Lamb Meat Quality Progress Report Number 2. Preliminary Results of an Evaluation of Effects of Breed of Sire on Carcass Composition and Sensory Traits of Lamb[1]

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Introduction

The sheep industry competes against beef, pork, poultry, and fish for food dollars of consumers who have many choices of high-quality meats. In this competitive environment, the sheep industry must monitor and react to changing preferences of consumers. A consumer-responsive goal of the sheep industry is consistent production of uniform, safe, nutritious, lean lamb that results in an enjoyable and pleasant eating experience. It is possible that important differences exist between breeds of sheep for traits that affect consumer perceptions of lamb quality. Such breed effects have a genetic basis and can be exploited by sheep producers. Therefore, a potentially efficient method to improve lamb quality is to evaluate breed effects and then to systematically use the most appropriate breeds in crossbreeding programs that produce market lambs. Yet, little is known about effects of breed on lamb meat quality. Thus, this experiment was conducted to compare the meat quality and carcass composition of a diverse sampling of sheep breeds. Breeds were chosen to represent wide ranges of performance and use in production of market lambs. Breeds can be classified as general purpose (Dorset, Texel), dam (Rambouillet, Finnsheep, Romanov), sire (Suffolk, Composite), and hair (Katahdin, Dorper). To provide general background information, a brief description of each breed is provided.

Dorset. Dorset Horn sheep were imported from England into the U.S. in 1885. A mutation occurred in 1945 resulting in development of Polled Dorset. The Dorset breed is widely used as a general-purpose breed for farm production.

Texel. The Texel breed evolved in The Netherlands. It was imported from Denmark and Finland by USDA-ARS in 1985 and released to producers in 1990. Several additional importations by the private industry subsequently occurred. In other countries, Texel are used as a terminal sire breed or as a general-purpose breed.

Rambouillet. Descendants of the Spanish Merino, Rambouillet sheep were developed in France and Germany and imported into the U.S. in the 1800s. The Rambouillet breed is the largest of the fine-wool breeds. Rambouillet are considered a dam breed and serve as the predominant breed for range

[1]Names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product, and use of the name by USDA implies no approval of the product to the exclusion of others that may also be suitable. This experiment was conducted in accordance to guidelines set forth by the MARC Animal Care and Use Committee.

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[3]We gratefully acknowledge the diligent support of this project provided by the staff of the Meat Animal Research Center.

and mountain production in the southwestern and western states of the U.S.

Finnsheep. Finnsheep were imported into Canada in 1966 and into the U.S. in 1968. The breed was imported primarily because of their high lambing rate. Finnsheep are classified as a dam breed and used in much of the U.S. to produce crossbred ewes for use in terminal crossbreeding systems.

Romanov. The Romanov breed originated in northwestern Russia and shares many characteristics similar to Finnsheep. The breed was imported from France into Canada in 1980 and then into the U.S. in 1986. Romanov were imported due to high reproductive performance. Romanov are used as a dam breed to produce crossbred ewes for mating to rams of terminal sire breeds.

Suffolk. The Suffolk breed developed in England from crosses between the Southdown and Norfolk breeds. Suffolks were first imported into the U.S. in 1888. The Suffolk breed is the largest-sized breed in the U.S. and widely used as a sire breed to produce market lambs in terminal crossbreeding systems.

Composite. Composite sheep were created in 1980 by USDA-ARS geneticists at the U.S. Meat Animal Research Center in Clay Center, Nebraska. Columbia rams were mated to Hampshire-Suffolk crossbred ewes to produce the terminal sire composite flock. The productivity of Composite sheep is at least equal to purebred Suffolk as determined by experimental comparison.

Katahdin. Katahdin sheep were created in Maine in the 1950s and subsequently developed as an easy-care hair breed from crosses of St. Croix (a hair breed), Wiltshire Horn (a British breed that sheds its wool), and several traditional wool breeds. Katahdin sheep can be of any color or color pattern. The Katahdin breed is growing in popularity in the U.S. and for export to tropical countries.

Dorper. The Dorper breed was established in the 1940s under the harsh, arid conditions of South Africa from crosses of Dorset and Blackheaded Persian, a fat-rumped hair breed from Eastern Africa. Dorpers have a mixture of hair and wool and are solid white or white with a black head. The breed was first imported into the U.S. in 1995 and subsequent importations followed.

