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SENSORY EVALUATION OF GROUND BEEF STORED IN DIFFERENT ATMOSPHERES

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Introduction

It is well established that sensory properties of beef loin steaks such as tenderness and juiciness decrease during storage in a modified atmosphere pack (MAP) containing high oxygen and that a rancid/oxidized/warmed over flavour (WOF) may develop (Seideman et al., 1979; Tørngren, 2003; Clausen, 2004; Sørheim et al., 2004). In contrast, the effect of MA packing on the sensory properties of ground beef has not been documented to the same extent (Jayasingh et al., 2002). Case ready meat packaging is a fast growing segment (Zilbermann, 2003), and when choosing a packing technology it is essential to ensure that it will maintain the eating quality of the meat during storage. MAP with high O_2 also increases the amount of oxymyoglobin, which gives rise to a well-done appearance at temperatures much lower than expected (Hunt et al., 1999). This might lead to an increase in food born illness if people use colour of meat as indicator of meat temperature, as pointed out by Tørngren & Madsen (2005).

An alternative to high O_2 MAP is CO_2, N_2 and CO alone or in combination. CO_2 is added to the gas mixture because of its antimicrobial properties (Jakobsen & Bertelsen, 2002) and thereby increases the shelf life. But CO_2 has also shown adverse effect on beefsteak quality. Increasing the CO_2 level to more than 20% will increase the development of pores and fissures after cooking caused by rapid release of CO_2 from the meat (Bruce et al., 1996; Penny, 1999; Kerry & Ledward, 2002; Sørheim et al. 2004). Increasing the amount of CO_2 may also lead to snug down (low pressure) because the CO_2 is absorbed by the meat. N_2 is an inert gas, but beef will appear purple (deoxymyoglobin (DMb)), if O_2 is excluded from the gas mixture, or brown (metmyoglobin (Mb)), if a low concentration of O_2 (½-1%) is left in the gas mixture. Low concentrations of CO (0.4%) will give the meat the desirable shiny red colour (oxymyoglobin (OMb)) corresponding to meat exposed to O_2. However, it is not allowed to use CO in the EU at the moment, but since it has been allowed in the USA, perhaps it may be an option in the future. 0.3-0.5% CO in a gas mixture is estimated not to constitute any health risk (European Commission, 2001). However, little is known about the sensory quality of meat stored in MAP containing CO.

Objectives

The purpose of the present study was to examine sensory quality of ground beef stored in five different atmospheres and cooked as patties.

Methodology

Source of meat: 30 x 500 g ground beef packs (ground twice though 6.0 and 2.5 mm holes, 10% fat), was sampled in a random standardized manner from a commercial packing plant. Six packs (replicates) were assigned to each of the following MA combinations at a commercial plant.

MA-combination	Abbreviation
25% CO2 / 75% O2	High O2
60% CO2/ 40% N2	High CO2
60% CO2/ 39,6% N2 / 0,4% CO	High CO2 + CO
30% CO2 / 70% N2	Low CO2
100% N2	Nitrogen

Packaging: Tray (13 x 18 x 6 cm), (O2 permeability: 15 cm3/m2/d, bar) covered with transparent film, (O2 permeability: 0.5 cm3/m2/d, bar), Cryovac. Sealed Air Corporation, top sealed (Mondini). The storage temperature was 2°C. All packages were kept in light surroundings (800-900 lux) for 2 days prior to the analysis.

Atmosphere content was measured at the time of packing in extra pack and prior to sensory analysis of all packs (Check Mate 9900, BPI Dansensor). Batches 1, 2 and 3 were stored for 7 days and batches 4, 5 and 6 for 8 days before sensory analysis.

Cooking and sensory evaluation: After storage the meat was equalized at room temperature (approx. 20°C) to an internal temperature of max. 15°C. 500 g minced meat from each pack were shaped into 5 patties using a template (thickness: 1.5 cm: diameter: 9.5 cm). The patties were fried on a preheated frying pan (155°C), turned every 2 minutes until an internal temperature of 76 ± 1°C was reached. The patties were halved and evaluated by 8 trained assessors using a 15-point non-structured line (where 0 = slight and 15 = intense). The attributes assessed were WOF, meat flavour, sour flavour, juiciness, spongy texture, firmness, gumminess, crumbling and doneness (internal colour). Cooking loss (%) was recorded by weighing 5 patties before and after cooking.

