ORGANIC FARMING RESEARCH FOUNDATION

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Project Report Summary

Ron Rosmann and his herd of spring cows, Harlan, Iowa

Feeding beef cattle to produce healthier and highly acceptable beef

In this on-farm study, Ron Rosmann and a research team from Iowa State University compared the finishing performance of cattle fed to USDA choice grade on pasture and in the drylot.

Rosmann Family Farms produces both organic grains and livestock, and this project tested a number of objectives. One was to determine whether pasture feeding could decrease the amount of corn fed to animals, thus making more grain available for sale off-farm or for other uses, and generating greater farm income. A second purpose was to produce a leaner beef with higher concentrations of healthful fatty acids such as conjugated linoleic acid (CLA), therefore differentiating the product as more healthful. The research team wanted to see whether it is possible to finish pastured cows on a ration that includes a small amount of grain--for the purpose of finishing to USDA choice grade--while at the same time maintaining fatty acid values seen in beef that are fed only on grass.

In summary, investigators sought to determine whether beef could be produced that is both healthier and highly acceptable to consumers by feeding cows on pasture with some supplemental grain, but less than is typically used during the finishing phase, while providing a better economic return to the farm.

Methods

Thirty yearling Red Angus cross steers and heifers were divided into two groups. Each 15-cow group was fed to choice grade, one group on pasture and the other in the drylot. Pastured cattle grazed primarily on cool-season endophyte-free tall fescue with some orchardgrass and alfalfa. The drylot group was fed with ground alfalfa-orchardgrass hay. Both groups of cattle were fed a corn-soybean concentrate mixture, at 0.5 to 1.0% of bodyweight for pasture-fed cattle, and at 2.0% bodyweight for drylot-finished cattle. Cattle were harvested upon reaching choice grade (determined visually). Steaks from each group were tested for sensory qualities, tenderness, and total lipid content and fatty acid composition.

Results

The average final weight of the pastured cattle was about 12 kg heavier than the drylot cattle, and had a 55-day longer feeding period (see performance tables). Average daily gain (ADG) of the pastured cattle was significantly slower than that of the drylot cattle (0.68 kg and 0.98 kg, respectively). The ADG and feed-to-gain ratio of the test animals were significantly lower than the industry standards. The investigators attribute this to "non-use of hormones and ionophores" in an organic production system. No significant differences were found in the sensory qualities, pH, or tenderness of steaks from the pastured and drylot cattle. CLA content concentrations of steaks, trim and adipose tissues from pasture finished cattle were more than twice the concentrations of the same parts from the drylot group. The ratios of omega-3 to omega-6 fatty acids were significantly greater for pasture-fed cattle compared with ratios for drylot-finished cattle in all three beef parts tested: steak, trim and adipose tissue.

The pasture-fed cattle had a lower dressing percentage and a lower percentage of choice than did the drylot cattle but had a higher percentage of yield

Project Notes

Principal investigator: Ron Rosmann, Rosmann Family Farms (certified organic), Harlan, Iowa

Cooperating investigators:
Faculty from Iowa State University, Ames Iowa:
Donald Beitz, Distinguished Professor of Animal Science and Biochemistry
Allen Trenkle, Distinguished Professor of Animal Science
John Lawrence, Associate Professor of Economics
Roberto Sonon, Jr., Visiting Scientist
James Russell, Professor of Animal Science

OFRF support for project: $13,870, awarded fall 2002 grade 1 and 2. The drylot cattle cattle produced slightly higher revenue with equal prices. The total cost of the pasture system was much less than the drylot system, hence, greater profit per head of pasture-fed cattle was realized.

Conclusions

Results from this study show that finishing cattle on pasture with limited grain supplementation is feasible and economically sound with reference to the usual practice on the farm where this study was conducted. Higher CLA and linolenic acid concentrations and omega-e to omega-6 fatty acid ratio strongly suggest that potentially healthier beef can be produced by the pasture system with limited grain supplementation. If beef with higher CLA and omega-e concentrations could be given a premium price, an even higher profit could be realized with the pasture-based finishing system.

Future research needs:

Can we increase further the concentrations of beneficial fatty acids in beef by feeding pasture only without sacrificing quality and acceptability by consumers?

Determine the concentrations of CLA and omega-3 fatty acids in beef as cattle are moved from summer grazing to winter rations.

