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Development of Intervention Strategies to Extend the Shelf- Life of Fresh Ground Pork

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Summary and Implications

The effects of storage time, packaging atmosphere and raw material source on shelf-life of fresh ground pork were studied. Fresh ground pork (18 percent fat) was packaged in an atmosphere of 80:20 percent 0_2:CO_2 or 100 percent CO_2 and placed in unlighted refrigerated storage (34°F) for a period of two or eight days to simulate distribution time of the product from manufacturer to retail merchandiser. Products were then placed under lighted storage for eight additional days (100 foot candles, 34°F) to simulate retail display conditions. Ground sirloin had higher percent surface metmyoglobin (darkness and brown color) than ground pork shoulder after eight days of lighted storage. Lipid oxidation (rancidity) was higher in ground pork shoulder than ground pork sirloin. Pork shoulder had higher a (redness) values than pork sirloin in both atmospheres. Microbial loads (aerobic microorganisms) were higher in product stored eight days versus two days; however, total aerobic microbial loads did not exceed 10^6 (the level commonly used to indicate microbial spoilage) for product stored in either atmosphere. Carbon dioxide successfully extends product shelf-life up to eight days under lighted storage conditions.*

Introduction

The preparation of meat products for retail display has changed dramatically over the last 20 years. Large supermarket chains have reduced or eliminated in-store preparation of fresh red meat products to reduce labor and capital equipment costs. Today, meat products are prepared, packaged and labeled at large processing facilities, and shipped in refrigerated trucks to centralized distribution warehouses which then distribute products to individual stores. A consequence of this change is the necessity of longer shelf-life for products to reach the consumer. Fresh red meats packaged in oxygen permeable film have an expected shelf-life of two to three days under retail display conditions. One method for increasing shelf-life of refrigerated meats is to modify the atmosphere within the package. The shelf-life of fresh meat can be increased to six to 10 days with modified atmosphere packaging in a high-oxygen environment, and up to 21 days in a low-oxygen environment.

Modified Atmosphere Packaging (MAP) is one of several methods used by processors to control microbial spoilage of food products. Normal atmosphere contains 20.9 percent oxygen and 0.1 percent carbon dioxide. By increasing the carbon dioxide levels in the package, growth of aerobic spoilage organisms can be delayed, thereby extending the shelf-life of the meat product.

The two most frequently used atmospheres in MAP products are an 80:20 percent mixture of oxygen and carbon dioxide and 100 percent carbon dioxide. These atmospheres use different strategies to achieve the same result. The 80:20 percent O_2:CO_2 mixture uses higher-than-normal carbon dioxide levels to reduce aerobic microorganisms in combination with higher-than-normal oxygen levels to help maintain red meat color normally associated with freshness. The atmosphere is sealed into individual packages which

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are boxed and shipped to the retail store, ready for display.

The 100 percent CO_2 product is prepared in a traditional oxygen permeable packaging, placed into a master container which is filled with carbon dioxide and then sealed. Packages are removed from the master pack, allowed to bloom to a bright red color and placed on the shelf for sale.

The objectives of this research were to determine differences in characteristics of ground pork placed in lighted storage due to: effects of atmosphere (80:20 percent O_2:CO_2 or 100 percent CO_2), length of storage (two days versus eight days unlighted storage) and raw material source (pork sirloin with pork loin fat trim or pork shoulder meat).

