M ELiSSA

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Review of menu elaboration strategy, identification of critical points and proposed selection method

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1 Foreword

In this TN all the indications of weight are expressed as hydrated gross weight of a raw or cooked product. For reasons of understanding in recipes and food plans, it is clearer to mention the actual weights to avoid sources of error of calculation or interpretation.
In the future, we can consider a computational algorithm to determine the dry weight.

2 Introduction

The document TN 98.1.1 specified the nutritional requirements, which were elaborated in specific nutritional requirements (6.1) based on the impact of nutrients on the biological functions and taking into account the nutritional countermeasures to be planned to avoid deficiencies during longer term space missions. In this document the elements which allow to define a best, varied, well-balanced, healthy and delicious MELiSSA menu are approached.
Man does not just eat nutriments but eats food. Everyone eats according to his hunger, appetite, taste and distaste, sensory or organoleptic criteria, seasons, national or family food habits, religious or philosophic, economic or other criteria. All of these are to be taken into account to correctly feed an astronaut.
The aim of this technical note is to translate correctly the nutritional requirements for astronauts for a mission on the moon or mars (as summarised from the currently available information in the table Annex 12 of TN98.1.1, and reproduced here as Annex 1) into food/menus. This technical note will describe the concept of a MELISSA food pyramid. This will permit to define nutritional criteria for food and recipes. A derived tool will allow to establish frequencies and quantities of consumption of food, determining the characteristics of the menu cycle, which is required to lead to a varied, well-balanced, healthy and delicious ”nutrition”. The usage of this tool will allow to conceive quickly and with precision menus adapted both on qualitative and quantitative aspects.
The use of this pyramid can also serve as educational tool to educate astronauts about their specific food needs.

With the evolution of medical science, nutrition recommendations become more accurate. But it is essential to communicate these simple nutrition messages to the population. Many models of patient education have emerged. Obviously no model is perfect. Currently, the most common food education model is the food pyramid. Many health institutes have adapted the pyramid depending on food habits of populations. According to Reedy et al, the food pyramid allows to cover precisely the needs for a given population.
Regarding the MELiSSA Pyramid we estimated that the food pyramid model developed at the Institut Paul Lambin can be a correct model. Of course, many adjustments must be made based on (1) the nutritional requirements developed in the annex of TN 98.1.1 and (2) the development of recipes and MELiSSA spacefood.

Recommendations were similar regarding almost all food groups for both the type and amount of foods. Primary differences were seen in the types of vegetables and protein sources recommended and the amount of dairy products and total oil recommended. Overall nutrient values were also similar for most nutrients, except vitamin A, vitamin E, and calcium. These food guides were derived from different types of nutrition research, yet they share consistent messages: eat more fruits, vegetables, legumes, and
whole grains; eat less added sugar and saturated fat; and emphasize plant oils.

3 Food selection

Catering for astronauts is a challenging task. The main objective is to supply menus and recipes which satisfy specific nutritional requirements, individual tastes and distastes, food habits and food availabilities.
Criteria (taste, color, habits, nutritional ...) for food selection are complex and may be influenced by many factors. Modification of eating habits can take a long time and need conscious effort. Any changes need to take into account taste, food quality, convenience, cost, health and nutrition beliefs, body image, social relationship. In a study of people eating in an army cafeteria, the main criteria were taste, quality and appearance, followed by size of the portion, price, length of the serving line, individual cravings, nutrient density of the food, amount of time available to eat, and appetite (sproul et al 2003).

3.1 Sensorial disturbances

During space flights, we observe a decrease of the appetite of the astronauts, dehydration and a loss of weight. Their food intake is hypocaloric and seems to be the main cause of their loss of body mass. Most astronauts find that space food is few appetizing and bland.
Appetite can vary significantly during a space mission. Especially during the first days of a spaceflight, due to space motion sickness. Taste of space food, stress, change in food habits, can lead to a reduction of appetite.
The role of taste in food selection is crucial. Foods high in fat and / or sugar are associated with feelings of personal satisfaction and reward. These perceptions often date back to early childhood and the discovery of flavors. There is no difference between genders.
Tasteful changes were described during space flights as well as a less good detection of food flavor. (Lane, 2000) Indeed, in microgravity, there is absence of currents of convection, smells do not circulate correctly into the retro nasal space. Furthermore, food floats in the mouth and thus is not constantly in contact with the taste buds. (Seddon, 1994)
Even during bed rest studies, subjects reported decreased appetite, due to a lack of taste. The threshold for taste sensitivity for all tastes seems to be increased. But a more recent bed rest study suggests that there is no specific factor involved to understand this fact.
It seems that astronauts have a preference for carbohydrate food. It would be due to the physiological answer to stress. The consequence is an increase of the concentration of tryptophane in the blood in the brain, precursor of serotonine, an appetite-suppressing agent.

The change of other neuroendocrine mediators coming from the answer to stress would decrease appetite and gastro-intestinal functions. (Da Silva, 2002). During fasting or low intake of calories or carbohydrates, the liver will produce ketone bodies. These metabolites have a major impact on decreased appetite. Moreover ketoacidosis can also have negative effects on bone and muscles metabolism.
Higher fat levels in food increase palatability and taste. Palatability, dietary acceptability and nutritional content are important factors in the selection of crops. Unfamiliar varieties can have psychological effects and create a certain stress.
The ingestion of sodium by astronauts often exceeds the upper limit. Salt being used to raise the taste of the preparations.
The zinc consumption by astronauts during the flights is lower than the recommended values. A deficiency can be associated with the disfunction of the sense of smell and taste during the space flights and thus affects the food intake. Even with a deficiency in retinol.
Changes in the perception of the sense of smell and taste as well as the gastrointestinal disturbances will alter the appetite and the nutritional absorption, and enhance the denutrition status of astronauts.
Gastrointestinal function is altered during space flight. Due to microgravity, fluid shifts, dehydration and chronic inactivity will reduce gastrointestinal motility. Gastrointestinal changes may influence the nutritional status by changes in appetite or absorption. At the gastric level, the stomach becomes "gaseous" because of the incapacity to eliminate gases. The chronic inactivity can increase the duration of the transit of food in the digestive tract. Influence on the microflora has to be determined. Furthermore, it would seem that microgravity perturbs the physical contact between the gastric contents and the intestinal mucous membrane. The redistribution of body fluids and dehydration can affect the gastrointestinal motility, maybe due to the decrease of the visceral circulation. (Lane 2000) Many astronauts suffering from space motion sickness develop an intestinal ileus. Moreover the low amount of dietary fibers in space food will enhance constipation. But many astronauts consume mild laxatives during flight.

4 Food guide

4.1 Food-based dietary guideline

The first food guide pyramid was published in Denmark in 1978 and later adopted by the USDA (United States Department of Agriculture) in 1992 to replace the earlier food groups classification system.
Since Food-guide pyramids are a form of food-based dietary guidelines that help translate nutrient goals into a visual representation of suggested food intake. Generally, the World Health Organization describes food-based dietary guidelines as “the expression of the principles of nutrition education mostly as foods; intended for use by individual members of

the general public; and written in language that avoids, as far as possible, the technical terms of nutritional science" (1998).
Nowadays, every country develops a specific model of food education. The Food pyramid is maybe not the best educational model, but it is certainly the most used one.

4.2 Food pyramid

The principle of the pyramid is simple: all food products are grouped into eight food families with similar/equivalent nutritional properties. (Fig. 1) (Tab. 1).
To facilitate the translation of dietary recommendations into practical advice, it is easier to gather food with similar nutritional characteristics in terms of macro and micronutrients. Thus, generally a fruit is equivalent to another fruit in terms of energy and nutrient density. This permits to give specific advice for each food group.
Thus, each food group can cover some requirements. An inadequate intake of foods from this food group will induce a risk of insufficient amounts of specific macro and micronutrients for this food group. Conversely excessive consumption will also induce an imbalance.
A balance between all the food groups can cover all the nutritional requirements of an individual.
In some cases, the nutritional characteristics in the various groups seem to be close. For example, for fruit and starchy foods, carbohydrate and fiber intake are roughly comparable. But, starchy foods are sources of complex carbohydrates, while fruits are sources of simple carbohydrates. Similarly, fruits provide vitamin C, while starchy foods do not. Another difference relates to the consumption habits: we do not eat fruit in the same way as we eat starchy foods.
Dairy and meat products are on the same floor in the pyramid as they are protein sources of high biological value, the difference however is that meat is rich in iron and low in calcium whereas milk is the reverse.

A daily intake of a certain amount of each group is necessary to insure a sufficient supply of indispensable nutrients. (annex 2, as reproduced from TN98.1.1, Annex, table Annex1) The more voluminous the floor or the level is, the more important the quantity to be consumed during the day is. The top of the pyramid represents the foods which are to be consumed in moderation. No food is forbidden, it is only a question of quantities and frequency.

Fig. 1 Example of a food guide pyramid (Absolonne, 1999)

4.2.1 Fluids:

This food group allows to cover the water needs. The basic pyramid recommends drinking 1–2 L of unsweetened fluids (still water, fizzy water, coffee, tea, ...) per day. (Soft drinks and alcoholic beverages are included in the 'occasional' food group.)

The total water needs are obviously higher. However, all foods can provide a certain amount of water. Some foods such as fruits and vegetables but also soups, juices or milk are foods rich in water. Despite this, it is essential to provide drinking water. Indeed, the daily losses are not covered only by food water , it is therefore essential to provide water as a drink. The requirements to drink 1-2 liters of water, is general but allows to cover the needs of all individuals. However, in cases of physical activity, high temperature or fever, needs are increased.

4.2.2 Starchy foods:

Starchy foods occupy the base of the food pyramid.

These foods should be present in all meals and readily available. The essential nutritional characteristics of carbohydrates are energy intake as carbohydrate complex represented by starch. If they are consumed as whole grains, they can also provide a good source of dietary fiber, B vitamins, minerals such as magnesium and iron. Starchy foods are low in fat with the exception of fried products. The nutritional objective is to reach at least 30% of energy intake as complex carbohydrate or starch with a maximum of 35%. If the references speak of 50%, this is unrealistic because of changing food choices in industrialized countries and the presence of carbohydrates in other food families e.g. lactose milk sugars are naturally present in fruits and vegetables (glucose, fructose, sucrose).

Cereals: wheat, barley, rye, oat, rice, spelt, corn, millet, triticale, …
Pseudo-cereals: amaranth, quinoa, buckwheat, …
Derivatives of cereals: flours, starches, hulled grains, grains of wheat, bulgur, semolina, …
Produced through panification: breads, melba toasts and products of bakery
Produced through pastification: pastas
Breakfast cereals: cornflakes, muesli, …
Other starchy vegetables rich in starch: potatoes, sweet-potato, manioc, tapioca

STARCHY FOODS
1 part = 14 g of carbohydrates and 3 g of dietary fibers

- 80 g of potato or purée (=mashed potato) (represents the volume of a big egg)
- 30 g of bread (miscellaneous) or 1 slice of square bread (800 g)
- 1/2 piccollo or 1/2 pitta or 4 cms of baguette (of 250 g)
- 2 cracottes
- 20 g of "breakfast" cereal or 5 tablespoons of cornflakes or 4 tablespoons of chocolate cereal or 2 tablespoons of muësli
- 20 g of raw rice or 50 g of cooked rice or 2 tablespoons
- 20 g of raw wheat or 50 g of cooked wheat or 50 g of cooked semolina of wheat
- 20 g of raw pastas or 50 g of cooked pastas
- 60 g of cooked legumes or 2 tablespoons

4.2.3 Vegetables

Vegetables occupy more than half of "the fruits-vegetables level ". Constituted by fresh and deep-frozen vegetables but not cooked. It includes also aromatic herbs. This food is rich in water, food fibers, minerals and trace elements, vitamins and polyphenols. They are poor in fats and sugars. They have a low energy density but a high nutritional density. The more they are colored, the more antioxidants (carotenoids, polyphenols-flavonoids) they contain. It is

recommended to strongly diversify vegetable intake and to choose 'season' vegetables in order to reduce the intake of nitrates. A daily intake of at least 200 g is recommended. This represents two portions of cooked vegetables (or soup) as well as a portion of raw vegetables. Fresh and raw aromatic herbs can be consumed as much as you like. The generous portions of vegetables participate, together with cereals and fruits, to reach the adequate objectives in fibers. Furthermore, they contribute to the volume of daily food portions, facilitating the feeling of saturation, with a low caloric intake.

VEGETABLES

1 part = 3.5 g of carbohydrates carbohydrates and 3 g of dietary fibers

- 100 ml of soup or vegetable juice either 1 ladle or 1/2 bowl
- 100 - 125 g of chicory (soupspoon 2), of cauliflower or broccoli (1 or 2 bouquets), of zucchini (2 soupspoons), of mushrooms (10 youngs), chopped spinach (2-3 soupspoons), asparagus tips (15 p.), 1 tomato (size of a tennis ball).
- 75 g of carrots (soupspoon 2), of chopped cabbage (size of a tennis ball), of eggplant (1/2), peeled tomato (size of a tennis ball)
- 50 g of Brussels sprouts, cut leek (soupspoon 2), of fennel (1/2 small bulb), of artichoke hearts (2 rooms (parts,plays)), celery (soupspoon 2 - 3).

4.2.4 Fruits

Placed at the same level as vegetables, they are rich in water, minerals, trace elements, vitamins and dietary fibers. They are poor in fats, their content in sugars (mono or disaccharides) is variable (from 4 % of sugar in currants to 20 % for banana). To provide sufficient antioxidants, one needs to choose the most colored fruits in combination with a good maturity. It is recommended to consume a minimum of 2 to 3 portions of different fruits or at least 200 g per day.

