QUALITY CONTROL SYSTEMS IN DAIRY REPLACEMENT HEIFER NUTRITION

Patrick C. Hoffman
Associate Professor – UWEX
Department of Dairy Science
University of Wisconsin-Madison

Introduction

The goal of feeding dairy replacement heifer management is to produce high quality replacement heifers at a low cost. This is a dual management objective and is fraught with subtle complexities. It is common for heifer growers not to fully address these subtle complexities of dairy replacement heifer nutrition and settle for more routine and less demanding management schemes. While understandable, these "less demanding" feeding programs can compromise the quality of the replacement heifer, or more likely, increase heifer rearing cost. Lessons from research and the custom heifer industry are teaching us that feed cost can be reduced without compromising future lactation performance. As a result, a "new wave" of nutrition quality control management systems for replacement heifers is taking place, but we have yet to discern all of the implications. It is virtually impossible to detail all of the business and biological aspects of developing a quality control management program for dairy replacement nutrition in this paper; therefore, general concepts will be offered.

Control Point # 1 -- Define All of the Feed Cost

There are no simple formulas or budgets to ascertain the feed cost of rearing dairy replacement heifers. The cost of feeding heifers should be determined on each individual operation and then broken down into utilitarian units for management purposes. Utilitarian units simply means that cost should be broken down into units that are meaningful in day-to-day management. For example, there is very little management utility knowing that it costs $.80/day to feed a replacement heifer, because no specific information is available to determine where cost of production improvements can be made. Presented in Table 1are feed cost data for heifers respectively broken down into specific cost categories. These data represent the average feed cost of a heifer for 62 Wisconsin dairy herds and can be used as a set of dairy calf and heifer feed cost benchmarks.

Control Point # 2 -- Monitoring Systems

Excellent heifer nutrition programs contain excellent monitoring programs starting with good basic records which at minimum include birth date, dam, sire, and permanent identification.

Monitoring calf and heifer growth and using the data is one of the keys in a successful heifer nutrition program. The method of monitoring growth can be simple or

complex. For example, a simple method for monitoring heifer growth is to use a weigh tape to estimate body weight and an altitude stick to measure height. Weigh tapes are a reasonably accurate method of estimating body weight—typically within 7 percent of actual body weight. Make sure to use a weight tape made after 1990, as many outdated ones misrepresent modern dairy heifers. For best results, tape and measure height at birth and then at six-month intervals. Taping and measuring height can also be done at key management times—birth, vaccinating, breeding, pregnancy check, calving—while the calf or heifer is otherwise restrained.

Heifer growth may also be monitored using more sophisticated technology. Basic components of a high-efficiency weighing system include: an animal handling corral, electronic scale, and a digital or computerized recording devise. In these systems, heifers can be handled, sorted, and moved efficiently. Collected data, such as heifer weights, can be directly downloaded for computer software applications. To be of value, data collected from monitoring systems need to be evaluated. Evaluation can be simple or full heifer production data systems can be used which are now available.

Critical Point # 3 – Manage Variance

Once data or information has been collected from the monitoring system, growth/weights, etc., of the heifers should be evaluated. It is common to evaluate the average daily gain of heifers or to plot the weights, heights, lengths of heifers on a graph for comparative purposes. While evaluating the average growth of heifers is useful, evaluating variances of heifer growth probably has greater day-to-day management utility. Growth of heifers varies for two reasons – genetics or a breach of management. The heifer monitoring and evaluation system should be able to capture any or all heifers that exceed variance tolerances. Surprisingly, there is little information regarding normal or strictly genetic variation of dairy replacement heifers. Some heifer growth charts (Heinrichs and Lammers, 1998) identify ranges of heifer growth -- but these ranges may be too wide for quality control systems because they include both genetic and phenotypic variance. Listed in Table 2 are variances of heifer growth from a single experimental herd, with an extremely low incidence of calf and heifer disease (Hoffman, et al., 1992). While limited, these data may serve as a general guideline of normal and reasonable – genetic – variance for Holstein heifers. Presented in Figure 1 is a plot of heifer weights from a small dairy producer with 77% of the heifers falling within the upper and lower ranges suggested in Table 2. Presented in Figure 2 is a plot of heifer weights from a custom heifer grower with only 41% of the heifers falling within acceptable variance limits. Interestingly, the mean heifer growth rates for both operations are identical. The contrast between heifer growth in Figures 1 and 2 clearly shows growth variance on the custom heifer operation (Figure 2) is excessive.

