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Potential for Small-Scale Farmers to Produce Niche Market Pork Using Alternative Diets, Breeds and Rearing Environments: Observations from North Carolina

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Abstract. With the extensive focus on lean conformation in the finished hog over the last twenty-five years, there is some indication that pork quality has suffered and taste has been bred out of today's pork. Similar to the Certified Angus Beef program (a breed noted for intra-muscular fat) small-scale farmers can promote a different "upscale" pork by using breeds that will focus on pork taste exclusively and feeding diets (possibly apart from corn and soybeans) to enhance flavor. Two experiments were devised to examine the influence of breed, rearing environment and diet on fresh pork quality and flavor. In Trial 1, three sow breed groups (Tamworth, Tamworth x Landrace, or Hampshire x Landrace) were mated to Duroc boars. Littermates (ninety-one pigs total) were randomly assigned at weaning to one of three treatments: 1) confinement, 2) dry-lot, 3) pasture. All pigs were ad-libitum fed a 16% CP grow-finish ration. Pasture pigs were allowed access to plots consisting of predominately white and crimson clovers with warm season grasses (Bermuda grass and crab grass). Hampshire crosses had higher Minolta L scores indicating a paler, less desirable loin. Pork quality was similar across rearing environments except for lower initial pH levels observed in the pasture system and higher drip-loss % recorded in both outdoor systems. In Trial 2, 42 Tamworth x Duroc littermates were randomly assigned to one of two rearing environments (confinement or pasture) at 55 kg and ad-libitum fed a 14% CP diet. Pigs finishing on pasture had access to standing, mature barley. Pork from the pasture system was darker than that from pigs reared in confinement. No differences were observed in sensory evaluation of the pork for the rearing environments examined. For both trials, intramuscular fat levels (< 2%) and* *visual color scores were too low to be considered for "upscale" markets. Alternative diets to produce niche-market pork are unlikely to influence flavor with out adequate levels of marbling.*

Keywords: pork quality, alternative hog systems, sustainable agriculture, niche markets.

Introduction:

"The Other Red Meat": A Different Pork Paradigm for Small Scale Hog Producers. Americans often take pride in the fact that we feed our country (and others) with less than 1.7% of our population. Land Grant Universities have helped realize this impressive goal by encouraging technologies for large-scale intensive farming systems. These systems are typically characterized by: 1) monoculture production requiring high consumption of fossil fuels, 2) and profiting from small margins gained through economies of scale. Consequently, we forget the importance of how diversified, small-scale integrated crop and animal systems have contributed to the net farm income for generations of small-scale farmers. In less than one generation (25 yrs) NC has lost over 20,000 small-scale hog farmers (<100 hogs) and with it, their knowledge base. Small-scale producers have been gradually squeezed out of the pork industry due to the overwhelming success of the vertically integrated corporate model. The importance associated with the loss of this resource may become even more pronounced as we face Homeland Security issues to insure National Food Security.

The pork industry, land grant universities and research stations have done an excellent job in developing and promoting animal efficiency and productivity by optimizing the housing environment and identifying diets and breeds of hogs to suit confinement rearing. As a result the method of raising hogs has changed dramatically over the last forty years, as well as the focus on *lean* conformation of the finished hog. As a consequence, there is some indication that the taste has been bred out of today's hog. In a gourmet publication, <u>The Art of Eating</u> , Ed Behr (1999) suggests that "the lean (corporate pork) meat is almost impossible to cook without making it dry and tough; the flavor is bland, so the texture stands out". Similar to the Certified Angus Beef program (a breed noted for intra-muscular fat) small farmers can promote a different "upscale" pork by using breeds that will focus on pork taste exclusively and feeding diets (possibly apart from corn and soybeans) to enhance flavor. Tamworths are a rare breed and were considered for this experiment because they are noted for their foraging ability; they also have excellent maternal ability for application in extensive rearing systems (Porter, 1993). Durocs were selected for use as terminal cross sires and are recognized for high intramuscular fat (IMF) levels which are considered important for producing “upscale pork” for the Japanese markets (Suzuki et al., 2003).

