THE EFFECTS OF NUTRIENT INTAKE AND PROTEIN DEGRADABILTY ON THE GROWTH AND DEVELOPMENT OF HOLSTEIN CALVES

by

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B.S., Western Kentucky University, 1987

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Ruminant Nutrition

Dept. of Animal Sciences and Industry

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1989

Approved by:

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Effect of nutrition on mammary development

Normal age at first calving for many large dairies is between 26 and 30 mo of age. Current recommendations are that Holstein heifers calve at 24 mo of age and weigh from 550 to 600 kg. This decrease in calving age will result in a reduction in feed costs and allow an earlier return on investments.

Any changes in feeding and management of heifers must be made without impairing future milk production. There is some disagreement on how fast heifers should be grown. Recent reports suggest that rapid growth may be detrimental to mammary secretory cell development.

The mammary gland consists of ductular and secretory alveolar epithelial cells (parenchyma) embraced in a heterogeneous matrix of other cell types, including myoepithial cells, adipocytes, fibroblasts, and smooth muscle. These latter four cell types comprise the stroma. In addition, leukocytes, lymphocytes, cells associated with the vascular system, and neurons are found in the mammary gland. Increasing the number of mammary alveolar epithelial cells has the potential to increase efficiency of milk production (Tucker, 1987).

Approximately 12% of total mammary growth occurs before puberty, as much as 48% occurs during gestation, and the remainder occurs during early lactation. At birth the mammary gland consists of a restricted immature duct system and a stromal portion that is proportionally larger and in mature form (Tucker, 1987). Before puberty there is an ordered extension of ducts within the stromal portion. There is an inhibitory zone around each duct into which other ducts cannot penetrate and in normal circumstances lobulo - alveolar tissue is not formed. Throughout this period there is an accompanying increase in stroma, primarily as a result of cell enlargement rather than cell proliferation (Knight et al., 1982).

The trial by Swanson (1960) is one of the earlier works which compared the effects of rearing rates to subsequent milk yields. Using seven pairs of identical-twin, Jersey heifers, one twin was fed heavily while the other was fed at levels maintaining weight gains slightly below standards. Average FCM production of rapidly reared heifers was 85% that of the normal heifers in the first lactation.

In the previous study all twins calved at approximately 26 mo which negated the benefits of rapid rearing and produced overconditioned heifers. However, rapidly reared heifers which were mated early and calved at approximately 22 mo still produced less milk than conventionally reared heifers that calved at 26 mo (Gardner et al., 1988).

It was questioned whether decrease in milk production of rapidly grown heifers was caused by the rapid growth or the early breeding of the heifers. Little and Kay (1979) divided 110 British Freisian into 3 groups. Groups A and B were fed to gain in excess of 1 kg per day while group C was fed to never exceed .74 kg daily gain. Group A was bred at 43 wk of age while groups B and C were bred at 78 wk of age. Milk yield was significantly lower in all lactations for rapidly reared animals irrespective of the age at breeding.

The most critical time for nutrition to affect mammary development in dairy cattle is when the initial allometric development of mammary ductular network occurs (Waldo et al., 1988). Mammary growth is 1.6 times faster than body weight gain between birth and 2 mo of age. This value increases to 3.5 between 3 and 9 mo and then decreases to 1.5 from 9 to 12 mo of age (Sinha and Tucker, 1969). Therefore, the most critical time to influence mammary development by nutrition is from 3 to 9 mo because this is the period of most rapid prepubertal mammary growth (Waldo et al., 1988).

Sejrsen et al. (1982) investigated whether the allometric period of mammary growth is especially sensitive to high energy intakes. Six prepubertal and six postpubertal heifers were assigned to restricted or ad lib feeding. Average daily gain of heifers on restricted feeding was 613 g compared with 1218 g for heifers fed ad lib. Prepubertal heifers were slaughtered at 15 mo and postpubertal heifers were slaughtered at 21 mo and their mammary glands were removed for analysis. Mammary secretory tissue weight was 23 % less and DNA content was 32 % less for the ad lib fed heifers than for the heifers on restricted feeding in the prepubertal period. There was no difference in growth of mammary secretory tissues between the postpubertal heifers. This experiment suggests that heifers raised on high planes of nutrition during the allometric phase of mammary development will have less secretory tissue in their mammary glands than those raised at a normal growth rate. However, rapid growth after this period does not seem to affect mammary secretory tissue.

Similar results have been shown with beef heifers and lambs. Hereford heifers from 2 to 8 mo of age fed to gain 1 kg per day produced less milk than heifers fed to gain .55 kg per day. However, there was no difference in milk yields of heifers from 8 to 14 mo on either rate of gain (Johnsson and Obst, 1984). Increasing the rate of gain from 14 to 20 wk of age in lambs decreased the amount of parenchymal tissue in the mammary gland. However, increasing the rates of gain from 20 to 36 wk of age increased the parenchymal weight. (Johnsson and Hart, 1985).

In all the previously mentioned studies, the rates of gain were increased by increasing the amount of energy. This may have led to overconditioning of the animals. It may be possible to increase the rate of gain without fattening. Heifers fed higher concentrations of both energy and protein from 60 to 172 d of age had higher weights and wither heights than the heifers fed only higher concentrations of energy (Kertz et al., 1987). Heifers from 230 to 369 days of age that were fed higher amounts of protein and energy had higher gains and heart girth was increased over heifers that were fed a control grower; however, there was no effect on wither height. According to these workers, calves from 3 to 6 mo of age may gain up to 1 kg daily without fattening. However, what effect increasing both rate of gain and skeletal growth has on mammary development remains to be seen.

Adding fats to calf starter rations

The amount of dry matter that a calf will eat is limited. This will limit the amount of energy the calf can consume and will affect rate of gain. One way to increase the amount of energy received is to increase the energy density of the ration. This can be done by increasing the amount of concentrate fed. However, young calves need roughage in their diet for normal rumen papillary development. Addition of roughages to calf starter rations also tends to raise the pH of the rumen and thus stimulate the calf to eat more of the ration (Williams, 1985). Fats, which have a high metabolizable energy concentration, may provide a means of either maintaining or increasing the energy concentration while raising the proportion of roughage.

Gardner and Wallentine (1972) found addition of tallow to a calf starter enhanced kidney fat, external carcass fat cover and resulted in carcasses of a quality equivalent to those of milk fed calves. However, when 6% tallow was fed to calves from 5 wk to 16 wk of age, daily dry matter intake and rate of gain decreased significantly (Kay et al., 1970). Amos (1986) also reported a decrease in dry matter intake and rate of gain when 6-7% tallow was fed. However, when the tallow was reduced to 2% there was no influence on dry matter intake.

Positive results were observed when fats were fed in the form of whole seeds. Abdelgadir et al. (1984) reported greater feed consumption, higher gains and less scours with calves fed processed soybeans, compared to calves fed SBM and fat. Calves fed whole cottonseed had higher feed consumption and higher gains than the control calves (Anderson et al., 1982).

Palmquist and Jenkins (1980) reported that addition of fats to diets for ruminants tends to depress fiber digestion. More recently, Palmquist (1984) reported that fats which bypass the rumen do not cause the magnitude of reduction in digestibility as do fatty acids from tallow (total fiber digestion was reduced by 13% with tallow but only by 6% with calcium soaps of fatty acids). They concluded that bypass fats were an effective means of incorporating fat into dairy rations since rumen fermentation was less affected than with fatty acids and the digestibility of fat was high.

