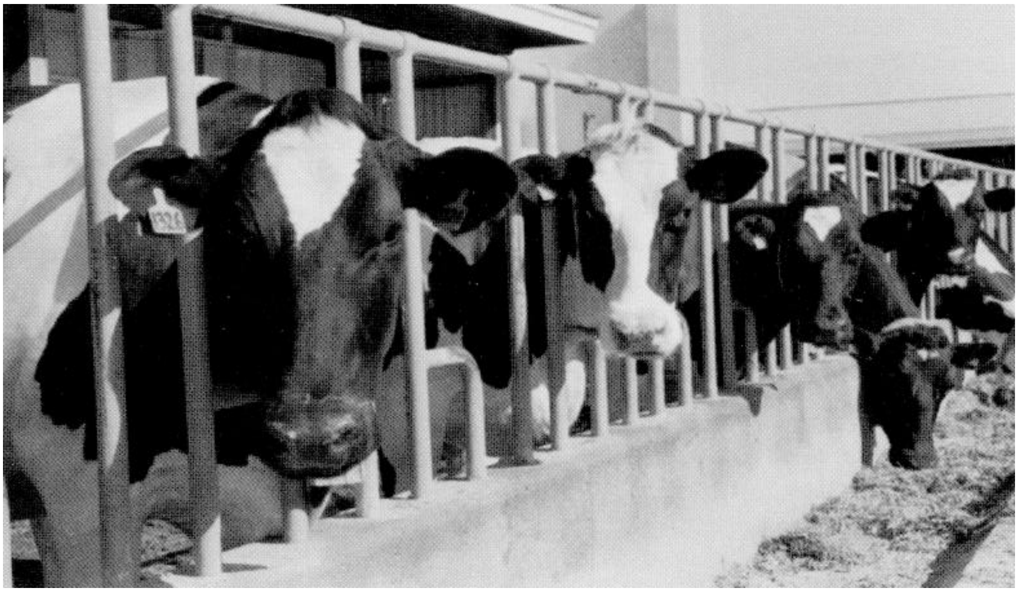


DAIRY DAY 1993

Report of Progress 694

Agricultural Experiment Station
Kansas State University, Manhattan
Marc A. Johnson, Director

FOREWORD

Members of the Dairy Commodity Group of the Department of Animal Sciences and Industry are pleased to present this Report of Progress, 1993. Dairying continues to be a viable business and contributes significantly to the total agricultural economy of Kansas. Annual farm value of milk produced (1.22 billion lb) on Kansas dairy farms was $153.7 million in June, 1993, with an impact on the economy of Kansas amounting to $769 million. Wide variation exists in the productivity per cow, as indicated by the production testing program (Dairy Herd Improvement Association or DHIA) in Kansas. Nearly one-half of the dairy herds (n = 1,164) and dairy cows (n = 85,000) in Kansas are enrolled in DHIA. Our testing program shows that all DHI-tested cows average 18,116 lb milk compared with approximately 13,708 lb for all nontested cows. Dairy herds enrolled in DHIA continue to average more income over feed cost ($1,263/cow) than nontested herds ($971/cow) in 1992. Most of this success occurs because of better management of what is measured in monthly DHI records. In addition, use of superior, proven sires in artificial insemination (AI) programs shows average predicted transmitting ability (PTA) of AI bulls in service to be +1, 111 lb compared to non-AI bulls whose average PTA is only +317 lb milk. More emphasis should be placed on furthering the DHIA program and encouraging use of its records in making management decisions.

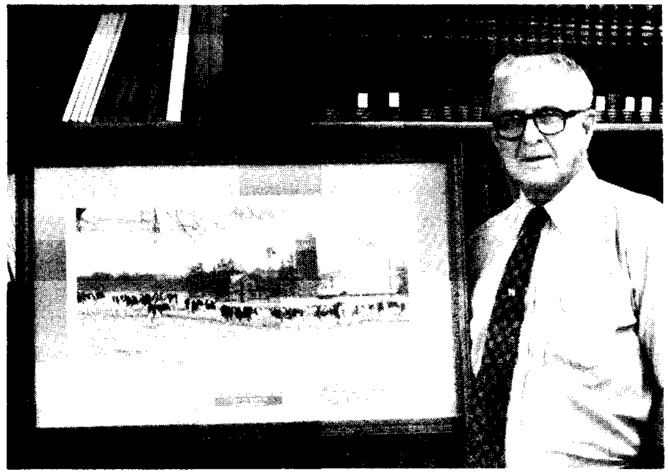
With our herd expansion program, which was begun in 1978 after we moved to the new Dairy Teaching and Research Center (DTRC), we peaked at about 210 cows. The herd expansion was made possible by the generous donation of 72 heifers and some monetary donations by Kansas dairy producers and friends. Herd expansion has enabled our research efforts to increase, while making the herd more efficient. Our rolling herd average was 19,052 lb in August, 1993, despite many research projects that do not promote production efficiency.

We are proud of our new 72-cow tie stall barn that was constructed in 1991 through the generous support of The Upjohn Company, Clay Equipment Company, and Monsanto Company and under the direction of Dr. John Shirley. This new facility will give us the ability to expand our research efforts in various studies involving nutrition and feeding, reproduction, and herd management. The excellent functioning of the DTRC is due to the special dedication of our staff. Appreciation is expressed to Richard K. Scoby (Manager, DTRC), Donald L. Thiemann (Asst. Manager, DTRC), Michael V. Scheffel (Research Assistant), Daniel J. Umsheid, Konrad Coe, Mary J. Rogers, Charlotte Kobiskie, Kathleen M. Cochran, Becky K. Pushee, Less Reeves, Tamara K. Redding, and Lloyd F. Manthe. Special thanks are given to Neil Wallace, Natalie W. Brockish, Betty Hensley, Lois M. Morales, and Cheryl K. Armendariz for their technical assistance in our laboratories.

As demonstrated, each dollar spent for research yields a 30 to 50 percent return in practical application. Research is not only tedious and painstakingly slow but expensive. Those interested in supporting dairy research are encouraged to consider participation in the Livestock and Meat Industry Council (LMIC), a philanthropic organization dedicated to furthering academic and research pursuits by the Department. More details about LMIC are provided at the end of this Report of Progress. Appreciation is expressed to Charles Michaels (Director) and the Kansas Artificial Breeding Service Unit (KABSU) for their continued support of dairy research in the Department. Appreciation also is expressed to the College of Veterinary Medicine for their continued cooperation. This relationship has fostered cooperative research and established an exemplary herd health program.

J. S. Stevenson, Editor
1993 Dairy Day Report of Progress

1993 Alfa Laval Agri Dairy Extension Award



Edward P. Call, professor of Animal Sciences and Industry, Kansas State University, was the recipient of the 1993 Alfa Laval Agri Dairy Extension Award. The citation was presented on June 15, 1993 at the 88th Annual Meeting, American Dairy Science Association at the University of Maryland, College Park. Alfa Laval Agri Inc. initiated the award in 1951 and annually presents the recognition.

Call was cited for his 20 years of service to the Kansas dairy industry as a member of the Cooperative Extension Service, Kansas State University. During that time, he has concentrated his efforts in the field of reproduction and has been a strong proponent of artificial insemination to maximize genetic gain. His AI Reprofresher Clinics held throughout Kansas have provided a unique teaching method. In collaboration with his coworker, Dr. J.R. Dunham, he has been a strong supporter of production testing as a means of measuring and evaluating cow and herd profitability. For many years, Kansas has been the Great Plains leader in participation in the DHI program.

Another cooperative effort has involved the Milking Management Clinics held around Kansas. These on-farm demonstrations have shown vividly that milking cows correctly yields more milk.

In addition to the 20 years in Extension, Call spent eight years on the resident staff at K-State, teaching reproduction and genetics courses and investigating methods to improve dairy cattle fertility. In cooperation with fellow staff member, Dr. J.S. Stevenson, Call has continued his interest in appropriate synchronization programs and means to improve the fertility of repeat breeders.

Born on a small dairy farm near Kent, Ohio, Call was active in 4-H youth work and served in the Pacific theater in World War II. Following graduation from Ohio State University, he was a DHIA supervisor and AI technician in Ohio before joining the staff at the Kansas Artificial Breeding Service Unit in 1952. He earned his doctorate from Kansas State in 1967 and was a Visiting Professor at the University of Florida in 1967-77. Call was named Kansas Dairy Leader in 1985 and Friend of Kansas County Agents in 1991.

('The award included an art piece by Bonnie Mohr shown with Call).

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Dairy Day 1993

LOOKING AHEAD WITH A LOOK BEHIND

E. P. Call

Summary

The current economic situation dictates that dairy producers use all available tools and resources to maximize efficiency. Yearly milk yield is the most reliable predictor of profitability. Because the genetic base dictates each cow's potential for converting feed into milk, using 80^{+} percentile proved sires is strongly recommended along with a 100% commitment to artificial insemination of cows and heifers. Current technology allows dairy producers to make significant gains in resolving poor reproductive performance.

A user friendly recordkeeping system to routinely measure individual cows' productivity along with overall herd performance is essential for maximizing return on capital investment.

Introduction

Lessons learned in the '80's will continue to apply to the dairy business in the '90's. Yearly milk production per cow seems to have the greatest impact on the probability for profit or loss. During the decade of the 1980's, production increased 23%. This was fortunate because milk price varied little, while other costs increased as much as 32%. Table 1 compares Kansas Dairy Herd Improvement (DHI) data for the years 1992 and 1982.