The true utility of a good heifer monitoring program is to find heifers that are varying from the system -- not to justify appropriate means. Once found, a specific plan of action should be implemented for heifers with excessive variance. Specific heifers that vary from growth objectives should be found and both the animal and records thoroughly

examined. Listed in Table 3 are possible factors that could cause growth variance to occur.

Heifer growers should consider special management and nutrition programs for heifers which excessively deviate from growth objectives. Special -- catch up or slow down -- management pens can usually be added to the management system at a reasonable expense. Heifers can then be fed diets or managed to increase or decrease growth as needed until the heifer is back within limits of acceptable growth.

Critical Point # 4 -- Control Feed Cost

Feed costs comprise 60 to70% of the total cost of rearing dairy replacement heifers, yet dairy producers and heifer growers seldom make a serious management effort to control feed cost. The philosophy of feeding replacement heifers is different from feeding lactating dairy cows. In general, dairy producers feed lactating dairy cows highly fortified diets to assure nutrient adequacy and that milk production will not be nutritionally limited. Philosophically, replacement heifers should be fed diets where nutrients are tightly controlled. Secondly, controlling feed cost in a heifer diet generally requires considerably more attention to long-term strategies as compared to short time manipulations in purchased feeds. Because the majority of cost of a heifer diet is associated with base forage – production – cost, the most effective area to reduce feed cost is heavily associated with reducing base forage -- production -- cost. Listed below are some key concepts to control feed cost in dairy replacement heifers.

Maintain Performance—Understand Heifer Nutritional Requirements

Good heifer nutrition starts with an understanding of the heifer's base nutrient requirements. The nutritional requirements and philosophies of feeding a growing animal are significantly different from feeding lactating cows and should be recognized as such. Dietary energy, protein, mineral, and vitamin feeding guidelines for large-breed dairy heifers gaining 1.8 pounds per day are presented in Tables 4, 5, and 6. These values assume the temperature in the animal's environment is in the thermal neutral zone, or between 50° F to 70° F.

Maintain Performance—Adjust Ration to Changing Environment

Because heifers are frequently reared in conditions outside of thermal neutrality—such as heat stress or cold stress—heifer nutrition programs need to be adjusted to the heifers' environment. Specifically, heifers will require more energy in the diet when the following conditions or combination of conditions exist: temperatures below 50°F; wet conditions; dirty haircoats; cold, wet, non-insulative resting areas; wind chill; or the absence of solar radiation. These conditions require more maintenance energy to be used by the animal. Therefore, more energy is needed in the diet for growth to occur.

The effects of environmental conditions on dietary energy needs are more profound on 300 pound heifers when compared to those heifers weighing more than

1,000 pounds. As heifers gain body mass and rumen capacity, they are much more adept at handling cold, wet environmental conditions. In most situations with young heifers, heifer raisers should provide a good environment and perfect resting areas rather than trying to feed more energy in the diet to overcome poor conditions.

Avoid Over Conditioning

While it is often necessary to vary dietary energy to maintain optimal heifer growth, feeding excessive dietary energy is the principal cause of over conditioning heifers. At calving, over-conditioned heifers will be more prone to calving difficulties and metabolic diseases. Dietary protein does play a minor role in heifer condition, but overfeeding energy remains the biggest culprit. When heifers become over-conditioned, dietary energy should be reduced by including a low energy forage, such as straw, into the diet or limiting the amount of feed offered.

