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The effects of packaging method (vacuum pouch vs. plastic tray) on spoilage in a cook-chill pork-based dish kept under refrigeration

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ABSTRACT

The effects of two packaging methods on the spoilage of a cook-chill pork-based dish kept under refrigeration were studied. Raw pork cuts and pre-cooked tomato sauce were packed under vacuum "*sous vide*" in polyamide–polypropylene pouches (SV) or into translucent polypropylene trays under modified atmosphere (80% N_2 + 20% CO_2) and sealed with a top film (PT). Samples were cooked inside the pack at an oven temperature/time of 70 °C/7 h, chilled at 3 °C and stored at 2 °C for up to 90 days. Microbial (psychrotrophs, lactic-acid bacteria, *Enterobacteriaceae*, moulds and yeasts), physical–chemical (pH, water activity and total acidity) and sensory (colour, odour, flavour, texture and acceptance) parameters were determined. Heat penetration was faster in SV (2 °C/min) than in PT (1 °C/min) (core temperature). Both packaging methods were equally effective in protecting against microbial spoilage for 90 day at 2 °C. Minor counts were only detected for lactic-acid bacteria and anaerobic psychrotrophs in SV. No *Enterobacteriaceae* growth was found. Slight differences between SV and PT in pH and total acidity were observed. SV and PT had similar effects on the sensory preservation of the dishes. A gradual loss of acceptance of the cooked pork and tomato sauce was observed. Rancid flavour in PT and warmed-over-flavour in SV were noted in the final stages of storage. According to acceptance scores, the shelf-life of both SV and PT was 56 days at 2 °C. Both packaging methods can be used to manufacture *sous vide* meat-based dishes subsequently stored under refrigeration for catering use.

1. Introduction

Catering services, food processing plants and retail sectors are employing novel methods to deliver home-made style meat-based meals of high quality and with a long shelf-life (Creed & Reeve, 1998; Hrdina-Dubsky, 1989). Present trends involve cooking the meat inside the final packaging in its own juice or accompanied by a sauce in order to make the cooking, preservation treatment and, frequently, final presentation a one-step process. *Sous vide* technology is defined "food cooked under controlled conditions of temperature and time inside heat-stable vacuum pouches" (Schellekens & Martens, 1992). *Sous vide* method involves cooking/pasteurisation temperatures of 65–95 °C applied over long periods (upto 16 h), followed by rapid cooling to attain a temperature of 3 °C in the centre of the product (Creed, 1998). Dishes are stored at temperatures below 3.3 °C to prevent the growth of *Clostridium botulinum*, *Bacillus cereus* and other pathogenic microbes resistant to the pasteurisation (Hatherway, 1992). However, refrigerated *sous vide* meat can suffer spoilage by the action of lactic-acid bacteria (Borch, Kant-Muermans, & Blixt, 1996; Korkeala & BjÎrkroth, 1997), which produce sour off-flavours and off-odours, milky exudates, a slimy texture and CO_2, which may cause swelling of the pack and/or greening (Egan, 1983; Korkeala & BjÎrkroth, 1997). Moulds and yeasts can also grow in refrigerated *sous vide* meats (Díaz, Nieto, Garrido, & Bañón, 2008; Nyati, 2000; Wang, Chang, & Chen, 2004). In addition, meat prepared by this method may undergo proteolysis, lipolysis and enzymatic and/or chemical oxidation during refrigerated storage, leading to changes in texture, colour, odour and flavour, sometimes accompanied by a loss of firmness, darkening, rancidity, sourness and other off-odours and off-flavours.

