EFFECTS OF GROWTH HORMONE ON MILK YIELD IN CATTLE

by

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Introduction

Growth hormone is a polypeptide hormone which is secreted from the anterior pituitary of the cow. Early research demonstrated that this hormone will increase growth rates and milk yield in cattle (Brumby, 1959; Brumby and Hancock, 1955). However, it was not possible to produce sufficient quantities for commercial use. Recent breakthroughs in biotechnology have now made study and commercial use of this hormone a reality.

Effects on Milk Yield

Injections of growth hormone have been known to increase growth rates in growing animals and milk yield in lactating dairy cattle. Therefore, this hormone is of great potential benefit to the dairy industry. Of the two processes, lactation has the greatest potential economic return. Therefore, it is not surprising that the majority of studies done with growth hormone in cattle have been lactation trials. To date, the only published report of growth hormone effects on growing cattle is the initial report by Brumby (1959) in which a positive response was reported. Studies in laboratory animals indicate that effects of growth hormone on growth are in part mediated by a wide variety of tissue specific growth factors (Bradshaw and Spron, 1983). The potential use of these growth factors in cattle remains to be elucidated.

Table 1, demonstrates the lactation responses reported by various investigators using different preparations of growth hormone at different stages of lactation. As can be noted from Table 1, growth hormone injections increase milk yield at every stage of lactation. The actual increase in milk yield appears to be similar in cattle in early or late lactation. However, due to lower milk yield during late lactation the percentage increase in milk yield is higher in these animals. Also apparent in Table 1, is the fact that genetically engineered or recombinant produced growth hormone was as effective as growth hormone of pituitary origin in increasing milk yield.

Recombinant growth hormone is produced by removing the growth hormone gene from cells in the pituitary of the cow and inserting this gene into bacteria. The bacteria then gain the capability to produce this hormone. Since bacteria grow quite rapidly it is possible to produce large quantities of the hormone in a short period of time. Thus, for the first time it is feasible to consider commercial use of growth hormone to increase productivity of dairy cattle.

Also of economic importance is the finding that cattle injected with growth hormone eat very little additional feed to produce the increase in milk yield. Growth hormone injection apparently causes an increase in gross efficiency of feed energy conversion to milk energy. This increase in gross efficiency of feed conversion does not appear to be due to a change in partial efficiency of energy utilization of metabolizable energy for milk synthesis (Tyrell et al., 1982). Growth hormone appears to cause a preferential partitioning of nutrients to the mammary gland at the expense of other tissues.

Thyroxine is also known to increase milk yield in cattle. However, long-term use of thyroid compounds resulted in "burned out" cows. Cattle on thyroid compounds did not produce as much milk in the subsequent lactation following treatment. We compared thyroxine and growth hormone injections on blood substrate concentration and their supply to the mammary gland to determine if growth hormone treatment would alter nutrient partitioning in cattle in a manner similar to thyroxine.

As shown in Table 2, both growth hormone and thyroxine treatment resulted in substantial increases in milk yield and fat yield. Also, both treatments resulted in large increases in mammary blood flow, Table 3. Increasing mammary blood flow would greatly increase nutrient availability to the udder. The increase in blood supply to the mammary gland was achieved by increasing the output of the heart, Table 3. This demonstrates that the heart acting as a pump increased its output to deliver more blood to the mammary gland. Did the growth hormone and thyroxine injection directly cause the increase in blood supply to the mammary gland. Probably not since blood flow is largely determined by metabolic activity of the tissue. An alternative explanation is that growth hormone and thyroxine increase the rate of milk synthesis. This increased metabolic activity results in the increase in mammary blood flow.

Data in Tables 4 and 5 demonstrate the difference between growth hormone and thyroxine treatment. Growth hormone injection did not result in any change in blood glucose, free fatty acids or triglycerides. This indicates that the increase in milk yield caused by growth hormone injection did not cause an excessive increase in fat metabolism. However, thyroxine treatment resulted in large increases in arterial free fatty acid and glucose concentrations and a decrease in triglyceride concentrations, Tables 4 and 5. This indicates that substantial mobilization of body reserves occurs in the thyroxine treated animal due in part to the fact that thyroxine treatment results in an increase in whole body metabolism while growth hormone treatment primarily increase the metabolic rate of the mammary gland. Of practical importance to the dairy farmer is the possibility that long term use of growth hormone in lactating cows should not be detrimental to their health or lifetime production.

Much additional research is required to determine effects of growth hormone under different feeding and management regimens. Data from Table 1 demonstrated that all breeds of Bos taurus respond to the hormone. However, research is also needed in the Bos indicus breeds to determine their response to this hormone. Additionally it is not known what effects different environments may have in response of cattle to growth hormone treatment.

