PRODUCT LIFE OF VACUUM PACKAGED BEEF IMPORTED INTO SAUDI ARABIA BY SEA.

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SUMMARY: Five transport and storage trials were conducted to determine the product life of vacuum packaged beef imported by sea. Three transport and storage temperature regimes, characterized by mean trial temperatures of 1.4, 0.8 and -0.9°C respectively, were recognized. Both the temperature experienced and the initial contaminating bioload influenced the time required for meat microfloras to reach spoilage levels (10^7cells/cm^2). The total volatile nitrogen and free fatty acid content rose significantly after attainment of such microbial populations. Microbial spoilage became apparent in the high temperature trial and in one medium temperature trial, 82 and 136 days after slaughter respectively. In the other trials textural deterioration became evident between 85 and 103 days after slaughter. Modest extension of the expiration period for vacuum packaged beef in Saudi Arabia beyond the present 70 days is not unreasonable, but must be accompanied by rigorous enforcement of transport and storage temperature requirements.

INTRODUCTION: Commercial experience in Saudi Arabia has shown that product life of vacuum packaged imported beef varies considerably. The present 70 day post slaughter expiration period, at a storage temperature between 0 and -2°C (SASO, 1986), is currently under review. This period is claimed by some importers to be too long, but claimed by some exporters to be too short. This apparent contradiction may reflect process hygiene and/or packaging technology used at the point of production, or conditions subsequently experienced during transportation to, or storage within, the Kingdom. To ensure that National Standards recognize technological advances, and continue to protect public health without causing unnecessary condemnation of wholesome product, the Saudi Arabian Standards Organization, in cooperation with the Meat Industry Research Institute of New Zealand, undertook a comprehensive study of the product life of vacuum packaged beef imported into the Kingdom by sea. The objectives of this investigation were to determine the product life of vacuum packaged beef and to identify product, processing, packaging, transportation or storage parameters influencing that product life.

MATERIALS AND METHODS: Between July 1990 and February 1992 five transport and storage trials were conducted on consignments of vacuum packaged beef half striploins imported by sea from Australia, New Zealand and the Republic of Ireland.

1) **Cold Chain:** In each of the five trials, the entire cold chain from point of production to the end of storage in Saudi Arabia was monitored by means of MIRINZ/DELPHI temperature loggers (Tru-Test, Auckland, New Zealand). Approximately 24 hours after slaughter six or eight temperature loggers were placed into each of six or eight cartons as they were filled with 2.5 to 3.6 kg vacuum packaged beef half striploins. The temperature loggers remained in the cartons, recording product temperature every 30 minutes with an accuracy of $\pm$0.25°C, until the accompanying vacuum packed half striploins were removed for microbiological, chemical and sensory evaluation in Saudi Arabia, after various periods of chilled storage.

2) **Microbiological Examination:** For each trial five half striploins were sampled for microbiological quality at the point of production, either at packaging or just before dispatch to Saudi Arabia a few days after packaging. Another five half striploins were examined on arrival at the coolstore in Riyadh, and thereafter groups of three were examined after various periods of chilled storage. A composite sample of

each half striploin examined was obtained by swabbing a 5 cm^2 site on the dorsal fat, the ventral lean and a lean cut end surface using first moistened then dry swabs. Serial dilutions were prepared in 0.1% peptone water and spread onto plate count agar. After incubation at 25°C for 72 hours, a differential count based on colonial appearance was made. From a single plate, one for each half striploin examined, 10 representative colonies, selected in numerical proportion to their relative abundance in the spoilage microflora, were subcultured and identified to genus level using the 7-test identification procedure of NEWTON et al. (1978).

3) **Chemical Analysis:** For each shipment samples were taken from seven vacuum packaged half striploins on arrival at the Riyadh coolstore and subsequently from groups of five half striploins after various periods of chilled storage. Separate analyses were performed on samples of superficial fat, mid muscle and ventral surface lean taken from each half striploin examined. The pH of minced tissue from the two lean sample sites was determined directly using a glass electrode. The Total Volatile Nitrogen (TVN) in tissue from the two lean sample sites was determined using a steam distillation procedure (SASO, 1977b). The Free Fatty Acid (FFA) content in the superficial fat and the two lean tissue samples was determined by titration following fat extraction in cold 40/60 petroleum ether (SASO, 1977a).

