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Effect of whey protein concentrate and sodium chloride addition plus tumbling procedures on technological parameters, physical properties and visual appearance of *sous vide* cooked beef

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Abstract

Beef muscles cooked by the *sous vide* system were evaluated for the effects of pre-injection tumbling, brine addition and post-injection tumbling on technological parameters, physical properties, visual appearance and tissue microstructure. The muscles were injected at 120% (over original weight) with a brine formulated to give a concentration of 3.5% whey protein concentrate and 0.7% sodium chloride on an injected raw product basis. Pre-injection tumbling did not affect most of the evaluated parameters. Brine addition reduced significantly the cooking and total weight losses. Total weight loss was 7.2% for injected muscles, and significantly higher (28.2%) for non-injected ones. Brine incorporation increased pH and reduced shear force values of cooked muscles. Extended post-injection tumbling (5 rpm–10 h) improved brine distribution and visual appearance, and also diminished the shear force values of cooked muscles. However, this treatment increased the weight losses of post-injection tumbling and cooking-pasteurization stages.

Keywords: Beef; Sous vide; Whey protein; Tumbling; Sodium chloride

1. Introduction

Sous vide processing is the application of a cooking-pasteurization thermal process to food packaged in a hermetically sealed vacuum pouch or tray (Church & Parsons, 1993). These products require refrigeration at temperatures of 0–3 °C, and under this condition they could be stored for 3–5 weeks before reheating and consumption (Nyati, 2000; Vaudagna et al., 2002).

The *sous vide* beef products appear as an interesting alternative to diversify the consumption of beef ready-to-eat products (Green, 2004). However, this type of products presents technological difficulties such as the retention, inside the package, of liquid released during cooking (Boles & Shand, 2002; Corrales et al., 2004). This problem is relevant, especially regarding commercial profits and product appearance. Hence, the use of mild thermal treatments (Califano, Bértola, Bevilacqua, & Zaritzky, 1997; Vaudagna et al., 2002) and the addition of brines containing sodium chloride (NaCl) and alkaline phosphates was suggested to reduce cooking weight loss. In order to improve salt distribution throughout the muscle, after brine incorporation, the use of an equilibration period at refrigerating

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temperature (Sheard, Nute, Richardson, Perry, & Taylor, 1999) or the application of mechanical treatments (i.e. massaging, tumbling) (Boles & Shand, 2002; Lachowicz et al., 2003; Pietrasik & Shand, 2003, 2004, 2005) was suggested.

During the last decade, several researchers have investigated the effect of natural functional ingredients (i.e. whey and soy protein isolate and concentrate, polysaccharide gums, starches and blood plasma) on physical and sensory characteristics of cooked meat products (Chen & Trout, 1991; Lin & Keeton, 1998; Shand, Sofos, & Schmidt, 1993; Thomsen, 1996). They evaluated the potential use of natural ingredients to replace or reduce the addition of NaCl and alkaline phosphates to meat products, because of health and technological concerns (Arnau, Guerrero, & Gou, 1998; Ruusunen & Puolanne, 2005). Particularly, whey protein concentrate (WPC) was employed to increase water holding capacity (WHC), improve sensory quality, enhance nutritional values and obtain stable emulsions (Corrales et al., 2004; El-Magoli, Laroia, & Hansen, 1996; Hayes, Desmond, Troy, Buckley, & Mehra, 2006; Hughes, Mullen, & Troy, 1998; Thomsen, 1996; US Patent 5.217.741, 1993).

Brines containing WPC present higher viscosity than conventional, and it induces an unevenly brine distribution in the injected meat pieces (Corrales & Corrales, 2005). This disadvantage is relevant, specially in high quality products processed with low injection rates (10–30%) and high WPC levels [i.e. 3.5% (w/w) product basis], where the brines are more concentrated. Therefore, to improve the adsorption and distribution of such brines, either the brine incorporation procedure applied or the selection of mechanical treatments becomes significant.

