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The effect of high pressure on the microbiological quality and other characteristics of cooked sausages packed in a modified atmosphere or vacuum

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ABSTRACT

The aim of this study was to analyse the effect of high pressure (HP) on the shelf life and other selected characteristics of two types of cooked sausages, which were packed under vacuum or modified atmosphere. The total viable count in samples treated with 600 MPa/5 min decreased during 35 days of storage (4 ± 2 °C) to a maximum of 1.3 log CFU/g. Microbial counts of 4–5 log CFU/g were detected in control samples not subjected to HP. Instrumental colour analysis did not reveal any statistically significant differences between the meat products subjected to HP and the control samples during the course of the experiment. No statistically significant differences were found during the sensory evaluation when meat samples subjected to HP and control samples were assessed.

1. Introduction

The spoilage of meat products occurs as the result of bacterial growth or chemical changes, primarily oxidation (Shah, Bosco, & Mir, 2014). If producers want to ensure an adequate shelf life for their products, or extend this shelf life, they must restrict the action of the given negative factors.

The main bacterial group associated with the spoilage of cooked meat products are lactic acid bacteria (Samelis, Kakouri, & Rementzis, 2000; Vermeiren, Devlieghere, De Graef, & Debevere, 2005). The combination of microaerophilic conditions in the product, the presence of sodium chloride and sodium nitrite, and reduced water activity is favourable to their growth (Audenaert et al., 2010). The cooking process plays a significant role in the selection of the bacteria that may get into the product along with the raw material (meat) and additives used or from the production environment (Comi & Iacumin, 2012). However, heat treatment is not always effective in view of thermo tolerant vegetative forms of bacteria, and has no effect on the secondary contamination that may occur during product handling following cooking (del Olmo, Calzada, & Nuñez, 2014a). Any surviving bacteria and secondary contaminating microbes multiply during the subsequent storage of meat products to reach values of 7 log CFU/g, often considered as the spoilage threshold, and higher (Matagaras, Skandamis, Nychas, & Drosinos, 2007; Pothakos, Samapundo, & Devlieghere, 2012).

In view of the resilience of microorganisms of meat product spoilage, and of lactic acid bacteria (LAB) in particular, it is not easy to apply measures for their complete inhibition (Gill & Holley, 2000). Bacteriocin nisin is an effective natural antimicrobial agent, though it is not, as yet, permitted for use in meat products in the EU (Regulation (EC) No. 1333/2008 of the European Parliament and of the Council). Other similar products, such as, for example, pediocin, are not effective against LAB and there are, therefore, no grounds for their addition to food products (Kalschne, Geitenes, Veit, Sarmento, & Colla, 2014).

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Among physical factors, the use of temperatures of more than 80 °C has a negative effect on the sensory characteristics of products and degrades their nutritional constituents. Treatment with high hydrostatic pressure (HP) would seem an attractive method of treatment to extend the shelf life and safety of meat products (Aymerich, Picouet, & Monfort, 2008; Bajovic, Bolumar, & Heinz, 2012). The majority of vegetative forms of microorganisms in meat products are inactivated by the action of pressures of 400–600 MPa for a period of several minutes at room temperature (Han et al., 2011). High-pressure processing (HPP) technology does not degrade the nutritional value of foodstuffs (Grossi, Søltoft-Jensen, Knudsen, Christensen, & Orlien, 2011) and reduces the necessity of certain additives without reducing the shelf life of the product (Huang, Lung, Yang, & Wang, 2014). A number of publications describing the effect of HPP on meat products have appeared in the literature in recent years (Al-Nehlawi, Guri, Guamis, & Saldo, 2014; Bak et al., 2012; Grossi et al., 2011; Han et al., 2011). While the effect of HPP on vegetative bacteria is clear (Campus, 2010), conflicting information is appearing in relation to HPP and certain product characteristics, e.g. their colour, and no comparison of the effect of HPP on identical products packed in various forms of protective packaging, i.e. under modified atmosphere and vacuum, has been published to date.

This study aims to analyse the effect of the action of high pressure on the shelf life and selected characteristics of typical cooked meat products during the course of refrigeration storage following their packing under vacuum or modified atmosphere.

2. Material and methods

2.1. Preparation of cooked sausages

Two types of cooked sausages were prepared in a meat-processing factory. The recipe of Sausage 1 consisted of (per 100 kg of finished product): pork trimmings 18.0 kg, mechanically deboned chicken meat 52.0 kg, ice 31.0 kg, soya protein 4.0 kg, potato starch 3.5 kg, nitrite curing salt 1.7 kg, seasonings 0.7 kg. The recipe of Sausage 2 was: pork trimmings 28.0 kg, mechanically deboned chicken meat 48.0 kg, ice 30.0 kg, soya protein 3.0 kg, potato starch 2.0 kg, nitrite curing salt 1.8 kg, seasonings 0.7 kg. The raw material and ingredients were ground and mixed in a bowl cutter (Laska, Traun, Austria) and emulsified in an emulsifier (Inotec GmbH, Reutlingen, Germany). The sausages were filled into casings by a Handtmann vacuum-filling machine (Biberach, Germany). Natural pork casings 30–32 mm in diameter were used for Sausage 1, while Devro collagen casings 19 mm in diameter (Slavkov, Czech Republic) were used for Sausage 2.