Cook-chill dishes are usually packed in vacuum flexible pouches or plastic semi-rigid trays (Ghazala, Ramaswamy, Smith, & Simpson, 1995). The vacuum pouches should present low oxygen and steam permeability and good thermal (−40/+120 °C) and mechanical resistance (Bañón, Nieto, & Díaz, 2007). The main advantages of using vacuum pouches are the complete elimination of oxygen and maximum heat transfer during cooking (De Baerdemaeker & Nicolaï, 1995). However, filling, packaging and manipulation of the pouches may be complicated in the case of dishes accompanied by sauces or liquid portions, while the storage of large numbers of the same may lead to them rupturing. At the same time, the presentation of the products may not be attractive to consumers and sometimes another container may be necessary for re-heating before eating. An alternative to using pouches for

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sous vide cooking can be to use plastic trays sealed with plastic films of low oxygen and steam permeability, since plastic trays are more resistant and easier to fill (in the case of liquids), more attractive to consumers and offers the possibility of being used both for re-heating and consumption. However, the use of plastic trays implies the use of gas mixtures to prevent them from collapsing and to eliminate head space oxygen. This type of packaging may also lead to condensation and moisture migration in the cooked product (Lingle, 1992). While several authors have looked at the quality and shelf-life of *sous vide* meat products cooked in pouches (Armstrong & McIlveen, 2000; Nyati, 2000; Vaudagna et al., 2002; Wang et al., 2004; Díaz et al., 2008), few have studied the effect that plastic trays sealed in a modified atmosphere have on the spoilage of cooked meat. For this reason, the objective of this work was to compare the effect of cooking in vacuum pouches and plastic trays on the sensory quality and shelf-life of meat-based cooked meals.

2. Materials and methods

2.1. Preparation of cook-chill pork with tomato sauce

Raw pork cuts and pre-cooked tomato sauce were prepared in polypropylene trays and vacuum pouches by a local company (Rational Food, S.A., Cartagena, Spain). Two batches of each product were manufactured (200 kg of pork and tomato sauce per batch). Hams were boned and backfat removed. Pork was cut in cubes (3 cm approximately), the cubes were mixed in a container and randomly distributed with the tomato sauce into packs. Tomato sauce (fried onion 10%, sugar 5%, fried tomato 65.5%, salt 0.5%, virgin olive oil 1% and concentrated tomato 18%) was pre-cooked in a kettle with stirrer at 150 °C/90 min. Each tray and pouch contained 220 g of pork (ham) and 280 g of tomato sauce. PT samples were packaged in polypropylene translucent trays (PC/45 TL, Hillfast Iberica, S.A., Barcelona, Spain) measuring 13 × 18 × 4 cm, with a capacity of 750 ± 0.5 ml and heat resistance from −25 °C to 115 °C. The trays were heat sealed (Taurus 420, ULMA, Oñati, Spain) with a top film (Xpoliester/PLPMC 12 + 75, Wipack, Hamburg, Germany) with an O_2 transmission rate of 114 $cm^3/m^2/24$ h and initial vacuum of 101 mbar, 30 mbar of initial gas mixture (80% N_2 + 20% CO_2) and 70 mbar of final gas mixture. SV samples were packed in polyamide–polypropylene pouches (Wipack, Hamburg, Germany) with a heat resistance from −40 °C to 120 °C, O_2 permeability of 7 $cm^3/m^2/24$ h at 4 °C/80% RH and water steam permeability of 0.8 $g/m^2/24$ h. The pouches were heat sealed using a vacuum sealing machine (EGAR 8, Egarvac S.L., Barcelona, Spain). All samples were cooked in an oven at 70 °C for 7 h (Climaplus Combi CPC G, Rational Aktiengesellschaft, Landsberg am Lech, Germany). Internal temperature/time was 70 °C/6 h + 44 min for SV and 70 °C/6 h + 15 min for PT. The internal temperature during heating was measured with a thermocouple. After heating, the samples were immediately chilled using a blast chiller (Friulinox, Pordedone, Italy) until reaching an internal temperature of 3 °C in 90 min. After chilling, samples were stored at 2 °C for 0, 13, 26, 41, 56, 69, 82 or 90 days in a cold room without lighting to evaluate the spoilage of the PT and SV dishes. The proximate composition of dish was a moisture content of 71.19 g/100 g (ISO 1442:1997), a protein content of 13.17 g/100 g (ISO 937:1978), a fat content of 5.05 g/100 g (ISO 1443:1973) and an ash content of 2.29 g/100 g (ISO 936:1998).