Enhancing pork flavor through diet, genetics and the environment raised: Smithfield Foods gained its original reputation by producing hams from hogs which gleaned residual peanuts from harvested fields. Melton's (1990) extensive review on the influence of diet on red meat flavor, suggests the wide possibilities dorsi (Lonergan et al., 2001). A more striking observation is the consistent effect of selection for lean growth efficiency on the ability of fresh pork to hold water. Percentage drip loss was significantly increased in the selection line over the control in the longissimus dorsi, semimembranosus and semitendinosus. It is likely that this effect is a direct result of selection line difference in postmortem pH decline and lactate production by 15 min postmortem (Lonergan et al., 2001). For the last 15 years, NC farmers have focused on lean conformation in their market hogs to attract premium prices.

Small-scale producers may be able to secure a place at the pork industry table by producing a different type of pork than the "the other white meat". By selecting for pork with higher levels of IMF, darker color and optimum pH levels, hog producers may be able to survive by marketing "the other red meat" through niche markets. Furthermore, there are opportunities for producer groups to align themselves with those consumers who require that their meat be produced in alternative systems (McGlone, 2001). All animal confinement operations are currently under close public and government scrutiny regarding issues related to animal well being and sub-therapeutic feeding of antibiotics. The number one buyer of US Pork is the McDonalds Corp. Similar to the company's stand on "forced molting" in poultry, McDonalds is considering the Animal Welfare Institute's position on sows raised in confinement crates.

Materials and Methods

Two experiments were devised to examine the influence of breed, rearing environment and diet on pork quality and flavor. In *Trial one,* three breed groups of sows, Tamworth (T), Tamworth x Landrace (TL), and Hampshire x Landrace (HL) were mated by natural service with Duroc (D) boars at the North Carolina Agricultural and Technical State University Swine Research Unit. The HL sows were raised in confinement and the T and TL sows were raised in outdoor dry-lots and wooded plots; the boars used were raised in the respective environments as the sows. Six littermates from sows farrowing during March 3^{rd} to March 27^{th} 2001 were randomly assigned at weaning to one of three treatments: 1) confinement, 2) dry-lot, 3) pasture. Six or seven sows represented each sow breed group. At weaning (30 days), pigs were moved to their respective nurseries (indoor or out-door treatment groups) until approximately seventy days of age. Out-door treatment pigs were then moved to an electric fence training lot until 110 days of age and transferred to their designated rearing environment. Ten pigs were randomly assigned to one of three pens or plots: confinement (2.4m x 4.7m), dirt-lots (15m x 30m) and pasture (70m x 70m). Each pasture plot was further divided by electric fence into six sections to allow for rotational grazing. All pigs were *ad-libitum* fed a 16% CP grow-finish ration with pasture pigs allowed access to plots (Figure 1.) consisting of predominately white and crimson clovers with warm season grasses, predominately Bermuda and crab grass (average crude protein 18%). Outdoor pigs were moved to confinement pens the night prior to shipment to facilitate truck loading.

Pigs were rested a minimum of six hours at the packing plant and slaughtered by electrical stunning. Initial pH (NWK Binar; Landeberg, Germany) and hot carcass weights were collected immediately after slaughter. Twenty-four hours post mortem carcasses were fabricated into primal cuts and the right loin from each pig was collected. One chop was collected from each loin at a location between the 10th and 11th ribs and allowed to bloom for 20 minutes. Each loin chop was scored visually for color, using a scale from 1 (pale) to 6 (very dark)and intra-muscular fat, using a scale from 1 (devoid) to 10 (abundant)by trained personnel according to National Pork Board standards (NPPC, 2000). Fat depth was measured using a steel ruler at a point ¾ of the distance along the loin muscle and loin muscle area was determined using a plastic grid (AS-235e, Iowa State University, Ames) placed on the cross-sectional surface. Ultimate pH was measured at 24 h post-mortem using a NWK Binar pH meter(Landeberg, Germany). A Minolta Chromameter model CR-200 (Minolta U.S.A., Ramsey, N.J.) was also used to determine color instrumentally (Commission Internationale de l'Eclairage (CIE) L* (muscle lightness) a* (muscle redness) and b* (muscle yellowness). The chromameter was set to D65 illuminant, using a 0° viewing angle, an 8 mm diameter viewing area and was calibrated with a white standard color plate. Color measurements were averaged across three different areas of the loin muscle for each chop. Fluid loss was measured using filter paper (S & S Filter Paper, Keene, N.H.) and percent drip loss was calculated using methods proposed by Kauffman et al. (1986). For this method a pre-weighed filter paper disc is placed on the cut surface of the loin for ten seconds and then re-weighed. Fluid loss is the difference calculated by subtracting the dry weight of the filter paper from the wet weight.

