FERMENTATION OF WHOLE MUSCLE MEATS

D.E.Gleeson[1,2],R.G.Leuschner[1,2],G.Schwarz[1,2] and E.K.Arendt.[1]

1.Department of Food Technology, University College Cork.
2.National Food Biotechnology Centre, University College Cork.

Key Words: Meat Fermentation, Starter Cultures, Fermented Ham, Diffusion .

Background:
Traditional fermented hams can take up to 18 months to produce, they are preserved by the NaCl, nitrate and/or nitrite and low a_w. These products undergo a fermentation due to indigenous or environmental microbial flora which may include lactic acid bacteria, Micrococcaceae and yeasts (Silla et al.,1989). However, there are certain risks associated with their production including contamination with spoilage and pathogenic microorganisms. In many cases, the product can be of inconsistent quality due to uncontrolled fermentation. Fermented sausages are also commonly produced by the deliberate addition of specific starter cultures which may include members of the genera *Lactobacillus, Pediococcus, Micrococcus* and *Staphylococcus* (Lücke et al.,1987). Such added cultures contribute to shorter ripening periods, desirable colour development and flavour characteristics, improved product quality and longer shelf life.

Objectives:
The aim of this study is to develop a fermented whole-muscle meat product using defined starter cultures which are commercially available for fermented sausages. The resulting product should be produced faster by a controlled fermentation by comparison with the traditional process. It should be of consistent quality, have controllable sensory attributes and moreover be a safer product due to its low pH and low a_w, both of which factors, cause inhibition of undesirable microorganisms.

Methods:
1. Diffusion from a single injection point : 1 ml of 50% glucose solution containing *Lb. sake* (overnight culture 10^{10} cfu/ml) was injected into the centre of a portion of pork muscle (*M. longissimus dorsi*). After injection meat was covered with sterile aluminium foil and incubated at 12°C for up to 7 days. Bacterial diffusion was determined by plate counts (MRS agar) of specific sections of meat, pH reduction and decrease in glucose concentration.
2. Influence of glucose, nitrite and NaCl concentration on the bacterial diffusion, pH, colour formation in meat model systems : - 1ml of solution varying in concentration of glucose, nitrite and NaCl (Table 1) containing *Lb. sake, St. carnosus* or a combination of both was injected and incubated as described above. Colour and pH change of meat and diffusion distance of bacteria were determined after incubation.
3. Pilot scale processing : Brine consisting of 15% NaCl, 2.66% glucose, 0.075% nitrite and 0.33% starter culture (freeze dried commercial mix of *Lb. sake* and *St. carnosus*) was used. *M. longissimus dorsi* muscles were injected using a hand injector with a 15% injection rate. Test meat was tumbled for 2h , control meat was not subjected to tumbling. Meat was covered with remainder of brine and incubated at 12, 18 and 24°C. Colour and pH change and microbiological analysis (plate counts: *Lactobacillus* - MRS agar, *Staphylococcus* - PM agar, Total plate counts - PCA agar) were evaluated on day 0, 1, 2, 4 and 7.

Table 1: Concentrations of glucose, nitrite and salt used for injections of model systems.

Glucose concentration	[% w/v]	0	5	10	15	20	
Nitrite conc. +10% Glucose	[ppm]	0	200	400	600	800	1,000
Salt conc. +10% Glucose +200ppm nitrite	[% w/v]	0	4	8	12	16	20

Results and discussion:
1. Diffusion from a single injection point : After 24 h an oval shaped pale zone (1 x 1 x 3 cm) was detected around injection point. It was observed that diffusion was greater in direction of the muscle fibre. This pale coloured zone is due to acid production by *Lb. sake*. In the pale area, the number of bacterial cells per gram was 10^9, the pH had decreased from 5.8 to 4.6 and the glucose level had decreased from the initial 50% glucose injected solution to 0. After an additional 24 h of incubation, zone size had doubled. Further diffusion was not observed with continued incubation.
2. Influence of glucose, nitrite and NaCl concentration on the bacterial diffusion, pH, colour formation in meat model systems : After 48 h a pale zone was observed, due to pH drop (*Lb. sake* and combination). This was surrounded by a pink zone (2.5 x 2.5 x 3 cm), due to nitrite reduction and cure colour formation. Only a pink zone was observed with injection of *St. carnosus* alone, as it does not produce acid. The different concentrations of glucose, nitrite and salt exhibited similar results with respect to pH drop, colour intensity and diffusion distance (data not shown).
3. Pilot scale processing : It was observed that pH began to decrease on day 2. The decrease in pH is again evident as pale patches around injection points. A faster pH drop was observed in meat incubated at 18 and 24°C than at 12°C (Fig.1). On day 7 almost the entire muscle was a pale pink cured colour (Table 2) with a few dark patches at the edges. The colour was more uniform in muscles which underwent tumbling, these muscles also resulted in a slightly lower pH than the untumbled ones (data not shown). Microbiological analysis indicated bacterial growth increased from levels of 10^7 cfu/g initially to peak levels of 10^9 cfu/g on day 2 at 18 and 24°C (Table 3). After this time bacterial numbers began to decrease. Starter cultures in meat incubated at 12°C took longer to reach this peak level (day 4), after which time numbers began to decline similar to other temperatures. Microbiological analysis and pH of cover brine were also investigated. Cover brine pH remained relatively constant at 5.5 (approx.) over the seven day period. Plate counts resulted in bacterial numbers of 10^7 cfu/ml on day zero, this number did not increase significantly for any temperature used, and dropped to a lower level more rapidly than bacterial numbers in meat.

