ESA/ESTEC Project, hereafter referred to as MFC Phase1 Project.

1.3 About IPStar

IPStar is the valorization and technology transfer company for commercialization of technologies originating from the ESA MELiSSA research program. IPStar works in close cooperation with a large team of scientists that belong to the MELiSSA group.

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2 Nutrient solution optimisation for hydroponic plant production

2.1 Technology Summary

Hydroponics is a method of growing plants using mineral nutrient solutions, in water, without soil. Terrestrial plants may be grown with their roots in the mineral nutrient solution only or in an inert medium, such as perlite, gravel, mineral wool, or coconut husk. Researchers discovered in the 19th century that plants absorb essential mineral nutrients as inorganic ions in water. In natural conditions, soil acts as a mineral nutrient reservoir but the soil itself is not essential to plant growth. When the mineral nutrients in the soil dissolve in water, plant roots are able to absorb them. When the required mineral nutrients are introduced into a plant's water supply artificially, soil is no longer required for the plant to thrive. Almost any terrestrial plant will grow with hydroponics. Hydroponics is also a standard technique in biology research and teaching.

Some of the reasons why hydroponics is being adapted around the world for food production are the following:

* No soil is needed
* The water stays in the system and can be reused- thus, lower water costs
* It is possible to control the nutrition levels in their entirety- thus, lower nutrition costs
* No nutrition pollution is released into the environment because of the controlled system
* Stable and high yields

Today, hydroponics is an established branch of agronomy. Progress has been rapid, and results obtained in various countries have proved it to be thoroughly practical and to have very definite advantages over conventional methods of horticulture. The two chief merits of the soil-less cultivation of plants are, first, much higher crop yields, and second, hydroponics can be used in places where in-ground agriculture or gardening is not possible.

During the course of this commercial study an interview took place with Mr. Tom van der Kooij, manager operations at HZPV Holland BV. HZPC Holland B.V. acted as subcontractor with University of Ghent based upon their practical experience and expertise working with hydroponic cultures especially for potatoes. HZPC was established after the merger of two of the leading seed potato exporting companies in Holland, Hettema and De ZPC, each with 100 years of experience.

The core business of HZPC is the breeding, growing and marketing of seed potatoes. HZPC is one of the worlds largest private seed potato companies. Approximately 80 % of the sales are export sales, accounting for more than 40 % of the annual Dutch export volume. To support the core business (seed potatoes) HZPC also markets ware potatoes. In this way the protected varieties of HZPC are promoted within the supermarket chains. To follow the different markets closely, HZPC has subsidiary companies in Portugal, Spain, Italy, France, Poland, United Kingdom and in USA/Canada.

The objectives of HZPC are:

- development of new varieties, which comply with the different market demands.
- realization of optimum value for breeders, growers and shareholders.

The main reasons why HZPC uses hydroponics for their production process is:

- controllability of environment
- in vitro crop growth results in much better seed potato yields than pot culture

2.2 Development Status

UGent proposes nutrient solution optimization for hydroponic cultures (e.g. potato (HZPC), or other MELISSA crops as tomato, spinach, lettuce, in the future) or for horticulture on non-hydroponic, soil-less substrates. These culture methods will be referred to hereafter as soil-less cultures.

2.2.1 Commercial Applications

Soil-less crop growth generally speaking cannot compete with large scale open field plant culture due to the costs associated with the installations required. However it is expected to become commercially interesting on the medium or longer term. In The Netherlands green house growth is fuelled by gas. At some point gas will become scarce and therefore more expensive which means that other solutions can become interesting and need to be found.

Traditional field crop growth offers much fewer possibilities to control the growth process. For example most lettuce growth already is hydroponic, all nutrients that are introduced into the systems actually benefit the plant. The fact that in greenhouse environments full climate control is required for cooling, heating, et cetera means there is a need for significant investments. This naturally needs to be commercially viable.

The fact that one can control the growth means that it is possible to develop a plant with certain characteristics for example a 'light potato'. This is a product that could be interesting for the high end food industry.

