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EFFECTS OF MODIFIED ATMOSPHERE PACKAGING (HIGH OXYGEN) ON THE STORAGE-LIFE OF RETAIL-READY FRESH PRESERVED SAUSAGE.

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INTRODUCTION

Appearance, particularly colour, is one of the most important factors involved in consumer acceptance of fresh meat products. The bright red colour that consumers prefer in fresh meat is due to oxygenated myoglobin, with iron on the heme group in its ferrous state. Oxidative changes caused by bacterial, enzymatic or lipolytic action results in conversion of the heme iron to the ferric form, formation of metmyoglobin and loss of typical red colour.

Extension of shelf-life of fresh meats and fresh sausage my be possible through the use of modified atmospheres. The most widely used gases are oxygen, carbon dioxide and nitrogen. Oxygen concentrations of more than 5% are necessary to maintain the oxygenated form of myoglobin, but at such concentrations, the growth of aerobes may be accelerated. Carbon dioxide is bacteriostatic but at higher CO2 concentrations (>20%) may lead to meat discoloration. While use of dry ice (solid carbon dioxide) is advantageous for temperature control during production of fresh sausage, high levels of usage (30-40% of meat weight) may lead to colour fading (Legarreta *et al.*, 1987). Nitrogen is commonly added as an inert filler.

Few studies have examined the shelf-life of fresh pork sausage under modified atmosphere storage (MAP). In particular, limited research has been done on the use of high oxygen atmospheres on extending shelf-life of preserved sausage in retail ready packaging. Furthermore, there is little known regarding the fate of sodium erythorbate in high oxygen modified atmospheres. Thus, the objectives of this study were to evaluate MAP for shelf-life extension of fresh sausage.

MATERIALS AND METHODS

Fresh (ca one day post-mortem) pork (80/20 and 50/50 trim) and beef (75/25 trim and beef fat) were obtained from Intercontinental Packers Ltd. on each day of processing. Pork sausage trials were repeated three times while trials with beef sausage were repeated twice.

All processing was done in the Meat Lab at the University of Saskatchewan in a refrigerated room at 7-10°C. Equipment was sanitized and rinsed just prior to use. Meats were preground through a 1.6cm plate. Pork sausage formulations (meat, crushed ice, binder unit, and sodium erythorbate, Table 1) were mixed, reground (0.48cm), and then stuffed into collagen casings (23mm; Devro). Temperatures were monitored at each processing step. Links (15 links per tray; approx 600 grams, 29.6% fat, 9.7% protein, 51.5% moisture) were then set into oriented polystyrene trays (Grace Barrier Foam trays; 8.5cc O2/m2/24h@23°C; Cryovac Division, W.R. Grace & Co. of Canada Ltd. Mississauga, ON). Beef sausages were processed in a similar manner except that the final grind was through a 0.31cm plate and sausages (24.8% fat, 11.4% protein, 52.3% moisture) were stuffed into 28/32 hog casings and arranged five per tray (425g). Total calculated inputs of sodium erythorbate were 1075 and 600ppm for pork and beef sausages respectively.

For each experiment, trays were randomly assigned to one of two treatments:
a) modified atmosphere packaging (MAP; high oxygen), and

b) conventional (AIR).

The MAP trays were overwrapped with a oxygen impermeable film (Cryovac Barrier Foam Lidstock; multilayer barrier film; 43.4 ccO2/m2/24h@23 °C), flushed with a gas mixture of 60% oxygen, 20% carbon dioxide and 20 % nitrogen (certified, Canadian Liquid Air) and sealed using a Ross Model 580 Preformed Tray Machine (Reiser Packaging Inc., Canton, MA). The volume of the gas mixture to the meat in each package was maintained at approximately 0.6-0.75:1. During storage, conventionally wrapped trays were overwrapped with an oxygen permeable film (D-film; polyolefin; 3000 - 8000 ccO2/m2/24h@23 °C; Cryovac). In order to minimize appearance differences due to film clarity and a different sealing mechanism, those conventional trays needed for visual examination were sealed just prior to panels with the Cryovac Lidstock (flushed with air). Additional trays of sausages were frozen (-40 °C) for use as a "fresh" reference for sensory evaluation.