When 5 or 10% of protected tallow was fed in a steer finishing diet, feed intake and daily gain were decreased at the 10% amount but were increased at the 5% amount, compared with the control which contained no additional fat (Haaland et al., 1981). Those workers concluded that protected tallow should not be fed in excess of 5%. However, when a protected lipid was fed at 10 or 20% of a calf starter diet, feed intake was significantly lower at the 10% amount but not at the 20% amount, compared with the control which contained no additional fat (Fisher, 1980). Daily gain was lower than the control for calves on the 10% amount and higher for calves on the 20% amount. Feeding calcium soaps at 50, 100, or 200 g/kg dry matter of starter decreased feed intake and daily gain significantly, with the calves on the 50 g amount being the least affected and those on the 200 g amount the most affected (Fallon et al., 1986). As a result, it appears that feeding fats, both protected and unprotected, may be useful in calf starter rations, but amount should be limited.

Rumen bypass protein

Ruminants derive their intestinal protein supply from dietary protein which escapes ruminal degradation and microbial protein which is synthesized in the rumen. The combination of amino acids derived from these two sources constitutes the total supply to the animal.

The protein requirements of ruminants vary in relation to changing productive or physiological state. While microbial protein alone may be adequate for maintenance, slow growth or early pregnancy, it is inadequate for supporting fast growth, late pregnancy or early lactation (Kempton et al., 1977).

Traditionally, the protein requirements of ruminants have been described in terms of crude protein. It is now generally accepted that these systems do not describe accurately protein requirements. A new system based on 1) the nitrogen requirements of the rumen microbes and 2) the nitrogen requirements of the host animal tissue is used in the 1988 NRC Nutrient Requirements for Dairy Cattle.

Various methods are used to alter the amount of degradable protein in a ration :

Feed selection. Certain feeds are more soluble than others. Generally, decreasing the solubility increases the amount that will escape rumen degradation, but there are important exceptions and rumen solubility is not an accurate predictor of rumen escape potential. Blood meal, fish meal, corn gluten meal, brewers grains, and distillers dried grains are estimated to contain over 50% rumen undegradable protein in the crude protein fraction while corn, oats, barley, and soybeans contain only 20-40% rumen undegradable protein in the crude protein fraction.

Comparing calves that were fed either 30, 40, or 60% rumen degradable nitrogen (RDN), those on 30% RDN had significantly higher nitrogen retention than those at 45% RDN but not compared to those at 60% RDN. This may have been due to increased microbial protein production at 60% RDN (Cummins et al., 1982).

Heat treatment. Many of the feed processing methods either require or generate heat which will reduce protein degradability in the rumen. Pelleting and extruding of animal diets appear to protect protein from rumen degradation through the heat generated in the die. Heat treatment during solvent or pressure extraction of oilseeds also apparently increases the proportion of bypass protein in the resulting meals (Stern, 1981).

Heat treatment of soybean and sunflower meals reduced solubility of nitrogen 27 and 35%, respectively (Schingoethe and Ahrar, 1979). Amino acid composition of the heated meals was similar to the unheated meals. Heat treatment tended to reduce solubility of all amino acids in soybean meal to about the same extent whereas the relative solubility of several amino acids differed substantially between sunflower meal and heated sunflower meal.

Heat-treated SBM fed to cows, starting at 9 wk postpartum, increased milk production slightly during the first 8 wk when protein intake was limiting. In the later part of lactation when protein intake was more adequate, heat treatment of SBM had no effect on milk production (Ahrar and Schingoethe, 1979).

Feeding heat-treated SBM to young lambs had no effect on daily gain but did significantly increase feed efficiency (Hudson et al., 1969) and nitrogen retention (Nishimuta et al., 1973).

Beneficial effects have been seen when heat-treated whole soybeans were used. Heated soybeans fed to lactating cows increased milk production (Block et al., 1980, Mielke and Schingoethe, 1979, Smith et al., 1980). When extruded soybeans were fed to young calves, feed was utilized more efficiently compared to calves on SBM and fat (Daniels et al., 1973). Calves fed roasted soybeans had higher nitrogen retention than those fed microwave cooked soybeans (Prasad and Morrill, 1976). Calves consuming starters containing soybeans processed at 171^{0} C consumed more feed, gained more weight, had less scours, and less mortality than calves on SBM, SBM and fat, raw soybeans, or soybeans processed at 138^{0} or 191^{0} C (Abdelgadir et al., 1984).

It is important that appropriate temperature and heating times be employed for particular feeds, although the optimal conditions are often not known. Heating above the optimal temperature may over protect the dietary protein. Over-protected protein is that part of the bypass protein that is neither fermented in the rumen nor digested in the small intestine. The amount of over-protection depends on the degree of heat damage. The Maillard reaction between sugar aldehyde groups and the free amino groups of protein yields an amino-sugar complex which is responsible for much of the heat damage to protein when sugar is present. These linkages are more resistant to enzymatic hydrolysis than normal peptides. Even in the absence of sugars or carbohydrates, extensive heating causes unnatural amide bonds to form between the amino group of lysine and carbonyl groups of protein (Stern, 1981).

Chemical treatment. Certain chemical agents form reversible cross linkages with amino and amide groups which decrease solubility of proteins at the pH of the rumen. Chemically-treated proteins subsequently are made available by destruction of these linkages in the acidic abomasum (Chalupa, 1975). Agents investigated include tannins, formaldehyde, glutaraldehyde, glyoal and hexa-methylene tetramine (Kempton, 1977). Much more research has been done with formaldehyde than any of the others.

In calves fed 12 or 15% crude protein diets with or without formaldehyde-treated peanut meal, those on 12% crude protein had an increased rate of gain with the formaldehyde treated peanut meal. There were no differences between treatments at 15% crude protein (Faichney and Davies, 1973).

Lambs that were fed SBM treated with formalin retained significantly less nitrogen than the control lambs. However, when the SBM was treated with tannic acid the nitrogen retention was not significantly different than the control (Nishimuta et al., 1973).

Amino acid analogs. Structural manipulation of amino acids to create resistance to ruminal degradation is another potential method for rumen bypass of amino acids. Methionine hydroxy analog has been investigated in numerous studies, however, results have not been conclusive (Bishop, 1971, Olson and Grubaugh, 1974).

Rumen turnover. Rate of rumen turnover also influences the amount of protein degraded in the rumen. If flow rate is rapid, some highly soluble proteins may leave the rumen intact. Conversely, relatively insoluble proteins will be degraded if they are retained for long periods in the rumen (Kempton, et al., 1977).

Protection from ruminal degradation enables more amino acids to reach the intestine than otherwise would. Positive responses can be anticipated if the animal needs or can use more amino acids for maintenance plus production, but if amino acids supplies are adequate, additional quantities may produce zero or even negative responses (Chalupa, 1975).

THE EFFECTS OF NUTRIENT INTAKE AND PROTEIN DEGRADIBILITY ON THE GROWTH AND DEVELOPMENT OF HOLSTEIN CALVES.

INTRODUCTION

It is recommended that dairy heifers be bred such that they will calve at 24 mo of age. This necessitates feeding heifers adequately in order to ensure sufficient body condition to achieve conception at 15 mo of age. This can be accomplished by increasing the energy concentration of the diet. However, many times too much energy is fed which leads to overconditioning of heifers. This may impair future milk production. However, if all the major nutrients were simultaneously increased it may be possible to have them reach breeding and freshening size at an earlier age and/or reach larger mature weights without getting too fat.

