AIR TRAPPING DURING VACUUM PACKAGING OF HOT AND COLD BONED BEEF

Effect on gas composition and bacteriological condition

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SUMMARY

Vacuum packaging at 99% efficiency results in more evaporation from hot than from cold meat. This causes the packaging film to become moistened thus jeopardizing the sealability of the film and preventing adequate skinning. In addition, the surface of hot meat tends to be more sticky, resulting in "air trapping" in the course of vacuum packaging. The impact of such a deficient packaging technique on the composition of the trapped air and on the bacteriological condition of the packaged beef is examined.
The O_2 content of the residual air decreased faster and the CO_2 content was consistently higher in hot - than in cold boned packs. Bacteriological quality of hot boned beef was worse than of cold boned beef both with air-trapping. Possible mechanisms are discussed.

INTRODUCTION

Hot meat is more difficult to vacuum pack than cold meat. From hot meat of e.g. 30°C water will evaporate readily at residual air pressures of 31.8 mbar whereas in cold meat of e.g. 5°C this will happen at approximately 5.7 mbar. Vacuum packaging of hot meat at 99% efficiency, 10 mbar residual air pressure, will thus lead to increased evaporation. The increased evaporation may jeopardize the sealability of some films and prevent adequate skinning. Furthermore the sticky surface of hot meat tends to increase the risk of "air trapping" (Apple and Terlizzi, 1983).

The impact of such a deficient packaging technique on the bacteriological condition of hot meat is not known. The trapped air will contain O_2 which may accelerate growth of aerobic spoilage bacteria. However, the residual oxygen can be converted to CO_2 by respiration of meat tissue (Enfors and Molin, 1984). We expected the O_2 consumption rate and consequently the CO_2 production rate to be higher in hot meat than in cold meat. This would mean that vacuum packaging of hot meat with some oxygen, e.g. with air trapping, would offer the best protection against microbial growth. Purpose of this paper is to examine the impact of air trapping on the gas composition and on the bacteriological condition of packaged beef.

MATERIALS AND METHODS

The left- and righthandside M. longissimus dorsi of two boner-grade Dutch Frisian cows were hot boned. The righthandside longissimus muscles were divided in 14 chops, of approximately 200 grams each, which were immersed in a suspension of bacteria cultured from the scrapings of tables from a commercial beef cutting operation. After immersion chops were allowed to drain for ca. 10 s and vacuum packaged by use of a chamber-type-vacuum-packaging machine. After vacuum packaging air trapping was simulated by injecting 8-10 ml of air through air-tight rubber discs which had previously been glued to the vacuum film. Before refrigeration at 2°C, vacuum packs of righthandside longissimus were conditioned 5 h at 15°C. Expect the conditioning period the lefthandside longissimus received a similar treatment after 24 h refrigeration at 2°C. After 0, 7, 14, 21 and 28 days of storage the gas composition in vacuum packs of lefthand- and righthandside chops was assessed by gas chromatography. Subsequently chops were unpacked and sampled for bacteriological examination.

The vacuum bags had the following characteristics: transmission rate O_2: 8-13; CO_2 30-50; N_2: 3-5 ml/m²/24 h/1 atm/45% RH.

Bacteriological examination

The culture of bacteria originating from the cutting tables was prepared by adding scrapings to peptone-saline solution. After 8 h of stirring and seving the suspension was frozen. The day before the experiment the frozen suspension was allowed to thaw in the refrigerator at 5°C.
Longissimus cuts were sampled by means of sterile cork borers. Two tissue discs of approximatelly 5 cm² were punched out, subsequently macerated in 90 ml peptone-saline solution in a stomacher. Numbers of colony forming units (c.f.u.) of the following micro-organisms were assessed.
(a) aerobic colony counts: in poured plates of Tryptone Glucose Beef extract Agar; incubation 3 d 30°C, (b) Enterobacteriaceae in poured plates of Violet Red Bile Glucose agar with overlayer; incubation 1 d at 37°C, (c) Gram-negatives/Pseudomonas on spread plates of Gillenberg; incubation 3 d at 25°C, (d) Brochothrix thermosphacta on spread plates of STAA; incubation 2 d at 24°C (Gardner, 1966).

Gas chromatography

A Carlo Erba, model M gas chromatography equipped with a standard gas sampling system and a thermal conductivity detector was used. A splitter with a variable split ratio was mounted in the gas chromatograph to distribute the gas sample over the two columns: (a) 1.5 mx4 mm i.d. stainless steel packed with SILICAGEL, 80-100 mesh, (b) 1.5 mx4 mm i.d. stainless steel packed with molecular sieve 5A 40-60 mesh.
Analysis was done at approximately 5 ml trapped air (diluted with H_2.
The composition of the gas was calculated by means of the following formulas.

