The influence of post-mortem ageing time and packaging conditions on the quality of fresh packed beef

Owczarek-Fendor A. [1], De Meulenaer B. [1], De Smet S. [2], Vermeulen A. [3], Van Bree I. [1], Eriksson M. [1], Lescouhier S. [2], Vandersteene M. [1] and Devlieghere F. [1]

[1] Department of Food Safety and Food Quality (partner in Food2Know), Faculty of Bioscience Engineering, Ghent University, 9000 Ghent, Belgium
[2] Laboratory for Animal Nutrition and Animal Product Quality (partner in Food2Know), Department of Animal Production, Ghent University, 9000 Ghent, Belgium
[3] Pack4Food, Department of Food Safety and Food Quality, Faculty of Bioscience Engineering, Ghent University, 9000 Ghent, Belgium

Abstract— **The influence of post-mortem aging time and different packaging parameters on the quality of fresh beef (two muscles types: *Longissimus dorsi* and *Biceps femoris*) during storage simulating retail conditions (4 °C, 12h light/12h dark) was investigated. Colour, microbial parameters (TPAC, TPAnC and LAB) and lipid oxidation (malondialdehyde content) were analyzed. Microbial growth was higher for meat ripened in vacuum at 2 °C for 14 days than for 7 days. The shelf life of the meat was limited to 6 days due to high number of lactic acid bacteria. Moreover, for beef ripened for 14 days, discoloration appeared in the last three days of storage. No significant difference was observed between gas/product ratio of 1 and 0.5 on microbial growth, lipid oxidation and color when meat was packed in atmosphere containing 70% O_2 and 30% CO_2. Similarly, no influence of 2 different gas compositions (high and lower O_2 content) on the quality of beef could be noticed. Vacuum-packed and MA-packed beef showed the same microbial growth, however, very limited formation of malondialdehyde was observed in the vacuum.**

Keywords— **fresh beef, MAP, meat quality, shelf life**

I. INTRODUCTION

The initial quality of meat is of significant importance in the retail marketplace since it contributes to the shelf life of the meat and by consequence it influences consumers' selection. The quality of meat may vary between animals and is dependent mainly upon diet, stress before slaughtering and muscle fibre type [1, 2]. Post-mortem storage conditions, such as temperature, time of aging and the atmosphere of packaging affect the shelf life as well. All of these pre- and post-mortem conditions have a major influence on the colour stability, microbial spoilage, lipid oxidation, off-flavour formation and water loss; characteristics which all determine the quality of fresh meat. Apart from these factors, palatability is another crucial attribute for consumers. Therefore, post-mortem aging (chilled storage in air or vacuum) is applied to improve the palatability attributes, especially tenderness of the meat. The ageing time, however, can also influence the microbiological, colour, odour and rancidity characteristics.

The shelf life of meat can be extended with application of a modified atmosphere packaging (MAP) consisting of a mixture of O_2, CO_2 and/or N_2. However, the preservative effect of CO_2 can only be reached if CO_2 is added to the headspace in excess to the amount required to saturate the meat. The absorption capacity of the meat depends on several intrinsic characteristics, such as pH, water and fat content and also on the packaging and storage conditions e.g. temperature, CO_2 partial pressure and headspace to meat volume ratio. Devlieghere et al. [4] have observed a significant increase in dissolved CO_2 in the water phase of different meat products with increasing gas/product volume ratio (G/P) or decreasing temperature.

Presence of O_2 in MA-packed fresh beef is necessary to improve and retain the colour. Beef steaks are commonly displayed under high O_2 concentrations, however, such conditions may also cause quality deterioration through lipid oxidation and decreased tenderness [5].

The aim of this research was to study the influence of post-mortem ageing time, different gas to product ratio (G/P) and gas composition on the quality of fresh

MA-packed beef as compared to beef packed in vacuum.

II. MATERIALS AND METHODS

A. Meat samples

The *Longissimus dorsi* (LD) and *Biceps femoris* (BF) muscles from 4 double-muscled Belgian Blue beef carcasses (20.5 ± 2.1 months, 527 ± 32 kg) were obtained from the slaughter house at 3 days post-mortem.

B. Meat preparation and packing

Regarding the influence of ageing time, all meat cuts were vacuum-packed and ripened for 7 or 14 days in the dark at 2 °C. After vacuum storage, the cuts were divided into small pieces (6 x 7 x 2.5 cm) and packed in MA containing 70% O_2 and 30% CO_2.

For the experiment with different G/P ratios, meat was ripened for 7 days in vacuum and afterwards cut and packed in MA (70% O_2 and 30% CO_2), as described before. To have two different G/P ratios (G/P = 1 and G/P = 0.5), 3 or 4 meat pieces, respectively were placed on polypropylene trays having a volume of 640 ml. The amount of meat was controlled by weighing, assuming that the density of meat is 1 g/ cm^3.

For the experiment with different gas composition in MAP, meat was ripened for 7 days in vacuum, afterwards, it was cut as described before, and MA-packed using a Tray sealer MACA 900 (DecaTechnic, Belgium) with G/P = 1. Two gas compositions were applied: 70% O_2 + 30% CO_2 and 40% O_2 + 30% CO_2 + 30% N_2. Additionally, meat was vacuum packed by means of a Multivac A300/42 (Hagenmuller, Germany).