Produce High Tonnage Forages

Because forage comprises a large percentage of dairy replacement heifer diets, the cost of forage has a significant effect on heifer rearing cost. High tonnage forages such as corn silage are usually the lowest cost forages to produce. Corn silage cannot comprise the entire diet of replacement heifers because it contains too much energy and feeding excessive amounts in the diet can cause over-conditioning. Heifer growers should, however, consider altering agronomic practices to increase tonnage and decrease energy content of corn silage. Yield of corn silage can be increased and production cost reduced by varietal selection (Table 7), increased plant population (Table 7), reduced cutting height and delayed harvest (Wiersma, et al., 1993), reducing cutting height and varietal selection (Table 7). Heifers' diets can benefit from high quality alfalfa silage, especially heifers < 800 lbs, but heifers can also be fed low cost, high tonnage crops, such as corn stalks, sorghum silage, sweet corn silage, mid bloom alfalfa silage, straw, low quality grass hay, sorghum-sudan silage, and head stage small grain silage. As with corn silage, agronomic manipulation of perennial and annual forage crops can be used to reduce heifer feed cost. For example, alfalfa harvest can be delayed to dilute the energy content of corn silage in the heifer diets. Forages fed to heifers should be well stored, fermented, and free of mold, etc., and if energy and protein are slightly deficient, heifer diets can be easily fortified. Numerous grain and protein supplements can be used to fortify heifer diets and prices should be continuously monitored for cost to supply nutrients at the lowest cost.

Feed Protein Wisely

As with energy, protein requirements of heifers are dynamic. The younger a heifer is and the faster a heifer grows, the more protein required in the ration to meet growth demands; however, feeding excessive protein to heifers does not prevent over-conditioning or enhance stature growth. To prevent over-conditioning, heifer rations should be balanced using appropriate growth rates with energy densities appropriate for the heifers' environmental conditions.

Additionally, feeding proper protein to heifers assures proper body frame development, but over feeding protein to heifers is wasteful and does not enhance body height and length. When excess protein is fed, heifers simply excrete it as nitrogen in the urine. This disposal of protein is not economically prudent and can create environmental concerns.

Feed Precise Amounts of Minerals and Vitamins

Field studies show heifer raisers commonly over supplement minerals and vitamins to dairy heifers in an effort to assure dietary adequacy (Table 8). Over supplementing minerals and vitamins increases heifer rearing cost. To ensure proper levels of minerals and vitamins are fed, test forages and feeds for their mineral content using precision wet chemistry procedures and then provide supplements to reach requirements with modest overages allowed. If possible, free choice mineral and vitamin supplementation should be avoided. Specifically, heifer raisers should be sure to feed precise levels of dietary phosphorus because over supplementation results in excessive levels of the mineral in manure, which is an environmental concern.

Mineral and vitamin feeding guidelines are presented in Tables 5 and 6. Feeding these levels with only a small and reasonable overage is the most logical feeding practice to assure adequacy and minimize rearing expenses.

Don't Waste Feed

Feeding heifers is expensive and great care should be taken not to waste feed. Feed bunks should be designed and managed to control feed waste. Properly adjusting neck rails, throat heights, or installing slant bars in the feed alley can often dramatically reduce feed wastage. Hay racks, portable bunkers, or other make-do feeders should not be used as too much feed is lost on the ground. Do not feed heifers forages or grains placed on the ground. In addition, do not provide heifers unlimited feed. Precisely monitoring feed intakes and feeding heifers as needed should reduce feed wastage and increase feed efficiency. A simple bunk scoring system has great utility in feeding heifers (Table 9).

Consider Ionophores and Growth Promotants

Studies have demonstrated that ionophores improve feed efficiency or average daily gain when fed to dairy heifers. When fed, heifer raisers can expect average daily gain increases of 0.15 pounds per heifer per day or feed efficiency increases of 5 to 10 percent. In addition to feeding efficiency, ionophores help control coccidiosis. Bamermycin is also approved as a growth promotant for dairy replacement heifers. Bamermycin has ionophore-like properties, but is not a true ionophore and does not control coccidiosis. Bambermycin is fed at 10 to 20 milligrams per heifer per day.

Adopt a TMR Quality Control System

New and very powerful laboratory techniques are now commercially available to monitor the nutrient densities of total mixed rations. The new laboratory techniques use precision summative technology to closely estimate energy contents of total mixed rations. Other nutrients in the diet such as protein, digestible NDF, NDF, fat, non-fiber carbohydrates, ash, macro-minerals and micro-minerals can be monitored. An example TMR quality control report is presented in Figure 3.

