TREATMENT OF PORK WITH ORGANIC ACIDS PRIOR TO VACUUM-PACKAGING - A COMPARISON OF THE EFFECTIVENESS OF LACTIC AND ACETIC ACIDS

B.J. Shay[1], A.F. Egan1, Dianne Miller[1] and Tian Ai-Jia[2], [1]CSIRO Division of Food Processing, Meat Research Laboratory, P.O. Box 12, Cannon Hill, Queensland 4170, Australia, [2]Tianjin Food Research Institute, Tianjin, People's Republic of China

SUMMARY

Immersion of pork loins for 10 s in dilute solutions of either acetic or lactic acid at 55°C was effective in decontaminating the meat, the population of Gram-negative bacteria being reduced by about 90%. When the meat was vacuum-packaged and stored at 0°C, acetic acid treatment produced a more prolonged bacteriostatic effect on the Gram-negative flora than did treatment with lactic acid. Treatment with either acid resulted in an extension of storage life and in the case of acetic acid treatment, storage life was extended from three to six weeks. Whilst the use of either acid is suitable for decontamination, to obtain an extension of the storage life at 0°C of vacuum-packaged product, acetic acid treatment is preferable.

INTRODUCTION

By far the most important factors in controlling the degree of initial microbial contamination of fresh meat are the practices used during slaughtering and dressing procedures. However in spite of increased attention being given to the use of hygienic practices in recent years, carcasses still become contaminated with bacteria. Additional processes can be used to reduce the contamination of carcasses, or after boning, of primal cuts.

Organic acids, such as lactic acid and acetic acids, occur naturally in a variety of foods and have antimicrobial effects that are well documented. Dilute solutions of lactic acid (ca. 1-2%) have been recommended for the decontamination of carcasses and offal meats (reviewed by Smulders et al. 1986). The use of a dilute solution of acetic acid to decontaminate sheep carcasses prior to vacuum-packaging, has been shown to result in an increase in storage life (Eustace 1984).

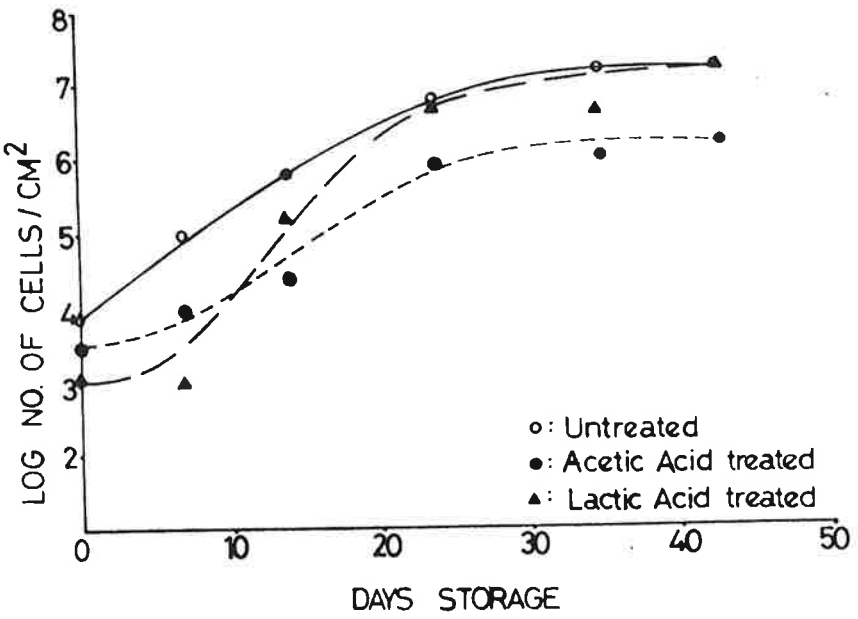
Vacuum-packaged beef has a storage life of up to 12 weeks at 0°C (Egan and Shay 1982) providing certain criteria are met. One of the most important of these is muscle pH. Vacuum-packaged meat of high pH (>5.9) has a much shorter storage life than meat of normal pH (5.4-5.8; Nicol et al. 1970; Gill and Newton 1979; Taylor and Shaw 1977).

In Australia processors report a storage life for vacuum-packaged pork of only 2-3 weeks under commercial conditions at temperatures around 5°C and this is considered inadequate, even for local catering use. The incidence of pork of high pH is sufficiently high to make it impractical to exclude it from vacuum-packaging and the packaging of high-pH meat appears to be a major factor causing the inadequate storage life.

We have shown that vacuum-packaged pork may be kept for up to six weeks without spoiling provided the pH is normal. At spoilage the bacterial flora of this product is composed almost entirely of lactic acid bacteria (Egan and Shay 1984). When pork of high pH is vacuum-packaged, certain types of Gram-negative psychrotrophs can grow to high populations (ca. $10^7/cm^2$). These may product hydrogen sulphide which reacts with myoglobin to produce sulphmyoglobin, which is green (Nicol et al. 1970). Growth of these organisms results in spoilage characterised by greening of the weep and fat surface. This may occur after three or four weeks storage at 0°C (Shay and Egan 1986).

Little information is available on the effect of treatment with organic acids on the storage life of vacuum-packaged

Fig 1.



The effect of treatment with dilute acids on the growth of gram-negative bacteria on the lean surface of vacuum-packaged high pH (6·2 – 6·5) pork stored at 0°C. o, untreated; ●, treated with acetic acid; ▲, treated with lactic acid.

pork. We have now investigated the effectiveness of treatment with lactic acid and acetic acid for this purpose. The target organisms for these treatments are the Gram-negative bacteria which cause the rapid spoilage of high-pH meat and our studies have concentrated on the effects of the acid treatments on this group of bacteria.

