Fat Deposition – Associated Production Efficiencies & Carcass Value

Savel et al. (1991) report that approximately 42% of all beef retail cuts are trimmed. Trimming this excess fat off of 42 % of retail cuts in the USA amounts to ~ 2.5 billion pounds of waste product each year, at a cost to the industry of $130/animal (Nunes 1992). Given that ~ 28 million animals are slaughtered each year the total ~ annual cost to the beef industry for excess fat is ~ 3.6 billion dollars. Further, an NCBA sponsored quality audit reported a significant proportion of cattle are not fed for an appropriate number of days (Boleman et al., 1998). This audit reported that 25% of carcasses were fed too long (as evidenced by carcasses with 15mm + of back fat), and another 25% of carcasses were not fed long enough (as evidenced by low quality grades and lightweight carcasses). These statistics are especially concerning to the beef industry in light of the fact advice by many nutritionists is for consumers to prefer lean meats and low fat meat products (Valsta et al. 2005). Given the tangible economic costs of excess fat to the slaughter industry and the decreased value of the animal to producers; due to marketing cattle at times when their carcasses do not meet the optimum end points (according to the specifications of the Canadian and US grading system), a management system that properly predicts **the optimal slaughter point** for individual animals would be of benefit to the entire beef industry. This management system would predict optimal days on feed (DOF) before slaughter, thus minimizing the over production of excess fat, whilst maintaining production efficiency and carcass quality. The economic benefits of such a system would not be a zero sum position to the industry, rather efficiencies are created in each sector within the beef industry and would lead to increased profit margins within the sectors themselves, ultimately creating an industry that can compete more effectively against other sources of protein consumed by the public.

Seasonal changes in feed prices and incoming cattle costs play a significant role in predicting break even prices at slaughter. Producers implement management strategies to try to enhance their chances of achieving profitability at slaughter of animals with many decisions - including DOF. Zinn et al. (1970), Hicks et al. (1987), and Dolezal et al. (1982) all report longer DOF will typically increase final wt, HCW (hot carcass wt), **backfat**, **yield grade**, and quality grade. Also Greene et al. (1989), Williams et al. (1989), and May et al. (1992) all report longer DOF increasing **yield grade** and **backfat** linearly. Later, Brethour (2000) published data suggesting that an exponential model describing fat deposition was a more accurate predictor of rates of back fat accretion than a linear model.

As noted in the above paragraph DOF impacts carcass traits, but what is also of interest is the understanding of how increasing DOF impacts intramuscular fat (marbling)? Would increasing DOF linearly increase marbling? Duckett et al. (1993) report that marbling content doubled between day **84** on feed and day **112** on feed. Interestingly though, between day 0 and day 84, and between day 112 and day 196 there was no statistically significant increase in marbling content – suggesting that marbling increases in a non linear fashion for a period of time, and then the rate of increase **declines**, and eventually levels off (Duckett et al., 1993; Van Koevering et al., 1995).

In addition to this work, Brethour (2000) described observations that were slight variations of these observations; that is marbling scores progress at a very slow rate through much of the feeding period, and then increases rapidly for a period of time, best described by a power function (a mathematical model), typically at the point of low Choice grade (AAA) to upper Choice grade (AAA).

Since fat is the most expensive tissue to lay down, energetically speaking, this information leads to the question – **What is the optimal DOF for maximizing performance efficiency and carcass quality**? Van Koevering et al. (1995) report that final live wt increased with DOF, resulting in a linear increase, but this increase was at a **decreasing rate**. In this same research DMI (dry matter intake) was measured, and since it numerically increased (i.e. was statistically equal), live animal performance and productive efficiency began to **decline**. Van Koevering et al. (1995) reported steers fed to 119 DOF (the time that the rate of marbling increase started to decline, and did not statistically change thereafter) statistically tended to be **superior in feed conversion** (on a carcass basis) when compared to groups slaughtered with longer DOF.