FRUITS

1 part = 13 g of carbohydrates and 3 g of dietary fibers

- mandarins or 3 plums or 1/2 big orange or 1 small orange
- 1/2 grapefruit or ½ small melon
- 1/2 apple or 1/2 pear or 1/2 hammers
- 1 peach or 1 nectarine or 1 kiwi
- 1 dozen strawberries (150 g)
- 75 g of grapes or a cluster the size of a tennis ball
- +/-10 cherries
- 100 ml of fruit juice or ½ glass

4.2.5 Dairy products

The main characteristic of dairy products is the contribution in calcium and in proteins of high biological value. The amount of fat, saturated fatty acids and liposoluble vitamins is very variable: low in skimmed milk and high in cheese. The variability of their content in proteins is also very important and depends on the process used for their preparation and on the moisture content. The same can be concluded for salt: milk is poor in salt, fermented cheeses contain from 1 to 3 g per 100g of cheese. The intake of calcium from dairy products is to be completed by calcium provided by vegetables and some waters.
It is recommended to consume 2 parts of dairy products for a menu of 2000 kcal and 3 parts for a menu of 3000 kcal. At least one part has to be in liquid form, to reduce the intake of fat, saturated fatty acids and salt.

In case of lactose intolerance or allergy to milk proteins, the use of products containing vegetable protein can be recommended. However, the quantity and quality of these proteins is not always comparable and the richness in micronutrients is highly variable. Calcium-fortified products with a value comparable to the calcium content of milk (~ 120 mg per 100 ml) are included in this food group.

DAIRY PRODUCTS
1 part = 8.5 g proteins and 220 mg calcium
· 1 glass of milk of 250 ml
· 2 jars of yoghurt (that is 250 ml)
· 1 small dish of cottage cheese (100 g)
· 30 - 40 g of hard cheeses, soft, in flowery crust
· 30 g of grated cheese or soupspoon 3 or the volume of an egg
· 70 g of soft white cheese or soupspoon 3
· 1 slice of Gouda cheese
· 1 individual portion of blue
· 1/6 of Pont L'évêque
· 1/8 in 1/6 of Camembert
· 4 points of knife of soft white cheese in herbs
· 2 slices of St Maure
· 1 tongue of Emmenthal
· 2 slices of cheese spread

4.2.6 Meat, Poultry, Fish, Eggs, vegetarian Alternatives and legumes

This food group is rich in proteins of high biological value as well as iron, vitamins (except for B12 in vegetarian alternatives and legumes) and trace elements. In European cultures, they are usually in the center of the plate and they are very widely appreciated. Based on nutritional requirements, it would be necessary to limit the daily protein intake of this group to less than 10 % of the total daily protein energy intake. Because of the European gastronomy and food

habits, this is not really realistic. So many entities determining nutritional requirements propose as reasonable and realistic objective a balanced protein intake up to 15 % of total energy intake. This means that consumers have to decrease the consumption of this food group and a choice of low fat items is encouraged. To achieve this, a weekly frequency is proposed: Twice a week fish; Twice a week poultry; Once a week white meat; once a week red meat and maximum once a week minced meat. Once a week, the replacement by vegetarians alternatives or legumes (with proteins of soya or wheat, mushroom proteins) is also a good solution. For a total energy intake of 2000 kcal, it is recommended to limit this group to 2 or 3 parts. For the BET of 3000 kcal, it is possible to give 3 parts of this food group per day.

VIANDES-VOLAILLES-POISSONS-EGGS
1 part = 10 g of proteins
· 50 g of meat or poultry or fish
· 2 small eggs
· 1/2 box of tuna (box 125 g)
· 1 fine slice of cooked ham
· 3 - 4 thin slices of sausage
· 2 slices of elbot or salmon smoked
· 1 net of smoked trout
· 3 batonnets of surimi
· 4 soupspoons of dices of Quorn or 5 soupspoons of chopped Quorn (80 g) or 1 net of Quorn
· 1/2 cutlet or 1/2 burger or 2 sausages of soya (50 g)
· 125 g of tofu

4.2.7 Visible added fats

Visible fats include butter, spreadable fats, oil, mayonnaises and cream. This family is rich in lipids and energy. Some of these products are also sources of interesting nutrients such as essential fatty acids, vitamins A, D and E. We have to mix the intake of various fatty acids to try to obtain a good n-6 / n-3 balance. It is recommended to use oil for cooking (olive, groundnut) and for seasoning (colza, soya, olive, sunflower, mixture of oil).
One part corresponds to 4 g of lipids and this represent: 1 teaspoon of oil · 1 teaspoon of margarine or butter · 1 teaspoon of mayonnaise.
We suggest using a maximum from 7 to 12 parts of visible added fats per day according to the energy needs. The quality is assured if we consume 5 to 7 parts in the form of oil and 2 to 5 parts in the choice among margarines, minarines, butter or cream.

VISIBLE ADDED FATS
1 part = 4 g of lipids
· 1 teaspoon of oil (vary sources)
· 1 teaspoon of margarine or butter (or a small point of knife)
· 1 teaspoon of mayonnaise

· 1 teaspoon spray-painted by minarine or by semi-skimmed butter or 1 big point of knife
· 1 soupspoon of cream (33 % MG)
· 1 soupspoon of dressing

4.2.8 Occasional

This food group represents all not indispensable foods being part of social life. They are mainly represented by sugar, lemonade, cake, pastry, cookie, chocolate and salty products such as chips ... All this food is of strong energy density and it should be consumed occasionally in small portions .
Alcoholic beverages are not included in the food pyramid as they are not necessary in human nutrition. At present , space agencies prohibit the presence of liquor in spacecrafts.

Added Sugar
1 part = 5 g of sugars
Sucrose, fructose, glucose, maltose, dextrin-maltose, honing, syrup fruit

Tab. 1 Nutritional specificities of each food groups and parts

Food groups	Nutrients	Amount/Part
Starchy foods	Carbohydrates (starch) Dietary fibres	± 14 g
Vegetables	Carbohydrates (mono and dissacharides) Dietary Fibres	± 3,4 g ± 3 g
Fruits	Carbohydrates (mono and dissacharides) Dietary Fibres	± 13 g ± 3 g
Dairy products or soy products enriched in calcium	Calcium Proteins	± 220 mg ± 8,5 g
Meat, poultry, fish, eggs, vegetarian alternatives, legumes	Proteins	± 10 g
Visible added fats	Lipids	± 4 g
Added sugars	Sugars	5 g

Tab. 2 Distribution of parts by meals and menus

	Starchy food		Vegetables		Fruits		Dairy products		Proteins		Fats added		Added sugar	
For (kcal)	2000*	3000*	2000	3000	2000	3000	2000	3000	2000	3000	2000	3000	2000	3000
Breakfast	3-4	5-6	0	0	0-3	0-3	0-2	0-3	0-1	0-1	1-3	1-4	0-5	0-5
Lunch	2-3	4-5	2-3	2-4	0-2	0-2	0-1	0-1	0-3	0-4	1-3	2-4	0-5	0-5
Snack	0-1	0-2	0	0	0-2	0-2	0-1	0-1	0	0	0-1	0-2	0-5	0-5
Diner	2-3	4-5	3-4	3-5	0-2	0-2	0-2	0-3	0-3	0-4	1-3	2-4	0-5	0-5
Objectives	10	17	7	7	5	5	2	3	3	4	8	12	<10	<15

*In accordance with annex of TN 98.1.1, 2000 kcal represents the average requirement for female astronauts and 3000 kcal represents the average requirement for male astronauts.

4.3 Principles of the nutritional evaluation of the MELiSSA Menus

The MELiSSA menus (as part of a menu rotation cycle) have to be the subject of an evaluation based on qualitative (choice of ingredients, techniques of cooking) and quantitative (nutritional content) criteria. This evaluation has to be made on both MELiSSA (annex 3) and all other ingredients. The nutritional criteria must be rated as marks and not as values not to be exceeded. The global appreciation of the MELiSSA menus also integrates specific constituents, according to specific nutritional requirements for a mission on the moon or on Mars (Annex1), or the fact of adapting or of creating MELiSSA recipes to make them nutritionally and appetizing.

4.3.1 Menu cycle definition and duration

To avoid any effect of lassitude, the negative impact on mood and a reduction of nutritional intake, ... it seems important to provide a sufficient variety of menus. To do this, the first proposal is to provide menu cycles of 4 weeks (28 days). In a second step, depending on the number of MELiSSA recipes, cycles of 6 to 8 weeks may be considered. To enjoy the menus, we will introduce dishes taking into account Earth's seasons, birthdays, national holidays and religion. Melissa menus will also take into account the European food habits. Indeed, in different countries, food and gastronomy can be very divers. It is important to provide international cuisine and sometimes add some specific regional recipes.

4.3.2 Visualization of the nutritional contents of the MELISSA menus

The Melissa menus consist of a breakfast, a lunch, a snack and a dinner.
Every meal is composed of several courses and every course can include several items. For example the main meal (dinner) is composed of 3 courses: a starter, a main dish, a dessert and has to include at least 7 different products.

4.3.3 Nutritional Criterias

The major criteria for the nutritional evaluation are the nutrients which have most impact on the health of the astronauts, taking into account specific elements related to space exploration missions. Each nutrient has to be consumed every day with a correct distribution to permit to act as countermeasures. (table 3)

4.3.3.1 Energy

The daily energy expenditure is determined based on the following principles:
The daily energy intake must be 100% supplied by the consumed meals. It is generally allowed to distribute the intake as follows: 15-25 % for the breakfast, 30-40 % for the lunch, 10-15 % for the snack and 30-40 % for the dinner. This distribution corresponds to European food habits.

The MELiSSA menu has to satisfy the energy needs for all astronauts, male and female. Women have lower energy needs men (at the same physical activity level). A meal has to satisfy the highest needs (male needs), because it is easier to leave food on the plate, than to be unsatisfied and still feel hungry after a meal because portions are adapted to lower energy needs. Another solution would be to plan minimal quantities and to allow more bread or one more snack. However, the ideal would be to define the precise food portions on a personal (per astronaut) basis. In the future it will be necessary to adapt each astronaut's portions following their specific needs and appetite. Adaption of portions is easier when portions are served in bulk, it is more difficult in the case of serving pre-packaged (on earth) portions.

4.3.3.2 Proteins

Proteins are generally consumed during lunch and dinner. However, for reasons of time-keeping and conviviality, the complete meal is scheduled in the evening. This implies that dinner is the main protein supplier (breakfasts rather provides carbohydrates), and can cover up to 50 % of the daily protein contribution. The lunch will cover 30 % of the daily needs. The animal/vegetable protein ratio close to 1 will be realized over an entire day and not within a single meal.

4.3.3.3 Fats

The nutritional requirements for exploration missions fix the total lipids intake to maximum 30-35 % of the total energy intake. This value is difficult to achieve due to our food habits, and in reality it is often very widely exceeded.

The contribution in total lipids is an important criterion for MELISSA menus, and it has to represent no more than 10-15 % of the lipid energy for the breakfast, 30-40 % for the lunch, 10-15 % for the snack and 40 % for the dinner as a complete meal.

4.3.3.4 Saturated fatty acids

The contribution of saturated fatty acids is an important criterion of MELISSA menus, and it has to represent no more than 10 % of the energy of the day.

4.3.3.5 Cholesterol

The upper intake limit is fixed to 300 mg a day

Dinner being considered the main meal is the most important source of proteins (and thus of fats of animal origin which are often associated with cholesterol)

4.3.3.6 Total carbohydrates

The nutritional recommended intake of total carbohydrates rise to a minimum of 55 % of the total energy intake. However, we know that such a value is extremely difficult to achieve. Due to the large amount of fat intake and also the fact that it is not always easy to consume more starch products, Carbohydrates must be present in all meals. The daily distribution is: 30% for breakfast, 30% for lunch, up to 20% for the snack and 30% for dinner.

4.3.3.7 Added sugars

The recommended nutritional intake for added sugars shall not exceed 10 % of the total energy intake. The contribution in added sugars must be controlled in all meals. Maximum intake for the breakfast is 40% of the total added sugar, for the lunch 20%, for the snack 30% and for the dinner 30 %.

4.3.3.8 Fruits and vegetables

Fruits and vegetables group constitute a major nutritional objective, and it is known that their consumption is highly insufficient. The MELiSSA menus guarantee to have at least 50 % of the minimal WHO recommended contribution in fruits and vegetables which is at least 400 g per day.

The quantity of vegetables has to reach at least 200 g per per day, representing 50 % of the recommended contribution.

4.3.3.9 Dietary Fibres

Rather than imposing a minimal value of dietary fiber per day or per meal, it is better to fix a minimal amount of fruits, vegetables and whole grains.

This minimal consumption of food rich in dietary fibers, allows to guarantee indirectly a minimal contribution of other ‘defender’ compounds such as a wide variety of antioxidants.

Tab. 3 Summary of nutritional objectives

Meal	**Energy (% of TEE)**	**Proteins (% of TEE)**	**Fats (% of TEE)**	**Saturated fatty acids (% of TEE)**	**Cholesterol (mg)**	**Carbohydrates (% of TEE)**	**Added sugar (% of TEE)**	**Dietary Fibres (g)**	**Fruits**	**Vegetables**
Breakfast	15-25%		10-15%	1-1.5%		30%	< 40%	>10g		
Lunch	30-40%	> 30%	30-40%	3-4%	Max 150	30%	< 20%	>10 g		
Snack	10-15%		10-15%	1-1.5%		20%	< 30	0 – 5		
Dinner	30-40%	50%	< 40%	4%	Max 150	30%	< 30%	>10 g		
Objectives (%)	100 %	15 %	max 35 %	max 10 %	max 300 mg	55 %	max 10 %	30 g	min 200 g	min 200 g

4.3.4 The choice within food groups

It is not only important to provide daily food from each food group, but also to select the best foods in each food group. Tab. 4 lists for each group and food product, a list of nutritional criteria to be met by ready to eat servings. All MELiSSA food or space food should comply to these criteria. If a product does not comply, it must be adapted or removed from the batch.