Control Point # 5 -- Cull Heifers

Heifers are often raised that have a very low probability of becoming an excellent milking cow. If there is a high risk that continuing to raise a replacement heifer is going to result in a poor milking animal, it may be prudent to cull the heifer or calf at the time the risk becomes evident. There are two high risk factors that occur in calves that may warrant immediate culling, which are freemartins and pneumonia. Freemartin heifers result when a heifer calf is born twin to a bull calf. In this situation, the heifer calf will often not fully develop a functional reproductive tract and thus is a culling candidate. Calves or heifers with severe cases of respiratory disease have been demonstrated in research to grow slower, breed and calve later, and produce less milk than respiratory disease free calves and heifers. It should be remembered that this is not the case with calf scours. There has been no research that has demonstrated that calf scours has a long term effect on heifer productivity; therefore, calves recovering from calf scours should not be culling candidates. As a group of heifers matures, there are often individual heifers that grow slowly or are otherwise unthrifty. In situations where the problem is a disease or condition that is difficult to remedy, such as persistently infected BVD, chronic navel infection, inbreeding, abortion, founder, etc., then culling should be an integral part of management programs.

Critical Point # 6 -- Develop a Management Team

In the author's opinion, the most important aspect of improving quality control of replacement heifer nutrition is building a good team to do so. Dairy growers management team members usually include the owner, key employees, nutrition consultant, veterinarian, and possibly a business consultant. Is the team employed to manage the calves and replacement heifers the same team employed to manage lactating dairy cows on other operations? Heifer growers should consider forming unique and challenging management teams for calves and heifers with team members including the owner, employees, nutrition consultant, and veterinarians who specialize in calf and replacement heifer management. In addition, heifer growers should consider another professional heifer grower and/or heifer industry representative for their management team.

Table 1. Survey of feed cost of 287 heifer groups from 62 commercial dairies. Hoffman et al., 1999, University of Wisconsin.

		Feed Cost		
Body Weight, lbs	Ag, mo	Mean $/day	Minimum $/day	Maximum $/day
218.9	3.0	0.66	0.34	1.18
299.5	4.4	0.76	0.42	2.27
403.3	6.1	0.76	0.39	1.43
511.2	8.5	0.80	0.49	1.39
601.4	10.0	0.74	0.48	1.21
699.9	12.0	0.91	0.63	1.91
809.6	14.2	0.92	0.54	1.75
905.8	16.3	1.02	0.69	1.88
1020.4	19.1	1.00	0.77	1.33
1114.2	20.7	1.14	0.52	1.79
1196.1	21.8	1.37	0.84	2.08

Table 2. Theoretical genetic deviation of body weight in Holstein replacement heifers (Hoffman et al., 1992).

Age	Body Weight lbs	Body Weight Genetic SD lbs	Body Weight Low Range lbs	Body Weight High Range lbs
0	93	19	74	112
1	139	19	120	158
2	185	21	164	206
3	239	23	216	262
4	293	26	266	319
5	347	29	318	376
6	400	32	368	432
7	454	37	417	491
8	507	40	466	547
9	562	44	518	606
10	615	48	567	663
11	669	51	618	720
12	722	54	668	775
13	777	57	720	883
14	830	59	771	889
15	884	61	823	945
16	937	63	874	999
17	991	65	926	1055
18	1045	66	978	1111
19	1099	67	1032	1166
20	1152	69	1083	1220
21	1206	70	1135	1276
22	1260	71	1188	1331
23	1314	72	1242	1385
24	1367	73	1294	1439

Table 3. Factors with the potential to cause variance in replacement heifer growth.

Pneumonia	Excessive dietary energy	Inbreeding
Hoof disease	Deficient dietary energy	BVD
Respiratory health	Deficient dietary protein	Acidosis
Salmonella db	Injury/trauma	Comfort
Parasites	Crypto/Coccidiosis	Twins
Bunk space	Abrupt diet transition	Low birth BW
Crowding	Liver abscess	Dystocia
Failed passive transfer	Hardware	Harsh environmental
conditions		

Table 4. Dietary energy and protein guidelines[1] for large breed dairy heifers gaining 1.8 lbs/day in a thermal neutral environment.

		Heifer Body Weight, lbs			
Item/Abbreviation	Unit	300	600	900	1200
Dry Matter Intake/DMI	lbs/d	9.3	13.7	19.4	26.9
Crude Protein/CP	% of DM	16.9	15.0	14.2	13.3
Rumen-Undegraded Protein/RUP	% of CP	39.4	33.8	30.3	26.3
Rumen-Degraded Protein/RDP	% of CP	60.6	66.2	69.7	73.7
Total Digestible Nutrients/TDN	% of DM	67.4	65.3	63.3	62.3

[1] Determined from the Nutrient Requirements of Dairy Cattle, 2001.

