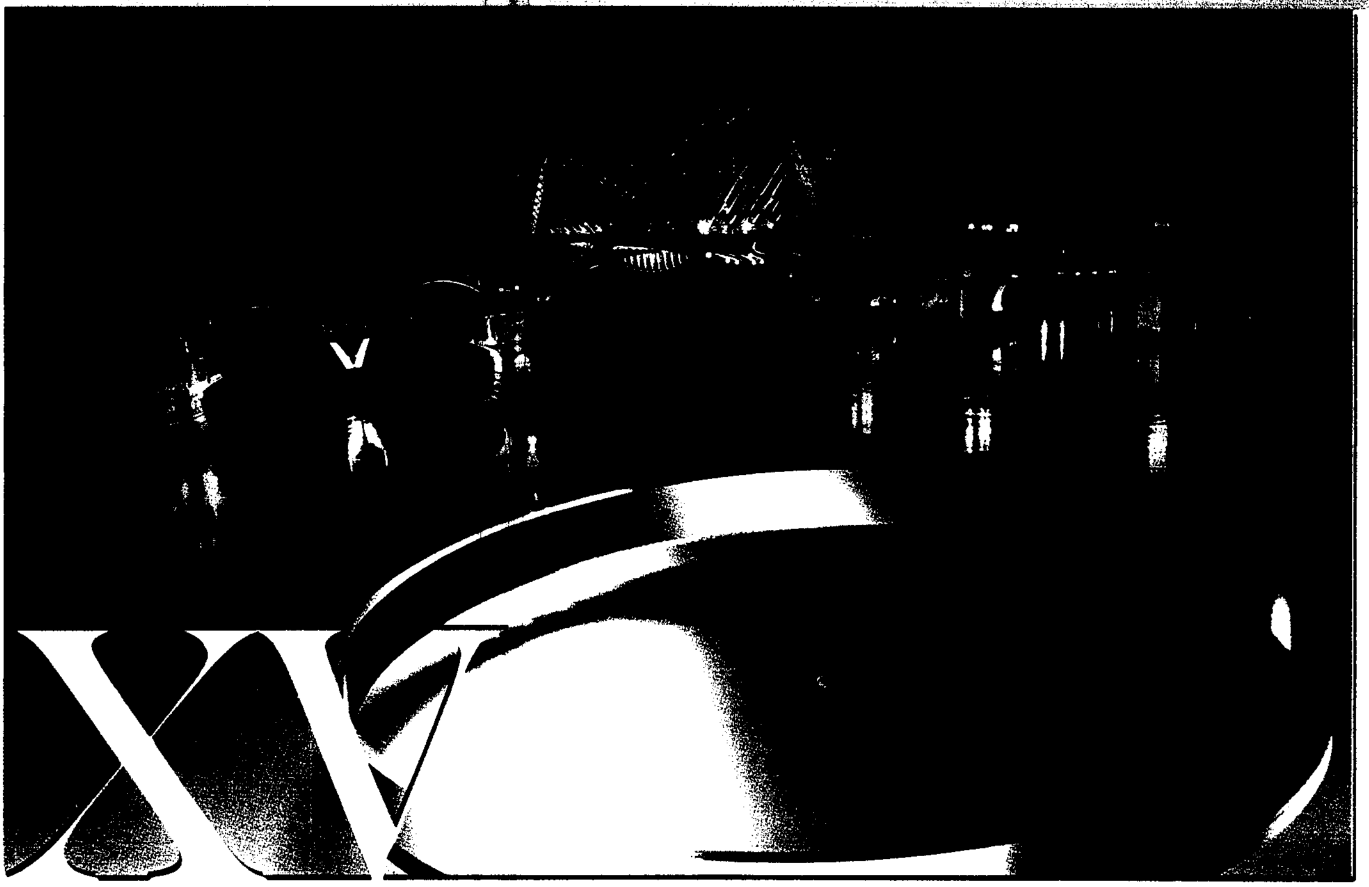

Congreso Nacional de Microbiología de los Alimentos

Ourense, 11-13 de septiembre de 2006

XV CONGRESO NACIONAL DE MICROBIOLOGÍA DE LOS ALIMENTOS

UNIVERSIDADE DE VIGO

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Facultade de Ciencias de Ourense

