factsheet

Pork Information Gateway

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Extension of Chilled Pork Storage Life

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Relevance to the Pork Industry

Effective marketing is the key to profitability in any industry. To effectively market in premium, remote export markets and in premium value-added domestic markets, products must have sufficient storage life to facilitate orderly distribution and merchandising.

Potential Opportunities

Substantial demand for chilled pork exists in remote export markets. However, residual storage life has largely restricted North American exports to the processing, rather than the retailing sector. Consequently, commodity rather than premium prices have traditionally been received.

Presently the average storage life of vacuum packaged, North American, chilled pork imported into Japan is six weeks. Consequently, the product has avery limited residual storage life upon arrival in Japan (2 to 5 days), making it very difficult to distribute and merchandise the product, often under less than ideal conditions. Therefore, a large proportion of North American chilled pork imports must be frozen in Japan to prevent spoilage losses, which completely defeats the purpose of importing chilled product. However, product produced to a high hygienic standard exported to Japan as a test shipment was universally accepted and was sold at an 82% premium over North American domestic prices. This product was received in Japan eight weeks after slaughter and had a residual storage life of four to six weeks in Japan (Rigaux and Jeremiah 1996).

Glossary

Chilled pork: Pork stored under refrigeration without being frozen.
Color stability: The ability of the muscle pigments to resist deterioration during storage.
Commercial contamination: The microbial contamination normally associated with commercial product. Controlled atmosphere packaging: Packaging in which the atmosphere is modified and then preserved through the use of gas impermeable packaging materials.
Dehairing process: The process of removing the hair from pork carcasses, involving scalding, scraping, singing, and polishing.
DFD: Dark, firm dry or high pH pork muscle.
Display-ready pork cuts: Overwrapped pork cuts ready for immediate retail display upon removal from the master pack, following an oxygenation or blooming interval.
Double metallized packaging: Plastic packaging film spattered twice with a metal, usually aluminum, to make it gas impermeable.
Dual chamber/snorkel vacuum packaging machine: A vacuum packaging machine which simultaneously draws a vacuum in a chamber over the package, as well as though a snorkel inserted into the package.
Foil laminate packaging: Packaging film with a layer of aluminum foil laminated between two plastic films. Hygienic control: Control of microbial contamination and growth, through optimized hygiene and sanitation.
Lactic acid bacteria: Bacteria which yield lactic acid as a product of sugar fermentation.
Modified atmosphere packaging: Packaging in which the atmosphere is modified initially but allowed to change over time through the use of gas permeable packaging material.
Pasteurization: A treatment (usually heat) which destroys essentially all organisms of importance.
Pathogenic organisms: Organisms which are toxic or produce toxins resulting in illness when consumed.
PSE: Pale, soft exudative (watery) or low pH pork.
Rancidity: Deterioration of lipids, through autoxidation, lipolysis, or microbial action, resulting in development of off-odors and off-flavors.
Residual storage life: The storage life remaining at a given point during storage.
Spoilage organisms: Organisms which produce spoilage as a result of their growth and metabolism.
Storage life: The time period a product can be stored before the onset of spoilage.
Temperature control: Control of product temperature.

Steadily increasing labor costs for preparation of retail cuts at the store level and the amount of valuable space presently devoted to processing and packaging of retail cuts in stores, rather than merchandising products has created a need for centralized processing and packaging of display-ready products. Centralized processing and packaging of display-ready products for continental distribution and merchandising has been estimated to reduce those costs by 50% (Farris et al., 1991).

Keys to Maximizing Storage Life

Five keys to maximizing storage life, in the order of their importance are:

1. Keep it cold
2. Keep it clean
3. Remove essentially all of the oxygen from the package
4. Prevent oxygen from re-entering the package
5. Provide an environment containing at least 25% carbon dioxide within the package

Capitalizing on Potential Opportunities

To capitalize on the above opportunities, products must have sufficient storage life to facilitate orderly distribution and merchandising. Boneless chilled pork destined for the retail sector of Pacific Rim export markets requires a storage life of at least ten weeks. Centrallyprocessed and packaged display-ready cuts destined for continental distribution require a storage life of at least three weeks.