Procedures

During each of two years, five rams per breed were single-sire mated with mature (> 2 years of age) Composite ewes during a 28 day breeding season that began in mid-September. An additional sampling of five rams per breed will be obtained for the third year. Thus, ultimately a total of 15 rams per breed and 135 rams overall will contribute to the experiment. Breed associations were contacted to request information relevant to the experiment and to seek advice on sources of seedstock.

Lambs were reared from birth until slaughter in a single production facility. All male lambs were castrated at 2 to 3 days of age. Lambs were weighed at 0 (birth), 8 (weaning), 10, and 20 weeks of age. At weaning, the dams were removed from the poleshed and drylot and the lambs remained in the same pen through 20 weeks of age. From 1 week of age (creep fed) to slaughter, lambs were given unrestricted (ad libitum) access to a diet that contained 88% dry matter and 77% total digestible nutrients. Crude protein level of the diet was 18% from birth to 10 weeks of age, 14.5% from 10 to 20 weeks of age, and 11.5% from 20 weeks of age to slaughter. Lambs were given unrestricted access to long-stem alfalfa hay. Lambs were not shorn.

Carcass and meat quality information were collected on approximately 30 lambs of each sire breed each year. To the extent possible, the sampling of lambs for evaluation was based on a goal of sampling six progeny per ram with equal sampling of ewes and wethers. Only naturally-reared lambs were sampled. Despite having passed a semen quality examination several rams sired less than six progeny. Thus, additional lambs were sampled from the other sires within the respective breeds to obtain the 30 lambs per year for evaluation (Table 1).

Each year, lambs were slaughtered at weekly intervals in 10 groups of approximately 27 lambs. The serial slaughter was initiated, when the average age of the lambs was 186 days and was completed when the average age of the lambs was 249 days. Each slaughter group consisted of 3 lambs of each sire breed. At least 1 ewe and at least 1 wether of each sire breed was included in each slaughter group. No more than one progeny of any sire was assigned to a given slaughter group.

Two weeks prior to the first slaughter date, lambs were sorted and penned in groups of lambs assigned to 2 or 3 slaughter dates. To minimize stress and any potential impacts that stress may have on meat quality, final live weight was determined 2 days before slaughter. At that time, lambs assigned to the upcoming slaughter group were sorted into a separate pen. Thus, lambs did not have to be sorted on the morning of slaughter. Lambs had unrestricted access to feed and water until the morning of slaughter. Lambs were transported to the MARC abattoir and slaughtered within 3 hours of being removed from their pen.

Lambs were stunned mechanically with a captive bolt pistol. Following evisceration, kidney-pelvic fat was removed from the carcass and weighed. Carcasses underwent a series of anti-microbial washes and a two-minute-long post-wash drip drying period before hot carcass weight was recorded. Carcasses were not electrically-stimulated and were not spray-chilled. Following chilling (24 hours at 32˚F and 24 hours at 34˚F), chilled carcass weight was recorded and carcasses were split longitudinally using a band saw.

The right carcass side was weighed for subsequent calculation of chemical composition. Fat thickness was measured at the midline adjacent to the 4th sacral vertebrae. The right side of the carcass was ribbed between the 12th and 13th ribs and marbling score was subjectively evaluated and 12th rib fat thickness and loin eye area were measured. A four-inch-long section of denuded loin eye (longissimus) muscle was obtained from the 12th rib region, weighed, ground, and ether-extracted to determine the level of intramuscular fat. The remainder of the right side was frozen, tempered, ground three times through a 1/4-inch diameter plate, and sampled for determination of ether-extractable fat level. Subsequently, the ether-extractable fat level of the entire right side was calculated mathematically using the weights and proximate composition of the two components.

The entire loin eye (longissimus) muscle was obtained from the left side of each carcass, vacuum-packaged, cooler (34˚F) aged until 7 days after slaughter, and frozen. Subsequently, eleven one-inch thick chops were obtained from the frozen muscles using a band saw. Two of the chops were thawed and grilled to an internal temperature of 160˚F (medium degree of doneness) and slice shear force, an instrumental measure of tenderness in which a higher value indicates less tender meat, was measured. After 5 to 7 days of frozen storage, chops were thawed and grilled for trained sensory panel evaluation. The trained sensory panel rated samples on 8-point scales for tenderness, juiciness, lamb flavor intensity, and off-flavor score, where 8 = extremely tender, extremely juicy, extremely intense, or no off-flavor and 1 = extremely tough, extremely dry, extremely bland, or extremely intense off-flavor.