MICROALGAE AND FOODS

Ana P. Carvalho & F. Xavier Malcata

Escola Superior de Biotecnologia, Universidade Católica Portuguesa, Rua Dr. António Bernardino de Almeida, 4200-072 Porto, Portugal. apcarvalho@mail.esb.ucp.pt, fxmalcata@esb.ucp.pt

"Microalgae" is a non-taxonomic term used to describe a diverse group of microscopic organisms - either prokaryotic (cyanobacteria) or eukaryotic (algae), usually photosynthetic, and unicellular or filamentous.

From an economic point of view, microalgae can be viewed as microorganisms able to "harvest the sun" and thus transform radiant energy into highly valuable products, at the expense of (theoretically) inexpensive natural resources. Indeed, they are able to synthesize, accumulate and excrete a large variety of metabolites using just water, carbon dioxide and mineral salts as nutrients, and light as energy source.

Interest in algal cultures began in the 50's - soon after the World War II, in attempts to devise inexpensive sources of protein able to replace those from animal sources, which were obviously difficult to obtain by the time. The advent of the oil crisis in the 70's led researchers to investigate microalgae also as sources of biomass for methane production; more recently, advances have been focused on the production of valuable chemicals taking advantage of their secondary metabolites.

The aforementioned evolution in goals relating to R&D in microalgae has thus addressed two major issues: (i) the need for alternative sources of some products, scarce because of political or economic causes; and (ii) the desire of more profitable biotechnological processes, with low production costs but high-added value products. However, the nature of those products has varied with time, in response to different market demands.

Microalgal biodiversity is paramount, with numbers between 200,000 and several million species, compared *e.g.* with only *ca.* 250,000 species of higher plants. Therefore, their potential applications are in principle rather diverse, ranging from biomass (with a market of about 5,000 t/yr of dry matter, able to generate a turnover of *ca.* 1.0×10^9 €/yr) to specific metabolites. Nowadays, a broad list of applications of microalgal cultures is described in the literature. In terms of food industry applications, the most important product of microalgal biotechnology (in volume and value) is still microalgal biomass itself. During the late decades 75% of microalgal biomass production was indeed used for the manufacture of powders, tablets or capsules. The main species in stake encompass *Spirulina*, *Chlorella* and *Dunaliella*. Algal biomass – following spray drying, sun drying or compression to form pastilles, is mostly sold for the human health food market. From the various attempts to explain the health-promoting effects of microalgae, the most likely is a general immune-modulating effect.

Microalgae are also used to produce valuable compounds employed in food industry such as functional ingredients; among those are food-colouring pigments (most of which also possess antioxidant activity) and polyunsaturated fatty acids. When compared with algal powders, functional foods produced with microalgal ingredients are much more attractive in sensory terms and putative diversity, since they combine both microalgal health benefits and attractiveness to the consumer; these products are explored below to some extent.

Food supplemented with microalgal biomass may have other positive influences such as prebiotic effects and mineral fortification. When the prebiotic effects of *Spirulina* biomass were investigated, both in a plain form and in a functional food application, results revealed positive effects on intestinal bacteria, regarded as beneficial. All *Spirulina* strains stimulated the growth of various lactobacilli species, namely *Lactobacillus acidophilus*.