Table 5. Mineral feeding guidelines[1] for large breed dairy heifers gaining 1.8 lbs/day.

		Heifer Body Weight, lbs			
Item/Abbreviation	Unit	300	600	900	1200
Calcium/Ca	% of DM	0.45	0.40	0.37	0.36
Phosphorus/P	% of DM	0.30	0.24	0.20	0.18
Potassium/K	% of DM	0.49	0.48	0.46	0.45
Sodium/Na	% of DM	0.09	0.08	0.07	0.07
Chlorine/Cl	% of DM	0.13	0.12	0.11	0.10
Sulfur/S	% of DM	0.20	0.20	0.20	0.20
Magnesium/Mg[2]	% of DM	0.11	0.11	0.11	0.11
Cobalt/Co	ppm	0.11	0.11	0.11	0.11
Copper/Cu	ppm	10	10	10	10
Iodine/I	ppm	0.10	0.30	0.30	0.30
Iron/Fe	ppm	45	35	15	13
Managnese/Mn	ppm	25	20	15	13
Selenium/Se	ppm	0.30	0.30	0.30	0.30
Zinc/Zn	ppm	35	29	20	17

[1] Determined from the Nutrient Requirements of Dairy Cattle, 2001 assuming bioavailabilities of alfalfa silage, corn silage, shelled corn, soybean meal, dicalcium phosphate and limestone.

[2] Diets containing excessive levels of K may require higher levels of Mg.

Table 6. Vitamin guidelines[1] for large breed dairy heifers gaining 1.8 lbs/day.

		Heifer Body Weight, lbs			
Item	Unit	300	600	900	1200
Dry Matter Intake	lbs/d	9.3	13.7	119.4	26.9
Vitamin A	IU/day	11000	22000	32500	43000
Vitamin D	IU/day	4100	8200	12250	16250
Vitamin E	IU/day	110	225	325	425
Vitamin A	IU/lb DM	1400-1600	1400-1600	1400-1600	1400-1600
Vitamin D	IU/lb DM	500-600	500-600	500-600	500-600
Vitamin E	IU/lb DM	15	15	15	15

[1] Determined from the Nutrient Requirements of Dairy Cattle, 2001.

Table 7. Contemporary corn silage variety and plant population evaluation. Unpublished data, WAPAC, Marshfield Ag Research Station, 2003.

	Variety				
Item	1	2	3	4	5
Dry Matter Yield, tons/acre	6.49^{b}	5.87^{c}	7.18^{a}	7.03^{a}	6.71^{ab}
Dry Matter	34.37^{a}	29.60^{b}	35.62^{a}	35.68^{a}	34.24^{b}
Crude Protein	7.40^{b}	7.81^{a}	6.84^{c}	7.24^{b}	7.38^{b}
ADF	23.495^{c}	25.617^{a}	23.645^{c}	24.182^{bc}	25.416^{ab}
NDF	39.685^{b}	43.406^{a}	42.509^{a}	42.194^{ab}	43.998^{a}
NDF Didestibility	59.411^{c}	71.776^{a}	64.103^{b}	61.920^{bc}	64.547^{b}
Non-fiber carbohydrate	48.075^{a}	42.807^{b}	45.180^{ab}	44.811^{b}	43.514^{b}
Starch	35.327^{a}	28.693^{b}	35.392^{a}	34.148^{a}	30.256^{b}
Starch Digestibilty	86.967^{b}	92.678^{a}	85.341^{b}	85.196^{b}	87.596^{b}
TDN	72.418^{b}	76.332^{a}	73.555^{b}	72.389^{b}	73.271^{b}
Milk/Ton	3620.00^{b}	4001.40^{a}	3743.90^{b}	3642.20^{b}	3727.50^{b}
P	0.193^{b}	0.203^{a}	0.188^{b}	0.192^{b}	0.193^{b}
Ca	0.222^{b}	0.242^{a}	0.215^{b}	0.219^{b}	0.223^{b}
K	0.923^{bc}	1.108^{a}	0.934^{bc}	0.947^{b}	0.885^{c}
Mg	0.177^{ab}	0.166^{bc}	0.161^{c}	0.179^{a}	0.183^{a}
Ash	3.937a	4.081^{a}	3.574^{bc}	3.854^{ab}	3.519^{c}
Milk/Acre	23059^{c}	23276^{bc}	26599^{a}	25298^{ab}	24975^{abc}

