e -food science project: Bio-functional foods

Olga Gortzi[1], Efstathia Tsakali [2]*, Arhontoula Chatzilazarou[3], Anna Galidi[1],
Dimitra Houhoula[2], Ioannis Tsaknis[2], Konstantinos Sflomos[2]

[1]Dept. of Food Technology, TEI of Thessaly, N. Temponera Str., 43 100, Karditsa, Greece
[2]Dept. of Food Technology, TEI of Athens, Agiou Spiridonos Str., 122 10 Egaleo Greece
[3]Dept. of Oenology and Beverage Technology, TEI of Athens, Agiou Spiridonos str., 122 10
Egaleo Greece

Abstract

Consumers are showing an increasing interest in obtaining additional benefits, beyond the provision of basic nutritional requirements, from food. Biofunctional foods have emerged on the market as a possible solution for such demands, since, by definition, their composition is such that promotes a beneficial effect on one or more target functions in the body beyond its inherent nutritional value. Some biologically active compounds which can be used in the development of functional foods are already associated with approved health claims by the European Food Safety Authority (EFSA). In these cases scientific evidence supports the identification, chemical, toxicological and technological characterization of bioactive compounds as well as detailed description of their biological mechanisms. Biofunctional food is a modern approach towards a healthier diet which needs strong scientific support. Food scientists are keys elements for the development of this new serious of products and need to be constantly updated on the latest research findings. The e-Food science is an Erasmus + project which aims to use the potential of Europes human and social capital originating from higher education institutes and the food industry, in order to develop innovative training material based on selected research findings originated from the participating institutions and also to exchange and transfer knowledge and know-how in food science and technology education in Europe. The objectives will be achieved by designing, developing and pilot testing freely accessible online educational material, for a common group of modules intended for current and potential food. The present work covers, apart of some theoretical approaches, specific analytical methods and test experiments for the incorporation in the biofunctional quivers of the food scientist and consumer of ingredients, originated from Hippophaes rhamnoides added in wine-based products.

Keywords:functional food, e-learning, wine, Hippophaes rhamnoides

*Corresponding author e-mail: etsakali@teiath

Over the last years scientific research has demonstrated the direct and strong link between the human diet and health. New scientific knowledge and development of new technologies have lead to major changes in life-styles, in the societies of abundance of the occidental, industrialized world. But at the same time new challenges, like increased costs of health care and increased life expectancy, have appeared (Roberfroid, 2002).

The In addition to maintaining a balanced diet, food scientists and technologists are working towards the objective of maximizing physiological functions (Milner, 2000) in order to ensure both maximum well-being and health and simultaneously minimize the risk of disease throughout the life-span (Roberfroid, 2002).

Better understanding of the interactions between genes and nutrition (Kok, 1999) could match the individual's unique biochemical needs with a tailored selection of nutrient intakes for that individual.

For the life and food sciences the new main target should be not only working towards extending life expectancy but also on improving wellness. On the road to optimized nutrition, 'functional food' is, amongst others, a new, interesting and stimulating concept (Roberfroid, 2002).

I. Functional Food

1.1 Definitions and legislation. An old believe which now have been considerably evidenced is that basic foods, such as fruits and vegetables, naturally contain chemicals (phytochemicals), which - when consumed in the appropriate quantities âĂŞ have a protective function and assist in the maintance of well being. There are cases that even the same phytochemicals have a preventive and / or therapeutic property against the development of certain diseases. Health professionals are gradually recognizing the role of phytochemicals in health enhancement (American Dietetic Association, ADA, 1995; Howard and Kritcheveky, 1997), aided in part by the Nutrition Labelling and Education Act of 1990 (NLEA). The NLEA required nutrition labelling for most foods and allowed disease- or health-related messages on food labels.

The term 'functional food' was first used in Japan, in the 1980s, to indicate food having a high content of natural metabolites with recognized health benefits such anticancer, antilipidemic, anticholesterol, antimicrobial, antibacterial, antifungal, antiviral, antihypertensive, anti-inflammatory and antioxidant properties (Lavecchia et al, 2010).

Over the next years the concept found a great acceptance in western world and in 1999, the European Commission's Concerted Action on Functional Food Science in Europe, defined that: a food product can only be considered functional if together with the basic nutritional impact it has beneficial effects on one or more functions of the human organism thus either improving the general and physical conditions or/and decreasing the risk of the evolution of diseases. The amount of intake and form of the functional food should be as normally expected for dietary purposes. Therefore, it should not be in the form of pill or capsule but as normal food (Diplock et al., 1999).