Materials and Methods

Fresh pork sirloin, pork loin fat trim and pork shoulder meat were purchased from a commercial processor five days after slaughter. The meat was analyzed for fat content and fresh sirloin meat and pork loin fat trim were formulated to a fat content equal to the shoulder meat (18 percent fat). The pork was ground through a 1/8 inch plate, chilled and made into half-pound portions. Ground pork was placed into packages and filled with either 100 percent carbon dioxide or an 80:20 percent mixture of oxygen and carbon dioxide. Packages of ground pork were placed in unlighted storage (34°F) for either two or eight days to simulate the range of time prepackaged meat would spend in route to retail outlets. Packaged products were then placed under light (1076 lux light, 34°F) for eight days to simulate lighting conditions found in retail display cases. The products were kept in their original atmospheric environment throughout the study. Individual packages were opened immediately prior to chemical and physical analysis. Product was evaluated every two days (zero to eight days of lighted storage) for total bacteria (APC), coliforms, psychrotropic bacteria, exterior color L* (lightness), a* (redness) and b* (yellowness) values, surface metmyoglobin and surface

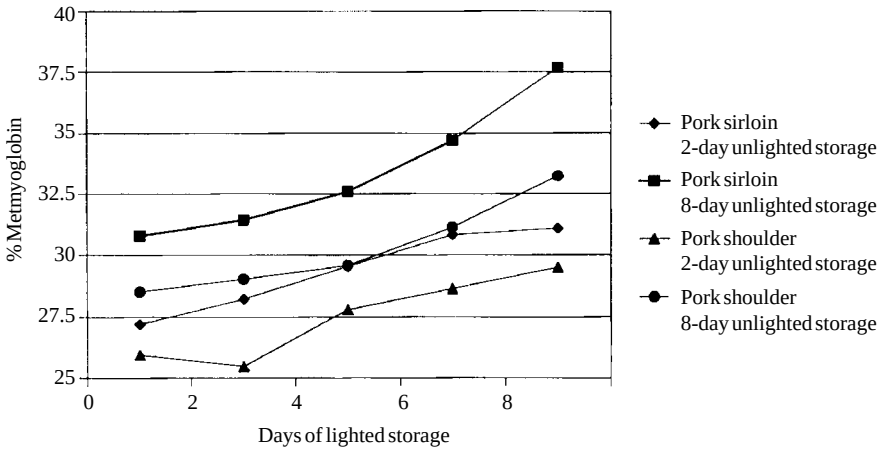

Figure 1. Surface metmyoglobin of ground pork in 80:20 percent oxygen:carbon dioxide modified atmosphere packaging.

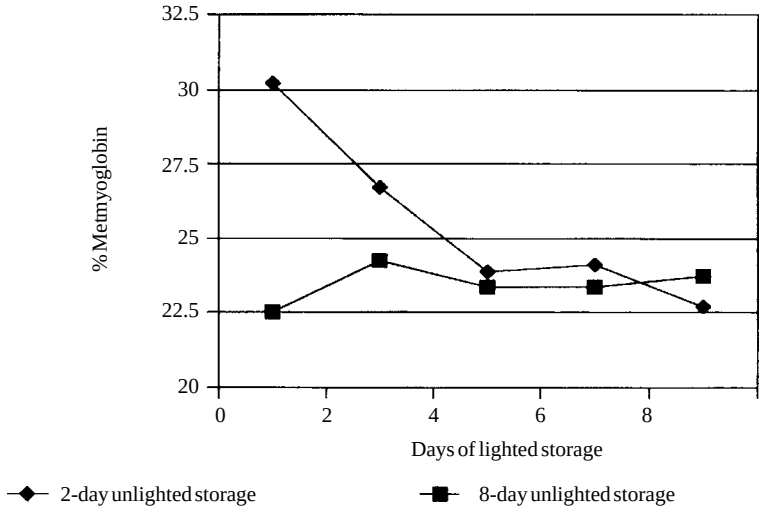

Figure 2. Surface metmyoglobin of ground pork in 100 percent carbon dioxide for product held either two or eight days in unlighted storage prior to lighted retail display.

metmyoglobin reducing ability (MRA), pH and oxidation reduction potential. Lipid oxidation was also measured and reported as thiobarbituric acid reactive substances (TBARS). Surface metmyoglobin formation was measured by obtaining reflectance readings through eight days of lighted storage.