To create this selection, it is important to select in each food group the food with the most abundant vitamins, minerals and other essential nutrients per portion and to limit food containing nutrients that need to be limited (salt, fat, added sugar ...)

Starchy foods

This food is a source of complex carbohydrates, they often are too little represented in the menu, of which mainly the proteins sources profit.

Breads : preferring bread containing, at least partly, sifted flours (whole-wheat bread…) over bread of white flower.

Potatoes : privileging the varieties with firm flesh and which can be eaten with the skin. Reducing the frequency of eating French fries and croquettes.

Cereals: the whole grain cereals (not refined) are preferred: whole grain, rice, quinoa, bulgur of whole grains, pasta… The character « whole » is better, but is not absolutely required all

the time.

Vegetables and Fruits

Raw and cooked vegetables are recommended. However, our food habits imply an important deficit of this food category. Fruits and vegetables bring with a large volume only a few calories (especially vegetables). The calory/lipid content depends on whether the vegetables are consumed cooked or raw and on the method of preparation or dressing. The Melissa menus must at least contain 200 g (edible weight) of fruits and vegetables. The use of several vegetables and fruits of different colors in the menus is recommended to ensure sufficient and divers antioxidants. On top of that, the plate will be more appetinzing.

Meats, Poultry, Poisons, Eggs, vegetarians Alternatives and legumes

The amount of these foods is often excessive in relation to the nutritional requirements. By choosing the right preparations and presentations we might be able to reduce the weight consumed and still have an acceptable and attractive dish. This aspect is particularly important if this food group is present in all meals.

Meat : all meats are permitted. But lean meat is the first choice. Sheep is however limited because of the high proportion of saturated fatty acids (thin lamb is not a problem). Chopped meat should be limited in amount and frequency, due to their high cholesterol content. The use of wild animals (game) is also interesting due to its particular fat composition.

Poultry : all poultry can appear on the menu. One will avoid however the preparations of poultry that contains some hidden chopped meat (ex: sausages or pâté of poultry).

Meat products : as for meat, one should choose the product that contains less fat. This food group is also a great salt supplier.

Fish and seafood: fat fish or mid-fat fish like sardine, tuna, mackerel, eel, salmon, pink trout, halibut… are excellent omega-3 sources. Smoked fish can be on the menu, but with a low frequency because of their high content in salt. Shellfish, crustaceans and other products of the sea can be present.

Eggs : Whereas the egg white is an excellent source of proteins, egg yolk is rich in cholesterol. It is not prescribed, but one will search to limit as much as possible the presence of egg yolk and therefore of preparations such as omelet, baked custard…

Vegetarian alternatives: There are many vegetarian alternatives to meat, and these are often interesting (tempeh, seïtan, tofu, Quorn, vegetable steak of soybean, of wheat, of rice, mushrooms…). Avoid cooking with a great amount of fat and avoid those products that are elaborated with palm oil.

Legums : lentils, dry beans… all the legumes are recommended (same on a small scale quantities). Associated to the cereals, they allow achieving a balanced protein food source.

Dairy products

The fat of the dairy products contain a high proportion of saturated fatty acids and cholesterol (cheese). This must be reduced. The thin dairy products can be used (in preparations that permit it). Fermented dairy products such as yogurts and fresh cheese are a good choice.

Fats

It is important to limit the use of large amounts of fat. But it is important to favour vegetable oils, avoiding palm, copra or coconut oil. Olive oil and soy oil are good choices for cooking and seasoning. It is interesting to also bring in some omega-3 (that is not the case for olive oil) for seasoning: rape, walnut... Butter is limited due to the stability with high temperature of cooking and amount of saturated fat and cholesterol.

Occasionals

This family group includes fat and/or sugar such as crisps, biscuits, chocolate, sweets…. These commodities are to be limited as much as possible in the menus.

Tab. 4 Nutritional criteria for Melissa food products

Food products	Nutrients to limit (per ready to consume portion)	Nutrients to favour
Drink	Energy : 10 kcal / 100 ml Sodium : < 200 mg/100 ml	Water
Bread and bakery products	Energy : < 400 kcal / 100 g Saturated fat : < 1.5 g/100g Trans fatty acids : <0.1 g/100g Added sugar : < 3 g/100 g Dietary fibres : >3 g/100g Sodium : < 500 mg/100 g	Fibres, Vit B, magnesium,
Breakfast Cereals	Energy : < 400 kcal / 100 g Saturated fat : < 1.5g/100 g Trans fatty acids : < 0.1 g / 100 g Added sugar : < 10 g / 100 g Dietary fibres : > 1.5 g / 100 g Sodium : < 120 mg / 100 g Whole cereals : > 50% of content	Fibres, Vit B, magnesium,
Potatoes, cooked rice, cooked pasta, cooked wheat, (fresh, frozen, thermostabilized, rehydratable)	Energy : < 400 kcal / 100 g Saturated fat : < 1.5 g/100 g Trans fatty acids :< 0.1 g/100 g Added sugar : < 3 g/100 g Dietary fibers :> 1.5 g/100 g Sodium : < 120 mg/100 g	Fibres, Vit B, magnesium,
Vegetables (fresh, frozen,	Energy : < 200 kcal / 100 g	Water, Fibres, Vit B9, Vit C,

thermostabilized, rehydratable) not prepared	Saturated fat : < 1.5g/100 g Trans fatty acids : < 0.1g/100 g Added sugar : < 3g/100 g Dietary fibres : > 1.5 g/100 g Sodium : < 120 mg/ 100g	Caroténoïdes, polyphenols,
Vegetables (fresh, frozen, thermostabilized, rehydratable) prepared	Energy : < 400 kcal / 100 g Saturated fat : < 1.5g/100 g Trans fatty acids : < 0.1g/100 g Added sugar : < 3g/100 g Dietary fibres : > 1.5 g/100 g Sodium : < 120 mg/ 100g	Water, Fibres, Vit B9, Vit C, Caroténoïdes, polyphenols,
Soup	Energy : < 150 kcal/100 ml Saturated fat : < 5 g/100 ml Trans fatty acids : < 0.1g/100 ml Added sugar : < 5g/100 ml Dietary fibres : >3 g/100 ml Sodium : < 120 mg/100ml Vegetables : min 40% of content	Water, Fibres, Vit B9, Vit C, Caroténoïdes, polyphenols,
Fruits (fresh, frozen, thermostabilized, rehydratable) not prepared	Energy : < 200 kcal / 100 g Saturated fat : < 1.5g/100 g Trans fatty acids : < 0.1g/100 g Added sugar : < 3g/100 g Dietary fibres : > 1.5 g/100 g Sodium : < 120 mg/ 100g	Water, Fibres, Vit B9, Vit C, Caroténoïdes, polyphenols,
Fruits (fresh, frozen, thermostabilized, rehydratable) prepared	Energy : < 400 kcal / 100 g Saturated fat : < 1.5g/100 g Trans fatty acids : < 0.1g/100 g Added sugar : < 7 g/100 g Dietary fibres : > 1.5 g/100 g Sodium : < 120 mg/ 100g	Water, Fibres, Vit B9, Vit C, Caroténoïdes, polyphenols,
Fruit juice (fresh, frozen, thermostabilized, rehydratable)	Energy : < 100 kcal/100 ml Saturated fat : no Trans fatty acids : no Added sugar : no sugar added Dietary fibers : >1g/100 ml Sodium : no Sodium added	Water, Fibres, Vit B9, Vit C, Caroténoïdes, polyphenols
Milk and dairy products Soy juice and soy products	Energy : < 150 kcal / 100 g Saturated fat : < 1.5 g/ 100 g Trans fatty acids : < 0.1 g/ 100 g Added sugar : < 7 g / 100 ml Dietary fibers : > 1g g/ 100 g (if fruit added) Sodium : < 120 mg/ 100 g Calcium : > 100 mg/ 100 g	Water, Proteins, Calcium, Vit B12
Cheese and cheese products	Energy : < 300 kcal/ 100 g Saturated fat : < 10g/ 100 g Trans fatty acids :< 0.1 g/ 100 g Added sugar : not added Dietary fibers : 0 Sodium : < 900 mg/ 100 g	Proteins, Calcium, Vit B12,

Meat, poultry, eggs, (fresh, frozen, thermostabilized, rehydratable) not prepared	Energy : < 200 kcal / 100 g Saturated fat : < 5 g/ 100 g Trans fatty acids : < 0.1 g / 100g Added sugar : no Dietary fibers : no Sodium : < 120 mg/ 100 g Protein content : > 8% Protein/fat > 1	Proteins, Iron, Vit B12, Zinc
Meat, poultry, eggs, (fresh, frozen, thermostabilized, rehydratable) prepared	Energy : < 300 kcal/ 100 g Saturated fat : < 5g /100 g Trans fatty acids : < 0.1 g/100 g Added sugar : no Dietary fibers : > 1 g/ 100 g (if vegetables added) Sodium : < 200 mg / 100 g Protein content : > 8% Protein/fat > 1	Proteins, Iron, Vit B12, zinc
Meat products	Energy : < 300 kcal/ 100 g Saturated fat : < 5g /100 g Trans fatty acids : Added sugar : < 3g / 100 g Dietary fibers : > 1 g/ 100 g (if vegetables added) Sodium : < 500 mg / 100 g Protein content : > 8% Protein/fat > 1	Proteins, Iron, Vit B12, zinc
Fish, sea products (fresh, frozen, thermostabilized, rehydratable) not prepared	Energy : < 200 kcal / 100 g Saturated fat : < 5 g/ 100 g Trans fatty acids : < 0.1 g / 100g Added sugar : no Dietary fibers : no Sodium : < 120 mg/ 100 g Protein content : > 8% Protein/fat > 1	Proteins, PUFA, Iodine, Vit D, Selenium, Iron
Fish, sea products (fresh, frozen, thermostabilized, rehydratable) prepared	Energy : < 300 kcal / 100 g Saturated fat : < 5 g/ 100 g Trans fatty acids : < 0.1 g / 100g Added sugar : no Dietary fibers : > 1 g/ 100 g (if vegetables added) Sodium : < 200 mg/ 100 g Protein content : > 8% Protein/fat > 1	Proteins, PUFA, Iodine, Vit D, Selenium, Iron
Oil, margarine, shortening, ...	Energy : < 900 kcal / 100 g Saturated fat : < 30 g / 100 g Trans fatty acids : < 0.1 g / 100 g Added sugar : no Dietary fibres : no Sodium : < 120 mg / 100 g	Essential Fatty Acids, MUFA, PUFA, Vit E, Vit D, Vit A

Meal	Energy : 400 to 700 kcal per portion Saturated fat : < 5 g/100 g Trans fatty acids : < 0.1 g / 100 g Added sugar : < 7 g / 100 g Dietary fibres : > 1 g / 100 g Sodium : < 200 mg / 100 g
Sandwiches	Energy : < 350 kcal per portion Saturated fat : < 10 g / 100 g Trans fatty acids : < 0.1 g/ 100 g Added sugar : < 7 g / 100 g Dietary fibers : > 1 g / 100 g Sodium : < 200 mg / 100 g

4.3.5 Conception of the menus and preparations

Table 5 includes all essential informations to select food in each food group and also the amount and frequency to permit to provide healty and balanced menus. Annex 5 includes the necessary amounts of each MELiSSA crop to feed 6 astronauts for one month.

Starter : to choose the preparations to lower part of raw or cooked vegetables (warm or cold soups, salads, mix of vegetables, …). If there is a source of animal proteins, choose the presentation or preparation that allows to limit the amount, especially if the main course also includes a source of proteins.

Main course: limit the amount of meat and other animal proteins, provide enough vegetables (to adapt according to what is proposed in the starter) and complex carbohydrates (starchy foods). Avoid fat sauces (Hollandaise sauce, béarnaise sauce, mayonnaise, cream…) and fried dish. Employ aromatic herbs and reduce salt.

Dessert: choose desserts with fruits, limit pastries, butter, cream...

Cooking methods: reduce the use of cooking methods with fat. In any case, limit the deep fat fryer. Use “al dente” point of cooking for vegetables. Use cooking methods that preserve vitamins and minerals.