Increasing the amount of protein that escapes ruminal protein degradation could result in improved protein nutrition or allow a decrease of total dietary protein. The 1988 NRC Nutrient Requirements for Dairy Cattle has made suggestions concerning the amount of dietary protein that should escape ruminal degradation; however, these values are not well tested. Information is needed concerning the effect of increasing ruminal protein bypass at different dietary protein concentrations for growing replacement heifers.

The three trials described herein were designed to provide information concerning these points.

MATERIALS AND METHODS

Trial 1

Sixty-seven Holstein heifer calves were used from birth to 8 wk of age. They were separated from their dams within 24 h postpartum. All calves were housed in outdoor hutches and bedded on straw. They were fed colostrum for 3 d, then whole milk until they were 3 wk of age, each at 8% of birth weight daily, fed in two equal feedings. From 3 to 4 wk of age they were fed milk at 4% of birth weight once daily, then weaned. Calves were fed a highly palatable, pelleted prestarter diet (Table 1) until a daily consumption of 227 g was reached. They were then fed, each day, a mixture of 227 g of prestarter and as much starter (Table 2) as they would consume. After 5 wk of age they were fed only the starter,which they could consume ad lib. Water was provided at all times, except during freezing weather when it was provided for an hour twice daily.

Calves were assigned to a block of four by age, then calves within a block were randomly assigned to one of four experimental starters. Composition of each calf starter is in Table 2. Starters A and B were formulated to provide, at estimated intake, 100% of NRC (1978) recommendations for energy, protein, calcium, phosphorous, and vitamins A, D, and

TABLE 1. Composition of prestarter.[1]

Ingredient	(%)
Whey, dried	46
7-60[2]	23
Skim milk, dried	19
Sodium caseinate	12
Additives[3]	+

[1]Calfweena™, Merricks, Union Center, WI.

[2]A mixture of milk solids and fat containing 7% protein and 60% animal fat.

[3]Includes chlortetracycline (200 g/ton), preservatives, vitamins, minerals, and flavoring compounds.

TABLE 2. Composition of calf starter in trial 1.

Starter	100% NRC A	100% NRC B	115% NRC C	115% NRC D
Ingredients, % as fed				
Alfalfa, ground	20	20	20	20
Corn, rolled	46	46	27	27
Oats, rolled	14	14	14	14
Molasses, wet	7	7	7	7
SBM, textured[1]	12	..	20	..
SBM, control	..	12	..	20
Prilled fat[2]	..	..	9	9
Dicalcium phosphate	.36	.36	.64	.64
Limestone, ground	.52	.52	.52	.52
Salt	.24	.24	.24	.24
Salt, trace mineral	.24	.24	.24	.24
Per kg feed				
Vitamin A, I.U.	2200	2200	2534	2534
Vitamin D, I.U.	304	304	356	356
Vitamin E, I.U.	55	55	64	64
Coccidostat[3], mg.	11	11	11	11
Analysis, as fed				
Dry matter	86.54	86.61	86.23	85.66
Crude protein	15.43	15.91	19.21	18.49
ADF	7.85	8.09	7.27	7.54

[1]TSP™, PMS Foods, Inc. Hutchinson, KS 67504.

[2]Energy Booster 100™, Milk Specialties Co., Dundee, IL 60118.

[3]Deccox™, brand of decoquinate, May & Baker Ltd.

E. Starters C and D were formulated to provide, at estimated intake, 115% of these nutrients. The supplemental protein source for A and C was a specially processed textured vegetable protein containing soy flour and caramel color with a crude protein of 50 %. Starters B and D contained soybean meal (SBM) as the supplemental protein source. The supplemental protein sources supplied 37 % of the total ration crude protein for starters A and B and 54 % of the total ration crude protein for starters C and D.

Amount of starter each calf consumed was recorded daily. Each calf was twice daily assigned a value for general appearance (good, fair or poor) and consistency of feces (1, normal through 4, watery; Larson, et al.,1977). Calves were weighed once weekly. At birth and at 8 wk of age wither height, body length (from point of shoulder to posterior edge of pin bone) and heart girth measurements were taken.

At 8 wk of age jugular blood was sampled and the separated serum was frozen until analyzed for different blood metabolites using the SMA12 analysis[1], which measures 14 blood metabolites, identified in Results section.

Trial 2

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[1]DACOS, Coulter Electronics, Inc., Hialeah, FL.

Sixty heifer and thirty-four bull calves were used from birth to 8 wk of age. Calves were fed colostrum for 3 d, then whole milk. Calves were weaned when they had eaten 681 g or more of the starter for three consecutive days.

Calves were assigned to a block of four by age, then calves within a block were randomly assigned to one of four treatment diets. Composition of each starter is in Table 3. Starters were formulated to contain two different amounts of fat and two different amounts of rumen degradable protein. The supplemental protein source used was SBM. Two of the starters contained a control SBM while the other two contained SBM extruded at 300^{0} F with an Insta Pro Dry Extruder, model 2000.

Amount of starter each calf consumed was recorded daily. Each calf was twice daily assigned a value for general appearance and consistency of feces as in Trial 1, and was weighed weekly. At birth and at 8 wk of age wither height, length and heart girth measurements of heifer calves were recorded. At 8 wk of age, blood samples from heifer calves were taken for SMA12 determination as in Trial 1.

Trial 3

One hundred and twelve Holstein heifers were used from 10 to 26 wk of age. Within each treatment, heifers were housed together from 10 to 18 wk of age and from 18 to 26 wk of age.

Heifers from Trials 1 and 2 were used for Trial 3.

TABLE 3. Composition of calf starter in trial 2.

Starter	1	2	3	4
Ingredients, % as fed				
Alfalfa, ground	20	20	20	20
Oats, rolled	15	15	15	15
Corn, cracked	39	39	39	39
SBM, control[1]	18	..	18	..
SBM, extruded[1]	..	17	..	17
Molasses, wet	6	6	6	6
Soy oil	1.5	1.5	1.5	1.5
Prilled fat[2]	..	..	2.5	2.5
Salt	.25	.25	.25	.25
Salt,trace mineral	.25	.25	.25	.25
Dicalcium phosphate	.29	.29	.23	.23
Limestone, ground	.87	.87	1.2	1.2
Vitamins ADE[3]	**	**	**	**
Coccidiostat[4]	**	**	**	**
Analysis, as fed				
Dry matter	86.43	86.51	86.54	86.61
Crude protein	18.61	18.22	17.83	20.26
ADF	7.54	7.63	7.62	7.77

[1]Triple "F" Products, Des Moines, IA 50322.

[2]Energy Booster 100™, Milk Specialties Co., Dundee, IL 60118.

[3]To provide 2200 IU A, 308 IU D and 55 IU E per kg feed.

[4]Deccox™ brand of decoquinate, May & Baker ,to provide 11 mg per kg of feed.

Heifers were assigned to a block of four by age, then heifers within a block were randomly assigned to one of four treatments. Brome hay was fed free choice. Amount of grower and hay, at estimated intake, provided either 100% or 115% of NRC (1978) recommendations for protein, energy, calcium, phosphorous, and vitamins A, D, and E. Composition of each grower is in Table 4. The supplemental protein sources were control and extruded SBM. The SBM was extruded, as in Trial 2, to decrease the amount that would be degraded in the rumen. Water was available at all times. All calves were group fed.