$$O_2 : \frac{x}{a} \times 20.9 = p \times \left(\frac{100}{pxqxr}\right) = \text{.....}\%$$

$$N_2 : \frac{y}{b} \times 79.1 = q \times \left(\frac{100}{pxqxr}\right) = \text{.....}\%$$

$$CO_2 : \frac{z}{c} \times 100 = r \times \left(\frac{100}{pxqxr}\right) = \text{.....}\%$$

a = peak height x attenuation for O_2 in air
b = peak height x attenuation for N_2 in air
c = peak height x attenuation for 100% CO_2
x = peak height x attenuation for O_2 in sample
y = peak height x attenuation for N_2 in sample
z = peak height x attenuation for CO_2 in sample

p = x/a x 20.9
q = y/b x 79.1
r = z/c x 100

Mathematical analysis of data

Significance of differences were assessed by student t-test. To determine significances of difference in bacterial colony count, samples with less than 7 colonies in the first decimal dilution plate and therefore inappropriate for colony assessment (Mossel and Drion, 1954) were assigned count corresponding with the limit of detection.

RESULTS AND DISCUSSION

Fig. 1 shows the changes of the gas composition. Immediately after vacuum packaging the composition of the trapped air is different from the atmospheric air. By vacumating CO_2 emerges from the meat into the air. This is reported earlier, the origin of this CO_2 evolution is not known (Enfors and Molin, 1984). During the 28 days storages the CO_2 percentage increases and the O_2 percentage decreases. It seems there is no difference in decrease of O_2 content between hot and cold packaged beef. The CO_2 content, however, in vacuum packs of hot boned meat is consistently higher than in cold boned counterparts. This is not in agreement with Enfors and Molin (1984) who found no differences between CO_2 evolution from pre-rigor and post-rigor meat. This discrepancy may be explained by the fact that they used porkloins. As the initial CO_2 content is also higher the difference can't be explained by microbial growth. A low O_2 content and a high CO_2 content is theoretically a unfavourable condition for growth of aerobic spoilage bacteria to a certain extend. So, it might be expected that air trapping has no or even a favourable effect on the bacteriological condition of vacuum packaged hot meat.

As can be seen in Fig. 2 up to 21 days the colony counts on hot boned beef were higher than on cold boned beef. After 28 days maximum colony counts are reached. So in spite of a higher CO_2 content and a low O_2 content the bacteriological growth on hot boned beef is faster than on cold boned beef. It is not as yet known what may be the explanation of these results. Perhaps O_2 content of the residual air is low but O_2 content on the surface of the meat is high(er). There may be more oxymyoglobine in hot than in cold boned meat. There is, however, theoretically no reason to expect this.

Another explanation may be the applied conditioning period for hot boned beef. This conditioning period is necessary to avoid shortening and tenderness problems (Chrystall, 1982; Smulders et al., 1985).

Some workers are of the opinion that the higher temperature of the meat on boning will allways give rise to increased bacterial numbers of hot boned meat as compared to cold boned meat. (Fung et al., 1980). Results observed by other workers with hot boned meat are, however, variable (Sheridan and Sherington, 1982).

Possible explanations will be investigated in following experiments.

CONCLUSIONS

Air trapping during vacuum packaging of hot boned conditioned beef gives rise to higher bacterial counts as compared to air trapping during vacuum packaging of cold boned beef. As no comparison has been made between vacuum packaged hot boned beef with and without air trapping it is not certain if higher bacterial counts are due to the "air trapping".

REFERENCES

1. Apple, J.M. and F.M. Terlizzi (1983). Food Technol 37 (5): 68-77.
2. Chrystall, B.B. (1982). In: Proc. Meat Science and Technology Symposium, Lincoln, Publ. National Livestock and Meat Board, Chicago. P. 221.
3. Enfors, S.O. and G. Molin (1984). Meat Sci. 10: 197-206.
4. Fung, D.Y.C., C.L. Kastner, M.C. Hunt, M.E. Dikeman and D.H. Kropf (1980). J. Food Prot. 43, 547-550.
5. Gardner, G.A. (1966). J. appl. Bact. 29, 455-460.
6. Mossel, D.A.A. and E.F. Drion (1954). Netherl. Milk Dairy J. 8: 106.
7. Sheridan, J.J. and J. Sherington (1982). Meat Sci. 7: 245-258.
8. Smulders, F.J.M., F. Korteknie, D.H.J. Woolthuis and G. Eikelenboom (1985). Proc. 30th Eur. Meat Res. Work., Bristol, 75.