EXPERIMENTAL METHODS

Pork loins were obtained from local processors. They were taken from carcasses 1-2 days post mortem and were selected on the basis of pH immediately after boning. In most experiments the skin was removed in the boning room. Loins were cut into three equally-sized pieces and these were placed in plastic bags. The packaging film used consisted of a layer of polyvinylidene chloride coated on both sides with ethylene-vinyl acetate copolymer; it had an oxygen permeability of 25-30 mL/m^2/24 h/atm measured at 25°C and 98% RH (W gauge Barrier Bag, W.R. Grace & Co.). Meat was vacuum-packed and heat sealed in the pouch using a Supervac chamber-type evacuator operated at maximum vacuum. Packs were not heat shrunk.

Pretreatment with acetic acid was carried out by total immersion of the meat for 10 s in a 1.5% (v/v) solution at 55°C (Eustace 1984). The pieces of meat were placed on a wire rack and allowed to drain for about 10 min before vacuum-packing. Treatment with lactic acid was done similarly except that the concentration used was 2% (v/v) and the acid was depolymerised before use (Johnson 1957). Samples for microbiological analysis were obtained by excision using a sterile cork borer of known cross sectional area. Samples (total area 10 cm^2) were homogenized in 90 ml of 0.1% (w/v) neutralised peptone water (Oxoid L34) for one min using a Colworth Stomacher Model 400. To determine the count of Gram-negative bacteria samples were plated on peptone agar (Grau, 1983). On this medium they form large colonies whereas the growth of lactic acid bacteria and *B.thermosphacta* is greatly restricted by the lack of carbohydrate (and these organisms form only small colonies).

Petri dishes were incubated at 25°C and colonies counted after 2 days. A duplicate set of dishes were incubated for 2 weeks at 5°C. For confirmation, colonies were tested for Gram reaction using the method of Buck (1982).

One piece of meat from each loin was allocated to each of the three treatments - acetic acid treated, lactic acid treated and non-treated. The vacuum-packaged meat was stored at 0°C in the dark at ca. 90% RH. Meat was sampled weekly for six weeks, and at each sampling time, the three pieces from the same loin were chosen.

The presence of sulphmyoglobin was detected as described by Nicol et al. (1970). All other procedures have been described previously (Egan and Shay 1984).

RESULTS

In the first experiment the reductions in the population of Gram-negative bacteria produced by the acetic acid and lactic acid treatments were 50% and 85% respectively.

The growth of the Gram-negative bacteria on the vacuum-packaged pork stored at 0°C is shown in Fig. 1. These bacteria grew most rapidly on the pork which had not been treated with acid and reached a population in excess of $10^6/cm^2$ after about two weeks storage. During further storage, the population on the non-treated meat reached a maximum of about $2 \times 10^7/cm^2$. The growth of the Gram-negative bacteria was inhibited by the acid treatments, and these organisms reached a population of about $10^6/cm^2$ after about two and a half and four weeks storage for the lactic and acetic acid treatments respectively.

The meat which had not been acid-treated spoiled the most rapidly. Putrid odours were detected after three weeks. After four weeks storage the exudate present in packs containing non-treated meat was slightly green in colour and spectrophotometric analysis confirmed the presence of sulphmyoglobin. Meat treated with lactic acid had a putrid odour after five weeks storage and greening had occurred after six weeks. No putrid odour or green discolouration was detected in the case of meat treated with acetic acid, even after six weeks storage.

Similar results were obtained in the second experiment with the exception that acetic acid treatment resulted in a more effective decontamination than did lactic (95% and 90% reductions respectively).

DISCUSSION

Treatment with acetic acid extended the storage life of vacuum-packaged high pH pork from about three weeks to six weeks. In the case of meat treated with lactic acid, the storage life was about five weeks. Acetic acid may be somewhat more effective for this purpose than lactic, since this result was obtained in two independent storage trials. Acetic acid treatment resulted in a more prolonged inhibition of the growth of the Gram-negative bacteria than did lactic. Since putrefaction and greening were delayed by this treatment, these results agree with previous observations suggesting that the Gram-negative bacteria are a major cause of these problems (Taylor and Shaw 1977; Gill and Newton 1979).

The pH of the meat used in these experiments was 6.2-6.5. The acid treatment is likely to be less effective if meat pH is even higher.

ACKNOWLEDGEMENT

The authors are grateful for support provided by the Pig Research Council, Australia.

REFERENCES

Buck, J.D. (1982). *Applied and Environmental Microbiology* **44**:992.

Egan, A.F. and Shay, B.J. (1982). *Journal of Food Science* **47**:1119.

Egan, A.F. and Shay, B.J. (1984). Proceedings, 30 th European Meeting of Meat Research Workers p. 215.

Eustace, I.J. (1984). *CSIRO Food Research Quarterly* **44**:60.

Gill, C.O. and Newton, K.G. (1979). *Applied and Environmental Microbiology* **37**:362.

Grau, F.H. (1983). *Journal of Food Science* **48**:326.

Johnson, M.J. (1957). *In:* Manometric Techniques, 3rd Edition p. 287. Eds. W.W. Umbreit, R.H. Burris and J.F. Stauffer. Burgess Publishing Co. New York.

Nicol, D.J., Shaw, M.K. and Ledward, D.A. (1970). *Applied Microbiology* **19**:937.

Shay, B.J. and Egan, A.F. (1986). *Food Technology in Australia* **38**:144.

Smulders, F.J.M., Barendsen, J.G., van Logtestijn, J.G., Mossel, D.A.A. and van der Marel, G.M. (1986). *Journal of Food Technology* **21**:419.

Taylor, A.A. and Shaw, B.G. (1977). *Journal of Food Technology* **12**:515.