Each week, individual body weights were taken. Average daily feed consumption for each treatment was determined for that week. At 18 and 26 wk of age body measurements (height, length, heart girth) were taken. At 26 wk of age, visual body scores (1, thin to 5, fat) were recorded.

Statistical Analysis

Data were analyzed by analysis of variance using the general linear models (GLM) procedure of SAS (SAS Institute, Inc., 1982). Included in the analysis of variance model for analysis were block, treatment, amount of rumen degradable protein, percent NRC recommendations for trials 1 and 3, and amount of fat for trial 2. All interactions were considered. Significant differences were detected by separating LS means using a protected least significant difference test.

TABLE 4. Composition of calf grower in trial 3.

	RATION[1]			
	LC	LE	HC	HE
Ingredients, % as fed				
Corn, cracked	65	65	66	66
Oats, rolled	15	15	15	15
SBM, extruded[2]	..	18	..	16
SBM, control[2]	18	..	16	..
Limestone, ground	2	2	1.9	1.9
Salt	.25	.25	.25	.25
Salt, trace mineral	.25	.25	.25	.25
Per kg feed				
Vitamin A, I.U.	2200	2200	2530	2530
Vitamin D, I.U.	308	308	354	354
Vitamin E, I.U.	55	55	64	64
Coccidiostat[3], mg	24	24	24	24
Analysis, as fed				
Dry matter	87.16	87.49	87.22	87.38
Crude protein	11.36	11.21	14.63	12.85
ADF	9.42	7.91	6.26	7.73

[1]L=lower nutrient amount, H=higher nutrient amount, C=control SBM, E=extruded SBM.

[2]Triple "F" Products, Des Moines, IA 50322.

[3]Deccox™, brand of decoquinate, May & Baker.

RESULTS AND DISCUSSION

TRIAL 1

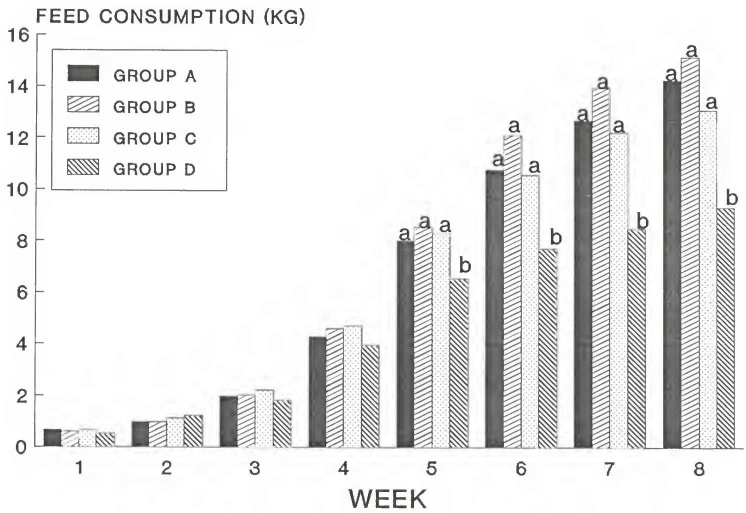
Feed consumption

Mean weekly feed consumption for the four treatment groups is shown in Figure 1. In the pre-weaning period (wk 1-4) there were no significant differences in feed consumption among the four groups. However, group D did not appear to adapt to the dry feed as well as the other three groups.

In the post weaning period (wk 5-8), there was an interaction between the nutrient amount and type of SBM, where calves on the 100% NRC receiving the control SBM consumed more feed than those on the textured SBM but those on the 115% amount receiving the textured SBM consumed more feed than calves receiving the control SBM.

Even though group C did not consume the most feed they did consume the most nutrients because their feed was more nutrient-dense than groups A and B. They consumed 10% more nutrients than group A, 2% more than group B and 25% more than group D. Group D consumed less feed than any of the other three groups ($P<.05$). The decreased intake of these calves may have been due to the increased softness of the pellets, which created a fine feed that crumbled easily. It may also have been due to the amount of fat. Even though a rumen bypass fat

Figure 1. Feed consumption of calves fed 100% of NRC recommended nutrients with textured (group A) or control (group B) SBM and calves fed 115% of NRC recommendations with textured (group C) or control (group D) SBM. Means within a week with different superscripts differ (P<.05).

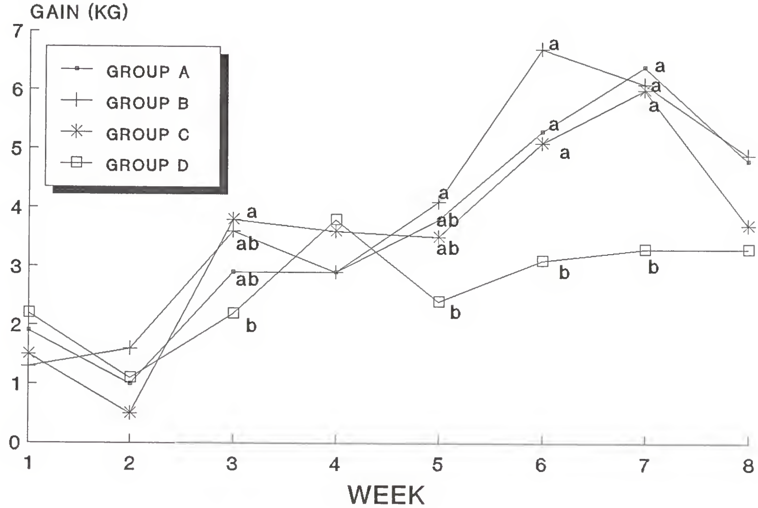

FEED CONSUMPTION (KG)
16
14
12
10
8
6
4
2
0
GROUP A
GROUP B
GROUP C
GROUP D
a
b
1
2
3
4
5
6
7
8
WEEK

was used, 9% is a large amount and may have affected palatability. Similar decreases in intake were seen when protected fats were fed at 10% of the ration dry matter but not when it was fed at 20% (Fisher, 1980). Inclusion of calcium soaps of fat at 50, 100, or 200 g/kg DM in rations of calves from 14-17 d of age decreased DMI significantly with increasing fat (Fallon et al., 1986). Why the fat affected the pellets for group D more than it did the pellets fed to group C is not easily explained. The only difference between the two rations was the type of SBM. Perhaps the textured SBM included in the ration for group C gave the pellet more substance. The increased intake of group C might also have been the result of a more desirable calorie to protein ratio at the small intestine because of the greater amount of protein escaping ruminal degradation.

Weight gain

The mean weekly gains of calves for the four treatment groups are shown in Figure 2. There were no significant differences in birth weights between the four groups. In the pre-weaning period there were no differences in gain except at wk 3. Group C gained more weight than group D ($P<.05$). In the post-weaning period, group D gained less than group B during wk 5 ($P<.05$). Group D gained less than the other three groups in both wk 6 and wk 7 ($P<.05$). There were no

Figure 2. Weekly gains of calves fed 100% of NRC recommended nutrients with textured (group A) or control (group B) SBM and calves fed 115% of NRC recommendations with textured (group C) or control (group D) SBM. Means within a week with different superscripts differ ($P<.05$).


GAIN (KG)
GROUP A
GROUP B
GROUP C
GROUP D
WEEK

significant differences in gains at wk 8, although group C and D numerically displayed less gain than groups A and B.