The increased productivity is a real testimony to the ability of Kansas dairy producers to implement research findings into management practices that make the dairy cow more efficient. Some of the factors involved during the 1980's include:

1. New National Research Council (NRC) nutrient requirements.
2. Higher energy and protein dense rations.
3. Improved accuracy and acceptance of sire summaries.
4. Use of prostaglandins (PGF) and gonadotropin releasing hormone (GnRH) to improve reproductive performance.
5. Enhanced recordkeeping systems, particularly those adapted for on-farm computers such as the electronic barn sheet (EBS).
6. Somatic cell count (SCC) as a monitor of udder health, milk quality, and milk loss, which serves as a basis for premium payments.

Milk production is under genetic control, but heritability estimates are around 25% ($h^2 \cong .25$) - the lowest of any of the economic traits in farm animals. Great biological variation exists, as seen in Table 2, which groups Kansas Holstein herds by yearly milk per cow.

As much or more variation exists among cows within a herd, which necessitates a production testing program to evaluate cows for production traits (milk, % fat, % protein) as well as somatic cells (SCC).

Because feed costs reflect 45-55 % of the cost of producing milk, the key to profit is income-over-feed cost and factors that affect it, such as yearly milk and ration costs. Feed costs for maintenance are mostly constant when comparing cows of similar body size and are not dependent upon yearly milk. Consequently, as noted in Table 2, as yearly milk increases 70% from the low to high groups, income-over-feed cost increases 114%, significantly improving the chance for profit.

A negative genetic correlation exists between production and reproduction. However, yearly milk per cow has little effect on calving interval (Table 2) and other measures of reproduction. Apparently, managers of higher producing herds "overmanage" the negative effect.

Do genetics limit production? Yes! The genetic effect is easily seen when comparing daily or lactation milk yields between beef and dairy cows after many generations of selection. However, within a breed or within a herd, the genetic effects are subtle and difficult to assess, because environmental factors and chance account for 75% of the variation among cows' yearly milk production. Genetic progress is limited because involuntary culling (mastitis, reproduction, injury, death) is greater than voluntary disposal for inferior milk production. By necessity, all herds keep cows below the genetic base to satisfy milk volume and heifer replacements. Genetic gain can be maximized only by selecting the top echelon of proved bulls to breed both cows and heifers.

Figure 1 presents USDA data that show changes in milk production using 1960 as the base and estimates genetic change over time. It was not until the late 1960's that reliable estimates of sires' breeding worth became available to effectively rank bulls. More recently (1980's), the animal model has further refined the reliability and accuracy of ranking bulls for production traits.

Table 3 presents insight on the genetic effect on yearly milk per cow. Although little difference occurs in the average breeding value of the proved sires (MFP$) among the various groups, the percentage of cows sired by proved bulls is startling! The same situation holds for the percent of cows identified by sire. If the nonproved sires in Table 3 were assumed to have breeding values of zero (MFP$ =0), the genetic difference between the low and high herds would be MPF$ = 86 or about 700 lb milk.

As shown in Table 4, the value of using AI proved bulls strongly recommends the commitment to a total AI program, if profit is the primary motive for milking cows.

Competing in the 90's will be more enjoyable and profitable if:

1. Commitment to AI (cows + heifers) is total.
2. PGF and GnRH are a part of reproduction management.
3. Least cost ration formulation is based upon forage analyses.
4. Herd SCC permits premium payments.
5. Herd health program minimizes medical problems.
6. Recordkeeping system readily allows economic analyses of various management areas.

Table 1. Comparative DHIA Data for 1992 and 1982 with Percent Change

Item	1982	1992	± Change
Milk/cow	13,939 lb	18,116 lb	+30%
Price/cwt	$12.91	$12.43	-4 %
Feed Cost	$747	$988	+32%
Feed cost/cwt	$5.36	$5.44	+1%
Income/feed cost	$1,053	$1,263	+20%
Cows/herd	69	74	+7%

Table 2. Kansas DHI Holstein Herds Grouped by Yearly Milk Per Cow and the Effect on Income, Reproduction, and Summit Milk Yield (SMY), 1992

Yearly milk (lb)	Summit milk yield* (lb)	Income/ feed cost ($)	Calving interval (days)
12,451	55	707	404
15,153	64	979	412
17,102	70	1,129	404
19,066	76	1,304	405
21,265	83	1,516	403

***Summit Milk Yield (SMY) estimates daily peak yield. Calculated by averaging the two highest test day milk weights of the first three months after calving.**

Table 3. Genetic Merit of Sires of Producing Cows in Kansas Holstein Herds Grouped by Yearly Milk Per Cow, 1992

Yearly milk	% Cows ID by sire	cows w/ proved sires	Proved sires' avg MPF$
(lb)	(%)	(%)	($)
12,451	**38**	23	104
15,153	**60**	46	104
17,102	65	54	118
19,066	84	78	128
21,265	84	82	134

Table 4. Average Breeding Value (MFP$) for All U.S. Bulls Summarized in July, 1993

Breeds	Active AI (MFP$)	1st Time AI (MFP$)	Non-AI (lst) (MFP$)
Ayrshire	+ 104	+70	+34
Brown Swiss	+ 144	+ 107	+37
Guernsey	+ 143	+ 124	+73
Holstein	+225	+181	+91
Jersey	+ 193	+141	+87

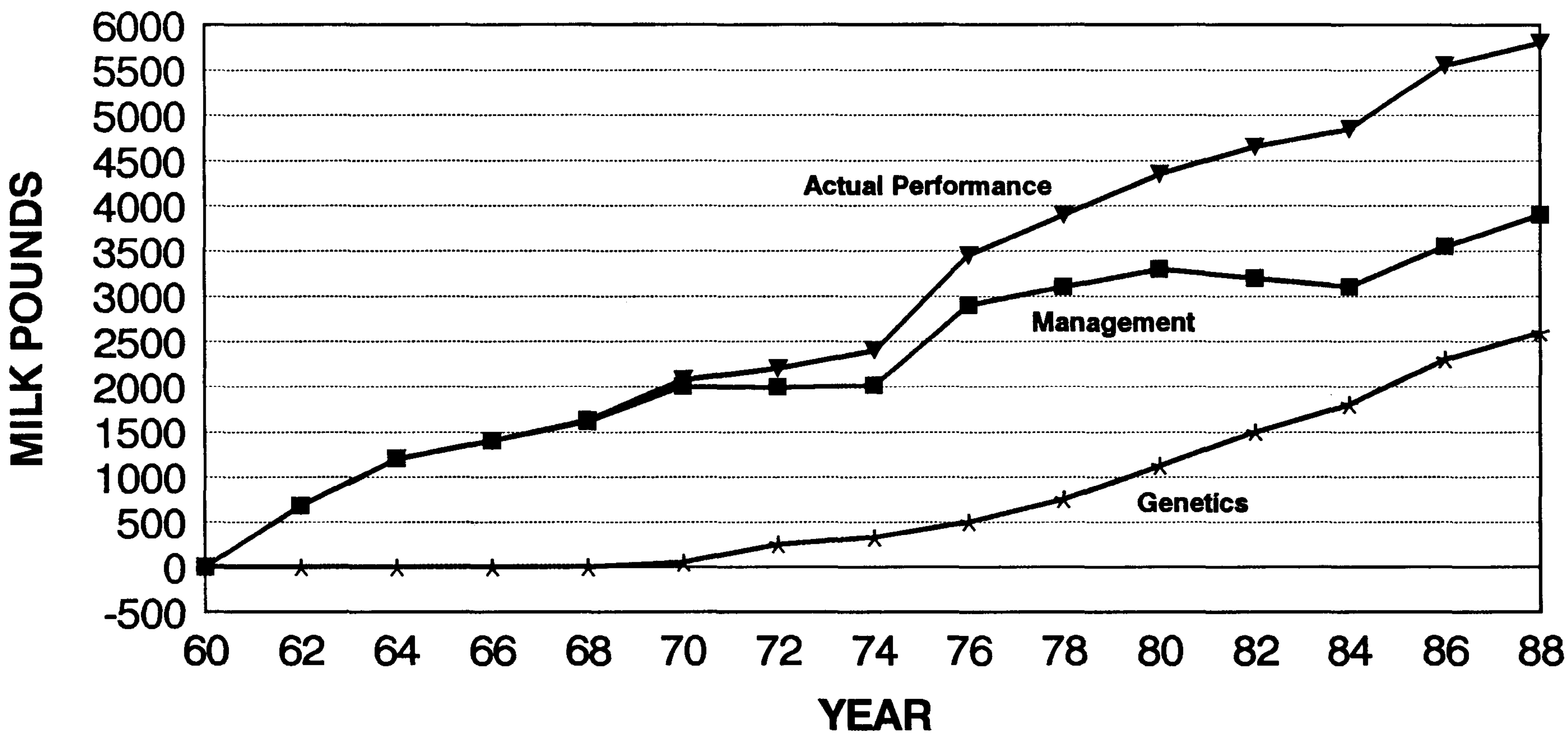

Figure 1. **Changes in Milk Production and Effects of Management and Genetics (Modified Data, AIPL, USDA)**

COMPONENTS OF A PROGRESSIVE REPRODUCTIVE MANAGEMENT PROGRAM

J. S. Stevenson

Summary

These are somewhat exciting times for dairy producers because of the new arsenal of hormones available for controlling estrous cycles and improving fertility. Using Bovilene® seems to assist cows in releasing a retained placenta. Most studies have demonstrated that using GnRH as a follow-up treatment (day 10 to 18 postpartum) for dairy cows with periparturient problems such as retained placenta improves their subsequent reproductive performance. Prophylactic treatment of early postpartum cows with GnRH (days 10 to 18) or prostaglandin $F_{2\alpha}$ (days 20 to 40) improved their reproductive performance in most studies as well. Injections of GnRH at the time of insemination during late estrus in repeat-service cows effectively improves pregnancy rates. As with all new technologies and hormonal therapies, it is critical that attention be paid to consistent heat detection and good A.I. technique. Use of hormones will not replace, only supplement, good management procedures and common sense.

