

YIELD AND QUALITY OF HOLSTEIN BEEF

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Introduction

Beef derived from Holstein steers is a significant source of the U.S. beef supply. The nation's 9.1 million dairy cows in 2003 were 22% of the U.S. cow herd (NASS, 2005). Given the typical breed distribution of dairy cows, calving interval, full-term pregnancy rate, peri-natal calf death loss (NAHMS, 2002), gender distribution, dairy beef placement (80%) and survival to market (94%), it can be estimated that 2.35 million Holstein steers are marketed annually. This population constitutes about 8.0-8.5% of the 28 million head (Cattle-Fax, 2005) of U.S. finished steer and heifer harvest. This estimate exceeds the frequency (5.7%) of Holsteins observed in the 2000 National Beef Quality Audit (McKenna et al., 2002). Given the distinctive Holstein coat color pattern and lack of crossbreeding in the dairy industry, Holstein genetics may be the largest recognizable single-breed source of beef in the U.S. Dairy cattle breeders have selected for milk production and milk components, and not meat yield or quality traits, so the resulting finished Holstein steer population has the potential to be relatively homogeneous in meat yield and quality if management and other environmental sources of variation are minimized. The purpose of this review is to highlight research of the past 25 years that describes Holstein steer meat yield and quality. Beef derived from Holstein cows culled from the dairy herd is also a significant source of beef in the U.S., but this source will not be addressed here.

Meat Yield

The carcass weight yield from live weight, or dressing percentage, for Holstein steers is typically less than that of beef-breed steers (Buege, 1988). Nour et al. (1983a) found small-frame Angus steers to yield 5.28 percentage units more carcass than Holstein steers at the same shrunk live weight. Factors that account for this reduced yield are increased proportion of gut (Nour et al., 1983b; Taylor and Murray, 1991), reduced muscling score (Kauffman et al., 1976), reduced subcutaneous fatness (Nour et al., 1983a), increased liver size, and increased proportion of intra-abdominal fat as mesenteric and omental fat (Taylor and Murray, 1991). Selection for high milk production and therefore high metabolic capacity in lactating Holsteins is considered to account for their maintenance energy requirement being 20% greater than beef breeds of *Bos taurus* cattle (NRC, 1996). Liver and digestive tract tissues are a major component of maintenance energy expenditures (Ferrell, 1988). Taylor and Murray (1991) considered liver proportion to be positively correlated with maintenance energy requirement, and liver and intra-abdominal fat proportions to be also positively related to 'lactability'. Liver weight as a percentage of live weight responds to energy intake in compensating Holstein steers (Renk, 1985). Hide as a fraction of body weight is less for dairy breeds (Taylor and Murray, 1991), which is a dressing percentage advantage for

Holsteins. Buege (1988) commented that Holstein steer hides are more valuable than beef breed hides because they are thinner, larger and not damaged by hot-iron branding. About 25% of native beef carcasses are branded (McKenna et al., 2002). Holsteins did not differ from Angus in 48-hr cooler shrinkage (Nour et al., 1983a).

It is noteworthy that Holsteins, when harvested in the range of 454 to 635 kg, are similar to other cattle breeds in their accumulation of 0.74 kg of hot carcass weight per kilogram of live shrunk weight (Nour et al., 1983a). This suggests that technologies applied in the late finishing phase to accelerate carcass weight gain should be as efficacious in Holsteins as in other breeds.

The gut fill of Holstein steers is more sensitive to diet composition than is true for Angus steers. Nour et al. (1983b) fed diets of either 10% or 93% corn silage to small-frame Angus or large-frame Holstein steers. Serial harvest of steers occurred at 363-544 kg for Angus and 454-635 kg for Holstein steers. Carcass primal cuts were obtained and trimmed to 1 cm of subcutaneous fat thickness. Weight of trimmed primal cuts at a given shrunk liveweight was not affected by diet for Angus steers. However, Holstein steers fed the low-silage diet yielded 6.73 kg more of trimmed primal cuts than high-silage Holstein steers when compared at a constant shrunk liveweight. The trimmed primal cut yield of low-silage Holstein steers was better than either Angus-diet combination, while the yield for the high-silage Holstein steers was less than for either Angus-diet combination.