Results and Discussion

In a high-oxygen environment (80:20 percent oxygen:carbon dioxide) surface metmyoglobin was higher for ground pork from sirloin than for ground pork shoulder meat (Figure 1) in product held two or eight days (unlighted storage) prior to lighted retail display. Surface metmyoglobin levels remained below 50 percent throughout eight days of lighted retail storage (50 percent metmyoglobin is the value commonly used as the level above which consumers reject meat for purchase based on color perception). Surface metmyoglobin increased during lighted storage from 27.5 percent to 31 percent (sirloin) and 31 percent to 37.5 percent (shoulder) after two days of unlighted storage and from 31 percent to 37.5 percent (sirloin) and 28 percent to 33 percent (shoulder) after eight days of unlighted storage. Surface metmyoglobin of products in an atmosphere of 100 percent CO_2 decreased over time from 30 percent to 23 percent (after two days of unlighted storage) due to enzymatic reduction of the meat system, but remained relatively constant at 23 percent after eight

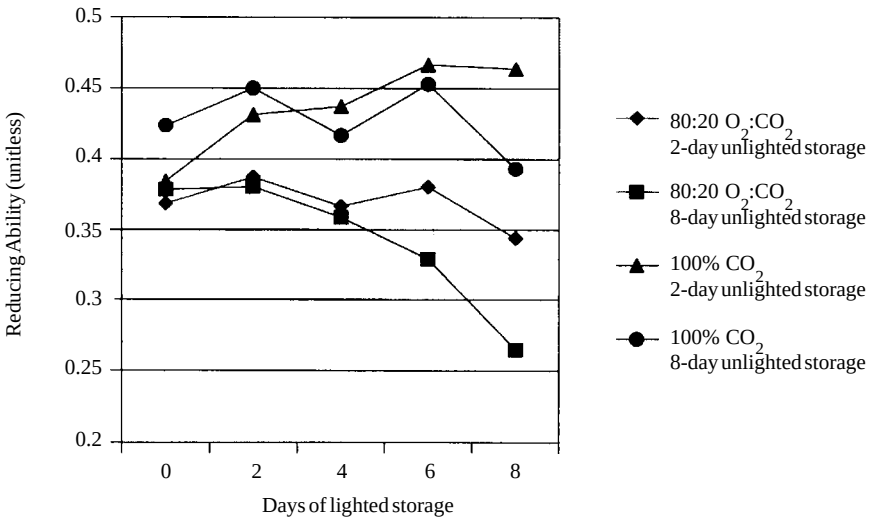

Figure 3. Metmyoglobin reducing ability of ground pork in modified atmosphere packaging.

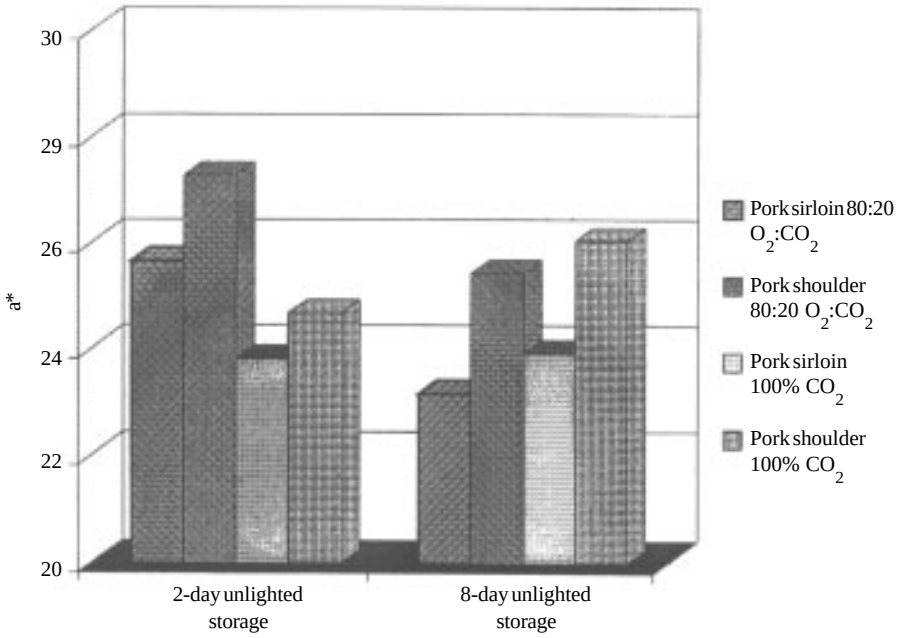

Figure 4. Changes in surface redness due to different meat source and atmosphere.

