INHIBITION OF LIPID OXIDATION AND ENHANCED ACCEPTABILITY OF PRERIGOR GROUND AND SALTED PORK

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INTRODUCTION

PRERIGOR PROCESSING of meat offers potential advantages in energy savings and speed of processing (Kastner, 1977) and improved binding properties (Hamm, 1960; Trautman, 1964). Only limited information is available on the flavor stability and rate of lipid oxidation in products processed from prerigor meat. Honikel and Hamm (1978) have shown that prerigor salting (NaCl) of beef preserves the water binding capacity of prerigor meat. Salt has a prooxidant effect in meat products (Watts, 1954; Watts, 1962). However, prerigor salting of meat inhibits glycolysis and increases meat pH (Honikel and Hamm, 1978). High muscle pH is associated with lower rates of autoxidation during storage at 5°C (Keskinel et al., 1964) or in the frozen state (Owen and Lawrie, 1975).

In this study, we have investigated the effects of prerigor grinding and salting on autoxidation of pork muscle and fresh pork sausage and on binding and textural properties of pork sausage prepared from prerigor ground and salted meat.

MATERIALS AND METHODS

PORK semitendinosus or shoulder muscles were obtained within 45 min or at approximately 24 hr postmortem for pre- and postrigor samples. Samples were ground immediately and those to be salted were mixed with 2% NaCl. Semitendinosus muscle samples were mixed with 1% antibiotic (Polymyxin B-bacitracin-neomycin), pressed into thin sheets and wrapped in oxygen permeable polyethylene film. Oxidation was measured by the 2-thiobarbituric acid procedure after 0, 3, 7 and 10 days of storage at 2°C.

Shoulder muscle samples were placed in polypropylene tubes and the tubes were closed with plastic stoppers and held at 0, 5, 10, 15 or 20°C for 5 hr to allow rigor development in prerigor ground samples. At 24 hr postmortem, pH and lactic acid (Gutman and Wahlefeld, 1974) were determined. Samples were heated in a 77°C water bath for 1 hr, centrifuged while still hot at 1000 x G for 10 min and the supernatant fluid was decanted and cook loss was calculated.

Fresh pork sausage containing 20 to 25% fat was prepared from boneless shoulders and jowls. The following combinations of prerigor or postrigor grinding and salting were used: 1) prerigor ground and salted (2% NaCl), 2) prerigor ground and postrigor (5 hr after grinding) salted and 3) postrigor (24 hr postmortem) ground and salted. Prior to fine grinding, 2.5% chipped ice, 0.25% black pepper and 0.2% ginger were added. Powdered CO_2 was added to prerigor ground meat to reduce temperature to 4°C immediately prior to the final grinding procedure. The sausage was packaged in vapor impermeable polyethylene tubes and stored at either 0° or -20°C.

Sausage patties (1 cm thick x 5 cm diameter) were prepared after 2 week storage at 0°C and placed on wire mesh and cooked to an internal temperature of 80°C in an oven heated to 150°C. Cooked patties were cooled to 20°C and breaking strength was measured using an Instron Universal Testing Machine. Other patties were evaluated immediately after cooking for juiciness and texture by a taste panel using a scoring system where 1 = extremely dry or extremely crumbly (mealy) and 8 = extremely juicy or extremely rubbery. Oxidation was determined by TBA analysis every 5 days for product stored at 0°C and every 10 days for product stored at -20°C. The entire experiment was replicated three times.

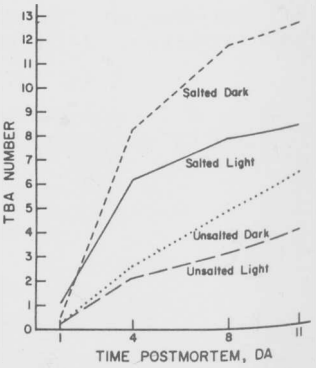

Figure 1. Effect of NaCl and muscle type on TBA numbers in postrigor ground pork semitendinosus muscle stored aerobically at 2°C. Each data point is the mean of 10 observations. (From: Judge and Aberle, 1980).

Table 1. Influence of pre- and postrigor grinding, salt and muscle type[a] on ultimate pH of pork muscle[b].

