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Mix-dry the *Spirulina*

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Özet : *Spirulina'nın Karıştırma ile Kurutulması.* *Spirulina*'nın kurutulmasında kullanılan mevcut metodlarından biri de filtrasyondur. Bunu sprey kurutma yöntemi takip eder .Bu işlemlerin sonunda oldukça geniş yüzey alanına sahip, kokusu ve tadı iyi olan, ıslanması zor olan, diğer gıdalarla harman yapılabilen toz elde edilir. Ayrıca bu metoda çok miktarda enerji harcanır, pahalıdır.

Güneşten faydalanılarak yapılan kurutma işlemi çok fazla vakit alır. Oksidasyon sırasında ürüne zarar verebilir. Hava durumuna göre ayarlanır.

Spirulina'nın içeriği; yüksek miktarda protein, önemli miktarda vitamin, mineral ve esansiyel doymamış yağ asitleridir. Ama oldukça düşük kalorilidir. Geleneksel olarak tahıllar ile karıştılarak yenir. Bu şekilde protein-enerji yönünden yetersiz beslenme problemi çözümlenmiş olur .Hatta genel olarak beslenmede de kullanılabilir.

Eğer filtrasyon sonunda elde edilen yapı, ön pişirilmesi yapılmış ve kurutulmuş tahıl ununu ilave edilirse, karıştırma kurutma yöntemi ile Spirulina'nın tüm nemi birkaç saniye içinde pedallar karıştırarak %5'e indirilebilir.

Tahıl unu ilk olarak buhar ile kurutulduktan sonra pedallı karıştırıcılara konur. Sindirilebilir hale gelir. Daha sonrada ısının altında karıştırmaya devam edilerek, kurutulur. Kullanılan ısı ile, filtre keki de olabilen bir kontaminasyondan kurtulmuş olur.

Karıştırmadan faydalanılarak yapılan kurutma yöntemi düşük masraflıdır. Filtre edilen Spirulina'nın yetersiz beslenen kişiler için uygun bir forma dönüştürülmesi işlemi, gelişmiş bir teknolojiye ihtiyaç duymaz.

Abstract : Present methods used for drying Spirulina (Arthrospira) include filtration, usually followed by spray drying. This creates an extremely fine powder which, due to its great surface area, exaggerates the odor and taste of the product and makes it difficult to wet and blend with other foods. In addition, this method is energy-intensive and expensive.
Sun-drying methods take a long time, can degrade the product through oxidation, and are at the mercy of the weather.

The composition of Spirulina shows clearly that it is a high protein content food, with important amounts of vitamins, minerals, and essential non-saturated fatty acids, but low in calorie sources.

Traditionally it has been eaten in combination with cereals, thus making it an appropriate food for treating protein-energy malnutrition – as well as for general nutrition.
If the "algae" filter cake obtained by filtration is added to pre-cooked and dried cereal flour, one can mix-dry the Spirulina down to an overall moisture content of approximately 5% in a matter of seconds in a paddle mixer.

The cereal flour first is vapor-cooked inside the paddle mixer to render it digestible; and then dried by continuing mixing under heat. Residual heat in the dried flour will react for a few seconds on any contamination which might be present in the filter cake.

Mix-drying appears to be the solution for low cost, low tech conversion of filtered Spirulina into an acceptable, controlled formula food for malnutrition victims.

Introduction

The Cyanobacterium or Cyanoprokaryote, *Arthrospira platensis*, which has been eaten by man for hundreds, and probably thousands of years in the Kanem region of Chad and the lake region of Mexico now is sold worldwide as a health food and also used in the treatment of protein-energy malnutrition. The Kanembou people call it Dihé and the Aztecs called it Techuitlatl. Due to about 100 years of confusion among algologists it has assumed the popular name of its much smaller but related genus, *Spirulina*. For us this is most fortunate as we are seeking acceptance of this organism as an everyday food. Few would consider voluntarily eating a bacterium called *Arthrospira*, and much less a cyano anything, for back in our vocabulary lurks cyanide. For acceptance and commercialization, for common sense reasons, and for the music in the name "*Spirulina*", that is what we shall call it. After all, we call zea maize, "corn".