More relevant from the public interest perspective is the possibility 'create' more effective nutritional products such as rice, apples or strawberry in view of the growing world population and the challenges associated with food scarcity.

Breeding plants with specific features was done traditionally by crossing different varieties/species to creating hybrids with features that you want to have. One drawback with this approach is that after a period of approximately 3 years being just a few generations of the hybrid plant the productivity generally decreases and the cycle needs to be restarted which is not very efficient. The breeding industry is of course happy with this fact, because this phenomenon offers a logic opportunity to sell new products every three years.

This approach is completely different because the goal to obtain certain characteristics is obtained by influencing the nutritional process and growing conditions including (sun-)light, temperature and so on.

2.3 Competitive Advantage

The greenhouse industry produces a relatively high amount of non-edible biomass. Also current technology does not provide an exact determination of ions in the liquid medium. This causes accumulation in the medium which requires regular replacement of the medium as a total. A more precise nutrient medium could (partially) resolve these issues to a certain extent.

Soil-less crop growth technology offers advantages from its design and capabilities:
- efficient water usage (HZPC claims 100% rainwater usage);
- continuous harvesting. The plant can remain within the systems. HZPC ‘milks’ potato plants leaving the plant itself for a period of up to 12 weeks. After this the plant is depleted;
- the nutrient solution can be very accurately manipulated in order to achieve specific nutritional effects or taste;

One of the major drawbacks connected to hydroponic soil-less culture methods is the weakness of the system when there is a contamination with pathogens. Pathogens are circulated through the entire system which may cause the entire harvest to be wasted.

2.3.1 Patent Potential

Hydroponic Plant Growth technology is a common application already used in Russia in the sixties of the previous century. The technique is well understood. The patentability of know-how of precise formulations of nutrient solutions depends on the novelty of the formulation and therefore uncertain.

It would be interesting to research the interest from the industry for applications like this. This could be done in a follow-up study.

2.3.2 Recommendations

- after completion of the research on the effects of nutrient solution composition on the crop growth performances this know-how could be interesting to improve production technology for the soil-less crop growth / greenhouse industry.
- indirectly approach food industry to gauge interest for large scale soil-less crop growth
- goal is to offer consultancy services or know how to companies that advise the agro-food industry

3 Closed chamber plant production (R&D)

3.1 Technology Summary

Closed Chamber Plant Production ("CCPP") is widely used for research and development purposes. One of the main activities associated with the use of CCPP was for GMO studies. However regulation has recently relaxed and the need to use CCPP has diminished, as long as the process is well controlled. MELiSSA research has shown that existing CCPP systems lack uniformity and in fact that it is a major technical challenge to develop a uniform system. At least the MELiSSA community understands the shortcomings of its system. Arguably, this notion poses an essential challenge as a starting point for a successful commercial technology transfer effort.

The supplier market of CCPP has basically merged into one large European supplier: Schunk GmbH in Germany. After discussions with Prof. Mike Dixon, Christel Paille en Christophe Lasseur it has become clear that an effective independent commercial exploitation of hardware oriented products seems hardly likely. It is a niche market dominated by one supplier. A full analysis of Competitive Advantage, commercial Use, Patent Potential presumes the existence of a business case that justifies an independent commercial technology transfer. Considering the characteristics of this market this is not the case. There is no point to research the CCPP market in more detail as such because it is a true niche market that can only be catered by a company that has a much wider spread.