4) **Sensory Evaluation:** On arrival at the coolstore in Riyadh, 13 unopened vacuum packaged half striploins were taken from each consignment and frozen to serve as controls. Each sensory evaluation session was conducted in two parts to determine firstly the onset of spoilage, and secondly consumer acceptability. Steaks (2 cm thick) were cut from one thawed control and two chilled half striploins and cooked at 160-180°C for ten minutes per side in a lightly greased electric frying pan. The cooked meat was assessed by a 9-member experienced screening panel to identify the onset of spoilage conditions using a 3-point scale where: 1= Acceptable- no spoilage evident; 2= Marginal- incipient spoilage suspected; and 3= Reject- overt spoilage evident. Unless overt spoilage was evident in the chilled product, 500-700 g roasts were cut from thawed control and chilled half striploins and distributed to a small "take home" panel who assessed the meat samples for aroma, texture, taste and overall liking using a 7-point hedonic scale where: 7= like very much, and 1= dislike very much.

RESULTS AND DISCUSSION: The beef half striploins in all five trials were packaged in Cryovac vacuum shrink packs. The barrier films, manufactured by W.R. Grace Limited, had stated oxygen permeabilities of 30-40 $ml/m^2/24h/Atm$ at 23°C and 90% relative humidity. Shipments from Australasia were imported through the Gulf port of Dammam and those from Ireland through the Red Sea port of Jeddah.

1) **Cold Chain:** The cold chain is conveniently considered to be made up of two phases: transport - from logger placement to arrival at the Riyadh coolstore; and storage - from arrival at the coolstore to the termination of storage. Within the five trials, three transport and storage temperature regimes were evident. These were classified as high (n=1), medium (n=2) and low (n=2) characterized by mean trial temperatures of 1.4, 0.8 and -0.9°C respectively. The storage phase was appreciably longer than the transport phase (Figure 1), and consequently was the more important in determining the mean temperature obtaining over a complete trial. Storage temperature differences appear to have resulted from different chiller temperature settings rather than problems of temperature maintenance within the storage chillers.

2) **Microbiological Examination:** In only one trial can questionable process hygiene, indicated by an initial microbial count exceeding 10^3 cells/cm^2, be considered to have compromised product storage life. In all five trials lactobacilli predominated in the microfloras that developed on the vacuum packaged beef

during transport and storage at chill temperatures. The time required for the microfloras to reach spoilage levels (10^7cells/cm^2) was determined by the size of the initial contaminating microflora and the temperature regime subsequently experienced during transport and storage (Figure 2). Microbiological spoilage, evidenced by a persistent, putrid odour and taste, occurred in two trials: the trial involving the high initial bioload and a medium temperature regime, and the high temperature regime trial; 136 and 82 days after slaughter, respectively. A 0.8°C higher mean trial temperature and a significant presence of Enterobacteriaceae in the spoilage microflora accounts for the more rapid onset of spoilage observed in the high temperature trial (NEWTON and GILL, 1978).

3) **Chemical Analysis:** Normal ultimate pH beef was packaged in all trials. The pH values measured at the two lean tissue sites were similar, ranging from 5.5 to 5.9, and pH did not change during chilled storage. The TVN content of surface samples was 0.2±0.5 mg N/100 g higher than in corresponding mid muscle samples. At both sites, once the microfloras reached spoilage levels (10^7cells/cm^2), there was a trend for TVN levels to rise to more than 18 mg N/100 g, with levels exceeding 24 mg N/100 g when spoilage became organoleptically evident. The FFA content of the superficial fat was 50 to 70% higher than that of fat extracted from the two lean tissue sites. A strong rising trend in FFA became evident after meat microfloras reached 10^7cells/cm^2. The FFA content of the superficial fat rose to 1.9% in some unspoiled samples before declining to levels of between 1.3 and 1.4% with spoilage onset. A fall in FFA level with the approach of spoilage was not observed in fat extracted from lean tissue. The rise and fall phenomenon observed in superficial fat may result from the local utilization of these volatile compounds by Pseudomonas populations colonizing the inside surfaces of the vacuum packs (MADDEN and BOLTON, 1991).

4) **Sensory Evaluation:** Meat was rejected because of spoilage onset in only two trials, as previously discussed. The "take home" panel awarded product in all trials, tested before spoilage onset, mean scores above 6.0 on the 7-point scale. Texture, in contrast to toughness, is not considered a critical attribute in the Middle East. However, as storage, and hence meat aging, progressed, standard deviation about the mean score tended to increase, indicating less consistent ratings. In both low temperature regime trials, textural deterioration, resulting from enzyme activity during aging, was observed by sensory evaluation staff 103 days after slaughter, when the superficial fat was distinctly pink and separated readily from the soft, sticky underlying lean tissue. When cut with a sharp knife, the lean tended to tear, leaving a "ragged" cut surface with small fragments of tissue left adhering to the knife blade. In the medium temperature regime trials, with normal and high initial bioloads, softening of the meat, accompanied by confinement odours, was noticed 85 and 73 days after slaughter, respectively, In the high temperature regime trial, textural deterioration was not evident before spoilage onset. However, signs of incipient spoilage appeared as mild cheesey or sour odours during cooking two weeks before the onset of overt microbial spoilage 82 days after slaughter.

