EFFECT OF Ar/CO_2 MODIFIED ATMOSTHERE PAKAGING ON TURKEY MEAT CHARACTERISTICS

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Background

Modified atmosphere packaging (MAP) with low storage temperature are important hurdles contributing to microbial and lipid oxidation stability of meat products and increasing their shelf life. Also the use of MAP improves product presentation, facility of storage, distribution, sale and utilisation (Ohlsson, 1994). The success of these technologies depends on the specificity of gas mixtures related to the product, type of meat, the nature and initial quality of meat, the temperature control, the barrier properties of the packaging film and the efficacy of the equipment (Taylor, 1996).
The use of CO_2 enriched atmospheres extends the shelf life of raw poultry by inhibiting the psychotrophic gram-negative bacteria and *Pseudomonas spp.*. Although later meat spoilage and changes on organoleptic characteristics are observed because slower-growing microorganisms (*Carnobacterium spp., Brochotrix thermosphacta, Lactobacillus spp*.) proliferate (Blakistone, 1999).
Apart the CO_2, O_2 and N_2 gas mixtures used on raw meat packaging only carbon monoxide (CO) has been adopted and studied on red meat (Sorheim *et al*., 1997) but its use is interdicted by law. However, Argon (Ar) is one of the gases authorised by the Directive 95/2/CE (1995) to be in contact with food. It's inert, odourless and tasteless, more dense and soluble than N_2. A study of sliced cooked ham packaged with Argon report advantages on oxidation control and microbial proliferation extending the product shelf life (Fachon, 2002).
It is important to clarify the influence of mixtures with Argon on the behaviour of spoilage flora and lipid oxidation of turkey meat.

Objectives

The aim of this work was to study the effect of Ar/CO_2 packaging atmosphere on spoilage flora and lipids oxidation stability of sliced turkey meat stored under refrigeration at 0±1ºC.

Materials and methods

The sampling of breast muscles from turkey carcasses (BIG 6 and BUT 9), selected for deboning according to plant criteria, was performed on different slaughter days under commercial conditions. The breast muscles were sliced with 1.5 cm thickness and a surface area of approximately 90-100cm^2. Scallops were transported in a refrigerated box to the laboratory and in less than one hour were packaged according to different study conditions.
Samples have been individually packaged in an aerobic atmosphere (polystyrene trays wrapped in an oxygen permeable polyvinyl film) and in four different modified atmospheres (MA) containing different gas mixtures as G1=100% N_2, G2=50% Ar/50% N_2, G3=50% Ar/50% CO_2 and G4= 50% N_2/50% CO_2 in "HBX-070" bags (a multilayer film EVOH-based) sealed with a packaging machine (EVT-7-CD, Tecnoprip, Barcelona). The aerobic atmosphere and MA packaged meat have been immediately stored (0±1ºC in the dark) for 12 and 25 days respectively. Each study condition was repeated at least nine times.
On days 0, 5, 12, 19, and 25 the following analyses were carried out:
Microbiological analysis: Total psycrotrophic aerobic counts at 7ºC for 10 days (Plate Count Agar, Merck, Germany), anaerobic count at 7ºC for 10 days (Brewer Anaerobic Agar, Merck, Germany), *Enterobactereaceae* counts in Violet Red Bile agar (VRB agar, Merck, Germany) at 37ºC for 2 days, *Pseudomonas spp*. counts (CFC agar base, Oxoid, UK) after incubation at 30ºC for 2 days, lactic acid bacteria (LAB) counts on Man Rogosa Sharpe Agar (Oxoid, UK) incubated at 30ºC for 3 days and *Brochothrix termosphacta* count in streptomycin, actidione, thallous acetate agar (STAA, Oxoid, UK) incubated for 2 days at 30ºC. Counts were expressed as log cfu/g.

Lipid oxidation evaluation by thiobarbituric acid test (TBA) was performed according to NP-3355 (1990). The total fat content was determined by Soxhlet method according to NP-1224 (1982).