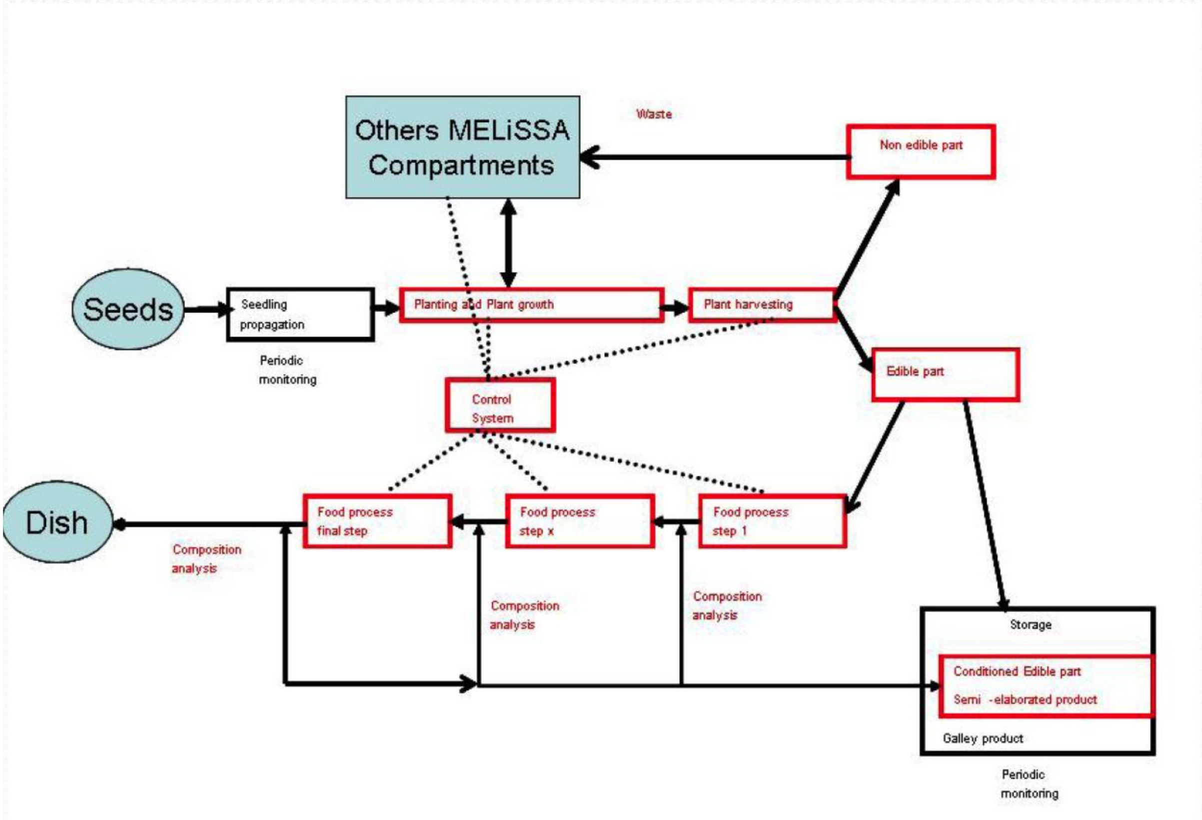
3.2 Recommendations:

1. research the question whether Schunk has an R&D department studying new design or optimizing existing design.
2. contact Schunk to see if there is an interest to upgrade their existing CCPP technology and related products. If this is the case the MELiSSA community can provide consultancy services to Schunk.

4 Food processing steps

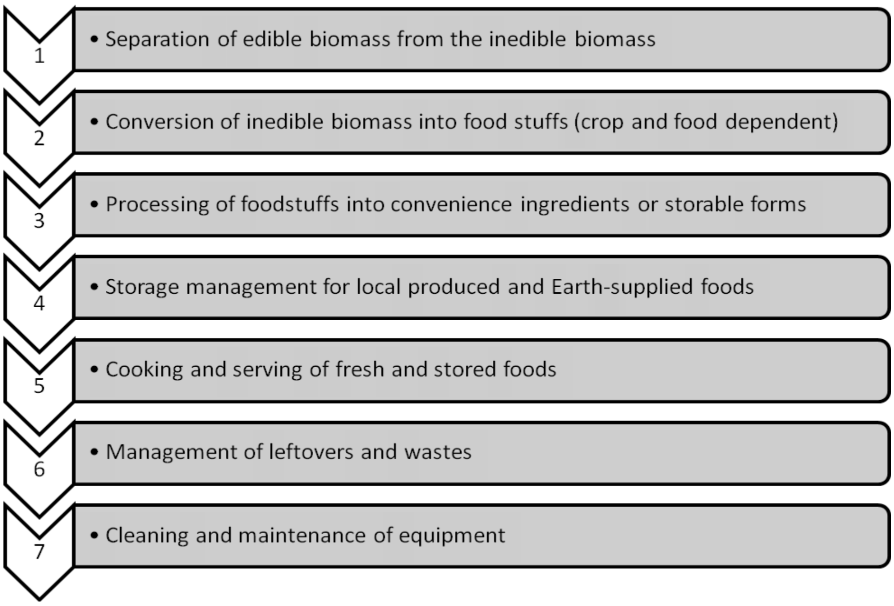
The MELiSSA Food Production and Preparation System (FPPS) is a system that supplies fresh food to the crew of a long-term mission (Moon or Mars base). The system shall be designed for a 6 member's crew and for a surface stay of around 730 days.