C. Storage conditions

MAP- and vacuum-packed meat samples were stored in chilled conditions (4 °C), with 12 h dark/12 h light cycle (fluorescent light, approx. 900 lux). Samples were stored for a total of 8 days (experiment with different ripening time and G/P ratio), 10 days (experiment with different gas composition) or 13 days (vacuum-packed samples).

D. Microbiological analysis

For the microbial analysis, a sample of 25 g of packed beef was collected and homogenized (Lab Blender 400) aseptically in a stomacher bag and the appropriate successive 10-fold dilutions in PPS (0.85% NaCl, 0.1% peptone) were carried out. Microbiological enumeration was performed on respectively plate count agar (PCA; Oxoid, U.K.) for total psychrotrophic aerobic count (TPAC; incubation at 22 °C, 4-6 days), on Man Rogosa Sharpe agar (MRS; Oxoid) for number of lactic acid bacteria (LAB; incubation at 22 °C, 4-6 days) and on reinforced clostridial agar (RCA; Oxoid) for total psychrotrophic anaerobic count (TPAnC, anaerobic incubation, 22 °C, 4-6 days).

E. Colour measurement

Instrumental colour measurement was performed on the top surface of meat sample using a Konica Minolta spectrophotometer CM-2500d (Konica Minolta, Japan), operating in the CIE L*a*b* colour space. After taking a sub-sample for the microbial analysis, a piece of meat was transferred to a transparent plastic bag and the colour was measured (10 separate readings) 5 min after opening the original package.

F. Lipid oxidation

Lipid oxidation was evaluated by determination of malondialdehyde (MDA) in the top surface (fixed thickness of 4 mm) of the meat samples. The analysis of MDA was performed with HPLC-FLD following the procedure described by Mendez et al. [6] with some modifications. In the first step, the meat samples were deprotonized with 7.5% trichloroacetic acid (TCA) solution [7.5% TCA (Acros, Belgium), 0.1% EDTA (ChemLab, Belgium), 0.1% propyl gallate (Fluka, Germany)]. Afterwards, it was incubated with 40 mM thiobarbituric acid (TBA, Sigma-Aldrich, Germany) solution in a boiling water bath for 35 min. The separation of MDA-TBA complex was performed on a C18 column (5 µm, 150 × 4.6 mm i.d., Varian, USA). The mobile phase consisted of 50 mM KH_2PO_4 (ChemLab), methanol (HPLC-grade, VWR, Belgium) and acetonitrile (HPLC-grade, VWR) in the proportion

72/17/11 (v/v). The fluorescence detector was set at 525 nm for the excitation wavelength and at 545 nm for the emission wavelength.

II. RESULTS AND DISSCUSION

A. Influence of ripening time

It was observed that a 14-days ripening time in vacuum before MA packaging resulted in higher initial microbial load for TPAC, TPAnC and LAB as compared to 7 days ripening. This is in line with the study of Nortje and Shaw [3]. The LAB growth curves are presented in Fig. 1.

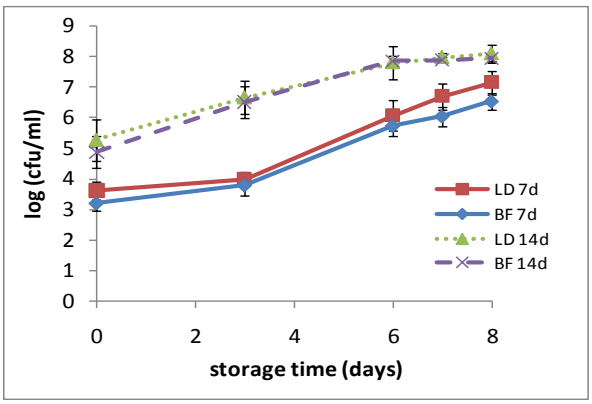

Fig. 1 Counts of lactic acid bacteria (LAB) on MA-packed beef (LD and BF) aged for 7 or 14 days in vacuum at 2 °C.

For meat ripened for 14 days, the growth curve from day 0 till day 6 was already in the exponential phase while in the case of shorter ripening time (7 days), 3 days of lag phase were observed. The same trend was observed also for TPAC and TPAnC. Moreover, due to the high number of lactic acid bacteria, the shelf life of beef ripened for 14 days was limited to 6 days. No significant difference in the microbial load could be noticed between different muscle types, aged for the same time.

Regarding colour, an initial increase in a*-value (redness) was observed between day 0 and 3 due to the high O_2 concentration in MAP resulting in the formation of oxymyoglobin (Fig 2). The a*-value showed a decreasing trend towards the end of the shelf life. This could be due to oxidation of myoglobin to metmyoglobin which is responsible for the brown pigment.