Tab. 5 Synoptic table of MELiSSA Menus

BREAK-FAST Category	recommended quantities	Frequency to a menu of 28 days	Food	To favour	To limit or to avoid
Drinks	200 - 400 ml	Every day	Water, coffee, tea	Water	sugar
Starchy foods	2000 M: 3-4 parts 3000 M: 5-6 parts	Every day		Little sifted or whole wheat bread, french stick, crackers, rusk,…	White bread
		Every day if complemented with bread or max 2 times per week if consumed 'alone'	Small cereals, Muesli, cornflakes, porridge,…		Sugared cereals
		Max once a week	Viennese bread		Limited frequency, trans fatty acids
Fat (cooking and seasoning)	2000 M: 1-3 parts 3000 M: 1-4 parts	Every day if bread	Vegetable oils	All	Palm oil, hydrogenated oil, trans fatty acids
		Every day if bread	Fat to spread (butter, margarines, minarine,…)	Vegetable margarines rich in polyunsaturated fatty acids	Butter, hydrogenated oil, trans fatty acids

Sugar garnish	2000 M: 0-5 parts 3000 M: 0-5 parts	Every day	All sugars, including honey, jam, syrup of fruits, chocolate spreads	moderation	Authorized, but to limit as much as possible
Foods, poultry, eggs	2000 M: 0-1 parts 3000 M: 0-1 parts	Every day	Pork meat products	Lean pork meat products (ham, smoked ham, turkey fillet, chicken fillet…)	Fat pork meat products (sausage, salami, pâté…)
		Max once a week	eggs	White part of the egg, eggs rich in « oméga-3 »	
Fruits	2000 M: 0-3 parts 3000 M: 0-3 parts		Fruits, fruit juices without sugar addition	All. To favour fruits to crunch	canned fruits, fruits with syrup, juice of sugared fruits.
Oleaginous (fruits and seeds)	30g max	2*/week with breakfast cereals	Walnut, almonds, sunflower, sesame, pistachio,…	All	
Dairy products and alternative vegetable products	2000 M: 0-2 parts 3000 M: 0-3 parts	Every day	Milk	skimmed or half-skimmed	Full cream milk
		in substitution for milk	Fermented yogurts and milks	skimmed or half-skimmed	Max 7% of sugar addition, limited in fat
		in substitution for milk	Juice of soybean (soy milk), of rice, of wheat, of oat…	All versions « nature »	Max 7% of sugar addition, limited in fat
		Every day	Cheeses	All, but in small quantities. Promoting	cheeses enriched with cream (cottage cheese,

				lowfat cheeses	…), highfat cheese, high content of salt
Drinks		Every day	Water, coffee, tea	Water	Soft drinks, sugar

LUNCH Category	**Quantity**	**Frequency to a menu of 28 days**	**Food**	**To favour**	**To limit or to avoid**
Starchy food	2000 M: 2-3 parts 3000 M: 4-5 parts	Every day	Bread	Little sifted or whole wheat bread, French stick, crackers, rusk,…	White
		in substitution for bread, or 12 times per month	Potato	Natural, jacket potatoes, oven-baked, browned with small amount of fat, mashed, salads	Frying (max 1 times by week)
		in substitution for bread 6 times per month	Pasta	All pasta «simples», preferably whole cereals, chinese noodles	Rich in fat (after cooking), salted
		in substitution for bread 4 times per month	Rice	All, preferably whole cereals,	
		in substitution for bread 4 times per	Wheat	whole wheat, freekeh, couscous, bulgur	

		month			
		in substitution for bread 2 times per month	Other starchy foods	Flours, quinoa, Sarasin, sweet potato,…	
Vegetables	2000 M: 2-3 parts 3000 M: 2-4 parts	Every day	Raw vegetables	All vegetables of season	
		in substitution for raw vegetables	Cooked	All vegetables of season fresh or deep-frozen not prepared, canned or in jars	Canned salted vegetables
		Every day	Soup	All	Soup creams, salt
Meat, poultry, fish, game, eggs vegetarian alternative, legums	2000 M: 0-3 parts 3000 M: 0-4 parts	Every day	Meat, poultry, game	all lean meat or meat with less than 13% of fat content	All fat meat (sausages, meatloaf…) with exception of pure beef (steak). Sheep, Giblets or offal, bread-crumbed meat.
		in substitution for meat	Fish	All	Smoked fish (salmon, halibut…)
		in substitution for meat	Eggs	White part of eeg, eggs with « oméga-3»	Yolk
		in substitution for meat	Pork meat products	Lean pork meat products (ham, smoked)	Fat pork meat products (sausage, salami, pâté…)

		in substitution for meat	Tofu, quorn, seitan, tempeh…	All,	Max 10 % of fat, pastries, fried… or bread-crumbed products
		8 times per 28d	Dry lentils, chickpeas, beans…	All	Canned (preserved in salt)
Fruits	2000 M: 0-2 parts 3000 M: 0-2 parts	Every day	fresh fruits, dryed	All	canned fruits, fruits in syrup (occasionally)
Dairy products and alternative vegetable	2000 M: 0-1 parts 3000 M: 0-1 parts	8 time per 28d	Milk	skimmed or half-skimmed	whole
		in substitution for milk	juice "milk"» of soybean, of rice, of oat…	All 'nature' versions	Max 7% of sugar addition, limited in fat
		in substitution for milk	Cheeses	All, small quantity, promoting lowfat cheeses	Cheeses processed with cream (cottage cheese …). High fat cheese,high sodium content
		10 times per 28d	Fermented yogurts and milks	All	Max 7% sugar addition, limited in fat
		in substitution for milk or yogurt	Dairy dessert	All	Max 7% sugar addition, limited in fat
Fat (cooking and seasoning)	2000 M: 1-3 parts 3000 M: 2-4 parts	Every day	Vegetable oils	All	Palmoil, hydrogenated oil, trans fatty acids
		If cooking	Fats for cooking	Vegetable margarines	Butter, hydrogenated

		requiring fat	(margarines…)	rich in polyunsaturated fatty acids	fat, trans fatty acids
		Max 1 time per week	Cream, soy-cream yofu	Cream lightened (max 20 % of fat content)	Cream with more than 20 % of fat content, coconut milk
		Max 2 times per week	Cold sauces	Dressing with a max of 40 % of fat content, vinaigrette, yogurt sauce	Mayonnaise and derivatives
		Max 8 times per 28 d	Warm sauces	All ‘fonds’ sauces, béchamel with skimmed milk, vegetables sauce, liquid purée of vegetables/fruits, warm vinaigrettes…	Fat sauces (with cream, butter, yolk), béarnaise, Hollandaise, …
Sugar	2000 M: 0-5 parts 3000 M: 0-5parts	Max 8 times per 28d	All sugars, including honey, fruit syrup	moderation	Authorized, but to limit as much as possible
Seasoning				Aromatic herbs, deep-frozen, dried, spices, mixed spices	Limiting the addition of salt, spiced salt, celery salt…
Methods of cooking				All, preferably low fat content	Frying max 1 per week, or use of butter for cooking

Drinks	Every day	Water, coffee, tea	Water	Soft drinks, sugar

SNACK					
Category	**Quantity**	**Frequency to a menu of 28 days**	**Food**	**To favour**	**To limit or to avoid**
Starchy foods	2000 M: 0-1 parts 3000 M: 0-2 parts	Every day	Bread	Little sifted or wole wheat bread, French stick, crackers, rusk,…	white
		in substitution for bread	Other starchy foods	Pancakes, biscuits, cereals, fruit cake, pastries,…	Added sugar > 7%
Fruits	2000 M: 0-2 parts 3000 M: 0-2 parts	Daily in alternation with the evening dessert	Fruits	All	Canned fruits, fruits in syrup
Oleaginous (fruits and seeds)	Max 30 g	2*/week	Sesame, sunflower, walnut, almonds…	All	
Dairy products and alternative vegetable products	2000 M: 0-1 parts 3000 M: 0-1 parts	In alternation with the morning and the evening dessert	Milk	skimmed or half-skimmed	whole
		Idem	Cheeses	All, occasionally Promote lowfat cheeses	cheeses enriched with cream (cottage cheese,…), high fat

					cheese, high sodium content
		Idem	Fermented yogurts and milks	All without addition of cream	Sugar >7%. Rich in fat
		Idem	« juice » of soybean, of rice, of oat…	All 'nature' versions	Sugar >7%. Rich in fat
Fat (cooking and seasoning)	2000 M: 0-1 parts 3000 M: 0-2 parts	For cooking / meal preparation	Vegetable oils	All	Palm oil, hydrogenated oil or trans fatty acids
		On bread	Fat for seasoning (margarines…)	Vegetable margarines rich in polyunsaturated fatty acids	Butter, hydrogenated oil,trans fatty acids
			Fat for cooking (margarines…)	Vegetable margarines rich in monounsaturated fatty acids	Butter, hydrogenated oil, trans fatty acids
			Cream	'Light' Cream (max 20 % fat content)	Cream with more than 20 % fat content
			Soy «Cream», yofu	Less than 20% of fat content	Coconut milk
			Cold sauces	Dressing sauces with max 40 % of fat, vinaigrette, yogurt sauce	Mayonnaise and derivatives (e.g. cocktail sauce), except if diluted with min ¾ of yogurt

Sugar	2000 M: 0-5 parts 3000 M: 0-5 parts		All sugars, including honey, fruit syrup	moderation	Authorized, but to limit as much that possible
Drinks		Every day	Water, coffee, tea	Water	Soft drinks, sugar

DINNER	**Category**	**Quantity**	**Frequency to a menu of 28 d**	**Food**	**To favour**	**To limit or to avoid**
Starter	**Vegetables**	2000 M: 0-3 parts 3000 M: 0-3 parts	14 times	Soup	All	Cream Soup, salt
			14 times	Raw, salads	All raw vegetables	seasoning with max 3 parts of oil rich in polyunsaturated fatty acids
Main course	**Starchy foods**	2000 M: 2-3 parts 3000 M: 4-5 parts	10 times	Potato	'Nature', jacket potatoes, oven-baked, browned with small amountof oil, mashed potatoes, salad	Frying
			8 times	Pasta	All 'simple' pasta, with whole cereals	Rich in fat (after cooking), salted
			4 times	Rice	All, whole cereal, Chinese noodles	
			4 times	Wheat	Whole wheat, freekeh,	

				couscous, bulgur	
		Optional	Bread	Little sifted or whole wheat bread, french stick, crackers, rusk,…	White
		2 times	Other starchy foods	Flours, quinoa, Sarasin, sweet potato,…	
Vegetables	2000 M: 3-4 parts 3000 M: 3-5 parts	12 times	Raw vegetables	All raw vegetables	
		16 times	Cooked	All raw vegetables, deep-frozen not prepared, canned or in jars	Canned salted vegetables
Meat, poultry, fish, eggs, alternative vegetarian, leguminous	2000 M: 0-3 parts 3000 M: 0-4 parts	Red lean meat 4 times White lean meat 4 times	Meat	all lowfat meat or meat with a fat content lower than 13%	All ground meat (sausages, meatloaf,…) with the exception of pure beef (steak). Sheep, giblets, offal, bread-crumbed foods
		Poultry 6 times	Poultry	all lowfat poultry or a fat content lower than 13%	Chopped poultry meat, bread-crumbed foods
		6 times	Fish	All	Smoked fish
		2 times	Eggs	egg white, eggs rich in« oméga-3 »	Yolk
		4 times	Tofu, quorn, seitan, tempeh…	All, as far as max 10 % of fat content	Bread-crumbed versions or other fat versions (fried,

					pastries…)
		2 times	Lentils, chickpeas, beans…	All	Canned
Fat (cooking and seasoning)	2000 M: 1-3 parts 3000 M: 1-4 parts	Every day	Vegetable oils	All	Palm oil, hydrogenated oil, trans fatty acids
		Instead of oil	Fat for cooking (margarines…)	Vegetable margarines rich in polyunsaturated fatty acids	Butter, hydrogenated oil, trans fatty acids
		Optional	Cream	'light' cream (max 20 % fat content)	Cream with more than 20 % of fat content
		Optional	Soy « Cream», yofu	'light' cream (max 20 % fat content)	Coconut milk
Sauces	2000 M: 0-2 parts 3000 M: 0-2 parts	Optional	Cold sauces	Dressing with max 40 % of fat content, vinaigrette, yogurt sauce	Mayonnaise and derivatives
		Optional	Warm sauces	All basic sauces (fonds, béchamel with skimmed milk, vegetable sauce, reduced vegetables/fruits, warm vinaigrettes…	Fat sauces (with cream, butter , yolk), béarnaise, hollandaise…
Condiments, aromatics,				Aromatic herbs, deep-frozen, dried, spices, mixed spices, ketchup, mustard, pickles,	Limiting as much as possible the addition of salt spiced salt, celery salt…

				piccalilli, soy sauce,…	
	methods of cooking			All (preferably with little fat), except for frying	Frying (max 4 times per 28d), butter
Dessert	**Fruits**	14 times	Fruits	All	Conserved fruits, fruits in syrup, on a small quantity
	Dairy products and alternative vegetable	2 times	Cheese	All, Promoting lowfat cheeses	processed cheeses enriched with cream (cottage cheese, …)
		4 times	Fermented yogurts and milks	All without addition of cream	Max 7% of sugar addition, limited in fat
		4 times	Dairy dessert	Pudding, cream pudding,	Max 7% of sweetners addition, limited in fat
	Pastries	4 times	Fruit cake, pancakes, biscuits,		Limiting lipids and sugars to max 10%
	Sugar		All sugars, including honey, jam, syrup of fruits…	moderation	Authorized, but to limit as much that possible
Drinks	**Drinks**	Every day	Water, coffee, tea	Water	Soft drinks, sugar

4.3.6 Assessment of crew time use

In this document it will not be possible to provide a detailed method on how to evaluate time needed (versus allowed by the possible mission scenarios) to prepare dishes. Indeed, more details are needed: amount of raw product available, cycle of harvest, every day meal production or only reheated dishes, proportion and type of ISS space food, …This includes the assessment of possibilities for storage of semi-elaborated products.
The only reference available at this time is the time allowed to astronauts on board of the ISS to take their meals. For breakfast and lunch this represent 20 minutes, for snacks only 5 to 10 minutes. But for dinner they are allowed 45 minutes to prepare/reheat meals and dispose them in a tray, 30 minutes to eat their meal and 15 minutes to clean.