functional aspects of the product



Food processing is needed to transform food ingredients into palatable and nutritious dishes based on the dish recipes. Equipment for food processing for space missions is expected to be specially designed to satisfy some criteria. Ideally, the equipment must have a high degree of automation, be multifunctional, and minimized in size, mass, power consumption, heat generation, and crew time requirement. Currently, the information on food processes and equipment suitable for use in Advanced Life Support System (ALSS) continues to be under development. Some specifications may be estimated or predicted based on the earth bound equipment and the results from recent research and development efforts.

For each recipe, all tasks and necessary ingredients and materials related to the recipe have to be described. For example, Hunter J. and Drysdale A. (1996) have worked on food processing and on the overall strategy required to process food in a CELSS (Controlled Environment Life Support System). According to them, the ideal food production system will require optimization on three axes: high versatility, low labor requirements, and minimum processing residues. Any long-duration mission will require efficient food processing technology as opposed to short-term missions, due to the need for more efficient logistics. A regenerative system will start from raw materials and will thus require somewhat more food preparation than would use a physico-chemical system, but there will be many common items. Finally, food processing includes the tasks described in the following figure.



For MELiSSA database, steps concerning transformation of crops into ingredients have to be included in processes for each plant. Moreover, food processing also generates waste. The types and quantity of waste from preparing a dish may be estimated by considering all the tasks called for by the recipe of the dish. The power consumption, heat generation, and crew time requirement for food processing may be calculated by the same way. In addition, preparing the dish using a non-automated method may be investigated to serve as a reference for comparison with an automated method.

If we look at the food chain at the terrestrial level we have the following observations. The agro-food industry comprises an integrated complex production chain which ranges from the primary agriculture to the mature food and beverage sector. It is considered as one of the largest sectors worldwide with significant contribution to the economic advancement of nations and major social impact. While food corporations and individual farmers adapt their production to consumer expectations, international and governmental institutions promote the respect of the environment, protect medium- and/or small-sized farms and help food producers. The industry's future sustainability and effectiveness is considered to depend upon the mutual implementation of the following actions:

- Making the healthy choice easy for consumers,
- Developing value-added food products (e.g. superior quality, quick to prepare, cheap),
- Assuring safe food that consumer can trust,
- Achieving sustainable food production,
- Achieving effective management of the food chain, and
- Comply with environmental rules and directives.

One of the angles to approach the issue is to assess the interest for optimization of current processing units/steps in the agro-food industry. The question would be if industry is prepared to invest in upgrading their existing technology. Another issue is id there are governmental (e.g. European Commission) subsidies available for such a public/private cooperation. In fact both are related. The food industry only invests money or resources in the event there is a benefit for them in terms of optimizing profit margins either by more efficient production processes of the creation of better products that provide a competitive edge or ideally a combination of such factors.

4.1 Conclusions and recommendations

There is no FPPS unit yet, so there is no proof of principle to support claims of efficiency or enhanced productivity. On the other hand it is a well known fact that industrial processes are constantly being scrutinized and revised.

