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Application of seaweeds to develop new food products with enhanced shelf-life, quality and health-related beneficial properties

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ABSTRACT

Edible seaweeds are a good source of antioxidants, dietary fibers, essential amino acids, vitamins, phytochemicals, polyunsaturated fatty acids, and minerals. Many studies have evaluated the gelling, thickening and therapeutic properties of seaweeds when they are used individually. This review gives an overview on the nutritional, textural, sensorial, and health-related properties of food products enriched with seaweeds and seaweed extracts. The effect of seaweed incorporation on properties of meat, fish, bakery, and other food products were highlighted in depth. Moreover, the positive effects of foods enriched with seaweeds and seaweed extracts on different lifestyle diseases such as obesity, dyslipidemia, hypertension, and diabetes were also discussed. The results of the studies demonstrated that the addition of seaweeds, in powder or extract form, can improve the nutritional and textural properties of food products. Additionally, low-fat products with less calories and less saturated fatty acids can be prepared using seaweeds. Moreover, the addition of seaweeds also affected the health properties of food products. The results of these studies demonstrated that the health value, shelf-life and overall quality of foods can be improved through the addition of either seaweeds or seaweed extracts.

1. Introduction

The consumption of marine products has been and is increasingly gaining attention, as people become more aware of the relation between diet and health. Nowadays, many new marine products have been developed and marketed, offering enhanced health benefits and the potential to decrease the risk of diseases. Selling such "functional foods" has significantly increased in Europe and other parts of the world (Annunziata & Vecchio, 2011). Moreover, marine foods and their ingredients such as fish oils, fish proteins, bioactive peptides, seaweeds, macroalgae and microalgae can be added to different food products such as meat, dairy, fish or vegetable-based products to make them more "functional" (Jimenez-Colmenero, 2007).

Among cultivated marine organisms, edible seaweeds or marine macroalgae are one of the richest sources of natural antioxidants and antimicrobials, which are traditionally consumed by humans as food (Gupta & Abu-Ghannam, 2011). Several studies have reported the antioxidant and antimicrobial influence of crude extracts from seaweeds using simple and fast *in vitro* assays (Cox, Abu-Ghannam, & Gupta, 2010; Rajauria, Jaiswal, Abu-Ghannam, & Gupta, 2010). The potential of using seaweed powder and extracts against lipid oxidation in foods and oxidative stress in target tissues has been widely studied. Moreover, the food industry is still the main market for the seaweed hydrocolloids where they are used as texturing agents and stabilizers (Bixler & Porse, 2011). Seaweed polysaccharides are a potential source of soluble and insoluble dietary fibers. These compounds exhibit higher water holding capacity than cellulosic (insoluble) fibers. Soluble dietary fibers demonstrate the ability to increase viscosity, form gels and/or act as emulsifiers (Elleuch et al., 2011).

In addition to the vast range of functional properties such as nutritional, physicochemical and textural properties that seaweeds impart to food products, many studies showed their health benefits either when they are consumed directly or after minor pre-processing as dietary supplements (Mikami & Hosokawa, 2013; Yende, Harle, &

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Chaugule, 2014). For instance, bioactive peptides isolated from fish protein hydrolysates as well as algal fucans, galactans and alginates showed anticoagulant, anticancer, and hypercholesterolemic activities (Lordan, Ross, & Stanton, 2011). On the other hand, evidences showing that these bioactive compounds have a clear health benefit present a dilemma because the effect of the compounds on the human body may be very small and not constant over a period. However, it is believed that seaweeds' bioactive components can significantly increase the health status if they are consumed throughout life as part of the daily diet (Biesalski et al., 2009).

Considering the extensive data that is available on the functional properties of seaweed and seaweed extracts, it will be interesting to review how effective these compounds have been when they are incorporated into several food products (Fig. 1). Thus, the purpose of this review is to highlight the potential applications of seaweed extracts or whole seaweeds as functional ingredients to increase the nutritional, textural, and sensorial properties of food products (e.g. meat, bakery, dairy, and other products). Moreover, the effect of seaweed addition on improving the health-related properties of the food products against different diseases (e.g. obesity, dyslipidemia, hypertension, diabetes) has been also discussed in this review.

