RETAIL PACKAGING OF PRE-SALTED BEEF PATTIES STORED IN HIGH OR NON-OXYGEN ATMOSPHERE

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***Abstract*—Pre-salted beef sold in retail outlets can be packed in high-oxygen modified atmosphere packaging (MAP) in order to preserve an attractive bloomed red colour and extend the shelf-life compared with traditional wrap. It is, however, commonly known that salt accelerates oxidation processes, and the effect on meat quality in pre-salted meat stored in high-oxygen MAP has still not been fully explored. This study evaluates the effect of recipe (no salt (fresh) or 0.5 % NaCl (pre-salted)) and packaging atmosphere (high-oxygen: 70% O_2/30% CO_2, non-oxygen: 30 % CO_2/70 % N_2 or 100 % N_2) on the sensory quality and the progression of lipid oxidation of beef patties during storage (1, 3, 6 days) at 4°C. The sensory quality of cooked beef patties was evaluated by a trained panel using a 15-point unstructured line scale. The development of lipid oxidation was measured as thiobarbituric reactive substances (TBARS) in µmol MDA/kg of meat. Packaging with non-oxygen-containing atmospheres minimised the development of TBARS in the beef patties and preserved the intensity of meat flavour and internal colour. In pre-salted beef patties, TBARS was found to develop very rapidly compared with the beef patties without salt. However, the salt taste was found to mask the rancid flavour generated by the lipid oxidation processes. Furthermore, pre-salting improved the juiciness of beef patties during storage.**

***Index Terms*—beef patties, pre-salting, high-oxygen MAP, sensory evaluation, lipid oxidation.**

I. INTRODUCTION

Pre-salted meat products packed in MAP are commonly found in retail outlets. It is a well-known fact that salt accelerates oxidation processes, and it is therefore expected that pre-salting may impair the quality compared with non-salted fresh meat. Traditional MAP with high oxygen (70-80% O_2) and 20-30% carbon dioxide (CO_2) preserves a bright red colour of the meat and increases shelf-life by reducing microbial growth (Okayama et al. 1995), although unfortunately it also affects the oxidation processes in meat. Several studies on high-oxygen MAP-stored meat have shown that lipids are decomposed into secondary lipid oxidation products, which are rancid (Cayuela et al, 2004; Monahan, 2003). The rancid aromas often have very low threshold values and are easily perceived by the consumers (Skibsted et al,. 1998). Furthermore, studies have shown a negative effect on tenderness (Tørngren, 2003) and the water-holding capacity of the meat (Lund, 2007) due to increased cross-linkages of the myofibrillar tissue. Packaging in high-oxygen atmospheres also leads to rubbery texture and reduced juiciness (Tørngren, 2008) and premature browning in cooked patties (Hauge et al., 1994; Tørngren, 2005). It has been established that non-oxygen MAP minimises unnecessary damage to the eating quality during retail storage of MA-packed fresh meat compared with high-oxygen packaging (Clausen et al. 2009) and might explain why Scandinavian consumers clearly prefer beef steaks packed without oxygen (Aaslyng et al., 2010).

The objective of this study was to investigate the effect of non-oxygen MA packaging (30 % CO_2/70 % N_2 or 100 % N_2) on the eating quality and lipid oxidation of pre-salted beef patties stored for up to 6 days at 4°C in comparison with high oxygen packaging. For that purpose, beef patties (fresh or pre-salted) were evaluated by a trained sensory panel, and the secondary lipid oxidation products were quantified by TBARS analysis.