One of the ways to achieve successful technology transfer is in providing consultancy services to the food industry directly, but perhaps even better to the food consulting industry, such as PWC and other smaller consultancy companies.

In order to support a suitable value proposition a thorough comparative analysis of the existing MELiSSA know how would have to be made prior to approach the industry.

5 Diet management system

5.1 Technology Summary

University Blaise Pascal (UBP) has developed a specific MELiSSA software program in combination with an extensive food characterization database. The aim is to store a vast variety of accessible information about different types of foodstuffs. UBP developed a ‘food management system’ in order to match the food production capability of the Life Support System with the needs of the crew. A specific part is related to nutritional information.

During the preparation of this report several interviews took place with Mr. Serge Pieters, dietician at the Institut Paul Lambin (Haute Ecole Léonard de Vinci). The discussions with Mr. Pieters provided deeper insight in the development status of the food database and the diet management system.

5.2 Development Status

The Melissa approach to the diet management systems obviously is not designed to include commercial end-user applications. The system as a whole is developed as a tool for weight control and ensuring sufficient intake of nutrients for astronauts as opposed to for example weight loss. Astronauts are exposed to weightlessness, radiation and limited possibility for physical activity. This causes all sorts of adverse effects to the human body. The goal of the food management systems is to maintain weight, muscular mass and bone status, in short to provide a tool to neutralize the effects of living in space. So weight loss is not the prime goal, however, future developments include the option to manage/lose weight. The system is also still very much under development both in terms of technological evolution as well as quality contents. Some recommendations that have been made by IPL have relevance for the development of a commercial product. For example:

1. inclusion of a module for the management of dietary recommendations taking into account gender and age.
2. integration of a data management module with anthropometric and biological information.
3. dynamic recommendations for dietary supplement. For example if an astronaut has failed to cover his magnesium intake the computer must advise the astronaut (or the consumer) to take dried fruit. In case of excess of a certain element, the computer will propose to adapt the quantities of this element during the following meal(s). In both cases a procedure must be defined to determine an acceptable range between intakes and recommendations.

4. integration of a module that can calculate the nutritional needs of consumers based on their physical activities during the day. This module should use the model to estimate the physical activity level (PAL) with specific criteria for astronauts. The PAL factor can be used to compute the amount of calories one must consume in order to reach specific targets.

The structure of the current UBP database is first-rate. It is based on ‘gold standards’ like euroFIR, and it contains a vast variety of characteristics of specific food products.

In addition the information is based on food chemical analyses carried out by Institut Paul Lambin, University of Napoli and the ETH Zürich. As such the UBP food database is similar to the German Food Composition Table “Souci–Fachmann–Kraut“. The Souci database provides detailed food composition data of about 800 food items and 260 food constituents. The documentation includes the average values and variations of the nutrient concentrations, as well as energy- and waste values of the specific food items. The starting point for the MELiSSA diet management system is the safety of astronauts so there is no margin for error. This means that the information in the database must have a 100% quality level.

Changing the software environment is more complex. For this an analysis needs to be carried out by experts that are familiar with the different functions and components:

- user interface
- database access and retrieval software
- nutritional calculation modules

An example of the artificial intelligence features that are expected to be necessary for commercial purposes is the flexibility allowing the end user that wishes to lose weight to provide his preferences for food tastes but also allergy information. Some people simply do not like to eat Brussels sprouts so the system must be able to adapt its recommendations while retaining the nutritional values and targets.

5.3 Competitive Advantage

Most existing food databases lack accuracy. This makes them generally speaking unsuitable as a reference source for dietary purposes. The existence of several databases that all have different structures makes it very difficult to get a clear perspective on available food databases.

EuroFIR (European Food Information Resource) is a program to harmonize existing food databases. It was a five-year Network of Excellence funded by the European Commission's Research Directorate General under the "Food Quality and Safety Priority" of the Sixth Framework Programme for Research and Technological Development. The network involved 49 partners from universities, research institutes and small-to-medium sized enterprises from 27 European countries. The EuroFIR project officially ended on 30th June 2010.

