

Physical-chemical, microbial and sensory spoilage during the refrigerated storage of cooked Iberian pig *massetero* muscle with sauce processed by the *sous vide* method

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Abstract

The aim was to study spoilage during the refrigerated storage of cooked Iberian pig *massetero* muscle with vegetables sauce processed by the *sous vide* method. Samples under modified atmosphere (80% N₂ y 20% CO₂) were packaged into white polypropylene trays and sealed with transparent film, cooked at an oven temperature/time of 70 °C/16 h, chilled at 3 °C and stored at 2°C for 0, 15, 29, 43, 57, 72, 85 or 98 days. Microbial (lactic acid bacteria, *Enterobacteriaceae*, moulds and yeasts), physical-chemical (pH, water activity and acidity) and sensory (appearance, odour, flavour, texture and acceptance of meat and sauce) parameters were determined. The results showed that sensory spoilage preceded microbiological spoilage. Counts below 1 log cfu/g of moulds and yeasts and absence of lactic acid bacteria and *Enterobacteriaceae* were detected in any control day. Water activity no changed during storage and minor changes in pH and acidity were associated with spoilage. This dish was unacceptable after 98 days due to acceptance loss. This fact mainly was produced by meaty flavour and odour loss, increase of warmed over flavours and odours, colour loss and changes in texture of meat and sauce. The sensory analysis was the most effective method for determining the shelf life of the *sous vide* meat-sauce-based dishes.

Introduction

Sous vide technology permits pre-cooked meat-based dishes of high sensory and nutritional quality to be obtained with a longer shelf life than is possible using other cooking-cooling methods. The vacuum packing used in *sous vide* technology delay the oxidation of lipids and muscle pigments, while slowing down the microbiological spoilage of cooked foods during refrigerated storage. The shelf life of *sous vide* cooked meat-based products has been established at 4-7 weeks, depending on the product and processing conditions.

Materials and methods

Two batches of cooked Iberian pig *massetero* muscle with vegetables sauce were prepared. Vegetables sauce (commercial fried onion, commercial fried tomato, salt, virgin olive oil, cooked meat, carrots, peas, meat juice, crushed garlic, pepper, roux and wine) was pre-cooked in a kettle with agitator at 100°C/30 min. The samples were packaged into white polypropylene trays with dimensions of 30 x 24 x 5 cm³, capacity of 3000 ± 10 ml and temperatures range from -25°C to +115°C. Each tray contained 2 Kg of pre-thawed Iberian pig *massetero* muscle and 500 g of vegetables sauce. The trays were heat sealed using a packer (Taurus 420, ULMA, Oñati, Spain) with a top film (Xpoliester/PLPMC 12+75, Wipack, Hamburg, Germany) with an O₂ transmission rate of 114 cm³/m²/24h and initial vacuum of 101 mbar, 30 mbar of initial gas mixture (80% N₂ + 20% CO₂) and 20 mbar of final gas mixture. All samples were cooked in oven at 70°C for 16 h. Internal temperature/time measured with a thermocouple was 70°C/15h+4 min. After heating, the samples were immediately chilled using a blast chiller until reaching a internal temperature of 3°C in 90 min. After chilling, samples were stored at 2°C for 0, 15, 29, 43, 57, 72, 85 or 98 days in a cold room without lighting to evaluate the physical-chemical, microbial and sensory spoilage. For the physical-chemical analysis, water activity, pH and total acidity were determined on the homogeneous sample (44% thin of pork + 66% tomato sauce and vegetables). To evaluate microbial spoilage, lactic acid bacteria (LAB), *Enterobacteriaceae* (EC) and moulds and yeasts (MY) were counted. Sensorial analysis (11 trained judges) was carried out according to ISO 4121 (2003). The samples were evaluated using 9 spoilage attributes and 7 quality attributes. Attributes were scored using a point scale ranging from 1 to 7. The scales used were: 1 (non-perceivable) to 7 (strong intensity) for spoilage and quality attributes. If the score was lower than 4, the product was considered as unacceptable. A completely random statistical model was designed. Descriptive statistics were determined, considering days of storage as treatments. Effect of storage were determined by ANOVA (Scheffe means Test).

Results and discussion

The physical-chemical parameters studied point to no significant effect on the product's shelf-life. The water activity remained at a mean value of 0.94, while pH ranged between 5.64 and 6.04. Acidity began at 0.006% and remained constant until day 43, when it rose significantly ($P<0.05$) to 0.10%. This level was then maintained until day 57 (0.12%), after which it fell to 0.08% after 98 days of storage.