II. MATERIALS AND METHODS

A. Preparation, packaging and storage of beef patties

Bovine back rib purchased from a commercial Danish slaughterhouse, was chopped into 1 cm x 1 cm cubes. Recipe "Fresh": 46.3 kg meat cubes mixed with 3.7 L cold water, and recipe "Pre-salted": 46.3 kg meat cubes mixed with 3.7 L cold salt brine containing 6.8 % NaCl, 4 % maltodextrin, and 6.2 % C*Polar Tex (maize starch, SFK, Denmark) to obtain a total of 0.5 % salt (analysed to 0.51±0.02 % sodium chloride) in the meat. The fresh meat and the pre-salted meat were minced separately and were mechanically formed into 100-g beef patties using Wolfking Y/D-REV (CFS, Denmark) and a Vemag ROBOT HP17C (Vemag, Germany). Four beef (7.8±0.6 % fat, and 2.8±0.2 % collagen) patties were placed in each tray (187 mm x 187 mm x 36 mm, Mod-PP, Færch plast, Denmark), and the meat was packed in three different modified atmospheres (100 % N_2, 70 % N_2/30 % CO_2, and 70 % O_2/30 % CO_2) using a Sealpac 800+ (SEALPAC UK LTD, Seal-pack, Germany). The packages were stored in the dark at 4°C for up to 6 days. Samples were collected at days 1, 3, and 6. One sample consists of four beef patties packed together in one tray. Each sample was prepared in three independent replicates (A, B, C).

B. Sensory analysis

The beef patties were evaluated by a professional and trained sensory panel consisting of 9 assessors at the Danish Meat Research Institute. All the assessors had participated in 3 training sessions in accordance with ISO 4121, ASTM-MNL 13, DIN 13299 and were familiar with sensory assessment of meat. All beef patties were evaluated on the same day as they were collected from storage on a 15-point unstructured scale anchored at the extremes (0=low intensity and 15= high intensity).The beef patties were placed on a pre-heated pan (170°C) greased with a thin layer of grape seed oil. The patties were turned every 2 minutes and cooked to a core temperature of 72°C. Each beef patty was divided between 2-3 assessors and served under aluminium covers on preheated plates. The beef patties were assessed according to descriptors developed during the training of the panel. The descriptive attribute for appearance was: internal colour. The descriptive attributes for taste were: salt, acid and bitter. The descriptive attributes for flavour were: warmed-over flavour, metallic flavour and bouillon. The descriptive attributes for texture were: juiciness and coherence.

C. Lipid oxidation products by TBARS analysis

The secondary lipid oxidation product malondialdehyde (MDA) was quantified by TBARS analysis according to Vyncke (1970) and Sørensen & Jørgensen (1996). The meat was analysed on the same day as the sample was collected from the storage room and had therefore not been frozen. An aliquot of 10.0 g meat was homogenised in 30 ml 7.5 % TCA with 0.10 % propylgallate and 0.10 % EDTA using an Ultra Turrax for 60 seconds at 13,500 rpm and filtered. Filtrate (5.0 ml) was mixed with 5.0 ml 20 mM thiobarbituric acid (TBA) and incubated at 100°C in a water bath for 40 minutes. Absorbance was measured at 532 and 600 nm at room temperature. Results are expressed as 2-thiobarbituric reactive substances (TBARS) in µmol MDA/kg meat using a standard curve. Each sample consisted of three independent replicates (A, B, C).

E. Statistical analysis

Data were analysed using mixed models (SAS 8.2, 1999-2001). The model included packaging, storage time and recipe as fixed effects, and assessors as random effects. Non-significant interactions were deleted from the model. Least squares (LSmeans) were calculated and separated using probability of difference. Levels of significance: $p > 0.05$ = non-significant (ns), $0.05 > p > 0.01$ = *, $0.01 > p > 0.001$ = **, $p < 0.0001$ = ***.

III. RESULTS AND DISCUSSION

Packaging of fresh beef patties in a non-oxygen atmosphere preserved the meat flavour during the first 3 days of storage. In contrast, meat flavour decreased after 1 day of storage if high oxygen atmosphere was used. The meat flavour of pre-salted beef patties decreased during storage independently of the packaging atmosphere (Figure 1).