The structure of the current UBP database is based on ‘gold standards’ such as euroFIR, and in addition it contains a vast variety of characteristics of specific food products. From this perspective the UBP database is state-of-the-art both in terms of functionally, structure as well in terms of content potential.

The current UBP food database can be further improved to the right level. More in particular the amount of data needs to be increased to include energy values, micronutrients (iron, calcium, sodium, magnesium, (protein, fat, carbohydrates).

The Institut Paul Lambin has access to nutritional information of 2000 food products spread over a wide variety of species including. For each of these food products there is more than 70 types of nutritional information types such as fat, carbohydrates, calcium and so on. According to Mr. Pieters it would be possible to enrich the UBP database within a relative brief amount of time. Clearly this would immensely contribute to the relevance of the database for a commercial product.

There are several diet management systems on the market. However, they rely mainly on inadequate data. The problem is that the reliability of the products used by consumers at home compared to the nutritional data available in databases is uncertain. The error percentage can be up to 30%.

One of the best diet management systems is Nutrilog. Nutrilog uses three types of food databases: Institut Paul Lanbin, Ciqual and the USDA database. The main disadvantage of Nutrilog is that it doesn't take into account the individual likes and dislikes of individuals. The Nutrilog program is able to recommend a diet selecting certain products with certain nutritional composition, but it is not possible to individualize the system. Very often people are not able to follow the diet all the way to the end target because the system tells them to change too many habits. It is generally known that people that follow a diet have a limited ability to change their food habits and the MELiSSA diet system can be designed to take this psychological factor into account.

The ability to exactly calculate the nutritional values of a daily menu is a strong competitive advantage of the MELiSSA food management system. In most programs calculations have to be done by the end-user which is prone to errors. Only Nutrilog has a feature to automatically calculate the daily menu for a specific user. However, taste preferences and individual habits are not included in this systems which sometimes leads to odd recommendations such as the consumption of three spoons of sugar.

5.4 Areas of Applications

Generally an efficient user friendly diet management system can be used not only to lose weight but also to gain weight and to control weight more in general. Another very important benefit can be to increase the quality of diet and food composition thereby increasing individual health.

From this perspective the following markets are identified:

1. weight loss market
2. sport / athletes
3. hospitals / elderly homes / prisons
4. schools

Within the scope of this commercial evaluation we have concentrated on the most obvious market: the weight loss market. Please note that the following analysis does not target obese people since this is a medical condition that requires a totally different approach. The following will concentrate on more or less healthy consumers that are interested to use a scientific method to lose a few pounds. Not only can a diet management system provide people with the proper guidance but also the weight loss market for people that are slightly overweight is much larger.

Background

Excess bodyweight is a major public health concern. Recently an analysis of long-term trends of body-mass index (BMI) has been done estimating worldwide trends in population mean BMI for adults 20 years and older in 199 countries and territories. Data was obtained from published and unpublished health examination surveys and epidemiological studies (960 country-years and 9.1 million participants). For each sex, a Bayesian hierarchical model was used to estimate mean BMI by age, country, and year, accounting for whether a study was nationally representative.