Spring cows on their way to pasture. Rosmann Family Farms, Harlan, Iowa.

Performance Tables

The complete project report includes 9 tables. Tables 4-6 are included here.

(Note: Table 4 is derived from Ron Rosmann's project report, with additional notations by E. Walz. These notes include identification of some of the fatty acid names, identification of the most atherogenic fatty acids (highlighted in pink), the least atherogenic fatty acid (highlighted in green) and identification of the omega-3 to omega-6 ratio line (yellow highlight). Notes below the table further describe the data, based on a conversation with investigator Roberto Sonon. Any errors are unintentional. Readers may refer to the original project report for the tables as they were submitted. –EW)

Table 4: Fatty acid composition of feeds

The fatty acid composition of the pooled samples of pasture grass, ground hay, and concentrate mixture are shown in Table 4. Linolenic acid (C18:3*n-3*) comprised the greatest percentage of the total fatty acids for pasture and hay forages, whereas linoleic acid (C18:2*n-6*) was the largest component among the fatty acids in the corn-based concentrate mix. Pasture forage had the highest ratio of omega-3 to omega-6 fatty acids, and this ratio was lowest for the concentrate mix. Atherogenic index was similar for pasture and hay forages, which were higher than that of the concentrate mix.

Table 4. Fatty acid composition of feeds.

	Fatty acid	Full name	Pasture	Hay	Concentrate mix
			----------------g/100 g of fatty acids--------------		
Most atherogenic fatty acids	C12:0	Lauric acid	0.79	0.83	nd
	C14:0	Myristic acid	1.07	1.38	0.04
	C14:1		0.10	0.27	nd
	C15:0		0.20	0.40	nd
	C16:0	Palmitic acid	19.27	18.99	11.61
	C16:1		0.53	0.80	0.08
	C17:0		0.21	0.35	0.08
	C18:0	Stearic acid	1.85	3.30	2.41
	C18:1	Monounsaturated oleic acid	4.97	6.64	25.59
	C18:2*n-6*	Linoleic acid (o-6)	25.45	27.06	55.95
	C18:3*n-3*	Linolenic acid (o-3)	43.88	36.75	3.71
	C20:0		0.46	0.82	0.29
	C20:1		0.12	0.14	0.01
	C20:2		0.08	0.07	nd
	C20:3*n-6*		0.20	0.22	nd
	C20:4*n-6*		0.03	0.05	nd
	C22:0		0.36	0.89	0.13
	C23:0		0.13	0.40	0.01
	C24:0		0.30	0.64	0.10
	n-3/n-6[1]		1.95	1.62	0.07
	AI[2]		0.32	0.35	0.14

[1]*n3/n6*=calculated as the sum of all omega-3 fatty acids divided by the sum of all omega-6 fatty acids.

[2]AI=atherogenic index calculated as the sum of C12:0+4*C14:0+C16:0 divided by the sum of all unsaturated fatty acids.

nd=not detected.

Notes:

C14: Myristic acid – is the most atherogenic of all fatty acids, having the greatest low density lipoprotein (LDL) or "bad" cholesterol.

Fatty acids C12 through C16 as a group are considered the most atherogenic fatty acids.

Acids containing ":0" in the name refer to a saturated fatty acid.

Acids containing :*n-6* are an omega-6 fatty acid.

Acids containing :*n-3* are an omega-3 fatty acid.

While fatty acids values are shown for feeds, CLA (conjugated linoleic acid) values are not, because CLA is synthesized in the tissue of the animal

Post-project commentary by investigators Ron Rosmann and Roberto Sonon

Ron Rosmann: I was really happy with this study in the sense that every question we were asking and hoping would be positive turned out positive. CLA content was higher, there were no differences in taste and tenderness, and economic returns were better. Something we still don't know is what's really desirable for human health. Roberto Sonon did most of the work. We both thought, sure we have these ratios, but we don't know what's really desirable as far as the human diet. Is there research out there that tells you what ratios are good, what's enough, what's not enough? We need dietary studies on humans.

We were aware of some other researchers doing work on grass-fed animals--among them Dr. Tilak Dhiman at Utah State University. But we couldn't find values at the time to compare with what we were looking for. There's a lot of anecdotal information. And I think what was available from Dr. Dhiman was on butter, eggs and dairy. We didn't find data regarding meat products.