Time of grinding	n	Salted		Unsalted	
		Light	Dark	Light	Dark
Postrigor	10	5.77 ± .07[c]	5.92 ± .08	5.73 ± .10	5.90 ± .07
Prerigor	10	6.14 ± .02	6.26 ± .02	5.93 ± .06	6.06 ± .05

[a] Light and dark portions of semitendinosus muscle

[b] From: Judge and Aberle. 1980. J. Food Sci. (accepted)

[c] Mean ± standard error.

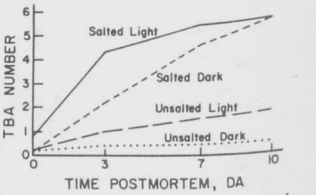

Figure 2. Effect of NaCl and muscle type on TBA numbers in prerigor ground pork semitendinosus muscle stored aerobically at 2°C. Each data point is the mean of 10 observations. (From: Judge and Aberle, 1980).

RESULTS AND DISCUSSION

PRERIGOR grinding and salting resulted in higher ultimate pH in pork semitendinosus (table 1) and shoulder muscles (table 2) compared to postrigor grinding and salting as has been previously reported by Hamm (1977). Temperature during rigor development also affected lactic acid production in ground muscle, particularly in the absence of salt (table 2). Lactic acid accumulation in prerigor ground, unsalted muscle was lowest at 5°C, in agreement with Honikel and Hamm (1978), but in the presence of 2% NaCl, lactic acid concentration was not affected by temperature during rigor development (table 2).

Prerigor grinding without prerigor addition of salt appeared to limit the extent of pH decline (tables 1, 2 and 3) as compared to postrigor grinding. It has been documented by several workers that pH decline is accelerated in ground, prerigor muscle (Hamm, 1977). However, the extent of pH decline may have been limited by prolonged aerobic metabolism supported by the oxygen introduced during grinding. Lawrie (1979) indicated that the presence of oxygen will stimulate respiration in muscle during development of rigor mortis.

Table 2. Influence of pre- and postrigor grinding, temperature during rigor development and salt on ultimate pH and lactate and cooking loss in pork shoulder muscles.

Salt	n	Prerigor ground- Temperature for rigor development (°C)						Postrigor ground	
		0	5	10	15	20	S.E.[a]	Mean	S.E.[a]
					pH				
0%	10	6.04	5.99	6.02	6.05	5.98	.11	5.85	.04
2%	10	6.27	6.28	6.31	6.29	6.25	.11	5.84	.04
					Lactic acid (μmoles/g tissue)				
0%	10	49.3	44.7	53.0	53.0	55.4	1.3	56.7	4.1
2%	10	37.9	34.3	37.0	38.3	36.3	1.3	50.1	4.1
					% Cook loss				
0%	10	20.0	20.6	21.3	22.0	22.0	.3	23.6	1.3
2%	10	8.8	6.8	6.9	6.4	7.2	.3	18.0	1.3

[a] Pooled standard error.

Salted and unsalted semitendinosus muscle samples that were ground prerigor had lower TBA values during storage at 2°C than corresponding samples that were ground postrigor (figures 1 and 2). The prooxidant effect of salt was evident in both prerigor and postrigor samples but it was obvious that prerigor salted muscle was less susceptible to autoxidation than was postrigor salted muscle. In postrigor muscle, the dark portion of the semitendinosus muscle was more susceptible to oxidation, but in prerigor muscle the light portion was more easily oxidized.

Correlation analyses within each processing condition and day of storage revealed that high ultimate pH was associated with low TBA values (All "r" values between pH and TBA number were negative and 14 of 16 "r" values were significant, $P < .05$). Other reports show that high pH delays autoxidation in meat. There was an inverse relationship between pH and TBA number in ground beef adjusted to various pH values and stored for 10 days (Keskinel et al., 1964) and peroxide values were reduced in frozen pork with induced high pH (Owen and Lawrie, 1975).