	Plant Population, plants/acre		
Item	32177	40961	51888
Silage Yield, tons DM/acre	7.4^{a}	8.5^{b}	9.1^{c}
Grain Yield, bu/acre	174^{a}	204^{b}	190^{b}

Columns with unlike superscipts differ P<0.05

Table 8. Percent of Wisconsin dairy herds feeding excess minerals to 660 lb replacement dairy heifers.

	NRC (Adequacy)[1]		Mineral Nutrition Status[2]		
Mineral	Lower	Upper	Deficient	Adequate	Excess
Macro-mineral, % of DM					
Ca	0.41	0.51	3	4	93
P	0.23	0.29	7	7	86
Mg	0.11	0.14	0	7	93
Cl	0.12	0.15	0	0	100
K	0.48	0.60	0	0	100
Na	0.08	0.10	27	10	63
S	0.20	0.25	37	47	16
Micro-mineral, mg/kg					
Cu	10	13	13	14	73
Fe	31	39	0	0	100
Mn	20	25	0	0	100
Zn	27	34	10	10	80

[1] The upper level is the NR, 2001 requirement plus 255 overage.
[2] Percent of diets.

Table 9. Feed bunk scoring system.

Score	Criteria
0	No feed, slick concrete.
1	A few scattered feed particles remaining.
2	Numerous feed particles remaining, but feed particles are individual (no feed piles), concrete is still visible.
3	Feed covers the bottom of the feed bunk < 1.0” deep.
4	A deep layer of feed > 1.0” covers the bottom of the feed bunk. Feed has been eaten and disturbed.
5	Feed is undisturbed and appears as if no animal has eaten.

Figure 1. Comparison of individual herd heifer growth rates to desired variance.

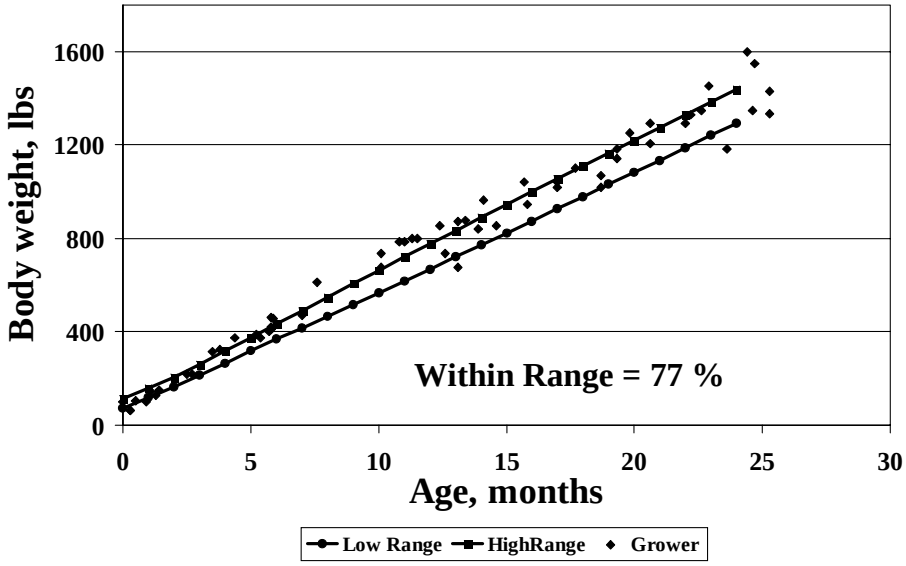

Figure 2. Comparison of individual herd heifer growth rates to variance.