The one thing that was most eye-opening was that nobody had even looked at this part of the equation yet. I couldn't find any references in a literature search about comparing grass fed to corn fed animals for CLA content.

Roberto Sonon: In previous studies, CLA has been shown to be higher in animals on pasture under research conditions, but this had not been tested in a farm-based setting. And now we've determined that in a farm setting. We found that pastured animals, even if supplemented with a concentrate to obtain desired meat qualities, obtain higher CLA levels. That is the biggest finding.

Ron Rosmann: We modified a few things in our management based on the results. For instance this spring we took all of our yearling cattle--they'd over wintered in the yard eating roughage with no

Performance tables, cont'd.

Table 5. Fatty acid composition of the different beef parts

Presented in Table 5 is the fatty acid composition of the different beef parts. The monounsaturated oleic acid (C18:1) accounted for the greatest concentration of the fatty acids in all three beef parts. This fatty acid was followed by palmitic acid (C16:0) and stearic acid (18:0) in a descending order of percentage. Myristic acid (14:0), which is the most atherogenic of all fatty acids, was found to be highest in the adipose tissue. Consequently, AI of adipose tissue was observed to be higher than that of the steak and trim. Linoleic acid, an omega-6 fatty acid, was highest in the ribeye steaks and lowest in the adipose tissue. Docosapentaenoic acid (C22:5), an omega-3 fatty acid, was also highest in ribeye steaks and almost negligible in the adipose tissue. Within a beef part, most of the fatty acids did not differ significantly ($p>0.05$) between the two finishing systems. In all three beef parts, the omega-3 linolenic acid (C18:3) was significantly higher in parts from the pasture-finished cattle than in those from drylot-fed cattle. This result indicates that some of the C18:3*n-3* in the feed, which makes up about 44% of the total fatty acids of the pasture forage, was transferred effectively to animal tissues. On the other hand, C18:2*n-6* content of adipose tissue was significantly higher in parts from the drylot-finished cattle than in parts from pasture-fed cattle. A similar trend was observed for this fatty acid in the ribeye steak as the concentration of C18:2n-6 tended to be significantly greater ($p=0.053$) with drylot-finished cattle. The ratios of omega-3 to omega-6 fatty acids were significantly greater for pasture-fed cattle compared with ratios for drylot-finished cattle in all three beef parts.

Table 5. Fatty acid composition of the different beef parts[1].

	Beef part					
	Ribeye steak		Trim		Adipose	
	Finishing system		Finishing system		Finishing system	
	Pasture	Drylot	Pasture	Drylot	Pasture	Drylot
Fatty acid	g/100 g of fatty acids					
C12:0	0.08	0.06	0.08	0.10	0.10	0.10
C14:0	2.95	2.61	3.12	3.16	4.27	4.22
C14:1	0.56	0.52	0.95	0.59	1.42	1.50
C15:0	0.41[a]	0.26[b]	0.52	0.46	0.59[a]	0.46[b]
C16:0	28.51	29.01	26.18	27.05	27.18	27.49
C16:1	3.56	3.34	4.48	3.33	5.64	5.17
C17:0	0.96[a]	0.78[b]	1.00	1.02	1.07	0.97
C18:0	15.96	14.94	15.28	18.65	13.52	12.96
C18:1	38.44	40.13	40.47	39.69	39.98	42.61
C18:2*n-6*	3.74	4.80	3.20	3.13	1.77[b]	2.26[a]
C18:3*n-3*	0.79[a]	0.61[b]	0.74[a]	0.54[b]	0.60[a]	0.46[b]
C20:0	0.09	0.08	0.09	0.11	0.09	0.09
C20:1	0.03	0.05	0.03	0.03	0.02	0.02
C20:2	0.03[b]	0.05[a]	0.04	0.04	0.02	0.02
C20:3*n-6*	0.29	0.40	0.22	0.18	0.07	0.08
C20:4*n-6*	0.87	1.20	0.65	0.36	0.06	0.05
C20:5*n-3*	nd	nd	nd	nd	0.03	nd
C22:5*n-3*	0.31	0.33	0.24	0.13	0.02	0.01
C24:0	0.15	0.15	0.11	0.03	nd	nd
n-3/n-6[2]	0.26[a]	0.15[b]	0.25[a]	0.19[b]	0.35[a]	0.19[b]
AI[3]	0.80	0.76	0.74	0.81	0.85	0.83
	n=9	n=7	n=8	n=7	n=9	n=7

[1]Means within a beef part and within a row with unlike superscripts differ (p .05).