Data was analyzed by the General Linear Models procedure of SAS (SAS Institute, 1994) using a 3 x 3 Factorial Design. The statistical model included breed group and rearing environment as fixed effects; non-significant interactions were removed from the final model. The interaction of plot x rearing environment was used as the error term to determine differences in rearing environment. Age at slaughter was used as a covariate for models examining differences in IMF due to rearing environments. Differences among rearing environments and breed group means were considered significantly different at $P < 0.05$.

Methodology for a subsequent experiment (*Trial 2*) was similar to trial one except that T x D pigs (born November 10th to November 26th 2002) were used exclusively, a 14% CP ration was fed *ad-libitum*, and only two rearing environments were considered, pasture and confinement. At 130 d, pigs were moved from dirt lots to the experimental pasture plots (Figure 2.) containing standing mature barley (average crude protein 11%). Pigs were slaughtered on July 15, 2002. Pork quality data were collected as described for Trial 1. In addition, sensory evaluation data was collected for Trial 2, the loin chops were stored at 4°C for 2 days and subsequently cooked on a grill to an internal temperature of 71° C. Each chop was cut into 1.3 x 1.3 x 2.5-cm pieces for sensory evaluation and served warm at two locations: 1) to students and faculty (n = 30) at the A&T Student Union on July 18, 2002, and 2) participants (n = 55) in a Field Day at the University Farm on July 18, 2002. Participants scored each chop for juiciness, color tenderness and flavor on a 1 (dislike extremely) to 9 (like extremely) scale. Participants also scored each chop for off-flavors with 1 = off-flavor and 0 = no off-flavor. An overall rank was determined based on the four primary sensory attributes.

Data were analyzed by the General Linear Models procedure of SAS (SAS Institute, 1994) using a Complete Randomized Design with animal as the experimental unit. The statistical model for pork quality analysis included the fixed effect of rearing environment; final weight was also included as a covariate for the models examining differences in intra-muscular fat. Differences among treatment means were determined using the student's *t* test and considered significantly different when $P<0.05$. A similar model was used for pork sensory analysis however, location (farm or student union) of test was included. Mean differences in pork sensory evaluation due to rearing environment were detected using ANOVA after adjusting for location tested.

Results and Discussion

There were no differences in growth rate for breed groups represented; loin-eye areas were larger in Tamworth crosses than Hampshire crosses (Table 1.1). Except for Minolta L* scores, pork quality was similar across the breed groups tested (Table 1.1). Crosses with Hampshire had lighter pork (Minolta L*; $P < 0.05$) than those with Tamworth. This result agrees with previous studies (Hamilton et al., 2000; Moeller et al., 2003) reporting paler pork from Hampshire sired pig that carried a mutation for the Rendement Napole (RN^-) allele. Although these animals were not genotyped for the RN^- gene it is prevalent at a high frequency in swine of Hampshire descent (LeRoy et al, 1999).

All pork quality measures were lower than anticipated, even though Durocs were used as terminal line sires suggesting that the individual boars used had poor transmitting ability for improving carcass quality. All breed groups represented, had pork loins that scored below 2% marbling and 3 for visual color scores. These scores are typical of the "other white meat" in the grocery meat case but not suitable for the Japanese or upscale markets.

Pigs reared outside grew 50% faster ($P < 0.05$) than confinement raised pigs (Table 1.2). Hogs reared on rotated sections in pasture (22% CP) grew faster (0.97 kg/d) than those raised in confinement (0.64 kg /d). Except for initial pH and water holding capacity, pork loin characteristics were similar across rearing environments. Initial pH was lower ($P < 0.05$) in pasture raised pigs than for those kept in confinement or dirt lots. Similar to the findings of Wariss et al. (1983) and Enfalt et al. (1997), water-holding capacity for outdoor rearing environments was lower than for pigs reared indoors. One possibility for the observations in our study may have been due to stress caused by moving the outdoor animals into confinement the night before slaughter to facilitate early morning truck loading. In Trial 2, hogs were loaded directly from their rearing environments and differences in these traits were not observed (Table 2.1). However, studies that compare indoor with outdoor systems are often inconsistent due to variation in climate across seasons and years (Gentry, 2001).