This *Spirulina* is a multicellular, spiraled blue-green filament growing in highly alkaline water, and barely visible to the naked eye. For use as food it must be harvested, concentrated and dried. If not dried, because of its high food value and easily digested outer cell walls, it will become fermented and most disagreeable within a few hours. Harvesting is done by filtration; different options being chosen for different volumes of culture water to be processed. Dewatering of small quantities of *Spirulina* filter cake usually is done, after rinsing the cake with clean water, by compressing the filter cake to remove water from and between the surfaces of the "algal" filaments. The remaining filter cake (still containing around 80% water) then is spread in a thin layer upon plastic sheeting; or, better, extruded through 1 to 2-millimeter diameter holes as "spaghettis" (Jourdan, 1999; Min Thein, 1993) onto plastic drying screens and set out to dry, preferably in a black plastic film tunnel through which solar-heated air passes. This kind of drying process takes from 2 to 6 or more hours, depending on the amount of humidity in the air. The "spaghettis" or "noodles" can be broken to short pieces or crushed to make granules which make a pleasant, tasty addition to salads, soups, or sauces.

When the size of a *Spirulina* farm is more than about 2500 m² the present method for drying, after obtaining the wet filter cake, is to use spray-drying (the method used for producing powdered milk, for example). This creates an extremely fine powder - in the range of from 2 to 10 μ in

diameter. Thus a dose of 10 grams (approximately 20 ml) could have a surface area of about 31.3 square meters!

Because of this enormous surface area, the odor and the taste of the product are exaggerated (more molecules get to our sensory receptors) and the moment of high temperature in the primary cyclone of the spray dryer also can alter the chemistry and subsequently the odor and taste. (When one eats the freshly-collected and rinsed algal cake there is practically no odor or taste to *Spirulina*). In addition, this extremely large surface area makes it difficult to wet and blend the product with other foods.

Clearly, the product has little appeal to most people - as one can deduce from the production and sales figures. Health food stores should be selling 10,000 tons of *Spirulina* a year now and the world's children suffering from malnutrition should be getting at least 200,000 tons. Production today is only about 3000 tons!

The solution proposed by the large-scale Spirulina producers has been to put the powders into capsules or pills. Frankly, this solution lacks imagination, adds unnecessary cost, and puts the product uncomfortably close to the category of medicine.

The composition of *Spirulina* (Busson, 1971; Fox, 1999; Henrikson, 1997 and Pfrommer et al, 1970) shows clearly that it is a high protein content food with important amounts of vitamins, minerals, and essential non-saturated fatty acids, but low in calorie sources. Traditionally it has been eaten in combination with cereals, thus making it an appropriate food for treating protein-energy malnutrition - as well as for general nutrition.

If the *Spirulina* is not to be eaten immediately at the production site it should be dried to a residual humidity content of 7% (Becker, 1994) or less. Once dried and kept from oxidation and sunlight the product can be kept for long periods (years) enabling stockage and distribution.

The equipment used for spray drying is costly and it requires major amounts (around 1 KWh per kilo of dried product) of energy to operate. We find that the filter cake instead of going to the spray drying process can be dried simply by being mixed with dry, precooked cereal flour such as wheat, maize, millet, rice, oats, barley, etc...

Materials and Methods

The dose of *Spirulina* recommended for children 4 to 6 years of age is 5 grams per day (giving 3.25 grams of protein).

One milliliter of algae cake at 80% humidity contains around 0.2 ml of biomass. The specific gravity of *Spirulina* is 0.950, so one milliliter of algae cake contains about 0.19 grams of dry *Spirulina*. To obtain 5 grams of *Spirulina* one needs 26.3 ml of algae cake, which weighs 25 grams.

Wheat flour has a specific gravity of 0.418, or 0.418 g per milliliter. Mixing flour with algae cake in a volume ratio 10:1, one would need 263 ml flour, weighing 110 grams. So, the mixture is either 26.3 ml algae cake - 263 ml of flour or 25 grams algae - 110 grams flour.

The calorie count of cereals usually is about 360 Kcal per 100 grams. Thus, the 110 grams of flour would contain 396 Kcal; and, at 10% protein, would contain 11 grams of protein. So the mixture, containing 3.25g of protein from the Spirulina, has a total of 14.25 grams of protein. A child of 4 to 6 years requires from 1000 to 1700 Kcalories a day, so the mixture would provide 40% of the calories and a total of 14.25 g protein. By controlling the mixing temperature and time, one can reach other desired balances of Kcal and protein for children of other ages while still arriving at a product with final humidity of between 3 and 9%.
The mixed powder obtained can either be added directly to usual foods or it can be fed between steel rollers machined to give tiny pellets that can be eaten like breakfast food.

