Livestock Research

Alternative Swine Rations

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In a Nutshell

- Grass- or forage-finished meat is gaining in popularity for perceived environmental and health benefits.
- Cooperator John Arbuckle designed a trial to test whether hogs could be finished solely with forage and other non-concentrate feeds.
- The experimental group received a widely-varied diet of forages, household leftovers, overripe vegetables, weeds and dairy.
- Experimental hog carcasses were lighter than control carcasses. but meat quality did not differ.
- Concentration of three individual saturated fatty acids were greater in experimental than control diets.
- Experimental hogs, despite lighter carcass weights, were cheaper to raise to that weight.

Project Timeline:

April – November 2013

Background

Grass- or forage-finished meat is gaining in popularity for perceived environmental and health benefits (Edwards 2005). Beef research has found improved fatty acid profile in grass-fed beef (Daley et al. 2010), including fewer cholesterol-increasing saturated fatty acids and more conjugated linoleic acids. Because of their monogastric digestive system, there is an upper limit of forage utilization by hogs (Wheaton and Rea 1993), but forage inclusion in the diet can reduce concentrate consumption by supplying protein and vitamins (Bowden and Clarke 1963; Wheaton and Rea 1993). Trials using various forms and inclusion rates of forage in swine diets have generally found slower, but leaner, gain (Bowden and Clarke 1963; Danielsen et al. 1999). Quality is a concern with grass-finished meat; grass-fed beef is leaner and has a different taste profile due to the lower fat content and different fatty acid profile (Daley et al. 2010), and pigs fed a low-concentrate diet produced less tender, more acid meat (Danielsen et al. 1999). Cooperator John Arbuckle designed a trial to test whether hogs could be finished solely with forage and other non-concentrate feeds, and how these hogs would differ in performance and carcass quality from hogs raised with some concentrate.

Materials and Methods

John purchased 15 young pigs for the trial (average weight 30.5 ± 2 lb) in April. Pigs were maintained on pasture. For the first four weeks they were all supplemented with standard high-concentrate, due to the high protein and nutrient requirements of young pigs (Whitney et al. 2010). On June 1, two pigs were selected as the experimental group, and were fed and housed separately.

The experimental group received a widely-varied diet of forages (peas, beets, turnips, grass, legumes), household leftovers (banana peels, apple cores, carrot tops), overripe vegetables (broccoli, cabbage, potatoes, cucumbers, peppers, squash), weeds (dock, lambsquarter, shepherd's purse, purslane, pigweed, dandelion), and dairy (raw whole milk or whey, or powdered milk replacer).

The control group received some vegetables and whey, lots of grass and turnips, and free-choice non-GMO concentrate feed.

In early August, all non-grain feed resources were unavailable: pastures were too drought-stressed, and no milk or whey was available from the dairy. Experimental hogs were at first supplemented with alfalfa and whey, but after refusing it, were switched to a grain ration for 21 days. On August 21 John obtained some grain-free milk replacer and apples and the experimental hogs returned to grain-free diets.

Carcasses were weighed after slaughter, and meat samples were taken for further analysis of fatty acid profile, tenderness, and color.

Data were analyzed with SAS 9.3 (SAS Institute Inc., Cary, NC) using the MIXED procedure, and least-squares means are reported. Significance was established if $P \leq 0.05$, and tendencies noted if $0.05 < P \leq 0.10$.

Results

Feed intake

Due to the highly variable nature of both groups' diets, it is impossible to estimate feed intake of all dietary components. John summarized some aspects of the diets, which follow. Following the August reversion to a grain-based diet, the experimental pigs were receiving a cup of milk replacer and nearly a five-gallon bucket's worth of unsalable produce, twice a day. The control group consumed 850 lb of non-GMO feed per pig, over the course of the trial.

Experimental group

- Unknown amounts of produce, weeds, forage, etc. at no charge (other than time and labor required to obtain it)
- Swine grower feed, 16% protein: approx. 190 lb at $0.33/lb = $62.36
- Raw milk:five 50-gal barrels at $0.25/gal = $62.50
- Milk replacer: two 50-lb bags at $82.50/bag = $165
- Total feed cost: $289.86 or $144.93/hog

Control group

- Swine grower feed, 16% protein: approx. 11,050 lb at $0.33/lb = $3646.50 or $280.50/hog

Carcass information

Hogs were slaughtered in two groups on two separate dates (mid-October and mid-November). The experimental hogs were in the first group. Results and comparisons are made both between treatments and between slaughter groups.

