Etudes et stratégies en Agro-Alimentaire

MELiSSA

Memorandum of Understanding
ECT/FG/MMM/97.012

TECHNICAL NOTE 63.4

SPIRULINA FOOD PREPARATION STUDY :
FIRST ANALYSIS OF RECIPES

Version 1
Issue 0

July 2002

M. Timsit – M. Laniau

Document change log

Version	Issue	Date	Observations
0	0	April 2002	Draft version
1	0	July 2002	Final release

Content

I I Introduction

This workpackage is the first part of the report concerning the « spirulina food preparation study ».
The second workpackage focuses on the « identification of new technical possibilities and possible process improvements.

The aim of this study was to make a first analysis of how to use spirulina to produce meals adapted to technical and non-technical space constraints.

Spirulina whose production has been thoroughly studied in the Melissa Project will contribute to provide dioxygene to other plants. Spirulina will also provide proteins to astronauts.
In the sixties and the seventies, lots of works have been done to promote the production and uses of Spirulina, considering that it could be a highly promising product, with high yields and low production costs, rather easy to grow and very well suited to the needs of developing countries.

However, in spite of some industrial level productions in Mexico for example, Spirulina did not meet the expected development as a food base.

Today, Spirulina is used as a food complement, for its high content in vitamins and minerals, mainly in developed countries.

The planetary exploration programs have specific needs for food products that are easy to prepare and well suited to planetary exploration criteria. But for astronauts, it is necessary to eat food as close as possible to food consumed on earth. Thus the food must be sufficiently varied and of good organoleptic quality.

So, it appears necessary to work on the different possible uses of Spirulina.

The objective of the present work has been:
- to realise a first exploration of the different ways to prepare it, starting from the identification of different recipes
- Then to make a typology of the different meals which can include spirulina.
- In the second workpackage, we will make a first analysis of the different menus which would include spirulina and think of the criteria of evaluation of recipes, which could be applied to other recipes and to the various foodstuffs produced and manufactured in space basies.

II PRESENTATION: THE SPIRULINA COMPOSITION AND NUTRITIONAL QUALITY

II.1 Composition

II.1.1 The average composition of spirulina is detailed in the following table :

Rough Protein composition (% N x 6,25)	55 % - 70 %
Moisture	4 % - 7 %
Ashes	6,4 % - 9 %
Carbohydrates	13 % - 16 %
Lipids	6 % - 7 %

The pure and dehydrated spirulina is particularly rich in vegetal proteins (8 essential amino acids and 9 non-essential amino acids).
36 grams of spirulina cover 100 % of the requirements in essential amino acids for an adult (Earth Food Spirulina, R. Henrikson).

II.1.2 Nutritional quality

It should be stressed that the protein content of spirulina varies according to its sources, depending upon the origin and perhaps upon the producing process.

The nucleic acid content (ADN and ARN) is a very significant nutritional point because the biochemical degradation of some of their components produces lastly some uric acid (leading to renal calculus).
Based on an average value of 5 % content in nucleic acids (% of dry matter), the daily limit of 4 G of nucleic acid represent a maximum daily absorption of 80 G of dry spirulina (Antenna Technology, J Falquet, Geneva, Switzerland).

The study concerning human consumption (mentioned in the reference (3)) is that of Delpeuch, Joseph and Rider, a work carried out with the assistance of the DGRST (Délégation Générale à la Recherche Scientifique et Technique, 1983), in Chad, concerning different tribes of which the Kanembous, who traditionally consume spirulina.
The spirulina of Chad is one of the rare examples of human consumption of continental alga (except consumption in dietetics).
A close species (Oscillatories maxima) was used as food by the people living in Tenochtitlan (current Mexico City). Moreover it is this species which has been produced under " semi-natural conditions " by Sosa the Texcoco".

In Chad, the traditional dish containing spirulina is called " dié " or " dihé ".
Dried dihé (moisture 4 to 12 %) has a protein content of about 12 to 33 G for 100 G because of the presence of impurities (mainly sand).

The base of the food consists of millet, especially consumed in the shape of balls of dough. The traditional meal consists of a ball of millet or corn cooked with water, with a sauce the composition of which may vary : sauces with meat, fish, beans, milk, or spirulina.

It is thus primarily in sauces that the spirulina is consumed. These sauces can contain some chips of dry onion and or sorrel, tomato powder, pepper, some powder of okras to thiken the sauce and some millet flour.
Meat, fish or beans can be added to sauces (78 % of the families of the sample generally eat dihé without accompaniment), ten grams of dihé are used as sauce ingredient (for Kanembou) by person

The authors indicate they have found (investigation concerning 414 families) a consumption of spirulina of 9 to 13 g by person and by day (mini and maxi of 4 and 24 g), corresponding to about 5 to 8 % of the daily needs in protein.