Conclusions:
Results from diffusion studies carried out, indicate considerable bacterial diffusion capacity in whole muscle, particularly in the direction of the muscle fibre. Model system investigations suggest that relatively low levels of glucose, nitrite and NaCl are sufficient for a fermented product as higher levels do not appear to be more advantageous. Pilot scale processing yielded a product with very low pH (4.4- 4.7) and satisfactory cure colour formation, which can be produced equally well at temperatures ranging from 12 - 24°C.

References:
1. Lücke, F.K. and H. Hechelmann (1987): Starter cultures for dry sausages and raw ham. Composition and effect. *Fleischwirtschaft*, **67** (3) 307- 314.

2. Silla, H., I. Molina, J. Flores and D. Silvestre (1989): A study of the microbial flora of dry- cured ham. *Fleischwirtschaft*, **69** (7) 1128 - 1131.

Acknowledgements:
We would like to thank Mr. Eddie Beatty and Mr. Nick Bergin for their technical support. This project was supported by the Department of Agriculture, Food and Forestry, Dublin, Ireland.

Table 2: Effect of temperature on colour (Δ E values) of fermented meat (tumbled)

Time (days)	12°C pale	12°C dark	18°C pale	18°C dark	24°C pale	24°C dark
1	8.249	14.604	11.359	16.727	8.952	10.971
2	7.931	12.138	7.339	15.019	6.532	9.663
4	6.918	10.203	7.390	10.502	9.359	6.041
7	5.596	11.213	8.932	1.717	12.274	2.129

Table 3: Effect of temperature on microbiological growth (cfu/g) of fermented meat (tumbled)

Time	MRS			PM			PCA		
(days)	12°C	18°C	24°C	12°C	18°C	24°C	12°C	18°C	24°C
0	3×10^4	3×10^4	3×10^4	3×10^4	3×10^4	3×10^4	4.5×10^4	4.5×10^4	4.5×10^4
1	1×10^7	6.5×10^7	9×10^7	1×10^7	5.5×10^7	3×10^8	1×10^7	5.5×10^7	2×10^8
2	4.5×10^7	5×10^9	5.5×10^9	7.5×10^7	2×10^9	7.5×10^9	4.5×10^7	4×10^8	1×10^9
4	1.5×10^9	2×10^9	1×10^8	1.5×10^9	1×10^9	1×10^8	1.2×10^9	1.5×10^9	1×10^8
7	5.5×10^8	3.5×10^8	1×10^7	1.5×10^9	3.5×10^8	1×10^8	8.5×10^8	5.5×10^8	1×10^7

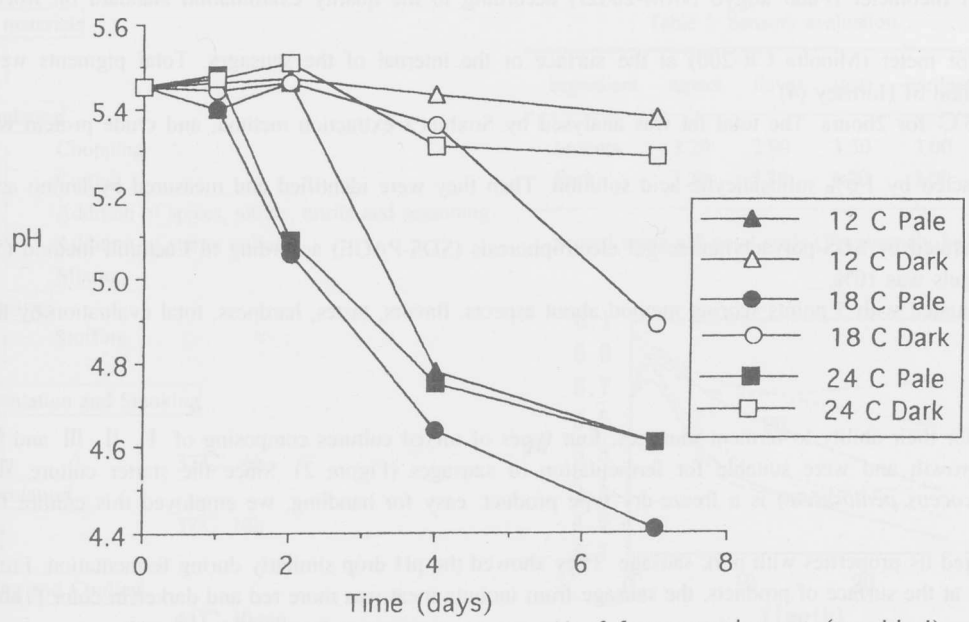

Fig.1 Effect of temperature on pH of fermented meat (tumbled)