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Effects of pulsed electric fields on water-soluble vitamins and ACE inhibitory peptides added to a mixed orange juice and milk beverage

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Abstract

The effects of pulsed electric fields technology (15–40 kV/cm; 0–700 μs) and thermal processing (84 °C and 95 °C, 15–120 s) were studied on an orange juice and milk mixed beverage fortified with water-soluble vitamins (biotin, folic acid, pantothenic acid and riboflavin) and angiotensin-I-converting enzyme (ACE) inhibitory peptides. The evaluation of the technologies was carried out from two points of view: effect of treatments and effect of storage (4 °C, 81 days). The results confirmed the stability of the vitamins and the ACE inhibitory activity after the PEF treatment and during storage.

Keywords: ACE inhibitor peptides; Biotin; Folic acid; Orange juice–milk beverage; Pantothenic acid; Pasteurization; Pulsed electric fields; Riboflavin; Storage

1. Introduction

The increasing concern of consumers about their health and new lifestyles that are driving them away from healthy dietary habits has prompted the industry to become involved in the need for food products which contribute to the prevention of illness. The natural drinks (soy-based drinks or drinkable yogurts) that consumers consider healthy constitute one of the food industry sectors with highest growth worldwide (31% for soy-based drinks; and 19% for drinkable yogurts, in 2004) (Sloan, 2005). Reflecting a similar concern, as a result of the new Dietetic Guides for the Americans, published in 2005, the International Food Information Council has declared that now, and in the immediate future, food research and nutrition professionals must make the most of opportunities to develop functional foods that support and promote health (Davis & Reinhardt, 2005).

Among the most consumed functional foods are mixed fruit juice and milk beverages fortified with vitamins, biologically active peptides, minerals and fibre (Pszczola, 2005). In Spain, consumption of enriched juices of this kind, in 2005, represented 19.47% of the total *per capita* consumption of juices (http://www.mapa.es/es/alimentacion/pags/consumo/BD/resultado1.asp). Recently, milk beverages fortified with bioactive peptides and minerals with antihypertensive properties have been commercialized (Sloan, 2005).

One of the nutritive compounds to take into account is the group of water-soluble vitamins. B group vitamins are water-soluble vitamins that have many different fundamental biological properties, such as protection against cancer, heart disease, and birth defects (Lucock, 2004). The stability of B vitamins depends on each vitamin and on external factors, such as presence of oxygen, light and acids. Another cause of vitamin B group losses is thermal treat-

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ment, which is the classical technology generally applied to foods of this kind to preserve them. Heat-induced losses of vitamin content make it necessary to over-fortify foods to compensate for this degradation. The thermal stability of water-soluble vitamins depends on each vitamin, with riboflavin being the most thermostable and ascorbic acid the most thermosensitive under aerobic conditions. When milk is pasteurized, only 10% of the riboflavin is destroyed (Ford, Porter, Thompson, Toothill, & Edward-Webb, 1969; Haddad & Loewenstein, 1983; Lavigne, Zee, Simard, & Bellveau, 1989). Haddad and Loewenstein (1983) reported a thiamine destruction of 12% after mild heat treatment (72 °C for 16 s), and 25–50% after in-bottle pasteurization. In the case of ascorbic acid, thermal destruction in milk varies between 40% and 60%, depending on treatment intensity (Ford et al., 1969; Haddad & Loewenstein, 1983; Lavigne et al., 1989; Mottar & Naudts, 1979; Van Eeklen & Heijne, 1965).

Biologically active peptides are food-derived peptides that, in addition to their nutritional value, exert a physiological effect on the body. These bioactive peptides are inactive within the original protein but, once released, function as regulatory compounds with hormone-like activity, based on their inherent amino acid composition and sequence (Meisel, 1997; Tome, 1998). Numerous peptides exhibiting various activities have been reported, including opiate, mineral binding, immunomodulatory, angiotensin-I-converting enzyme (ACE) inhibitory, antithrombotic, and antimicrobial peptides (Clare & Swaisgood, 2000; Korhonen & Philanto-Leppälä, 2003; Meisel, 1998). Milk proteins are currently the main source of bioactive peptides (Dziuba, Minkiewicz, & Nalecz, 1999), and milk fermentation is a successful strategy for producing them (Gobetti, Ferranti, Smacchi, Goffredi, & Addeo, 2000; Korhonen & Philanto-Leppälä, 2003; Silva & Malcata, 2005).

