OPTIMISING THE SHELF-LIFE OF PORK CHOPS WITH NEW GAS COMPOSITIONS AND REDUCED HEADSPACE

Bozec A, Vautier A, L'Hommeau T, Le Roux A.

IFIP, meat quality and safety, Le Rheu, France

*arnaud.bozec@ifip.asso.fr

Abstract – The objective of this study was to evaluate the influence of several gases compositions and headspaces on pork chops packages. Three batches of fresh pork meat packed under Modified Atmosphere Packaging (MAP) were studied. The evolutions of the gas composition, pH during storage were monitored and the evolutions of the spoilage microflora were evaluated. A panel of consumers realized sensorial analyses.

The composition of gases followed the same evolution in the two headspaces. There are no statistical differences between headspace 1 (H1) and H2. The H1 allowed an equivalent conservation H2. Consumers prefer smaller trays (H1). The best purchase intent (78%) is obtained by containing the lowest oxygen content (40%). The growth of *Enterobacteriacae* and *Brochothrix* shows respectively a 1 log and 2 log reduction with increasing CO_2 rate (60% *vs* 30%). Small headspace (H1) with both 50%-50% and 60%-40% O_2/CO_2 mixture induced an overall microbiological quality that is in agreement with the GHP recommendations, and allows a 4 days extension of the shelf life.

INTRODUCTION

Nowadays consumers are looking for fresh, tasty and safe to eat meat products, and want them in a convenient, easy-to-choose tray. Because consumers use meat color as an indicator of wholesomeness, recent researches in MAP have been focused on finding the correct gas mixture. Objectives are to maximize initial color, color stability, and shelf life while also minimizing microbial growth, lipid oxidation, and gaseous headspace (Mancini et al, 2005). Jakobsen et al (2000) reported that while oxygen levels higher than 20% were necessary to promote meat color, package oxygen contents higher than 55% did not result in additional color stabilizing benefits.

The effectiveness of MAP is generally determined by the amount of available CO_2. CO_2 dissolves into the aqueous part of the product in traditional MA package resulting in a volume contraction of a flexible package. The package collapse is usually reduced by lowering the CO_2 partial pressure by introducing gases with significantly less solubility, that is, N_2 or O_2, in the MA. This is, however, not optimal for packaged products (Bjørn Tore Rotabakk, 2007).

Suppliers of packaging are actively improving environmental performance through total material utilization, recycling or reuse of industrial scrap. These actions contribute to decrease packaging waste through progressively thinner, lighter, yet stronger materials. Another way to limit environnemental impact is to reduce the height of the tray with the optimization of the headspace. According to (Kenneth, et al 2008), headspace gas must be approximately 1.5–2 times the meat volume and package collapse is generally thought to be prevented by headspace gas to meat volumes of 2 to 3 (Gill & Gill, 2005).

The first objective of this study was to investigate the effect of different gas compositions and headspaces (four-gas MAP, two headspaces) on shelf-life and consumers perception of fresh pork packaging. The second objective was to confirm shelf-life with new determined gas compositions and optimized headspace.

MATERIALS AND METHODS

Three batches of fresh pork chops were packed in four different gas compositions using two different headspaces, then analyzed during 9 days of storage. For each of the 3 repetitions, pigs were selected according to weight (kg) and carcass composition (TMP). The same slaughter process was used for all the batches: slaughtering on Monday, pH24, cutting, deboning, shell freezing and slicing on Tuesday then MApacking on Wednesday (day 0).

Packing: 2 x chops (150 g) MApacked in four gas compositions: 1. 70% O_2 + 30% CO_2 (70/30); 2. 60% O_2 + 40% CO_2 (60/40); 3. 50% O_2 + 50% CO_2 (50/50); 4. 40% O_2 + 60% CO_2 (40/60) on a tray sealer (Guelt, OPS1000, France). The trays used were, PS EVOH PE 11000 (Form' Plast) with a 30 mm headspace (H1) and a 50 mm headspace (H2). The film was LINTOP PE HB A40 (Linpaq). The pH of meat were measured using a Sydel pH meter and a lot406 Metter Toledo electrode. Analysis of gas (% O_2 and % CO_2) were also performed (Checkpoint II, PBI Dansensor). Sensory analyses were performed using a panel of French consumers who evaluated the products in the trays and after cooking on a pan and served at 64°C. Case-ready packagings (n=250) were stored in the dark at 4°C for 9 days in a cold room.

The microbiological evolutions of the *lactic acid bacteria* (NF ISO 15214), *enterobacteriacae* (NF ISO 21528-2), *Pseudomonas* (NF V04-504), *Brochothrix thermosphacta* (NF V04-505) and Aerobic colony count (NF EN ISO 4833) were monitored. At each point of analysis (days 2, 5, 9), bacterial counts were performed on five samples of each batch. Those products (n=250) were placed for 1/3 of their microbiological shelf-life at 4°C and for 2/3 at 8°C in a cold room.

