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The effects of transglutaminase on the functional properties of the myofibrillar protein concentrate obtained from beef heart

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Abstract

The aim of the present study was to evaluate the effect of bacterial transglutaminase on the functional properties of the myofibrillar protein concentrate from beef heart. The degrees of hydration and aggregation and emulsifying properties were studied. The degree of polymerization of the myofibrillar proteins depended on the enzyme concentration and setting time; the best results in terms of functional properties were obtained with 0.3 g transglutaminase/100 g protein with 60 min setting at 35 °C. This investigation confirms that transglutaminase may be used for the production of myofibrillar protein aggregates with enhanced functional properties.

Keywords: Myofibrillar proteins; Bacterial transglutaminase; Functional properties; Rheological behavior

1. Introduction

Myofibrillar proteins play an important role when processing meat, being responsible for the formation of cohesive structures and a firm texture following thermal treatment (Xiong, 1997).

Functional behavior of myofibrillar proteins is influenced by their ability to form viscous gels via protein–protein interactions, to retain water and, in the case of emulsions, to form resistant films on the surface of the fat droplets. The properties of processed meat products such as, tenderness, juiciness and perception of flavors during mastication are based on these functional properties of the proteins.

In order to improve the functional properties of meats, processors are currently using a wide range of vegetable additives, especially soy protein derivates. Often, consumers reject these additives as being chemically modified or as being obtained from genetically modified plants.

Nowadays, interest in developing new technologies to obtain functional extracts, ingredients and additives from slaughter-house by-products, is increasing (McKeith, Bechetel, Novakofski, Park, & Arnold, 1988; Srinivasan, Xiong, & Decker, 1996; Wan, Xiong, & Decker, 1993). Due to their functional properties, myofibrillar protein concentrates obtained from mechanically deboned poultry meat and beef heart can be used in various meat products (Desmond & Kenny, 1998; Ionescu, Aprodu, Zara, & Porneala, 2006; Ionescu, Aprodu, Zara, Vasile, & Gurau, 2003).

Functional properties of proteins, such as gelling capacity, gel strength, viscosity, thermal stability and water-holding capacity are directly related with the proteins' composition and structure. The use of enzymatically catalyzed reactions to modify protein structure is an important way of improving their functional properties (Sakamoto, Kumazawa, & Motoki, 1994; Seguro, Kumazawa, Ohtsuka, Toiguchi, & Motoki, 1995; Seki et al., 1990). One of the most studied enzymes used for structural modification of myofibrillar proteins is bacterial transglutaminase.

Transglutaminase (TGase; EC 2.3.2.13) is an enzyme widely spread in nature; in animal organisms it is localized

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in liver, muscular tissue and body fluids. Transglutaminase catalyses the intra- and intermolecular transverse cross-linking of proteins by an acyl transfer reaction between glutamine (Glu) and lysine (Lys) residues. The structure of the proteins is stabilized by the strong covalent (ε-(γ-Glu)Lys) cross-links between the peptide chains. Jiang, Hsieh, Ho, and Chung (2000) proved, through SDS–PAGE analysis, that bands corresponding to H-meromyosin disappeared and bands corresponding to cross-linked polymers appeared.

The affinity of TGase for different types of protein depends on the distribution of Glu residues as well on the secondary and tertiary structures of the proteins (Matsumura, Chanyongvorakul, Kumazawa, Ohtsuka, & Mori, 1996). Casein, soy proteins, conalbumin, rabbit and carp myosin, beef actin and myosin, ovomucin are examples of proteins which are suitable substrates for TGase (Christensen, Sørensen, Højrup, Petersen, & Ramussen, 1996; Kato, Wada, Kobayashi, Seguro, & Motoki, 1991; Muguruma, Sakamoto, Numata, Yamada, & Nakamura, 1990; Nonaka et al., 1989; Nonaka, Toiguchi, Sakamoto, Kawajiri, Soeda & Motoki, 1994; Sakamoto et al., 1994; Tanaka, Nonaka, & Motoki, 1990).

Moreover, Carrascal and Regenstein (2002) found the effect of microbial TGase on the functional properties of chicken meat proteins. They report an enhancement of emulsion stability and water uptake of chicken muscle proteins treated with TGase.

Our study was focused on bacterial TGase obtained by industrial fermentation of *Streptoverticillium mobarense*, which is commercialized under the name Activa TG, WM, and MP. The Activa products offer various possibilities for the processed food industry (dairy products, meat products, fish and surimi based foods) by (i) standardizing the texture and water-holding capacity, (ii) improving gel consistency and increasing the firmness, elasticity and juiciness of hams, salamis and products based on concentrates of myofibrillar proteins, (iii) improving the nutritive value of the raw materials of low biological value, and (iv) substituting polyphosphates in hams and salamis while maintaining the taste and flavor.

There is little information about the interaction of MTGase with myofibrillar proteins from beef heart. We may expect some variations regarding the interaction between MTGase and myofibrillar proteins from beef heart with respect to those ones reported for chicken muscle proteins, due to differences in the structural organization within the fibers. Myosin of the red fibers, which are the main fibers of cardiac muscle, generally form shorter filaments than the myosin of white muscular fibers. Xiong (1997) found that at protein concentrations of 4–10 mg/ml, the consistency index of breast poultry protein suspensions (white fibers) was higher than one of poultry thighs (red fibers).

The objectives of the present paper were to obtain a functional ingredient based on beef heart myofibrillar proteins and to determine the effect of MTGase on its functional properties.

2. Materials and methods

2.1. Materials

Activa TG-1 MTGase, provided by Ajinomoto (Inc. Teanec, NJ, USA) was used. The enzymatic product is made up of 99% maltodextrin and 1% transglutaminase with a declared enzymatic activity of about 100 UE/g. The enzyme is active over large ranges of temperature (2–60 °C) and pH (5–8), and is inactivated at high temperatures, depending on the composition of the food.

Lygamme EFI80, which is a mixture of 30% xanthan gum and 70% guar gum, was obtained from Eurofood International.

Beef hearts were purchased chilled from specialized stores.

All chemicals used are of analytical grade.

2.2. Proximate composition and pH

The moisture, protein and ash contents of the MPCBH were determined according to standard AOAC (1995) methods. The crude fat content was determined by AOAC (1991) method 991.36. All determinations were made in duplicate.

pH measurements were made according to AOAC (1984). Ten grams of sample was homogenized with 90 ml distilled water for 2 min using the Braun mixer. The obtained mixture was filtered and the pH of the filtrate determined by means of a Hanna digital pH-meter.

2.3. Sample preparation

The myofibrillar protein concentrate was obtained according to Ionescu, Aprodu, Zara, and Porneala (2006). The wet precipitate obtained after the final washing with phosphate with addition of 0.01% propyl gallate, as antioxidant, and centrifugation, was designated the myofibrillar protein concentrate of beef heart (MPCBH) and was characterized. To avoid protein denaturation during the entire washing cycle, the temperature of the dispersion was maintained below 10 °C.

The protein batter was obtained from wet MPCBH by mixing it with a 0.2 g mixture of guar and xanthan gum / 100 g proteins. Homogenization was performed in a Braun mixer for 2 min, with temperature control to avoid raising the temperature. In order to study the effect of transglutaminase concentration and setting time on the functional properties of MPCBH, many tests were performed using different enzyme concentrations (0.0, 0.5, 0.10, 0.20, 0.30, and 0.40 MTGase/100 g protein), and different setting times (30, 60 and 90 min) at 35 °C. After adding the enzyme followed by 1 min homogenization, the samples were maintained in a water bath at 35 °C for the given