Ripley D. Fox (8), who quotes P. Busson (Spirulina platensis and Spirulina geitleri, Cyanophycées alimentaires, Service de santé, Parc du Pharo, Marseille, 1971) disputed these results: the latter indicates that at Goranes near Kanem, a family consumes 250 g of dihé per day, (50 g approximately per person).

Also, Ripley D. Fox reports acceptability tests by a group at the Bichat hospital:

10 persons have expressed a poor acceptability after having tested
- some dishes with some meat and with 20 to 50 % of spirulina,
- soups containing 1,7 to 3,3 % of spirulina,
- omelette and dessert containing 5 to 10 %.

The acceptability (odour, colour and taste) has been weakening when spirulina content is high.

II.2 Current consumption

The authors of the main studies concerning spirulina declare they have been consuming some 20 grams per day of it for many years.
High level sportsmen would consume 20 g/day (reduction of the lactic acid accumulation). The Cuban and Chinese Olympic teams regularly use spirulina during their preparation (Ripley, D. Fox).

II.3 Astronauts consumption

Proteins: for an active adult, on earth, the Recommended Dietary Allowance for proteins is at: 60-70 G per day.

The study carried out by M. Heer (2) concerning the intake of selected nutrients by the astronauts during a 10 days mission (D2 mission) and a 29 days mission (Euromir) showed that the consumed average was quite lower than the recommended quantities.

« If astronauts are allowed to freely choose their food,…this may lead to a diet deficient in protein compared to the RDA ».
M. Heer underlines however that "*The specific amino acids required in microgravity are not known, and neither is it clear whether ingesting extra quantities of certain amino acids can counteract the effects of microgravity".*
In the Melissa project, the basic assumption could be that the spirulina should represent 20 % of recommended total proteins, that is to say 12 to 14 G of pure protein, corresponding to 20-23 G of commercial spirulina (5 –7 % of moisture).

This quantity may be considered, at this stage, as a maximum because of the poor acceptability of the product and of possible appetite cutting properties mentioned in the literature (treatment of obesity).

III SCREENING OF RECIPES

III.1 Recipes identification and listing

Gem has made a large international literature review of the uses of spirulina and of the cooking recipes.

2 main authors can be mentioned:

- Belda Sisso, painter and professor of yoga, spirulina supporter, who wished to transmit the art to prepare it. She organised training courses of tasting
- Sonia Beasley also developed many recipes, making it possible to consume the spirulina in an alternative way than in tablets.
- Other recipe come frome vegetarian cooking or from spirulina produces.

We have selected the recipes allowing to include a significant quantity of spirulina
- The different recipes we selected are listed in annex (1)

III.2 Typology of recipes

The recipes were gathered by main type: one type may to correspond to several recipes, which use the same type of ingredients, or the same mode of preparation.
At this stage of the study, we did not take into account the ingredients available in the base. However, the number of recipes mainly based on eggs or of dairy products has been limited.

The following tables show the different types of possible recipes.

We classify the recipes in two main categories:
- recipes with cooking
- recipes without cooking

The occasion of consumption and the quantity of spirulina included per consumption unit are specified.

The examination of these recipes makes it possible to mention some preliminary conclusions:

- the majority of the suggested recipes are vegetarians recipes

- Even when the spirulina is a significant ingredient of the dish, consumption by people and by meal is less than 10 grams

- the cereals and soya have a significant place in these recipes

USUAL TYPES OF RECIPES INCLUDING SPIRULINA

WITHOUT COOKING (1)

TYPE of MEAL	**Juice**	**Cereal for breakfast**	**Delicacy for breakfast**	**Oats flakes tibite**
Type of Recipe **Ingredients**	**Grapefruit, lemon orange, peach, apple, pineapple, tomato juice + soja milk**	**Cottage cheese or yoghurt, dry fruits Oaks flakes or others cereals, dried fruit or other fruit (banana, pear)**	**Honey, broken nuts (4 nuts)**	**Corn meal + oats flakes + Sugar + coconut + apple juice + sesame or sunflower oil**
Consuming occasion	**Breakfast**	**Breakfast**	**Breakfast**	**Breakfast**
Spirulina content per consumption unit	**5-10 g per glass**	**5 g per yoghurt**	**5-10 g (on bread)**	**50 g for 500 g ingredients (30 pieces)** **5g for pieces**