(Key Words: GnRH, Prostaglandins, Fertility, A. I.)

Introduction

Postpartum Reproductive Events. Initiating early reestablishment of normal estrous cycles after calving is essential to allow adequate time for cows to be inseminated and maintain a 12- to 13-month calving interval. Normally, intervals from parturition to first ovulation average 3 to 4 wk in milking cows. Because most first ovulations are not preceded by estrus, interval to first heat averages about 5 to 6 wk. Involution of the previously gravid uterus is another critical event that must occur during the early postpartum period. The rate of involution is somewhat remarkable because by 20 days after calving, tissue sloughing and hemorrhaging have ceased, and the size of the uterus has been reduced by more than 80%. By 40 days, the uterus has completely involuted except for isolated pockets of leukocytes. All of these events (involution, first estrus, and first ovulation) are delayed in cows with periparturient problems such as dystocia; twinning; uterine infections; ovarian cysts; injury; or metabolic diseases such as ketosis, displaced abomasum, and milk fever. Furthermore, all measures of reproductive efficiency are reduced in cows with periparturient problems compared to normal cows. Infertility or reproductive failure is often difficult to resolve because of its multiple causes. However, many new tools are available to dairy producers to enable them to prevent, properly treat, and improve the overall reproductive health of the dairy herd.

Calving Intervals. Numerous studies have concluded that 12- to 13-month calving intervals are optimal for achieving maximal annual milk yield and economic value for dairy producers. Conceptions occurring before 60 days in milk resulted in shorter calving intervals and reduced cumulative milk yields of current and following annualized lactations. Calving intervals longer than optimum resulted in cows spending a greater proportion of their productive herd life in later and less profitable stages of the lactation curve. Moreover, economic losses associated with more or less than optimal calving intervals often go undetected, because they represent lost potential income in lieu of actual "out-of-the-pocket" expenses.

Replacement Heifers. Proper scheduling and introduction of replacement heifers into the milking string are of equal importance. Heifers should enter the milking herd no later than 2 years of age to maximize their lifetime performance and reduce maintenance costs. Inseminating growthy and well-developed heifers at younger ages offers the advantage of earlier recovery of their rearing costs. As long as special attention is paid to the nutrition and growth of heifers, and proven sires with known calving ease (less than 9% DBH [difficult first births]) are used as breeding sires, research has shown that heifers can calve earlier than 2 years of age. It is not difficult to find excellent sires with acceptable levels of calving ease because 36 of the top 100 Holstein sires in the USDA Sire Summary (January, 1993) had DBH scores of 8 or less (9.1% is breed average for Holstein sires).

Controlled Breeding programs. In managing the breeding of both heifers and cows, use of prostaglandin-$F_{2\alpha}$ (PG) or one of its analogs offers many options to the dairy producer. Beyond the broad concept of estrous synchronization, these products allow manipulation of the estrous cycle according to the goals and convenience of the herd manager, including managing insemination schedules of lactating cows to optimize calving intervals and age at first breeding in heifers.

The purpose of this report is to present some realistic applications of current techniques available to allow dairy producers to manage a progressive reproductive program.

Periparturient Health

Treatment for Retained Placenta. Retention of the fetal membranes or retained placenta (RP) probably is one of the most common postpartum reproductive abnormalities in dairy cattle. The incidence of RP averages about 10% in Holsteins and is affected by dystocia, milk fever, abortion, twinning, nutritional deficiencies, sex of calf, and induced calving. If the placenta has not been released by 24 hr after calving, it is unlikely to do so for 4 to 8 days. Although RP might cause reproductive problems itself, it is a predisposing factor for clinical metritis, which is strongly associated with decreased reproductive performance. A successful treatment for dairy cows with RP is one of the PG's. When injections of Bovilene® (2 cc; 1 mg s.c.) were given to cows with RP 6 hr after calving, 67% had expelled their placenta by 4 days after calving compared to only 45% of the control cows given saline. Neither Lutalyse® nor Estrumate® has produced positive results comparable to Bovilene® in this application.

Variously administered treatments of GnRH have met with success when given to dairy cows, which earlier had an RP, in attempt to preclude the negative effects of resulting uterine infections on the reproductive performance of those cows. In two studies, administration of GnRH during the second week postpartum (days 10 to 18) resulted in earlier first ovulation, more estrous cycles before day 60 postpartum, reduced interval from calving to first service and conception, and tendency for fewer services per conception. In one study, 378 cows with RP were treated with GnRH or saline on day 15 postpartum. However, the GnRH treatment was successful in improving overall reproductive performance of only 39 cows when first breeding began before an average of 80 days postpartum in several herds.

Husbandry of Cows with Retained Placenta. Good husbandry of cows with RP is very critical. A recent study utilized Holstein heifers that were induced to calve with a prostaglandin injection (500 **μg** Estrumate®) on day 274 of pregnancy. Sixteen heifers retained their placentas and were assigned randomly to either allow their placentas to be expelled without intervention (RP left) or to attempt manual removal of the placenta for 15 min on day 3 after calving (RP removed). These two treatment groups were compared to 17 heifers without RP's (seven of whom were induced to calve but did not retain their placentas). Manual removal of the RP prolonged the interval from calving to first appearance of a functional corpus luteum (CL) by 20 days, increased interval to first service, increased the severity of uterine infection, and prolonged the presence of pathogenic bacteria in the uterus compared to allowing the placenta to expel spontaneously. In those heifers in which the placentas were untreated the characteristics described were not different than in the control group.

Treatments with GnRH and/or Prostaglandin. Since the mid 1970's, a number of studies have validated the benefit of utilizing GnRH as a prophylactic treatment for postpartum dairy cows. Injections of GnRH were first demonstrated to induce ovulation and normal cycling activity in dairy cows as early as day 14 postpartum. Use of GnRH is effective in inducing ovulation in 80 to 90% of the dairy cows treated around days 10 to 14 postpartum. Those CL formed in response to GnRH are responsive to an injection of prostaglandin in approximately 5 to 6 days. Various studies have examined the reproductive performance of cows treated with both hormones in the early postpartum period. The rationale for giving GnRH 10 to 18 days postpartum, followed by a prostaglandin in about 10 days, is based on the observation that fertility of dairy cows during the normal breeding period is directly proportional to the number of estrous cycles occurring before breeding and the idea that GnRH should enhance the chances of earlier cycling activity followed by a prostaglandin to reduce the length of the first induced estrous cycle. One theory for the beneficial effects of these hormones and the increase in the number of estrous cycles in treated cows is the conditioning effect that several heats have on the uterus. Normal uterine contractions during estrus probably aid in preparing the uterus for subsequent pregnancy. Injections of GnRH also hasten the process of uterine involution.

Several studies have shown that cows with periparturient disorders (reproductive or metabolic) are likely to benefit from GnRH given 10 to 18 days postpartum. In an earlier study, cows were classified before day 18 postpartum as abnormal based on enlargement of one or both uterine horns; poor uterine tone; an enlarged; inflamed or dilated cervix; little ovarian activity; or a significant purulent, mucopurulent, or bloody vulvar discharge. When treated with 100 **μg** GnRH at 12 to 18 days postpartum, abnormal cows responded with earlier first estrus, and fewer days open and services per conception, whereas similarly treated, normal cows had no improvement after GnRH treatment.

In another study (Table 1), marked improvement in the reproductive performance of cows occurred as evidenced by reduced days open and fewer services per conception in normal and abnormal cows when treated with either GnRH or PG, but not both, except for fewer services per conception in normal cows treated with GnRH and PG.

Various treatments of dairy cows with PG have demonstrated profertility effects when cycling cows (i.e., most cows assumed to be cycling with a functional CL at the time of treatment with PG) were treated during the early postpartum period before the onset of the breeding period (i.e., before 40 to 60 days postpartum). When PG was given on day 26 and/or day 40 after calving, interval to first estrus was delayed, but treatments reduced intervals to conception compared with placebo-treated controls.

Table 1. Fertility Traits Associated with Postpartum Treatments with GnRH and/or Prostaglandin $F_2\alpha$ (PG)

Trait	Saline-Saline	GnRH-Saline	Saline-PG	GnRH-PG
No. cows	59	59	59	57
Days open	115	88[a]	86[a]	96
Normal	97	92	83	82
Abnormal	133	85[a]	90[a]	109
Services/conception	2.3	1.7[a]	1.8[a]	2.1
Normal	2.2	1.7[a]	1.6[a]	1.7[a]
Abnormal	2.4	1.7[a]	1.9[a]	2.4

Source: Adapted from Benmrad and Stevenson (1986) J. Dairy Sci. 69:800.
[a]Different ($P < .05$) from saline-saline group within health status.

Prebreeding Anestrus

Attempts to induce cycling activity in dairy cows with prolonged anestrus (smooth ovary cows with no ovulation [anovulation] and no observed estrus [anestrus]) have been few. The incidence of anovulation, which includes those cases in which dairy cows have prolonged or delayed intervals to first postpartum ovulation, ranges from 2 to 22% (average = 5%). Recent observations in one California dairy herd with a rolling herd average exceeding 20,000 lb, based on evaluation of milk progesterone, indicated that about 15 to 20% of cows in their first lactation and 5 to 10% of older cows were not cycling before 60 days postpartum. Problems associated with negative energy balance and periparturient problems are probably contributing to this greater incidence of anovulation. High milk-producing cows that lose more weight and fail to maintain adequate dry matter intakes are slower to cycle than cows of similar milk-producing ability that consume more dry matter.