4.3.7 Determination of processing equipment needs

Depending on the needs and/or possibilities of combining:
- fresh crop produce,
- semi-finished (originating from crop processing) stable stored products
- 'resupply' type food (to be further defined)

the equipment needs will need to be adjusted/finetuned. The menu elaboration strategy will be tightly coupled to the crop processing strategy (TN98.3.31). Possibilities/strategies for obtaining ready to eat meals by combining the 3 above categories can only be proposed in a preliminary way.
Based on this, the equipment needs for the final preparation steps to yield menus ready for consumption are only known in terms of equipment classes.
Needs for water in this step?
Waste expected?
At this time, it is not possible to determine each processing equipement needed. Only in phase 2, we can expect to obtain more detailed information.

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6 Annexes

6.1 Annex 1: Nutritional requirements estimates for moon and mars mission

(from annex 12 in the annex to TN 98.1.1)

Nutrients	Units	Moon	Mars
Energy expenditure	kilocalories (kcal) or kilojoules (kJ) 1 kJ = 4.184 kcal	40-45 kcal.kg^{-1}.d^{-1} Example : M :70 kg = 2800-3150 kcal W : 56 kg = 2240- 2520 kcal	40-45 kcal.kg^{-1}.d^{-1} Example : M :70 kg = 2800-3150 kcal W : 56 kg = 2240- 2520 kcal
		M: < 30 y. 1.7*(15.3*W+679) M: > 30 y. 1,7*(11,6*W+879) W: < 30 y. 1,6*(14,7*W+496) W: > 30 y. 1,6*(8,7*W+829) Example : M :70 kg < 30 y. = 2975 kcal M: 70 kg > 30 y. = 2875 kcal W : 56 kg < 30 y. = 2110 kcal W : 56 kg > 30 y. = 2105 kcal	M: < 30 y. 1.7*(15.3*W+679) M: > 30 y. 1,7*(11,6*W+879) W: < 30 y. 1,6*(14,7*W+496) W: > 30 y. 1,6*(8,7*W+829) Example : M :70 kg < 30 y. = 2975 kcal M: 70 kg > 30 y. = 2875 kcal W : 56 kg < 30 y. = 2110 kcal W : 56 kg > 30 y. = 2105 kcal
EVA	kJ/h (kcal/h)	M: 500 – 1300 (120-310) W: 670 (160)	M: 500 – 1300 (120-310) W: 670 (160)
	kJ.kg^{-1}.h^{-1} kcal.kg^{-1}.h^{-1}	M : 10.5±2.4 (2.5±0.6) W : 10.9±2.3 (2.6±0.6)	M : 10.5±2.4 (2.5±0.6) W : 10.9±2.3 (2.6±0.6)
Moon :Driving or riding in thelunar rover (Schoeller, 2000)	kJ/h (% less at earth)	510 (40%)	TBD
Moon : various experiments outside the lunar module (Schoeller, 2000)	kJ/h (% less at earth)	950 (49)	TBD
Moon : general activities (Schoeller, 2000)	kJ/h (% less at earth)	1150 (28)	TBD
Protein	% total energy consumed	10-15 (max 25)	10-15 (max 25)
	g	First 2 months : 1.5 to 1.7 g.kg^{-1}.d^{-1} after 1.2 g.kg^{-1}.d^{-1} Minimum 0.8 g.kg^{-1}.d^{-1}	First 2 months : 1.5 to 1.7 g.kg^{-1}.d^{-1} after 1.2 g.kg^{-1}.d^{-1} Minimum 0.8 g.kg^{-1}.d^{-1}
	N g/ energy(no protein)	1g N / 150 – 200 kcal	1g N / 150 – 200 kcal
Indispensable amino acids			
Histidine	mg/g protein	15	15
	mg/kg per day	10	10
Isoleucine	mg/g protein	30	30
	mg/kg per day	20	20
Leucine	mg/g protein	59	59
	mg/kg per day	39	39

Nutrients	Units	Moon	Mars
Lysine	mg/g protein	45	45
	mg/kg per day	30	30
Methionine and Cysteine	mg/g protein	22	22
	mg/kg per day	15	15
Methionine	mg/g protein	16	16
	mg/kg per day	10	10
Cysteine	mg/g protein	6	6
	mg/kg per day	4	4
Phenylalanine & Tyrosine	mg/g protein	38	38
	mg/kg per day	25	25
Threonine	mg/g protein	23	23
	mg/kg per day	15	15
Tryptophane	mg/g protein	6	6
	mg/kg per day	4	4
Valine	mg/g protein	39	39
	mg/kg per day	26	26
Total indispensable amino acids	mg/g protein	277	277
	mg/kg per day	184	184
Carbohydrates	% total energy consumed	50 – 55 (45 – 65)	50 – 55 (45 – 65)
	g	4 – 6 $g.kg^{-1}.d^{-1}$ Before EVA : 1-4 $g.kg^{-1}.d^{-1}$, 1-4 h before During EVA, at least 37g CHO/hour or 1 g $CHO.kg^{-1}.h^{-1}$	4 – 6 $g.kg^{-1}.d^{-1}$ Before EVA : 1-4 $g.kg^{-1}.d^{-1}$, 1-4 h before During EVA, at least 37g CHO/hour or 1 g $CHO.kg^{-1}.h^{-1}$
Added sugar	% total energy consumed	<10	<10
Total fiber	g	>30 g	>30g
Fat	% total energy consumed	20-35	20-35
n-6 polyunsaturated fatty acids (linoleic acid)	% total energy consumed	5 - 10	5 - 10
	g		
n-3 polyunsaturated fatty acids (a-linolenic acid)	% total energy consumed	0,6 – 1.2	0,6 – 1.2
	g		
Saturated and trans fatty acids	% total energy consumed	nd	Nd
Fluid	ml per kcal	1-1.5	1-1.5
	Litres	M : 3-4.5 W : 2,1-3.1 At least 2000 ml/d	M : 3-4.5 W : 2,1-3.1 At least 2000 ml/d
	If physical activity or EVA	Min 600 ml/h of effort	Min 600 ml/h of effort
Vitamin A (includes	µg retinol	M: 1000	M : 1000

Nutrients	Units	Moon	Mars
provitamin A carotenoids)	equivalent	W: 1000 Max : 3000	W : 1000 Max : 3000
Vitamin D (calciferol)	µg	M : 5-10 W : 5-10 Max : 50 risk of deficiency	M : 5-10 W : 5-10 Max : 50 risk of deficiency
Vitamin E (a-tocopherol)	mg α-tocopherol equivalent	M : 10-20 W : 10-20 Max : 300	M : 10-20 W : 10 -20 Max : 300
Vitamin K	µg	M : 50-70 W : 50-70 Max : nd	M : 65-120 W :55-90 Max : nd
Vitamin C (ascorbic acid, dehydroascorbic acid)	mg	M : 75-100 W : 75 -100 Max : 2000	M : 75-100 W : 75 -100 Max : 2000
Vitamin B12 (cobalamin)	µg	M : 2.4 W : 2.4 Max : nd risk of deficiency	M : 2.4 W : 2.4 Max : nd risk of deficiency
Vitamin B6 (pyridoxal, pyridoxine, pyridoxamine, 5'-phosphates (PLP, PNP, PMP)	mg	M : 1.3 - 2 W : 1.3 - 2 Max : 100	M : 1.3 - 2 W : 1.3 - 2 Max : 100
Thiamin (B1; aneurine)	mg	M : 1.2 – 1.5 W : 1.1 -1.5 Max : nd	M : 1.2 – 1.5 W : 1.1 -1.5 Max : nd
Riboflavin (B2)	mg	M : 1.3 - 2 W :1.1 - 2 Max : nd risk of deficiency	M : 1.3 - 2 W :1.1 - 2 Max : nd risk of deficiency
Folate	µg	M : 400 W : 400 Max : 1000	M : 400 or more ? W : 400 or more ? Max : 1000
Niacin	mg Niacin equivalents	M : 16 - 20 W : 14 - 20 Max : 35	M : 16 - 20 W : 14 - 20 Max : 35
Biotin	µg	M : 30 W : 30 Max :nd	M : 30 W : 30 Max :nd
Pantothenic Acid	mg	M : 5 W : 5 Max :nd	M : 5 W : 5 Max :nd
Calcium	mg	M : 1200 W : 1200 Max : 2500	M : 1200 W : 1200 Max : 2500
Phosphorus	mg	M : 800 W : 800 Max : 4000	M : 800 W : 800 Max : 4000
Calcium/Phosphorus		1.5	1.5
Magnesium	mg	M :260 - 420 W : 220 - 320 Max : 3500	M :260 - 420 W : 220 - 320 Max : 3500
Sodium	mg	M : 2000-2500 W : 2000-2500	M : 2000-2500 W : 2000-2500

Nutrients	Units	Moon	Mars
		Max : 3500	Max : 3500
Chloride	mg	M : 3000-3800 W : 3000-3800 Max : 5400	M : 3000-3800 W : 3000-3800 Max : 5400
Potassium	mg	M : 3000-4000 W : 3000-4000 Max : nd	M : 3000 - 4000 W : 3000 - 4000 Max : nd
Iron	mg	M : 10 W : 10 Max : 45 risk of deficiency	M : 10 W : 19.6 Max : 45 risk of deficiency
Copper	mg	M : 1.5 – 3.0 W : 1.5 – 3.0 Max : 5.0	M : 1.5- 3.0 W : 1.5 – 3.0 Max : 5.0
Manganese	mg	M : 2.0 W : 2.0 Max : 5.0	M : 2.0 W : 2.0 Max : 5.0
Fluoride	mg	M : 3 W : 3 Max : 10	M : 3 W : 3 Max : 10
Zinc	mg	M : 4.2 - 15 W : 3 - 15 Max : 40	M : 4.2 - 15 W : 3 - 15 Max : 40
Selenium	µg	M : 70 W : 60 Max : 400	M : 70 W : 60 Max : 400
Iodine	µg	M : 150 W : 150 Max :1100 Risk of deficiency	M : 150 W : 150 Max :1100 Risk of deficiency
Chromium	µg	M : 35 W : 25 Max : 250 as supplement	M : 35 W : 25 Max : 250 as supplement
Molybdene	µg	M : 45 -50 W : 45 - 50 Max : 2000	M : 45 -50 W : 45 - 50 Max : 2000
Choline	mg	M : 550 W : 425 Max :nd	M : 550 W : 425 Max :nd
Arsenic	mg	M : nd W : nd Max :nd	M : nd W : nd Max :nd
Boron	mg	M : nd W : nd Max :nd	M : nd W : nd Max :nd
Nickel	mg	M : nd W : nd Max :1	M : nd W : nd Max :1
Silicon	mg	M : nd W :nd Max :nd	M : nd W :nd Max :nd
Vanadium	mg	M : nd W : nd Max : 1.8	M : nd W : nd Max : 1.8

Nutrients	Units	Moon	Mars
Inorganic sulfate	mg	M : nd W : nd Max :nd	M : nd W : nd Max :nd

Male astronaut pre-flight weight is 75 kg. Male astronaut in-flight weight is 73kg

6.2 Annex 2: Table of functions, deficiencies and excess of nutrients

(from annex 12 in the annex of TN 98.1.1)

Compound	Function	Food sources	Deficiency	Excess	Special consideration
Energy					
Energy	Provide energy for organs, muscles, …	Fat (9 kcal), Alcohol (7 kcal), Carbohydrates (4 kcal), protein (4 kcal), Dietary fibers (2 kcal), Polyols (2,4 kcal), Organic acids (3 kcal)	Denutrition, malnutrition	Overweight, obesity, cardiovascular diseases, cancer, diabetes type 2, …	
Macronutrients					
Carbohydrate – total digestive	RDA based on its role as the primary energy source for the brain; AMDR based on its role as a source of kilocalories to maintain body weight	Starch (Grains, corn, pasta, rice, potatoes, breads), and natural sugar (fruits, fruit juice) Added sugar (soft		Starch and sugar are the major types of carbohydrates. Grains and vegetables (corn, pasta, rice, potatoes, breads) are sources of starch. Natural sugars are found in fruits and	While no defined intake level at which potential adverse effects of total digestible carbohydrate was identified, the upper end of the adequate macronutrient distribution range (AMDR) was based on decreasing risk of chronic disease and providing

Compound	Function	Food sources	Deficiency	Excess	Special consideration
		drinks, candy, fruit drinks, desserts)		juices. Sources of added sugars are soft drinks, candy, fruit drinks, and desserts.	adequate intake of other nutrients. It is suggested that the maximal intake of added sugars be limited to providing no more than 25 percent of energy.
Total Fiber	Improves laxation, reduces risk of coronary heart disease, assists in maintaining normal blood glucose levels.	dietary fiber naturally present in grains, (soats, wheat, unmilled rice) and functionnal fiber synthesized or isolated from plants or animals and shown to be of benefit to health		Includes dietary fiber naturally present in grains (such as found in oats, wheat, or unmilled rice) and functional fiber synthesized or isolated from plants or animals and shown to be of benefit to health	Dietary fiber can have variable compositions and therefore it is difficult to link a specific source of fiber with a particular adverse effect, especially when phytate is also present in the natural fiber source. It is concluded that as part of an overall healthy diet, a high intake of dietary fiber will not produce deleterious effects in healthy individuals. While occasional adverse gastrointestinal symptoms are observed when consuming some isolated or synthetic fibers, serious chronic adverse effects have not been observed. Due to the bulky nature of fibers, excess consumption is likely to be self-