Hypertension is one of the most common chronic medical conditions in the developed world. It is estimated that about 20% of the world's adult population suffer from hypertension. The prevalence of high blood pressure increases with age, affecting approximately 65% of the population aged 65–74 in western nations (Alper, Calhoun, & Oparil, 2001; Duprez, Van Helshoecht, Van den Eynde, & Leeman, 2002). ACE plays an important role in the renninangiotensin system, which regulates arterial blood pressure as well as salt and water balance (Eriksson, Dzanilczyk, & Penninger, 2002; Riordan, 2003). Consequently, inhibition of ACE, by ACE inhibitory drugs and natural ACE inhibitory peptides, has been shown to result in an antihypertensive effect in hypertensive human subjects and animals (Cushman & Ondetti, 1999; Takano, 1998).

There are noteworthy antecedents proving that nonthermal preservation technologies, such as pulsed electric fields (PEF), are able to maintain the quality of certain fresh foods, improving their safety and shelf life, without changing their sensory and nutritive aspects as does thermal pasteurization (Barbosa-Canovas & Sepúlveda, 2005). Fruit and vegetable juices, liquid eggs, milk, and milk derivates are the most common foods to which PEF technology has been applied, mainly from a microbiological and enzymatic point of view (Elez-Martinez, Soliva-Fortuny, & Martin-Belloso, 2006; Rivas, Rodrigo, Martínez, Barbosa-Cánovas, & Rodrigo, 2006; Rodrigo, Barbosa-Cánovas, Martínez, & Rodrigo, 2003; Sobrino & Martín-Belloso, 2006). Recently, various studies have proved the validity of PEF technology for inactivating microorganisms in a more complex food, such as a mixed orange juice and milk beverage (Rivas, Sampedro, Rodrigo, Martínez, & Rodrigo, 2006; Sampedro, Rivas, Rodrigo, Martínez, & Rodrigo, 2006).

From a nutritive point of view, PEF studies have focussed on milk and fruit and vegetable juices. On the whole, vitamin C, carotenoids, flavonoids, and antioxidant activity are the nutritive compounds most studied (Bendicho, Espachs, Arántegui, & Martín, 2002; Cortés, Torregrosa, Esteve, & Frígola, 2006; Sánchez-Moreno, Pilar-Cano, et al., 2005; Sánchez-Moreno et al., 2005; Torregrosa, Cortés, Esteve, & Frígola, 2006; Torregrosa, Esteve, Frígola, & Cortés, 2006). However, no information has been published about the effectiveness of PEF treatment on water-soluble vitamins or ACE inhibitory peptides in a more complex product (a mixture of orange juice and milk). The aim of this study, therefore, was to evaluate the impact of PEF and thermal technologies on ACE inhibitory peptide activity and water-soluble vitamin (riboflavin, biotin, pantothenic acid, and folic acid) contents in a mixed orange juice and milk beverage, and their stability during storage.

2. Materials and methods

2.1. Beverage preparation

Frozen pasteurized squeezed orange juice (commercial source), UHT skimmed milk (commercial source), high methoxyl pectin (Unipectine, Degussa Texturant Systems France SAS, Boulogne, France), citric acid, distilled water and sugar (commercial source) were used to prepare the beverage. The beverage formulation was: orange juice (50% (v/v)), water (30% (v/v)), milk (20% (v/v)), sugar (7.5% (w/v)), citric acid (0.1% (w/v)), and pectin (0.3% (w/v)). The sugar, citric acid, and pectin were added to the water prior to the addition of the juice and milk. The electrical conductivity (Crison 525 conductimeter, Crison Instruments SA, Alella, Barcelona, Spain), pH (Crison 2001 pH-meter, Crison Instruments SA, Alella, Barcelona, Spain), viscosity (Haake Viscotester VT5, Thermo Electron Corporation, Sussex, UK), and soluble solids content (Atago RX-1000 digital refractometer, Atago Company Ltd., Tokyo, Japan) of the beverage were determined. The beverage was prepared immediately before PEF treatment.

The beverage had an electrical conductivity of 2.91 mS/cm and a pH of 4.05.