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TABLE 1
EFFECT OF GROWTH HORMONE INJECTIONS AT VARIOUS STAGES OF LACTATION ON MILK YIELD IN DAIRY CATTLE

Reference	Breed	Stage of lactation	Control milk yield, kg	Δ Milk yield, kg	Δ Milk yield, %	GH[a] dose mg	Duration GH treatment	Diet
Brumby and Hancock (1955)	Mixed breeds	Peak	11.0	7.0	64	50	12 wk	Grass + Meal (oats:bran, 4:1)
Brumby and Hancock (1955)	Mixed breeds	Late (265 d)	7.0	3.0	43	50	4 wk	Pasture only
Bines et al. (1980)	Friesian	7 mo	18.0	2.3	12.5	30	1 wk	Hay concentrate
Davis et al. (1983)	Jersey	3-6 mo	16.2	3.0	18.7	40	4 wk	Complete diet
Machlin (1973)	Holstein	NR	13.3	3.3	25	33	10 d	Complete diet
Machlin (1973)	Holstein	NR	14	5.0	35	40	8 wk	Complete diet
Peel et al. (1983)	Holstein	Early	28	4.3	14	44	10 d	Complete diet
Peel et al. (1983)	Holstein	Late	12	3.9	31	44	10 d	Complete diet

[a]GH = growth hormone.
NR = not reported.
From Collier, R. J., J. P. McNamara, C. R. Wallace and M. H. Dehoff. Endocrine regulation of metabolism during lactation. J. Anim. Sci. (In Press).

Table 2. Effect of Growth Hormone and Thyroxine on Milk Yield, Milk Fat % and Milk Fat Yield

	Growth Hormone[1]				Thyroxine[2]			
Parameter	Control	Treatment	SEM	Δ(%)	Control	Treatment	SEM	Δ(%)
Milk yield (kg/day)	16.2	19.2	0.2	+18.7	15.5	19.4	0.4	+24.8
Milk fat %	4.86	5.11	0.08	+5.1	4.63	5.41	0.14	+16.5
Milk fat yield (g/udder half)	370.7	495.6	29.6	+33.7	365.6	527.6	12.1	+44.3

[1]40 mg/day Miles Lot #12
[2]25 ng/day

Table 3. Effect of Growth Hormone and Thyroxine on Mammary Blood Flow and Cardiac Output in Jersey Cows

	Growth Hormone[1]				Thyroxine[2]			
Parameter	Control	Treatment	SEM	Δ(%)	Control	Treatment	SEM	Δ(%)
Half udder blood flow (L/min)	2.43	3.22	0.06	+31.5	2.57	4.04	0.07	+57.3
Cardiac output (L/min)	46.20	50.30	1.07	+8.8	45.44	51.30	1.36	+11.2

[1]40 mg/day Miles Lot #12
[2]25 mg/day

Table 4. Effect of Growth Hormone and Thyroxine on Mammary Acetate and Glucose Uptake

Parameter	Growth Hormone[1]				Thyroxine[2]			
	Control	Treatment	SEM	Δ(%)	Control	Treatment	SEM	Δ(%)
Arterial glucose (mg %)	70.7	70.7	0.8	0.0	66.78	78.7	1.5	+17.9
Glucose uptake (mg/min)	429.3	507.4	15.5	+18.2	36.3	484	16.7	+34.7
Acetate A-V (mg %) difference	6.62	7.79	0.54	+17.6	6.62	6.15	0.42	-7.1
Acetate uptake (mg/min)	160.9	250.8		+55.9	170.1	248.5		+46.1

[1] 40 mg/day Miles Lot #19
[2] 25 mg/day

Table 5. Effect of Growth Hormone and Thyroxine on Free Fatty Acid Supply and Triglyceride Uptake at the Mammary Gland.

	Growth Hormone[1]				Thyroxine[2]			
Parameter	Control	Treatment	SEM	Δ(%)	Control	Treatment	SEM	Δ(%)
Art [FFA] (μeq/L)	302.2	361.2	34.5	0	377.4	444.1	27.6	+17.6
FFA Supply (μeg/L)	734.3	1163.1	98.0	+58.4	969.9	1794.2	159.1	+84.9
Art [TG] (ng/100 ml)	33.3	35.2	1.4	0	32.3	27.0	1.4	-32.3
TG A-V diff (ng/100 ml)	14.7	14.3	1.3	0	8.62	5.35	0.60	-61.1
TG Uptake (ng/100 ml)	364.8	468.3	39.1	+28.4	239.3	194.4	26.6	-23.1

[1]40 mg/day Miles Lot #19
[2]25 mg/day