Compound	Function	Food sources	Deficiency	Excess	Special consideration
					limiting. Therefore, a UL was not set for individual functional fibers.
Total Fat	Energy source and when found in foods, is a source of *n*-6 and *n*-3 polyunsaturated fatty acids. Its presence in the diet increases absorption of fat soluble vitamins and precursors such as vitamin A and pro-vitamin A carotenoids.	Butter, margarine, vegetable oils, whole milk, visible faton meat and poultry products, invisible fat in fish, shellfish, some plant products (seeds, nuts), bakery products		While no defined intake level at which potential adverse effects of total fat was identified, the upper end of AMDR is based on decreasing risk of chronic disease and providing adequate intake of other nutrients. The lower end of the AMDR is based on concerns related to the increase in plasma triacylglycerol concentrations and decreased HDL cheolesterol concentrations seen with very low fat (and thus high carbohydrate) diets.	
***n*-6**	Essential component of	Nuts, seeds,		While no defined intake	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
polyunsaturated fatty acids (linoleic acid)	structural membrane lipids, involved with cell signaling, and precursor of eicosanoids. Required for normal skin function.	vegetables oils (soybean, sunflower, corn)		level at which potential adverse effects of *n*-6 polyunsaturated fatty acids was identified, the upper end of the AMDR is based the lack of evidence that demonstrates long-term safety and human in vitro studies which show increased free-radical formation and lipid peroxidation with higher amounts of n-6 fatty acids. Lipid peroxidation is thought to be a component of in the development of atherosclerotic plaques.	
***n*-3 polyunsaturated fatty acids (α-linolenic acid)**	Involved with neurological development and growth. Precursor of eicosanoids.	Vegetable oils (soybean, canola, flax seed oil) fish oils, fatty fish		While no defined intake level at which potential adverse effects of *n*-3 polyunsaturated fatty acids was identified, the	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
		and smaller amount in meats and eggs		upper end of AMDR is based on maintaining the appropriate balance with n-6 fatty acids and on the lack of evidence that demonstrates long-term safety, along with human in vitro studies which show increased free-radical formation and lipid peroxidation with higher amounts of polyunsaturated fatty acids. Lipid peroxidation is thought to be a component of in the development of atherosclerotic plaques.	
Saturated and *trans* fatty acids, and cholesterol	No required role for these nutrients other than as energy sources was identified; the body can synthesize its needs for saturated fatty acids	Animal fats (meat and butter), coconut, palm kernel oils. Sources of		There is an incremental increase in plasma total and low-density lipoprotein cholesterol concentrations with increased intake of	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
	and cholesterol from other sources.	cholesterol (liver, eggs, food contain eggs (cheesecake, custard peis. Sources of tans fatty acids include stickmargarines and foods containing hydrogenated or partially-hydrogenated vegetable shortenings		saturated or *trans* fatty acids or with cholesterol at even very low levels in the diet. Therefore, the intakes of each should be minimized while consuming a nutritionally adequate diet.	
Protein and amino acids	Proteins from animal sources, such as meat, poultry, fish, eggs, milk, cheese, and yogurt, provide all nine indispensable amino acids in adequate	Animal sources (Meat, poultry, fish, eggs, milk, cheese, yogurt); vegetable sources (legumes,		While no defined intake level at which potential adverse effects of protein was identified, the upper end of AMDR based on complementing the	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
	amounts, and for this reason are considered "complete proteins". Proteins from plants, legumes, grains, nuts, seeds, and vegetables tend to be deficient in one or more of the indispensable amino acids and are called 'incomplete proteins'. Vegan diets adequate in total protein content can be "complete" by combining sources of incomplete proteins which lack different indispensable amino acids.	grains, nuts, seeds, vegetables)		AMDR for carbohydrate and fat for the various age groups. The lower end of the AMDR is set at approximately the RDA..	
Indispensable amino acids: Histidine, Isoleucine, Leucine,	The building blocks of all proteins in the body and some hormones. These nine amino acids must be provided in			Since there is no evidence that amino acids found in usual or even high intakes of protein from food	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
Lysine, Methionine & Cysteine, Phenylalanine & Tyrosine, Threonine, Tryptophan, Valine	the diet and thus are termed indispensable amino acids. The body can make the other amino acids needed to synthesize specific structures from other amino acids and carbohydrate precursors.			present any risk, attention was focused on intakes of the L-form of these and other amino acid found in dietary protein and amino acid supplements. Even from well-studied amino acids, adequate dose-response data from human or animal studies on which to base a UL were not available. While no defined intake level at which potential adverse effects of protein was identified for any amino acid, this does not mean that there is no potential for adverse effects resulting from high intakes of amino acids from dietary supplements. Since data	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
				on the adverse effects of high levels of amino acid intakes from dietary supplements are limited, caution may be warranted.	
Water and electrolytes					
Sodium	Maintains fluid volume outside of cells and thus normal cell function.	Salt (40% sodium by weight), Processed foodsto wich sodium chloride, benzoate, phosphate have been added; salted meats, nuts, cold cuts; margarine, salted butter		Hypertension; increased risk of cardiovascular disease and stroke.	The AI is set based on being able to obtain a nutritionally adequate diet for other nutrients and to meet the needs for sweat losses for individuals engaged in recommended levels of physical activity. Individuals engaged in activity at higher levels or in humid climates resulting in excessive sweat may need more than the AI. The UL applies to apparently healthy individuals without hypertension; it thus may be too high for individuals who already have hypertension or who are under the care of a health care professional.

Compound	Function	Food sources	Deficiency	Excess	Special consideration
Chloride	With sodium, maintains fluid volume outside of cells and thus normal cell function.	Same as sodium, 60% by weight of salt		In concert with sodium, results in hypertension.	Chloride is lost usually with sodium in sweat, as well as in vomiting and diarrhea. The AI and UL are equi-molar in amount to sodium since most of sodium in diet comes as sodium chloride (salt).
Potassium	Maintains fluid volume inside/outside of cells and thus normal cell function; acts to blunt the rise of blood pressure in response to excess sodium intake, and decrease markers of bone turnover and recurrence of kidney stones.	Fruits, vegetables, dried peas, dairy products, meats, nuts	The nutritional deficiency of potassium is rare, because potassium is contained in most foods.	None documented from food alone; however, potassium from supplements or salt substitutes can result in hyperkalemia and possibly sudden death if excess is consumed by individuals with chronic renal insufficiency (kidney disease) or diabetes.	Individuals taking drugs for cardiovascular disease such as ACE inhibitors, ARBs (Angiontensin Receptor Blockers), or potassium sparing diuretics should be careful to not consume supplements containing potassium and may need to consume less than the AI for potassium.
Water	Maintains homeostasis in the body and allows for transport of nutrients to cells and removal and excretion	Water, all beverages, moisture in foods		No UL because normally functioning kidneys can handle more than 0.7 L (24 oz) of fluid per hour;	Recommended intakes for water are based on median intakes of generally healthy individuals who are adequately hydrated; individuals can be adequately

Compound	Function	Food sources	Deficiency	Excess	Special consideration
	of waste products of metabolism.			symptoms of water intoxication include hyponatremia which can result in heart failure and rhabdomyolosis (skeletal muscle tissue injury) which can lead to kidney failure.	hydrated at levels below as well as above the AIs provided. The AIs provided are for total water in temperate climates. All sources can contribute to total water needs: beverages (including tea, coffee, juices, sodas, and drinking water) and moisture found in foods. Moisture in food accounts for about 20% of total water intake. Thirst and consumption of beverages at meals are adequate to maintain hydration.
Inorganic Sulfate	Required for biosynthesis of 3'-phosphoadenosine- 5'-phosphate (PAPS), which provides sulfate when sulfurcontaining compounds are needed such as chondroitin sulfate and cerebroside sulfate.	Dried fruits, soy flour, fruit juices, coconut milk, red and white wine, bread, meat, sulfated water		Osmotic diarrhea was observed in areas where water supply had high levels; odor and off taste usually limit intake, and thus no UL was set.	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
Minerals and elements					
Arsenic	No biological function in humans although animal data indicate a requirement	Dairy products, meat, poultry, fish, grains, cereal		No data on the possible adverse effects of organic arsenic compounds in food were found. Inorganic arsenic is a known toxic substance. Although the UL was not determined for arsenic, there is no justification for adding arsenic to food or supplements.	
Boron	No clear biological function in humans although animal data indicate a functional role	Fruit-based beverages and products, potatoes, legumes, milk, avocado, peanut butter, peanuts		Reproductive and developmental effects as observed in animal studies.	
Calcium	Essential role in blood clotting, muscle contraction, nerve	Milk, cheese, yogurt, cron tortillas,	chronic deficit can lead to a reduction in the density of bone	Kidney stones, hypercalcemia, milk alkali syndrome, and	There is no consistent data to support that a high protein intake increases calcium

Compound	Function	Food sources	Deficiency	Excess	Special consideration
	transmission, and bone and tooth formation	calcium-set tofu, chinese cabbage, kale, broccoli	mass and fracture risk more frequent	renal insufficiency	requirement.
Chromium	Helps to maintain normal blood glucose levels	Some cereals, meats, poultry, fish, beer	Chromium deficiency is characterized by decreased glucose tolerance, which translates to: hyperinsulinemia, fasting hyperglycemia and increased triglyceride and cholesterol plasma. Neurological signs are observed in cases of severe deficiency (which remains anecdotal) such as peripheral neuropathy and metabolic encephalopathy. Disorders related to a less pronounced	Chronic renal failure	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
			deficiency were observed in diabetics, the elderly or the malnourished child while severe impairments have been reported in patients with prolonged total parenteral nutrition.		
Copper	Component of enzymes in iron metabolism	Organ meats, seafood, nuts, seeds, wheat bran cereals, whole grain, products, cocoa products		Gastrointestinal distress, liver damage	Idiopathic copper toxicosis may be at adverse effects from excess intake
Fluoride	Inhibits the initiation and progression of dental caries and stimulates new bone formation	Fluoridated water, teas, marine fish, fluoridated dental products		Enamel and skeletal fluorosis	
Iodine	Component of the thyroid hormones; and	Marine origin, processed	Neonatal mortality, psychomotor	Elevated thyroid stimulating hormone	Individuals with autoimmune thyroid disease, previous iodine

Compound	Function	Food sources	Deficiency	Excess	Special consideration
	prevents goiter and cretinism	foods, iodized salt	development, goiter and cretinism	(TSH) concentration	deficiency, or nodular goiter are distinctly susceptible to the adverse effect of excess iodine intake. Therefore, individuals with these conditions may not be protected by the UL for iodine intake for the general population.
Iron	Component of hemoglobin and numerous enzymes; prevents microcytic hypochromic anemia	Meats and poultry (heme iron sources); fruits, vegetables and fortified bread and grain products such as cereal (non-heme iron sources)	Effects of iron deficiency are known as incidence on the level of physical activity, on brain development and intellectual. Decreased attention, ability to concentrate and impaired memory. Lack of iron also affects the immune system and body's defences against infection.	Gastrointestinal distress	Non-heme iron absorption is lower for those consuming vegetarian diets than for those eating nonvegetarian diets. Therefore, it has been suggested that the iron requirement for those consuming a vegetarian diet is approximately 2- fold greater than for those consuming a nonvegetarian diet. Recommended intake assumes 75% of iron is from heme iron sources.
Magnesium	Cofactor for enzyme systems	Green leafy, vegetables,		There is no evidence of adverse effects from the	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
		unpolished grains, nuts, meat, starches, milk		consumption of naturally occurring magnesium in foods. Adverse effects from magnesium containing supplements may include osmotic diarrhea. The UL for magnesium represents intake from a pharmacological agent only and does not include intake from food and water.	
Manganese	Involved in the formation of bone, as well as in enzymes involved in amino acid, cholesterol, and carbohydrate metabolism	Nuts, legumes, tea, whole grains	Manganese deficiency was mainly observed in animals and results in growth defects, impaired reproductive function, skeletal abnormalities, glucose intolerance and other violations of carbohydrate and lipid	Elevated blood concentration and neurotoxicity	Because manganese in drinking water and supplements may be more bioavailable than manganese from food, caution should be taken when using manganese supplements especially among those persons already consuming large amounts of manganese from diets high in plant products. In addition,

Compound	Function	Food sources	Deficiency	Excess	Special consideration
			metabolism. The different effects are sometimes contradictory and do not always relate to the human. However, its essential character for man was demonstrated when pronounced deficiencies in children or subjects in total parenteral nutrition who are accompanied by events such as bone demineralization, growth retardation and various carbohydrate and lipid disorders, reversed by adequate supplementation. The antagonism with iron		individuals with liver disease may be distinctly susceptible to the adverse effects of excess manganese intake.

Compound	Function	Food sources	Deficiency	Excess	Special consideration
			seems especially significant to the point that an excess in one or another element may precipitate a deficiency in his element antagonist.		
Molybdenum	Cofactor for enzymes involved in catabolism of sulfur amino acids, purines and pyridines.	legumes, grain products, nuts	Molybdenum deficiency is extremely rare in men. But has been reported in varying degrees in younger patients or in patients with Total Parenteral Nutrition not adequately supplemented. It is accompanied by cardiac rhythm disorders (tachycardia) of tachypnea, neurological disorders (loss of night vision,	Reproductive effects as observed in animal studies.	Individuals who are deficient in dietary copper intake or have some dysfunction in copper metabolism that makes them copper-deficient could be at increased risk of molybdenum toxicity.

Compound	Function	Food sources	Deficiency	Excess	Special consideration
			encephalopathy and coma) as well as various biochemical alterations (Hypermethioninemia, hypouricemia, hyperxanthinurie, hypersulfiturie, hyposulfaturie and hypo -uricosuric).		
Nickel	No clear biological function in humans has been identified. May serve as a cofactor of metalloenzymes and facilitate iron absorption or metabolism in microorganisms.	Nuts, legumes, cereals, sweeteners, chocolates milk powder, chocolate candy		Decreased body weight gain Note: As observed in animal studies	Individuals with preexisting nickel hypersensitivity (from previous dermal exposure) and kidney dysfunction are distinctly susceptible to the adverse effects of excess nickel intake
Phosphorus	Maintenance of pH, storage and transfer of energy and nucleotide synthesis	Milk, yogurt, ice cream, cheese, peas, meat, eggs, some cereals	The phosphorus deficiency is rare. A drop of phosphate can lead to osteomalacia	Metastatic calcification, skeletal porosity, interference with calcium absorption	Athletes and others with high energy expenditure frequently consume amounts from food greater than the UL without apparent effect.