Table 1. Fatty acid profile of ground pork.

	Ground Pork Sirloin		Ground Pork Shoulder	
Fatty Acid	Mean (n=8)	SEM[a]	Mean (n=8)	SEM[a]
Mystiric Acid (14:0)	1.40	0.14	1.40	0.06
Palmitic Acid (16:0)	23.23	0.56	22.93	0.72
Palmitoleic (16:1)	3.30	0.22	3.94	0.19
Stearic (18:0)	12.65	0.52	11.67	0.30
Oleic (18:1)	43.48	0.84	45.16	0.55
Linoleic (18:2)	15.48	0.44	14.45	0.76
Arachidonic (18:3)	0.46	0.09	0.55	0.13
Total	100.00		100.00	

[a]Standard error of the mean.

days of unlighted storage (Figure 2). Metmyoglobin reducing ability of ground pork packaged in 100 percent carbon dioxide was higher than ground pork packaged in 80:20 percent oxygen:carbon dioxide (Figure 3). In an anaerobic environment, enzymes will reduce metmyoglobin to deoxymyoglobin, reducing the level of surface metmyoglobin (Figure 2) over time, as long as reducing equivalents are not depleted.

Lipid oxidation of ground pork is measured as thiobarbituric acid reactive substances (TBARS). A TBARS value of 1.0 is considered the threshold value for consumers to detect rancidity in fresh ground pork. Ground shoulder meat was higher in unsaturated fatty acids (palmitoleic, oleic and arachidonic fatty acids) than ground sirloin (Table 1). Unsaturated fatty acids contribute to higher lipid oxidation and correspondingly higher TBARS values. The TBARS values for ground pork in 100 percent carbon dioxide remained below 0.3 mg malonaldehyde/kg meat throughout lighted storage and there were no significant differences between meat sources (data not shown). Surface a* values (redness) were higher for pork shoulder than for pork sirloin (Figure 4) for both atmospheres.

Total aerobic plate counts, coliforms and psychotropic bacteria counts are given in Tables 2 through 4. In an 80:20 percent O_2:CO_2 atmosphere, products held for eight days in unlighted storage had higher bacterial levels than products held for two days, although levels remained below 10^6 throughout eight days of lighted storage. Aerobic plate counts were lower for products stored in 100 percent CO_2 and remained low throughout lighted storage (Table 2). Carbon dioxide has an inhibitory effect on the growth of microorganisms by both extending the lag phase of bacteria prior to the growth phase and decreasing pH due to increased solubility of carbon dioxide in meat at low temperatures. Psychotropic plate counts and coliforms remained low throughout lighted storage in both atmospheres (Tables 3 and 4).

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Table 2. Mean aerobic plate counts for ground pork in modified atmosphere packaging.