In Trial 2, pork assessment of TxD pigs was similar across rearing environments except that outdoor reared pigs had darker pork color (visual and instrumental readings) than confinement pigs (Table 2.1). Darker pork colors did not translate into pork with more flavor, juiciness or tenderness by the sensory evaluation (Table 2.2). There was no indication that the sensory judges could identify (favorably or unfavorably) differences in eating quality of those pigs that were raised outside. The lower crude protein ration fed in trial 2 (14% compared to a 16% in trial 1), may have contributed to older hogs at market (260 d in trial 2 vs. 200 d in trial 1) but did not influence IMF levels across rearing environments. With minimal levels of intra-muscular fat in the outdoor hogs (< 2%), it is unlikely that even subtle differences in flavor would be detected in the diet supplemented with barley. van der Wal reported similar findings when comparing eating quality assessment of outdoor vs. indoor raised pigs.

Conclusions and Observations:

Similar to the majority of market hogs, IMF levels (< 2%) and color scores (< 3) from the pork produced in this experiment (regardless of breed or rearing environment) were too low to be considered optimum for "upscale" markets. It is clear from the results of this experiment, small-scale farmers need to consider using boars with proven abilities for enhancing pork quality and not base their decisions on breed characteristics alone.

Additional research is needed to understand the effects of alternative feedstuffs on pork flavor. Farmers who have orchards may be able to produce *"Porque de Seasons"* by using finishing hogs to glean fallen cherries in the spring, peaches in the summer, and apples or acorns in the fall. Iberian Hams command five times the price of hams produced from conventionally (European breeds bred for confinement) raised hogs, due to the unique flavor acquired when Iberian hogs glean the acorns from under the cork trees. Farmers with excess produce i.e. pumpkins, goat whey, garlic, rosemary, sage, etc., may be able to produce unique flavors in the pork which are also unique to their farm and local niche markets. However, alternative diets to produce niche-market pork are unlikely to influence flavor without adequate levels of IMF. It is likely that the niche market farmer needs to examine genetic lines of Duroc or Berkshire boars that have not been selected for lean gain.

Many people refer to pastured pigs as "old timey" farming, straight out of the folklore book, Fox Fire (Wigginton, 1968). A better term (that farmers understand) might be profitable farming, especially if farmers can produce a unique product that stands out from commodity pork. Books that document folklore and pre-confinement practices i.e. Morrison's Feeds and Feeding (1949) provide insight into production and marketing opportunities which were once common place.

With funding assistance from USDA SARE, The Golden LEAF Foundation and Heifer Project International, The NC A&T Small-Scale Hog Producer project assists farmers in finding new markets and higher profit margins by raising swine in alternative systems that enhance the flavor of pork (diet, genetics and management practices) as well as the environment they are raised in. Current research focus is in developing protocols to test and identify breeds and breed combinations noted for enhancing IMF and as well as other traits that effect pork quality and flavor.

REFERENCES:

1. Behr, E. 1999; "The Lost Taste of Pork: Finding a Place for the Iowa Family Farm"; The Art of Eating. vol 51.

2. De Vol, D.L., F.K. McKeith, P.J. Bechtel, J. Novakoski, R.D. Shanks, T.R. Carr. 1988. Variation in composition and palatability traits and relationships between muscle characteristics and palatability in a random sample of pork carcasses. Journal of Animal Science. 69 (12):4858-4865.

3. Enfält, A. C., K. Lundstrom, I. Hansson, N. Lundheim and P.E. Nystrom. 1997. Effects of outdoor rearing and sire breed (Duroc or Yorkshire) on carcass composition and sensory and technological meat quality. Meat Science. 45:1-15.

4. Field, R.A., J.C. Williams, C.L. Ferrell, J.D. Crouse and J.E. Kunsman. 1978. Dietary alteration of palatability and fatty acids in meat from light and heavy weight ram lambs. Journal of Animal Science. 47:858.

5. Gentry, J.G. 2001. Alternative and outdoor housing systems for pigs: effects on growth, meat quality, and muscle characteristics. Ph. D. Thesis. Texas Tech. Univ. Lubbock, TX.

6. Hamilton, D. N., M. Ellis, K. D. Miller, F. K. McKeith, and D. F. Parrett. 2000. The effect of the Halothane and Rendement Napole genes on carcass and meat quality characteristics of pigs. Journal of Animal Science. 78:2862-2867.

7. Kauffman, R. G., G. Eikelenboom, P. G. van der Wal. 1986. A comparison of methods to estimate water-holding capacity in post-rigor porcine muscle. Meat Science. 18:307-322.