Statistical Analysis. Data were analyzed by mixed-model procedures using models that included fixed effects for sire breed, sex of lamb, and year, the random effect of sire within breed of sire, and either slaughter age or hot carcass weight as a covariate.

Results

Age-constant basis

Breed means for growth and carcass composition traits, adjusted to the mean slaughter age of 215 days, are presented in Tables 2 and 3. Progeny of Suffolk sires were 9 to 21 pounds heavier than progeny of all other breeds ($P < 0.05$). The carcasses of progeny of Suffolk sires were heavier ($P < 0.05$) than those of the progeny of all other breeds except Dorper. The carcasses of progeny of Finnsheep sires were lighter ($P < 0.05$) than those of the progeny of all other breeds except Romanov.

Dressing percentage, which is hot carcass weight expressed as a percentage of live weight, was greater ($P < 0.01$) for progeny of Dorper sires than those sired by all other breeds. Due to apparent variation in pelt weight and other dress-off items, there was substantial variation in dressing percentage among the breeds.

Although breed of sire affected weight of kidney-pelvic fat, differences among breeds were clearest when we expressed kidney-pelvic fat relative to hot carcass weight (100 X KP / [KP+HCW]) and termed this trait as kidney-pelvic fat percentage. Progeny of Romanov, Finnsheep and Katahdin sires had the a higher ($P < 0.05$) kidney-pelvic fat percentage than progeny of Composite, Texel, Suffolk, and Dorset sires. This contributed to the low dressing percentage of progeny of Romanov and Finnsheep sires.

Leg score, which is a subjective evaluation of carcass muscularity in which higher scores are indicative of greater muscularity, was greater ($P < 0.05$) for progeny of Texel sires than those of all other breeds. Leg scores were lower ($P < 0.05$) for progeny of Romanov sires than progeny of all other breeds except Finnsheep, Katahdin and Rambouillet. Loin eye (longissimus) muscle area was larger ($P < 0.05$) for progeny of Texel, Suffolk, and Dorper sires than those sired by all other breeds. Loin eye area was lower ($P < 0.05$) for progeny of Finnsheep sires than progeny of all other breeds except Romanov.

The hair breeds, Dorper and Katahdin, had the highest 12th rib fat thickness and Romanov, Texel, and Rambouillet had the lowest 12th rib fat thickness. Fat thickness at the 4th sacral vertebrae was greater ($P < 0.001$) for progeny of Dorper sires than those of all other breeds. This result is consistent with the lineage of Dorper, which descended from the “fat-rumped” Black-headed Persian breed.

Among the 554 carcasses sampled, whole-carcass ether-extractable fat percentage ranged from 15% to 40%. However, most of that variation was not due to differences among breeds. The range in breed of sire means for carcass ether-extractable fat percentage was 4.1%, from 26.3% for Texel to 30.4% for Kathadin.

Breed of sire affected both loin eye ether-extractable intramuscular fat percentage and marbling score (Tables 4). As expected, differences among breed of sire means for ether-extractable intramuscular fat percentage and marbling score were highly correlated (R = 0.95). The loin eye muscle of progeny of Finnsheep and Romanov sires contained a higher ($P < 0.05$) percentage of intramuscular fat and received higher ($P < 0.05$) marbling scores than all breeds except Dorper and Katahdin.

Progeny of Finnsheep sires had the numerically lowest slice shear values and the highest ($P < 0.05$) trained sensory panel tenderness ratings (Table 5). Progeny of Composite sires had the numerically highest slice shear values and the numerically lowest trained sensory panel tenderness ratings. Thus, it appears that there are breed differences in lamb tenderness that could affect consumer satisfaction. However, no differences among breeds were observed for lamb flavor intensity or off-flavor ratings. Although the level of difference between breeds was quite small, loin eye chops from progeny of Finnsheep sires were more juicy than those of progeny of Dorper, Texel, Composite, and Rambouillet sires.