Packages from each treatment were stored in the dark at -1 °C for 11, 18 and 25 days. At selected intervals, packages of sausage were placed in a closed retail display cooler at 4±1 °C and held for up to three days d under continuous fluorescent lighting (100ftc). Evaluations of sausage colour intensity, colour acceptability, odour intensity, off-odour intensity, odour acceptability, overall acceptability and purchase decision were made by a 12-14 member consumer panel. Each attribute was rated on 6-point intensity or hedonic scales: 6= dark pink or red, no odour, no off odour, very acceptable, definitely purchase/cook/consume and 1= dark brown/other, extremely strong, very unacceptable, definitely no. Products were considered not suitable for sale when mean values for acceptability fell below 3.5 on the 6 point scale. Panellists individually evaluated raw product quality by examining coded packages in the display case. Sausage portions in small portion cups were evaluated for odour. Fresh (thawed) "REF" and coded (hidden reference) trays were included in each set.

At each sampling interval, headspace oxygen was determined in duplicate on selected packages prior to opening using a Mocon headspace oxygen analyzer. Microbial analyses (total plate counts and lactic acid bacteria) and chemical analyses (pH, fat, moisture, protein, sodium erythorbate) were performed using standard techniques. Instrumental measures of colour (Hunter L, a, b) were also performed using a Hunterlab Colour Quest 45/0.

RESULTS AND DISCUSSION

After 11 days of storage at -1 °C, the gas composition of pork sausages packaged under MAP had dropped to 54.1% oxygen from initial levels of 59 to 62%. By day 25, oxygen levels had reached 46% (Table 2). For beef sausage under MAP, day 11 and 18 oxygen levels were at 52.9 and 51.3% respectively. Data for beef sausages were not collected beyond day 21 (18+3 days display) because of obvious spoilage.

Canadian regulations for fresh preserved sausage allow the use of sodium ascorbate or sodium erythorbate according to Good Manufacturing Practices, typically 500 to 600ppm. Additional erythorbate was added to the pork sausage formulation (total calculated input of 1075ppm). By day 11, residual erythorbate levels for AIR and MAP treatments were 379 and 93ppm respectively. With additional storage, residual erythorbate dropped to 53 to 54ppm. Thus, addition of sodium erythorbate did not make a large contribution to increased colour stability during extended storage in a high oxygen environment since over 90% of the erythorbate input to MAP products was lost during the first 11 days of storage.

For both pork and beef sausages, loss of pink or red colour was the primary defect that led to product rejection by the consumer panel (Table 3). The Hunter `a' value that corresponded to an unacceptable colour rating (3.0 or less on the 6 point scale) was 18 for pork sausages and 23 for beef sausages. Thus, conventionally packaged pork sausages retained an acceptable colour on only day 11 of storage, while colour of MAP packaged pork sausages was acceptable up to day 25. For beef sausage, corresponding limits of colour acceptability were 11 and 18 days respectively. Both treatments had significantly lower Hunter a values following three days of continuous display; however, AIR packaged products lost more redness during the display period than MAP treatments. In addition, beef sausages (which had a more intense red colour initially) exhibited much more dramatic losses in redness than pork sausages during extended storage.

In this project, care was taken to ensure that the initial microbial contamination was relatively low. Meats used for these experiments were very fresh (one day post-mortem) and had been removed from the boning lines early in the shift. During processing and storage, low product temperatures were maintained. For the fresh pork sausage, initial microbial levels (total plate counts, TPC) in the sausage was 3.99log cfu/g (Table 1). Following 11 days of storage at -1°C, TPCs had remained fairly stable (3.91 and 4.18 for MAP and AIR respectively, Table 2). While initial product microbial levels for beef sausage also were fairly low (TPC, 4.25log cfu/g), counts had reached 5.49 to 6.15log cfu/g by day 11. It is possible that the use of natural hog casings for the beef sausages may have contributed to an increased microbial load (Table 1).

For pork sausages, MAP products showed significantly slower microbial growth than comparable AIR treatments. At day 11, the difference was 0.30log units; by day 25, the difference was 2.00 log units. For beef sausage, TPC for MAP sausages at both day 11 and 18 were 0.60 log units lower than comparable AIR treatments. For both treatments, microbial levels increased dramatically during the three days of display at 4°C, illustrating the critical importance of temperature on spoilage of fresh sausage.

Lactic acid bacteria were also enumerated in these experiments. Results for lactics were similar to those described for TPC. It appears, though that lactic acid bacteria made up a greater proportion of the flora for pork sausages than for beef. Further investigation of flora composition may indicate why beef sausages spoiled more rapidly than fresh pork sausages.