After years of too many legislative frameworks regulating the approval of products a new regulation on nutrition and health claims made on foods (EC No. 1924/2006), a list of authorised claims was to be published for all member states and nutrient profile will be required for food making health claims. In the late 1990s, instead of 'functional foods', the term 'nutraceutical' (from the words nutrition and pharmaceuticals) was also used, but it was not prevailed. However, it should be reiterated that - as supported by ADA-all foods may be considered as functional at a specific level.

Under the broad term of functional foods a long list of products could be included which could be further divided in five subcategories. The first one includes food or ingredients which according to strong scientific evidence have a direct impact on the prevention of diseases. Another group of functional foods are those which are enriched or fortified with one or more ingredients with estimated strong effect on the prevention or dietary treatment of a disease or its clinical symptoms. A third subcategory includes specific foods that are directly related to a reduced risk of appearance of some diseases. There is a limited use of such a claim in a commercial level since it is necessary to present in vitro, *in vivo* and epidemiology studies to support it, and by now, the clinical results are limited and sometimes biased. Foods with a reduced content -due to partly or whole- removal of specific ingredients which are proved harmful, substitute the forth subcategory. These foodstuffs are known as diet or light products.

Dietary supplements consist the fifth group of functional food. These are basically ingredients with important biological properties that can be isolated from their natural source and can be consumed directly or to be added in other foodstuffs in order to modify their properties in a functional way (Sflomos, 2010).

Being clearly positioned as part of nutrition, the functional food concept is, however, quite distinct from other approaches like food supplementation or food fortification, and functional foods are different from nutraceuticals, pharmafoods and vitafoods, all terms that are not defined conceptually. Functional foods are food products to be taken as part of the usual diet in order to have beneficial effects that go beyond what are known as traditional nutritional effects.

Moreover, these beneficial effects have to be demonstrated scientifically to justify two specific types of claim: the enhanced function claim or the reduction of disease risk claim (Lavecchia et al, 2010). Recently the term biofunctional food is also used to describe a food item or component with a specific desirable biological effect-which is not necessarily related to human health (these are bioactive components).

1.2 Consumers' opinion on Functional food. The most common functional foods are those fortified with vitamins and/or minerals such as retinol (vitamin A), tocopherol (vitamin E), folic acid, zinc, iron and calcium. Recently, however, attention has moved to food fortified with various nutrients such as omega-3 fatty acids, phytosterols and phytochemical substances having antioxidant properties such as carotenoids, phenolic compounds (flavonoids, phenolic acids, catechins, stilbenes, curcumin etc.), phytoestrogens (isoflavones, lignans) or anticarcinogenic agents such as limonene, allicin, glucosinolates and capsaicinoids. All these substances are able to promote good health, but, if in excess, in some cases, they can result in the opposite effect: vitamins C and E protect cells against damage by free radicals due to their antioxidant properties. On the other hand, excess of vitamin E may increase the risk of bleeding, particularly for adults who are also taking an anticoagulant.

Occasionally, adults who utilized very high doses developed muscle weakness, fatigue and nausea (Lavecchia et al, 2010).

The food industry has showed a profound interest for food products that meet the consumers' demand for a healthy life style. By definition functional foods may cover this demand. In 2008 the entire functional foods market was worth over an estimated US dollar 80 billion, with the US holding a majority share in the nutraceuticals market (35%), followed by Japan (25%) and with the ever-growing European market, currently estimated at US dollar 8 billion (Vergari, Tibuzzi and Basile, 2010).

People consider the healthfulness of food to be an important factor influencing their overall dietary choices (Grunert, 2005; Krystallis, Maglaras and Mamalis, 2008). Nutrition and health claims are used to highlight specific properties of foods that contain (added) beneficial ingredients or are lower in nutrients we should be eating less of. Some also view claims as a legitimate educational tool that will have a positive impact on consumer behaviour and nutrition awareness and as such contribute to public health (Williams, 2005).

However, taste (Lyly, Roininen, Honkapaa et al., 2007; Sabbe, Verbeke, Deliza et al., 2009; Miele, Di Monaco, Cavella et al., 2010; Lalor, Madden, McKenzie et al., 2011; Vidigal, Minim , Carvalho et al., 2011), brand and price (Ares, Gimenez and Deliza, 2010), attractiveness of the product (Krystallis, Maglaras and Mamalis, 2008; Siegrist, Stampfli and Kastenholz, 2008) and packaging (Lalor, Madden, McKenzie et al., 2011) seem to be more important than health claims in influencing purchasing decisions (Wills, Bonsmann, Kolka and Grunert, 2012).

II. The e-food Science Project

The e-food science project aims to use the potential of Europe's human and social capital originating from higher education's institutes and the food industry.