Compound	Function	Food sources	Deficiency	Excess	Special consideration
		and breads			
Selenium	Defense against oxidative stress and regulation of thyroid hormone action, and the reduction and oxidation status of vitamin C and other molecules	organ meats, seafood, plants (dependind on soil selenium content)	The lack of intake of selenium is accompanied by various biochemical and clinical disturbances of varying intensity depending on the degree of impairment. Decreased resistance to oxidative stress, increased susceptibility to infections (including viral infections), increased incidence of cancer or cardiovascular disease, impaired fertility, etc.. We currently attaches special attention to the anticancer properties of	Hair and nail brittleness and loss	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
			selenium, particularly with the prostate cancer		
Silicon	No biological function in humans has been identified. Involved in bone function in animal studies.	Plant-based foods		There is no evidence that silicon that occurs naturally in food and water produces adverse health effects.	
Vanadium	No biological function in humans has been identified.	Mushrooms, shellfish, black pepper, parsley, and dill seed		Renal lesions as observed in animal studies.	
Zinc	Component of multiple enzymes and proteins; involved in the regulation of gene expression.	Fortified cereals, red meats, certain seafood		Reduced copper status	Zinc absorption is lower for those consuming vegetarian diets than for those eating nonvegetarian diets. Therefore, it has been suggested that the zinc requirement for those consuming a vegetarian diet is approximately 2- fold greater than for those consuming a nonvegetarian diet.
Vitamins					
Vitamin A	Required for normal	Liver, dairy	blindness,	Teratological effects, liver	Individuals with high alcohol

Compound	Function	Food sources	Deficiency	Excess	Special consideration
	vision, gene expression, reproduction, embryonic development and immune function	products, fish, darkly colored fruits and leafy vegetables	xerophthalmia. In industrialized countries, vitamin A deficiency is rare. Important quantity in the liver.	toxicity Note: From preformed Vitamin A only.	intake, preexisting liver disease, hyperlipidemia or severe protein malnutrition may be distinctly susceptible to the adverse effects of excess preformed vitamin A intake. !-carotene supplements are advised only to serve as a provitamin A source for individuals at risk of vitamin A deficiency.
Vitamin D	Maintain serum calcium and phosphorus concentrations.	Fish liver oils, flesh or fatty fish, liver and fat from seals and polar bears, eggs from hens that have been fed vitamin D, fortified milk products and fortified cereals	rickets but also osteoporosis and osteomalacia, incidence in cancer development	Elevated plasma 25 (OH) D concentration causing hypercalcemia	
Vitamin E	A metabolic function has not yet been	vegetable oils, unprocessed	The deficiency in vitamin E are rare in	There is no evidence of adverse effects from the	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
	identified. Vitamin E's major function appears to be as a nonspecific chainbreaking antioxidant.	cereals grain, nuts, fruits, vegetables, meats	adults and are often associated with food (very) rich in PUFA. Deficiencies can cause a clinical picture of hemolytic anemia and/or neurological disorders (Dupuytren disease), including motor combined and ocular cerebellar ataxia. The peripheral damage leads to chronic denervation and myopathy with degeneration lipopigmentaire, infertility. If these neurological grow very slowly in adults, they seem to be irreversible.	consumption of vitamin E naturally occurring in foods. Adverse effects from vitamin E containing supplements may include hemorrhagic toxicity. The UL for vitamin E applies to any form of "-tocopherol obtained from supplements, fortified foods, or a combination of the two.	
Vitamin K	Coenzyme during the synthesis of many	synthesized by the bacterial	In industrialized countries, clinical	No adverse effects associated with vitamin K	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
	proteins involved in blood clotting and bone metabolism	flora of the colon. Green vegetables (collard, spinach, salad greens, broccoli), brussel sprouts, cabbage, plant oils and margarine	deficiency in adults are rare because of high bioavailability of vitamin K, whether from food or synthesized by the bacterial flora of the colon. Deficiency requiring supplement vitamin K can however occur in the context of severe liver disease during prolonged antibiotic therapy combined with a lack of dietary vitamin K, in malabsorption due to food intolerance (celiac disease) or as a complication of bariatric surgery (biliopancreatic diversion) dedicated	consumption from food or supplements have been reported in humans or animals. This does not mean that there is no potential for adverse effects resulting from high intakes. Because data on the adverse effects of vitamin K are limited, caution may be warranted	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
			to the treatment of obesity.		
Biotin	Coenzyme in synthesis of fat, glycogen, and amino acids	liver, fruits, meats	This deficiency results in mucocutaneous a keratoconjunctivitis, candidiasis, as well as neuropsychiatric disorders (depression, paresthesia, muscle pain, drowsiness) and gastrointestinal (nausea, vomiting, hepatic steatosis).	No adverse effects of biotin in humans or animals were found. This does not mean that there is no potential for adverse effects resulting from high intakes. Because data on the adverse effects of biotin are limited, caution may be warranted.	
Choline	Precursor for acetylcholine, phospholipids and betaine	milk, liver, eggs, peanut		Fishy body odor, sweating, salivation, hypotension, hepatotoxicity	Individuals with trimethylaminuria, renal disease, liver disease, depression and Parkinson's disease, may be at risk of adverse effects with choline intakes at the UL. Although AIs have been set for choline, there are few data to

Compound	Function	Food sources	Deficiency	Excess	Special consideration
					assess whether a dietary supply of choline is needed at all stages of the life cycle, and it may be that the choline requirement can be met by endogenous synthesis at some of these stages.
Folate	Coenzyme in the metabolism of nucleic and amino acids; prevents megaloblastic anemia	cereals grains, dark leafy vegetables, enriched and whole-grain breads and bread products, fortified ready-to-eat cereals	lack of red blood cells and platelets in the blood	Masks neurological complication in people with vitamin B12 deficiency. No adverse effects associated with folate from food or supplements have been reported. This does not mean that there is no potential for adverse effects resulting from high intakes. Because data on the adverse effects of folate are limited, caution may be warranted. The UL for folate applies to synthetic forms obtained	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
				from supplements and/or fortified foods.	
Niacin	Coenzyme or cosubstrate in many biological reduction and oxidation reactions—thus required for energy metabolism	meat, fish, poultry, enriched and whole grain breads and bread products, fortified ready-to eat cereals	Pellagra, solar intolerance, gastrointestinal mucositis. This deficiency exists in the countries where the diet contains little animal protein.	There is no evidence of adverse effects from the consumption of naturally occurring niacin in foods. Adverse effects from niacin containing supplements may include flushing and gastrointestinal distress. The UL for niacin applies to synthetic forms obtained from supplements, fortified foods, or a combination of the two.	
Pantothenic Acid	Coenzyme in fatty acid metabolism	chicken, bef, potatoes, oats, cereals, tomato products, liver, kidney, yeast, egg yolk, broccoli, whole	Fatigue, headache, insomnia and paraesthesia of hands and feet.	No adverse effects associated with pantothenic acid from food or supplements have been reported. This does not mean that there is no potential for adverse	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
		grains		effects resulting from high intakes. Because data on the adverse effects of pantothenic acid are limited, caution may be warranted.	
Riboflavin	Coenzyme in numerous redox reactions	organ meats, milk, bread products, fortified cereals	Its deficiency, although rare, can cause mucosal and cutaneous infection (lip, mouth, tongue ...)	No adverse effects associated with riboflavin consumption from food or supplements have been reported. This does not mean that there is no potential for adverse effects resulting from high intakes. Because data on the adverse effects of riboflavin are limited, caution may be warranted.	
Thiamin	Coenzyme in the metabolism of carbohydrates and branched chain amino acids	enriched, fortified or whole-grain, products, bread and bread products,	clinical consequences can be serious: the Beri-Beri, alcoholic encephalopathy	No adverse effects associated with thiamin from food or supplements have been reported. This does not mean that there is no	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
		mixed foods whose main ingredient is grain, and ready-to-eat cereals		potential for adverse effects resulting from high intakes. Because data on the adverse effects of thiamin are limited, caution may be warranted.	
Vitamin K	Coenzyme during the synthesis of many proteins involved in blood clotting and bone metabolism	synthesized by the bacterial flora of the colon. Green vegetables (collard, spinach, salad greens, broccoli), brussel sprouts, cabbage, plant oils and margarine	In industrialized countries, clinical deficiency in adults are rare because of high bioavailability of vitamin K, whether from food or synthesized by the bacterial flora of the colon. Deficiency requiring supplement vitamin K can however occur in the context of severe liver disease during prolonged antibiotic therapy combined with a lack of dietary	No adverse effects associated with vitamin K consumption from food or supplements have been reported in humans or animals. This does not mean that there is no potential for adverse effects resulting from high intakes. Because data on the adverse effects of vitamin K are limited, caution may be warranted	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
			vitamin K, in malabsorption due to food intolerance (celiac disease) or as a complication of bariatric surgery (biliopancreatic diversion) dedicated to the treatment of obesity.		
Vitamin B6	Coenzyme in the metabolism of amino acids, glycogen and sphingoid bases	fortified cereals, organ meats, fortified soy-based meat substitutes	Vitamin B6 deficiency generally result of several factors involved. The clinical implications are then: stunted growth, nervous disorders, arteriosclerosis, decreased immunity	No adverse effects associated with Vitamin B6 from food have been reported. This does not mean that there is no potential for adverse effects resulting from high intakes. Because data on the adverse effects of Vitamin B6 are limited, caution may be warranted. Sensory neuropathy has occurred from high intakes of supplemental	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
				forms.	
Vitamin B12	Coenzyme in nucleic acid metabolism; prevents megaloblastic anaemia	fortified cereals, meat, fish, poultry	pernicious anaemia	No adverse effects have been associated with the consumption of the amounts of vitamin B12 normally found in foods or supplements. This does not mean that there is no potential for adverse effects resulting from high intakes. Because data on the adverse effects of vitamin B12 are limited, caution may be warranted.	
Vitamin C	Cofactor for reactions requiring reduced copper or iron metalloenzyme and as a protective antioxidant	citrus fruits, tomatoes, tomato juice, potatoes, brussel sprouts, cauliflower, broccoli, strawberries, cabbage and	Scurvy, anaemia,	Gastrointestinal disturbances, kidney stones, excess iron absorption	

Compound	Function	Food sources	Deficiency	Excess	Special consideration
		spinach			

6.3 Annex 3: List of MELiSSA foods and ingredients (no-exhaustive)

POTATOES	WHEAT	SOYA BEAN	RICE	ONIONS	TOMATOES	LETTUCES	Spinash	Kale	RED BEET	SPIRULINA
Firm flesh potatoes	Tender wheat	Soya bean	Cargo boat rice	Onions	Tomatoes	Lettuce	Spinash	Kale	Red beet	Raw Spirulina
Waxy flesh potatoes	Hard wheat	Germs of soya bean	White rice		Juice of tomato					Dryed Spirulina
Starch	Flour	Oil of soya bean	Flour		Liquid purée of tomato					
Flakes of potatoes	Semolina	Proteins of soya bean	Oil of rice							
Proteins of potatoes	Bulgur	Flour of soya bean	His of rice							
Starch of potatoes	Germs of wheat	Tofu	Juice of rice							
	Freekeh	Tonyu (juice	Bran of							

		of soya bean)	rice							
	His of wheat	Tempeh								
	Gluten	Shôyu								
	Oil of wheat	Okara								
	Juice of wheat	Natto								
		Kinako								
		Kôya-Dôfu								
		Abura-agé								

6.4 Annex 4 : Example of food frequency to create a MELiSSA Monthly Menu

Meal	Foods	**Frequency per month**	**Quantity (g)**	**Total amount per month (g) per astronaut**
Breakfast	Breads or bakery products	**Each day**	**150**	**4650**
	And/or breakfast Cereals	**Each day or 2*/week**	**100**	**800**
	Fat	**Each day**		
	Sweet products	Each day		
	Protein products	Each day		
	Dairy “soy” products (juice, yoghurt, ...)	**Each day**	**250**	**7750**
	Fruits or fruit juices	Each day		
	Hot drinks	Each day		
	Water	Each day		
Lunch*	Soup or raw vegetables	**23 potages**		
		8 crudités		
	Meat, poultry, fish, eggs, ...	Fish : 8 per month		
		Poultry : 8 per month		
		White meat : 7 per month		
		Red meat : 4 per month		
		Minced or breaded meat : max 4 per month		
	Starch products	**Potatoes : 12 per month**	**400**	**4800**
		Pasta (raw and dry weight) : 6 per month	**100**	**600**
		Rice (raw and dry weight): 4 per month	**100**	**400**
		Wheat (raw and dry weight): 3 per month	**100**	**300**
		Semolina (raw and dry weight): 2 per month	**100**	**200**

		Fried food (ex French fries) : max 4 per month	**150**	**600**
	Vegetables	**Cooked : 24 per month**		
		Raw : 4 per month (pas les jours de crudités en entrée)		
		Compotes : 3 per month		
	Desserts	Fruits or processed fruits : 17 per month		
		Dairy "soy" desserts (soy juice, yoghurt, rice pudding, ...) : 11 per month	250	2750
			60	180
		Pastries : 3 per month		
	Drinks	Water : Each day		
Snacks	Snacks	Fruits or processed fruits : 11 per month		
		Dairy "soy" desserts : 10 per month	250	2500
		Pastries or biscuits : 5 per month	60	300
		Cereals or cereal bars : 5 per month	50	250
		Drinks : water, coffee, tea, fruit juice, ... : Each day		
Dinner [2]	Soup or raw vegetables	**Soup : 15 per month**		
		Raw vegetables : 16 per month		
	Starch products	**Breads : Each day**	**30**	**930**
		Pasta : 9 per month	**80**	**720**
		Rice : 4 per month	**80**	**320**
		Semolina, bulgur : 4 per month	**80**	**320**
		Wheat : 4 per month	**80**	**320**
		Potatoes : 10 per month	**320**	**3200**
	Vegetables	**Raw vegetables : 12 per month (not if include in the startere)**		
		Cold cooked vegetables : 12 per month		
		Hot cooked vegetables : 7 per month		
	Proteins products	Lean meat products : 8 per month		

		Fat meat products : max 4 per month		
		Cheese : 8 per month		
	Fat	**Fat spreads or oil : Each day**		
	Desserts	Fruits or processed fruits : 17 per month		
		Dairy "soy" desserts: 11 per month	250	2750
		Pastries : 3 per month	60	180
	Drinks	Water or fruit juice : Each day		

* : based on ≈ 3000 kcal/day/astronaut (cf TN98.1.1 Nutritional requirements)

In bold : recipes developed entirely or in part with food/ingredients MELiSSA

1 Lunch can be served as a single dish in which we will simply add a source of protein from feed store types International Space Station.