A paucity of information exists assessing treatments for resolving the problem of anovulation in dairy cows. One French study found that regular monitoring of anovulatory cows with milk progesterone tests to determine when cows began to cycle after an injection of GnRH was successful in reducing the interval to first breeding compared to no treatment or treatments with GnRH but without progesterone monitoring. Some field observations by veterinary practitioners and dairy producers have suggested that treating such anovulatory cows with progestin for several days appeared to induce ovarian cycles. In some preliminary work, we found that implanting two anovulatory dairy cows (> 100 days postpartum) with Syncro-Mate-B" implants (one implant per ear containing 6 mg norgestomet per implant) induced ovulation in both cows, one of which was preceded by estrus. In a more recent study utilizing GnRH in dairy cows in an aggressive herd monitoring and ovarian palpation protocol, reproductive performance was improved compared to controls without GnRH treatments. Cows not responding to an initial treatment with GnRH were followed up with a second treatment 14 days later. If cows cycled spontaneously early postpartum or responded to the first or second injection of GnRH, they had higher pregnancy rates at 180 days in milk; overall reduced calving intervals; and, in some cases, required fewer services per conception.

Available Products for Controlling Estrus

Currently, three prostaglandin products are labelled for use in cattle. However, only Lutalyse® and Estrumate® are labelled for use in lactating dairy cows. Lutalyse® or PG, the first prostaglandin product cleared by the FDA in the U. S., is identical to the substance naturally produced by the uterine endometrium. It is capable of inducing luteolysis or the demise of the corpus luteum (CL). The two remaining PG's are chemical analogs of Lutalyse® produced by various substitutions on the terminal carbons of the fatty acid-like structure, which increase their plasma half-life but not their efficacy. Although inferences have been made about the relative efficacy of these products based on their longer plasma half-lives, all three PG's are equally effective in their ability to lyse and destroy the CL in the nonpregnant cow or heifer. Furthermore, the label claims of all three PG's provide evidence for their efficacy as abortifacients in heifers through 150 days of pregnancy. At the present time, only one progestin product (Syncro-Mate-B®) is approved by the FDA for the use in only dairy heifers.

Heat Detection

Voluntary signs of heat such as mounting and standing in dairy cattle are influenced by many factors. Those factors that are most important on dairy farms are: 1) number of sexually active animals in a group, 2) freedom for sexually active animals to interact, 3) freedom from interfering activities, 4) ambient temperature, and 5) footing conditions. Behavioral signs of heat require that at least two animals interact. Secondary signs such as butting, licking, and head-resting are influenced less by environmental conditions than are the primary signs of heat, such as mounting and standing. Most experienced observers utilize these secondary signs to pick out cows that are most likely to be in heat even when the immediate environmental conditions limit mounting and standing activity.

A cow will not be detected to stand if no other animal is available to mount. Mounting activity is stimulated strongly by estrogen and inhibited by progesterone. Thus, mounting frequency is considerably greater for cows in proestrus or estrus than for cows that are out of heat or in midcycle with a functional CL. Once there are four or more sexually active animals (proestrus or estrus) in a group, mounting activity will normally be sufficient for maximal efficiency of heat detection.

Table 2 indicates relative mounting activity that one might expect to observe in various locations and conditions on dairy farms. These empirical values are based on data from several published and unpublished studies and on casual observations made on many farms. A value of 1.0 is assigned to mounting activity expected to occur on a relatively dry, grooved, concrete alley. A high index means more mounting activity.

Activities or conditions that restrict interactions among cows influence whether cows show heat. Cows that are eating or are crowded in holding pens or alleys do less mounting. Cows that are on slippery alleys, frozen ground, or any surface that makes footing tenuous show less mounting activity. Cows in heat are more likely to mount one another if the other cows are loose rather than tied. Perhaps this indicates that freedom to interact before mounting is important for maximum expression of mounting activity. Cows that have foot problems, regardless of whether the problem is structural, subclinical, or clinical, apparently show less mounting activity. Many of the foot problems that affect mounting activity can be alleviated by proper foot care (foot baths, dry cows on dirt, etc.) and regular hoof trimming.

Table 2. Relative Indexes of Mounting Activity

Location of cows during heat detection	Mounting Index
Milking parlor	0.1
Feedbunk while eating	0.2
Holding pen	0.3
Dry concrete alley	1.0
Dry concrete alley + movement	1.1
Dry dirt lot	1.6
Dry dirt lot + movement	1.8

Source: J.H. Britt, personal communication

No firm experimental evidence shows that high levels of milk yield influence mounting or standing activity. Evidence does show that energy balance during the early postpartum period can influence whether a cow is detected in heat at the beginning of the first postpartum cycle. Apparently, cows experiencing a severe negative energy balance can produce enough estrogen to elicit an LH surge without causing them to show heat. Once cycles have begun, energy balance does not seem to affect intensity or duration of heat, but might affect fertility.

Extremes in temperature affect intensity of heat. Mounting activity is lower on very "hot" or "cold" days than on days when the temperature is near the thermoneutral zone of the cow (30 to 50°F). Heats may appear to be shorter when the temperatures are extreme, but it is unclear whether this is because of less mounting activity or because of less willingness to stand.

Insemination Protocols after Prostaglandin

Various calculations and research trials have shown that most cycling cattle injected once with PG and then reinjected 10 to 14 days later, regardless of their response to the first injection, should be at a stage of the cycle (days 5 to 17) at which luteolysis would occur after the second of two injections. This theoretical projection generally has proved correct (although not as well in lactating dairy cows unless injections are given 14 days apart) and served as a basis of one of four protocols promoted by the suppliers of the various PG's in their marketing information containing the labelled usages.

Four scheduled breeding programs are illustrated in Table 3. Program A consists of injecting all cattle twice with PG 10 to 14 days apart. Inseminations follow only the second of two injections. According to the labelled directions of each supplier, inseminations can be made according to observed heats or by appointment at 72, 80, or 72 + 96 hr after the second injection. Program B is a variation of Program A, in which all animals detected in heat after the first injection are inseminated based **only** on heat detection and **only** the remaining noninseminated cattle are reinjected 10 to 14 days later and then inseminated according to the choices given above for Program A. Program C consists of breeding for 6 days to: 1) detect estrus in those cattle that are on days 17 through 21 of their cycles that would come into heat spontaneously but would not respond to the injected PG, and 2) allow those cattle recently in heat to develop a CL (to at least day 6 of the cycle) that can respond to an injection of PG before **only** undetected and noninseminated cattle receive a first and only injection of PG on the seventh day. Inseminations in this program should follow heat detection or timed inseminations at 72, 80, or 72 + 96 hr after PG. Program D is designed to be used after cattle are palpated for the presence of a functional CL. Success of this program requires great expertise by the veterinary practitioner because of the difficulty of assessing functionality of the CL based on palpation per rectum or on the use of a commercial milk progesterone test to validate high concentrations of progesterone in milk. Those cattle with a functional CL are injected and then inseminated like any of those after a second injection of PG in the previous protocols.

Factors Altering Success of Various Prostaglandins Protocols

Stage of the Estrous Cycle. Some earlier reports had suggested a potential seasonal influence on the timing of estrus after PG. However, it is clear in reports of the last 15 years that the interval to heat after PG in both cows and heifers varies according to the stage of the cycle in which the injection occurs. Injections given on days 5 through 8 resulted in the shortest intervals to estrus (average = 49 hr), compared to days 8 to 11 (average = 70 hr) or days 12 to 15 (average = 62 hr). When heifers were inseminated according to signs of estrus, pregnancy rates were similar regardless of the stage of cycle. However, when heifers were inseminated at 80 hr after the second of two PG injections, pregnancy rates were lower than when they were bred according to detected estrus. This reduction in pregnancy rate undoubtedly occurs because approximately 60% of the heifers inseminated at 80 hr are bred too late relative to the onset of estrus after the second injection of PG. When using one or two injections of PG (i.e., Programs A or B in Table 3), it is recommended to inseminate heifers according to signs of heat after the second injection (Program A) or after both injections (Table 4). Furthermore, we have found that heifers not observed in estrus by 80 hr after the second injection will conceive to a fixed-time insemination at 72 to 80 hr after the second injection about as well as heifers inseminated according to detected heat. This timed service is successful because about 10 to 20 % of the heifers that are in heat after the second injection are not detected in estrus.

Fixed-Time Inseminations in Lactating Dairy Cows

Similar variations in the intervals to estrus have been observed in dairy cows given PG at various stages of the estrous cycle. We have observed that various fixed-time inseminations after the second of two injections of PG (11 days apart) in dairy cows resulted in less than acceptable pregnancy rates. When cows were inseminated either at 80 hr, with or without an injection of GnRH at 72 hr, or at 72 + 96 hr (double insemination) after the second of two injections, pregnancy rates ranged from 23 to 31%, compared to 51% in control cows inseminated according to signs of heat but without prior injections of PG.