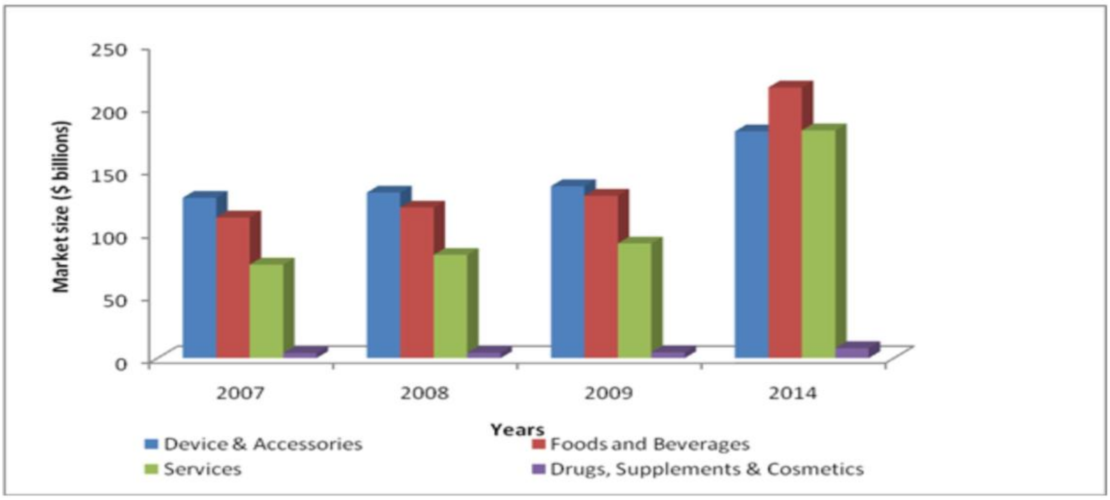
Between 1980 and 2008, mean BMI worldwide increased by 0.4 kg/mx2 per decade for men and 0.5 kg/m2 per decade for women. National BMI change for women ranged from non-significant decreases in 19 countries to increases of more than 2.0 kg/m2 per decade in nine countries in Oceania. Male BMI increased in all but eight countries, by more than 2 kg/m2 per decade in Nauru and Cook Islands. Male and female BMIs in 2008 were highest in some Oceania countries, reaching 33.9 kg/m2 for men and 35.0 kg/m2 for women in Nauru. Female BMI was lowest in Bangladesh (20.5 kg/m2) and male BMI in Democratic Republic of the Congo 19.9 kg/m2, with BMI less than 21.5 kg/m2 for both sexes in a few countries in sub-Saharan Africa, and east, south, and southeast Asia.

The USA had the highest BMI of high-income countries. In 2008, an estimated 1.46 billion adults worldwide had BMI of 25 kg/m2 or greater, of these 205 million men and 297 million women were obese.

Globally, mean BMI has increased since 1980. The trends since 1980, and mean population BMI in 2008, varied substantially between nations. Interventions and policies that can curb or reverse the increase, and mitigate the health effects of high BMI by targeting its metabolic /mediators, are needed in most countries.

According to recent healthcare market research report ‘Global Weight Loss and Gain Market (2009 – 2014)’, published by MarketsandMarkets, the total global weight loss market is expected to be worth US$586.3 billion by 2014. The market has a compound annual growth rate (CAGR) of 10.9% from 2009 to 2014

GLOBAL WEIGHT MANAGEMENT MARKET BY PRODUCT THROUGH 2014 ($ Billions)



Source: MarketsandMarkets

The food and beverage (F&B) market is the largest segment and is expected to reach $355.7 billion by 2014 at a CAGR of 12.2%. The F&B market owes its growth to the introduction of new components in this segment, as well as increased demand from consumers.

U.S. is the largest geographical segment; and is expected to be worth $310 billion by 2014. Its 12.2% CAGR (2009 to 2014) is driven by the greater availability of products and services, as well as greater consumer awareness in this region.

The next largest segment is Europe, which has a CAGR of 10.9%. It is expected to reach $238 billion by 2014. This segment is growing due to the increasing number of products and services in this region. Consumers are becoming more health-conscious and also have greater awareness about the availability of weight management products.

Based upon the information made available one of the ways to commercialize the diet management system is to choose the Nespresso approach. Considering the size of the market it would be interesting to research the interest from the industry to sell certain food products that have been carefully analyzed in combination with the UBP database and software tools that can be accessed through the internet. If the consumer that wishes to lose some weight purchases a food product he will be given a login code to access a personalized page on the internet. After the login, the consumer is invited to enter personal data such as:

a) age
b) gender
c) weight
d) body length
e) target weight
f) desired time frame

Naturally this list can be extended to include all sorts of information such as use of medicines, physical condition et cetera et cetera. After inclusion of this information the software interactively calculates a weight loss program by providing a diet for example on a weekly of even daily basis. The user would have to login to the system and enter all information that the system requires to adapt and tune the diet program such as actual food consumption, physical activity level et cetera.