2. Chemical composition of seaweeds

Although the detailed chemical composition of seaweeds is not well known, these marine plants have been reported to be a good source of micro- and macronutrients (Gupta & Abu-Ghannam, 2011; Kadam & Prabhasankar, 2010). Seaweeds are a rich source of micronutrient compounds such as vitamins (e.g. vitamin A, B_1, B_2, B_3, B_6, B_{12}, C, D, E, pantothenic acid and folic acid) (Kolb, Vallorani, Milanovic, & Stocchi, 2004; Ferraces-Casais, Lage-Yusty, de Quirós, & López-Hernández, 2012), sterols (Lopes et al., 2011; Lopes, Sousa, Valentao, & Andrade, 2013), and minerals (e.g. calcium, magnesium, potassium, iodine, sodium, phosphorus, nickel, chromium, selenium, iron, zinc, manganese, copper, lead, cadmium, mercury and arsenic) (Kolb, Vallorani, Milanovic, & Stocchi, 2004; Ferraces-Casais, Lage-Yusty, de Quirós, & López-Hernández, 2012; Ladra-Ramos, Domínguez-González, Moreda-Piñeiro, Bermejo-Barrera, & Bermejo-Barrera, 2005; García-Casal, Pereira, Leets, Ramírez, & Quiroga, 2007; Marsham, Scott, & Tobin, 2007; Moreda-Piñeiro et al., 2007; Patarra, Paiva, Neto, Lima, & Baptista, 2011; Peña-Rodríguez, Mawhinney, Ricque-Marie, & Cruz-Suárez, 2011). Moreover, seaweeds are known to be one of the best natural sources of iodine (Nagataki 2008; Zimmermann 2008;

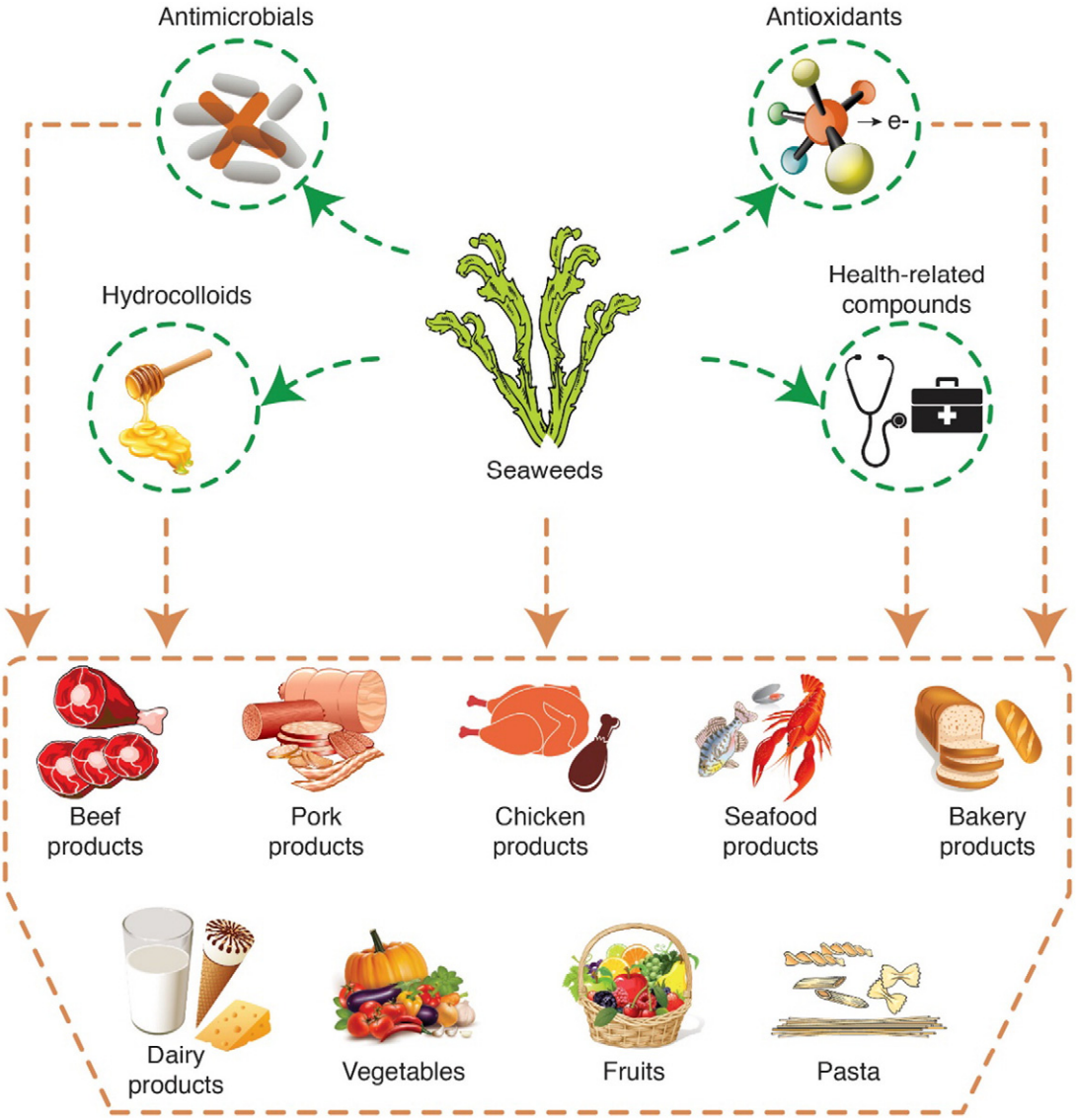

Fig. 1. Application of seaweed and seaweed extracts to develop new food products.