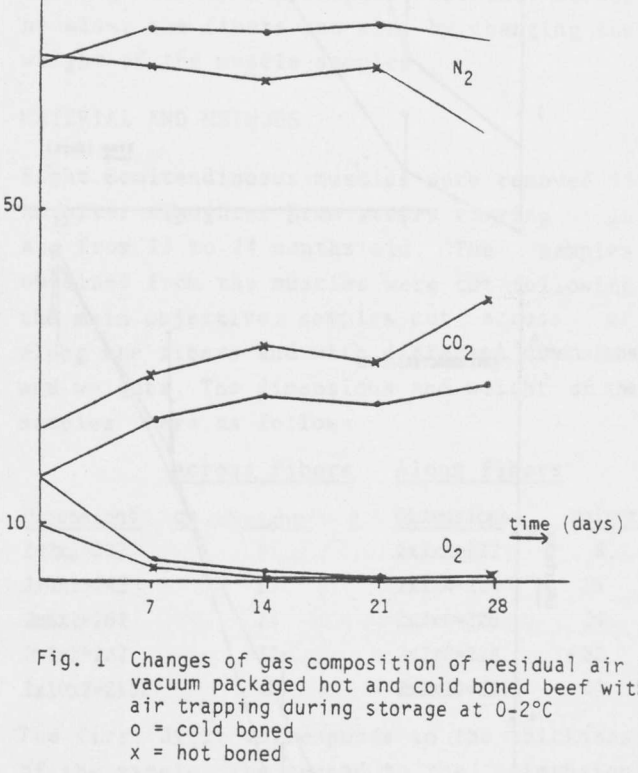

Fig. 1 Changes of gas composition of residual air in vacuum packaged hot and cold boned beef with air trapping during storage at 0-2°C
o = cold boned
x = hot boned

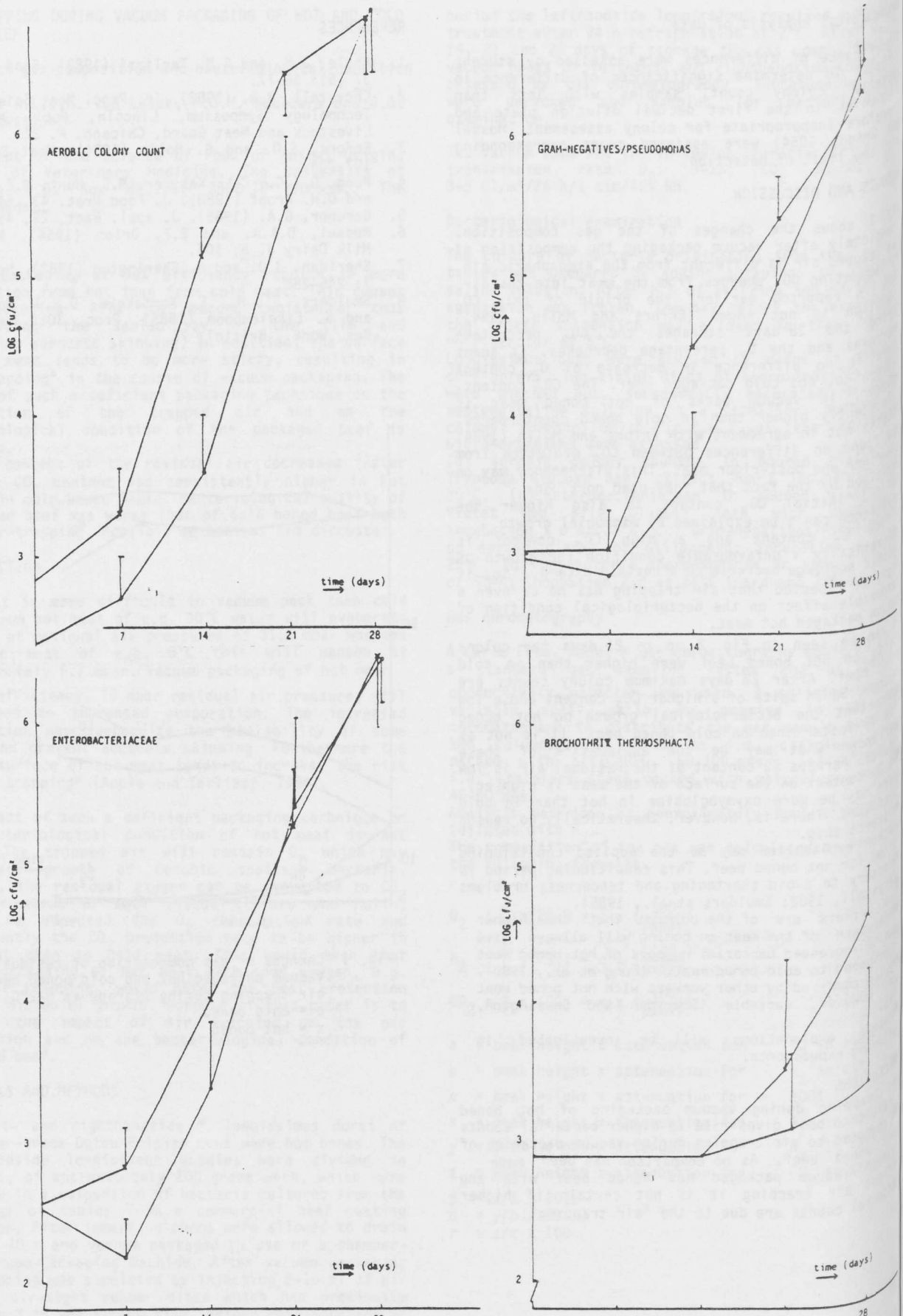

Fig. 2: The effect of air trapping in hot and cold boned vacuumpackaged beef on bacteriological quality
o = cold boned
x = hot boned