2.2. Microbiological analyses

For microbiological assays, bags were aseptically opened in a microbiology cabinet (Telstar, Bio-II-A, Tarrasa, Spain) and samples were weighed with a sterile tweezers into masticator bags and blended with peptone water (Oxoid Ltd. CM0087, Tryptone water, 0.1%) in a masticator (IUL Instruments, GMBH, Königswinter, Germany). Total anaerobic psychrotrophs (ANP) were counted on Tryptone Soya Agar (TSA) (Oxoid Ltd. CM0131, Basingstoke, Hampshire, United Kingdom) in anaerobic jars at 4 °C for 7 days. Total aerobic psychrotrophs (ARP) were counted on Plate Count Agar (PCA) (Oxoid Ltd. CM0325, Basingstoke, Hampshire, United Kingdom) at 4 °C for 7 days (ISO 17410, 2001). Lactic-acid bacteria (LAB) were counted on De Man, Rogosa, Sharpe Agar plates (MRS) (Oxoid Ltd. CM0361, Basingstoke, Hampshire, United Kingdom) and incubated at 30 °C for 72 h in ST 6120 culture incubator (Heraeus S.A., Boadilla, Madrid, Spain) (ISO 15214, 1998). Total *Enterobacteriaceae* (EN) were counted on Violet Red Bile Glucose Agar plates (VRBG) (Oxoid Ltd. CM0485, Basingstoke, Hampshire, United Kingdom) and incubated at 37 °C for 24 h (ISO 21528-2, 2004). Moulds and yeasts (MY) were counted on Rose-Bengal plates with chloramphenicol (RB) (Oxoid Ltd. CM0549, Basingstoke, Hampshire, United Kingdom) and incubating at 25 °C for 5 days (ISO 21527-1, 2008).

2.3. Physical and chemical analyses

Water activity, pH and total acidity were determined. Water activity (a_w) was measured using a water activity meter (Novasina TH200 Axair AG, Pfäffikon, Switzerland) (ISO 21807, 2004). The pH was measured with a Crison micropH 2001 pH meter (Crison, Barcelona, Spain) using a combined electrode Cat no. 52-22 (Ingold Electrodes, Inc. Wilmington, USA) (ISO 2917, 1999). Total acidity was measured by titrating with NaOH, using phenolphthalein (1%) as indicator. Total acidity was determined as lactic acid in grams per 100 g sample (Salfield, 1975).

2.4. Sensory analysis

For the sensory analysis, samples were heated in a covered plastic container using a microwave (Balay S.A., South Korea) at full power (850 W) for 2.5 min until reaching an internal temperature of 72 °C, as measured by a portable T200 thermometer. The warmed samples were then presented to the eleven panellists in small aluminium trays. The panellists were selected and trained according to ISO standards (ISO 8586-1, 1993). There were four training sessions. In the two first sessions, the colour, odour, flavour and texture descriptors of cooked pork meat with tomato sauce were studied; the next two sessions were concerned with identifying, selecting and quantifying cooked product spoilage attributes. Sensory analysis was carried out according to ISO 4121 (2003). Cooked pork meat with tomato sauce was evaluated using eight spoilage attributes: warmed-over odour (WO), rancid odour (RO), acid odour (AO), warmed-over-flavour (WF), rancid flavour (RF), acid flavour (AF), darkening (DR) and emulsion loss (EL). Nine quality attributes were also studied: colour (CQ), odour (OQ), flavour (FQ), meat tenderness (TE), meat juiciness (JU), consistency of the tomato sauce (CS), tomato sauce quality (SQ), vegetables quality (VQ) and overall acceptance (OA). Attributes were scored using a point scale ranging from 1 to 7. The ends of the scale were: 1 (minimum perception) and 7 (maximum perception) for TE, JU, VQ and SQ; 1 (not perceptible) and 7 (maximum perception) for CQ, OQ, FQ and DR; 1 (no phase separation) and 7 (maximum phase separation) for EL; 1 (minimum viscosity) and 7 (maximum viscosity) for CS and 1 (minimum acceptance) and 7 (maximum acceptance) for OA. If the score was lower than 4, the product was considered to be unacceptable. Sensory analysis was made on days 0, 13, 26, 41, 56, 69, 82 and 90 of storage.