Polyunsaturated fatty acids

Of particular interest are omega-3 polyunsaturated fatty acids (ω-3-PUFA), which obtained their name from the position of the double bond nearest to the methyl terminus of the molecule. Among the ω-3 family, two PUFA deserve particular attention, owing to their major role in the human body: the eicosapentaenoic acid (EPA) and the docosahexaenoic acid (DHA). DHA is an important structural fatty acid in such nervous tissues as the brain and the retina, whereas EPA has important inhibitory effects on platelet coagulation. Although these are not classified as essential fatty acids, certain human groups such as premature and ill people, are unable to synthesize them; even in normal people, due to age, smoking, alcohol intake and poor fitness habits, the enzymatic system does often malfunction, which leads to inadequate extents of biosynthesis. Accordingly, a direct intake of such fatty acids is generally recommended. Although fish is the most common source of those PUFA for incorporation in functional foods, it is not devoid of problems: fish oils exhibit strong odour and taste, as well as oxidative instability; there are also increasing concerns associated with limited and unpredictable supply, aggravated by the potential chemical contamination when harvest takes place in near-shore environments. All these factors have constrained the use of fish oil as a functional food ingredient, and have accordingly promoted search for alternative sources. In fact, and despite their relatively high content in those compounds, fish do not synthesize ω-3 PUFA to significant levels, but instead acquire them by eating zooplankton, which in turn had been previously fed with microalgae. Therefore, in order to circumvent these problems, microalgae have been claimed to be alternative sources: some microalgae are indeed rich in PUFA, and their content can, to a certain degree, be modulated by varying the culture conditions, thus allowing a more constant production rate, irrespective of weather conditions and geographical location.

Nowadays, a broad range of products artificially enriched in ω-3 PUFA is marketed by distribution chains, from fruit juices to meat, eggs, bread, pasta, cookies and milk. It is interesting to notice that the advent of these new sources of ω-3 PUFA brought about novel ways of incorporating such ingredients in foods: besides extracting and purifying microalgal oil through a procedure similar to that employed with fish oils, microalgae can also be used as a whole, since the oil is naturally encapsulated inside the cells. These dried whole-cells can be directly added to animal feed, thus contributing to the increase in the proportion of ω-3 PUFA in both the resulting meat and other animal products (*e.g.* eggs). This process offers several advantages, namely the reduction in processing costs, due to elimination of the expensive steps of extraction and purification of the oil, and the circumvention of legal restrictions regarding incorporation of fermentative-based ingredients in food products.

Food-colouring products

Although synthetic pigments traditionally used by food industry still continue on the rise, the increasing consumer preference for natural food additives has been changing this status. The major pigments produced by microalgae include chlorophyll *a*, *b* and *c*, β-carotene (a yellow pigment from *Dunaliella*), phycocyanin (a blue pigment from *Spirulina*), xanthophylls and phycoerythrin (a red pigment from *Porphyridium*). The industrial production of β-carotene and astaxanthin (using *Haematococcus*) are case studies of success. Apart from their colouring effect, these pigments also possess antioxidant properties, which enable the human body to mediate the harmful effects of free radicals, which are implicated in several diseases. β-carotene is one of the leading food colorants in the world, applied to a range of food and beverage products such as margarine, cheese, fruit juices, baked goods, dairy products, canned goods and confectionary.

References

Carvalho, A.P.; Malcata, F.X. 2003. *Recent Res. Develop. Biotechnol. Bioeng.* 5: 1-11

Carvalho, A.P.; Malcata, F.X. 1996. *World Ingred.* March-April: 22-26

Dufossé, L.; Galaup, P.; Yaron, A.; Arad, S.M.; Blanc, P.; Murthy, K.N.C.; Ravishankar, G.A. 2005. *Trends Food Sci. Technol.* 16: 389-406

Eonseon, J.; Polle, J.E.W.; Lee, H.K., Hyun, S.M., Chang, M. 2003. *J. Microbiol. Biotechnol.* 13: 165-174

Lorenz, R.T.; Cysewski, G.R. 2000. *TIBTECH* 18: 160-167

Kay, R.A. 1991. *Critical Reviews Food Sci. Nutrition* 30: 555-573

Margalith, P.Z. 1999. *Appl. Microbiol. Biotechnol.* 51: 431-438

Pulz, O.; Gross, W. 2004. *Appl. Microbiol. Biotechnol.* 65: 635-648

Vílchez, C.; Garbayo, I.; Lobato, M.; Vega, J.M. 1997. *Enzyme Microbial Technol.* 20: 562-572

Walker, T.L.; Purton, S.; Becker, D.K.; Collet, C. 2005. *Plant Cell Rep.* 24: 629-641