

Short Communication

## Vitamin content of four marine microalgae. Potential use as source of vitamins in nutrition

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### SUMMARY

Certain marine microalgae contain water- and lipid-soluble vitamins and can be used as food supplements or food ingredients. A number of vitamins are present in higher concentrations in the microalgae than in conventional foods traditionally considered rich in them. Ingestion of relatively small quantities of microalgae can cover the requirements for some vitamins in animal nutrition, including human nutrition, while supplementing others. Marine microalgae can thus be considered to represent a non-conventional source of vitamins or a vitamin supplement for animal or human nutrition.

## Keywords

Marine microalgae; Vitamins; Nutritional requirements; Vitamin supplements

## INTRODUCTION

Marine microalgae are considered today to be an important potential for a variety of products: they are useful in aquaculture [20, 28], in the bioconversion of solar energy [17, 18], as a source of glycerol, carotene and dry algal meal [5], pharmaceutical products [1, 9], a raw material for Single Cell Protein (SCP) [10], or as supply of minerals in fish diets [11]. We report here the vitamin composition of four marine microalgae and consider their potential use as source of vitamins for animal and/or human nutrition.

## MATERIALS AND METHODS

*Raw material.* Four marine photosynthetic microalgae were selected for this study: *Tetraselmis suecica* (Prasinophyceae), *Isochrysis galbana* (Haptophyceae), *Dunaliella tertiolecta* and *Chlorella stigmatophora* (Chlorophyceae). Culture conditions for these micro algae had previously been optimized for maximum biomass production [12-15]. *Tetraselmis suecica* was isolated from Ria de Arosa waters (NW of Spain); the remaining species were obtained from The Culture Centre of Algae and Protozoa, in Cambridge, U.K.

*Analytical methods.* The cells were collected at the end of their logarithmic phase, centrifuged at 3000 x g and dried in an oven at 60°C for 24-30 h. Samples for  $\beta$ -carotene determination were saponified under reflux and extracted with hexane. An aliquot of the hexane extract was chromatographed on alumina and the  $\beta$ -carotene determined by a colorimetric method [7]. Results were expressed as vitamin A activity in I.U., taking into account that 1 I.U. of vitamin A = 0.6  $\mu$ g of  $\beta$ -carotene. Group B vitamins and biotin were determined by microbiological assays [2,27]. The microorganisms used for these determinations were *Lactobacillus fermenti* (ATCC 9338) for thiamin, *Lactobacillus casei* (ATCC 7469) for riboflavin and folic acid assays, *Lactobacillus leichmanii* (ATCC 7830) for cobalamin, *Lactobacillus arabinosus*

(ATCC 8041) for nicotinic acid, pantothenic acid and biotin, and *Saccharomyces carlsbergensis* (ATCC 9080) for pyridoxin. Each vitamin was assayed, after the corresponding extraction procedure [2,27], in the vitamin assay medium of Merck. Vitamin E was extracted with petroleum ether and diethyl ether [19], the extract chromatographed by Florisil (SIGMA) and the vitamin E determined fluorimetrically in the appropriate fraction [6]. Ascorbic acid was determined as described by Roe [26] and Omaye [22].

## RESULTS AND DISCUSSION

The vitamin composition pattern was very similar in the four marine microalgae assayed (Table 1). In general, they are rich in lipid-soluble and B group vitamins. The microalgae showing maximum concentrations of the different vitamins were *Tetraselmis suecica* for thiamin, pyridoxin, nicotinic acid, pantothenic acid and ascorbic acid; *Dunaliella tertiolecta* for  $\beta$ -carotene, riboflavin, cobalamin and folic acid, and *Chlorella stigmatophora* for tocopherol (vitamin E) and biotin (Table 1). In addition, almost all the remaining vitamins were found in high concentrations and all the vitamins assayed were found in the four marine micro algae studied. Four vitamins,  $\beta$ -carotene, tocopherol, thiamin and folic acid, were found in higher concentrations in some of these marine microalgae than in conventional foods traditionally considered as rich sources of these vitamins (Table 2). The microalgae showing these maximum concentrations were *D. tertiolecta* and *C. stigmatophora* for vitamin A activity, and *T. suecica* and *D. tertiolecta* for thiamin. All the microalgae assayed presented higher tocopherol and folic acid values than the conventional foods reported. Tocopherol values are especially high in *T. suecica* and *C. stigmatophora*, with 421.8 and 669.0 mg/kg (dry weight), respectively, whereas the highest folic acid value occurred in *D. tertiolecta* (4.8 mg/kg dry weight).

