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Muscle fiber characteristics, postmortem shortening and tenderness of pork

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Investigations have revealed that a complex of factors influences postmortem metabolism in porcine muscle. For this reason one cannot generalize in describing the causative factors for the extreme variations in the physical properties of pork. Similar degrees of quality may be induced by or associated with such widely divergent variables as breed of animal, muscle location, predominant fiber type or storage temperature postmortem. Consequently there is a need for research studies which identify the influential factors under carefully controlled conditions.

We selected twenty animals with representatives of two breeds (Hampshire and Poland China) which have a substantial incidence of pale, soft, exudative (PSE) muscle. The muscles from these experimental animals ranged from extremely PSE to normal. Our objectives were to characterize two muscles from these animals with respect to (1) fiber type and size, (2) propensity to undergo rigor shortening at two storage temperatures and (3) tenderness after storage at the two temperatures. Following is a review of some of the published findings of the study.

Table 1 shows the means for the histological traits of selected large and small bundles in the longissimus and biceps femoris muscles. The fiber diameters were measured with a Zeiss Particle Size Analyzer as described by Miller et al. (1971). Fiber type was determined by staining with Sudan black B. The incidence and area of the dark and light fiber types were also determined.

Table 1. Means for histological traits for porcine muscle[a]

	Fiber diameter, μ			Dark fibers	
	Dark	Light	Weighted ave.	%	Area %
Hampshire					
Longissimus					
Small bundle	58.8	72.5	69.2	24.0	17.8
Large bundle	60.2	75.0	71.7	22.1	15.7
Biceps femoris					
Small bundle	59.5	74.4	68.8	26.9	20.0
Large bundle	61.1	77.3	73.1	25.5	17.8
Poland China					
Longissimus					
Small bundle	63.3	71.3	69.2	24.8	20.4
Large bundle	67.6	74.3	72.9	23.0	20.1
Biceps femoris					
Small bundle	65.8	81.5	76.9	28.7	21.2
Large bundle	66.3	82.0	77.6	26.9	19.5
Significant effects					
Breed	*				
Muscle				*	

*$P < .05$

[a]From Hendricks et al. (1971).

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Breed differences were noted in the size of the dark muscle fibers. The Poland China pigs had larger dark fibers than the Hampshire pigs, a finding that is consistent with previous literature. Lister et al. (1967) reported that Poland China pigs had larger dark fibers and a higher incidence of PSE muscle than Chester White pigs. The Poland China pigs of the present study also tended to have a greater severity of PSE muscle than the Hampshire pigs.

There were significant differences due to muscle for the percent dark fibers. Although the biceps femoris had more dark fibers than the longissimus the differences were not as great as those reported by Beecher et al. (1965) for the dark and light portions of the semitendinosus muscle.

Muscle strips were placed in Myotron (Forrest et al., 1969) chambers for shortening determinations. Striking differences were observed in the amount of time required for maximum shortening to occur (Table 2). The main effects of breed, muscle and temperature were accompanied by significant breed-temperature and muscle-temperature interactions.

Table 2. Means for postmortem shortening and tenderness of porcine muscle.

	Time for maximum shortening, hr.[a]	Percent shortening[a]	Sarcomere length, μ[a]	Allo Kramer shear, kg/g[b]
Hampshire				
Longissimus				
2C	21.6	15.1	1.66	9.2
16C	8.6	3.7	1.69	6.2
Biceps femoris				
2C	32.6	18.2	1.55	19.2
16C	10.8	3.6	1.62	14.5
Poland China				
Longissimus				
2C	7.2	13.0	1.47	10.9
16C	4.9	1.0	1.54	8.8
Biceps femoris				
2C	10.4	15.2	1.48	24.9
16C	7.6	2.1	1.68	22.5
Significant effects				
Breed (B)	***		*	**
Muscle (M)	***			**
B X M			*	
Temperature (T)	***	***	*	**
B X T	***			
M X T	**			

* P< .05
** P< .01
*** P< .001
[a] From Hendricks et al. (1971)
[b] From Lafferty (1969)

The percent shortening data revealed that the only influential factor studied was the temperature (Table 2). Yet, sarcomere length measurements indicated that the extent of shortening was dependent on breed, temperature and breed-muscle interactions. The data of Locker and Hagyard (1963) showed similar effects of temperature on the degree of shortening of beef muscle.

The observations on muscle shortening show that Hampshire muscles required several hours more than Poland China muscles to attain maximum shortening, yet the sarcomere lengths indicated that muscles from the Poland Chinas underwent more severe shortening. Likewise, the 2C temperature treatment delayed the time for maximum shortening (in Hampshire pigs) but also caused higher percent shortening and shorter sarcomeres than the 16C treatment.

The biceps femoris muscle required more time for maximum shortening than the longissimus muscle and this difference was more apparent at 2C than at 16C. Muscle differences in sarcomere length were also modified by breed influences as shown by the fact that Hampshire muscles had longer sarcomeres in the longissimus than the biceps femoris but this was reversed in Poland China muscles.

Significant effects of breed, muscle and temperature were noted for tenderness as measured by the Allo-Kramer shearing device (Table 2). Hampshire muscles were more tender than Poland China muscles, longissimus muscles were more tender than biceps femoris muscles and 16C storage resulted in greater tenderness than 2C storage. The breed and temperature differences support the suggestion of Locker (1960) that the degree of contraction is a factor in tenderness, but, in the Poland China animals, the greater tenderness of the longissimus was associated with equal or shorter sarcomeres as compared to the biceps femoris.

In summary, the following observations were made relative to the influences of breed, muscle and temperature on the fiber characteristics, postmortem shortening and tenderness of pork:

(1) Hampshire longissimus and biceps femoris muscles had larger dark fibers, required longer time for maximum shortening and were more tender than Poland China muscles. Hampshire longissimus muscles had longer sarcomeres than Poland China muscles.

(2) The longissimus muscles had a lower percent dark fibers, required less time for maximum shortening and were more tender than the biceps femoris muscles.

(3) Storage of excised muscles at 2C resulted in greater time for maximum shortening, greater percent shortening, shorter sarcomeres and less tenderness than storage at 16C. Storage temperature effects on time for maximum shortening were more pronounced for the biceps femoris than the longissimus muscles.

The findings emphasize the wide differences that may exist in postmortem shortening and tenderness of pork. The study has identified or confirmed the identity of some of the contributing factors. Of particular interest is the variation in time required for maximum shortening and the extent of shortening in isolated muscle strips. Further studies are needed to determine the extent to which similar shortening patterns occur in muscles of the intact carcass. Likewise, information is needed on the proportion of the toughening that occurred in these excised muscles that also occurs in the intact carcass under the conditions specified.

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