Several factors account for the poor results achieved after fixed-timed inseminations of lactating dairy cows. Injections of PG were only 85% effective in regressing the functional CL (defined as high [> 1 ng/mL] serum concentrations of progesterone at the time of the injection and low [<1 ng/mL] concentrations 24 to 48 hr later) regardless of whether it was after the first (40 to 46 days postpartum) or at second (51 to 57 days postpartum) injection of PG. This efficacy of induced luteolysis was similar to that in other studies with cows (91 to 92%) but less than that observed with heifers (95 to 100%). Another limitation to success was that 15% of all cows had low concentrations of progesterone (no CL) at the time of the second injection. One third of these cows was anestrus and the remaining two-thirds were cycling but had low progesterone at the time of the second injection and had high progesterone at the time of the first injection. This latter category suggested that cows were anovulatory, had ovulatory disturbances, or were at an unresponsive stage of the estrous cycle (days 17 to 21 or days 0 to 4) prior to the second injection because they failed to respond to the first injection 11 days earlier. More recent work in Israel with lactating dairy cows has shown some promising results with fixed-time inseminations. When two injections of PG were given to primiparous cows at 11 versus 14 days apart, 84% of those receiving injections 14 days apart conceived within 30 days of their first service compared to 62% of those given injections 11 days apart.

Table 3. Scheduled Breeding Programs Utilizing Prostaglandins (PG)

Program A	Program B	Program C	Program D
Inject **all** females with PG - **first** injection	Inject **all** females with PG - **first** injection ↓		Palpation or positive milk P_4 test: ↓
↓	Detect heat and A.I. for 14 d ↓	Detect heat and breed for 6 d ↓	Must have a functional CL ↓
Inject **all** females with PG 14 d later-**second** injection ↓	Inject **only** females **not yet bred** with PG 14 d after the first injection ↓	Inject **only** females **not yet bred** with PG on d 7 ↓	Inject **all** eligible females with PG ↓
Inseminate	Inseminate	Inseminate	Inseminate

Table 4. Fertility of Dairy Heifers in 45 Michigan Herds with Different A.I. Schedules after Prostaglandins (PG)

		Pregnancy rate, %			
Schedule for insemination	N	Mean	Minimum	Maximum	Range
Insemination at estrus					
After first PG	766	65.4[a]	47.6[a]	95.9[a]	48.3[a]
After second PG	1025	60.9[b]	33.3[b]	92.3[a]	59.0[a,b]
Insemination at 80 hr after second PG					
No observations made for estrus	561	40.6[c]	6.7[c]	85.7[a,b]	79.9[b]
Observations made for estrus	384	36.9[c]	0[c]	73.3[c]	73.3[b]

Source: Adapted from Fogwell et al. (1986) J. Dairy Sci. 69:1665.
[a,b,c]Values lacking a common superscript letter differ ($P < .05$).

Use of Prostaglandins in Reproductive Management Schemes

Weekly Insemination Groups. Although estrous synchronization of many cows or heifers is not feasible in most dairy situations (except in large herds or where seasonal calving is practiced), use of PG for handling small groups of cows and heifers that enter the breeding group based on calving or birth date, respectively, is desirable. This type of system works well when coupled with a weekly or biweekly herd-health visit by the veterinary practitioner. A summary in Table 5 highlights one method in which eligible cows or heifers entered their respective breeding groups when found to have a functional CL. Milking cows given PG were inseminated 11 days earlier and conceived 19 days sooner than controls after assignment to the study. Furthermore, heifers treated in a similar fashion with PG were inseminated 13 days sooner and conceived 18 days earlier than their untreated herd mates. This type of reproductive management, coupled with inseminations based on good heat detection, is an example of utilizing Program D.

Table 5. Use of Prostaglandins (PG) in Reproductive Management of Cows and Heifers

Item	Control cows	PG cows	Control heifers	PG heifers
No. animals	228	219	51	48
Assigned to study[a]	58	58	14.1	14.1
Days to first service	81 ± 1	70 ± 1[b]	21 ± 2	8 ± 1[b]
Days to conception	111 ± 3	93 ± 3[b]	38 ± 4	20 ± 3[b]

Source: Adapted from Seguin et al. (1983) J. Amer. Vet. Med Assoc. 183:533.
[a]Days postpartum for cows or months of age for heifers when entering the breeding group.
[b]Different ($P < .01$) from controls within cow or heifer columns.

Monday Injections of Prostaglandin. Based on the distribution of estrus after PG in the previous study (Table 5), about 88% of all first inseminations in cows could be given on 4 days of the week. This translated subsequently into 82% of all repeat inseminations of cows that returned to estrus occurring on 4 days of the 40-h work week. From these responses, it was suggested that Monday use of PG could allow most of the inseminations to occur on Wednesday through Saturday. Similar programs have been proposed in which eligible cows (at least 40 to 50 days postpartum), formed into small breeding groups or clusters, are given PG (generally without knowledge of stage of the estrous cycle) on Monday mornings and observed for heat during that week. Cows not showing estrus are re-injected on the following Monday. This procedure is repeated on a third Monday if needed. Any cow not detected in heat after a third Monday injection of PG should then be presented for a reproductive examination by the herd veterinary practitioner. A recent study compared the weekly administration of PG to open cows to a system in which all open cows with a CL identified weekly by ovarian palpation were administered PG. Cows receiving weekly doses of PG had a 30% higher pregnancy rate per unit of time. We recently completed a similar study in which cows were given PG based on a high milk progesterone test and compared that system to using no PG's but only inseminating based on natural heats. The results are shown in Table 6. Use of PG improved nearly all measures of reproductive performance.

Table 6. Reproductive Performance of Dairy Cows Given Weekly Injections of Prostaglandin $F_{2\alpha}$ (PG) versus Using No PG (Control) in a Scheduled Breeding Program

	Treatment			
Trait	Control	Milk P4 + PG	SE	P value
No. cows	72	127		
Days to first service	83.6	71.4	3.1	.006
First-service pregnancy rate, %	34.7	41.7	-	.257
Percentage bred once in first 21 d	38.9[2]	52.8	-	.053
Calving interval	406.4	383.1	8.9	.068
Pregnant by 120 d, %	62.3	72.0	-	.174
Overall pregnancy rate, %	73.6	73.2	-	.993

[1]Control cows were inseminated when estrus was detected by visual observation without the use of PG. Cows in the milk progesterone (P_4) + PG group were inseminated when estrus was detected by visual observation after an injection of PG following a high milk P_4 test. Cows in the latter group were tested for high or low milk P_4 status and given injections of PG accordingly, for up to 3 wk.

[2]Days from beginning of breeding period (42 days postpartum) for controls and days from first estimate of milk P_4 in the milk P_4 + PG group.

We attempted to examine the cost effectiveness of our two treatments (milk progesterone + PG vs control) relative to the cost of each pregnancy achieved. Cost comparisons for our two treatments are summarized in Table 7, in addition to those of two other PG systems described above. Costs were estimated to approach realistic values for milk P_4 tests, PG, and individual palpations of cows. An additional cost was added to our control group because of its longer calving interval. Studies assessing the cost of days open beyond 365 days (12-mo calving interval) range from $.25 to $4.68 per day open beyond 85 days. We conservatively used the estimate of $1 per day open for controls beyond that which was achieved in the milk P_4 + PG group, for a total of $23.30 per pregnancy in the controls. The cost per pregnancy in controls was $30.32 compared to a lower cost of $20.59 for the treated cows. To make the cost per pregnancy equal in our two treatment groups, the cost of 1 day open beyond 85 days would have to equal only $.35. In comparison to similar estimates of cost in the previous study, weekly injections of PG cost $17.69 per pregnancy and palpation + PG cost $14.14.

Table 7. Cost Comparison for Breeding Programs Involving Only Visual Detection of Estrus (Control), Milk Progesterone (P_4) + Prostaglandin $F_{2\alpha}$ (PG), Weekly Blind Injections of PG, and Palpation + PG

	Treatment[1]			
Item	Control	Milk P4 + PG	weekly PG	Palpation + PG
No. cows assigned	72	127	184	188
No. pregnancies	53	93	156	154
Cost of milk P_4 ($3 each)	0	864	0	0
Cost of PG ($3 each)	0	399	1665	507
No. of injections/pregnancy	0	1.4	3.6	1.1
Cost of palpations ($2 each)	372	652	1094	1670
Cost of longer days open ($1/day)[2]	1235	0	0	0
Total costs, $	1607	1915	2759	2177
Cost/pregnancy, $	30.32	20.59	17.69	14.14

[1]Control cows were inseminated when estrus was detected by visual observation without the use of PG. Cows in the milk progesterone (P_4) + PG group were inseminated when estrus was detected by visual observation after an injection of PG following a high milk P_4 test. Cows in the latter group were tested for high or low milk P_4 status and given injections of PG accordingly for up to 3 wk. Information for the last two treatments was adapted from a recent report in which weekly injections of PG were given blindly without knowledge of corpus luteum (CL) or P_4 status (weekly PG) or injections of PG were given to cows with a palpable CL (palpation + PG). In both of the latter cases, treatments continued until inseminations occurred or the cow was culled from the herd.

[2]Included was an assessment of $23.30 per control cow ($1 per day open) that did not conceive until 23.3 days later than the milk P_4 + PG group. Median days open were 97 and 110 days for the latter two groups in another, which were similar to that in our milk P_4 + PG group (average = 101 days).