The main objective is the exchange and transfer of knowledge and know-how in food science and technology education, by the creation and development of a network that will provide opportunities for cooperation among stakeholders. The project's partnership consists of five European higher educational institutions (TEI of Thessaly/coordinator, TEI of Athens, Cyprus University of Technology, Universidade Catolica Portuguesa, Universidad de Leon) an Information technology enterprise (Syst Serv), and a local development agency (ANKA).

A series of collaborating stakeholders from food industries based in the participating countries for developing case studies material for training purposes are linked to the project as associated partners. This project aims to design, develop and pilot test freely accessible online educational material, for a common group of modules intended for 'food science' students.

The general objectives of this project include firstly an effort to enhance the quality and relevance of the learning offer in education by developing new and innovative education approaches and supporting the dissemination of best practices in food science and technology education.

Furthermore, it aims to promote innovative practices in education by supporting personalised learning approaches, collaborative learning and critical thinking, strategic use of Information and Communication Technologies (ICT), open educational resources (OER), open and flexible learning, virtual mobility and other new pedagogies.

It is also important to increase labour market relevance of learning provision and qualifications and reinforcing links between education and the world of the food industry. The final objective is to improve the capacities of the participating universities in the areas of strategic development, quality of learning provision and internationalisation

The scientific design in order to fulfil the general and more specific objectives of this project includes a seven step process. Starting with the evaluation the training needs in Food Science and Technology Study Programmes in European Higher Education Organizations in order to ensure that EU labour has the skills and knowledge to face the emerging food sector market related to functional foods.

The second stage is related to the development of innovative education training materials (including case studies) for EU Universities, by enhancing the potential of the agri-food sector for the production and promotion of functional foods in Europe (including all the ethical and safety aspects), by developing in parallel entrepreneurship skills of the trainees.

The development of a freely accessible innovative on line platform for the training material will help the access on produced material. Training the trainers on the training material and the potentials of the on line training platform is also crucial. On the direction of this purpose the design and the implementation of pilot seminars are planned, for students in order to test and evaluate the newly developed training material.

Translation if the training material from English to Greek, Spanish and Portuguese will make accessibility easier at a European level. The final step is the dissemination of the complete training package (material, platform, teaching methods etc.) to the collaborating partners from participating and other EU countries through a multiplier event and a comprehensive communication campaign.

III. Case Study: Fermentation of *Hippophaes rhamnoides* Fruit Juice for the Production of Bio-functional Beverage

Hippophaes rhannoides is a native plant at the temperate zones of Europe and Asia but it is also well represented at higher altitudes in the subtropical zones of Asia. It belongs to the Elaeagnaceae family a spiny bush with long and narrow leaves and orange-yellow berries, which are spherical and have diameter between 3-8mm (Bal, Meda, Naik and Santosh, 2011). It is known for centuries for its unique properties and nowadays is a popular functional food since its berries, leaves and bark contain many bioactive compounds (Oomah, 2003). Its fruits contain a wide range of vitamins such as provitamin A, vitamins B (thiamin), B2 (riboflavin), E (tocopherol), K (phyllokinon) but also mineral elements like Ca, P, Fe and especially K (Bal, Meda, Naik and Santosh, 2011).

In particular Hippophae fruits have high levels of vitamin C (695 mg/100g, which is comparatively more than in lemons and oranges), tocopherols (1-10 mg/100g) and carotenoids (3-15 mg/100g) especially β-carotene, lycopene, zeaxanthine (Gao, Ohlander, Jeppsson, Bjork, and Trajkovski, 2000; Zeb, 2004). Malic and quinic acids, as well as oxalic citric and tartaric acids are present (Kumar, Kumar, Chaurasia and Singh, 2011) while the peel of the stem and the berries contains 5-hydroxytryptamine, which is rare among plants. Hippophae berries contain high amounts of natural antioxidants like ascorbic acid, whereas they also contain tocopherols, carotenoids, and flavonoids like isorhamnetin, isorham-netin-3-O-13-D-glucoside, rutin, ustzagalin, quercetin, myricetin and kaempferol (Christaki, 2012).