Hot carcass weight-constant basis

For the most part, breed differences at a hot carcass weight-constant basis were similar to breed differences at an age-constant basis. However, for carcass ether-extractable fat percentage, there was more variation among breeds at a hot carcass weight-constant basis than at an age-constant basis. On a carcass weight-constant basis, progeny of Suffolk and Texel sires had a lower ($P < 0.005$)

percentage of ether-extractable carcass fat than progeny of all other breeds.

Discussion

Between the two general purpose breeds, Dorset and Texel, progeny of Texel sires expressed greater muscularity and, consequently, less fat at various locations and throughout the carcass. Growth rates of Dorset- and Texel-sired lambs were similar.

Among the three dam breeds evaluated, Finnsheep and Romanov are noted for high litter size. These two breeds have similar levels of performance for many carcass composition and meat quality traits. Progeny of these breeds grew less rapidly, had high levels of intramuscular and carcass fat, and produced relatively small loin eyes. However, Finnsheep- and Romanov-sired lambs produced the most tender loin eye muscle chops. Rambouillet-sired lambs grew more rapidly than Finnsheep and Romanov progeny and produced carcasses with more muscle and less fat.

Comparison of Suffolk and Composite as sire breeds indicated that Suffolk-sired lambs grew more rapidly and produced leaner carcasses than progeny by Composite sires. Relative to other breeds evaluated, loin eye muscle chops of progeny from Suffolk and Composite were the least tender.

Differences in performance were noted for progeny of Katahdin and Dorper, two hair breeds. Dorper-sired lambs grew more rapidly, had larger loin eyes, and produced leaner carcasses than lambs by Katahdin sires. Although there have been non-scientific reports that hair breeds of sheep produce meat with a milder flavor, we did not detect any differences in flavor among the nine breeds.

These results document that each breed has relative strengths and weaknesses across traits and that no single breed excels for all relevant traits. This fact provides the basis for strategic use of breeds in structured crossbreeding systems. Efficiency of commercial lamb production is maximized in terminal crossbreeding systems by use of sire breeds to complement characteristics of crossbred ewes produced from general purpose and dam breeds..

Table 1. Sampling of lambs for evaluation.

	Number of progeny										
	Ram										
	A	B	C	D	E	F	G	H	I	J	Total
Finnsheep	8*	8	7*	7	6*	6*	6*	6	6	6	66
Romanov	9*	7*	7	7	7	6*	6*	6	5		60
Dorper	7*	6*	6*	6*	6*	6*	6*	6*	6*	5*	60
Katahdin	6*	6*	6*	6*	6*	6*	6*	6*	6*	6*	60
Rambouillet	7*	6*	6*	6*	6*	6*	6*	6*	6*	5*	60
Texel	8*	7*	6*	6*	6*	6*	6	6	6	3*	60
Suffolk	9*	8*	7*	7	6*	6*	5*	5	4	3*	60
Dorset	6*	6*	6*	6*	6*	6	6	6	6	4*	58
Composite	8	7	7	7	7	6	6	6	4	2	60

*Ram was purchased from the industry.