[2]*n3/n6*=calculated as the sum of all omega-3 fatty acids divided by the sum of all omega-6 fatty acids.

[3]AI=atherogenic index calculated as the sum of C12:0+4*C14:0+C16:0 divided by the sum of all unsaturated fatty acids.

nd=not detected.

Performance tables, cont'd.

Table 6. Trans vaccenic acid and conjugated linoleic acid concentrations of the different beef parts

Table 6 shows the trans vaccenic acid (C18:*t11*) and CLA concentrations of the different beef parts. Among the four CLA isomers determined, *cis9 trans11* accounted for about 78% of the total CLA. Adipose tissue had the greatest amount of *cis9 trans11* CLA, which was followed in a decreasing order by the trim and ribeye steak. In all three beef parts, CLA concentrations were significantly greater from the pasture-finished cattle, having more than twice those from the drylot-finished cattle. These data are complemented by the higher concentration of trans vaccenic acid in parts from the pasture-fed cattle than in parts from the drylot-finished cattle; the differences were significant (p 0.05) for the ribeye steak and adipose tissue. Trans vaccenic acid is a precursor for CLA synthesis in animal tissues. Linolenic acid coming from pasture may have supplied the additional trans vaccenic acid produced during ruminal biodydrogenation.

Table 6. Trans vaccenic acid and conjugated linoleic acid concentrations of the different beef parts[1].

Beef part[2]	Finishing system	*c18:1t11*	C18:2 CLA isomers *c9, t11*	*t10, c12*	*c9, c11*	*t9, t11*	Total CLA
		-------------------g/100 g of fatty acids-------------------					
Ribeye steak	Pasture	1.70^{a}	0.44^{a}	0.02^{a}	0.02	0.07^{a}	0.56^{a}
	Drylot	0.44^{b}	0.17^{b}	0.01^{b}	nd	0.04^{b}	0.22^{b}
Trim	Pasture	1.68	0.61^{a}	0.04^{a}	0.03^{a}	0.12^{a}	0.81^{a}
	Drylot	1.06	0.26^{b}	0.02^{b}	0.01^{b}	0.07^{b}	0.36^{b}
Adipose	Pasture	2.39^{a}	0.82^{a}	0.05^{a}	0.04^{a}	0.16^{a}	1.08^{a}
	Drylot	1.09^{b}	0.34^{b}	0.02^{b}	0.01^{b}	0.07^{b}	0.44^{b}

[1]Means within a beef part within a column with unlike superscripts differ (p 0.05).

[2]n=9 for parts from pasture-fed cattle, except for trim where n=8; n=7 for parts from drylot-fed cattle.

nd=not detected.

Post-project commentary, cont'd

corn in their diet, they were fed silage, hay and ground oats—in April they all went out to grass and as a supplement we fed them ground oats 7-8 lbs per head per day, from May 1 to end of August. After that we put them in the feedlot, and grained them the last 90-120 days. We put them in the feedlot because we're faced with a marketplace that rewards for Choice 1s and 2s [grade]. But this process does cut the costs down. We haven't changed our marketing. We're still responding to the market demand for grain-fed choice beef, but producing it differently.

But right now for economic reasons we're trying to do everything to not feed corn, because we can sell all the corn to the big three: the organic beef industry, the organic broiler industry and dairy industry. From what I understand, the market for organic corn is about 1/3, 1/3 and 1/3 in those categories, roughly.

We have at times thought about using a "higher CLA content" meat label, but marketing grass-fed beef is still difficult. While we do also produce a fully grass-fed beef, I really don't have any demand for it--it has only been requested by one retail customer. For the rest, it doesn't register as an issue of importance.

Roberto Sonon: That is an interesting thing about this, that the farmer wants to produce leaner and healthier beef but the market calls for these top choice grades, so the farmer is caught in between.

Ron Rosmann: So we didn't market it as grass-fed. But no one complained about the quality, and as far as we know, they couldn't tell the difference. It's also exciting to think about other factors we can try such as adding flax to feed. We're going to grow flax next year. It's been suggested that the flax straw, too, is good for cattle. [Flax is high in omega-3 content.]