Temperature Control

Maximum storage life is achieved when meat is stored at the lowest possible temperature, without the product freezing. In practice, the optimum storage temperature is -1°C (30°F) for unwrapped product and -1.5°C (29°F) for cartoned product in preservative packaging (Gill and Shand 1993); 100% of the storage life attainable is obtained at this temperature. Reduction in storage life is profound with only small increases in storage temperature (Figure 1). Consequently, stringent temperature control is the most critical factor, irrespective of all other factors. Product temperature, rather than ambient temperature, must be monitored to be adequately managed. Remember, for every degree reduction in storage temperature toward the optimum, product storage life is increased at least 10% (Gill and Shand, 1993). In this regard exposing carcasses to blast chilling (-20°C (-4°F) for 45 to 60 minutes) prior to conventional chilling substantially improves the hygienic efficiency of the carcass chilling process (Gill and Jones 1992).

Hygienic Control

High levels of microbial contamination on meat reduce the time prior to the onset of spoilage, irrespective of all other factors. Consequently, prevention of contamination of the product during slaughter, chilling, processing, and packaging is essential to extend storage life (Gill et al., 1992). The dehairing process, during pork slaughter, usually contaminates the entire carcass with a relatively heavy load of both spoilage and pathogenic organisms, including lactics (Gill and Bryant, 1992a; Gill and Jones,1995). In addition, early off-flavor development constitutes the limiting factor for chilled pork storage life extension (Jeremiah et al., 1995a,b; Jeremiah and Gibson, 1995). This early off-flavor development coincides with lactic acid bacteria approaching maximum numbers (Jeremiah et al.,1995a,b; Jeremiah and Gibson,1995). Jeremiah and Gibson (1995) reported the flavor of samples with commercial contamination deteriorated to unacceptable levels during nine weeks of storage, while meaningful flavor deterioration was not observed during 24 weeks of storage in samples with substantially reduced contamination. Consequently, carcass decontamination (pasteurization) following the dehairing process is essential. Gill et al. (1995) reported log10 numbers of spoilage bacteria on the surfaces of pork carcasses were reduced by 2.5 by subjecting them to an online pasteurization (85°C water for 20 seconds)

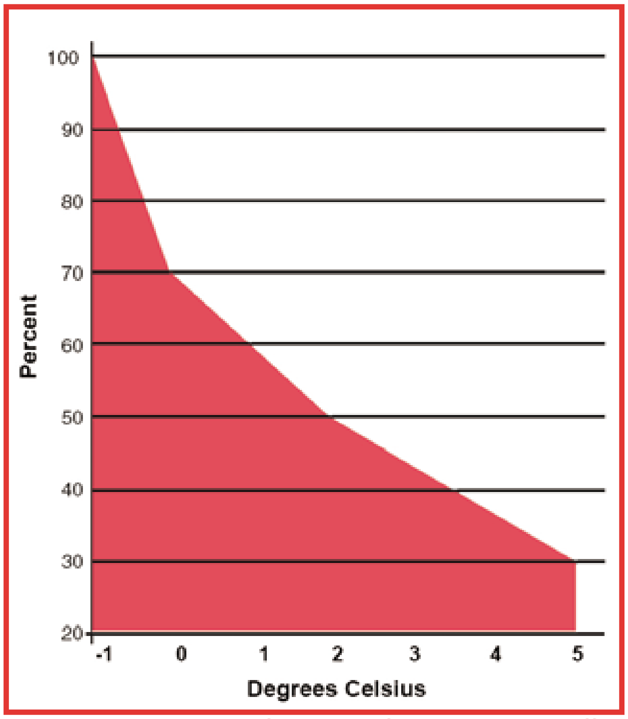

Figure 1. Percentage of storage life attainable at different storage temperatures.

(Table 1) and spoilage bacteria were reduced from more than 50% of the flora to less than 10% (Gill et al., 1995).However, carcass pasteurization will be ineffective and a waste of resources unless stringent hygienic control is applied to all subsequent processes to prevent prod-uct recontamination. An excellent guide for cleaning of equipment used for carcass fabrication in pig slaughtering plants is available (Gill and Bryant, 1992b).

Carcass Region	Treatment	
	Treated	Control
Loin-Lumbar	1.09	2.99
Loin-Thoracic	0.00	2.50
Foreleg	0.99	3.27
Belly	0.00	2.35

Table 1. Total bacterial numbers recovered from specific regions of polished pork carcasses selected at random from processes with and without hot water pasteurization (85°) (185°F) for seconds.

