# MICROBIAL AND RETAIL LIFE EVALUATION OF PSE, NORMAL AND DFD PORK UNDER AEROBIC REFRIGERATION

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## INTRODUCTION

The sensorial quality of pork is closely associated with genetics and other factors such as *ante-mortem* handling and carcass cooling rate. From the interaction of such factors, meat with abnormal structural and physico-chemical characteristics often appears in meat processing plants. Extreme abnormal examples are PSE (Pale, Soft, Exudative) and DFD (Dark, Firm, Dry) meats.
Based on pH and water holding capacity differences of these meat categories when compared to Normal pork, it is reasonable to think that the quality status could quantitative and qualitatively influence the storage microbiology, affecting their retail case life (Greer & Murray, 1988). In this area, the published results are scarce and often contradictory. Rey *et al.* (1976) and Greer & Murray (1988) pointed out a lower microbial development on PSE when compared with Normal and DFD meats. However, Smith & Carpenter (1976), Hermansen (1980) and Fox *et al.* (1980) state no significant differences between meat categories. Additionally, Newton & Gill (1978, 1980) supported that growth rate of meat spoilage bacteria in beef was similar, over the range of pH observed in fresh meats.
The objective of this work is to evaluate the microbial characteristics of different pig meat categories (PSE/Normal/DFD) stored under aerobic refrigeration and their retail case life.

## MATERIALS AND METHODS

Twenty three loins with distinct meat quality status were assigned according to muscle internal reflectance (Fibre Optic Probe) and pH measured 24h *post-mortem* (respectively $FOP_{24}$ and $pH_{24}$) between the 3rd and 4th lumbar vertebra, being PSE, DFD or Normal those presenting respectively $FOP_{24}$ >60, $pH_{24}$>6.0 and $FOP_{24}$< 50 concomitantly with a $pH_{24}$<5.8.
**Sampling** - Three trials were performed, each including three loins of the different meat categories (PSE/Normal/DFD). After deboning, the Longissimus portion between last lumbar and the 10th thoracic vertebra was divided into chops of approximately 1cm thick (±50g) for evaluation of microbial and sensorial characteristics. Each chop was put in a styrofoam tray, over wrapped in an oxygen permeable polyvinyl retail wrap and displayed during 7 days at 4°C, simulating commercial retail conditions (12h/light and 12h/darkness). While sensorial analysis was done on a daily basis until the appearance of off-odours, the microbial evaluation took place respectively at 0h, 3 days and 7 days of storage.
**Microbiological Determinations** - Twenty grams of each chop were homogenised with 180ml triptone-salt solution in a stomacher for one minute. After serial dilutions, 1ml of each was surface plated on appropriate media for total mesophylic (Plate Count Agar (Merck, Germany) at 30°C for 3 days) and lactic acid bacteria (Man-Rogosa-Sharpe agar (Oxoid, England) at 30°C for 3 days), and 0,1ml of each was used for Pseudomonads (CFC agar base with cephaloridine-fucidin-cetrimide supplement (Oxoid, England) for 48h at 30°C). All bacterial counts were converted to common logarithms and expressed as log colony forming units/g (log cfu/g).
**Retail Case Life** - Samples, exclusively prepared for this purpose, were daily assessed by a 4 member panel, in relation to colour and odour acceptability, till the 6th storage day. Colour and odour were evaluated using respectively a 5 (1- extremely desirable; 5- extremely undesirable) and 3 (1- acceptable; 3- unacceptable) point scales. Retail case life was arbitrary defined as the time in days for each sample to reach a mean value lower than 3 and 2, respectively for colour and odour.
**Statistical Analysis** - Factorial model analysis of variance based on a completely randomised block experimental design (Norman & Bailey, 1981). Differences among means were compared with the Least Significant Difference Test (LSD) at the 95% level calculated from the residual mean square.

## RESULTS AND DISCUSSION

**Microbiological Characteristics** - Changes in the microbial characteristics concerning the three meat categories along the storage period are shown in Table 1. Regarding the total mesophylic and lactic acid bacteria counts, no significant differences were found between all sample categories in relation to the storage periods. However, mean values in Normal meat were always lower than those in the PSE and DFD status (Fig. 1a and b). Irrespective of the meat quality groups, these microbial parameters showed a progressive growth during the chilling storage, being the number of Lactic Acid bacteria lower than the mesophylic counts.
In relation to *Pseudomonas* spp (Fig. 1c) the results indicated a significant effect of meat quality status ($p<0.01$) and storage time ($p<0.001$) on the population.