Unobserved Estrus

Despite problems discussed above, there is a place for fixed-time inseminations in dairy cows. Cows that fail to exhibit estrus (or whose heats are missed) at various stages after calving will have delayed intervals to first service and generally longer than average calving intervals. In addition, cows that have unobserved heats after insemination and are found open at pregnancy examination (40 to 50 days after the most recent service) generally have longer than acceptable calving intervals. Both types of cows mentioned are candidates for PG. These cows with observed estrus, which might be difficult to detect in estrus because of subtle or weak signs of heat, are best handled according to Program D in Table 3. Earlier work suggested that about 90% of these cows are cycling but not detected in heat. In our study, every cow with a palpable CL (based on assignment of cows by the various veterinary practitioners in 16 commercial dairy farms) was assigned on an alternate basis to serve as a control (no treatment) or to receive PG. All control cows were inseminated according to heat observations made by the dairy producers and all

PG-treated cows were likewise observed for heat and bred accordingly. However, those cows not detected in heat by 72 hr after the injection of PG were double inseminated at 72 and 96 hr after PG. Cows treated with PG conceived 20 days sooner than controls, even though pregnancy rates were similar to those of controls and only 53% of the treated cows were detected in heat (Table 8). Therefore, 47% of the cows inseminated after PG were not observed in heat and their pregnancy rate was 44% following a double insemination at 72 and 96 hr. Without timed inseminations, 49 pregnancies would not have occurred after treatment with PG. Another study reported nearly equal success with only one fixed-time insemination at 80 hr.

Table 8. Response of Dairy Cows with Unobserved Estrus to Prostaglandins (PG)

Item	Control	PG
No. cows	100	176
Pregnancy rates, %	43	43
Inseminated at estrus, %	43	42
Inseminated at 72 + 96 hr		44
Observed in standing estrus, %	100	53
Interval from treatment to conception, d	55 ± 6	35 ± 4[a]

Source: Adapted from Plunkett et al. (1984) J. Dairy Sci. 67:380.
[a]Different ($P < .05$) from control cows.

The success of the results described in Table 8 depended upon a high degree of accuracy in diagnosing a functional CL (91 % accuracy). The hazards of ovarian palpation per rectum for identifying accurately a functional CL were reported recently in a summary of four studies. The accuracy of diagnosis was verified by concentrations of serum progesterone at the time of palpation. The accuracy of diagnosing a functional CL palpated per rectum was 82% (ranged from 79 to 85%), and the accuracy of diagnosing no functional CL was 70% (ranged from 61 to 75%). In other words, 18% of the cows diagnosed to have a CL did not have high concentrations of progesterone and 30% of the cows with high concentrations of progesterone in their serum were diagnosed as not having a functional CL.

Uses of GnRH to Improve Fertility at Insemination

Repeat Breeders. Administration of GnRH or one of its agonists to repeat breeders (cows that generally failed to conceive after at least two previous services) at the time of insemination has improved fertility in almost all studies. We recently published a six-herd study in which we tested a single versus a double insemination with or without the GnRH treatment, hypothesizing that the repeat breeder is ovulating later after estrus than more fertile cows. A single injection of GnRH given at the time of a single insemination (according to the AM-PM rule) consistently produced the highest pregnancy rates in all six herds (Table 9).

Conclusions

Heifers. Programs A and B (Table 3) seem to be best suited for breeding replacement heifers (Table 3). Program B will require less PG per pregnancy than Program A, but it necessitates two periods of heat detection for each breeding group or cluster formed. Many recommend injecting heifers to be inseminated and then

Table 9. Pregnancy Rates in Repeat Breeders after GnRH Administration and Single or Double Insemination

	Single Insemination		Double Insemination	
Trait	No Injection	GnRH	No injection	GnRH
No. of cows	391	381	383	390
Pregnancy rate, %	33[a]	41[b]	33[a]	37[a,b]

Source: Adapted from Stevenson et al. (1990) J. Dairy Sci. 73:1766.
[ab]percentages without common superscript letters differ (P < .05).

observe for estrus and breed for at least 5 days after the first injection, then reinject the remaining noninseminated heifers 14 days after the first injection of PG and inseminate according to heat detection for 5 more days. We have found that any heifer not observed in heat by 72 hr after the second of two injections should be timed inseminated at 72 hr, not 80 hr, which works well for cows. The reason for the earlier fixed-timed insemination at 72 hr is because heifers come into estrus about 10 to 12 hr earlier than cows. Inseminating heifers at 72 hr after the second injection in the absence of detected heat will produce pregnancy rates nearly equal to those of heifers bred according to heat observations. Program D is a viable alternative, if the veterinary practitioner visits the herd on a weekly or biweekly basis and can work closely with the dairy producer in managing the breeding groups in conjunction with routine ovarian palpation as demonstrated in Table 5. Use of Syncro-Mate-B® has merits for inseminating groups of heifers based on heat detection or fixed-time inseminations. Pregnancy rates seem to be similar when heifers are inseminated based on detection of estrus or a fixed-time insemination is used at 48 to 54 hr after removal of the SMB implant.

Cows. Two approaches for cows are appropriate. Injecting cows once with PG is effective for inducing estrus, if cows are between days 5 and 17 of their estrous cycle. About 60% of cows should respond to PG by coming into heat at any given time, if estrous cycles are nearly randomly distributed across the herd. REMEMBER that these results are based on identifying ALL cows in heat and doing so with nearly 100 % ACCURACY. Inseminations should be based solely on heat detection in the case where only one injection of PG is given without evaluating the CL status by palpation or performing a milk progesterone test. A second approach, which fits the weekly (Monday morning) breeding group or cluster concept, is ideal for handling cows blindly without knowledge of ovarian status or recent heat periods. For those cows that fail to be inseminated by 80 to 100 days postpartum (whatever tolerable limit is set by management), as well as those cows found open at pregnancy diagnosis, Program D is a recommended method of treatment (Table 3). Cows with a positive milk progesterone test or diagnosed to have a functional CL by palpation should be given PG and then watched for estrus. Those not caught in heat by 72 hr should be inseminated at 72 hr and reinseminated at 96 hr after PG. The objective is to get these problem cows inseminated and possibly pregnant before giving up and designating them as reproductive culls. One must remember that cows with unobserved heats might have subtle, weak, short periods of estrus and might benefit from a fixed-time insemination(s). If two injections of PG are used to synchronize estrus, an interval of 14 days is recommended. Regardless of the program (Table 3) selected, the best results occur following good heat detection. Timed inseminations have a role, but we must continue to concentrate on achieving better heat detection.

FEEDING THE HIGH PRODUCING COW

D. J. Schingoethe[1]

Summary

Dairy cows must consume a lot of feed to achieve the levels of production expected today; however, the nutrient needs of dairy cows vary immensely between the dry period and peak lactation. Requirements for the former often can be met with forages alone, whereas the latter may require a considerable amount of high-energy feeds such as grains and supplemental fat and ruminally undegradable proteins of good quality that are digestible in the gastrointestinal tract. The challenge for a dairy feeding program is to meet the cow's nutrient needs while minimizing body weight loss, not causing digestive upsets, and maintaining health.

(Key Words: Cows, Lactating, Feeding, Energy, Protein.)

The Lactation and Gestation Cycle

The relationships between milk production, dry matter intake, and body weight changes typically observed during the normal lactation and gestation cycle are illustrated in Figure 1. Production increases rapidly, and peak (maximum) daily production is reached about 6 to 8 wk after calving. However, appetite lags behind production, such that maximum daily dry matter intake often does not occur until 12 to 15 wk postpartum. Thus, most cows are in negative energy balance for 8 to 10 wk and possibly as long as 20 or more wk for some high producers. The cow makes up these nutrient deficits by "borrowing" from her body stores. Cows in good condition often lose 200 to 300 lb of body weight during early lactation, which is sufficient to support 1,500 to 2,000 lb of milk production. If that source of nutrients is not available, peak production and total lactational production will likely be less than optimal.

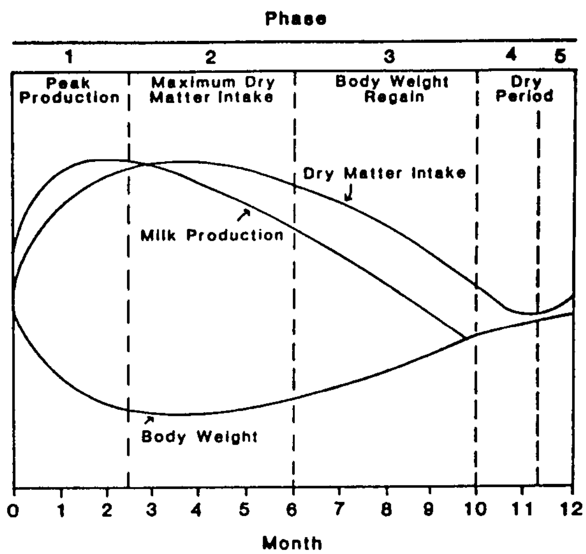

Figure 1. Milk Yield, Dry Matter Intake, and Body Weights of Cows during Phases of the Lactation-dry Period Cycle

After maximum dry matter intake is achieved, intake tends to follow production requirements and decreases as production decreases. But, there is still a lag in intake, only now the cow tends to consume more than she needs during later lactation.

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This allows her to regain the body weight lost in early lactation. The cow should regain most of this body weight during late lactation for optimal energetic efficiency, with most of the weight gain during the dry period being accounted for by fetal growth.

Feeding programs for the various phases of the lactation and gestation cycle will be discussed below. Discussion will start with the dry period (phases 4 and 5) and then proceed through lactation. Suggested ration specifications are in Table 1.

Dry Cow Rations

Feeding for high production actually starts during the dry period. Cows should consume enough during the dry period to maintain or get into good condition but not excessively fat. A body condition score of 3.5 to 4 at calving is ideal for high milk yield, fat test, and reproductive performance.

Dry cow rations can be quite simple but should consider the following items. 1) Feed a minimum of 1% of body weight as long-stem dry forage. Preferably, this should be grass hay because the excessive calcium and low phosphorus in legumes may increase the incidence of milk fever. 2) Avoid feeding corn silage free choice because it leads to excessive energy intake as well as increases the likelihood of displaced abomasum and fat cow syndrome. 3) Limit grain intake to amounts required to meet energy and protein needs. 4) Keep calcium intake under 100 g/day, while providing adequate amounts of phosphorus (35 to 40 g/day) to minimize the incidence of milk fever.

