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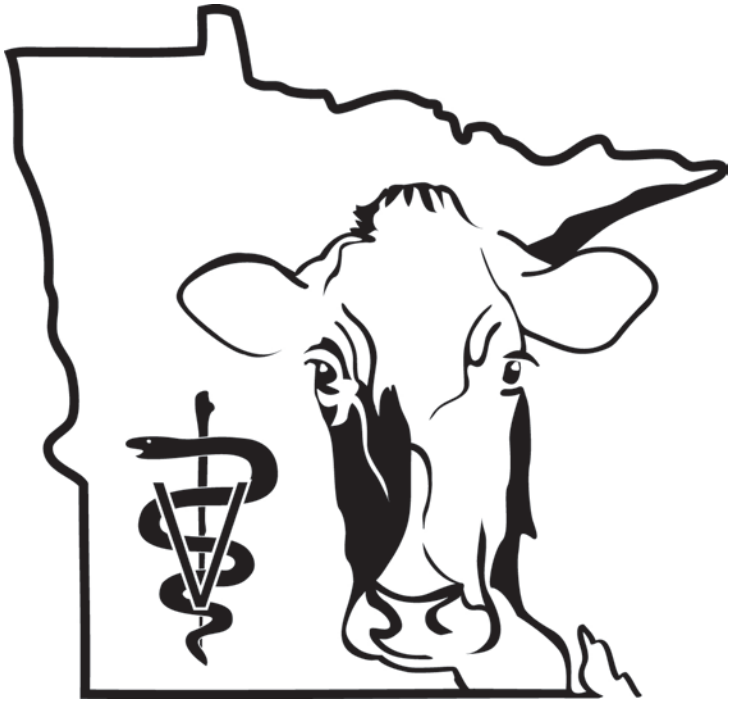

ST. PAUL, MINNESOTA
UNITED STATES OF MINNESOTA

DAIRY HEIFER NUTRITION

J. Linn, D. Kjome and H. Chester-Jones
University of Minnesota

The goal of raising replacement heifers is to develop an adequately grown heifer that has optimum milk production potential and will calve by two years of age. The rearing program also should be as economical as possible. Although many factors are important in assuring heifers are raised successfully, nutrition deserves the most attention as it has the greatest affect on health and is the most costly item associated with heifer raising.

Total cost estimates on raising heifers from birth to freshening are generally about $.90 to $1.00/lb of body weight (BW) with about 60% of the cost being feed related (11). Any improvements in management to reduce costs without reducing production potential can significantly reduce heifer rearing costs. Age at first calving is one of the most significant cost factors as delays beyond 24 months result in animals being in a non-productive state longer. However, if lactation potential is lost because of accelerated growth and fattening, any savings in feed and management costs must be weighed against lost milk income. This paper will review the nutrition basics of heifer raising required to achieve growth and development for optimum milk production by 22 to 24 months of age. Goals for evaluating growing heifer performance are in Table 1.

Table 1. Goals for evaluating growing heifer performance.

	Breed		
Measure	Holstein Brown Swiss	Jersey	Ayrshire Guernsey
Mortality (%), 1st 3 months	<5.0	<5.0	<5.0
Daily gain - birth to calving, lb/d	1.8 - 2.0	1.2 - 1.3	1.3 - 1.4
Weight at breeding, lb	750 - 850	550 - 600	600 - 700
Height at breeding, inches	49 - 50	43 - 45	46 - 48
Age at calving, months	23 - 25	22 - 24	22 - 24
Weight - post calving, lb	>1,200	>800	>900
Height at calving, inches	52	48	51
Body condition at calving	3.5	3.5	3.5
Peak milk yield, lb	>70	>55	>60

BIRTH

High quality colostrum is needed by the calf immediately after birth to provide disease defenses and nutrition. Recommendations for the minimum amount of immunoglobulin calves should ingest to achieve passive immunity is 100 grams with 200 to 300 grams of immunoglobulins preferred (6). The immunoglobulins should be delivered in 1 gallon of colostrum fed via nipple bottle or stomach tube as soon as possible after birth. Nursing may provide better immunity to calves than artificial feeding; however, it is an unreliable method of providing adequate amounts of immunoglobulins in a timely matter after birth.