Hog liveweight at finish is not available, but carcass weights were taken after harvest. Experimental hog carcasses were lighter than control carcasses (173 vs 223 lb, $P < 0.01$) and control hog carcass weights tended to be lighter in the first than in the second slaughter group (210 vs 233 lb, $P = 0.06$). Lower energy content in the experimental rations because of limited concentrate prevented maximal rate of gain and final carcass weight in those hogs (Edwards 2005); the difference between first and second slaughter group control hogs is due to a longer feeding and thus growth period for the second round hogs.

Loin eye area (LEA) did not differ between treatments, but only between slaughter groups – as with carcass weight, the second slaughter group had a greater average LEA because of additional growth time.

Other summary carcass data is presented in **Table 1**. Carcasses did not differ significantly between either diet treatment or between either slaughter group of control hogs. Backfat at both the 10th rib and last rib were smaller in experimental hogs but the difference was not significant ($P = 0.19$ and 0.10 respectively) and the last rib backfat values fall within USDA normal range of 1-3 in (O'Rourke et al. 2005). Darker pink pork is desirable (between 3-4, Lammers et al. 2007), though the USDA average is 2-3 (O'Rourke et al. 2005). The hogs here are a bit below that ideal. pH determines waterholding capacity of the meat and can affect taste and texture. A high pH indicates DFD (dark, firm, dry) meat; a low pH indicates PSE (pale, soft, exudative) meat, and both are undesirable (van Laack et al. 1995). The target pH range is 5.6-5.9 (Lammers et al. 2007), and the trial hogs all fall within that range.

Selected meat quality values are shown in **Table 2**. Again, there were few differences between treatments or between slaughter groups. Warner-Bratzler shear force indicates tenderness by measuring the force or weight required to penetrate a meat sample. A lower value is better, indicating greater tenderness. Hogs fed high levels of concentrate as well as clover forage had greater tenderness than those fed less concentrate (Danielsen et al. 1999), but no differences were observed in the current trial. Drip loss is the amount of water lost from cut pork, expressed as a percent of initial sample weight. Lower loss is preferable; the trial hogs all exceeded the minimum of 2.5% (Lammers et al. 2007). Greater loss is associated with

Table 1

Carcass quality characteristics of hogs fed either a control or experimental (low-grain) diet, and hogs on a control diet harvested in mid-October (Group 1) and in mid-November (Group 2)

	10th rib backfat (in)	Last-rib backfat (in)	Color[1]	pH	Marbling[2]
Control	0.9	1.3	1.6	5.7	1.7
Experimental	0.7	0.7	n/a	5.8	n/a
Group 1	1.0	1.3	1.6	5.8 a	2.0
Group 2	0.9	1.2	1.7	5.7 b	1.5
Mean of all hogs	0.9	1.2	1.6	5.7	1.7

Within a column, means followed by different letters are different ($P < 0.05$).
[1] Color is graded visually on a 1-6 scale (light to dark).
[2] Marbling is graded visually on a 1-10 scale (devoid to excessive).

Table 2

Meat quality characteristics of hogs fed either a control or experimental (low-grain) diet, and hogs fed a control diet harvested in mid-October (Group 1) and in mid-November (Group 2)

	Shear force (kg)	Drip loss (%)
Control	3.1	3.9
Experimental	3.3	4.8
Group 1	2.9	2.7 b
Group 2	3.3	4.8 a
Mean of all hogs	3.2	4.1

Within a column, means followed by different letters are different ($P < 0.05$).

lighter-colored meat (Lammers et al. 2007), and this was also observed in the current trial (**Table 1**).

Fatty acid profile

Meat samples from the first slaughter group of hogs only were tested for concentrations of different fatty acids (**Table 3**).