Statistics: Data were used for an analysis of variance model (mixed procedure, SAS version 8.2). The fixed effect in the model was the main effect.

Sensory data: Yijk = μ + packing gas i (fixed) + batch j (random) + assessors k (random) + packing gas*assessors ik (random) + packing gas* batch ij (random) + x batch * assessors jk (random) + e ijk

Cooking loss: Yijk = μ + packing gas i (fixed) + batch j (random) + packing gas* batch ij (random) + e ij

Results & Discussion

Results of the sensory evaluations are shown in Table 1.

Flavour. Patties prepared from meat stored in high O_2 for 7 to 8 days scored high for WOF (7.4 points) whereas meat stored without O_2 scored between 2.6-3.5 points ($P<0.01$). WOF is normally related to cooked, stored and reheated meat and is mainly caused by oxidation of fatty acid (Konopka and Grosch, 1991). Other investigations have also shown an increase in WOF or in TBARS during storage of raw meat in high O_2 (Jacobsen & Bertelsen, 2000; Tørngren, 2003; Clausen, 2004; John et al., 2004; Sørheim

et al., 2004; Seyfert et al., 2005). In this study only three of the trained assessors could identify a substantial difference in WOF in meat stored with or without O_2 (a difference larger than 6 points). Two assessors identified a minor difference (approx. 1 point) and three assessors found no difference. We therefore assume that not all people are sensitive to WOF.

Meat stored in 100% N_2 had the lowest score for intensity of meat flavour (4.9 points) and meat stored with CO_2 had the highest score (6.1-6.5 points)($P<0.05$). In between lies meat stored in high O_2 with a score of 5.7 points. This is surprising since other investigations have shown that beefsteaks stored without O_2 scored higher in meat flavour than meat stored in high O_2 (Tørngren, 2003; Clausen, 2004). The explanation is probably a pronounced microbiological growth in packs with 100% N_2. This assumption is supported by a high score for sour/acidic flavour in meat packed in 100% N_2.

Juiciness: The meat stored in high O_2 or high CO_2 had the lowest score in juiciness (6.1–6.4 points) and meat stored in 100% N_2 or 30% CO_2/70% N_2 scored highest (7.0-7.2 points)($P<0.05$). Clausen (2004), Sørheim (2005) and Jayasingh et al. (2002) showed that meat stored in 80% O_2/20% CO_2 had a reduced juiciness compared to meat stored without high O_2 and CO_2. Tørngren (2003) found that storage 16 days storage in 50% CO_2/50% N_2 did not result in a reduced juiciness compared to storage in a vacuum packaging. More research is required to elucidate whether it is O_2 only that is the cause of the decreasing juiciness or whether it is a combination of both O_2 and CO_2.

Texture: No significant differences were found in the attributes spongy texture, firmness, gumminess and crumbling. Using a statistic design with all effects fixed, the spongy texture was significantly higher in meat stored in 100% N_2. Jayasingh et al. (2002) found minced meat stored in 80% O_2/20% CO_2 to be less tender than fresh minced meat. Other studies have shown that beefsteaks become less tender during storage in high O_2 MAP (Tørngren, 2003; Clausen, 2004; Sørheim, 2004).

Internal colour: The assessors found significant differences in internal colour of the cooked meat ($P<0.001$). Meat that had been stored in high O_2 appeared most well done (11.8 points) followed by meat stored without O_2 and CO (10.9-11.3 points) and least well done was meat stored in 0.4% CO (7.3 points). Hunt et al. (1999) have demonstrated that OMb looks well done at 55°C and DMb looks well done at 75°C. Anyway, at 75°C patties with DMb had a significantly lower visual score (less brown) than the patties with OMb. John et al. (2004) showed that patties stored in 0.4% CO and cooked to 79°C remained somewhat red even at the internal temperature of 79°C. Packaging ground beef in MA containing CO could lead the consumer to cook the patties to a higher internal temperature than usual to obtain a well done colour. This will lead to higher cooking loss and less juicy meat (Martens et al., 1982). Similarly Tørngren & Madsen (2005) have demonstrated that different packaging methods with more or less O_2 largely influence the cooked appearance of ground beef and that neither internal colour nor colour of meat juice can be used as indicators for safe cooking. Thus measurement of the core temperature of ground beef patties is necessary to obtain a safe cooking procedure, which at the same time ensures the optimal eating quality.