Determining the quality of colostrum, in terms of immunoglobulin quantity on the farm, is difficult. Recent research indicates a low concentration of immunoglobulins in colostrum is a result of dilution by accumulated milk in the mammary gland rather than a failure of the cow to produce or transport immunoglobulins into colostrum (8, 9). The Colostrometer is an instrument used to estimate immunoglobulin content of colostrum from specific gravity of the colostrum. This hydrometer is calibrated in immunoglobulin concentrations of 5 mg/ml from 0 to 180 mg/ml and has three color coded quality regions: red-poor (<22 mg/ml), yellow-moderate (22 to 50 mg/ml) and green-excellent (>50 mg/ml). Although a rapid and easy to use technique, the Colostrometer reading is affected by temperature of the colostrum (14) and accuracy in measuring immunoglobulin concentrations (19). To minimize under feeding of immunoglobulins to calves based on incorrect Colostrometer readings, 3 quarts of colostrum with a 65 mg/ml reading or higher needs to be fed at first feeding or at least 4 quarts with a 26 mg/ml reading or higher.

Several commercial colostrum supplements are available. These products can enhance cow colostrum, but should not be used as a replacement for good quality colostrum. Recent research has shown that calf health was not improved with feeding a colostrum supplement as the first feeding followed by dam's colostrum 4 hours later, but feed efficiency was greater through weaning (21). Most commercial colostrum supplements also are rather low in immunoglobulin amounts compared to what high quality dam's colostrum can be.

BIRTH TO WEANING

Several options exist for feeding the calf from day 4 of life to weaning. However, most dairy producers feed milk replacer as all or at least part of the liquid feed fed during this time (Dairy Heifer Evaluation Project conducted in 1991-1992). Milk replacers can provide high quality nutrition at an economical cost. Recent research indicates milk replacers should contain at least 22% protein (5, 7, 22). However, the quality of the protein should be considered as well as the amount (Table 2). Only milk replacers containing protein ingredients in the acceptable category should be fed. Fat content generally ranges from 10 to 22% in milk replacers. The choice of fat content should be determined by environmental conditions with a high fat (20%) replacer used in the winter and a moderate fat replacer (15%) used in the warmer months, if desired (7, 22).

The clotting or not clotting of milk replacers with rennet (reflection of clotting in the abomasum) is no indication of quality. Whey proteins (milk origin) will not clot with rennet. Casein is the only protein to coagulate in the presence of rennet. The only true test of milk replacer quality is in calf performance.

Table 2. Protein classification and recommended use in milk replacer[a]

Classification	Recommendation[b]
All milk proteins	R, A or NR
Dried whey protein concentrate	R
Dried whey	R
Dried whey product	R
Skim milk	R
Casein	R
Sodium or calcium caseinate	R
Alternative proteins	
Soy protein isolate	R
Protein modified soy flour	R
Soy protein concentrate	R
Soy flour	A
Plasma protein	A
Modified wheat protein	R
Meat solubles	NR
Fish protein	NR
Wheat flour	NR

[a] Adapted from Drackley and Garthwaite (5).

[b] R = recommended: either milk proteins or special processed protein sources; A = acceptable: protein source is variable in quality and not suitable for calves under 3 weeks of age; NR = not recommended for use in milk replacer.