Total fatty acids analysis: Lyophilised muscle samples were weighed into a culture tube and fatty acids were extracted and methylated by the method of Rule (1997). Quantification of fatty acid methyl esters was performed using 2 mg of nonadecanoic acid (C19:0) as internal standard, with analysis conducted by GLC using 30-m fused silica capillary column Omega Wax 250 (Supelco, Bellefonte, PA, USA) with a 0.25-mm internal diameter and a 0.25-mm film thickness. A Varian CP-3800 chromatograph (Varian Analytic Instruments, Walnut Creek, CA, USA), working with helium as gas carrier (1.3ml/min) and a flame ionisation detector, was used. The initial column temperature of 150ºC was held 11 min., increased to 220ºC at 3ºC/min and held 20min.The injector and detector temperature were 250ºC and 220ºC respectively. Peak identification was based on co-chromatography with known standards of fatty acid methyl esters (Sigma, St Louis, MO, USA). All results are presented (weight%) of total fatty acids assuming direct proportionality between peak area and fatty acid methyl ester weight.

Statistical analysis: Data was analysed using SPSS 11.5 for Windows. The comparison between gas mixtures package conditions, for microbial parameters, was performed by model adjustment of a one-way ANOVA for each day. For the parameters total fatty acid and TBA an ANCOVA model was adjusted to each day, considering as covariates the total fatty acid content (mg/g dry mater) and the total fat content (%) respectively. If *F* test from ANOVA or ANCOVA was significant, a LSD test post hoc multiple comparisons for observed Means has been performed. The comparison between days, considering each gas condition, was made by t-test for dependent samples.

Results and discussion

The evolution of microbial flora on sliced turkey meat packaged on different MA study conditions is reported on Figures 1 and 2. The initial contamination of sliced turkey meat (day 0), for total psicrotrophic counts, was approximately 4.6-4.9 log cfu/g. The aerobic packaging of sliced turkey meat allowed psycrotrophic counts to reach 6.9 log cfu/g on 5th day of storage and a higher level on the 12th day, about 9.9 log cfu/g, out of limit microbial criteria acceptability (7 log cfu/g). The facultative anaerobic flora also reached high levels. The dominant flora was *Pseudomonas spp*. followed by *Brochothrix termosphacta* and *Enterobactereaceae*, stated also by Santé *et al.* (1994).

The anaerobic conditions created by packaging with all gas mixtures (G1-4) delayed significantly ($p<0.001$) the development of dominant flora when compared with the aerobic packaging on the 12th days of meat storage. This inhibition of flora development regards particularly the meat packaged on G3 and G4 mixtures with CO_2. In what concerns the lactic acid bacteria (Figure 2, f), a slower growing microorganism group, there was an exception since that all gas mixtures packaging did not have any inibiting effect as it was stated by other authors (Saucier *et al.*, 2000; Blakistone, 1999).

The microbial development on meat MAP conditions G1 and G2 was similar (Figure 1 and 2). Ar, in mixture G2, does not add a microbial inhibitory effect. Despite the delay of flora development, with G1 and G2 gas mixture, had been relevant in particular to *Brochothrix termosphacta* (Figure 2-d), it was the presence of CO_2, on mixtures G3 and G4, which added a significant bacteriostatic effect on *Pseudomonas spp.* (Figure 1-b) and *Enterobactereaceae* (Figure 1-c) development during storage period.

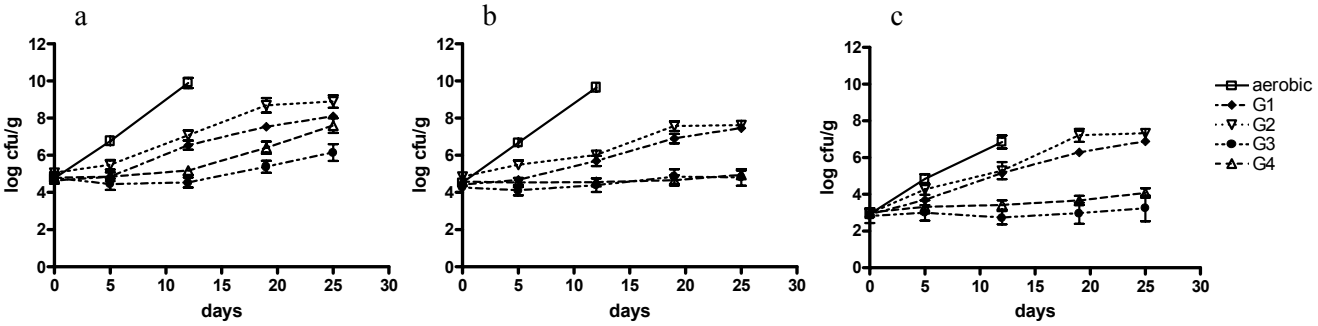

Figure 1: Evolution of total psycrotrophic flora (a), *Pseudomonas spp*. (b) and *Enterobactereaceae* (c) on sliced turkey meat packaged in an aerobic atmosphere and in four different MAP gas mixtures: G1=100% N_2, G2=50% Ar/50% N_2, G3=50% Ar/50% CO_2 and G4= 50% N_2/50% CO_2.