8. LeRoy, P., C. Moreno, J. M. Elsen, J. C. Caritez, Y. Billon, H. Lagant, A. Talmant, P. Vernin, Y. Amigues, P. Sellier, and G. Monin. 1999. Interactive effects of the HAL and RN major genes on carcass quality traits in pigs: preliminary results. In: Quality of meat and fat in pigs as affected by genetics and nutrition. EAAP. Zuric, Switzerland. 100:139-142.

9. Lonergan, S. M., E. Huff-Lonergan, L. J. Rowe, D. L. Kuhlers, and S. J. Aungst. 2001. Selection for lean growth efficiency in Duroc pigs influences pork quality. Journal of Animal Science. 79:2075-2085.

10. McGlone, J.J. 2001. Farm animal welfare in context of other society issues: toward sustainable systems. Livestock Production Science. 72:75-81.

11. Melton, S. 1990. Effects of feeds on flavor of red meat: A Review. Journal of Animal Science. 68:4421-4435.

12. Moeller, S. J., T. J. Baas, T. D. Leeds, R. S. Emnett, and K. M Irvin. 2003. Rendement Napole gene effects and a comparison of glycolytic potential and DNA genotyping for classification of Rendement Napole status in Hampshire-sired pigs. Journal of Animal Science. 81:402-410.

13. Morrison, F. B. 1949. Feeds and Feeding: A Handbook for the Student and Stockman. 21st ed. The Morrison Publishing Co. Ithaca, NY.

14. NPPC. 2000. Pork Quality Standards. National Pork Producers Council, Des Moines, IA.

15. NPPC. 1999a. Marbling and Tenderness. Ed. By L. E. Jeremiah. NPPC Fact sheet #NPB- 04310. Des Moines IA.

16. NPPC. 1999b. The Impact of Genetics on Pork Quality. Ed. by T. Baas and J. Mabry. Des Moines, IA.

17. Porter, V. 1993. <u>Pigs: A handbook to the breeds of the world</u>. Comstock Pub. Assoc. Ithaca, NY.

18. SAS Institute Inc. 1994. SAS/STAT User's Guide: Version 6. (4th edition) Sas Institute Inc., Cary North Carolina.

19. Suzuki, K., T. Shibita, H. Kadowaki, H. Abe and T. Toyoshima. 2003. Meat quality comparison of Berkshire, Duroc and crossbred pigs sired by Berkshire and Duroc. Meat Science. 64:35-42.

20. van der Wal, P.G. 1991. Free range pigs: carcass characteristics and meat quality. In: Proc. 35th International Congress Of Meat Science and Technology. August 20-25, Copenhagen, Denmark. P 202-205.

21. Wasserman, A.E., and A.M. Spinelli. 1972. Effect of some water-soluable components on aroma of heated adipose tissue. Journal of Agricultural Food Chemistry. 20:171.

22. Warriss, P.D., S.C. Kestin and J.M. Robinson. 1983. A note on the influence of rearing environment on meat quality in pigs. Meat Science 9:271-279.

23. Wigginton, Eliot. 1968. *The Foxfire Book*. Anchor Press, Garden City, NY.

Table 1.1 Breed group production and carcass characteristics adjusted for hogs raised in three rearing environments

Measure	(H x L) x D	(L x T) x D	T x D	SEM	*P Value*
1-hr pH[1]	5.98	6.07	6.04	0.05	0.4509
24-hr pH[1]	5.43	5.48	5.43	0.110	0.9021
% drip-loss	6.08	5.01	4.60	0.62	0.1666
% marbling[3]	1.76	1.93	1.92	0.191	0.7375
Minolta L*[4]	56.27[a]	53.16[b]	53.90[b]	1.05	0.0424
Minolta a*[4]	7.81	7.38	7.95	0.34	0.2688
Minolta b*[4]	6.62	5.89	6.53	0.39	0.1170
Visual color[2]	2.29	2.73	2.67	0.246	0.3296
Finish Wt. kg	99.22[a]	106.05[b]	110.34[b]	6.13	0.0057
ADG, kg/d	1.76	1.77	1.75	0.06	0.9070
LEA, cm^2	38.90[a]	42.77[b]	44.32[b]	1.41	0.0054

[1]pH was measured between the 9th and 10th ribs in the longissimus muscle.
[2]Marbling scores range from 1 (deoid) to10 (abundant).
[3]Values were measured on the longissimus muscle at the 10th rib.
[4]Color scores range from 1 to 6, 1 = pale, pinkish gray and 6 = dark, purplish-red.
Means in same row with unlike superscripts [ab] are different (*P* < *0.05*).