The general recommendation is to feed 1 lb of milk replacer powder in 1 gallon of water per day (12.5% solids). However, this may not always meet the nutritional needs of the calf. Increasing the powder feeding rate by 10 to 25% may improve calf performance, particularly during the first 14 days of life when calf starter intake is limited (22). This also is advised for calves in hutches during cold months. Increasing powder feeding rates after 14 days of life can increase calf growth, but usually at the expense of decreased calf starter intake, a cheaper source of nutrients than milk replacer. The inclusion of antibiotics at a low rate in milk replacers continues to demonstrate an improvement in calf performance over the feeding of non-medicated milk replacers (7, 22). Inclusion of decoquinate in milk replacer is recommended where coccidia challenges are present.

A high quality, palatable calf starter should be offered beginning at 4 days of age along with free-choice water. During the first 6 weeks of life, 75% of the weight gained by the calf can be attributed to starter intake (7). Research conducted at the University of Minnesota on calf starters showed maximum calf starter intake and calf growth was achieved with starters containing 19 to 20% crude protein, dry matter basis (1). Additional research with starter energy content indicated calves offered a high fat (7.6%) starter consumed less dry matter and gained less before weaning than calves offered a starter with no fat added (12).

Calves should be weaned when consuming 1.5 lb of starter per day. The dry feed intake is required to stimulate rumen development. The volatile fatty acids (VFAs) produced from the bacterial digestion of feed in the rumen stimulate rumen mucosal tissue and papillae development. A good calf starter is better than hay as more VFAs will be produced during fermentation to stimulate rumen development. Hay should not be fed until after weaning. Hay or any forage feeding can be delayed until after 2 months of age without any loss of rumen development. Introduce hay during the third month of life after the calf is off to a healthy, fast growing start.

WEANING TO BREEDING WEIGHT

The most efficient and profitable time to feed heifers is the period from weaning to breeding. During this period, growth of the animal is in lean tissue (muscle and bone) which is very efficient and maintenance costs are minimal (23). Delaying this growth phase increases costs later as weight is gained less efficiently and at a higher maintenance cost. Nutrition during this phase needs to be monitored closely. Underfeeding will delay growth and increase rearing costs while excess feeding can fatten heifers decreasing mammary gland development and reducing future milk production.

To achieve a successful nutrition program during this phase, heifers must be grouped so rations can be balanced and feed delivered to meet nutrient requirements. A suggested grouping strategy for large breed heifers to minimize nutrient variation and competition among animals for the feed is:

Age (months)	Body weight (lb)
2 - 5	175 - 325
6 - 10	325 - 550
11 - 12	550 - 725
Breeding age	725 - 875
Bred	850 - 1200
Springers	1200 - 1350

Starter should be fed until intakes are 4 to 5 lb per day. After this, a less expensive calf grower can be substituted along with good quality forage. Hay or haylage is acceptable during this growth phase, but corn silage should be fed until after 4 months of age and then restricted in amounts offered.

Young, light weight heifers should be receiving rations containing 16 to 17% crude protein. As they approach breeding age, crude protein content of the ration can be decreased to around 15%. Requirements for undegradable or bypass protein for heifers are not well established. Research on the use of bypass protein in heifer rations have demonstrated mixed results (3). Several amino acids are suggested as being limiting or co-limiting for growing ruminants (15). Use of ionophores has been shown to reduce ammonia concentration in the rumen and, therefore, increase the amino acid flow from the rumen (20). The best current recommendation is to feed rations balanced to meet crude protein requirements containing predominately soybean meal as the supplemental protein source and an ionophore.

The suggested nutrient content of rations for heifers gaining about 1.8 lb per day is in Table 3. Hoffman (10) demonstrated that environment and management factors can greatly affect the energy requirements of heifers. A very poor relationship (r^2 = .07) was found between predicted and actual daily gain in 19 commercial heifer raising facilities. Modifications to the energy requirement of heifers based on housing and environmental conditions are in Table 4.