Cooking loss: The mean cooking loss varied from 28.7-29.7% between the different storage atmospheres, and there were no significant differences between the different packaging methods. Sørheim et al. (2004) found that minced beef that had been stored in 50-80% CO_2/20-50% N_2 lost more juice during cooking than meat stored in 100% N_2 or

vacuum packed. However, Bentley et al. (1989) did not find any difference in cooking loss when stored in 100% CO_2 or 100 N_2.

Gas composition after storing: The gas composition in the packages was measured after 7 to 8 days storage (Table 2). At the time of packing approx. ½% O_2 was left in the package, but after 7 to 8 days of storage the amount of O_2 was reduced to zero probably due to microbiological growth. CO_2 had decreased during storage due to absorption in the meat.

Conclusions

Patties of ground beef stored for 7 to 8 days in MA containing high O2 (80% O2/20% CO2) scored higher points for WOF, were less juicy and looked more well done compared to meat stored in 100% N2. Patties of ground beef stored in high CO2 were less juicy than meat stored in low CO2. Patties of ground beef stored in CO looked less well done compared to meat stored in MA with or without O2. Otherwise meat from the CO packs did not differ significantly with respect to sensory attributes from packs without CO. Patties of ground beef stored in 100% N2 scored higher points for sour flavour and less for meat flavour compared to meat stored in other types of MA packaging. The explanation is probably pronounced microbiological growth. In conclusion, this study showed that packaging with high concentrations of O2 also has a negative impact on the eating quality of cooked ground beef.

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Tables and Figures

Table 1. Mean (incl. min. and max.) sensory score (8 trained assessors using a non-structured line scale, anchored to the extremes; 0= slight, 15=intense) of beef patties repared from ground beef meat stored in different MAP (n=6).

Modified Atmosphere	Warmed over flavour	Meat Flavour	Sour/acid Flavour	Juiciness	Internal Colour Doneness	Gumminess
25%CO_2/75%O_2	7,4$_a$	5,7$_{ab}$	0,6$_c$	6,1$_c$	11,8$_a$	3,1
	6,8-8,0	4,9-6,5	0-0,9	4,2-5,3	11,3-12,2	1,7-4,4
60%CO_2/40%N_2	2,6$_b$	6,5$_a$	1,8$_{bc}$	6,4$_{bc}$	11,3$_b$	3,7
	1,2-3,3	5,4-7,7	0,5-3,2	5,4-7,1	10,7-11,9	1,9-5,8
60%CO_2/40%N_2/						
0,4% CO	2,6$_b$	6,2$_a$	2,7$_b$	6,4$_{bc}$	7,3$_c$	3,1
	1,2-4,5	5,3-7,4	1,4-4,1	6,0-7,0	6,9-7,7	2,0-5,6
30%CO_2/70%N_2	2,9$_b$	6,1$_a$	3,7$_b$	7,2$_a$	11,1$_b$	3,1
	2,1-4,2	4,8-7,7	1,5-6,2	6,8-7,7	10,8-11,3	2,4-4,2
100% N_2	3,5$_b$	4,9$_b$	5,8$_a$	7,0$_{ab}$	10,9$_b$	4,2
	2,8-4,0	3,8-5,9	3,9-9,5	6,6-7,3	10,4-11,4	3,4-4,7
Significance	**	**	***	*	***	ns

*: P<0.05 **: P<0,01 ***: P<0,001 ns: not significant Within columns, means with different letters differ (P<0.05)

Table 2. Mean (incl. min. and max.) O_2 and CO_2 content after 7 to 8 days MAP

Modified Atmosphere	O_2 %	CO_2
25% CO_2 / 75%O_2	67,7	23,5
	62,9-72,4	21,5-26,6
60% CO_2/ 40% N_2	0,0	39,9
	0,0-0,4	34,8-43,0
60% CO_2/ 40% N_2/ 0,4% CO	0,0	40,3
	0,0-0,0	34,4-43,2
30% CO_2/ 70% N_2	0,0	22,8
	0,0-0,0	21,5-23,9
100% N_2	0,0	11,5
	0,0-0,0	10,2-14,0