Therefore, there appears to be strong evidence that the optimal DOF, in regards to optimal productive efficiency & carcass quality, is at the point where the rate of intramuscular fat, (marbling) begins to decline and level off. Feeding beyond this period will result in backfat and yield grade continuing to increase, which is not appealing to producers (Van Koevering et al., 1995), and productive efficiencies begins to decline, i.e. worse feed conversions (Van Koevering et al., 1995; Kononoff et al., 2005a). Brethour (2000) goes so far as to caution extending the feeding period to improve the proportion of Choice carcasses may be counterproductive, because back fat seems to increase more rapidly than intramuscular fat (marbling).

Because of this knowledge, factors that regulate fat deposition are areas of importance for feedlot management. One of the most important factors that help to regulate fat deposition is the genetics of the individual. Fat deposition, and state of energy balance as a phenotype are polygenic traits. That is, several (more than one) genes contribute to the measured (observed) phenotype we see, i.e. backfat, marbling, yield grade, etc. As we identify one gene at a time, or several at once, knowledge of each genes' biological mechanism will serve to reduce the variation observed within each phenotype.

The *obese* gene (**leptin**) has been identified (Buchanan et al., 2002) to impact several fat stores. Leptin is a hormonal product of adipose tissue whose expression reflects the body's state of nutritional reserves (Thornton et al. 1997). Leptin acts on the brain to regulate feeding, metabolism, and reproduction (Thornton et al. 1997). Specifically, a functional mutation, R4C, has been identified to affect backfat, marbling, % rib fat, Yield Grade and Quality Grade (Buchanan et al., 2002; Kononoff et al. 2005). In the Buchanan et al. (2002) research, three genotypes were identified - **tt**, **ct**, and **cc**. It was observed that the t allele is the mutation, and the allele which is associated with **increased fat deposition**. The identification of these significant genotype/phenotype interactions can help to explain the variation observed in kill lots of feedlot animals. Kononoff et al. (2005) report that the observed differences in backfat and marbling between genotypes was observed in feedlot animals in the form of Yield Grade and Quality Grade, (ie. YG1, YG2, or YG3; and QG AAA, AA, or A). Kononoff et al. (2005) observed that the **tt** genotype (those with the greatest genetic potential for fat deposition) had a significant increase in YG3 and tended to have an increase in AAA; while the **cc** genotype had a significant increase in YG1 and tended to have a decrease in AAA. Further, when serial Ultrasound measures were taken on growing feedlot steers, it was observed that the **tt's** had an significantly higher rate of fat accretion than the ct's; and slowest was the **cc's**. This, in part, helps explain the observations in the Kononoff et al. (2005) report, which were that tt's have an increase in YG3 (more fat), and cc's have an increase in YG1 (less fat).

The knowledge generated out of all this research is that different genotypes have phenotypic traits that can be managed to extract the most economic value available to individual animals. Armed with this knowledge **feedlot management** can be tailored to optimize each genotype of cattle within feedlot groups, all the while maximizing productive efficiency. That is to say, since the tt's have increased YG3's under typical management, they are likely beyond their optimal DOF endpoint, and need to have their feeding period decreased to a point where the rate of the marbling increase (%AAA) is decreasing, and %YG1 is maximized. Conversely the cc's are more likely to need an increase in DOF as compared to the tt's, ultimately culminating in the optimal efficiency, and maximization of YG1's & AAA's. Each genotype will require a different DOF target to reach their optimal slaughter end point to maximize the value of the carcass and to optimize the cost structure of the feeding period.

Examples of this are :
Note – In the **Non Genotype Management** the % YG1 is significantly lower than in the **Genotype Management** groups; and the %YG3 are significantly higher in the **Non Genotype Management** groups when compared to the **Genotype Management groups**; all the while %AAA is not significantly affected.