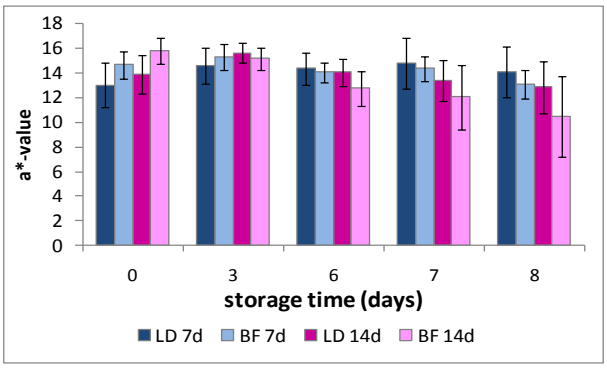

Fig. 2 a*-values measured on the surface of MA-packed beef (LD and BF) aged for 7 or 14 days in vacuum at 2 °C.

Lipid oxidation of MA-packed beef, defined by MDA content, was not influenced by the ripening time till the 7th day of storage and on day 8 it was significantly higher on the longer ripening time (results not shown). Moreover, it was noticed that BF was more sensitive to lipid oxidation than LD.

B. Influence of gas/product ratio

Based on the results from the previous experiment, it was decided to study the effect of G/P ratio on the quality of MA-packed meat that was aged for 7 days.

There was no significant difference in growth of microbial flora (TPAC, TPAnC and LAB) between beef samples packed in MAP with G/P = 1 or 0.5. However, it was expected that a higher G/P ratio would result in slower microbial growth due to an increase in the concentration of dissolved CO_2 [4].

Regarding colour, the a*-value increased in the first 3 days of storage and afterwards it did not change significantly. Lipid oxidation was not influenced by the different G/P ratios (results not shown).

C. Influence of different gas composition

In the last series of experiments, an influence of different gas composition [high (70%) and lower (40%) O_2 concentration] on the quality of MA-packed beef was studied. Additionally, vacuum-packed beef was also investigated. Since no significant effect of

G/P ratio was observed, beef was packed with G/P = 1.

Similarly as in the previous experiment, the microbial load (TPAC, TPAnC, LAB), the a*-value (Fig. 3) and MDA content (Fig. 4) were not affected by the different gas composition.

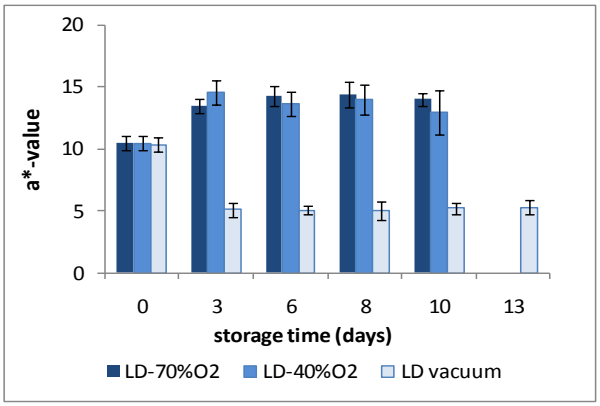

Fig. 3 a*-values measured on the surface of beef (LD) packed under vacuum and in MA with 2 gas compositions (70% O_2 + 30% CO_2 or 40% O_2 + 30% CO_2 + 30% N_2)

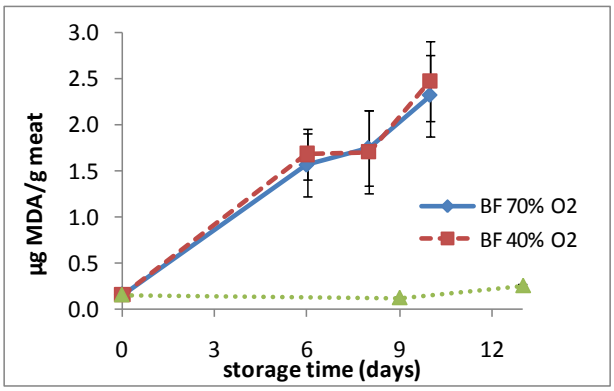

Fig. 4 Malondialdehyde (MDA) content in beef (BF) packed under vacuum and in MA with 2 gas compositions (70% O_2 + 30% CO_2 or 40% O_2 + 30% CO_2 + 30% N_2)

Regarding lipid oxidation, it was expected that a higher O_2 concentration would increase the MDA content. However, it seemed that meat was already saturated with O_2 if packed in MA containing 40% O_2 and a further increase in O_2 concentration did not affect lipid oxidation. Vacuum-packed beef compared to MAP showed very limited formation of MDA, however, microbial growth was comparable. As expected, the a*-value in vacuum was significantly lower from day 3 as compared to beef packed in MAP due to the absence of O_2 and thus the formation of deoxymyoglobin responsible for the dark purplish red colour.

IV. CONCLUSIONS

In conclusion, it was observed that meat packed in MA following 14 days ripening compared to 7 days resulted in a shorter shelf life due to the higher initial levels of bacteria thus their faster growth. At the end of the storage in MA, a trend in decreasing a*-value was noticed. Different G/P ratio and gas composition had no significant influence on microbial growth, lipid oxidation and colour of MA-packed fresh beef.

ACKNOWLEDGMENT

The research is supported by the Agency for Innovation by Science and Technology (IWT); project n° 080726.

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