A recent audit (McKenna et al., 2002) of the U. S. finished steer and heifer population details characteristics of Holstein steer carcasses currently produced in the industry. Compared to native, presumably crossbred, beef steers, Holsteins had a less desirable yield grade because of more carcass weight, substantially less longissimus muscle area and decidedly more kidney, pelvic and heart fat (Table 1). A Holstein steer attribute continues to be their lower adjusted subcutaneous fat thickness (McKenna et al., 2002). In an earlier summary of steers born in 1969 and 1970, Holstein steers were already reported to have less fat thickness and smaller longissimus muscle area than Angus and Herefords (Bertrand et al., 1983). Nour et al. (1983a) reported kidney, pelvic and heart fat percentage to be similar for Holstein and Angus steers in the carcass weight range of 250-350 kg, but at heavier weights there were apparently exponential increases in this fat depot compared to Angus steers. With regard to meat yield, Angus steers yielded primal cuts that possessed a larger amount of trimmable fat and slightly less bone. The net effect of these compositional differences was that Holstein carcasses yielded slightly more trimmed, boneless primal cuts than Angus at any given chilled carcass weight (Nour et al., 1983b). This advantage, though slight, for Holsteins in trimmed boneless primal cut yield prompts the view that it is dressing percentage differences rather than carcass compositional differences that account for most of the justifiable price discount applied to Holstein versus beef-breed steers on a liveweight basis, at least for liveweights that do not exceed 590 kg.

Thonney et al. (1984) investigated the relationship between yield of primal cuts and chilled carcass weight in small-frame Angus and large-frame Holstein steers. These

relationships may explain the surprising acceptance of very heavy (e.g., 725 kg) Holstein steers in the current market. When percentage of total trimmed primal cuts was regressed on carcass weight, Angus carcasses yielded progressively less primal cuts as carcass weight increased while the yield of Holstein primal cuts was less negatively affected. Upon closer examination, it was recognized that the percentages for Holstein trimmed chuck and rib did not decline as chilled carcass weight increased whereas Angus chuck, rib, loin and round and Holstein loin and round did decrease as expected. Thonney et al. (1984) explained these results on the basis of assumed differences in seam (i.e., intermuscular) fat deposition by Holsteins in the chuck and rib. So long as the chuck is marketed as a primal or its sub-primal components, this would be supportive to the pricing of heavy Holstein steers. On the other hand, dissection of the chuck to capture the advantages of tender muscles revealed by muscle profiling research (Kirchofer et al., 2002) could possibly result in seam fat trimming and hence loss of the seam fat contribution to chuck yield. This view should be tempered by realization that Thonney et al. (1984) studied small-frame Angus steers while the present-day Angus cattle are primarily medium in frame size.

When offered high-energy diets for long periods, Holstein steers will become excessively fat. Holstein steers raised from 4 mo of age and 160 kg on a high-corn diet to 18 mo of age and 635 kg possessed 0.9 cm for ribeye fat thickness (Schaefer et al., 1991). This result was similar to the ribeye fat thickness of 0.8 cm for Holstein steers harvested at 635 kg by the Cornell University group (Nour et al., 1981). However when Schaefer et al. (1991) continued to feed Holstein steers to 24 mo of age and 773 kg, subcutaneous fat thickness became 1.5 cm and the average USDA yield grade was 4.7. It is conceivable that weight at which high-grain diet feeding is initiated influences the partitioning of surplus dietary energy between subcutaneous (Comerford et al., 2001) and intermuscular adipose depots. Presumably, Holstein steers raised on lower energy diets to intermediate weights and then finished to heavy harvest weights on high-energy diets will convey the chuck yield advantage recognized by Thonney et al. (1984).

Holstein steers are often criticized in comparison to beef breed steers for having a low muscle:bone ratio. This criterion for breed evaluation was examined by Nour et al. (1981) who removed 9th-10th-11th rib sections from Angus and Holstein steers and dissected the sections into muscle, fat and bone. When muscle:bone ratio was regressed on rib section weight, the conclusion was that Angus had a superior ratio to that of Holsteins. Yet, when muscle weight was regressed on bone weight, there was no effect of breed. Curiously, when muscle weight was regressed on rib eye area, Holsteins had more muscle weight at a constant rib eye area. How can this be? The explanation apparently lies in recognition that the rib section from Holstein carcasses is longer than that from Angus carcasses (Nour et al., 1981). Since the longissimus, as a percentage of total muscle, does not differ among breeds (Berg and Butterfield, 1976), the rib eye area of Holsteins is smaller because the longissimus is longer. Furthermore, the regression of muscle weight on bone weight is a more reliable indicator of muscularity than is the regression of muscle:bone ratio on rib sub-primal weight. In the latter case, the dependent and independent variables both are influenced by muscle and bone weight.

Meat Quality

Dairy steers were reported to have higher quality grades than native beef breed cattle in the 2000 National Beef Quality Audit (McKenna et al., 2002; Table 1). Their quality grade advantage was due to higher marbling (i.e. intramuscular fat) scores. No cattle-type effect was noted for maturity as assessed by muscle color or skeletal ossification. Nour et al. (1983a) found that carcass weight accounted for 57% of the variation in marbling score in Holsteins. They described the relationship with a linear function that indicates marbling score increased by 2.9 units, for example from Small⁰⁰ to Moderate⁹⁰, for each 100 kg increase in carcass weight.