***JAS (2005)* Non Genotype Management**					
Animal type	***# animals***	***% YG1***	***% YG3***	***% AAA***	***Ave CW***
Yrlng H & S	1577	**44.0%**	**18.5%**	**55.8%**	801.8

***Van Raay Farms - Jan/05 - Feb/05* Non Genotype Management**								
Animal type	***# animals***	***% YG1***	***% YG3***	***% AAA***	***Yield***	***Ave DOF***	***Proj DOF***	***Ave COG***
Yrlng Heifers	670	**41.8%**	**18.3%**	**71.0%**	~ 59.3%	137	150	$ 0.57

***Cattleland Feedyard June/04 - July/04* Genotype Management**											
An. Type	***# hd***	***% YG1***	***% YG3***	***% AAA***	***Yield***	***Ave DOF****	***Proj DOF****	***Ave ADG****	***Ave COG****	***In wt****	***Kill w***
steers	875	**69.7%**	**6.7%**	**58.1%**	60.2%	139	164	3.69	0.51	807.6	129

***Van Raay Farms - Dec/04 - Jan/05* Genotype Management**								
Animal type	***# animals***	***% YG1***	***% YG3***	***% AAA***	***Yield***	***Ave DOF***	***Proj DOF***	***Ave COG****
Yrlng Heifers	413	**64.6%**	**4.8%**	**56.4%**	59.3%	101	150	$ 0.497

***Hiltona Holdings Feb/05* Genotype Management**							
Animal type	***animals***	***% YG1***	***% YG3***	***% AAA***	***Yield***	***Avg DOF***	***Proj DOF***
Yrlng Heifers	**257**	**88.3%**	**1.2%**	**52.5%**	**61.0%**	**139**	**159**

In the instance below, these animals were managed using BW as a predictor of starting back fat. As reported by Kononoff et al. (2005c) BW is an inefficient predictor of finish, as seen here. %YG1 is down & %YG3 is slightly up – when compared to QGI "typical" Management. This is evidence when using BW as a predictor of starting back fat, optimal DOF is exceeded.

CL Sept/04	Genotype Management w/o UltraSound					
Animal type	# animals	% YG1	% YG 2	% YG3	% AAA	Yield
strs	186	28.5%	61.3%	10.2%	49.0%	60.5%

An example of what overfeeding (%YG3) costs the industry is illustrated in the table below. For Western Canada, according to CanFax 2003, there was 11.3% of federally inspected carcasses grading Canada YG3. The same statistics report there was 2.03M youthful cattle slaughtered in this geographic region. If the incidence of YG3 was dropped in half, there would be ~ 115,000 less YG3 carcasses. This would equate to a reduction of ~ $133.62 USD/hd, or $15.4 M USD for Western Canada, or more precisely $167.03 CDN/hd; or $19.2M CDN (a conversion factor of $1.25 CDN/$1.00 USD).