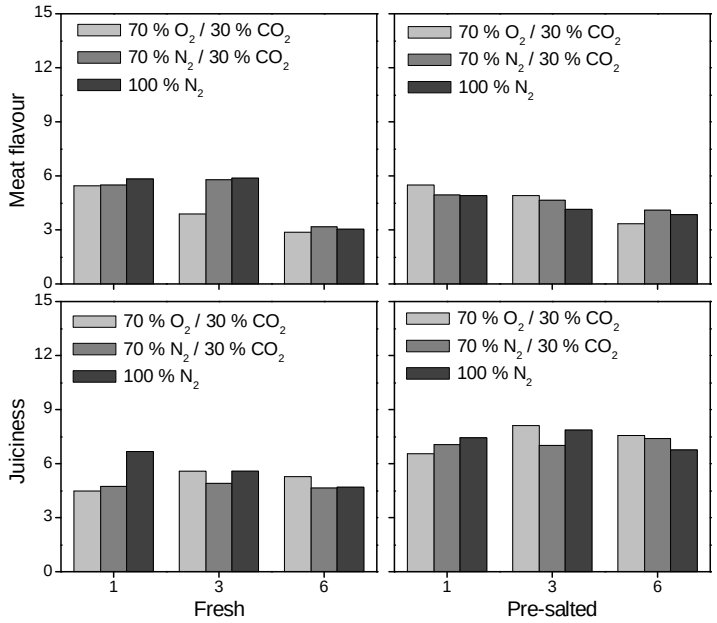

Figure 1. Upper panel: meat flavour in fresh or pre-salted beef patties packed in high or non-oxygen MAP after 1, 3, or 6 days of storage at 4°C. Lower panel: juiciness of fresh or pre-salted beef patties stored in high or non-oxygen MAP after 1, 3, or 6 days at 4°C.

Not surprisingly, salt taste (data not shown) is dependent on the recipe, and pre-salting resulted in a significant increase in salt taste (6 sensory units on average). The intensity of salt taste in pre-salted beef patties was lower (2 sensory units) for oxygen-containing atmospheres, probably because of a development of oxidation-related off-flavours.

The juiciness of pre-salted beef patties was highly improved compared with fresh beef patties (Figure 1). Furthermore, an unexpected interaction between atmosphere and storage period was observed, with juiciness decreasing for beef patties packed in 100% N_2 and increasing for beef patties packed in high oxygen. At day 6 beef patties packed in high-oxygen atmospheres were slightly juicier than patties packed in non-oxygen containing atmospheres. This interaction can be explained by differences in cooking loss (data not shown), but is in contrast to previous experiences with ground beef (Clausen & Madsen, 2005). This conflict might be related to the addition of water to the fresh beef patties.

Rancid flavour developed differently depending on the recipe and the packaging atmosphere. Fresh beef patties developed a rancid flavour between 4 and 6 days of storage when a non-oxygen-containing atmosphere was used. When packaging in a high-oxygen atmosphere, rancid flavour developed during the first 24 hours of storage. Pre-salted beef patties did not develop a rancid flavour for up to 6 days of storage when packed in a non-oxygen-containing atmosphere, probably because the intense salt taste masked the rancid off-flavour (Figure 4).