Oxygen Control

The presence of oxygen within the package promotes the growth and proliferation of spoilage organisms, the autolytic deterioration of meat properties, and oxidative changes resulting in rancidity.The presence of oxygen within the package, particularly at low partial pressures, accelerates the discoloration of meat surfaces (Ordonez and Ledward 1977). However, pork with normal or DFD muscle characteristics appears to be more stable in the presence of oxygen than either beef or lamb, while pork with PSE characteristics is extremely sensitive to low levels of oxygen within the package (Jeremiah et al., 1992a,b). Pork with both PSE and DFD charac-teristics in completely anoxic environments tends to normalize after prolonged storage (15 weeks) and come out of storage with a more acceptable appearance than when entering storage (Jeremiah et al.,1995b; Rousset and Rennere,1991).

Package selection for a particular purpose must be based upon considerations of product characteristics affecting storage stability; the environmental conditions the packaged product must withstand during storage, distribution, and merchandising; the storage life requirement for orderly distribution, merchandising and consumer use; and product and package characteristics which will satisfy the intended customer (Gill,1991). However, maximization of storage life requires removal of essentially all of the oxygen from the package (less than 300ppm).These levels can only be consistently reached by using a dual chamber/snorkel vacuum packaging machine. Re-entry of oxygen into the package, over time, can only be prevented through the use of packaging materials completely impermeable to oxygen (foil laminate or double metallized packaging materials) with oxygen impermeable heat seals on all perimeters, since all plastic materials are oxygen permeable to some degree. However, some plastic barrier films are nearly impermeable and are suitable where less than optimum storage life is required.

Carbon Dioxide Environment

Carbon dioxide is bacteriostatic and retards the growth of most spoilage organisms (Blickstad and Molin, 1983). Since meat absorbs relatively large quantities of carbon dioxide, excess carbon dioxide must be put into the package to prevent package collapse and provide the desired bacteriostatic effect after the meat has been saturated. It has been demonstrated two liters of carbon dioxide per kilogram of product is the optimum level to use in chilled pork packaging (Jeremiah et al., 1996). Although a mixture of carbon dioxide and nitrogen is often used to prevent package col lapse, sufficient carbon dioxide must remain after product saturation to provide the desired bacteriostatic effect.

Steps to Storage Life Extension

1. Bring product temperatures under control and provide stringent temperature control at -1°C, as soon as possible after slaughter.
2. After temperatures have been controlled, provide carcass pasteurization, after the dehairing process and stringent hygienic control, and thereafter, to prevent recontamination of carcasses and subse-quent cuts.
3. Only if steps 1 and 2 are achieved will the beneficial effects of appropriate preservative packaging be realized.
4. Removal of essentially all oxygen from the package to levels below 300ppm can only be achieved by using a dual snorkel/chamber vacuum packaging machine, because all air passages are kept open during evacuation of air from the package, and stress and strain are not exerted on either the product or the packaging mate-rial.This also minimizes leakers subsequent to packaging.
5. Re-entry of oxygen into the package, over time, can only be prevented through the use of oxygen impermeable, foil laminate or double metallized packaging materials with oxygen impermeable heat seals on all perimeters, or minimized through the use of plastic barrier films with very low oxygen permeabilities.
6. Introduction of 2 liters of 100% carbon dioxide per kilogram of product provides a bacteriostatic environment within the package, and avoids package collapse.

What Has Been Achieved?

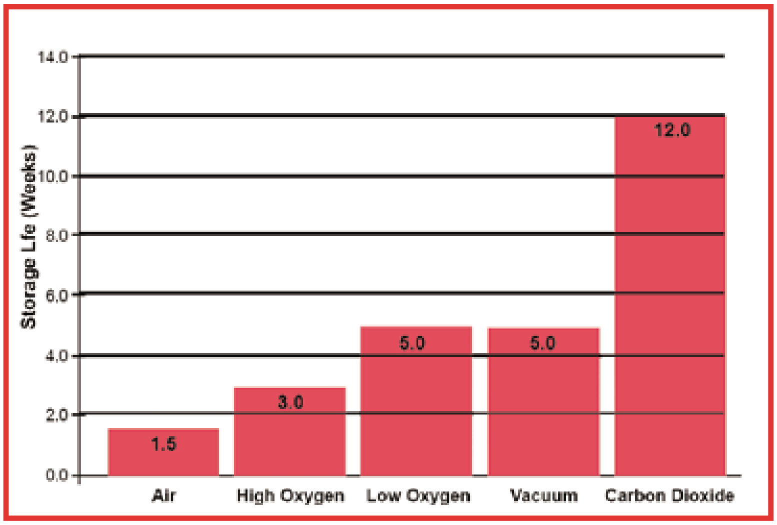

Figure 2. Storage life of chilled pork stored in different atmosphere at 0° (32°F)