Statistical analysis were conducted with 9.2 SAS software version (SAS Institute, USA) using ANOVA, the Turkey and Student tests.

RESULTS AND DISCUSSION

Impact of the headspace

We followed the composition of CO_2 and O_2 in each trays to investigate the effect of headspace on the composition of gas. The 50/50 gas follows the same pattern for the two headspaces (figure 1). The CO_2 dissolution in the water-phase and the fat-phase of the pork chop is observed during the first hours of storage. Metmyoglobin formation and microbial development are responsible for oxygen consumption and could influence gas composition after two days of storage. Gas composition follow the same trend that was estimated by Bjørn et al (2007) with his mathematical model. With the same initial gas injection, the estimated gas equilibrium reaches here 35.2% CO_2 and 58.5% O_2.

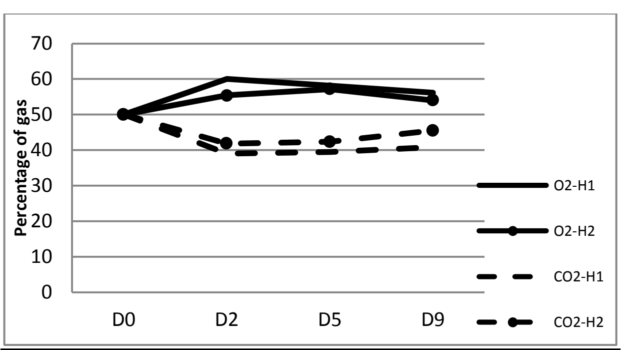

Fig. 1. Gas composition evolution in two different headspaces (n=250)

The dissolution of CO_2 during the first period of storage is influenced by temperature and pH values.

Gill (1988) showed a significant effect of temperature, type of fat tissue and fat content on the solubility of CO_2 in meat. Lower solubility at higher temperatures has been mentioned by many authors (Wolfe, 1980; Wimpfheimer et al., 1990; Zhao et al., 1994) as the reason for the minor effect of MAP at higher temperatures. In our study, pork chops were preserved at 4°C.

According to *Devlieghere* (1998), an increase in pH resulted in an increase of the CO_2 solubility and this effect was strongest at high pH values. Similar results were demonstrated by Löwenadler et al (1994). In our study pH measures were constant and homogenous during storage as we can see on the table 1.

Table 1 pH values in trays H1 and H2 with 50% O_2 and 50% CO_2

	50/50 H1 *(n=125)*	**50/50 H2** *(n=125)*
D2	5,7±0.3	5,7±0.2
D5	5,7±0.3	5,7±0.1
D9	5,6±0.3	5,7±0.2

Table 2 shows that the level of contamination of *Enterobacteriacae* at day 10 is significantly lower for small trays (H1) versus large sizes (H2) cf. table 2.

Table 2 Contamination level of E*nterobacteriacae* in two headspaces

Enterobacteriacae *Log cfu/cm² at 10 days (n=85)*		
Headspace	*Average*	*Level (5%) **
H1	0.19	A
H2	1.01	B

***a,b** Proportion within a column sharing the same letter are not significantly different (p>0,05).

Whatever the floras and dates, there are no significant differences between H1 and H2 trays; this means that the headspace H1 allowed an equivalent conservation as H2. We can conclude that it's possible to reduce the volume of gas and headspace whatever the gas mixture used.

When observing trays (table 3), consumers prefer smaller trays (small headspace). The best purchase intent (78%) is obtained with the lowest oxygen content (40%) gas. It may be noted that the most frequent used by and the pork meat industry (gas 70/30) is also very popular in a package with a reduced headspace with 74% purchase intent before opening.

Table 3 Evaluation of the trays by a panel of consumers

Gas/headspace	*Note /10*	*Percentage of consumers satisfied*
40/60H1	7.0a	65%
70/30H1	6.9a	63%
60/40H1	6.7ab	65%
50/50H1	6.5ab	49%
50/50H2	6.2abc	46%
40/60H2	6.2abc	42%
70/30H2	5.9bc	39%
60/40H2	5.5c	34%

***a, b** Proportion within a column sharing the same letter are not significantly different (p>0,05).

Impact of the gas compositions:

We followed the microbial evolution during the shelf life and the pork chops were evaluated by consumers in order to investigate the effect of gas composition. After 10 days of storage (table 4) gas composition shows a significant effect on microbial growth for *Pseudomonas, Enterobacteriaceae, and Brochothrix.*

Table 4 Comparison of contaminations after 10 days of storage

	Log cfu/cm² at 10 days (n=85)		
	Pseudomonas	*Entero-bacteriacae*	*Brochothrix*
O_2/CO_2	*Average*	*Average*	*Average*
40/60	1.68a	0.05a	2.57a
50/50	2.69ab	0.49ab	2.71a
60/40	2.47b	0.64ab	3.48b
70/30	3.56c	1.21b	4.22c