Table 1  
Vitamin content of four marine microalgae

|                              | <i>T. suecica</i> | <i>I. galbana</i> | <i>D. tertiolecta</i> | <i>C. stigmatophora</i> |
|------------------------------|-------------------|-------------------|-----------------------|-------------------------|
| Vitamin A                    | 493 750           | 127 500           | 137 500               | 82 300                  |
| Tocopherol (E)               | 421.8             | 58.2              | 116.3                 | 669.0                   |
| Thiamin (B <sub>1</sub> )    | 32.3              | 14.0              | 29.0                  | 14.6                    |
| Riboflavin (B <sub>2</sub> ) | 19.1              | 30.0              | 31.2                  | 19.6                    |
| Pyridoxin (B <sub>6</sub> )  | 2.8               | 1.8               | 2.2                   | 1.9                     |
| Cobalamin (B <sub>12</sub> ) | 0.5               | 0.6               | 0.7                   | 0.6                     |
| Folic acid                   | 3.0               | 3.0               | 4.8                   | 3.1                     |
| Nicotinic acid               | 89.3              | 77.7              | 79.3                  | 82.5                    |
| Pantothenic acid             | 37.7              | 9.1               | 13.2                  | 21.4                    |
| Biotin (H)                   | 0.8               | 1.0               | 0.9                   | 1.1                     |
| Ascorbic acid (C)            | 191.0             | 119.0             | 163.2                 | 100.2                   |

Vitamin A content is expressed as IU/kg dry weight (1 IU = 0.6 µg of β-carotene). The other vitamins are expressed as mg/kg dry weight

There is a considerable variation in the concentration of certain vitamins, such as β-carotene, tocopherol, pantothenic acid or thiamin, among the different species assayed, whereas the concentration of other vitamins appears similar. This characteristic could allow us to chose different mixtures of marine microalgae in order to cover specific dietary requirements, taking into account certain constraints, such as the different vitamin concentration in the different species; besides, some micro algae are easier to culture than others.

Table 2  
Vitamin contents of conventional foods which present maximum values for some vitamins [8]

|                               | Orange | Carrot                | Wheat flour | Corn flour | Rye flour | Soy flour | Cow liver |
|-------------------------------|--------|-----------------------|-------------|------------|-----------|-----------|-----------|
| Vitamin A <sup>a</sup>        | 14 728 | 175 438–<br>1 052 631 | 0           | 0          | 0         | 1538      | 659 793   |
| Tocopherol <sup>b</sup>       | 17.82  | 39.47                 | 25.00       | 0          | 9.41      | –         | 34.36     |
| Thiamin <sup>b</sup>          | 6.20   | 11.40                 | 6.36        | 4.31       | 5.34      | 8.46      | 9.27      |
| Riboflavin <sup>b</sup>       | 2.32   | 5.26                  | 1.36        | 1.25       | 2.38      | 3.07      | 96.21     |
| Pyridoxin <sup>b</sup>        | 9.30   | 16.66                 | 4.54        | 11.36      | 4.11      | 6.12      | 34.36     |
| Cobalamin <sup>b</sup>        | 0      | 0                     | 0           | 0          | 0         | 0         | 1.03      |
| Folic acid <sup>b</sup>       | 2.66   | 1.48                  | 0.66        | –          | 0.9       | –         | 1.71      |
| Nicotinic acid <sup>b</sup>   | 15.50  | 56.14                 | 11–45       | 22.72      | 19.31     | 3.29      | 553.26    |
| Pantothenic acid <sup>b</sup> | 15.50  | 70.17                 | 22.72       | 0.56       | 11.76     | 19.35     | 171.82    |
| Biotin <sup>b</sup>           | 0.07   | 0.06                  | 0.08        | –          | 0.007     | –         | 6.87      |
| Ascorbic acid <sup>b</sup>    | 3798   | 377                   | 0           | 0          | 0         | 0         | 1065      |

<sup>a</sup> I.U./kg dry weight.

<sup>b</sup> mg/kg dry weight.

It is difficult to compare the data obtained with those of other micro algae because there are very little reports on the vitamin content of microalgae and the contents of vitamins found in pure cultures of algae varied and were dependent upon the vitamin level in the external medium [25]. Data reported are normally referred to freshwater microalgae and show great differences, even for the same species [3, 4, 23].

The marine microalgae selected for this investigation have been reported to represent a good raw material for the production of Single Cell Protein (SCP): the organisms have an excellent biological value, high protein level, amino acid profiles comparable to the FAO reference protein and a nucleic acid content of less than 7% of dry matter [10]. Their potential use should therefore not be considered only as a protein source but also as a vitamin-rich food ingredient or supplement.

*Dunaliella tertiolecta* presented the best pattern having the highest protein (54.25% dry weight) and the lowest nucleic acid (4.83%) content [10]. The best vitamin profile is also found in this organism, containing maximum values of four of the vitamins assayed and containing these four vitamins ( $\beta$ -carotene, tocopherol, thiamin and folic acid) in higher concentrations than conventional foods. Its importance as a food supplement is highlighted by recent medical studies that have pointed out that human cancer risks are inversely correlated with dietary  $\beta$ -carotene intake [24]. The overall compositional profile of this microalga suggests its use as a health food. This is enhanced by the fact that *D. tertiolecta* lacks cell wall [21], showing better digestibility than cell wall possessing species. In the same way, hypocholesterolemic properties of *D. tertiolecta* have also been reported recently [16]. The intake of 3.63 g of *D. tertiolecta* per day can cover the human requirements for vitamin A; 7.14 g/day covers the cobalamin and vitamin A requirements and serves as a supplement for the other vitamins, although a large intake would be needed to cover the requirements of some vitamins such as pyridoxin, nicotinic acid and ascorbic acid. However, it must be taken into account that this microalga would not be used as sole food in the animal or human diet, but as a component or ingredient that can supply vitamins, besides protein [10] and minerals [11].

These characteristics suggest a potential use of these marine microalgae as health foods or as dietary supplements.

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