Microbiological counts were below the limit of detection (10 cfu/g) for MY and absent for EN and LAB after 98 days of storage.

Table 1 shows the mean values and standard deviations of the sensory attributes of *sous vide* Iberian pig *massetero* muscle kept refrigerated for 0, 15, 29, 43, 57, 72, 85 and 98 days. WF, RF, WO and PS were the only spoilage attributes that showed significant differences ($P<0.05$) during the 98 days of storage. WF increased from initial values of 1.14 to reach 2.12, an increase that may have been related with the increase in RF from 1.11 (day 0) to 1.85 (day 98). WO, with a minimum value of 1.02 (day 0) and maximum of 2.27 (day 98) evolved in a similar way to WF and RF. Storage led to phase separation in the sauce that was detectable from day 29. This was not observed in the recently cooked samples but PS values increased with time to reach values of 1.95 on day 29 and 2.22 on day 98. AF, RO, AO, DR and SF showed low values and only exceeded 2.00 on certain days.

All the quality attributes decreased during storage with statistically significant differences ($P<0.05$). The loss in CQ was significant after 57 days, while the decrease in OQ and FQ was noticeable after only 29 days. The scores for these attributes were above 4.00 during the whole 98 days of the experiment, and only FQ had fallen (2.75) by day 98. During storage, meat texture altered very little. TM and JM showed high values (6.50-4.77) and loss of texture was not noticeable until the end of the storage period (5.05 and 4.77, respectively). Storage affected the viscosity of the sauce due to separation of an aqueous phase. This resulted in a significant decrease ($P<0.05$) in SQ from day 29, to reach 3.97 by day 98. TPQ values in the recently cooked product were 6.8, which began to fall significantly ($P<0.05$) from day 29 (5.09). TPQ values were above 4.00 throughout storage except on day 98 (3.97). In this way, according to sensory criteria, the shelf-life of the Iberian pig *massetero* muscle with sauce prepared by the *sous vide* method was established to be 98 days.

The product remained stable according to the physical-chemical and microbiological spoilage indices. However, the sensory study pointed to the appearance of off-odours and off-flavours characteristic of spoilage in cook-chill foods. At the same time, storage led to a rapid loss of colour, odour and flavour quality, although the texture remained acceptable for a longer time. During storage the sauce also separated into phases, becoming more watery, an observation made by other authors for meat-based recipe dishes with sauce (Armstrong & McIlveen, 2000). According to the sensory quality parameters, the shelf-life of the product could be put at 98 days, which is far longer than other authors have suggested for *sous vide* meat dishes without sauce (Nyati, 2000, Díaz et al., 2008). The use of sauces in *sous vide* meat products may mask the changes produced in their sensory characteristics during storage and so prolong sensory quality (Schafheitle, 1990; Hansen, et al., 1995; Antoun & Tsimidou, 1997).

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Table 1. Average values and standar desviations of sensorial analysis of *sous vide* cooked Iberian pig *massetero* muscle stored during 0, 15, 29, 43, 57, 72, 85 or 98 days (2°C)