Table 3. Suggested ration specifications for replacement heifers.[a]

	Age (months)			
	3 - 6	7 - 12	13 - 18	19 - 22
	Average weight (lb, large-breed heifers)			
Item	300	600	900	1,200
Estimated DM intake, lb/d	7 - 9	12 - 16	17 - 21	24 - 28
Intake, % of body weight	2.9	2.7	2.5	2.2
	Nutrient specifications (% of dry matter)			
Crude protein	16	15	14	12
TDN	68 - 74	64 - 70	60 - 63	60 - 63
Calcium	.50 - .60	.40 - .50	.40 - .50	.40 - .50
Phosphorus	.35 - .40	.32 - .35	.28 - .32	.28 - .30
Trace mineral salt	.30	.30	.30	.30
ADF (minimum)	19	22	22	22
Forage[b]	20 - 60	30 - 90	40 - 100	40 - 100
Vitamin A (IU/lb DM)	1,000	1,000	1,000	1,000
Vitamin D (IU/lb DM)	140	140	140	140
Vitamin E (IU/lb DM)	11	11	11	11

[a] Adapted from Chester-Jones et al. (3).

[b] The percent fiber and lowest percent forage are minimums required for proper rumen function. Higher levels of ADF and forage are recommended for more economical rations and to limit TDN levels shown above.

Table 4. Modified energy requirements for dairy replacement heifers.[a]

Item	Weight (lb)			
	300	600	900	1200
Base requirements				
Average daily gain, lb/d	1.7	1.7	1.7	1.7
DM intake[b], lb/d (modified)	8.3	14.3	20.3	26.4
DM intake[c], lb/d (NRC)	8.1	14.0	21.0	30.0
TDN required, lb/d	5.6	9.1	12.8	17.0
TDN, % of DM (modified)	67.5	63.6	63.1	64.0
TDN, % of DM (NRC intake)	69.1	65.0	61.0	56.7
Energy adjustments	---------- TDN lb/d ----------			
Fall x Open housing	.15	.22	.33	.50
Winter x Open housing	.22	.30	.44	.60
Spring x Open housing	.15	.22	.33	.50
Summer x Confinement housing	.15	.22	.33	.50
Fall x Unwormed x Open housing	.15	.22	.33	.50
Winter x Unwormed x Open housing	.15	.22	.33	.50
Spring x Unwormed x Open housing	.15	.22	.33	.50
Moderate body mud coverage	.22	.30	.42	.60
Heavy body mud coverage	.29	.38	.50	.70
Ionophore fed	-.15	-.30	-.42	-.60
Gestation	---	---	---	2.63

[a] Adapted from Hoffman (10).
[b] DM intake calculated as 2.25 + (0.201 x BW).
[c] NRC Dairy (16).

BRED TO SPRINGING

The goal of this period is to meet the recommended weight, height and body condition score desired at calving. Rates of gain needed during this period will vary considerably across farms as well as within a farm. Higher gains than the standard 1.8 lb per day can be attained without loss in milk production potential if additional weight is needed before calving. Slower rates of gain (1 to 1.5 lb per day for large breeds) can be tolerated if heifers are getting fat, but heifers should never be fed at maintenance requirements.

North Dakota researchers (17) have used a "stair-step" approach to the allotment of energy during heifer growth from 6 to 24 months. The basic concept is to use compensatory gain during three phases of growth (prepubertal, puberty/conception and late gestation) to improve the efficiency of growth. Starting at 6 months of age, a restricted energy diet (15% < NRC) was fed for 3 months followed by a diet of 40% > NRC. These were followed by two additional alternating

periods of 5 months restricted and 2 months high energy feeding. The protein content in all diets was at or slightly above NRC (16) recommendations. Results from some of the first heifers to complete this research study are in Table 5. Heifers on the stair-step scheme had more efficient gains during the growing phase and produced about 10% more milk than traditionally raised heifers. Another study on heifers from 6 to 12 months of age confirm the North Dakota findings in that stair-step fed heifers have more milk secretory tissue in their mammary gland than conventionally fed heifers (18).

Table 5. Heifer growth and lactation performance from stair-step feeding program.