USUAL TYPES OF RECIPES INCLUDING SPIRULINA

WITHOUT COOKING (2)

TYPE of MEAL	**Delicacy**	**Dough to be spread**	**Dough tahini and miso**	**Salad**
Type of recipe **Ingredients**	**Date + Nut or almond, honey or sirup, roasted soya**	**Cottage cheese, yoghurt or soya yoghurt + spirulina + oil of soya, shallots capers or nitwits or garlic or miso or sauce tamari** **Variant + avocado**	**Tahini + miso + spirulina = dip for fresh végétable**	**Lettuce with cottage cheese or tofu, vinegar, aromatic plants, some honey**
Consuming occasion		**lunch**	**lunch**	**lunch**
Spirulina content per consumption unit	**10-20 g for 100 g**		**1 g or 2 g**	**20 g of spiruline (5g per person)**

USUAL TYPES OF RECIPES INCLUDING SPIRULINA

WITH COOKING (1)

TYPE of MEAL	**Soups**	**Wipe pastas**	**cooked cereal**	**Noodles spirulina**	**Zucchini puree**
Type of recipe **Ingerdients**	**vegetables : onions tomatoes, spinach, watercress, potatoes**	**Onions, tomatoes, olive oil**	**Mil, polenta wheat, quinoa + onions spices**	**Wheat flour (85%) spirulina (15%), hot pepper, oliv oil**	**Zucchinis, spinach, potatoes, onions, Garlic, olive oil**
Consuming occasion	**dinner**	**Lunch or dinner**	**Lunch or dinner**	**Lunch or dinner**	**Lunch or dinner**
Spirulina content per consumption unit	**20 g for a liter of soup, 5 g/ person**	**20 g of spiruline for 4 persons, 5 g/ person**	**10 g de spiruline per bowl**	**9 g**	**5 g per person**

USUAL TYPES OF RECIPES INCLUDING SPIRULINA

WITH COOKING (2)

TYPE of MEAL	**Bread**	**Rice spirulina**	**Petits fours**	**Marbled cake**
Type of Recipe **Ingredients**	**250g of corn meal, 50g of spirulina salt, water + (grains of sunflower)**	**1 bowl of whole rice, spices, (clove, canelle), seasoning**	**Flour, butter, dried fruits, sugar, water, lemon**	**Flour, sugar eggs, oil, almonds**
Consuming occasion		**Lunch or dinner**	**dessert**	**dessert**
Spirulina content per consumption unit	**2 g per piece**	**10 g of spirulina by bowl**	**1g / 10g dry content per piece**	**6-7g/100g**

USUAL TYPES OF RECIPES INCLUDING SPIRULINA

WITH COOKING (3)

TYPE of MEAL	**Spicy kebabs balls**	**Stuffed tomatoes, mushrooms**	**Quiche**	**Salmon, crab mousse or soufflé**
Type of recipe **Ingredients**	**500g ground beef or lamb, ground turkey, onions coriander garlic pepper, ginger butter, eggs Crumbed bread or flour**	**Tomatoes, Mushrooms, Potatoes… Stuffing : Anchovy Meat Vegetables**	**Eggs Heavy cream Cheese Chicken Or Spinach**	**Salmon, crab Bechamel or gelatin Heavy cream Eggs Variant : with spinach**
Consuming occasion	**Lunch or dinner**	**Lunch or dinner**	**Lunch or dinner**	**Lunch or dinner**
Spirulina content per consumption unit	**Few g per piece**	**Few g per piece**	**Few g per piece**	**Few g per piece**

Conclusion

In this work, it was realised a first exploration of the different ways to prepare Spirulina biomass as food source for the crew, starting from the identification of different recipes

A first typology of the different meals which can include spirulina was presented. There is two kind of recipes : recipes with cooking and recipes without cooking. For the

The occasion of consumption and the quantity of spirulina included per consumption unit are specified.
For the different meals and recipes examinate, it was possible to mention some preliminary conclusions:

- the majority of the suggested recipes are vegetarians recipes
- Even when the spirulina is a significant ingredient of the dish, consumption by people and by meal is less than 10 grams. It must be kept in mind that the maximum acceptable is about 20g spirulina/day
- the cereals and soya have a significant place in these recipes. It can be noticed that at the present time the 8 plants selected in MELiSSA which could be used as recipes are : wheat, potatoes, soybean, lettuce, rice , onion, spinach and tomatoes. This set of plants is representative of the plants studied as basis for the developpement of CELSS by several internationnal agencies (TN 32.2).