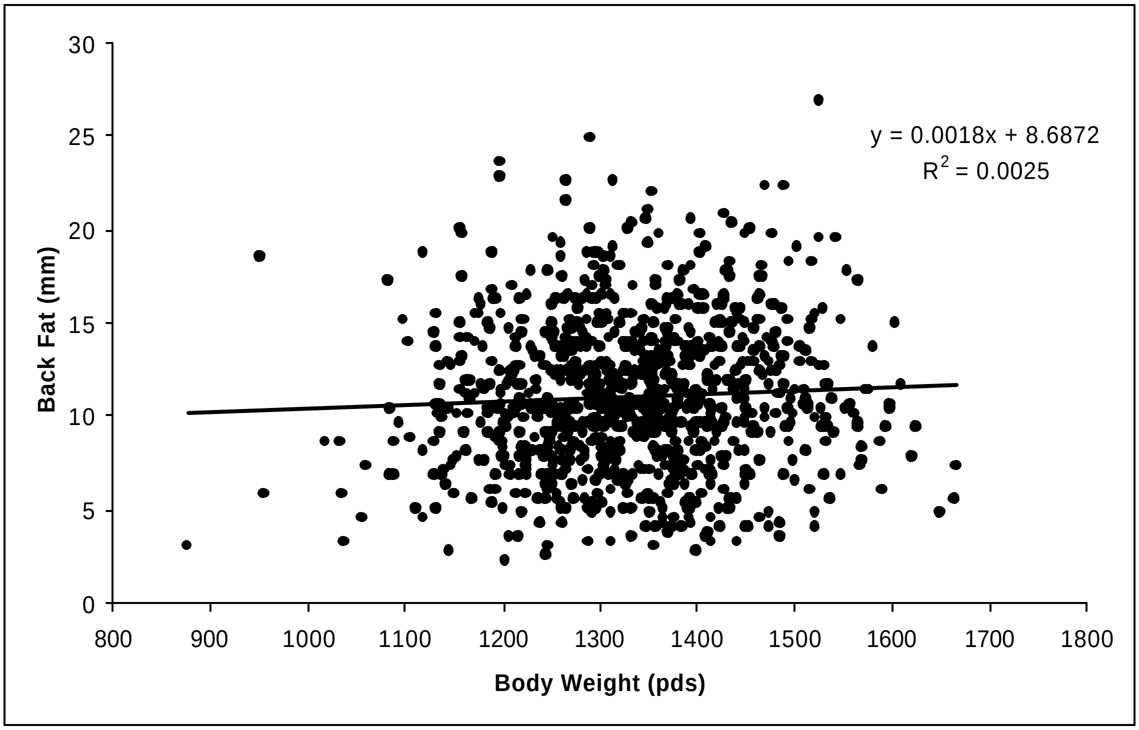
Further evidence of inefficiencies by overfeeding (i.e. YG3) is illustrated in the table below. Note: USDA YG1 & 2 are equivalent to Agriculture Canada YG1 & 2, but USDA YG3, 4, & 5 are equivalent to Agriculture Canada YG3. Therefore in the comparison below, it is analogous to Agriculture Canada YG2 vs. YG3.

Comparison of Yields of Retail Cuts and Retail Values Between U.S.D.A. YG2 &YG4 Beef Carcasses, Each Weighing 600 lbs (2001).

	Wt of Retail cuts from 600 lb Carcass*			RETAIL VALUE	
Retail cut	YG2	YG4	$/LB	YG2	YG4
Boneless rump	21	18.6	$3.29	$69.09	$61.19
Inside rd	27	22.2	3.49	94.23	77.48
Outside rd	27.6	25.2	2.99	79.76	72.83
Round tip	15.6	14.4	3.29	51.32	47.38
Sirloin	52.2	47.4	4.39	229.16	208.09
Short loin	31.2	30	5.29	165.05	158.7
Short cut rib	37.2	36	5.29	196.79	190.44
Blade chuck	56.4	50.4	1.89	106.6	95.26
Boneless chuck arm	36.6	33	2.59	94.79	85.47
Boneless brisket	13.8	11.4	2.69	37.12	30.67
Flank steak	3	3	5.19	15.57	15.57
Ground beef	141	115.8	1.59	224.19	184.12
Fat	76.2	137.4	0.1	7.62	13.74
Bone	59.4	53.4	0.05	2.97	2.67
Kidney	1.8	1.8	0.89	1.6	1.6
Totals	600	600		$1,378.83	$1,245.21

* Based on yields presented in marketing bulletin #45, USDA Yield Grades for beef, USDA 1968.

Relationship between BW and back fat. The observed relationship (R^2) in this population of cattle is very low, inferring that using BW as a predictor of degree of finish in these live animals was flawed.