Group B had the highest total gain (31.0 kg). Groups A and C gained 29.1 and 28.7 kg, respectively. Group D gained less (21.5 kg) than the other three groups ($P<.01$). The ending weights for the four groups were 70, 72, 70, and 60 kg for A, B, C, and D respectively. Group D's ending weight was less than the other three groups ($P<.01$).

Fecal score

The mean weekly fecal scores are in Figure 3. In most weeks groups C and D, which were fed the added fat in their rations, had numerically higher fecal scores (looser feces) than groups A and B. In week 7, group C had a higher fecal score than the other three groups ($P<.05$). In wk 8 group D had a higher fecal score than group A ($P<.05$). Average fecal scores for the 8 wk period were 1.12, 1.10, 1.17 and 1.14 for A, B, C and D, respectively, with group C being higher than group B ($P<.05$).

Body measurements

Body measurements taken at birth and at 8 wk are in Table 5. There were no differences in wither height at birth between the four groups. At 8 wk group D wither height was shorter than groups A and C ($P<.05$).

Figure 3. Weekly fecal scores of calves fed 100% of NRC recommended nutrients with textured (group A) or control (group B) SBM and calves fed 115% of NRC recommendations with textured (group C) or control (group D) SBM. Means within a week with different superscripts differ ($P<.05$).

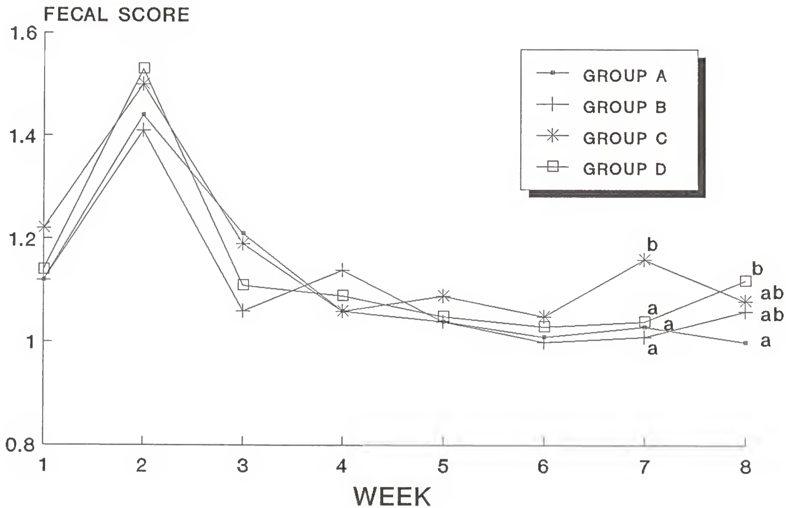

FECAL SCORE
1.6
1.4
1.2
1
0.8
1
2
3
4
5
6
7
8
WEEK
GROUP A
GROUP B
GROUP C
GROUP D
b
a
a
a
b
ab
ab
a

TABLE 5. Body measurements of calves in trial 1.

	100% NRC		115% NRC		
	A[1]	B[2]	C[1]	D[2]	SE
Height					
Birth	75.0	74.8	75.5	73.4	0.76
8 wks	82.6[a]	82.3[ab]	82.5[a]	79.9[b]	0.91
Increase	7.7	7.5	7.0	6.4	0.75
Length					
Birth	71.3	71.2	71.7	69.8	1.26
8 wks	83.1[a]	84.4[a]	83.5[a]	78.6[b]	1.33
Increase	11.8[ab]	13.2[a]	11.8[ab]	8.7[b]	1.44

[a,b] Means in same row with different superscripts differ (P<.05).

[1] Ration contained textured SBM.

[2] Ration contained control SBM.

Length of body measurements did not differ among treatments at the time of birth. Increase in length from birth to 8 wk was the shortest for group D and differed significantly from group B (P<.05).

Blood metabolites

The mean blood metabolite concentrations are in Table 6. Groups C and D had higher urea nitrogen concentrations than A and D (P<.05). This was probably due to the increased amount of protein in their diets. It may also be due to the added fat in their rations. When calcium soaps of fat were added to the diets of young calves rumen ammonia was significantly increased (Fallon et al., 1986). Increases in blood urea nitrogen are positively correlated with increases in rumen ammonia concentration (Rowlands et al., 1980).

Groups C and D had lower (P<.05) alkaline phosphatase concentrations than groups A and B.

Group A had a higher (P<.05) globulin concentration than any of the other three groups, although there were no significant differences in total protein or albumin between the four groups.

Groups C and D had lower calcium levels than A and B, even though their ration contained more calcium. This may have been due to the fat tying up the calcium.

TABLE 6. Blood metabolites of calves in trial 1.

	100% NRC		115% NRC	
Ration	A[1]	B[2]	C[1]	D[2]
Metabolite				
Sodium (mmol/L)	140	139	139	140
Potassium (mmol/L)	5.4	5.4	5.3	5.3
Chloride (mmol/L)	100	100	101	101
Carbon dioxide (mmol/L)	26.7	26.4	26.1	26.3
Glucose (mg/dL)	79.5	82.9	77.0	71.8
Urea nitrogen (mg/dL)	7.4[a]	8.0[a]	11.7[b]	11.9[b]
Creatinine (mg/dl)	0.95	0.93	0.94	1.01
Alkaline phosphatase (U/L)	291[a]	334[a]	173[b]	157[b]
Total protein (g/dL)	6.1	6.0	5.8	5.9
Globulin (g/dL)	2.9[a]	2.6[b]	2.5[b]	2.6[b]
Albumin (g/dL)	3.2	3.4	3.4	3.3
A/G ratio	1.14[a]	1.32[b]	1.41[b]	1.34[b]
Calcium (mg/dL)	10.9[a]	10.9[a]	10.6[ab]	10.4[b]
Phosphorus (mg/dL)	8.2	7.9	8.2	8.2

[a,b] Means within a row with different superscripts differ ($P<.05$).

[1] Ration contained textured SBM.

[2] Ration contained control SBM.

Summary

Increasing the amount of nutrient concentration did not improve calf performance when energy was increased by adding fat. This was due, in part, to the fact that the fat added to increase the energy concentration decreased consumption. It is also probable that the large amount of fat being fed exceeded the lipolytic activity in the intestine of the calf. When 50, 100 or 200 g of calcium soaps of fat per kg DM were fed to calves between 14 and 77 d of age, only the 50 g amount of fat was efficiently digested (Fallon et al., 1986) When 6% tallow was fed in a calf starter, the caloric value of the feces was 7% higher than that of calves which received no additional fat (Kay et al., 1970).

There was an interaction effect between the nutrient concentration and the type of SBM for total gain ($P<.05$), where the calves on the control SBM gained more than those on the textured SBM at the 100% NRC amount but calves on the textured SBM gained more than those on the control SBM at the 115% NRC amount.

Differences between the control and textured SBM-fed calves at the 100% amount may have been due to the fact that the protein supply was adequate; therefore, the additional by-pass protein provided by the textured SBM may have been in excess of the calf requirements.

Comparing the calves at the 115% amount, the difference in gain between the control and textured SBM appeared to be primarily related to feed consumption. Calves on the control SBM consumed significantly less than those on the textured SBM. This may have been due, in part, to the increased softness of the pellets. The increased performance of the calves on the textured SBM may also have been due to a more desirable energy to protein ratio.