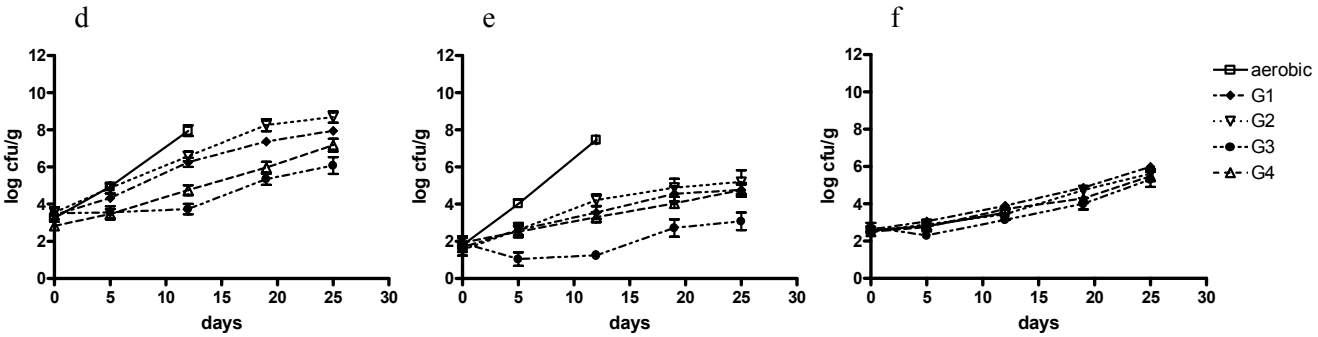

Figure 2: Evolution of total anaerobic flora (d), *Brochothrix termosphacta* (e) and Lactic acid bacteria (f) on sliced turkey meat packaged in an aerobic atmosphere and in four different MAP gas mixtures: G1=100% N_2, G2=50% Ar/50% N_2, G3=50% Ar/50% CO_2 and G4= 50% N_2/50% CO_2.

The mixture G3, with Argon associated to CO_2, was more efficient on delaying flora development than G4, without Ar. In these last study conditions (G3 and G4) there was more than 1 log difference, on the 25th day storage, for total psycrotrophic counts ($p<0.001$), total anaerobic counts ($p<0.05$) and *Brochothrix termosphacta* ($p<0.05$). This synergetic effect of Ar/CO_2 seemed to be related with the development delay of *Brochothrix termosphacta* and consequent relationship on anaerobic and aerobic psicrotrophic flora counts, which was lower than microbial criteria limit.

The microbial shelf life period extension of MA packaging on sliced turkey meat compared with aerobic packaging (5 days shelf life) is one more week for G1 and G2 mixtures, two weeks for G4 and three weeks to G3.

The results of lipid oxidation evaluation by TBA are presented on Figure 3. It was observed for aerobic packaging meat a significant increase ($p<0.05$) of TBA value after 5 days of storage (0.3 to 0.5 mg malonaldehyde /kg). The TBA value of aerobic package meat storage on 12th day has increased (0.7 mg/kg) but there was no significant difference from the 5th day. This last value do not exceed the cut off value of 2 mg malonaldehyde per kg of meat, at which rancidity may be detected by consumers indicated by Wood *et al*. (2003). The TBA results on 5th day of storage from anaerobic meat packaging conditions (G1-4) were slightly lower but not significantly different from those obtained on meat under aerobic package. However, on the 12th day of anaerobic storage conditions (G1, G2 and G3) the TBA values of turkey meat were significantly different ($p<0.05$) from the results obtained on aerobic meat packaging condition with exception to meat packaged with the G4 gas mixture.

The sliced turkey meat, after 19 days of packaging with G1 and G2 gas mixtures, had lower significant TBA values compared with those obtained from meat package with G3 condition. In fact, the meat packaged with G3 mixture had a significant increase of TBA value from the 12th to the 19th day of storage (0.54 to 0.7 mg/kg). The TBA value of meat under G3 package on the 25th of storage was significantly higher ($p<0.05$) than the results obtained from meat on the other anaerobic MAP conditions.