Beef quality grades are intended to be useful in sorting a heterogeneous population of beef carcasses into homogeneous groupings on the basis of palatability. Since most Holstein steers are harvested before the age of 30 months, marbling score is a primary determinant of USDA quality grade in commercial Holstein steer production. Strategies for enhancement of marbling scores in Holstein steers have been fruitless. In other breeds and presumably in Holsteins, the heritability of marbling is high ($h^2=0.68$, Dikeman et al., 2005; $h^2=0.35$, Splan et al., 2002) so selection for this trait would result in progress. However due to the absence of selection pressure for marbling in the Holstein breed, genetic progress has not been realized. Instead, efforts have focused on preservation of marbling score while attempting to improve rate or efficiency of weight gain by means of accelerating muscle growth.

Numerous evaluations of Holstein beef palatability have occurred, perhaps prompted by skepticism over derivation of this beef from a dairy breed. Schaefer et al. (1986) finished Holstein and Charolais-crossbred steers to 500 kg on a common high-corn:corn silage diet and then compared taste panel acceptability of longissimus steaks derived from Select and Choice Holstein carcasses with Choice crossbred steer steaks. There were no significant differences among any of the treatments for juiciness, tenderness, flavor, overall acceptability or Warner-Bratzler shear force (Table 2). Armbruster et al. (1983) compared the sensory attributes of Angus and Holstein longissimus obtained from rib roasts cooked to an internal temperature of 68 C. Samples from the Holstein muscle were less tender and required more chews pre-swallowing than Angus samples, but the practical significance of these differences is questionable. In Holsteins, marbling was correlated ($r=0.71$) with intramuscular ether extract percentage, but marbling was not correlated with taste panel tenderness. Taste panel juiciness was not affected by breed. From Slight to Slightly Abundant degrees of marbling, flavor of Holstein beef was rated more highly than for Angus beef. In a follow-up study by the same research group, longissimus steaks from Holstein and Simmental x Angus steers were compared (Thonney et al., 1991). In this experiment, all steers were harvested when they achieved the Small degree of marbling and were less than 16 mo of age. Holstein steaks were judged to be superior to the Simmental x Angus steaks in tenderness, pre-swallowing number of chews, flavor and overall acceptability. Holstein longissimus had higher palmitoleic and linoleic, and lower stearic acid concentrations than Angus x

Charolais x Simmental steers, but these differences were not manifested in differences in sensory evaluation (Mills et al., 1992).

Diet composition and nutritional management have not been shown to affect sensory characteristics of Holstein beef. Low (10%) or high (93%) corn silage diets did not affect tenderness, chew test, juiciness, or flavor (Armbruster et al., 1983). Likewise, finishing diets containing 20% corn silage or alfalfa haylage, or fish meal or soybean meal in the growing phase diets, did not affect sensory evaluation of rib eye steaks (Mills et al., 1992). Neither wet or dry distiller's grains affected shear force or taste panel sensory evaluation (Roerber et al., 2005). Sinclair et al. (2001) hypothesized that pre-harvest growth rate affects ante- and post-mortem muscle proteolysis which could influence meat tenderness. They fed moderate- or high-energy diets for 20 wks pre-harvest to Holstein steers to achieve moderate or rapid growth rates. Rapid ante-mortem growth was hypothesized to result in faster post-mortem muscle proteolysis and thereby enhanced meat tenderness. Their dietary treatments affected growth rate as expected, but no effect on tenderness as assessed by taste panelists or instrument was detected.

Anabolic implants have been shown to accelerate growth rate in Holstein steers, yet concern for adverse effects on carcass quality grade and meat palatability has arisen. Apple et al. (1991) applied five implant regimens to assess effects on growth as well as longissimus palatability. The most potent regimen was a combination of trenbolone acetate, estradiol benzoate and progesterone. This combination resulted in the greatest increase in growth rate, carcass weight, longissimus muscle area, and skeletal maturity. However, this regimen also resulted in the lowest percentage of Choice carcasses. While reductions in meat tenderness were anticipated, implant regimens did not affect taste panel tenderness ratings or shear force values. More recently, Scheffler et al. (2003) employed a moderately potent implant regimen, involving trenbolone acetate plus estradiol, in Holstein steers. Administration of this combination implant at d 0, d 112 and d 224 resulted in advanced skeletal maturity and elevated Warner-Bratzler shear force value. Two of 31 samples from this treatment had shear force values of greater than 5 kg, which exceed the consumer acceptability threshold of 4.5 kg (Shackelford et al., 1991). When this implant was administered only once or twice to Holstein steers, beef tenderness was not different from unimplanted controls. In general, evidence suggests that concern for tenderness should only arise when the most potent implants are introduced repeatedly, and even then effects on meat tenderness are not consistent or alarming.

