A Note on the Bacterial Spoilage of Mechanically Recovered Pork

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The recovery of meat from bones has attracted considerable interest in recent years for many "meat" species, including beef, lamb, pork, chicken, turkey and fish. Much of the interest has been directed towards the chemical composition of the recovered meat and, in particular, the level of bone content (calcium). The recovery of meat from bones can be achieved by two basic methods. The bones with meat can be pre-ground and the mixture then separated mechanically through fine filters, or the raw material can be subjected to high hydraulic pressure in a filter system which allows the "meat" to be readily separated from the "bone" mass. The advantage of this system is that bone particles and marrow are virtually absent from the recovered material. It was meat from the latter process which was the subject of our investigations.

It is generally recognised that mechanically recovered meats can spoil rapidly due to:-
a) the fineness of the product (i.e. large surface area/unit volume);
b) relatively high pH (6.5 and greater);
c) the bacteriological condition of the raw material;
d) the difficulty of cleaning and sterilizing the machinery.

Because of limited stability, mechanically recovered meats are either used within 24 hr as an ingredient in a processed product or alternatively frozen in blocks and held in cold store until required. In Wiltshire bacon manufacture the removal of the neck bones from the carcase is difficult, thus resulting in bone material with a high meat content. The recovery of this meat, mechanically recovered pork (MRP), is of considerable economic importance.

The aim of the work described in this paper was to:-
a) examine the bacteriological status of freshly produced MRP;
b) determine the rate of spoilage and identify the predominant bacterial species; and
c) ascertain the effect of sampling site on the bacteriology of MRP.

MATERIALS AND METHODS

Mechanically recovered pork (MRP). Neck bones from a pork butchery line were directly transferred to one or other of two machines, which can separate the meat from bone and connective tissue without pre-grinding. These were the Protecon Separator (Model MRS20, Protecon UK Ltd., Bedford) and the Hydrau Separator (Raymoll Systems Ltd., Kent). The MRP from each machine was packaged in polythene bags and moulded in blocks (30 x 20 x 9 cm deep). These were blast frozen at -34°C for 16 hr and then stored at -18°C for a period of up to 3 months.

Defrosting of frozen MRP was achieved by transferring the blocks from cold store (-18°C) to a chillroom (4°C).

Bacteriological analyses. Samples of fresh material were obtained by mixing ca. 500 g of MRP. During storage trials, both surface samples (not more than 5 mm deep) of the blocks and deep meat (centre samples) were taken separately for analysis. Colony counts were determined by mechanically shaking a 5 g sample of MRP with 45 ml diluent (0.1% peptone water) and plating out by the surface "drop and spread" method on the following media (Table 1).

Table 1. Media and incubation conditions used in the examination of mechanically recovered pork

Count	Medium	Incubation Temperature (°C)	Incubation Time (days)
Total colony count	TCM (Gardner, 1968)	22	5
Pseudomonas	CFCA (Mead & Adams, 1977)	25	3
B. thermosphacta	STAA (Gardner, 1966)	22	2
Aciduric lactic acid bacteria	AA (Rogosa, Mitchell & Wiseman, 1951)	30	3

Identification of isolates from total count medium. From the total count plates some 15-20 colonies were picked for purity by streaking on TCM plates, examined for Gram reaction and morphology, and identified by the methods and schemes given in Table 2.

Table 2. Scheme for identifying isolates

		Pseudomonas	Alteromonas	Enterobacteriaceae
A. Gram negative catalase positive rods	Oxidase[1]	+	+	-
	Mode of attack on glucose[2]	Oxidative	Oxidative or alkaline	Fermentative
	Anaerobic arginine breakdown[3]	+	-	-
	Motility[4]	+	+	+ or -
	Sensitivity to penicillin[5]	-	-	-
	Production of brown pigment[6]	-	+	-
			Lactobacillus	Streptococcus
B. Gram positive catalase negative rods or cocci	Morphology in APT broth[7]		Rods or coccobacilli	Cocci, in chains
	CO_2 from glucose[8]		+ or -	-

1. Kovacs (1956). 2. Hugh & Leifson (1953) (22° for 7 days). 3. Thornley (1960) (22° for 7 days). 4. Hanging drop method of overnight TCM broth cultures. 5. 2 i.u. discs (Oxoid) on streak plates of TCM. 6. Examination of colonies streaked on TCM agar after 7 days. 7. Overnight cultures in APT broth (Difco) at 30°C. 8. Medium of Gibson & Abd-el-Malek (1945) (incubation at 30°C for 14 days).

RESULTS AND DISCUSSION

Bacteriology of freshly produced MRP. The results of analyses of 30 samples are given in Table 3. All samples were examined for total and B. thermosphacta counts, but only a proportion were also examined for counts of Pseudomonas and aciduric lactic acid bacteria. Some 86.6% of samples had total colony counts below 10^5/gm and of this 33.3% were less than 10^4/gm; no sample had counts over 10^6/gm. Of the potential spoilage species examined Pseudomonas were found in all samples and in most instances composed a high proportion of the microflora. B. thermosphacta was less frequently found and generally in much lower numbers than Pseudomonas. Aciduric lactic acid bacteria were only found in 7/27 samples with counts over 250/gm, and it can be assumed that, if present, they represent a very minor proportion of the microflora.