	Control	Stair-step
Body weight, lb		
Initial	619	612
Final	1,220	1,268
Daily gain, lb/d	1.5	2.16
Lactation milk, lb	17,430	19,196

Adapted from Park (17).

Canadian researchers have studied the effect of feeding an ad lib diet (high) or a moderate diet (70 to 80% of ad lib) during the second isometric (12 months of age to 3 months of gestation) and allometric (3rd month of gestation until calving) phases of growth (13). All diets were balanced to meet NRC recommendations for heifer growth. No difference in first lactation milk production of the heifers across the four treatments was found. Heifers fed ad lib during isometric growth phase had a significantly higher incidence (40 vs 8.4%) of displaced abomasums than those fed the moderate diets. Heifers fed ad lib during the allometric phase averaged about 16 days longer to first observed estrus than moderately fed heifers. Overfeeding during the second year of life was found to decrease reproductive performance and increase health problems with no advantageous effect on milk production or rearing costs.

Other studies have evaluated accelerated growth of heifers. Kansas researchers reported feeding heifers 124% of NRC from 3 to 6 months and then 115% of NRC from 6 to 24 months improved skeletal growth without fattening which offered the potential for earlier calving (4). In another study, heifers fed 115% of NRC recommendations either before or after 1 year of age were not different in body weight, body size or age at conception (2). Conclusions from Cornell studies (23) on accelerated heifer growth indicate:

1) Feeding heifers to gain up to 2.1 lb per day did not significantly reduce milk yield when heifer rations were balanced for protein and energy to maintain body condition in an accepted range.

2) Post calving weight of heifers accounts for more variation in milk yield than prepubertal growth rate.

3) The optimum post calving weight is 82% or more of mature weight.

4) Source of protein fed (bypass vs degradable) during the prepubertal period did not affect milk yield.

CONCLUSIONS

Nutrition has a significant effect on the health, growth and ultimate milk production of a heifer. It appears modifications in NRC requirements and suggested growth standards during various periods of growth can be tolerated or may even be beneficial to future lactation performance. However, the overall general recommendation of a 1.8 lb per day average gain from birth to freshening at 23 to 24 months for large breed heifers is a valid standard. The exact periods of growth where faster or slower rates of gain are desirable are undetermined from the current research. However, it is clear a continuous rapid growth rate for 24 months is deleterious to lactation performance. The period of isometric growth between 10 months of age to about 3 months gestation appears to be a time when slower growth rates are most warranted. Rates of gain greater than 1.8 lb per day are least harmful and probably most beneficial during the last half of gestation.

REFERENCES

1. Akayezu, J.M., J.G. Linn, D.E. Otterby, W.P. Hansen and D.G. Johnson. 1994. Evaluation of calf starters containing different amounts of crude protein for growth of Holstein calves. J. Dairy Sci. 77:1882.

2. Bortone, E.J., J.L. Morrill, J.S. Stevenson and A.M. Feyerherm. 1994. Growth of heifers fed 100 or 115% of National Research Council requirements to 1 year of age and then changed to another treatment. J. Dairy Sci. 77:270.

3. Chester-Jones, H., P.C. Hoffman and A.L. Skidmore. 1993. Optimum heifer growth for production and profit. Proc. 54th MN Nutrition Conf., Bloomington, MN. Univ. of MN, St. Paul.

4. Daccarett, M.G., E.J. Bortone, D.E. Isbell, J.L. Morrill and A.M. Feyerherm. 1993. Performance of Holstein heifers fed 100% or more of National Research Council requirements. J. Dairy Sci. 76:606.

5. Drackley, J.K. and B.D. Garthwaite. 1994. New concepts in milk replacer and fluid therapy for calves. Prof. Dairy Mgmt. Seminar Proc., Dubuque, IA. IA State Univ., Ames.

6. Gary, F. and S. Wells. 1995. Colostral management: How good is your program? Proc. Western Large Herd Mgmt. Conf., Las Vegas, NV.