The pH of the pork sausages (data not shown) was between 6.8 and 6.6 for the duration of the study. For beef sausage, the initial product pH was 6.5 which declined by day 18+3 to 5.9 for AIR treatments and 6.3 for MAP treatments.

In general, storage time and packaging treatment had little effect on product odour (Table 3). For pork sausages, ratings for odour reached the point of unacceptability (3.0) for only pork AIR treatments on day 25+3 days display. For beef sausage, odour scores were at 3.0 or lower by day 11+3 for AIR treatments and 18+3 for MAP treatments.

Predictions of "saleable" storage life are difficult. By using a cutoff of 3.5 (out of 6) for overall acceptability in combination with microbial and chemical data, it was estimated that conventionally packaged pork sausages would have a shelf-life of 12 days (9 days at -1°C plus three days of retail display at 4°C), a gain of approximately five to seven days over typical industry practice. Pork sausages packaged under MAP achieved a total of 21 days (18 days at -1°C plus three days retail display at 4°C) due to good maintenance of colour and slower microbial growth. In general, beef sausages had a much shorter shelf-life than pork sausages due to greater colour changes with storage and more rapid microbial growth. Beef sausages, packaged either with modified atmospheres or conventionally, had a shelf-life of less than 14 days (approximately eight to nine days at -1°C plus three days of retail display at 4°C). In contrast to the results for pork sausage, MAP had little effect on extending shelf-life of beef sausages beyond that of the conventionally packaged treatments.

In summary, strict temperature control during storage (and distribution) would have a major effect on storage life of fresh sausage. While modified atmosphere packaging in retail ready trays (under high oxygen) was beneficial for extending the shelf-life and maintaining colour of fresh pork sausage, few benefits were seen for beef sausage.

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REFERENCES

LEGARRETA, I. G., USBORNE, W.R., and ASHTON, G.C. 1987. Effect of hot-boned pork on the keeping quality of fresh pork sausage. *Meat Sci.* 21:301-317.

Table 1. Fresh pork and beef sausage formulations and initial microbiology (day of processing).

Meat and Ingredients	% of batch	Total plate count logCFU/g	Lactic acid bacteria logCFU/g
Fresh Pork Sausage			
Pork trim 50/50			
Pork trim 80/20	65.0	3.82(3.76-3.85)	3.40(3.31-3.47)
Pork binder/	10.0	4.57(3.65-5.10)	4.09(2.96-4.72)
spice unit	10.45	2.78(2.77-2.78)	2.66(2.48-2.92)
(10-1386)			
Water (ice)			
Additional	14.50		
erythorbate	0.05		
Collagen			
casings		<1.00	<1.00
Pork sausages			
(day 0)		3.99(3.92-4.05)	3.61(3.57-3.66)
Fresh Beef Sausage			
Beef trim 75/25			
Beef fat	57.80	3.24(3.06-3.41)	2.54(2.30-2.78)
Beef binder/	14.40	3.61(3.34-3.88)	2.55(2.40-2.55)
spice unit	9.80	2.77(2.70-2.84)	2.09(2.00-2.18)
(10-1378)			
Water (ice)			
Hog casings	18.00		
Beef sausages		3.86(3.85-3.87)	3.45(3.40-3.50)
(day 0)		4.25(4.19-4.31)	3.45(3.19-3.71)

Griffith Pure Pork Sausage Binder Unit (10-1386): Toasted wheat crumb, sodium chloride (17%), dextrose, sugar, spice, hydrogenated vegetable oil (manufacturing aid), sodium erythorbate (0.55%), modified wheat flour. (Dextrose equivalent 58.5%)

Griffith Beef Sausage Binder Unit (10-1378): Toasted wheat crumb, sodium chloride (19%), wheat flour, buttermilk powder, spice, hydrogenated vegetable oil (manufacturing aid), sodium erythorbate (0.6%), dextrose and modified wheat flour. (Dextrose equivalent 56%)

Table 2. Effect of modified atmosphere packaging (high oxygen) of fresh pork and beef sausages on oxygen, sodium erythorbate , Hunter `a' values, total plate counts (TPC) and lactic acid bacteria.