Literature Cited

Boleman, S. L., S. J. Boleman, W. W. Morgan, D. S. Hale, D. B. Griffin, J. W. Savell, R. P. Ames, M. T. Smith, J. D. Tatum, T. G. Field, G. C. Smith, B. A. Gardner, J. B. Morgan, S. L. Northcutt, H. G. Dolezal, D. R. Gill, and F. K. Ray. 1998. National Beef Quality Audit – 1995: Survey of producer-related defects and carcass quality and quantity attributes. J. Anim. Sci. 76:96.

Brethour, J. R. 2000. Using serial ultrasound measures to generate models of marbling and backfat thickness changes in feedlot cattle. J. Anim. Sci. 78:2055.

Buchanan, F. C., C. J. Fitzsimmons, A. G. Van Kessel, T. D. Thue, D. C. Winkleman-Sim, and S. M. Schmutz. 2002. Association of a missense mutation in the bovine leptin gene with carcass fat content and leptin mRNA levels. Genetics Selection Evolution. 34:105.

Dolezal, H. G., G. C. Smith, J. W. Savell, and Z. L. Carpenter. 1982. Effect of time-on-feed on palatability of rib steaks from steers and heifers. J. Food Sci. 47:368.

Duckett, S. K., D. G. Wagner, L. D. Yates, H. G. Dolezal, and S. G. May. 1993. Effects on time on feed on beef nutrient composition. J. Anim. Sci. 71:2079.

Greene, B. B., W. R. Backus, and M. J. Riemann. 1989. Changes in lipid content of ground beef from yearling steers serially slaughtered after varying lengths of grain finishing. J. Anim. Sci. 67:711.

Hicks, R. B., F. N. Owens, D. R. Gill, J. J. Martin, H. G. Dolezal, F. K. Ray, V. S. Hays, and C. A. Strasia. 1987. The effect of slaughter date on carcass gain and carcass characteristics of feedlot steers. Oklahoma Agric. Exp. Sta. Res. Rep. MP-119:351.

Kononoff, P. J., and F. L. S. Marquess. 2005a. Data on file.

Kononoff, P. J., H. M. Deobald, E. L. Stewart, A. D. Laycock, and F. L. S. Marquess. 2005b. The effect of a leptin single nucleotide polymorphism on quality grade, yield grade and carcass weight of beef cattle. J. Anim. Sci. 83:927.

Kononoff, P. J., and F. L. S. Marquess. 2005c. Data on file.

Nunes, K. 1992. Quality and beef. Meat & Poultry. p 38 . June 1992.

May, S. G., H. G. Dolezal, D. R. Gill, F. K. Ray, and D. S. Buchanan. 1992. Effects of days fed, carcass grade traits, and subcutaneous fat removal on postmortem muscle characteristics and beef palatability. J. Anim. Sci. 70:444.

Savell, J. W., J. J. Harris, H. R. Cross, D. S. Hale, and L. C. Beasley. 1991. National Beef Market Basket Survey. J. Anim. Sci. 69:2883.

Thornton, E., C. Cheung, D.K. Clifton, and R.A. Steiner. 1997. Regulation of hypothalamic Proopiomelanocortin mRNA by Leptin in *ob/ob* mice.Endocrinology. 138:5063.

Valsta, L. M., H. Tapaninen, and S. Männistö. 2005 In Press. Meat fats in nutrition – a review. J. Meat Sci.

Van Koevering, M. T., D. R. Gill, F. N. Owens, H. G. Dolezal, and C. A. Strasia. 1995. Effect of time on feed on performance of feedlot steers, carcass characteristics and tenderness and composition of longissimus muscles. J. Anim. Sci. 73:21.

Williams, S. E., J. D. Tatum, and T. L. Stanton. 1989. The effects of muscle thickness and time of feed on hot fat trim yields, carcass characteristics and boneless subprimal yields. J. Anim. Sci. 67:2669.

Zinn, D. W., R. M. Durham, and H. B. Hedrick. 1970. Feedlot and carcass grade characteristics of steers and heifers as influenced by days on feed. J. Anim. Sci. 31:307.