Increase grain intake in the last 1 to 2 wk prior to calving, so that at parturition a cow is consuming .5 to 1 % of her body weight as grain mix. This will help adapt the ruminal microorganisms to the higher energy diet that will be fed postpartum and may minimize the chances of milk fever and ketosis. You may also consider increasing the vitamin E content of this mix to supply 500 to 1,000 IU/day and supplementing selenium to .30 ppm if you are in an area where selenium content of soils and feeds is low.

Rations for High Production

The most critical period for a dairy cow is from parturition until peak milk production. Thus, this presentation will concentrate on this phase of the lactation. But most ration considerations for early lactation apply to cows producing more than 5 lb of milk/100 lb of body weight during all stages of lactation. Each 1 lb increase in peak milk production usually means an additional 200 lb of milk production during the lactation. However, because appetite lags behind nutritional requirements, a negative energy balance usually occurs in the first two months of lactation. Ideally, body condition scores should not drop below 2 to 2.5 during lactation.

A successful phase 1 feeding program will maximize peak milk yield, utilize body weight as an energy source, minimize ketosis, and return cows to a positive energy balance by 8 to 10 wk postpartum. This is the period of lactation that requires the best in nutritional management. During this phase, positive responses to feed additives, special feed treatments, and special ration formulations are most likely to occur.

Maximizing dry matter (DM) intake is the key to high production. The objective during early lactation is to increase feed intake as rapidly as possible, so as to minimize the nutritional deficit, but not introduce ration changes so rapidly as to cause digestive upsets and off-feed. Conception rates will also be greater for cows in positive than in negative energy balance. Feed bunk management practices such as feeding more frequently, keeping the feed fresh, and having fresh water readily available encourage increased intake. Once the stress of calving has passed, grain intake can be increased by 1 to 1.5 lb/day. Or, if total mixed rations are fed, the forage to concentrate ratio can be gradually decreased to a minimum of 40% forage. At higher concentrate proportions, maintaining the recommended minimum of 18 to 19% acid detergent fiber may be difficult.

Maximum DM intake may reach 3.5 to 4% of body weight for most cows, with some cows consuming more than 5%. Don't be surprised to see some high producers consuming 55 to 60 lb or more of DM daily.

With higher DM intakes, the percent protein needed in the diet can be lower than that needed in early lactation, because the cow is now getting all of her needed energy as well as her needed protein supplied by the diet. The proportion of grain in the total diet can also be lower, because the rumen microorganisms can utilize more forage. Increased microbial protein synthesis stimulated by the greater DM intake, coupled with lower dietary protein percentages, means that these cows are less likely to benefit from bypass protein than they would have in early lactation.

Protein. Cows can compensate for much of their deficit in energy intake by "borrowing" the remaining needed energy from body fat; however, they cannot borrow very much protein. Thus, most of their protein must be supplied in the diet. When energy intake equals energy requirements, a diet containing 16 to 17% crude protein will meet protein requirements for most cows. However, in early lactation, 18 to 20% crude protein maybe needed to meet protein requirements when energy intake is not supplying all of the cow's needs.

Early lactation cows are most likely to benefit from ruminally undegraded (bypass) proteins. You should maximize rumen microbial protein synthesis, because it is higher quality and cheaper than most feed proteins. The protein requirement of cows producing up to 5 lb milk/100 lb body weight usually can be met by rumen microbial protein synthesis plus normal amounts of bypass protein. Cows producing more than this amount of milk will likely benefit when 35 to 40% of the crude protein is ruminally undegradable. But the bypass protein must be digested in the gastrointestinal tract and provide the needed amino acids in order to increase production. Some high bypass protein supplements available are poorly digested or may be deficient in certain limiting amino acids. Nonprotein nitrogen (NPN) supplements will not be efficiently used by these cows, although NPN utilization can be improved by increasing the amount of fermentable carbohydrates in the diet.

Energy. Increasing the energy density ($NE_{Lactation}$) of the diet to more than .78 Mcal/lb of DM also helps the early lactation cow more nearly meet her energy requirements. This can be achieved to a certain extent by increasing the amount of concentrates fed. Maximum microbial synthesis usually can be achieved with 35 to 40% of DM as nonstructural carbohydrates; higher grain diets are more apt to cause acidosis, digestive upsets, and milk fat depression.

Supplemental dietary fat may allow you to increase energy density of the diet while maintaining adequate fiber intake. Increased production from feeding supplemental fat during the first several months of lactation often persists throughout lactation. Most grains and forages contain 2 to 4% fat, but diets can easily contain 5 to 7% fat without causing digestive upsets or reductions in feed intake. All fat sources — oilseeds, animal fats, and dry fat products — are equally effective in boosting the energy density of diets and increasing production. Soybeans should be heated if feeding more than 4 to 5 lb/head are fed daily, but other oilseeds need no processing. Although oilseeds effectively increase production, feeding vegetable oils can drastically reduce milk fat percentages. Feed handling may be a consideration with cottonseed and animal fats. Unsaturated fat sources such as soybeans and sunflower seeds can improve the marketability of dairy products by increasing the proportion of unsaturated fatty acids in milk fat.

There are several dietary recommendations when feeding supplemental fat. 1) Increase the calcium content to more than .9% of DM and the magnesium to about .3%. 2) Provide adequate amounts of crude protein to maintain an acceptable protein: energy ratio. As a guideline, for each 1 lb of supplemental fat fed, increase the crude protein 1%, preferably from sources low in ruminal degradability. 3) Provide adequate amounts of fiber and fermentable energy. Milk protein content is typically reduced when supplemental fat is fed. The reasons are not entirely known, but you don't want to further aggravate the problem by feeding a diet that is deficient in protein or fermentable energy.

Feed Additives. Any feed additives that may increase production and/or animal health are most likely to be effective in early lactation. Buffers, such as sodium bicarbonate ($NaHCO_3$), alone or in combination with magnesium oxide, can be helpful during early lactation. Cows fed ensiled forages, especially of small particle size, and high amounts of soluble carbohydrates will likely benefit from 100 to 200 g/day of $NaHCO_3$ or its equivalent. The primary benefit is from maintaining ruminal pH, which minimizes acidosis, reduces digestive upsets, and results in increased DM intake.

Other feed additives such as niacin can also be beneficial during phase 1, but they will likely be of minimal benefit at other times. Niacin supplementation during the late dry period and early lactation will likely increase feed intake and reduce the chances of ketosis.

Mid and Late Lactation

These phases should be the easiest to manage because the cow is pregnant, nutrient intake equals or exceeds requirements, and milk production is declining. Late lactation is the time to replace the weight lost during early lactation, so that the cow is in good condition at drying off, but also to maintain milk persistency as great as possible. Keep in mind that young cows are still growing and, thus, need additional nutrients for growth as well as for weight regain. The usual guidelines for estimating nutrient requirements for growth are 20% of maintenance requirements for 2-year-olds and 10% of maintenance for 3-year-olds.

During this phase, you have an opportunity to minimize feed costs by increasing the forage to concentrate ratio to match nutrient needs based on milk production and body condition and by utilizing NPN. A lower protein content is likely sufficient because the protein to energy ratio needed for weight gain is less than the ratio needed for milk production. Nonprotein nitrogen sources can be utilized for a portion of the crude protein needs of these cows, whereas bypass proteins will be less cost effective than in earlier lactation when production was higher.

Managing with bST

Cows injected with bovine somatotropin (bST) should be fed and managed the same as any high producing cows. A production increase of 10 to 15%—the same increase as if switching from 2X to 3X milking—may occur, so the cows should be handled accordingly. DM intake will ultimately increase 3 to 5% to provide for the increased production. However, appetite lags behind the increased production just as in early lactation. Thus, ration considerations for early lactation need to be considered for more of the lactation. I would not recommend using bST before a cow is in positive energy balance. Thus, I wouldn't use bST before 50 to 60 days postpartum and maybe not until after the cow has reached peak DM intake and may already be bred.

Table 1. Recommended Nutrient Content of Dry Matter in Diets for Dairy Cattle[1]

Nutrient	Dry, pregnant cows	Lactating Cows			
		Early lactation[2]	Milk yield, lb/d 100	70	35
Energy, NE_L, Mcal/lb	.57	.76	.78	.73	.66
Crude protein, %	12	19	18	16	13
Fiber (minimum)					
Acid detergent fiber, %	27	21	19	21	21
Neutral detergent fiber, %	35	28	25	28	28
Minerals					
Calcium, %	.39	.77	.66	.58	.45
Phosphorus, %	.24	.48	.42	.36	.30
Vitamins					
A, IU/lb	1,800	1,800	1,450	1,450	1,450
D, IU/lb	540	450	450	450	450
E, IU/lb	7	7	7	7	7

[1]Adapted from NRC for dairy cattle (1989).
[2]First three weeks of lactation.

KANSAS FARM MANAGEMENT ASSOCIATION DAIRY COW HERD ENTERPRISE MANAGEMENT ANALYSIS

F. D. DeLano and L. N. Langemeier[1]

Summary

Actual dairy cow herd enterprise records from Kansas Farm Management Association farms over the past 4 years have shown an increase in returns over variable costs from $17,900 to $23,300 per farm for a 100-cow dairy herd in favor of herds with higher milk-producing cows. Cost per hundred weight of milk produced per cow decreased for the higher-producing herds compared with lower-producing herds, even though total cost per cow increased. In 1992, for every extra $1.00 spent on feed and other variable costs, the higher producing herds earned $1.71. This was a 71% return per dollar invested.