**Table 1** - Microbiological characteristics of different meat categories at 4°C during storage time.

| | Storage time (days) | | | | | | | | | Significance | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | | | 3 | | | 7 | | | | |
| | PSE | NORMAL | DFD | PSE | NORMAL | DFD | PSE | NORMAL | DFD | Quality | Time |
| Mesophyles (log cfu/g) | $4.00\pm1.24^{c}$ | $3.93\pm1.17^{c}$ | $4.01\pm0.92^{c}$ | $6.92\pm1.14^{b}$ | $6.65\pm0.98^{b}$ | $7.19\pm1.53^{b}$ | $10.16\pm1.49^{a}$ | $9.63\pm1.54^{a}$ | $10.20\pm1.69^{a}$ | ns | *** |
| Lactic acid bact. (log cfu/g) | $3.03\pm0.55^{c}$ | $2.63\pm1.10^{c}$ | $2.65\pm0.21^{c}$ | $4.25\pm1.05^{b}$ | $3.64\pm1.02^{bc}$ | $4.32\pm0.86^{b}$ | $6.20\pm1.01^{a}$ | $5.61\pm1.11^{a}$ | $6.33\pm1.13^{a}$ | ns | *** |
| Pseudomonas (log cfu/g) | $3.64\pm0.72^{d}$ | $2.89\pm0.37^{d}$ | ND | $3.71\pm1.73^{cd}$ | $3.40\pm1.43^{cd}$ | $2.70\pm1.10^{d}$ | $7.30\pm0.47^{a}$ | $5.87\pm1.52^{ab}$ | $5.19\pm1.82^{b}$ | ** | *** |

ns = not significant; ** $p<0.01$; *** $p<0.001$. In the same row, means with identical superscripts are not significantly different (test LSD, $p<0.05$).
ND - not detected (limit of detection: 1.5log cfu/g)

The initial contamination of PSE and Normal meats were not significantly different, while for DFD these microorganisms were not detected, despite the similar hygienic conditions during deboning, cutting and wrapping operations. However, at the 3rd day of display the results for *Pseudomonas* spp were not different between meat categories, which could mean that the growth rate of such microorganisms is initially faster on DFD than on other quality groups.This is in agreement with the findings of Gill & Newton (1977) and Newton & Gill (1978), who stated that pseudomonads grow at their maximum rate when utilizing aminoacids which do not became depleted at the meat surface and constitute the most important substract in DFD meat category and also that the lag phase length increased with the increase pH. Nevertheless, at that storage time, PSE meat still showed higher mean values than Normal and DFD meats. At the 7th day of storage, the number of *Pseudomonas* spp was significantly higher in PSE meats, being Normal and DFD categories not different. This is in absolute disagreement with the findings of Greer & Murray (1988) in relation to the numerical differences of the abnormal meat groups and could be due, perhaps, to the disparities between the studies in meat storage methods (frozen/thawed versus chilled muscle) as well as in pork quality status.

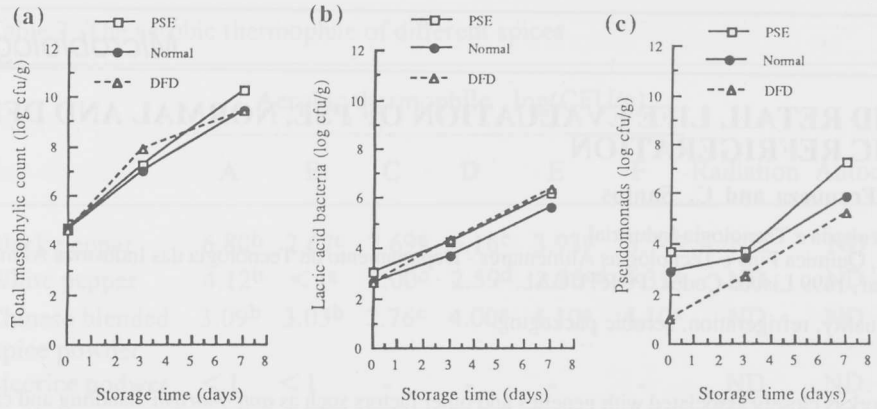


**Figure 1** - Mesophiles (a), Lactic Acid Bacteria (b) and Pseudomonads (c) counts in the three meat quality categories, during storage time.

The differences in the development of such group of bacteria along the storage period, could contribute to the early deterioration of quality (off-odour) observed on PSE and Normal meats, when compared with the DFD samples. Conversely to what Hermansen (1980) have pointed out, the *Pseudomonas* spp showed a significant growth rate on PSE and Normal meats from the 3rd day of storage.

**Retail Case Life** - The odour and colour acceptability of different meat quality groups during display time is shown on Table 2. In respect to colour, Normal meat received higher levels of preference at day 0 of storage when compared with PSE, being the DFD samples, from the beginning, rejected by the jury (mean value ≥3). These results do support the previous studies of Topel *et al.* (1976) and Wachholz *et al.* (1978) concerning consumers visual appraisal of pork chops. Up to 3 days of storage, PSE and Normal samples were classified as acceptable. On the 4th day, however, they were already considered undesirable mainly due to the appearance of browning greyish areas on the surface. The colour of DFD, despite its refusal by the panel, kept its initial colour score up to the 5th day of storage. Conversely to what Fox *et al.* (1980) stated, no significant differences on raw colour scores were observed between PSE and Normal pork after the 3rd of storage, presenting the normal status, generally, lower levels of acceptance.