TRIAL 2

Feed consumption

Mean weekly feed consumption levels for the four groups are in figure 4. From wk 5 through wk 8 groups 3 and 4, whose rations contained the added bypass fat, tended to consume less feed than groups 1 and 2, with group 4's consumption being significantly less ($P<.05$) than group 2's at wk 8. Starting at wk 3, there was a trend for group 2 to consume more feed than the other three groups during each week. Total feed consumption for the 8 wk period was 50.5, 53.1, 49.1 and 49.1 kg for groups 1, 2, 3 and 4, respectively.

Weight gain

Mean weekly gains for the four groups are in figure 5. There were no differences in gains except at wk 5 when group 2 gained more than group 3 ($P<.01$). Total gains for the 8 wk

Figure 4. Feed consumption of calves fed no bypass fat with either control SBM (group 1) or extruded SBM (group 2) and calves fed 2.5 % bypass fat with either control SBM (group 3) or extruded SBM (group 4). Means within a week with different superscripts differ ($P<.05$).

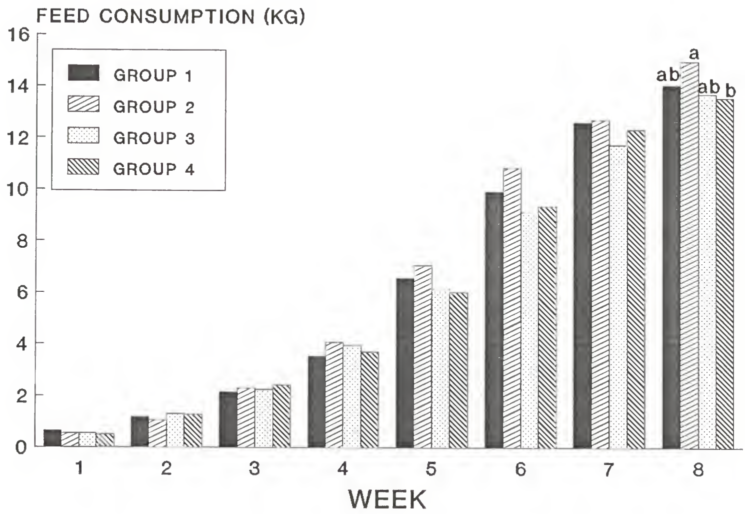
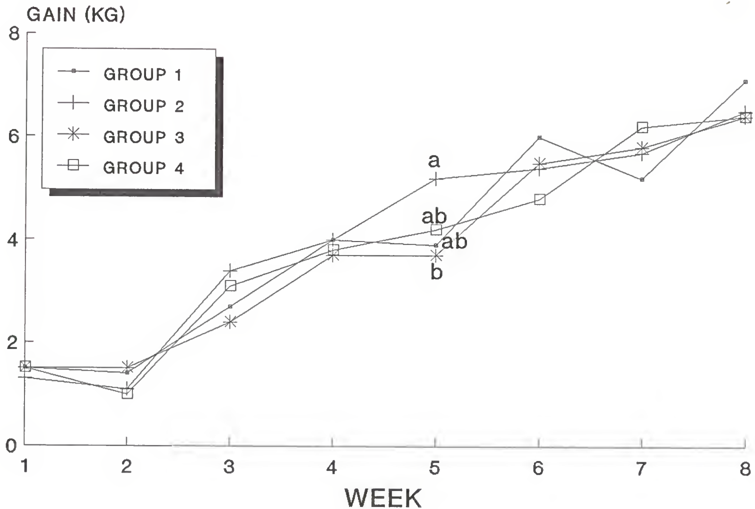

FEED CONSUMPTION (KG)
16
14
12
10
8
6
4
2
0
GROUP 1
GROUP 2
GROUP 3
GROUP 4
ab
a
ab
b
1
2
3
4
5
6
7
8
WEEK

Figure 5. Weekly gains of calves fed no bypass fat with either control SBM (group 1) or extruded SBM (group 2) and calves fed 2.5 % bypass fat with either control SBM (group 3) or extruded SBM (group 4). Means within a week with different superscripts differ ($P<.01$).


GAIN (KG)
8
6
4
2
0
GROUP 1
GROUP 2
GROUP 3
GROUP 4
a
ab
ab
b
1
2
3
4
5
6
7
8
WEEK

period were 31.6, 32.8, 30.4 and 31.2 kg and the end weights were 74, 73, 72 and 71 kg for groups 1, 2, 3 and 4, respectively.

Fecal scores

Mean weekly fecal scores are in figure 6. There were no significant differences in fecal scores among the four groups for any of the weeks during the 8 wk trial. The average fecal scores for the 8 wk were 1.19, 1.17, 1.20 and 1.16 for 1, 2, 3 and 4, respectively.

Body measurements

Body measurements for the four groups are in Table 7. There were no differences in wither height at birth. At 8 wk, groups 3 and 4 were shorter ($P<.05$) than group 1. There were no statistical differences in the increase in wither height from birth to 8 wk, but groups 1 and 2 grew more than groups 3 and 4.

There were no significant differences in either length of body or heart girth measurements at birth or at 8 wk and no differences in the increase in length or heart girth from birth to 8 wk.

Blood metabolites

Blood metabolites for the four groups are in Table 8.

Figure 6. Weekly fecal scores of calves fed no bypass fat with either control SBM (group 1) or extruded SBM (group 2) and calves fed 2.5 % bypass fat with either control SBM (group 3) or extruded SBM (group 4).

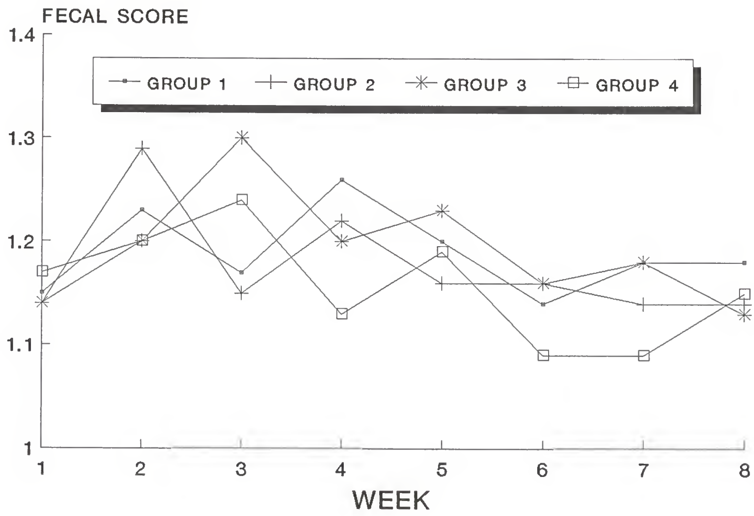

FECAL SCORE
1.4
1.3
1.2
1.1
1
GROUP 1
GROUP 2
GROUP 3
GROUP 4
1
2
3
4
5
6
7
8
WEEK

TABLE 7. Body measurements of calves in trial 2.

	No bypass fat		2.5% bypass fat		
	1[1]	2[2]	3[1]	4[2]	SE
Height					
Birth	75.7	74.6	74.0	74.4	0.70
8 wks	84.1[a]	83.4[ab]	81.2[b]	81.7[b]	0.78
Increase	8.3	8.9	7.7	7.3	0.63
Length					
Birth	72.9	72.2	71.6	71.7	0.82
8 wks	83.5	85.5	83.6	83.9	0.94
Increase	10.5	13.3	11.9	12.2	1.06
Heart girth					
Birth	80.0	79.0	78.9	78.4	0.98
8 wks	96.3	95.9	94.7	93.8	1.06
Increase	16.3	17.0	15.8	15.3	0.80

[a,b] Means in same row with different superscripts differ significantly ($P<.05$).