Table 3. Bacteriology of freshly produced mechanically recovered pork*

Count	No. of samples examined	Distribution of samples in categories ($x10^3$/gm)				
		< 0.25	0.25-1.0	1.1-10	10.1-100	101-1,000
Total colony count	30	0	0	10	13	7
Pseudomonas	18	0	0	10	7	1
B. thermosphacta	30	7	9	7	5	2
Aciduric lactic acid bacteria	27	20	6	1	0	0

* Of a total of 30 samples, 26 were recovered with the Protecon system and 4 with the Hydrau system

The wide variation in total colony counts most likely reflects the hygienic status of the equipment as well as the bacteriological quality of the raw material for processing. This in turn will be influenced by the hygiene of bone removal, the age of the carcase and the efficiency of chilling and holding with regard to both temperature and relative humidity. However, the results do show that MRP of good bacteriological quality ($< 10^4$/gm) can be produced in a commercial situation.

Bacteriological changes during storage of MRP. Blocks of MRP frozen for up to 6 months were defrosted and the results of bacteriological analyses of both "surface" and "centre" samples are given in Table 4. As the MRP recovered by both systems was prepared and frozen at the same time, the differences between surface and centre at each sampling will reflect the "natural" variation within such material. Nevertheless it can be seen that on the basis of geometric mean counts the material from the Hydrau process (21.4×10^4) is higher than that from the Protecon process (12.5×10^3). This difference is probably due to the variability in the raw material. However, it can be concluded that within this variability there is no obvious difference between counts on the surface of the block and counts from the centre.

Blocks of MRP were held at 4°C until spoiled, i.e. detectable off-odours, although it must be added that before organoleptic spoilage some discolourations were noted, i.e. browning. The results of total colony count analyses are given in Table 5. From this data two conclusions may be drawn.

Table 4. Total colony counts (log_{10}/gm) of defrosted mechanically recovered pork

Method of recovery	Sample site	Storage time at -18°C (months) 0	1	3	6	Geometric mean count/gm
Hydrau	Surface	4.86	4.97	5.28	5.44	5.14
	Centre	4.63	5.94	5.14	6.73	5.52
Protecon	Surface	3.86	4.54	5.05	3.76	4.30
	Centre	3.95	4.11	3.44	4.10	3.90

Table 5. Total colony counts (log_{10}/gm) of spoiled mechanically recovered pork

Method of recovery	Sample site	Spoilage time at -18°C (months) 0	1	3	6	Geometric mean count/gm
Hydrau	Surface	9.54	9.61	9.64	9.40	9.55
	Centre	7.78	8.61	8.36	7.88	8.16
Protecon	Surface	9.20	9.45	9.60	9.43	9.42
	Centre	6.72	8.62	8.48	6.57	7.51
Time to spoilage (days)*		12	10	10	7	

* No. of days at 4°C after transfer from -18°C

Firstly, it would appear that the subsequent keeping quality of defrosted MRP is dependent on the length of time in cold store (at -18°C). Unfrozen material had an organoleptic shelf life of 12 days, that stored for 1-3 months, 10 days, while MRP frozen in store for 6 months kept only 7 days. The practical and commercial implications of this are self-evident.

Secondly, the numbers of bacteria in defrosted blocks of MRP are highly dependent on the location of the sample. Surface counts were ca. 1.5 to 2 logs higher than those of the centre.

Analysis of the spoilage flora also indicated a distinct difference in species found on the surface of the blocks from those in the centre (Table 6). Surface samples were spoiled with bacteria mainly belonging to the genus Pseudomonas (96.6%), although a few Enterobacteriaceae (2.7%) were also found. In contrast, members of the genus Lactobacillus predominated (49.5%) in the centre samples along with Enterobacteriaceae (26.8%) and Streptococcus (12%).

Table 6. Identity of the microflora of organoleptically spoiled mechanically recovered pork* after storage at 4°C (7-12 days)

Sample site	No. of isolates examined	Incidence (%) in the flora of Pseudomonas	Entero-bacteriaceae	Lacto-bacillus	Strepto-coccus	Altero-monas	Unclass-ified
Surface	150	96.6	2.7	0	0	0	0.7
Centre	150	6.0	27.3	49.4	12.0	3.3	2.0

* Cumulated results of flora analyses from all spoiled samples given in Table 5

Thus one can conclude that the spoilage of blocks of MRP is primarily a surface phenomenon due to the growth and activity of Pseudomonas spp. Microbial growth in the centre of such blocks occurs at a much slower rate and the species involved are the facultatively anaerobic families of Lactobacillaceae and Enterobacteriaceae.

The commercial implications of these findings are such that if MRP has to be stored before incorporation into products, this should be done in an oxygen limited environment, e.g. vacuum packages. Alternatively, larger blocks could be moulded, thus reducing markedly the proportion of aerobic material. However, adequate freezing capability coupled with suitable packaging should greatly enhance the quality of MRP after thawing.

In the bacteriological examination of blocks of MRP stored aerobically it will be evident that surface sampling will be more relevant to bacteriological status (organoleptic quality) than samples taken from the centre or samples from mixtures of surface and deep meat.

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