**Table 2** - Odour and colour characteristics mean score of different meat quality groups during display time.

| Meat | COLOUR | | | | | ODOUR | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Storage time (days) | | | | | Storage time (days) | | | | |
| Categories | 0 | 3 | 4 | 5 | 6 | 0 | 3 | 4 | 5 | 6 |
| PSE | 2.16 | 2.60 | 3.42 | 4.36 | 4.90 | 1.00 | 1.55 | 2.38 | 2.71 | 2.90 |
| NORMAL | 1.99 | 2.15 | 3.86 | 4.74 | 4.71 | 1.00 | 1.78 | 2.40 | 2.54 | 2.76 |
| DFD | 3.20 | 2.95 | 3.05 | 2.92 | 3.52 | 1.00 | 1.41 | 1.94 | 2.32 | 2.65 |

Regarding off-odours appearance, the DFD meat was judged acceptable until the 4th day of retail whereas in PSE and Normal an off-odour was already present (sour odour) at this time, being enough to induce their rejection by the panel members.

The comparison of initial levels of contamination with those found out at the 4th day of storage (appearance of off-odours in PSE and Normal meats) showed that, despite the lower initial total count of PSE, this meat category appeared later highly spoiled than DFD.

Concerning to the development of the microorganisms during the storage time for the different meat categories, it can not be stated that Pseudomonads and Lactic Acid bacteria prevail in the shelf-life, respectively of DFD and Normal/PSE pork under aerobic refrigeration (Hermansen, 1980). The slightly longer shelf-life for DFD pork until the putrid characteristic smell appeared, could be associated, in part with the metabolic utilization of the substract, namely the proteins, since these molecules must be first degraded before they can be utilized by bacteria. However, Gill (1983) also points out that the utilization of nitrogenous materials by *Pseudomonas* spp soon takes place in DFD meats, because soluble protein and other low molecular weight components are always available

## CONCLUSIONS

Among PSE, Normal and DFD pork status were not found significant differences on total mesophylic and lactic acid bacteria counts along the storage period. However, Normal meat showed always lower mean counts than PSE or DFD categories. In relation to pseudomonads the DFD samples showed significant lower initial numbers comparatively to the other meat groups, keeping this trend along the storage period. However, closed to the storage time where off-odours came evident (around 3rd storage day) were not observed significant differences among the pork categories.

Unacceptable off-odours develop in the different pork categories when total counts in meat reaches about log 6-7. So, hygienic procedures all over the meat production chain is of basic importance in definition of pork shelf-life. Off-odour appearance is the most important limiting factor on extension of commercial chilled storage life of pork, under aerobic conditions.

Initial colour of fresh pork of Normal quality is sensoricaly more acceptable than PSE or DFD. Along the storage period, the DFD category is less sensitive to colour degradation than PSE or Normal. Even so, those last groups showed a quite good resistance to chemical modifications of heme pigment.

## REFERENCES

Fox, J.D.; Wolfram, S.A., Kemp, J.D. & Langlois, B.E. (1980). *J. Food Sci.*, **45**,.786.
Gill, C.O. & Newton, K.G. (1977). *J. Appl. Bacteriol.*, **43**:189-195.
Gill, C.O. (1983). *J. Food Prot.*, 46:5, pp. 444-452.
Greer, G.G. & Murray, A.C. (1988). *Meat Sci.*, **24**, 61-71.
Hermansen, P. (1980). Proc. 26th European Meeting of Meat Research Workers, Colorado Springs, Colorado, USA, pp. 300-303.
Newton, K.G. & Gill, C.O.(1978). *Appl. Environ. Microbiol.*, **36**, 375.
Newton, K.G. & Gill, C.O.(1980). *Meat Sci.*, 5, 223.
Norman, T. J. & Bailey, M. A. (1981). Statistical Methods in Biology. Ed. Hodder and Stoughton.
Rey, R.C.; Kraft, A.A.; Topel, D.G.; Parrish jr, F.C. & Hotchkiss, D.K. (1976). *J. Food Sci.*, 41, 111-116.
Smith, G.C. e Carpenter, Z.L. (1976). *J. Milk Food Technol.*, 39, 841-844.
Stabursvik, E.; Fretheim, K. e Froystein, T. (1984). *J. Sci. Food Agric.*, 35, 240-244.
Topel, D.G.; Miller, J:A.; Berger, P.J.; Rust, R.E., Parrish, F.C. & Ono, K. (1976). *J. Food Sci.*, 41, 628-630.
Wachholz, D.; Kauffman, R.G.; Henderson, D. e Lochner, J.V. (1978). *J. Food Sci.*, 43, 1150-1152.