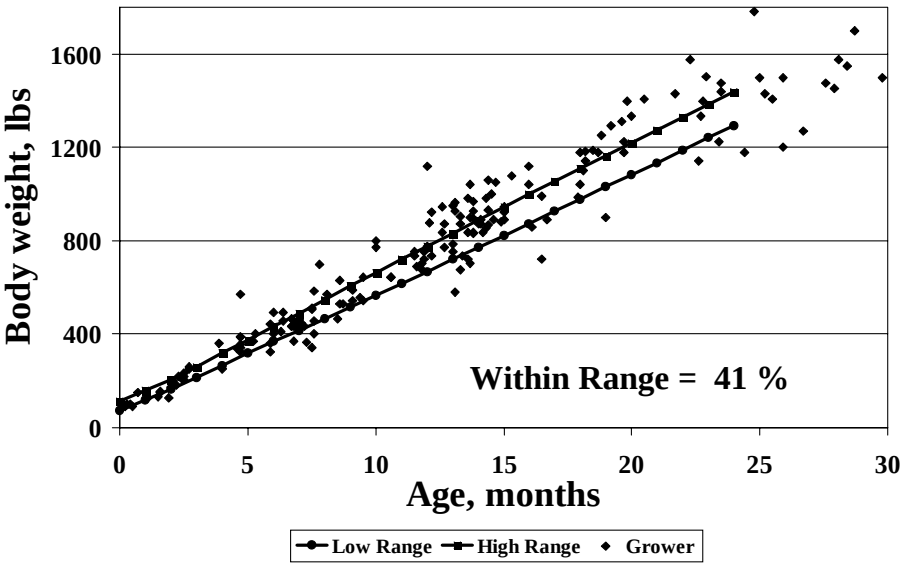

Figure 3. An example of a percision summative total mixed ration quality control report.

SOIL and FORAGE ANALYSIS LABORATORY
8396 Yellowstone Drive, Marshfield, WI 54449
Phone 715-387-2523 Fax 715-387-1723

University of
Wisconsin
Madison/Extension

Acct # **na**
Date **1/17/2003**

Comments
Johnson's Custom Heifer Farm

TMR - QUALITY CONTROL

Lab Number **4210** ***Sample Description*** **900 lb group #6**

Item	*Abbrev*	*Unit*	*Result*	*Method* [1]
Dry Matter	***DM***	***% as fed***	**48.00**	***WC***
Moisture		***% as fed***	**52.00**	***WC***
Protein Fractions				
Crude Protein	***CP***	***% of DM***	**15.20**	***WC***
Fiber Fractions				
Acid Detergent Fiber	***ADF***	***% of DM***		***NR***
Neutral Detergent Fiber	***aNDF***	***% of DM***	**38.00**	***WC***
Neutral Detergent Fiber Digestibiltiy 48 h	***NDFD***	***% of NDF***	**49.00**	***WC***
Carbohydrates and Fats				
Non Fiber Carbohydrate	***NFC***	***% of DM***	**39.10**	***C***
Fat		***% of DM***	**2.10**	***WC***
Energy Calculations:NRC,2001			******* Verified *******	
Total Digestible Nutrients,1X	***TDN***	***% of DM***	**62.75**	***C***
Net Energy , Lactation, 3X	***Nel***	***Mcals/lb***	**0.64**	***C***
Net Energy , Maintenance	***NEm***	***Mcals/lb***	**0.66**	***C***
Net Energy , Gain	***NEg***	***Mcals/lb***	**0.40**	***C***
Metabolizable Energy	***ME***	***Mcals/lb***	**1.06**	***C***

Macro Minerals					***Micro Minerals***				
Phosphorus	***P***	**0.38**	***% of DM***	***WC***	***Iron***	***Fe***	**151.00**	***ppm***	***NR***
Calcium	***Ca***	**0.80**	***% of DM***	***WC***	***Manganese***	***Mn***	**56.00**	***ppm***	***NR***
Potassium	***K***	**1.54**	***% of DM***	***WC***	***Zinc***	***Zn***	**41.00**	***ppm***	***NR***
Magnesium	***Mg***	**0.35**	***% of DM***	***WC***	***Copper***	***Cu***	**12.00**	***ppm***	***NR***
Sodium	***Na***	**0.23**	***% of DM***	***NR***					
Chloride	***Cl***	**0.34**	***% of DM***	***NR***	***Ash***		**8.10**	***%of DM***	***WC***
Sulfur	***S***	0.22	***% of DM***	***NR***					

[1] WC = wet chemistry, NIR = near infrared reflectance spectroscopy, C = Calculated, NR = Not requested.

[2] Calculated using NRC 2001 summative approach with NDFD values above used to determine caloric contribution of fiber.

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