Holstein beef has been criticized at times because the shape of the ribeye is elongated, relative to a similar 12th-13th rib longissimus cross-section from beef-breed steers. Thonney et al. (1991) placed ribeye steaks from Holstein or crossbred beef steers in front of 55 supermarket meat case managers. The managers correctly identified the breed of each steak only 50.9% of steaks, which is not different from their 50% chance of correct identification. Given the growing lack of familiarity with meat animals by U.S. consumers and probably meat case managers, it is unlikely that these individuals have a preferred ribeye shape or could associate Holstein breeding with a specific ribeye shape.

Likewise, Holstein beef has been discounted at times for having a less desirable color than beef steaks from native beef steers. Pertinent research is scant on this topic. Comerford et al. (1992) collected but did not do a statistical comparison of lean color scores obtained from Holstein and crossbred beef steers, yet the Holstein score indicates a slightly darker red longissimus muscle. Arnold et al. (1993) monitored discoloration of longissimus and gluteus medius muscles displayed under simulated retail display conditions. There was no difference in metmyoglobin accumulation between muscles from Holstein or crossbred beef steers. Furthermore, both muscles from both breed types responded to dietary vitamin E supplementation which delayed the onset of discoloration in these muscles.

Lastly, there is concern for injection site blemishes in Holstein beef. Holstein calves are raised using methods that are distinctly different from those used with non-dairy calves. Less frequent provision of colostrum to bull calves, dependence on milk replacer, and more environmental stressors due to year-around calving and confinement housing conspire to compromise the health of more Holstein calves than beef calves (NAHMS, 1997). With higher morbidity occurring during rearing, Holstein calves are more likely to receive injectable medicines. This may account for a 14% frequency of injection site lesions in the inside round of Holstein steers (P. VanderVest, personal communication). Additional research is needed to assess this issue and, if confirmed, to design health management strategies to mitigate this meat quality loss.

Summary

Holstein steers constitute approximately 8% of fed cattle harvested in the U.S. As such, this breed may constitute the largest pool of straightbred steers in the fed cattle population. Given the relative homogeneity which accompanies a single purebred population, the attributes and deficiencies of Holstein steers are predictable. While dressing percentage is a deficiency, trimmed boneless meat yield from carcasses and primals is an attribute. Quality of Holstein beef, in terms of palatability characteristics, is not different from beef derived from beef breed steers of comparable age and gross composition. Sensory characteristics of Holstein beef are resilient to a wide range of dietary and management factors. If modifications in beef quality characteristics were desired, the most fruitful approach appears to be genetic selection.

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Table 1. Means for carcass traits (SEM^a) within visually-appraised breed types (McKenna et al., 2002).

Trait	Breed type	
	Native ^b	Dairy ^c
USDA yield grade	3.0 ^g (0.01)	3.4 ^h (0.03)
Adjusted fat thickness, cm	1.3 ^h (0.01)	0.8 ^g (0.02)
Hot carcass weight, kg	357 ^g (0.46)	364 ^h (1.67)
Longissimus muscle area, cm ²	85.2 ^h (0.13)	75.7 ^g (0.39)
Kidney, pelvic and heart fat, %	2.3 ^g (0.01)	3.6 ^h (0.03)
USDA quality grade ^d	684 ^g (0.7)	710 ^h (2.4)
Marbling score ^e	419 ^g (1.1)	489 ^h (3.9)
Lean maturity ^f	164 (0.2)	166 (0.8)
Skeletal maturity ^f	167 (0.3)	168 (1.2)
Overall maturity ^f	166 (0.3)	168 (0.9)

^a Standard error of the least squares means.

^b Estimated number of observations is 8466.

^c Estimated number of observations is 648.

^d 600 = Select⁰⁰ and 700 = Choice⁰⁰.

^e 400 = Small⁰⁰ and 500 = Modest⁰⁰.

^f 100 = A⁰⁰ and 200 = B⁰⁰.

^{g,h} Means within a row lacking a common superscript differ (P<0.05).

Table 2. Taste panel evaluation of loin steaks aged seven days at 4 C (Schaefer et al., 1986).

Item	Breed and USDA Quality Grade		
	Holstein Select	Holstein Choice	Charolais cross-bred Choice
Loins, n	24	22	23
Juiciness ^a	5.0	5.3	5.2
Tenderness ^b	5.5	5.9	5.8
Flavor ^c	5.8	5.9	5.7
Overall ^c	5.5	5.8	5.7
Shear force, kg	3.6	3.4	3.6

^a 5 = slightly juicy, on a scale of 1-8

^b 5 = slightly tender, on a scale of 1-8

^c 5 = like slightly, on a scale of 1-8