There were some interesting differences between the dietary treatments. Concentration of three individual saturated FA (14:0, 15:0, and 18:0) were greater in experimental than control diets ($P < 0.01$, P = 0.02, and $P = 0.08$ respectively). This contributed to a slightly greater total saturated FA concentration in fat from experimental hogs ($P = 0.07$). Generally, saturated fats are considered "bad" in terms of health, as they contribute to hypercholesterolemia in humans; but 18:0 (stearic acid) does not increase cholesterol as much as myristic (14:0) or palmitic (16:0) (Meinsink 1993). Since experimental hogs had both higher stearic and myristic acids, it is hard to say whether the experimental- or control-fed hogs produce "healthier" fat. Concentrations of other FA did not differ between treatments. Past research suggests that forage-fed hogs have fat with greater polyunsaturated FA concentrations than those raised on concentrate (Edwards 2005). Both treatment groups in the current trial received some forages, which may account for the lack of difference in polyunsaturated FA concentration.

Omega-3 FA are considered to be heart healthy, and diets with a low omega-6 to omega-3 ratio (<4:0) are recommended for humans (Wood et al. 2008). The table above lists omega-3 and -6 totals, but it should be noted that these are just the FA that were tested for; there are other omega-3 and -6 FA that were not tested in this study. Only three pigs (one experimental and two control) had enough detectable omega-3 to allow a ratio calculation, and all were far greater than 4. However, pork fat is an 'imbalanced' fat; physiological mechanisms incorporate more omega-6 FA than are ideal into fat, irrespective of diet (Wood et al. 2008).

Table 3

Fatty acid (FA) profile of hogs fed either a control or experimental (low-grain) diet, expressed as a % of total lipid

Fatty acid	Isomer	Type	Control	Experimental	Mean of all hogs
myristic acid	C 14:0	saturated	0.94 b	1.28 a	1.03
pentadecanoic acid	C 15:0	saturated	0.89 a	0.25 b	0.71
palmitic acid	C 16:0	saturated	23.09	24.51	23.49
palmitoleic acid	C 16:1	monounsaturated	2.90	2.69	2.84
heptadecenoic acid	C 17:1	monounsaturated	0.64	0.31	0.55
stearic acid	C 18:0	saturated	11.97 y	13.18 x	12.32
oleic acid	C 18:1n9t	monounsaturated	0.00	0.23	0.07
oleic acid	C 18:1n9c	monounsaturated	40.72	40.68	40.71
oleic acid	C 18:1n7	monounsaturated	3.88	3.58	3.80
linoleic acid	C 18:2n6c	polyunsaturated, omega-6	2.45	6.05	3.48
gamma-linolenic acid	C 18:3n6	polyunsaturated, omega-6	0.32	0.29	0.31
alpha-linolenic acid	C 18:3n3	polyunsaturated, omega-3	0.15	0.27	0.19
arachidonic acid	C 20:4n6	polyunsaturated, omega-6	1.70	1.67	1.69
		Saturated FA	36.89 y	39.21 x	37.55
		Monounsaturated FA	48.15	47.48	47.96
		Polyunsaturated FA	4.63	8.27	5.67
		Omega-3	0.15	0.27	0.19
		Omega-6	4.48	8.00	5.48

Economics

Earlier, the feed costs for the hogs from the two diet treatments were calculated, and the carcass weights were provided. From that information it is possible to roughly calculate and compare costs and potential revenue from the sale of the hogs.

- **Control hogs**:
  average carcass weight 223 lb,
  cost to feed $280.50/hog
- **Experimental hogs**:
  average carcass weight 173 lb,
  cost to feed $144.93/hog

Control hogs were more expensive to raise, but yielded heavier carcasses. But were the extra inputs economical? Below, the feed cost is divided by the carcass weight to determine carcass cost per pound:

- **Control hogs**:
  $280.50 ÷ 233 lb = $1.26/lb
- **Experimental hogs**:
  $144.93 ÷ 173 lb = $0.84/lb

Experimental hogs, despite lighter carcass weights, were cheaper to raise to that weight. An additional cost would be the labor to acquire the assorted feeds the experimental hogs received, as well as any costs of maintaining the pastures they grazed. Still, a $0.40/lb difference in feed cost per pound of carcass is considerable.

Conclusions and Next Steps

John's trial shows that hogs can be finished with nearly grain-free diets, and done so inexpensively. The tradeoff is in labor and time to obtain the alternative feeds. Still, the costs of gain were much reduced for hogs on the experimental diet. John will experiment with feeding ensiled forages in the future along with whey, still working to keep as much grain out of the diets as he can, and working to improve eating quality and nutrient health profile of the meat. In the long run he hopes to identify those animals that finish well on grain-free diets, and to establish a forage-hardy line of hogs for the Midwest.

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