Table 2. Effects of breed of sire on growth and carcass traits

Breed of sire	Slaughter age (days)	Live weight (lbs)	Hot carcass weight (lbs)	Dressing percentage	Kidney-pelvic fat weight (lbs)	Kidney-pelvic fat percentage
	--------------- Means adjusted to a constant slaughter age of 215 days ---------------					
Finnsheep	------	119^{e}	59.7^{f}	50.1^{ef}	2.04^{ab}	3.26^{ab}
Romanov	------	121^{de}	60.7^{ef}	49.9^{f}	2.18^{a}	3.39^{a}
Dorper	------	131^{b}	70.2^{ab}	53.3^{a}	2.07^{ab}	2.80^{bcd}
Katahdin	------	125^{cd}	65.1^{cd}	51.9^{b}	2.14^{ab}	3.08^{abc}
Rambouillet	------	125^{cd}	63.4^{de}	50.5^{ef}	1.85^{abc}	2.78^{cd}
Suffolk	------	140^{a}	72.3^{a}	51.4^{bcd}	1.78^{bc}	2.35^{de}
Texel	------	130^{bc}	67.0^{bc}	51.6^{bc}	1.65^{c}	2.34^{de}
Dorset	------	129^{bc}	66.0^{cd}	50.9^{cde}	1.64^{c}	2.40^{de}
Composite	------	130^{bc}	66.2^{cd}	50.6^{def}	1.58^{c}	2.26^{e}
	----------- Means adjusted to a constant hot carcass weight of 65 pounds -----------					
Finnsheep	224^{a}	128^{ab}	------	51.0^{cd}	2.41^{a}	3.55^{ab}
Romanov	222^{ab}	129^{ab}	------	50.7^{cd}	2.47^{a}	3.63^{a}
Dorper	211^{cd}	124^{d}	------	52.7^{a}	1.80^{cd}	2.60^{de}
Katahdin	216^{bc}	126^{c}	------	52.0^{b}	2.17^{ab}	3.11^{bc}
Rambouillet	216^{bc}	129^{ab}	------	50.7^{cd}	1.96^{bc}	2.87^{cd}
Suffolk	205^{d}	130^{a}	------	50.4^{d}	1.35^{e}	2.00^{f}
Texel	212^{c}	127^{bc}	------	51.3^{bc}	1.54^{de}	2.24^{ef}
Dorset	216^{bc}	128^{ab}	------	50.9^{cd}	1.62^{de}	2.39^{ef}
Composite	214^{c}	129^{a}	------	50.5^{cd}	1.53^{de}	2.22^{ef}

^{abcdef}Means, within a column and slaughter endpoint, that do not share a common superscript letter differ significantly ($P < 0.05$). That is, for a given trait (column), if the means for any two breeds do not share a common superscript letter, then the probability that those two breeds differ for that trait is greater than 95%.

Table 3. Effects of breed of sire on carcass composition traits

Breed of sire	Leg score	Loin eye area, square inches	Fat thickness, inches: 12th rib	Fat thickness, inches: 4th sacral vertebrae	Carcass ether-extractable fat percentage
	--------------- Means adjusted to a constant slaughter age of 215 days ---------------				
Finnsheep	10.8[f]	2.24[d]	0.25[bc]	0.60[de]	29.7[a]
Romanov	10.7[f]	2.32[cd]	0.22[c]	0.57[e]	29.3[ab]
Dorper	12.3[b]	2.76[a]	0.31[a]	0.96[a]	30.1[a]
Katahdin	11.0[f]	2.48[b]	0.31[ab]	0.75[b]	30.4[a]
Rambouillet	11.1[ef]	2.45[bc]	0.22[c]	0.59[de]	27.0[c]
Suffolk	12.2[bc]	2.78[a]	0.24[c]	0.62[cde]	27.1[c]
Texel	12.9[a]	2.82[a]	0.22[c]	0.63[cde]	26.3[c]
Dorset	11.5[de]	2.49[b]	0.27[abc]	0.69[bcd]	27.9[bc]
Composite	11.7[cd]	2.56[b]	0.26[bc]	0.71[bc]	27.6[c]
	----------- Means adjusted to a constant hot carcass weight of 65 pounds -----------				
Finnsheep	11.2[e]	2.39[e]	0.30[ab]	0.70[bcd]	31.4[a]
Romanov	11.0[e]	2.44[de]	0.26[bcd]	0.65[cd]	30.7[a]
Dorper	12.1[b]	2.64[b]	0.29[abc]	0.91[a]	28.9[b]
Katahdin	11.0[e]	2.49[cde]	0.31[a]	0.77[b]	30.6[a]
Rambouillet	11.2[de]	2.51[cde]	0.24[cde]	0.63[cd]	27.6[b]
Suffolk	11.8[bc]	2.61[bc]	0.20[e]	0.53[e]	25.1[c]
Texel	12.8[a]	2.78[a]	0.21[de]	0.61[de]	25.7[c]
Dorset	11.5[cde]	2.48[de]	0.27[abc]	0.69[bcd]	27.8[b]
Composite	11.7[bcd]	2.54[bcd]	0.26[bcd]	0.71[bc]	27.4[b]

[abcdef]Means, within a column and slaughter endpoint, that do not share a common superscript letter differ significantly ($P < 0.05$). That is, for a given trait (column), if the means for any two breeds do not share a common superscript letter, then the probability that those two breeds differ for that trait is greater than 95%.