A combination of 100% carbon dioxide packaging and storage at 0°C provided a storage life of three months to uncured cuts and more than five months to cured cuts (Blickstad and Molin, 1983). Rousset and Renerre (1991) also reported carbon dioxide in the package environment gave high pH (DFD) meat a storage life of up to 42 days. Gill and Harrison (1989) reported vacuum packaged pork loins with the subcutaneous fat and skin intact were grossly spoiled after two weeks at 3°C and after five weeks at -1.5°C, while similar cuts packaged in 100% carbon dioxide remained unspoiled for five and one half weeks at 3°C and for between 18 and 26 weeks at -1.5°C. Jeremiah et al. (1992a) reported closely trimmed, boneless pork loins with substantially reduced microbial contamination had a storage life of 18 weeks in vacuum and over 24 weeks in 100% carbon dioxide at -1.5°C. However, in 1995 it was reported, pork, irrespective of inherent muscle quality, had a storage life of up to 15 weeks in 100% carbon dioxide at -1.5°C, based upon visual and olfactory properties, but of only six weeks, based upon flavor (Jeremiah et al., 1995a,b).

Moreover, Greer et al. (1993) observed retail case-life progressively deteriorated from five days to one and a half days during storage in 100% carbon dioxide for 24 weeks at -1.5°C. Off-flavor development was not detected during 24 weeks of storage in 100% carbon dioxide at -1.5°C when microbial contamination was substantially reduced (Jeremiah et al.,1992a; Jeremiah and Gibson,1995). Figure 2 illustrates the average storage life attainable with pork primals stored in different atmospheres at 0°C (32°F) (Gill 1991).

Although the cited laboratory studies provide a clear indication adequate storage life should be attainable to facilitate all export and domestic marketing activities, the processing and packaging system described must be tested under commercial conditions. This was done in 1993 when a test shipment of two sea containers of closely trimmed, boneless pork primals was exported to Japan from Manitoba (Rigaux and Jeremiah, 1996). Product for the shipment was treated using carcass pasteurization,100% carbon dioxide, controlled atmosphere packaging, and stringent hygienic and temperature control. The product had a four to six week residual storage life upon arrival in Japan and was assessed by the Japanese customers eight weeks after slaughter, to be fresher and of higher quality than any other chilled pork available to them, including Japanese domestic pork slaughtered two days previously.

With regard to centralized packaging of display-ready pork cuts, it has been reported the color stability was maximized by storage in 100% carbon dioxide at subzero (<0°C) temperature (-1.5°C, 29°F) (Jeremiah and Gibson, 1997a) and an atmosphere of 70% oxygen and 30% carbon dioxide had the greatest preservative properties, for up to 24 days (Jeremiah and Gibson, 1997b). Scholtz et al., (1992) reported display-ready pork cuts had a storage life at 0°C of 7 days in vacuum skin packaging, 14 days in modified atmosphere (75% oxygen; 25% carbon dioxide), and 21 days in100% carbon dioxide. Gill and Jones (1996) reported chops stored in 100% nitrogen and 100% carbon dioxide for 2 to 35 days or in 67% oxygen and 33% carbon dioxide for 4 to 12 days had a retail case-life equivalent to freshly cut chops. They also reported off-odor developed after 21 days in 100% nitrogen and 100% carbon dioxide and after 12 days in 67% oxygen and 33% carbon dioxide. However, early off-flavor development was also observed to constitute the limiting factor for storage life extension and restricted the storage life of commercial display-ready pork roasts to less than 12 days (Jeremiah and Gibson,1997c). Despite these findings, available evidence clearly indi-cates sufficient storage life is attainable to facilitate continental distribution of centrally processed display-ready pork cuts, if product temperature is adequately controlled at -1°C(30°F), and the contamination on the commercial product is reduced sufficiently to prevent spoilage organisms, including lactics, from rapidly growing to maximum numbers and producing early off-flavor development.

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