Roberto Sonon: Already there are products on the market labeled "high omega-3 content, based on flax in the animal's diet--most notably eggs. In monogastric animals such as chickens, pigs and humans, omega-3 is transferred readily from these diets. But not so much in beef, because of their multiple stomachs. So for example feeding flax to chickens will easily raise level of omega-3 in eggs and chicken meat products. It will be interesting to see the results of feeding flax to cattle.

The project report includes some technical terminology. [For readers who download the full project report, this

Post-project commentary, cont'd

information may be helpful.] The first example is the data on fatty acids and other values for ribeye steak, adipose tissue and trim. Adipose tissue is taken from the back of an animal, specifically in the underarm area. In layman's terms it is fat, but adipose tissue is not eaten. Trim is material that is generally used in meat products, such as hamburger and other ground meat products. It is fat that is blended with or used with the muscle, while adipose tissue is not.

The second example is the "atherogenic index." The atherogenic index relates to the LDL:HDL ratio. LDL refers to low density lipoprotein, which is known as "bad" cholesterol. HDL, or high density lipoprotein, is known as "good" cholesterol.

We have a formula for calculating the atherogenic index (AI):

$$AI = \frac{\%C12{:}0 + 4X\ C14{:}0 + C16}{\text{Sum of mono and saturated fatty acids} + \text{polyunsaturated fatty acids}}$$

Where C12 = Lauric acid;
C14 = Myristic acid; and
C16 = Palmitic acid

These fatty acids, C12 through C16, shown in the numerator of the formula, are considered "bad" fatty acids, contributing to LDL. These are the "most atherogenic" fatty acids, resulting in higher cholesterol content in the blood. Therefore, the lower the AI, the healthier the product. As consumers, we want to look at this ratio. The higher the ratio of n-3 (omega-3) to n-6 (omega-6) fatty acids, the healthier the product. In this case, the higher the omega-3 fatty acid content, the greater potential health value of the beef.

In Table 4 and Table 5 of the full report, the ratio value n-3/n-6 is derived from the sum of all the n-3s in the column, over the sum of the n-6s in the column. Note that 80% of the n-3 is derived from C18:3n-3: linolenic acid. While there are other n-3s they are less present or undetectable. So really what we're looking for is product with the highest C18:3n-3 content.

To a layman, based on numbers alone, the "good" and "bad" fatty acids appear similar. For example, conjugated linoleic acid (CLA), which is "good", is identified as C18:2, while C18:2n-6 is Omega 6, which is "bad."CLA is made up of isomers of C18:2. CLA is an isomer that has been found to benefit humans.

There is one important point on comparing the presence of omega-3s and omega-6s and CLAs: You will find the omega-3 and omega-6 fatty acids in the feed, which is why we test for them in the feedstuffs. But you won't find CLA content in the feed because CLA is synthesized in the adipose tissue of the animal and in the stomach, so this is why adipose tissue is tested, even if we don't use it as a food product. It is expressed in the body of the animal and in animal products, such as dairy. If you look again at Table 6, there are five columns of identified CLA isomers. 80% of these isomers are held in c9, t11 [column 2]. The following three columns are also isomers. However, c18:1t11, shown in column 1, is not really a CLA isomer, but it is shown because it is a precursor for synthesis of the isomers, so it is important to know this value.

Another point about CLA is that it is readily expressed in dairy products. The difference is very dramatic, more so than in meat products, as high as five-fold.

Ron Rosmann: If we want to take this research to where it really needs to go—which could take the rest of my life and then some—what we'd want to do is look toward the right mix of quality of forage and the right genetics in cattle to get them to grade choice on grass. They'd have marbling, taste and tenderness. I think it's possible by selecting genetics of cattle that have a deeper body. These are generally the English breeds, black angus and red angus. Though you have to take into consideration that even the genetics of Angus have changed of late--they've been bred for other qualities and to finish on grain. But there are some people working on this. We really don't know effects of pasture quality, either. So it's genetics and pasture managemen--the two big things to look at in the future, these definitely need more research.

Roberto Sonon: Since this work was conducted, I've transferred to University of Georgia, where I'm continuing this kind of work. Also, there is a SARE project proposal that I worked on while at Iowa State, prior to transferring to Georgia, that has been funded to do this study in humans-- those human studies Ron was talking about.

This commentary is based on interviews conducted and edited by Erica Walz, December 2004.