[1] Ration contained control SBM.

[2] Ration contained extruded SBM.

TABLE 8. Blood metabolites of calves in trial 2.

	No bypass fat		2.5 % bypass fat	
	1[1]	2[2]	3[1]	4[2]
Metabolite				
Sodium (mmol/L)	142[a]	143[ab]	143[ab]	144[b]
Potassium (mmol/L)	5.2	5.3	5.3	5.4
Chloride (mmol/L)	100	100	102	102
Carbon dioxide (mmol/L)	29.5	29.2	28.9	29.4
Glucose (mg/dL)	85.5	85.3	80.4	80.8
Urea nitrogen (mg/dL)	9.0	9.5	10.1	9.5
Creatinine (mg/dl)	1.03	0.99	1.03	0.99
Alkaline phosphatase (U/L)	301	295	243	244
Total protein (g/dL)	6.0	6.1	6.0	6.0
Globulin (g/dL)	3.3	3.4	3.3	3.3
Albumin (g/dL)	2.6	2.7	2.7	2.8
A/G ratio	1.3	1.3	1.3	1.3
Calcium (mg/dL)	10.5	10.6	10.4	10.3
Phosphorus (mg/dL)	7.6	7.9	7.6	8.0

[a,b] Means within a row with different superscripts differ (P<.05).

[1] Ration contained control SBM.

[2] Ration contained extruded SBM.

Group 1's sodium level was significantly less (P<.05) than group 4's. The reason for this is not apparent. There were no other differences between the four groups for any of the other metabolites.

Summary

There were no significant interactions between type of protein supplement and energy concentration.

There were no statistical differences between the calves which received the bypass fat and those which did not. However, the trend favored the calves which did not receive the additional fat. They tended to have higher gains (32.2 vs 30.8 kg), higher feed consumption (51.8 vs 49.1 kg), and greater increases in wither height (8.6 vs 7.5 cm) and heart girth (16.7 vs 15.6).

There were no statistical differences between calves on the extruded and control SBM. However, calves which received the extruded SBM tended to have higher feed consumption (51.1 vs 49.8 kg), higher gains (32.0 vs 31.0 kg), and a greater increase in length (12.8 vs 11.2 cm).

TRIAL 3

The weights and body measurements of heifers from 10-18 wk of age are in Table 9 and of heifers from 18-26 wk of age are in Table 10.

TABLE 9. Growth measurements of heifers from 10-18 wk of age.

	RATION[1]				
	LC	LE	HC	HE	SE
Weight, kg					
10 wk	76.4	78.0	78.4	77.1	1.5
18 wk	115.0^{acd}	118.0^{abc}	125.2^{bd}	124.6^{bd}	2.2
ADG, kg					
10-18 wk	$.69^{a}$	$.71^{a}$	$.84^{b}$	$.85^{b}$	1.1
Wither height, cm					
10 wk	82.5	83.3	82.9	82.4	0.7
18 wk	90.8^{acd}	91.7^{abd}	92.3^{abcd}	93.4^{bd}	0.6
Increase, cm					
10-18 wk	8.3^{acd}	8.4^{acd}	9.4^{bc}	11.0^{bd}	0.5
Length, cm					
10 wk	84.4	84.9	82.9	84.2	0.9
18 wk	95.7^{c}	97.5^{cd}	98.2^{d}	97.5^{cd}	0.8
Increase, cm					
10-18 wk	11.3^{a}	12.6^{ab}	15.3^{b}	12.7^{ab}	1.1
Heart girth, cm					
10 wk	96.6	98.2	97.0	95.9	1.0
18 wk	113.6^{c}	115.0^{cd}	117.0^{d}	116.3^{cd}	1.1
Increase, cm					
10-18 wk	16.2^{c}	16.5^{c}	19.1^{cd}	19.9^{d}	1.1

[1] L=lower nutrient amount, H=higher nutrient amount, C=control SBM, E=extruded SBM.

^{ab}Means in same row with different superscripts differ (P<.01).

^{cd}Means in same row with different superscripts differ (P<.05).

TABLE 10. Growth measurements of heifers from 18-26 wk of age.

	RATION[1]				
	LC	LE	HC	HE	SE
Weight, kg					
18 wk	115.0[acd]	118.0[abc]	125.2[bc]	124.6[bd]	2.2
26 wk	153.5[a]	155.5[a]	169.8[b]	170.3[b]	2.9
ADG, kg					
18-26 wk	.69[a]	.67[a]	.80[b]	.81b[b]	1.3
Wither height, cm					
18 wk	90.8[acd]	91.7[abd]	92.3[abcd]	93.4[bd]	0.6
26 wk	101.8[a]	102.5[a]	104.4[b]	105.0[b]	0.7
Increase, cm					
18-26 wk	11.0	10.8	12.1	11.6	0.5
Length, cm					
18 wk	95.7[c]	97.5[cd]	98.2[d]	97.5[cd]	0.8
26 wk	105.7[ac]	108.4[abd]	110.4[bcd]	109.5[bcd]	1.0
Increase, cm					
18-26 wk	10.1[c]	10.9[cd]	12.2[d]	11.9[cd]	0.8
Heart girth, cm					
18 wk	113.6[c]	115.0[cd]	117.0[d]	116.3[cd]	1.1
26 wk	124.3[ac]	126.6[abcd]	129.2[bcd]	128.3[abd]	1.3
Increase, cm					
18-26 wk	10.7[cd]	9.9[c]	12.1[d]	11.9[d]	0.7

[1] L=lower nutrient amount, H=higher nutrient amount, C=control SBM, E=extruded SBM.

[ab]Means in same row with different superscripts differ (P<.01).

[cd]Means in same row with different superscripts differ (P<.05).

There were no differences in weights among the four groups at the start of the trial. At 18 wk of age and at 26 wk of age, heifers on the higher nutrient amount receiving control SBM (HC) and extruded SBM (HE) weighed more (P<.01) than those on the lower nutrient amount receiving control SBM (LC) and extruded SBM (LE). The ADG was greater (P<.01) for HC and HE heifers than for LC and LE heifers in both the 10-18 wk period and the 18-26 wk period. There were no differences in weights or ADG between LC and LE heifers or between HC and HE heifers.

Comparing the weights at 10, 18 and 26 wk of age to the Beltsville (Matthews and Fohrman, 1954) growth standard, which has been the primary standard used for years and is still used some today, heifers on all four treatments were underweight. They were also under the weights reported by Heinrichs and Hargrove (1987) for herds with > 7264 kg herd average milk yield at 10 and 18 wk of age. LC and LE heifers were underweight, while HC and HE heifers were at the reported weight at 26 wk of age. Because of recent studies which indicate that high rates of gain in the prepartum period may be detrimental to future milk production, a new set of goals which are lower than the old standards was suggested by Waldo, et al. (1988). Compared to those standards, the heifers at 10 wk of age were still below the desired weight. However, at 18 and 26 wk of age, heifers on LC and LE were near the desired weight, but heifers on HC and HE exceeded that weight.