2 Dinner can be served as a composed salad, cold pasta salad, risotto, taboulé, ...

IN SUMMARY

Food items	Total amount per month (grams)per astronaut		For 6 crew members	
Breads or bakery products	4650+930	5580 ± 10%	33,480 kg ± 10%	
Breakfast cereals (or cereal bars)	800+250	1050 ± 10%	6,300 kg ± 10%	
Pastries or biscuits	180+300+180	660 ± 10%	3,960 kg ± 10%	
Potatoes	4800+ 600+3200	8600 ± 10%	51,600 kg ± 10%	
Pasta (raw and dry weight)	600+720	1320 ± 10%	7,920 kg ± 10%	
Rice (raw and dry weight)	400+320	720 ± 10%	4,320 kg ± 10%	
Wheat (raw and dry weight)	300+320	620 ± 10%	3,720 kg ± 10%	
Semolina, bulgur (raw and dry weight)	200+320	520 ± 10%	3,120 kg ± 10%	
Flour (to include in recipes)	1000	1000 ± 10%	6,000 kg ± 10%	
Dairy “Soy” products	7750+2750+ 2500+2750	15750 ± 10%	94,500 kg ± 10%	This represent around 25kg of raw soy

7 Replies by IPL to 2nd ESTEC Review:

Genral comments issue 1 review 0		General comments issue 1 review 0		Replies UGent
	The technical note aims at reviewing the different strategies of menu elaboration. Based on the content of the document it is not completely clear which strategy has been selected and why. This should be clarified.		the strategy for fulfilling the nutritional requirements have been clarified as to fulfill the highest energy needs of the crew as a group and portioning in accordance with individual needs.	
	the technical note aims at identifying the critical points in the menu elaboration. Based on the current content of the document, the reader does not see where shortcomings can arise. The food groups criteria provided in tab4 seem to rely on an average wet composition of the food product. However it is shown elsewhere in the study that the wet composition of durum wheat can vary drastically depending on the time of harvest. This should be clarified and the criteria should probably be expressed in a different manner.		The revised technical note does not mention any difficulty in the menu elaboration. What is planned as a correction strategy in case of meal left-over? What is planned as a counter-measure when nutrient absorption by the body in micro-gravity is modified? Answers can be provided in the present worksheet.	What is planned as a correction strategy in case of meal left-over? Surplus can be processed or stored. If left-overs were on astronauts plates they will directly go into the waste collectors. If the amount of left-overs is low, there is no impact on the health. If left-overs are high, this indicates that quantities are too large compared to the real needs. We will have to reduce and rehabilitate quantities. If the individual is not hungry during a short time, there is a low health impact. If this continues, snacks will be necessary. If it is a matter of taste, we have to readapt the menus. What is planned as a counter-measure when nutrient absorption by the body in micro-gravity is modified? Nutritional requirements as indicate in

				annex of TN 98.1.1. take this aspect into account.
	From the annexe 4, which presents the food frequency to create MELiSSA monthly menu, can average composition required for the raw products be calculated (assuming in a first step that the processing will not alter the macro-nutrient quantities)?		Few of the detailled comments have not been really answered in the revised Technical note. For the sake of completeness, please answer those questions in the present worksheet.	
	the summary table is very much appreciated and is understood to provide ground for assessing an overall production surface of raw products.		Providing the remaining questions are answered in the present worksheet, the TN is approved	
Detailed comments Issue 1 Review 0				
Section	Comment	**Section**	**Comment**	**Reply UGent**
3.2	It is not clear what the parts indicated for each food group are based on. For instance, for the family of "meat, poultry, fish, eggs, vegetarian alternatives and legumes" one part equals 10 g of protein. Are we talking of pure proteins?	4.2.5	if the interest of the dairy product in the food pyramide is the provision of proteins and calcium, why not considering egg white with added calcium instead of a glass of milk?	It is for a dietician a strange point of view to consume enriched egg to provide calcium needs. Indeed if we can feed all the nutrients in a food product, it might be easier to feed the astronauts. But there is no food product complete, in fact, each family food has nutritional and anti-nutritional value. More and more additions or enhancements in micronutrients are increasingly regarded as toxic (low or high). Because often the dosages are too high or inappropriate for particular situations. The development of an enrichment requires serious

				studies on the benefits and risks. A well known example is the problem of folate in preventing severe disease, such as “spina bifida” in the foetus. Now we know that Folate supplementation is strongly recommended early in pregnancy and even more in the weeks before fertilization. Unfortunately, due to our European and American eating habits, folate intake is quite low because we choose a diet based on refined grains and hence low in folate. So one solution would be to supplement certain foods in folate. But there is not a specific food consumed by expectant mothers. So we have to look at the food sources of folate and products consumed by the entire population. Thus we arrive on flour and bread. So Canada has now an enrichment policy. But here is where the debate begins, as other health institutes believe that complementing the bread for the entire population could create risks for other categories of people (cancer, Alzheimer's in elderly) and therefore refuse such a policy. (Publication of the Higher Health Council No. 8309. Nutritional recommendations for Belgium. Revised 2009) So back to the enrichment of calcium in egg white. Indeed, the egg white is a protein of high biological value to easily cover the protein needs of astronauts, provided they are not allergic to egg protein. On the other hand, the egg white is not part of Melissa food.

				The shelf life of liquid egg white is of short duration. There is egg white powder, but I have to learn about the technological quality and stability of this product. Is that added calcium would cover the needs? As a theoretical point of view, I would say yes, but it means that every day the astronauts need to eat egg whites to cover their needs. Moreover, it is important to choose the calcium salt and verify the bioavailability, absorption, fixation on bone and calcium excretion before considering such a product. Don't forget also that water is a product that can be a valuable source of calcium. Now what do we know about the calcium content in water after a MELiSSA loop? And what is the interest to add a specific calcium salt?
3.2.1	this recommendation considers drinking 1-2L of unsweetened fluid per day. It is assumed to come in addition to the unsweetened fluid contained in the food products of the other groups. Is there a recommended upper value for total unsweetened fluid?	4.2 tab 1	the dietary fiber from the starchy food is no longer mentioned while it was in section 3.2.2. Any reason for this?	Dietary fiber consists of non-digestible carbohydrates and lignin that are intrinsic and intact in plants. Functional Fiber consists of isolated, non-digestible carbohydrates that have beneficial physiological effects in humans. Total Fiber is the sum of Dietary Fiber and Functional Fiber. Fibers have different properties that result in different physiological effects (gastric emptying, repletion, delay of postprandial blood glucose, reduce absorption of dietary fat and cholesterol, ameliorate gut transit, ...). Food sources of dietary fibers and functional fibers

				are whole grain, starchy products, fruits and vegetables. If we consume starchy products as whole grain, we can expect to provide 3 g of dietary fibers for 1 part. As wecan seein table 2: an astronaut have to eat 17 parts of starchy products. This represents 51 g, with fruits (5 parts of 3g) 15g and vegetables (7 parts of 3 g) 21g. TOTAL : 87 g. This is more than required. If we are not regulars to a consumption so important, some digestive problems may occur. But in reality, in our food habits we consume many strachy products as refined carbohydrates.
3.2.2 and 3.2.4	the parts for both starchy food and fruits are equivalent. Why are they differentiated in the food pyramide?	4.2 tab 1	dairy products now "includes" soy products meanwhile not mentioned in section 3.2.5. Can soy products be taken as an alternative to dairy products?	Yes if soy products are enriched in calcium. We expect that the enrichment will provide 100 mg of calcium per 100 ml.
3.2.5	if the interest of the dairy product in the food pyramide is the provision of proteins and calcium, why not considering egg white with added calcium instead of a glass of milk?	4.3.3.1	"it is allowed to distribute the intake as follows". Is there a strict requirement to follow this distribution or is it a baseline?. Instead would not it be more appropriate to adapt it to demanding physical activities schedule (e.g EVA)?	This is a baseline and not strictly a recommendation. This distribution corresponds to European food habits and permits to provide sufficient energy at each meal. If EVA is scheduled, we have to increase energy by ~500 kcal/day. There are many possibilities to adapt the raise of energy. First proposition, the astronauts will take food in the suit during the EVA like (jelly made from fruit paste, biscuits, cereals bars, ... and water with sugar or sport drink), in this case we have to change de

				proportion of calories and place all calories during EVA. We can also raise energy before and after the EVA, in this case if EVA occurs in the first phase of the workday, we will raise energy for the breakfast and for the lunch. We will use for this snack rich in energy or increase portions. It is the same scheme If EVA occurs in the second phase of the workday, more energy during the lunch and more in the dinner. If EVA will take a long time, more than 4 hours, energy will be higher for the breakfast, during the EVA with many snacks, and after.
3.2 tab 1	the dietary fiber from the starchy food is no longer mentioned while it was in section 3.2.2. Any reason for this?	4.3.3.3	the lipid distribution over the day is completely reflecting the energy intake. Is it a coincidence? Besides, the fact that 40% of the lipid is provided at dinner is not completely understood. Is it due to cooking aspects or due to a specific lipid need related to night metabolism?	It is true. But it is also a coincidence. There is no specific requirements on macronutrients during the day. There are some guidelines that indicate the importance on protein in the morning because protein can enhance the alertness and carbohydrates can on the other side have an impact on drowsiness, especially to fight jet-lag. But we know also that a breakfast low in carbohydrates due to the loss of hepatic glycogen (stores of carbohydrates) in the morning will induce hypoglycemia. The risk of snacking is more important during the day. Some new publications indicates that the composition on the last meal in the evening will have an impact on fat or glucose oxidation in the day after. So a dinner low in complex carbohydrates and low in dietary fibers may oxidize more glucose and create more hypoglycemia during the day. A dinner high in

				complex carbohydrates and dietary fibers may oxidize more fat, interesting to lose a small amount of fat. A reason to provide fat at each meal is to permit to provide fat because, fat is important for the taste, the palatability, and because a large amount of products contain fat. More fat are prescribe at the dinner for the cooking methods and we add also fat for salad of raw vegetables for the taste and to provide good fat sources, rich in polyunsaturated fat acids like omega-3
3.2 tab 1	dairy products now "includes" soy products meanwhile not mentioned in section 3.2.5. Can soy products be taken as an alternative to dairy products?			
3.2 tab 2	is the distribution of parts by meals and menu the result of cultural habits or is it the targetted distribution for a space mission? If it is a target for the space mission, what motivates this distribution?			
3.3.3.1	"it is allowed to distribute the intake as follows". Is there a strict requirement to follow this distribution or is it a baseline?. Instead would not it be more appropriate to adapt it to demanding physical activities schedule (e.g EVA)?			
3.3.3.1	two strategies are proposed to provide a fulfillment of energy intake: 1) satisfaction of the highest need with no possibility to limit people having lower need or 2)			

	satisfaction of the lowest need with substantiation of the highest need with complement. Those 2 strategies are group oriented and do not consider the individualities, which is raising a risk of underfeeding or overfeeding few individuals. What would be the advantage and drawback of a individual-oriented strategy?			
3.3.3.2	the dinner is reported to cover up to 50% of daily protein need. Is there any link with night metabolism? What motivates this distribution over the day?			
3.3.3.3	the lipid distribution over the day is completely reflecting the energy intake. Is it a coincidence? Besides, the fact that 40% of the lipid is provided at dinner is not completely understood. Is it due to cooking aspects or due to a specific lipid need related to night metabolism?			
3.3.3.7	the recommendation is not to exceed 10% of daily energy intake. The other percentages given are percentages of what?			
3.3.3.9	"rather than to impose a minimal value, it is better to fix a minimal content in fruit, vegetables and grains", it is not completely clear what is meant by this.			
3.3.4	"the MELiSSA menu must at least contain			

	200g of fruit and vegetable". Is it the dry weight (approaching the real value of sugar content) or the fresh weight which is understood here?			
3.3.4 tab 4	is the 100g base of product expressed in wet weight (what about rice and pasta)? If so what happens when the water content varies (i.e. a raw wheat containing 20g of water/100g of grain or 80g of water/100g of grain). In addition, is this table representing the main composition that has to be targetted in terms of food product (e.g. the raw potatoes produced in the MELiSSA loop have to provide less than 400kcal per 100 g of fresh weight)?			