Spirulina filter cake contains 80 to 90% humidity. After having been heated, the flour typically contains around 2%; and its resistivity at 1 cm between electrodes is 10,000 ohms. Mixing equal volumes (1ml for example of simulated filter cake - dampened *Spirulina* powder - and 1ml of flour) brings the humidity of the mixture down to ± 45% and the resistivity to 550 ohms. This mixture with 1ml of flour added (total now 3ml) has a resistivity of 600 ohms. Add a third 1ml of flour and the resistivity becomes 1250 ohms. A fourth 1ml of flour brings the mixture's resistivity up to 1550 ohms. Adding a fifth 1ml of flour makes the resistivity rise to 10,000 ohms and the water activity of the total volume (now 6ml) descend to ± 7% (within the desired range).

The experiment was repeated with filter cake, using an Amprobe Model THWD-1 digital sling psychrometer to determine residual water activity in the algae-flour mixture. The mixture was placed in an airtight plastic box, with the instrument sensor inserted into a fitted hole in the end of the box while the instrument case was held tightly against a rubber seal in order to insure isolation of the contents of the box from the outside air.

110 g of wheat flour heated in an oven to 83°C for 25 minutes was then mixed with 25 g of *Spirulina* filter cake and placed inside the plastic box. Immediately the % relative humidity of the air inside the box read 99%. The reading of the water activity then dropped slowly to where, according to a standard sorption isotherm for algae powders, it showed a residual humidity of 8.5% [still within the Indian Standard Food Grade Specification for Spirulina (C.V. Seshadri & Jeeji Bai, 1992)].

The results obtained are not offered as precise and repeatable numbers, for pinpointing methods and equipment were not available to me. However, the principle of Mix-Drying as described is definitely promising and will, I am sure, prove its usefulness in the production of *Spirulina.*

Discussion

Although the digestion of cereals starts taking place in the mouth through the action of the salivary enzyme ptyalin and continues for a time in the center area of the stomach, the pancreatic enzyme, amylase, and the carbohydraze enzymes of the small intestine complete the digestion of carbohydrates. To aid the enzyme actions on cereals they traditionally are cooked before eating.

Some cereals are available in pre-cooked form. Others are not.

We find that there already is a machine perfectly suited for mix-drying of *Spirulina*: the standard 2-shaft, contra-rotating multi-paddle mixer made by Ingeniorfirmaet Halvor Forberg AS, Hegdal, N-3261 Larvic, Norway. This mixer is manufactured in many different sizes; and while usually they are powered by electrical motors, it is possible to drive the machine manually (includes 20-liter model) for those areas where electricity is not available.

For the *Spirulina*-cereal mixture, one first pre-cooks the flour in the mixer. This is done with a heat source underneath the mixer, while the mixing paddles are in motion. This not only starts the breakdown of starch but also reduces the humidity level in the flour to practically nil. When the flour in the mixer cools down to about 80°C the *Spirulina* filter cake is added. While this remaining heat is being absorbed by the water in the filter cake, a kind of pasteurization takes place. The efficiency of the mixing machine is so great that mix-drying is accomplished within 10 seconds after admitting the *Spirulina* filter cake.

The mixed product, which is a fine powder (but can be granulated in the mixer or pelletized between steel strollers) is stored until ready for use in metallized plastic bags to prevent nutrient loss through oxidation. Soups and sauces with balanced nutrition can be made from the mixed product simply by adding clean water, or it can be sprinkled over other foods (using a measuring spoon to assure the right dose). The dried mixture is a very light greenish-gray color. In water or when cooked it is a light olive green.

Another possibility is to mix-dry only until the water content reaches 40% and then run the mixture through a noodle making machine and finish drying in the sunlight or in an oven.

I call the mix-dried *Spirulina* products: CEREALINA or SPIRUGRAINS, or SPIRUWHEAT, SPIRUCORN, SPIRUOATS, SPIRUSORG, SPIRUBARLY, SPIRURYE in English, and the equivalents in other languages; for example SPIRUBLE, SPIRUMAÏS, SPIRURIZ, SPIRUMIL in French.

Various flavors can be added during the Dry-Mixing process to suit the local taste preferences.

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