There were no differences in wither height at 10 wk of age. By 18 wk of age, heifers on HE had an increase in height greater than LC and LE (P<.001) and HC (P<.05) heifers. The wither height was greater for heifers on HC and HE than those on LC and LE (P<.01) at 26 wk of age; however, the increases in height from 18-26 wk were not significantly different.

The wither heights for all heifers at 10 wk of age are below heights reported by Heinrichs and Hargrove (1987). However, at 18 wk of age, LC and LE heifers were under, while HC and HE were near the suggested height. At 26 wk of age, LC and LE heifers were at the suggested height, while HC and HE heifers were over this height.

There were no differences in lengths at the start of the trial. The increase in length for HC heifers was greater than for LC heifers from 10-18 wk (P<.01) and from 18-26 wk (P<.05). The actual length was greater for HC heifers than for LC heifers (P<.05) at 18 wk. At 26 wk, the LC heifers' length was shorter than the lengths of LE (P<.05), HC and HE (P<.01) heifers.

There were no differences in heart girths at 10 wk of age. At 18 wk of age, heifers on LC had a lower heart girth measurement than heifers on HC (P<.05). The increase from 10 to 18 wk of age was less for heifers on LC and LE than for heifers on HE (P<.05). At 26 wk of age, heifers on LC had a lower heart girth than heifers on HC (P<.01) and HE (P<.05). The increase in heart girth from 18 to 26 wk of age was less for LE than for HC and HE (P<.05).

The ADG and increase in body measurements from 10 to 26 wk of age are in Table 11. The heifers on HE and HC gained more weight (P<.01) and had a greater increase (P<.05) in all three body measurements than the heifers on LC and LE for the 16 wk trial. There were no statistical differences or set patterns between the heifers on LC and LE or between the heifers on HC and HE.

The ending body scores were not significantly different. Heifers on the higher nutrient amount scored 3.00 and those on the lower nutrient amount scored 2.95.

The average daily hay consumption is in Table 12. Hay consumption was less (P<.05) for heifers on the 115% NRC amount than for those on the 100% NRC amount in both the 10-18 wk period and the 18-26 wk period. This was expected and accounted for because of the lower amount of concentrate being fed to these animals. Actual hay consumption was higher than what was estimated when formulating the rations. Actual percent of the NRC recommended nutrients that the heifers received were 107, 108, 125, and 124 % for LC, LE, HC and HE, respectively, in the 10-18 wk period. In the 18-26 wk period heifers received 109, 105, 129, and 125 % of NRC recommendations for LC, LE, HC and HE, respectively.

TABLE 11. Growth measurements of heifers in trial 3.

	RATION[1]			
10-26 wks of age	LC	LE	HC	HE
Gain, kg	77.1^{a}	77.6^{a}	91.6^{b}	93.2^{b}
ADG, kg	$.69^{a}$	$.69^{a}$	$.82^{b}$	$.83^{b}$
Increase, cm				
wither height	19.3^{acd}	19.2^{acd}	21.4^{bc}	22.5^{bd}
length	21.3^{acd}	23.5^{abc}	27.5^{bd}	25.2^{bd}
heart girth	27.8^{a}	26.1^{a}	31.2^{b}	32.0^{b}

[1] L=lower nutrient amount, H=higher nutrient amount, C=control SBM, E=extruded SBM.

^{ab}Means in same row with different superscripts differ (P<.01).

^{cd}Means in same row with different superscripts differ (P<.05).

TABLE 12. Average daily gain and hay consumption for pens in trial 3.

	RATION[1]			
	LC	LE	HC	HE
10-18 wk of age				
ADHay, kg.	1.21[acd]	1.29[abc]	0.98[bd]	0.95[bd]
18-26 wk of age				
ADHay, kg.	2.93[a]	2.73[a]	2.46[b]	2.26[b]

[1] L=lower nutrient amount, H=higher nutrient amount, C=control SBM, E=extruded SBM.

[ab]Means in same row with different superscripts differ (P<.01).

[cd]Means in same row with different superscripts differ (P<.05).

[fg]Means in same row with different superscripts differ (P<.05).

Summary

There was a significant increase in gain (P<.01) by increasing the amounts of nutrients from both 10-18 wk and 18-26 wk of age. Heifers on the higher nutrient amount gained 47 kg between 10 and 18 wk vs 39 kg for the heifers on the lower nutrient amount. From 18 to 26 wk heifers on the higher amount gained 45 kg while heifers on the lower amount gained 38 kg. This increased rate of gain exceeds that recommended by Serjsen, et al., (1982) for optimum development of the mammary gland. However, animals may have high weight gains without fattening due to greater skeletal growth. In this study there was also a greater increase (P<.05) in wither height (22 vs 19 cm), length (26 vs 22 cm), and heart girth (32 vs 27 cm) for the heifers receiving the increased nutrients. There were no significant differences in body scores. Those on the higher nutrient amount had an ending body score of 3.0 compared to 2.95 of the heifers on the lower nutrient amount. It remains to be seen what effects increasing the rate of gain without overconditioning the animal will have on mammary secretory cell development.

There were no significant differences in gain or growth between the control SBM fed heifers and those on the extruded SBM. Total gain for the control SBM calves was 84 kg vs 85 kg for the extruded SBM calves. Increases in body measurements were, wither height (20 vs 20 cm), length (24 vs 24 cm), and heart girth (30 vs 29 cm) for control SBM heifers and extruded SBM heifers, respectively. In the 10-18 wk period, comparing the heifers on the 100% NRC nutrient level, those receiving the extruded SBM had higher weights and greater body measurements, but the differences were slight and not statistically significant. There was no definite pattern for the heifers on the 115% NRC level or for either nutrient level in the 18-26 wk period.

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THE EFFECTS OF NUTRIENT INTAKE AND PROTEIN DEGRADABILITY ON THE GROWTH AND DEVELOPMENT OF HOLSTEIN CALVES

by

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B.S., Western Kentucky University, 1987

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

Ruminant nutrition

Dept. of Animal Science and Industry

Kansas State University

Manhattan, Kansas

1989

This study was designed to determine the effects of different amounts of nutrients, rumen degradable protein and fat on the growth (weight, height, length, and heart girth) of Holstein calves.

In trial 1, 67 Holstein heifer calves were fed, at estimated intake, either 100% or 115% of NRC (1978) recommendations for the major nutrients and either textured or control SBM from birth to 8 wk of age. Calves on the 115% NRC had poorer gains and growth, because consumption was decreased by the fat added to increase the energy concentration. Calves on the control SBM consumed more feed and had higher gains than those on the textured SBM at the 100% NRC amount. At the 115% NRC amount, calves receiving the textured SBM consumed more feed and had higher gains than those on the control SBM.

In trial 2, 60 heifer and 34 bull calves were fed either control or extruded SBM and either 2.5% or no bypass fat from birth to 8 wk of age. There were no interactions between the type of SBM and the amount of fat. There were no significant differences between the control and extruded SBM calves or between the fat supplemented calves, although the trends favored the extruded SBM fed calves and those receiving no bypass fat.

In trial 3, 112 heifers were fed either 100% or 115% of NRC recommendations for the major nutrients and either control or extruded SBM from 10-26 wk of age. There were no interactions between the nutrient amount and type of SBM. Heifers on the 115% nutrient amount gained 93 kg vs 77 kg for the 100% heifers. Those on the 115% amount also had greater increases in height (22 vs 19 cm), length (26 vs 22 cm) and heart girth (32 vs 27 cm). There were no statistical differences or apparent trends between the extruded and control SBM fed calves.