Tumbling is a well recognised technique in meat industry. It induces tissue structure softening and rupture, which causes an increase of brine sorption and protein extraction, and consequently an increment of cooking yield (Xargayó, Freixanet, Lagares, Fernandez, & De Jaeger-Ponnet, 1998). Tumbling treatments have been widely applied to pork. However, information about tumbling applied to beef is scarce and non quite appropriate referring to the incorporation of natural functional ingredients. Recently, the application of mechanical treatments previous to brine addition and its effect on processing parameters of cooked beef have been investigated. Boles and Shand (2002) found that the application of short tumbling prior to injection improved yield and tenderness of roast beef. Moreover, according to Xargayó et al. (1998) the pre-massaging of hind quarter bovine muscles improved the brine penetration, reduced the total massaging time required to get the final product and increased the product binding and yield. Hence, the pre-injection tumbling procedure seems to be a useful tool to improve WPC brine distribution.

The aim of the present research was to evaluate the combined effect of WPC and NaCl addition plus the application of pre- and post-injection tumbling procedures on technological parameters, physical properties and visual appearance of *sous vide* cooked beef muscles.

2. Materials and methods

2.1. Materials

One hundred and eight *Semitendinosus* muscles were dissected from British breed steer carcasses 48 h post slaughter, trimmed free of fat, vacuum packaged (Cryovac BB4L, Sealed Air Co., Buenos Aires, Argentina), stored for 72 h at 1.5 ± 0.5 °C and then processed. The trimmed raw muscles had an average weight of 1607.6 ± 131.5 g and a pH of 5.59 ± 0.08. Total viable count mean value of raw muscles was 2.1 log CFU cm^{-2}.

The ingredients used in the brine formulation were whey protein concentrate [Lacprodan 80, Arla Food Ingredients S.A., Buenos Aires, Argentina; protein content as is $78 \pm 2\%$ (w/w)] and sodium chloride (Dos Anclas, Buenos Aires, Argentina).

2.2. Preparation of the samples

The main factors investigated were pre-injection tumbling (PreIT: 0, 1.5 and 3 h at 2.5 rpm), brine injection (non-injected muscles, NIM; injected muscles, IM) and post-injection tumbling (PostIT: 0, 2 and 10 h at 5 rpm). The factorial design applied is described in Table 1. The complete design was carried out in triplicate (total number of muscles: 108). For each replicate, 36 muscles were randomly assigned to the 18 treatments (two muscles per treatment).

All muscles were weighted and vacuum packaged (Cryovac CN510, Sealed Air Co., Buenos Aires, Argentina). The muscles assigned to PreIT treatment were submitted to continuous tumbling at 2.5 rpm for 1.5 or 3 h at 1.5 ± 0.5 °C in a Lance Industries tumbler (model LT-15, Allenton, USA). For this purpose, a drum load of approximately 45 kg (half of working capacity) was used under constant vacuum (15 mmHg). Instead, non-tumbled muscles (NPreIT) were stored at 1.5 ± 0.5 °C. Then, the muscles selected for brine incorporation were weighed and injected with a one needle hand operated brine pump (needle diameter: 4 mm, number of holes: 14; Dick Lokespritze Esslingen A.NX., Germany). The first injection (central point) was applied axially from each end to the medial portion of the muscle. After that, another four injections were made also axially around the central point, close to the surface. Beef muscles were injected to 120% over original weight (measured before the pre-tumbling treatment). The brine was formulated to give a concentration of 3.5% (w/w) WPC (maximum amount approved, USDA, 2001) and 0.7% (w/w) NaCl based on raw injected muscle basis. Brine temperature was 1.5 ± 0.5 °C and the pH was 6.30 ± 0.12. Muscles temperature previous to the injection was 3.0 ± 1.0 °C. After the injection procedure, the muscles were immediately vacuum packaged in Cryovac CN510 bags (Sealed Air Co., Buenos Aires, Argentina).