With good process hygiene at the point of production, and with transport and storage temperatures maintained between 0 and -2°C as mandated (SASO, 1986), textural deterioration rather than microbial spoilage will limit the product life of vacuum packaged beef (RIGG and NEWTON, 1979). Consequently, chemical criteria based on the accumulation of by-products of microbial metabolism, such as TVN or FFA, are inappropriate as indicators of the fitness of vacuum packaged beef for human consumption. Failure of some trials to comply with mandated temperature requirements appears to have resulted from mismanagement in the setting of

refrigeration equipment rather than the inability of that equipment to maintain the set temperature. Extension of the expiration period for vacuum packaged beef in Saudi Arabia beyond the present 70 days (SASO, 1986) seems not to be unreasonable, provided transport and storage temperature requirements are rigorously enforced.

CONCLUSION: Extension of the expiration period of vacuum packaged beef sea freighted to Saudi Arabia beyond 70 days can be scientifically supported, provided Quality Control Systems are in place that assure: 1) only normal ultimate pH beef is vacuum packed; 2) bacterial contamination at packaging does not exceed 10^3 cells/cm^2; 3) oxygen permeability of the packaging film does not exceed 50 ml/m^2/24h/Atm at 23°C and 90% RH; and 4) the product temperature during transport and storage is maintained between 0 and -2°C.

REFERENCES:

MADDEN R.H. and BOLTON G. 1991. Influence of anaerobes on volatiles in vacuum packaged beef. In Proceedings 37th Int. Cong. Meat Sci. & Technol. Kulmbach, 587-590 pp.

NEWTON K.G. and GILL C.O. 1978, The development of the anaerobic spoilage flora of meat stored at chill temperatures. J. Appl. Bacteriol., 44, 91-95.

NEWTON K.G., HARRISON J.C.L. and WAUTERS, A.M. 1978. Sources of psychrotrophic bacteria on meat at the abattoir. J. Appl. Bacteriol., 45, 75-82.

RIGG W.J. and NEWTON K.G. 1979. Oxygen-free storage of chilled meat. MIRINZ Publication 709, Hamilton, N.Z.

SASO, 1977a. Physical and chemical methods for testing edible vegetable oils and fats. Saudi Standard 30. Saudi Arabian Standards Organization, Riyadh.

SASO, 1977b. Methods for physical and chemical analysis of meat and meat products. Saudi Standard 45. Saudi Arabian Standards Organization, Riyadh.

SASO, 1986. Expiration periods for food products. Saudi Standard 457. Saudi Arabian Standards Organization, Riyadh.

Figure 1. Temperature records for vacuum packaged beef experiencing (A) High, (B) Medium and (C) Low temperature regimes during chilled transport (1) and storage (2).

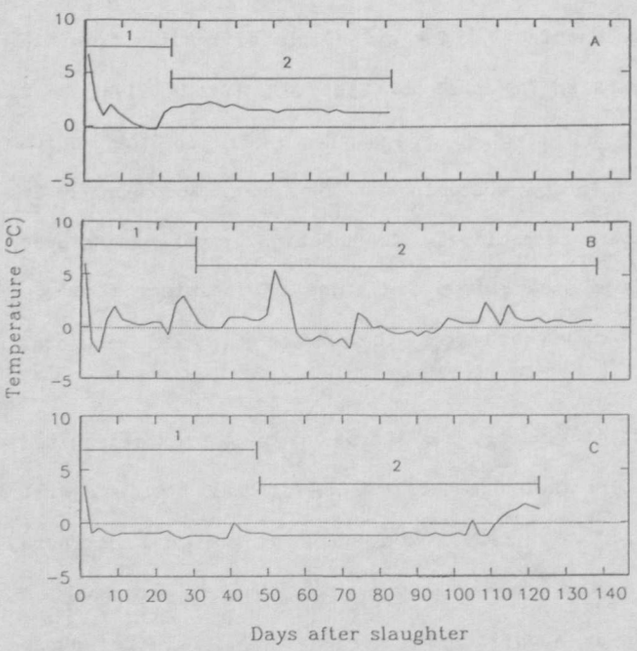

Figure 2. Development of spoilage microflora on vacuum packaged beef experiencing High (▽), Medium (●) and Low (○) temperature regimes during chilled transport and storage. Vertical arrows indicate overt microbial spoilage.