References

1 **Food processing on a space station**: feasibility and opportunities. Dmitriy V. Z SYPKIN and TUNG-CHING LEE. Life support and Biosphere Science ; Vol. 6 pp. 39-52, 1999

2 **Nutrient supply during recent European missions** : M. Heer. A. Boeger. N. Kamps. C. Mika. C. Korr ; Pflügers Arch- Eur J Physiol ; (2000) 441

3 **Consommation alimentaire et apport nutritionnel des algues bleues** (Oscillatoria platensis) chez quelques population du KANEM (TCHAD), F. Delpeuch, A. Joseph, C. Cavelier : Ann. Nutr. Alim ; 1976, 29, 497-916

4 **Spirulina, Aspects nutritionnels** : J.Falquet ;1996 Antenna technologie (29, rue de Neuchâtel CH-1201 Genève, Suisse)

5 **The spirulina Cook Book** : Sonia Beasley, University of the Trees Press, P.O. Box 644, Boulder Creek, California 95 006 ,USA

6 **Saveurs et vertus de la spirulina** : recettes et réflexions : Belda Sisso. Mama éditions-Paris (mamaeditions.com)

7 **Spirulina : The whole food revolution :** Larry SWITZER; 1980, Bantam book INC

8 **Spirulina, Technique pratique et promesse** : Ripley D. FOX, EDISUD

9 **Manuel de culture artisanale de la spiruline :** Jean-Paul Jourdan, Le Castanet Mialet, 30140 ANDUZ jpj@bsi.fr

10 **Repertoire général des aliments** : INRA, Lavoisier édition

11 **Recueil de données sur la composition des aliments** : Travail du Laboratoire de Physiologie de l'UFR de Médecine et du C.H.R.U. de Dijon

ANNEXES

Recipes including spirulina

We have gathered here a selection of recipes mainly coming from vegetarian gastronomy books, using spirulina.
The recipes are ranged in 10 different categories, taking into account the type of dish and consuming occasion: the aim of this listing is to give an idea of the possible variety of recipes we found in this literature review, even if in each category, several may be recipes rather similar.
For each selected recipe, we mention the bibliographical references.
At last, we present some examples of detailed recipes.

Bibliographical references

BOOK 1: Forme et santé par la spiruline by Didier LOPERRE; édition: LPM/ EURONAT Z.A La Boissonette, 07 340 PEAUGRES, FRANCE ; 1998 ; 39 pages.

BOOK 2: Saveurs et vertus de la spiruline. Recettes et réflexions by Belda SISSO; edition: mamaedition.com 117 bd Voltaire, 75 011 Paris, FRANCE; 2001 ; 80 pages.

BOOK 3: Spirulina The whole food revolution by Larry SWITZER; third édition. Bantam book INC, USA; 1980 ; 101 pages.

BOOK 4: The spirulina cookbook by Sonia BEASLEY ; edition : UTP PO Box 644 Boulder Creek,USA, CA 95 006 ; 1981 ; 184 pages.

BOOK 5 : Spiruline Technique pratique et promesse by Ripley D.Fox edition : EDISUD La calade 3120 Route d'Avignon 13090 Aix-en-provence, FRANCE ; 1999 ; 246 pages.

BREAKFAST

Agathe breakfast. (Yoghurt) (BOOK 2)
Cereal-cheese breakfast (BOOK 2)
Honey breakfast (BOOK 2)
Scrambled eggs with tofu (BOOK 4)
Semolina with spirulina (BOOK 4)
Spirulina muesli (BOOK 4)
Spirulina toast (BOOK 4)
Spirulina nut rissoles (BOOK 4)

FRUITS AND VEGETABLES JUICE

Tomato-celery juice (BOOK 2)
Yoghurt-cucumber juice (BOOK 2)
Vegetables cocktail (BOOK 2)
Peach velvety (BOOK 2)

Water melon velvety (BOOK 2)
Melon velvety (BOOK 2)
Strawberry milk-shake (BOOK 2)
Tofu-banana delight (BOOK 2)
Grapefruit velvety (BOOK 2)
Coconut delight (BOOK 2)
Pear delight (BOOK 2)
Grape delight (BOOK 2)
Tonic cocktails (BOOK 1)

STARTER AND APPETIZERS

Dressed Avocado (BOOK 1)
Sea salad (BOOK 1)
Quinoa taboule (BOOK 1)
"Guacamole" dips (BOOK 4)
Spinach dipping sauce (BOOK 4)
Cheese balls (BOOK 4)
Smocked fish or nori and spirulina appetisers (BOOK 4)
Spirulina bites (BOOK 4)
Spirulina butter with white cheese (BOOK 2)
Spirulina caviar (BOOK 2)
'Lactic' caviar (BOOK 2)
Tofu-miso butter (BOOK 2)
Avocado cream (BOOK 2)
Tahini and miso dough (BOOK 2)
Aquamole (BOOK 5)
Aquamole (Avocado and white cheese) (BOOK 5)