Table 1.2 Adjusted production and carcass means for hogs reared in three environments.

Measure	Pasture	Indoor	Dry-Lot	SEM	*P Value*
1-hr pH[1]	5.90[a]	6.07[b]	6.11[b]	0.05	0.0423
24-hr pH[1]	5.30	5.54	5.50	0.103	0.2697
% drip-loss	6.27[b]	3.81[a]	5.61[b]	0.54	0.0041
% marbling[3]	1.71	2.03	1.86	0.175	0.5164
Minolta L*[4]	56.03	52.42	54.84	0.88	0.1367
Minolta a*[4]	8.09	7.16	7.76	0.29	0.1970
Minolta b*[4]	7.14	5.50	6.41	0.33	0.1500
Visual Color[2]	2.19	2.99	2.52	0.225	0.3430
Finish Wt. kg	108.45	103.93	103.24	5.82	0.5524
ADG, kg/d	2.13[b]	1.41[a]	1.74[a]	0.51	0.0469
LEA, cm^2	41.22	43.42	41.35	1.35	0.5893

[1]pH was measured at the 9th and 10th rib on the longissimus muscle.
[2]Marbling scores range from 1-10, 1 = devoid and 10 = abundant.
[3]Values were measured on the longissimus muscle at the 10th rib.
[4]Color scores range from 1 to 6, 1 = pale, pinkish gray and 6 = dark, purplish-red.
Means in same row with unlike superscripts [ab] are different ($P < 0.05$).

Table 2.1 Production and carcass means for Tamworth x Duroc crosses raised in confinement or pasture lots containing standing barley.

Measure	Pasture	Indoor	SEM	*P Value*
1-hr pH[1]	6.09	6.01	0.09	0.5073
24-hr pH[1]	5.62	5.64	0.024	0.6128
% drip-loss	2.05	2.09	0.23	0.8944
% marbling[3]	1.96	2.10	0.13	0.5016
Back-Fat	25.40	26.81	1.42	0.4323
Minolta L*[4]	50.78[b]	52.79[a]	0.782	0.0734
Minolta a*[4]	9.70[b]	10.93[a]	0.334	0.0124
Minolta b*[4]	5.14[b]	6.27[a]	0.291	0.0086
Visual Color[2]	3.71[a]	2.94[b]	0.201	0.0088
Finish Wt. kg	113.13	110.86	3.08	0.6058
ADG, kg	0.81	0.75	0.04	0.2829
LEA, cm^2	41.22	43.42	1.35	0.1495

[1]pH was measured at the 9^{th} and 10^{th} rib on the longissimus muscle.
[2]Marbling scores range from 1-10, 1 = devoid and 10 = abundant .
[3]Values were measured on the longissimus muscle at the 10^{th} rib.
[4]Color scores range from 1 to 6, 1 = pale, pinkish gray and 6 = dark, purplish-red.
Means in same row with unlike superscripts [ab] are different ($P < 0.05$).

Table 2.2 Sensory attributes of pork from Tamworth x Duroc hogs raised in confinement or pasture lots containing standing barley.

Measure	Pasture	Indoor	SEM	*P Value*
Juciness[1]	6.14	6.05	0.219	0.7570
Color[1]	6.50	6.39	0.189	0.6708
Tenderness[1]	6.17	6.49	0.199	0.3127
Flavor[1]	6.59	6.23	0.21	0.2154
Overall Rank	6.49	6.58	0.199	0.7348
Off Flavor[2]	0.15	0.09	0.039	0.3783

[1]Sensory panel scores for juiciness, color, tenderness, flavor and overall rank range from 1 to 9 with 1 = dislike extremely, dislike very much, dislike moderately, dislike slightly, neither like nor dislike, like slightly, like moderately, like very much and 9 = like extremely.
[2]Scores for off-flavor are 1 = off-flavor and 0 = no off-flavor

Figure 1. July 20, 2001. Pigs grazing clover grass mix plots. NC A&T Alternative Swine Systems Research Unit. Chuck Talbott.

Figure 2. Pigs "hogging down" plots with standing mixed barley. June 20, 2002. NC A&T Alternative Swine Systems Research Unit. Chuck Talbott.