Table 4. Effects of breed of sire on marbling

Breed of sire	Ether-extractable intramuscular fat percentage	Marbling score
	--------------- Means adjusted to a constant slaughter age of 215 days ---------------	
Finnsheep	4.11[a]	572[ab]
Romanov	4.22[a]	583[a]
Dorper	3.87[ab]	564[ab]
Katahdin	3.91[ab]	543[bc]
Rambouillet	3.33[c]	497[d]
Suffolk	3.57[bc]	520[cd]
Texel	3.39[c]	523[cd]
Dorset	3.58[bc]	522[cd]
Composite	3.41[c]	496[d]
	----------- Means adjusted to a constant hot carcass weight of 65 pounds -----------	
Finnsheep	4.32[ab]	589[ab]
Romanov	4.39[a]	597[a]
Dorper	3.73[cd]	551[bc]
Katahdin	3.93[bc]	544[c]
Rambouillet	3.39[d]	503[d]
Suffolk	3.32[d]	500[d]
Texel	3.32[d]	518[cd]
Dorset	3.57[cd]	520[cd]
Composite	3.38[d]	494[d]

[abcd]Means, within a column and slaughter endpoint, that do not share a common superscript letter differ significantly ($P < 0.05$). That is, for a given trait (column), if the means for any two breeds do not share a common superscript letter, then the probability that those two breeds differ for that trait is greater than 95%.

Table 5. Effects of breed of sire on sensory traits

Breed of sire	Slice shear force, kg	Tenderness	Juiciness	Lamb flavor intensity	Off-flavor
	--------------- Means adjusted to a constant slaughter age of 215 days ---------------				
Finnsheep	19.9^{b}	5.93^{a}	5.57^{a}	4.79^{a}	4.51^{a}
Romanov	21.4^{ab}	5.82^{ab}	5.54^{ab}	4.90^{a}	4.57^{a}
Dorper	22.0^{ab}	5.65^{ab}	5.42^{c}	4.72^{a}	4.46^{a}
Katahdin	21.0^{ab}	5.73^{ab}	5.53^{ab}	4.88^{a}	4.55^{a}
Rambouillet	23.0^{ab}	5.71^{ab}	5.46^{bc}	4.73^{a}	4.47^{a}
Suffolk	25.0^{a}	5.52^{bc}	5.52^{ab}	4.66^{a}	4.35^{a}
Texel	22.1^{ab}	5.58^{bc}	5.46^{bc}	4.87^{a}	4.60^{a}
Dorset	23.6^{ab}	5.48^{bc}	5.48^{abc}	4.74^{a}	4.46^{a}
Composite	25.6^{a}	5.30^{c}	5.47^{bc}	4.72^{a}	4.39^{a}
	----------- Means adjusted to a constant hot carcass weight of 65 pounds -----------				
Finnsheep	19.3^{d}	5.91^{a}	5.56^{a}	4.75^{a}	4.47^{a}
Romanov	20.9^{cd}	5.80^{ab}	5.54^{ab}	4.86^{a}	4.54^{a}
Dorper	22.8^{abcd}	5.65^{ab}	5.42^{c}	4.74^{a}	4.48^{a}
Katahdin	21.1^{bcd}	5.72^{ab}	5.53^{ab}	4.87^{a}	4.54^{a}
Rambouillet	22.5^{abcd}	5.72^{ab}	5.46^{bc}	4.73^{a}	4.46^{a}
Suffolk	25.6^{ab}	5.56^{abc}	5.53^{ab}	4.72^{a}	4.40^{a}
Texel	22.0^{abcd}	5.60^{abc}	5.46^{bc}	4.89^{a}	4.61^{a}
Dorset	23.8^{abc}	5.47^{bc}	5.48^{abc}	4.73^{a}	4.46^{a}
Composite	25.7^{a}	5.30^{c}	5.47^{bc}	4.73^{a}	4.40^{a}

^{abcd}Means, within a column and slaughter endpoint, that do not share a common superscript letter differ significantly ($P < 0.05$). That is, for a given trait (column), if the means for any two breeds do not share a common superscript letter, then the probability that those two breeds differ for that trait is greater than 95%.