Cooking was performed along with smoking with hot smoke in a Vemag device (Verden, Germany) to a core temperature of 70 °C for a period of 10 min. The temperature was monitored with a PT 100 insert thermometer (Vemag, Verden, Germany) and a traditional smoke generator with beech chips was used for smoke production. Cooking was followed by cooling to 4 °C and protective packing.

A Tiromat thermoformer packing machine (Krämer-Grebe, Germany) was used for packing. Half the products of each type were vacuum-packed, the other half packed in a modified CO_2: N_2 atmosphere at a ratio of 30%: 70%. Buergofol top film (Siegenburg, Germany) of a thickness of 55 μm with an OTR of 5 $cm^3/m^2/24$ h/1 atm was used for packing. The bottom film used was Flex F 170 (Bemis, Prague, Czech Republic) of a thickness of 170 μm with an OTR of 20 $cm^3/m^2/24$ h/1 atm. Each package contained around 200 g of product. A total of 192 samples of packed meat products were prepared and tested.

2.2. High-pressure treatment

High-pressure treatment was performed on packed meat products 24 h after packaging. Storage temperature of sausages after manufacture and before high pressure treatment was 2 ± 2 °C. A Multivac HPP 055 device (Wolfertschwenden, Germany) was used with parameters set to 600 MPa for a period of 5 min at room temperature. A total of 96 packages were treated with high pressure, the remaining 96 packages were left untreated as a control. After treatment, the samples were stored at 4 ± 2 °C until the end of the experiment. Sampling for tests took place 24 h after HP treatment (0) and then on days 21, 28 and 35. Six packages from each experimental unit were sampled on each of these days – Sausage 1: vacuum non-treated (VNT), vacuum with HP (VHP), modified atmosphere non-treated (MNT), modified atmosphere with HP (MHP); Sausage 2: vacuum non-treated (VNT), vacuum with HP (VHP), modified atmosphere non-treated (MNT), modified atmosphere with HP (MHP).

2.3. Microbiological analyses

Sampling took place according to EN ISO 6887-2. Samples were analysed for various groups of spoilage bacteria – *Enterobacteriaceae*, Total Viable Count (TVC), Lactic Acid Bacteria (LAB) and psychrotrophic bacteria (PSY).

TVC and PSY were determined using Plate Count Agar (Merck, Germany) after incubation for 72 ± 3 h at 30 °C and 10 days at 6.5 °C, respectively, according to EN ISO 4833 and EN ISO 17410. The quantification of LAB was performed on de Man, Rogosa and Sharpe agar (MRS Agar, CM0361, Oxoid) incubated for 72 ± 3 h at 30 ± 1 °C, in accordance with ISO 15214. The *Enterobacteriaceae* count was determined using Violet Red Bile Glucose agar (VRBG, Oxoid) incubated for 24 h at 37 °C according to ISO 21528-2.

The number of colonies formed was counted and reported as log CFU/g for each sample.

2.4. Sensory evaluation

The sausages were evaluated by a panel consisting of 12 judges selected from the students and staff members of the Department of Meat Hygiene and Technology, taking into account their habits, acquaintance with the material to be analysed, sensitivity and ability to reproduce judgements. Evaluations were performed in individual booths prepared as described by ISO 6658. Unsalted crackers and water at room temperature were provided to clean the palate between samples. The sensory analysis was carried out using non-structured 100-mm hedonic scales on which the panellists evaluated various attributes: cut surface appearance, odour, colour, consistency, texture, taste, matrix, intensity of salt and overall acceptance (0 = very unpleasant and 100 = very pleasant). The sausage samples were warmed before evaluation (water bath 70 °C/5 min).

2.5. Instrumental colour measurement and determination of thiobarbituric reactive substances (TBARS)

Colour (on the cut) was measured by the CIE L*a*b* system using a Minolta CM 2600d (Konica Minolta, Japan). A measuring area of 8 mm, illuminant D65 and 10° standard observer were used. The instrument was standardised using a standard white plate. CIE L* – lightness, a* – redness, b* – yellowness were calculated. The mean value of every sample was calculated from five measurements.

The degree of lipid oxidation was measured by reaction with thiobarbituric acid after distillation according to the method of Castellini, Mugnai, and Dal Bosco (2002) – TBARS value