Fruits are rich in unsaturated fatty acids (oleic acid, linoleic acid, linolenic acid) with an average of 86.3% (Suryakumar, Gupta, 2011). Berries also contain phytosterols like β-sitosterol, ergosterol and amyrins. The leaves also contain important bio-active components, especially phenolics, represented by flavonols leucoanthocya-nidins, epicatechin, gallocatechin, epigallocatechin and gallic acid (Suryakumar, Gupta, 2011). According to Guan et al., fresh leaves are rich in total carotenoids (26.3 mg/100g) and total chlorophyll (98.8 mg/100g), an indicator of quality for green vegetables; whereas dried leaves still contained large quantities of bioactive compounds comparable to commonly consumed vegetables. Hippophae leaves also contain significant amounts of proteins (20.7%), amino acids (0.73% lysine, 0.13% methionine & cystine), minerals (Ca, Mg and K), folic acid, catechins, esterified sterols, triterpenols, isoprenols and tannins hippophaenins A and B (Christaki, 2012). All these components give to *Hippophaes rhannoides* important properties such as: cardioprotective, anti-atherogenic and immunomodulatory activity, antioxidant, anticancer, anti-bacterial and anti-vital effects, and anti-Inflammatory capacity (Christaki, 2012). For the above bioâĂŞfunctional constituents. *Hippophaes rhannoides* can be used for the production of bio-fuctional food and beverages.

Due to its large amounts of sugars-mainly glucose and fructose-that vary widely in berry juice from 0.6 to 24.2 g/100mL, *Hippophaes rhannoides* is ideal as a substrate for fermented products. Negi and Dey (2009) produced a *Hippophaes rhannoides* beverage using alcoholic fermentation. They also compared its total phenolic content which was determined using the Folin-Ciocalteu reaction with gallic acid as the standard-with those of selected fruit wines from grape, apple and blackcurrant produced with same strain under similar conditions. The initial total phenolic content of Hippophaes rhannoides juice was 933 mg of gallic acid equilevant (GAE)/L while in *Hippophaes rhannoides* beverage it was 689 mg GAE/L which is comparable to grape wine (647 mg GAE/L). It was also proved that the intake of phenolic with 100 mL of *Hippophaes rhannoides* beverage is at least 68.6 mg GAE which falls in the range of intakes of phenolic compounds from some other well known beverages like black tea 57-357 mg, linden flower 0.27-24mg, sage, 1-105 mg, grape molasses (1-42 mg) and violet carrot juice (6-

110 mg) per day, respectively (Karakaya and Tas, 200). Hence, *Hippophaes rhamnoides* beverage can also serve as a good supply of phenolic compounds.

Hippophaes rhamnoides' high antioxidant capacity makes it also feasible for addition as a natural preservative in wine based products.

IV. Conclusion

The research field for bio-functional food is particularly rich and driven by the market's demands it may offer lot of potential. The e- food science project can help higher education institutions and the food industry to collaborate in order to educate and train food scientists and technologists. These scientists will upgrade their knowledge and they will be qualified to serve this challenging research field. Most importantly they will implement a high level scientific knowledge into the production of functional food.

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References

[1] ADA (1995). Position of the American Dietetic Association: Phytochemicals and functional foods. Journal of American Dietary Association. 95: 493-496.

[2] Ares G., Gimenez A. and Deliza R. (2010). Influence of three non-sensory factors on consumer choice of functional yogurts over regular ones. Food Quality and Preference 21, 361-367.

[3] Bal L. M., Meda V., Naik S. N., Santosh S. (2011). Sea buck-thorn berries: A potential source of valuable nutrients for nutraceuticals and cosmoceuticals. Food Research International. 44: 1718-1727

[4] Christaki E. (2012). Hippophae Rhamnoides L. (Sea Buckthorn): a Potential Source of Nutraceuticals. Food and Public Health 2012, 2(3): 69-72.

[5] Diplock A., Aggett P., Bornet F., Roberfroid M. (1999). Scientific concepts of functional foods in Europe-consensus document. British Journal of Nutrition, 81(1):1-27.

[6] Gao X., Ohlander M., Jeppsson N., Bjork L. and Trajkovski V. (2000). Changes in antioxidant effects and their relationship to phytonutrients in fruits of Sea buckthorn (Hippophae rhamnoides L.) during maturation. Journal of Agricultural Food Chemistry. 48: 1485-1490

[7] Grunert K.G. (2005). Food quality and safety: Consumer perception and demand. European Review on Agricultural Economics 32, 369-391.

[8] Guan T.T.Y., Cenkowski S. and Hydamaka A. (2005). Effect of drying on the nutraceutical quality of sea buckthorn (Hippo-phae rhamnoides L. ssp. Sinensis) leaves. Journal of Food Science. 70: E514-E518

[9] Howard B.V. and Kritchevsky D., (1997). Phytochemicals and cardiovascular disease. A statement for healthcare professionals from the American Heart Association. Circulation 95: 2591-2593

[10] Karakaya S., El S.N.. and Tas A.A., (2001). Antioxidant activity of some foods containing phenolic compounds. International. Journal of Food Science. and Nutrition., vol. 52, pp. 501-508.