Treatment			Aerobic plate counts (log_{10} cf.u./gram					
			Day 0	Day 2	Day 4	Day 6	Day 8	SEM
80:20 O_2:CO_2		2-day unlighted storage	3.27^{a}	3.25^{a}	3.41^{ab}	3.81^{bc}	3.94^{c}	0.12
		8-day unlighted storage	3.95^{c}	4.14^{d}	4.65^{e}	5.22^{f}	5.51^{g}	0.12
		Pork sirloin	3.38^{a}	3.59^{b}	3.96^{c}	4.36^{d}	4.63^{e}	0.09
		Pork shoulder	3.85^{c}	3.80^{cd}	4.11^{cd}	4.67^{e}	4.82^{e}	0.09
100% CO_2	Pork sirloin	2-day unlighted storage	3.19^{w}	3.05^{w}	3.14^{w}	3.17^{w}	3.13^{w}	0.06
		8-day unlighted storage	3.15^{w}	3.21^{w}	3.26^{w}	3.63^{y}	4.00^{z}	0.06
	Pork shoulder	2-day unlighted storage	3.37^{x}	3.34^{wx}	3.41^{x}	3.51^{x}	3.47^{x}	0.06
		8-day unlighted storage	3.49^{xy}	3.33^{wx}	3.58^{y}	3.49^{y}	3.56^{y}	0.06

$^{a-g,w-z}$Means within an atmosphere treatment with the same subscript are not significantly different (P<0.05).

Table 3. Mean psychotropic plate counts for ground pork stored in modified atmosphere packaging.

Treatment			Psychrotrophic plate counts (log_{10} cf.u./gram)					
			Day 0	Day 2	Day 4	Day 6	Day 8	SEM
80:20 O_2:CO_2		2-day unlighted storage	2.79^{a}	3.33^{b}	3.42^{b}	13.68^{c}	4.31^{de}	0.08
		8-day unlighted storage	4.09^{d}	4.39^{e}	5.11^{f}	5.61^{g}	5.87^{b}	0.08
100% CO_2	Sirloin	2-day unlighted storage	2.39^{w}	2.62^{wx}	2.52^{w}	2.42^{w}	2.68^{wx}	0.14
		8-day unlighted storage	2.06^{wx}	2.52^{w}	3.23^{y}	3.49^{y}	4.11^{z}	0.14
	Shoulder	2-day unlighted storage	2.78^{wx}	3.32^{y}	3.10^{y}	2.59^{wx}	2.85^{xy}	0.14
		8-day unlighted storage	2.91^{xy}	2.52^{w}	3.27^{y}	3.33^{y}	3.61^{y}	0.14

$^{a-d,w-z}$Means within an atmosphere treatment with the same letter are not significantly different (P<0.05).

Table 4. Mean coliform plate counts for ground pork stored in modified atmosphere packaging.

Treatment		Coliforms (c.f.u./gram)					
		Day 0	Day 2	Day 4	Day 6	Day 8	SEM
80:20 O_2:CO_2	2-day unlighted storage	15^{a}	14^{a}	20^{a}	16^{a}	12^{a}	1.15
	8-day unlighted storage	12^{a}	51^{b}	19^{a}	20^{a}	18^{a}	1.15
	Pork Sirloin	13^{a}	52^{d}	38^{cd}	35^{c}	22^{b}	1.15
	Pork Shoulder	14^{a}	13^{a}	10^{a}	$<10^{a}$	$<10^{a}$	1.15
100% CO_2	2-day unlighted storage	14^{w}	11^{x}	$<10^{x}$	$<10^{x}$	$<10^{x}$	1.11
	8-day unlighted storage	$<10^{x}$	$<10^{x}$	$<10^{x}$	$<10^{x}$	$<10^{x}$	1.11

$^{a-b,w-x}$Means within an atmosphere treatment with the same letter are not significantly different (P<0.05).

Conclusions

The generally excepted shelf-life of red meat packaged in oxygen permeable films is two to three days. Modified atmosphere packaging was successful in extending shelf-life of ground pork from two to three days of lighted storage to at least six days for color and up to eight days for microbial spoilage. Ground pork shoulder meat had greater redness than ground pork sirloin meat. Microbial spoilage of ground pork was maintained below spoilage levels for up to eight days of lighted display. Ground pork packaged in an atmosphere of 80:20 percent O_2:CO_2 can be held in unlighted storage for up to eight days and achieve an additional six to eight days of lighted storage shelf-life, provided ground pork is produced from freshly slaughtered meats and processed in a clean, sanitary environment with good temperature control.

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