From a commercial point of view the strengths of this approach are the following:

a) the food producing company has a 'captive audience'. Once you start to follow this method you need to stick to it, because otherwise your efforts are wasted;
b) the system is intelligent and flexible. It does not say you cannot eat carbohydrates at all, instead it tells the consumer what quantities of certain food types are required to have a balanced food intake and at the same time achieve individual weight loss targets;
c) it has a scientific quality coming from space technology used to maintain astronauts health. In the perception of consumers it 'must be a good system';
d) the fact that the consumer needs to return to the log in page provides very powerful advertizing and marketing opportunities to sell other related products such as the food

packages used within the program, food supplements, vitamins, books about healthy lifestyles, fitness machines, and even holiday trips to health resorts which are becoming increasingly popular.

The platform to deliver the software features would be the internet due the capability of interactive exchange between the ‘database’ and the end user. Applications for smartphones could be a very good tool in view of its great accessibility while people are in transit. People need to be in touch with the system as often as possible.

One of the companies that could be approached to discuss this opportunity is Nutrition & Santé. N&S is Number One in Europe on the dietetics and organic food markets. The group is present in all the main distribution networks and in all the principle dietetic and organic food sectors. One of the N&S strengths lies in its well-known brands: Gerblé, Isostar, Gerlinéa. Modifast, Céréal Bio, Soy. N&S is involved in nutritional research and constantly innovates to offer food solutions adapted to the pace of modern life.

Some markers about the company (2007)
- turnover: 260 M€
- 924 collaborators
- 3 skills: creation, fabrication, sales
- distribution in 41 countries
- 3 specialist production sites
- 3 branches in Spain, Italy and the Benelux

5.5 Recommendations

Technical:

- make detailed analysis of the current development status of the food database and the software

- inventory of required modifications / improvements both with respect to the database and the user interface, database retrieval software and nutritional calculation modules
- create model including technical and functional specifications of the end product
- analysis and estimate of required efforts (time and money) to realize the modifications

Commercial:

- have initial discussions with the industry f.i. N&S
- close MoU with industry and involve them both from the product development point of view as well as from financial point of view

Legal:

- create partnership agreement with Ugent / UBP defining terms on the commercialization of the diet management system

6 Conclusion and action list

6.1 Conclusions

The commercial evaluation of the MFCP1 has shown that there are promising facets that justify further review. At the same time it must be acknowledged that the technology is largely still in its infancy. This can also be considered an advantage under specific conditions because it allows interested potential partners to be involved in the development process at an early stage. On the other hand most industrial partners are risk adverse and demand a 'proof of principle' before they would consider an investment. Taking all aspects into consideration a focus on the diet management system and the nutrient solutions optimisation for Hydroponic Plant production appear the best candidates for successful technology transfer. The CCPP as well as the FPPS technology is either very early stage or the market appears to be rather small after a first evaluation.

6.2 Action list

Nutrient solutions:

1. Develop a report containing:
    - details about the of advantages of using MELiSSA technology for nutrient optimisation compared to traditional solutions;
    - a financial analysis of the costs and benefits attached to the use of optimized nutrient solutions;
    - make a long list of industrial players that are active in providing consultancy services to the agro-food production chain
2. create a business plan focusing on the sale of know how to companies that advise the agro-food industry;

Apart from the time that is required to carry out the above action list which would have to be funded, no important out of pocket costs are expected during this phase.

Diet Management System:

1. make detailed analysis of the current development status of the food database and the software
2. create model including technical and functional specifications of the optimum end product
3. report on required modifications / improvements both with respect to the database and the user interface, database retrieval software and nutritional calculation modules
4. analysis and estimate of required efforts (time and money) to realize the modifications
5. Create business plan for overall development of the product and marketing strategy including financial analysis
6. have initial discussions with the industry f.i. N&S and close MoU with industry and involve them both from the product development point of view as well as from financial point of view
7. create partnership agreement with IPL / UBP defining terms on the commercialization of the diet management system