***a,b** Proportion within a column sharing the same letter are not significantly different (p>0,05).

In the same thermal scenario there are 3.56 versus 1.68 log cfu/cm² of *Pseudomonas* with gas 70/30 compared to 40/60. The growth of *Enterobacteriacae* is reduced of 1 log and 2 log of *Brochothrix* with 60% of CO_2 versus 30%. The growth of bacteria is quite similar with 60 and 50% of CO_2. The effect of modified atmosphere packaging is not surprising can mainly be attributed to the bacteriostatic action of CO_2.
*Devlieghere (*1998) reported that the growth of *P. fluorescens* was highly influenced by CO_2. A significant increase in the lag phase and a decrease in the growth rate of *P. fluorescens* was, as could be expected, noticed with increasing CO_2 concentrations. The figure 1 represents of growth of aerobic colony count during ten days for all gases and headspaces. According to the microbial results (fig. 2), the shelf life of pork chops may vary between gas compositions.

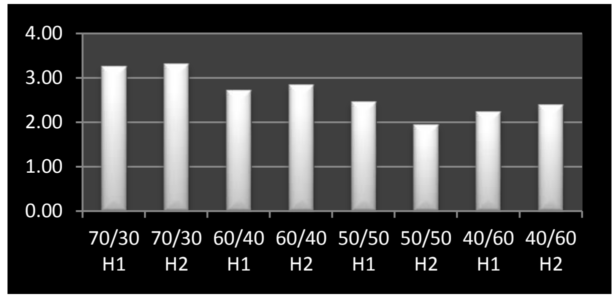

Fig. 2 The growth of aerobic colony count during ten days (log cfu/cm²)

After 7 days of storage at 4°C, pork chop were evaluated by 65 consumers.

Table 5 Tasting session by a panel of consumers

Products	*Overall impression (n=250)*		*Re-consume Intention*
	Note /10	*Percentage of consumers satisfied*	RI
70/30H1	6.9a	63%	74% a
70/30H2	6.6ab	55%	65% ab
50/50H2	6.4ab	51%	55% b
60/40H2	6.4ab	48%	63% ab
50/50H1	6.3ab	52%	62% ab
40/60H1	6.1b	46%	57% b
60/40H1	5.9b	42%	54% b
40/60H2	5.7b	48%	51% b

***a,b** Proportion within a column sharing the same letter are not significantly different (p>0,05).

At the tasting, gas with the highest CO_2 level is found ranked lower. Clearly, the gas mixture commonly used is the most appreciated by the consumer panel when combined with a small headspace. The intention to re-consume the product is statistically equivalent between the reference sample (70/30 H2) and the product (50/50 H1). Consumers noticed dryness of the meat in the (40/60) gas composition. Most of the consumers panel were satisfied by the gas mixture (70/30) with the small headspace.

Validation of shelf life

According to the experimental results the trays with the lowest headspace enable a microbial preservation at least equivalent to those with large headspace. Furthermore they are more appreciated by consumers.
The choice of the gas mixture was oriented towards the gas having the highest rates of CO_2, because they provide a longer shelf life.
With the aim of increasing the shelf life of pork chops. Two batches of trays packed under two gas compositions 40/60 H1 and 50/50 H1 products

were monitored (evolution of gas and growth of bacteria) on two scenarios:

Scenario 1: 4°C until D8, 8°C until D12
Scenario 2: 4°C until D9, 8°C until D14

Table 6 Evolution of contaminations of several floras in two scenarios of temperature

	Log cfu/cm² 40/60 H1				*Log cfu/cm² 50/50 H1*			
Days	*Pseud.*	*Ent*	*ACC*	*List.*	*Pseud.*	*Ent*	*ACC*	*List.*
D1 (*n=5*)	1.86	1.00	2.39	Abs	2.00	1.06	2.22	Abs
D8 (*n=5*)	2.25	1.75	4.48	Abs	2.38	1.63	4.58	Abs
D12 (*n=5*)	2.43	2.60	6.60	Abs	3.18	3.08	6.65	Abs
D9 (*n=5*)	2.22	1.53	4.99	Abs	2.00	1.33	4.38	Abs
D14 (*n=5*)	3.08	2.21	6.49	Abs	3.51	3.51	6.83	Abs

This observation means that within the two scenarios for shelf life evaluations, the *Pseudomonas* concentration obtained under gases (40/60 and 50/50) at the end of the shelf life remains acceptable according to the GHP guide criterion (6 log cfu/cm²). In the same way *Enterobacteriacae* remains acceptable according to the GHP guide criterion (5 log cfu/cm²).

These results confirm a shelf life of 12 and 14 days for your individual retail packs, 4 days longer than the SL currently positioned on the individual retail packs.

CONCLUSION

This study confirms that a reduction of the O_2 percentage of oxygen from 70% to 40% in the gas mixture doesn't impact the color of the pork meat for consumers. The increase of the CO_2 percentage extends the shelf life of MAP. Consumers are sensible to the volume reduction of the trays. This reduction of headspace can lower the environmental impact without degrading the sanitary quality of the meat.

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