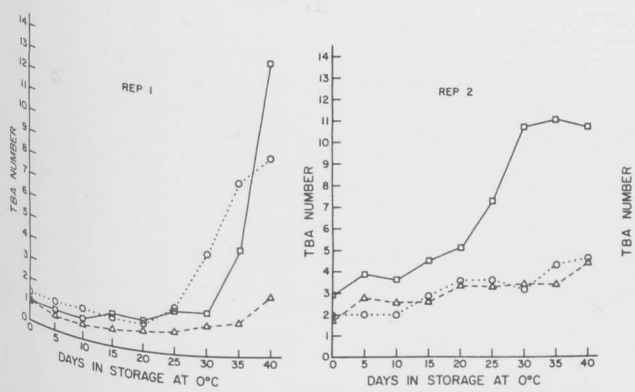

Figure 3. Effect of prerigor and postrigor grinding and salting on TBA numbers of seasoned fresh pork sausage stored at 0°C. Prerigor ground and salted Δ---Δ. Prerigor ground and postrigor salted □—□. Postrigor ground and salted ○···○. (From Aberle et al., 1980).

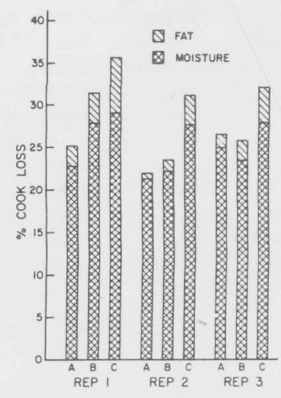

Figure 4. Effect of prerigor and postrigor grinding and salting on cooking losses in seasoned fresh pork sausage. Prerigor ground and salted-A. Prerigor ground and postrigor salted-B. Postrigor ground and salted-C. (From: Aberle et al., 1980).

Table 3. Influence of prerigor and postrigor grinding and salting on pH, patty breaking force and sensory evaluations of fresh pork sausage.[a]

Treatment	pH			Breaking force (g)		
	Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3
Prerigor ground + salted	6.30^{c}	6.35^{c}	6.15^{c}	709^{c}	994^{c}	1222^{c}
Prerigor ground + postrigor salted	6.01^{d}	6.09^{c,d}	5.90^{d}	487^{d}	750^{d}	1006^{d}
Postrigor ground + salted	5.95^{d}	5.90^{d}	5.79^{e}	496^{d}	604^{d}	939^{d}
	Juiciness score[b]			Fragmentation score[b]		
	Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3
Prerigor ground + salted	5.88	5.50^{c}	6.13^{c}	5.44	6.44^{c}	5.19
Prerigor ground + postrigor salted	5.31	5.44^{c}	6.00^{c}	4.31	5.44^{d}	4.88
Postrigor ground + salted	5.06	4.69^{d}	5.06^{d}	4.25	4.44^{e}	4.50

[a]From: Aberle et al. 1980. J. Food Sci. (submitted).

[b]1 = extremely dry or extremely crumbly 8 = extremely juicy or extremely rubbery.

[c,d,e]Means in the same replicate with different superscripts are significantly different ($P < .05$).

TBA values of fresh pork sausage during storage at 0°C were generally lower in sausage produced from prerigor ground and salted meat compared to sausage prepared from either prerigor ground-postrigor salted or postrigor ground and salted meat (figure 3). Prerigor ground and salted sausage also had higher pH than the other treatments (table 3). Storage at -20°C reduced the oxidation rate in all treatments and there was little difference in TBA values among treatments (data not shown).

Cooked patties prepared from prerigor ground and salted sausage had greater binding strength as measured by the force required to break each patty and by taste panel evaluation of fragmentation (table 3). Postrigor ground and salted sausage had the lowest binding strength. Prerigor ground and salted sausage had lower percentage cooking loss that the other treatments (figure 4) and as a result, received higher juiciness scores from the taste panel (table 3). Retention of high binding capacity by prerigor salting of meat has been shown by Hamm (1960), Trautman (1964), Siegel and Schmidt (1979) and others.

SUMMARY

PRERIGOR grinding and salting of pork reduced the amount of lactic acid formed during postmortem glycolysis and resulted in higher than normal ultimate pH. To a lesser extent, prerigor grinding alone resulted in higher ultimate pH than postrigor grinding. Prerigor grinding of semitendinosus muscle also reduced the rate of lipid oxidation compared to postrigor grinding. Prerigor grinding and salting reduced the rate of oxidation compared to postrigor grinding and salting in pork muscle and in fresh pork sausage. TBA number and ultimate pH were highly negatively correlated. Sausage prepared from prerigor ground and salted pork shoulders were more juicy, produced firmer, less easily fragmented patties and underwent less shrinkage during cooking than sausage from postrigor ground and salted shoulders.

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