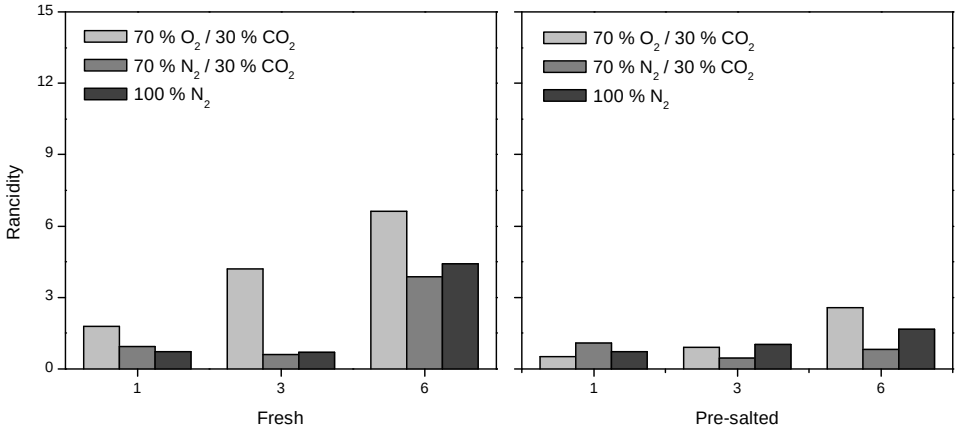

Figure 2. Rancid flavour in fresh and pre-salted beef patties packed in high or non-oxygen MAP after 1, 3, or 6 days of storage at 4°C.

Lipid oxidation was measured as secondary oxidation products (TBARS). Figure 3 (left panel) shows increasing TBARS values when fresh meat was stored in high oxygen MAP. No increase was observed for TBARS when fresh beef patties were stored in non-oxygen MAP. TBARS values increased significantly in pre-salted beef patties during the 6 days of storage when the patties were packed in a non-oxygen atmosphere (Figure 3, right panel). At first sight, it would appear that the TBARS values decreased when pre-salted beef patties were packed in high-oxygen MAP. However, this is unlikely because of the well-known pro-oxidative behaviour of salt and oxygen. A highly probable explanation for this could be that the lipid oxidation reactions progressed into the development of tertiary lipid oxidation products, and the TBARS values decreased as the secondary oxidation products were converted.

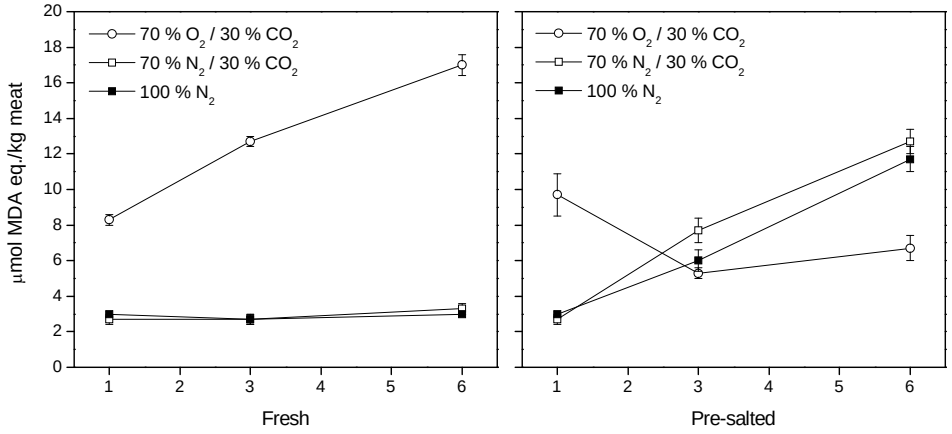

Figure 3. Formation of secondary lipid oxidation products measured in MDA equivalents of MA-packed beef patties stored in the dark for up to 6 days at 4°C. All data points represent the mean±SEM of three independent replicates (n=3). Left panel: fresh beef patties. Right panel: pre-salted beef patties

IV. CONCLUSION

Packaging with non-oxygen-containing atmospheres minimised oxidation of beef patties and preserved the intensity of the meat flavour and salt taste, while high-oxygen packaging seemed to increase juiciness compared to non-oxygen atmospheres.

In pre-salted beef patties, oxidation developed very rapidly. However, the salt taste was found to mask the rancid flavour. Furthermore, pre-salting improved the juiciness of beef patties during storage.

ACKNOWLEDGEMENTS

The authors thank Pia Krautwald, Danish Crown, Sdr. Felding, Denmark, for invaluable assistance during the preparation of the beef patties, and the laboratory technicians at the Danish Meat Research Institute (a division of the Danish Technological Institute), Roskilde, Denmark, for conducting the TBARS analyses.

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