Days	0	15	29	43	57	72	85	98
WF	1.14 ± 0.31 ^b	1.26 ± 0.50 ^b	1.34 ± 0.56 ^b	1.67 ± 0.63 ^{ab}	1.70 ± 0.64 ^{ab}	1.55 ± 0.68 ^{ab}	1.80 ± 0.80 ^{ab}	2.12 ± 0.81 ^a
RF	1.11 ± 0.31 ^{ab}	1.00 ± 0.00 ^b	1.23 ± 0.46 ^{ab}	1.30 ± 0.57 ^{ab}	1.42 ± 0.54 ^{ab}	1.50 ± 0.58 ^{ab}	1.65 ± 0.67 ^{ab}	1.85 ± 1.23 ^a
AF	1.64 ± 0.76	1.82 ± 0.61	2.09 ± 1.01	1.70 ± 0.59	1.77 ± 0.62	1.55 ± 0.50	2.47 ± 0.55	1.97 ± 0.73
WO	1.02 ± 0.11 ^b	1.29 ± 0.59 ^b	1.57 ± 0.54 ^{ab}	1.47 ± 0.66 ^b	1.60 ± 0.68 ^{ab}	1.75 ± 0.72 ^{ab}	1.75 ± 0.82 ^{ab}	2.27 ± 0.92 ^a
RO	1.00 ± 0.00	1.03 ± 0.12	1.04 ± 0.21	1.17 ± 0.59	1.35 ± 0.46	1.55 ± 0.76	1.35 ± 0.56	1.37 ± 0.74
AO	1.59 ± 0.50	1.85 ± 0.58	1.93 ± 0.47	1.90 ± 0.45	2.05 ± 0.74	2.15 ± 0.94	2.17 ± 0.73	1.97 ± 0.77
DR	1.00 ± 0.00	1.09 ± 0.26	1.29 ± 0.50	1.60 ± 0.58	1.30 ± 0.44	1.00 ± 0.00	1.47 ± 0.72	1.35 ± 0.81
SF	1.04 ± 0.21	1.06 ± 0.17	1.61 ± 0.75	1.80 ± 1.20	1.85 ± 1.10	1.70 ± 0.54	2.05 ± 1.46	2.10 ± 1.01
PS	1.00 ± 0.00 ^c	1.18 ± 0.39 ^{bc}	1.95 ± 0.72 ^{ab}	2.20 ± 0.78 ^a	2.10 ± 0.80 ^{ab}	2.35 ± 0.91 ^a	2.20 ± 1.12 ^a	2.22 ± 0.83 ^a
CQ	6.27 ± 0.88 ^a	6.12 ± 0.78 ^{ab}	5.25 ± 1.11 ^{abc}	5.15 ± 0.74 ^{abc}	4.87 ± 1.01 ^{bc}	4.95 ± 0.96 ^{abc}	4.90 ± 0.85 ^{bc}	4.67 ± 0.89 ^c
OQ	6.45 ± 0.72 ^a	5.65 ± 1.06 ^{ab}	5.11 ± 1.10 ^{bc}	5.05 ± 0.94 ^{bc}	4.80 ± 0.94 ^{bc}	4.60 ± 0.70 ^{bc}	4.75 ± 0.82 ^c	4.07 ± 0.89 ^c
FQ	6.20 ± 0.63 ^a	5.73 ± 0.83 ^{ab}	5.04 ± 1.14 ^{bc}	4.82 ± 0.95 ^{bcd}	4.80 ± 0.89 ^{bcd}	4.50 ± 0.71 ^{bcd}	4.75 ± 0.75 ^{cd}	3.75 ± 1.19 ^d
TM	6.50 ± 0.80 ^a	6.09 ± 0.79 ^{ab}	5.70 ± 1.01 ^{ab}	5.25 ± 1.24 ^{ab}	5.30 ± 1.30 ^{ab}	5.55 ± 1.07 ^{ab}	5.47 ± 1.21 ^{ab}	5.05 ± 1.39 ^b
JM	6.27 ± 0.61 ^a	6.15 ± 0.70 ^a	5.82 ± 1.10 ^{ab}	5.17 ± 0.99 ^{ab}	5.32 ± 1.15 ^{ab}	5.40 ± 1.07 ^{ab}	5.32 ± 1.04 ^{ab}	4.77 ± 0.91 ^b
SQ	6.33 ± 0.65 ^a	5.76 ± 0.75 ^{ab}	4.64 ± 0.94 ^{bc}	4.85 ± 0.97 ^{bc}	4.32 ± 1.03 ^c	4.60 ± 0.84 ^{bc}	4.20 ± 0.88 ^c	3.97 ± 0.98 ^c
TPQ	6.48 ± 0.63 ^a	5.91 ± 0.79 ^{ab}	5.09 ± 1.00 ^{bc}	4.97 ± 0.77 ^{bc}	4.70 ± 0.71 ^{cd}	4.65 ± 0.67 ^{cd}	4.52 ± 0.66 ^{cd}	3.97 ± 1.06 ^d

* Means with different superscripts are significantly different (P<0.05).

Spoilage attributes: **WF:** Warmed-over flavour; **RF:** Rancid flavour; **AF:** Acid flavour; **WO:** Warmed-over odour; **RO:** Rancid odour; **AO:** Acid odour; **DR:** Darkening; **SF:** Softening; **PS:** Phases separation; **Quality attributes:** **CQ:** Colour; **OQ:** Odour; **FQ:** Flavour; **TM:** Tenderness meat; **JM:** Juiciness meat; **SQ:** Sauce quality; **TPQ:** Total product quality.