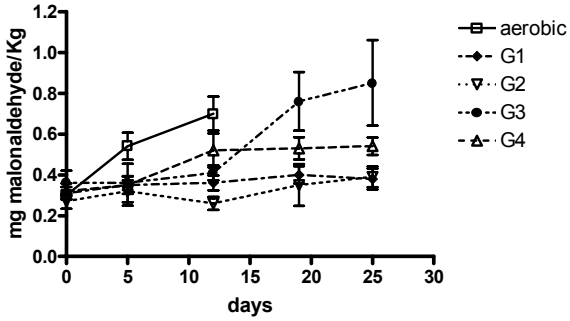

Figure 3 – Development of lipid oxidation measured by TBA content (mg malonaldehyde/kg) on sliced turkey meat packaged in an aerobic atmosphere and in four different MA gas mixtures.

This last observation was not supported by the evolution of polyunsaturated fatty acid content (PUFA) from sliced turkey meat package according to the study conditions (Figure 4).
The quantity of fatty acids on meat packaging under all MA gas mixtures was not affected since there were similar results at the beginning and end of storage. On 12th day of storage was observed a significant difference ($p<0.05$) between the C18:2 n-6 content of the meat packaged with G3 gas mixture (30.2%) and those on meat aerobically packaged (24.8%). In this aerobic condition, the PUFA meat content was significantly lower ($p<0.05$) than the observed on the beginning of storage.
On the 25th day of storage there were no significant differences in the amounts of polyunsaturated fatty acid of meat package with the four different gas mixtures. Comparing the results of total fatty acid from meat under anaerobic package conditions on the 25th day of storage with the control (samples aerobically package on the 12th day of storage), it was observed for the C18:3 n-3 content a significant difference between meat packaged with G1, G2 or G3 gas mixtures and meat aerobically packaged. The loss of polyunsaturated fatty acids was negligible in meat packaged under the anaerobic study conditions without any detectable difference between gas mixtures used on MAP. These accords with TBA values from the different meat anaerobically package, except for G3 condition. From our results, all anaerobic gas mixtures under study were effective on lipid meat oxidative preservation. The presence of Ar on gas mixtures did not seem to have any additional protective effect on lipid turkey meat oxidation.

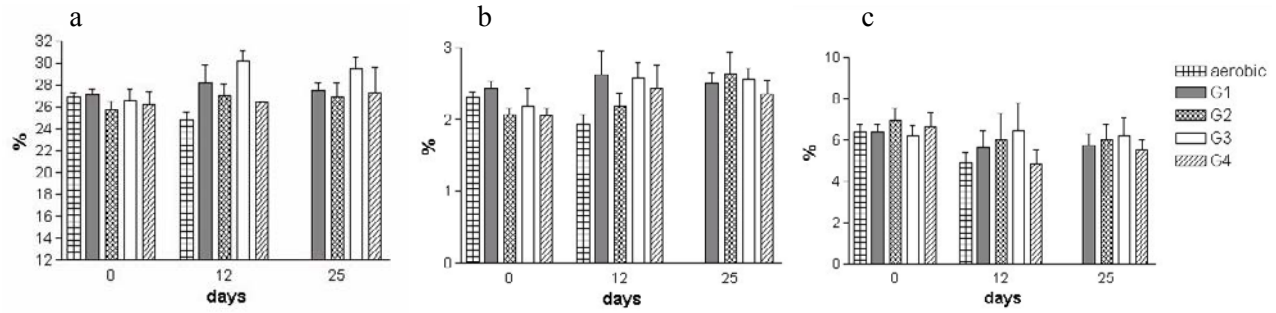

Figure 4: Evolution of fatty acid C18:2 n-6 (a), C18:3 n-3 (b) and C20:4 n-6 (c) on sliced turkey meat packaged in an aerobic atmosphere and in four different MAP gas mixtures.

Conclusions

The mixture with Argon associated to CO_2 was more efficient on delaying flora development than CO_2/N_2 with 1 log difference, on the 25th day storage, for total psycrotrophic counts, total anaerobic counts and *Brochothrix termosphacta*. However, the presence of Ar on gas mixtures did not seem to have any additional protective effect on lipid turkey meat oxidation.

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