Attribute	Storage at -1°C	Conventional display at 4°C		High O2 display at 4°C		SEM
		0d	3d	0d	3d	
Fresh pork sausage						
Oxygen (%)	11	19.4c	18.9c	54.1a	48.4b	0.63
	18	19.4c	18.6c	48.2a	43.9b	0.97
	25	18.4b	17.5b	46.1a	44.2a	1.07
Erythorbate (ppm)	11	379.1a	267.3b	92.8c	66.6c	11.47
	18	120.5a	60.5b	58.8b	55.6b	7.32
	25	52.6a	58.9a	53.8a	53.3a	2.93
Hunter `a' (redness)	11	19.13b	16.40c	20.14a	19.15b	0.09
	18	18.10b	14.69c	19.66a	18.13b	0.11
	25	15.72b	14.12c	18.98a	15.86b	0.12
TPC (logCFU/g)	11	4.18c	6.46a	3.91d	5.03b	0.07
	18	5.26c	7.36a	4.30d	5.98b	0.08
	25	7.22b	9.04a	5.22d	6.84c	0.09
Lactics (logCFU/g)	11	3.75c	5.96a	3.53c	4.67b	0.08
	18	4.83c	7.07a	3.88d	5.67b	0.06
	25	6.33b	8.22a	4.82c	6.31b	0.05
Beef sausage						
Oxygen (%)	11	19.9c	19.0c	52.9a	49.2b	0.89
	18	19.0c	17.0c	51.3a	37.2b	0.75
Hunter `a' (redness)	11	27.55a	18.87b	27.42a	23.92b	0.12
	18	21.38b	15.70d	25.74a	18.20c	0.23
TPC (logCFU/g)	11	6.15ab	6.36a	5.49b	6.37a	0.07
	18	7.39c	8.87a	6.81d	8.64b	0.06
Lactics (logCFU/g)	11	4.14b	5.04a	3.65c	4.33b	0.15
	18	5.93b	6.51a	5.20d	5.61c	0.10

a,b,c,d Means followed by the same letter within a row are not significantly different at $P<0.05$.

Table 3. Effect of modified atmosphere packaging (high oxygen) of fresh pork and beef sausages on consumer panel evaluations.

Attribute/ storage at -1°C	Conventional display at 4°C 0d	3d	High O2 display at 4°C 0d	3d	Hidden reference display 4°C 0d	3d	SEM
Fresh pork sausage							
Colour intensity							
11	3.1c	2.5d	3.6b	3.9b	4.5a	4.5a	0.15
18	2.6c	2.1d	3.4b	3.4b	4.3a	4.6a	0.12
25	2.1d	2.1d	3.4b	2.4c	4.3a	4.6a	0.11
Colour acceptab.							
11	4.0c	3.0d	4.3bc	4.5b	5.1a	5.2a	0.15
18	3.3c	2.2d	3.9b	4.3b	5.0a	5.2a	0.14
25	2.4cd	2.2d	3.9b	2.7c	5.0a	5.1a	0.15
Odour acceptab.							
11	4.9ab	4.4b	4.8ab	5.0a	5.1a	5.1a	0.13
18	4.9ab	3.8c	4.9ab	4.5b	5.2a	5.2a	0.14
25	4.1b	2.9d	4.5ab	3.6c	5.0a	4.9ab	0.17
Overall acceptab.							
11	4.2b	3.3c	4.2b	4.4b	4.9a	5.1a	0.16
18	3.6c	2.4d	4.1b	3.9bc	4.9a	5.1a	0.14
25	2.6c	2.0d	3.6b	2.5cd	4.7a	4.8a	0.16
Fresh beef sausage							
Colour intensity							
11	4.3b	1.7d	5.1a	3.5c	5.0a	5.2a	0.12
18	2.5c	1.4e	4.2b	2.0d	5.2a	5.0a	0.11
Colour acceptab.							
11	5.0a	1.7c	5.1a	3.7b	5.3a	4.9a	0.12
18	2.8c	1.4d	4.6b	1.5d	5.3a	5.2a	0.12
Odour acceptab.							
11	4.5a	2.8c	4.2a	3.4b	4.8a	4.6a	0.22
18	2.9c	2.1d	3.7b	2.4d	4.8a	5.1a	0.12
Overall acceptab.							
11	4.4a	1.9c	4.5a	3.0b	4.7a	4.6a	0.17
18	2.4d	1.6e	3.5c	1.7e	4.7b	5.0a	0.10

a,b,c,d,e Means followed by the same letter within a row are not significantly different at P<0.05.