7. Fowler, M. 1993. Calf milk replacers and early rumen development. Anim. Sci. Mimeograph Series No. 165. 2nd Biennial NE Heifer Mgmt. Symp., Dept. of Anim. Sci. Cornell Univ., Ithaca, NY.

8. Guy, M.A., T.B. McFadden, D.C. Cockrell and T.E. Besser. 1994. Dilution is responsible for breed differences in colostral Ig G_1 concentration. J. Dairy Sci. 77:3002.

9. Guy, M.A., T.B. McFadden, D.C. Cockrell and T.E. Besser. 1994. Effects of unilateral prepartum milking on concentration of immunoglobulins G_1, and prolactin in colostrum. J. Dairy Sci. 77:3584.

10. Hoffman, P.C. 1993. New concepts in managing dairy replacement heifers. Anim. Sci. Mimeograph Series No. 165. 2nd Biennial NE Heifer Symp., Cornell Univ., Ithaca, NY.

11. Karszes, J. 1994. Dairy replacement programs: Cost and analysis. Western New York. 1993. Anim. Sci. Mimeograph Series No. 174, E.B. 94-8. Dept. Anim. Sci., and Agric. Resource and Mgmt. Econ., Cornell Univ., Ithaca, NY.

12. Kuehn, C.S., D.E. Otterby, J.G. Linn, W.G. Olson, H. Chester-Jones, G.D. Marx and J.A. Barmore. 1994. The effect of dietary energy concentration on calf performance. J. Dairy Sci. 77:2621.

13. LaCasse, P., E. Block, L.A. Guilbault and D. Pelitclerc. 1993. Effect of plane of nutrition of dairy heifers before and after gestation on milk production, reproduction and health. J. Dairy Sci. 76:3420.

14. Mechor, G.D., Y.T. Grohn and R.J. VanSaun. 1991. Effect of temperature on colostrometer readings for estimation of immunoglobulin concentration in bovine colostrum. J. Dairy Sci. 73:3940.

15. Merchen, N.R. and E.C. Tigemeyer. 1992. Manipulation of amino acid supply to the growing ruminant. J. Anim. Sci. 70:3238.

16. National Research Council. 1989. Nutrient requirements of dairy cattle. 6th Rev. Ed., Natl. Acad. Sci., Washington, D.C.

17. Park, C.S. 1993. Stair-step compensatory nutrition regimen for heifer growth and lactation. 34th Ann. New England Dairy Conf., West Lebanon, N.H.

18. Peri, I., A. Gertler, I. Bruckental and H. Barash. 1993. The effect of manipulation in energy allowance during the rearing period of heifers on hormone concentrations and milk production in first lactation cows. J. Dairy Sci. 76:742.

19. Pritchett, L.C., C.C. Gay, D.D. Hancock and T.E. Besser. 1994. Evaluation of the hydrometer for testing immunoglobulin G_1 concentrations in Holstein colostrum. J. Dairy Sci. 77:1761.

20. Quigley, J.D. 1995. Using different management systems for raising dairy heifers. 6th Ann. FL Ruminant Nutrition Symp., Gainesville, FL. Univ. of FL.

21 Seymour, W.M., J.E. Nocek and J. Siciliano-Jones. 1995. Effects of a colostrum substitute and of dietary brewers yeast on the health and performance of dairy calves. J. Dairy Sci. 78:412.

22. Tomkins, T., J. Sowinski and J.K. Drackley. 1994. New developments in milk replacers for pre-ruminants. Proc. 55th MN Nutrition Conf., Bloomington, MN. Univ. of MN, St. Paul.

23. VanAmburgh, M.E. and D.M. Galton. 1994. Accelerated growth of Holstein heifers - effects on lactation. Proc. of Cornell Nutrition Conf. for Feed Manufacturers, Rochester, NY. Cornell Univ., Ithaca, NY.