BREAD

Little rolls with sunflower seeds (BOOK 2)

SOUPS

Green soup (BOOK 4)
Chilled spirulina soup (BOOK 4)
Cream of asparagus soup (BOOK 4)
Cold broccoli soup (BOOK 4)
Spirulina basil soup (BOOK 4)
Tomato rasam (BOOK 4)
Black bean soup with shrimp (BOOK 4)
Spirulina "chikerina" (noodles and chicken) (BOOK 4)
Delicious spring soup (chicken spinach and watercress) (BOOK 4)
Cress velvety (BOOK 2)
Spinach velvety (BOOK 2)
Cabbage velvety (BOOK 2)

"Multivitaminée" Soup (BOOK 2)
Split peas soup (BOOK 2)

SIDE DISHES

Stuffed mushrooms (BOOK 4)
Salt fish fritters (BOOK 4)
Pineapple curry (BOOK 4)
Walnut spirulina rice (BOOK 4)
Avocado mousse (BOOK 4)
Celery, walnut, spirulina fritters (BOOK 4)
Spirulina zucchini fritters (BOOK 4)
Fish rolls (BOOK 4)
Spinach balls (BOOK 4)
Cashew curry BOOK 4)

MAIN DISHES VEGETARIAN

Spinach loaf with mushroom sauce (BOOK 4)
Spirulina filled "crêpes" (BOOK 4)
Eggs florentine with spirulina (BOOK 4)
Green pepper/tomato sauté (BOOK 4)
Pilaf (BOOK 4)
Vegetable stuffed tomatoes (BOOK 4)
Potato and nut loaf (BOOK 4)
Creamed spinach mimosa (BOOK 4)
Spinach, cheese and spirulina "quiche" (BOOK 4)
Stuffed green peppers (BOOK 4)
Zucchini puree

MAIN DISHES MEAT, FISH AND POULTRY

Savoury spirulina pudding (BOOK 4)
Savoury spirulina meat loaf (BOOK 4)
Spicy kebabs (BOOK 4)
Omelette primavera (BOOK 4)
Turkey balls (BOOK 4)
Eggs in spirulina sauce (BOOK 4)
Haddock and rice (BOOK 4)
Sweet and sour fish (BOOK 4)
Anchovy stuffed tomatoes (BOOK 4)
Salmon mousse (BOOK 4)
Salmon spinach soufflé (BOOK 4)
Spinach roll with crab stuffing (BOOK 4)
Chicken spinach "quiche" (BOOK 4)
Chicken cutlets with paprika (BOOK 4)
Sauce for spaghetti (BOOK 5)

Spirulina noodles (BOOK 5)
Pasta with zucchinis (BOOK 2)
Pasta with fresh vegetable (BOOK 2)
Summer pasta (BOOK 2)
Transparent jelly with small vegetables (BOOK 2)
Dihé (BOOK 5)
Gazpacho (BOOK 5)
Trout fillet with spirulina sauce (BOOK 1)
Spirulina risotto (BOOK 1)

SALADS

Bean sprout salad (BOOK 4)
Lettuce salad with spirulina honey cream dressing (BOOK 4)
Buckwheat salad (BOOK 4)
Chicken salad (BOOK 4)
Cucumber spirulina salad (BOOK 4)
Walnut and avocado salad (BOOK 4)
Lettuce (BOOK 5)

DESSERTS AND SWEETENED SPREAD PASTES

Banana-orange Coulis (BOOK 2)
Pineapple coulis (BOOK 2)
Mango desert (BOOK 2)
Tofu desert (BOOK 2)
Feast desert (BOOK 2)
Tahini pasta (BOOK 2)
Tahini with date juice (BOOK 2)
Summer transparency (fruit juice -agar agar) (BOOK 2)
Banana cream (BOOK 4)
Coconut pudding (BOOK 4)
Coconut ice cream (BOOK 4)
Spirulina cookies (BOOK 4)
Spirulina fruit and nut cakes (BOOK 4)
Green ‘petits fours (BOOK 2)
Oats flakes "bits" (BOOK 2)
Marbled cakes with spiruline (BOOK 2)
Delicacy (BOOK 2)
Almonds delights
Filled dates (BOOK 2)
Biscuit (BOOK 5)
Red fruit coulis (BOOK 2)