[11] Kok F.J., (1999). Functional foods: relevance of genetic susceptibility. Proc. of Forum on: Functional Food. Strasbour Council of Europe Publishers, pp. 217-229.

[12] Krystallis A., Maglaras G. and Mamalis S. (2008). Motivations and cognitive structures of consumers in their purchasing of functional foods. Food Quality and Preference, 19, 525-538.

[13] Kumar R., Kumar G. P., Chaurasia O. P. and Singh S. B. (2011) Phytochemical and pharmacological profile of Seabuckthorn oil: a review. Research Journal of Medicinal Plant. 5: 491-499

[14] Lalor F., Madden C., McKenzie K. and Wall P.G.. (2011) Health claims on foodstuffs: A focus group study of consumer attitudes. Journal of Functional Foods 3, 56=59.

[15] Lavecchia T., Tibuzzi A. and Giardi M.T. (2010). Biosensors for Functional Food Safety and Analysis. In BIO-FARMS FOR NUTRACEUTICALS: FUNCTIONAL FOOD AND SAFETY CONTROL BY BIOSENSORS. Giardi M.T., Rea G., Berra B. (Eds). Landes Bioscience / Springer Science+Business Media, LLC dual imprint. New York.

[16] Lyly M, Roininen K., Honkapaa K., Poutanen K. and Latheenmaki (2007) Factors influencing consumersâĂŹ willingness to use beverages and ready-to-eat frozen soups containing oat beta-glucan in Finland, France and Sweden. Food Quality and Preference 18, 242-255.

[17] Miele N.A., Di Monaco R., Cavella S. and Masi P.. (2010) Effect of meal accompaniments on the acceptability of a walnut oilenriched mayonnaise with and without a health claim. Food Quality and Preference, 21, 470-477.

[18] Milner J., (2000). Functional foods: the US perspective. American Journal of Clinical Nutrition 71, 1654S-1659S.

[19] Negi B. and Dey G. (2009). Comparative Analysis of Total Phenolic Content in Sea Buckthorn Wine and Other Selected Fruit Wines World Academy of Science, Engineering and Technology, 54

[20] Oomah B.D. (2003). Sea buckthorn lipids. In: Sea buckthorn (HippophaÃŮ rhamnoides): Production and utilization. Li T.S.C., Beveridge T. (Eds), NRC Research Press, Ottawa, ON. pp. 51-68

[21] Roberfroid M.B. (2002). Global view on functional foods: European perspectives. British Journal of Nutrition), 88, Suppl. 2, S133-S138

[22] Sabbe S., Verbeke W., Deliza R., Matta V. and Van Damme P. (2009). Effect of a health claim and personal characteristics on consumer acceptance of fruit juices with different concentrations of ac, aÃś (Euterpe oleracea Mart.). Appetite 53, 84-92.

[23] Sflomos, K. (2010). Food Chemistry Volume 1. Athens.

[24] Storcksdieck genannt Bonsmann S., Celemin L.F., Larranaga A., Egger S., Wills J.M., Hodgkins C., Raats M.M. (2010). Penetration of nutrition information on food labels across the EU-27 plus Turkey. European Journal of Clinical Nutrition 64, 1379-1385.

[25] Suryakumar G. And Gupta A. (2011). Medicinal and therapeutic potential of Sea buckthorn (Hippophae rhamnoides L.). Journal of Ethnopharmacology. 138: 268-278

[26] Vergari F., Tibuzzi A., and Basile G. (2010). An Overview of the Functional Food Market: From Marketing Issues and Commercial Players to Future Demand from Life in Space. In BIO-FARMS FOR NUTRACEUTICALS: FUNCTIONAL FOOD AND SAFETY CONTROL BY BIOSENSORS. Giardi M.T., Rea G., Berra B. (Eds). Landes Bioscience / Springer Science+Business Media, LLC dual imprint. New York.

[27] Vidigal, M.C.T.R., Minim, V.P.R., Carvalho, N.B., Milagres, M.P., and Goncalves, A.C.A. (2011). Effect of a health claim on consumer acceptance of exotic Brazilian fruit juices: AcÂÿal' (Euterpe oleracea Mart.), camucamu (Myrciaria dubia), caja' (Spondias lutea L.) and umbu (Spondias tuberosa Arruda). Food Research International, 44, 1988-1996.

[28] Williams P. (2005) Consumer understanding and use of health claims for foods. Nutrition Reviews 63, 256-264.

[29] Zeb A. (2004). Chemical and nutritional constituents of sea buckthorn juice. Pakistan Journal of Nutrition. 3: 99-106.