(Key Words: Economics, Dairy, Management.)

Introduction

Detailed dairy cow herd records from farms enrolled in the Kansas Farm Management Association program are analyzed each year using the K-MAR-105 mainframe computer as the basis for providing valuable information to each participating dairy farm. This detailed information is also useful to nonmembers for benchmark comparisons. Total dairy herd production expenses, along with production information, are made available on per hundred weight (cwt) of milk sold and per cow bases. This complete dairy herd enterprise analysis, along with DHIA records, provide the information for dairy farmers to evaluate correctly their dairy herd program.

Procedures

Dairy cow herd producers keep monthly receipt and expense records in an account book or on a computerized accounting program. Detailed crop production, feed, and inventory records are completed each year under the supervision of Extension Agricultural Economists, Farm Management Association Program.

Milk production is based totally on sales and, thus, does not include home use or milk fed to calves. The total feed expense includes all feed consumed by the dairy cow herd including pasture, value of stock fields, etc. Values are based on average farm market price for the current production year, inventory value, or actual purchase cost.

Results and Discussion

The 1992 dairy cow herd enterprise records from 108 dairy farms were analyzed by dividing the farms into herds with milk sales below and above 18,000 lb of milk per cow. High production per cow is very important to obtain acceptable returns to the operator for management, labor, and equity capital.

Table 1 compares these two milk production groups. In 1992, the higher-producing herds sold 3,757 lb more milk per

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cow (over 23% greater production), which resulted in $477 additional gross income per cow. For the higher-producing herds, total feed cost per cow increased by $151 and other variable costs (direct production costs) increased by $116. These herds returned $210 more per cow above variable costs than the lower-producing herds. For a 100-cow herd, higher production provided $21,000 more income for family living, debt repayment, replacement of machinery and equipment, and other capital investments. Table 2 provides information on all dairy cow herds in the Kansas Farm Management Association program for the past 4 years. Table 3 compares the difference in milk production, gross income, variable cost, and net returns between the high- and low-producing dairy herds for the period 1989 to 1992.

Table 1. Kansas Farm Management Association Dairy Cow Enterprise Analysis, 1992

Factor	Milk Sold per Cow: Under 18,000 lb		Milk Sold per Cow: 18,000 lb and over	
Production Data				
No. farms		55		53
No. cows/farm		79		94
Milk sold/cow, lb		16,052		19,809
	Per Cow	Per cwt Milk Sold	Per Cow	Per cwt Milk Sold
Production Returns				
Milk sold	$2,097	$13.06	$2,570	$12.97
Livestock sales and other	319	1.99	323	1.63
Gross income	$2,416	$15.05	$2,893	$14.60
Production Costs				
Feed fed	$1,281	$7.98	$1,432	$7.23
Hired labor	133	.83	168	.85
Vet, supplies, marketing	249	1.55	353	1.78
Repairs, fuel, utilities	215	1.34	198	1.00
Interest & miscellaneous	111	.69	105	.53
Total variable costs	$1,989	$12.39	$2,256	$11.39
Return over variable cost	$427	$2.66	$637	$3.21

Table 2. Kansas Farm Management Association Dairy Cow Enterprise Analysis, 1989-1992

Factor	1989	1990	1991	1992
Production Data				
No. farms	66	87	113	108
No. cows/farm	90	92	85	86
Milk sold/cow, lb	18,151	17,969	17,518	18,135
Production Returns	Per Cow			
Milk sold	$2,407	$2,471	$2,094	$2,360
Livestock and other	426	374	310	322
Gross income	$2,833	$2,845	$2,404	$2,682
Production Costs				
Feed fed	$1,431	$1,321	$1,311	$1,367
Hired labor	115	154	164	153
Vet, supplies, marketing	276	293	272	304
Repairs, fuel, utilities	181	211	209	218
Interest & miscellaneous	128	111	114	96
Total variable costs	$2,131	$2,090	$2,070	$2,138
Return over variable cost	$702	$755	$334	$544

Table 3. Impact of Differences in Milk Production on Returns from High-Producing Dairy Cows Compared to Low-Producing Dairy Cows, 1989-1992

	High Producers over Low Producers*			
Factor	1989	1990	1991	1992
	per cow			
Milk sold, lb	4,369	3,984	3,416	3,757
Gross income	$576	$628	$373	$477
Total variable cost	$343	$449	$449	$267
Returns above variable cost	$233	$179	$210	$210
Returns/100 dairy cow herd	$23,300	$17,900	$21,000	$21,000
Return/$1.00 spent	$1.68	$1.40	$1.47	$1.71

*The 1992 analysis separated herds on 18,000 lb milk produced per cow, whereas the 1989-91 analyses were separated on 17,000 lb.

EFFECT OF YEARLY MILK PER COW ON PROFITABILITY OF DAIRY HERDS

E. P. Call and J. R. Dunham

Summary

An analysis of Kansas Holstein herds in 1992 indicated that the yearly milk production per cow had a significant effect on returns to labor and management. The lowest quartile herds (13,445 lb per cow average) had a negative return to management. Herds averaging 20,614 lb per cow yielded $479 return to management. Records become increasingly important in managing the dairy operation, especially those that are readily analyzed and predict the degree of economic change when management is modified.

(Key Words: Milk Production, Profit, Dairy Cattle.)

Introduction

Compared with other agricultural projects, dairying is considered to be a highly skilled, labor-intensive business requiring medium capital investment with favorable long-term returns. However, dairy records show great variation among individual cows' production as well as among dairy herds. Numerous studies have shown that level of management has greater impact on profitability than degree of capitalization. One method of evaluating level of management is to measure average yearly milk production response.

Procedures

Kansas Holstein herds (n =565) participating in the dairy herd improvement program (DHI) were ranked by yearly milk production per cow (rolling herd average) and categorized by quartile. The data were analyzed using the KSU Dairy Computer Programs (DyS91-1): Cost and Returns (COST-RET) and Dairy Herd Analyzer (DHA). The data set included the calendar year - 1992.

Results and Discussion

Table 1 notes the effect of yearly milk per cow on feed costs and return above feed cost. With any production trait, increased yield must be accompanied by greater feed input especially during early lactation when appetite is near maximum. Comparing the four groups, feed costs increase 35% or $273 per cow. The efficiency of converting feed into milk at higher levels of yearly milk is evident by the 10% decline of feed cost per cwt milk from the high to low production groups. The 53% increase in production results in 79% improvement in income-over-feed cost when the bottom and top groups are compared.

Table 1. Effects of Yearly Milk Production per Cow on Income-Over-Feed Cost in Kansas Holstein Herds Ranked by Production Quartile

Yearly milk	Feed cost	Income/ feed cost	Feed Cost/ cwt milk
(lb)			
13,445	$ 788	$ 846	$5.81
16,470	943	1,082	5.65
18,213	988	1,282	5.42
20,614	1,061	1,512	5.23

The impact of feed required for maintenance is often overlooked. Like all animals, cows use feed first and foremost for body function and sustenance. Maintenance requirements are based on body weight and are similar for cows of comparable size. As illustrated by maintenance feed cost in Table 2, little difference in body weight was reported among the four groups. The value per unit of feed for maintenance was held constant across groups.

Table 2. Feed Cost Partitioned between Maintenance and Milk Production in Kansas Holstein Herds Ranked by Production Quartile

Yearly milk	Feed cost	Feed Cost Milk	Feed Cost Maintenance
13,445 lb	$ 788	$ 437	$ 351
16,470	943	583	360
18,213	988	627	361
20,614	1,061	697	364

When the top and bottom groups are compared, feed cost increased by 35% but the portion of total feed intake used for milk production improved by 59% in the 20,614 lb group. Further evidence of improved efficiency is shown by the percent of total feed used for maintenance in the low and high groups: 45% vs 34%.

Dairying requires a high labor input per cow unit (50-60 hr/cow/yr). Although studies have shown some increase in labor as production increases, the cost of investment is not necessarily related to cow productivity. Table 3 considers the effect of investment and feed costs for cows and heifers as generated by the KSU COST-RET program on return to labor and management. Although some return to labor occurs at all levels, the greatest impact of yearly milk per cow is on return to management only after the labor bill has been acknowledged.

Table 3. Effects of Yearly Milk Production per Cow on Return to Labor and Management in Kansas Holstein Herds Ranked by Quartile Production

Yearly milk	All costs	Return to management + labor	Return to management only
13,445 lb	$1,968	$198	$(-76)
16,470	2,106	+467	+159
18,213	2,195	+612	+285
20,614	2,298	+833	+479

Figure 1 indicates the lactation curves for the four groups of herds ranked by average yearly milk per cow. The effect of summit milk yield (SMY) and lactation profile on yearly milk production is readily apparent. Each pound increase in SMY generates another 300 lb increase in yearly milk. Once cows come off their peak (SMY), production declines at a rather constant rate (O. 1 lb/day).

Table 4. Changes in Income-over-Feed Cost per Cow during 1992 with Constant Milk and Feed Prices Compared with 1991

Management Area	Change: 1992 v 1991
Reproduction	- 8$
Nutrition	+22$
Milk Quality	0$
Genetics	+ 2$
	+16$

Table 4 provides an insight on the changes that occurred among Kansas Holstein herds in 1992 compared with the previous year. The four management areas are evaluated by keeping milk price and feed costs constant, which provides an accurate measure of changes in cash flow on an individual cow basis. Dairy producers can use this method of evaluating management levels in their herds by comparing their respective data with reachable goals.

As management intensifies, the value of records and the ability to interpret data and implement changes becomes more critical.

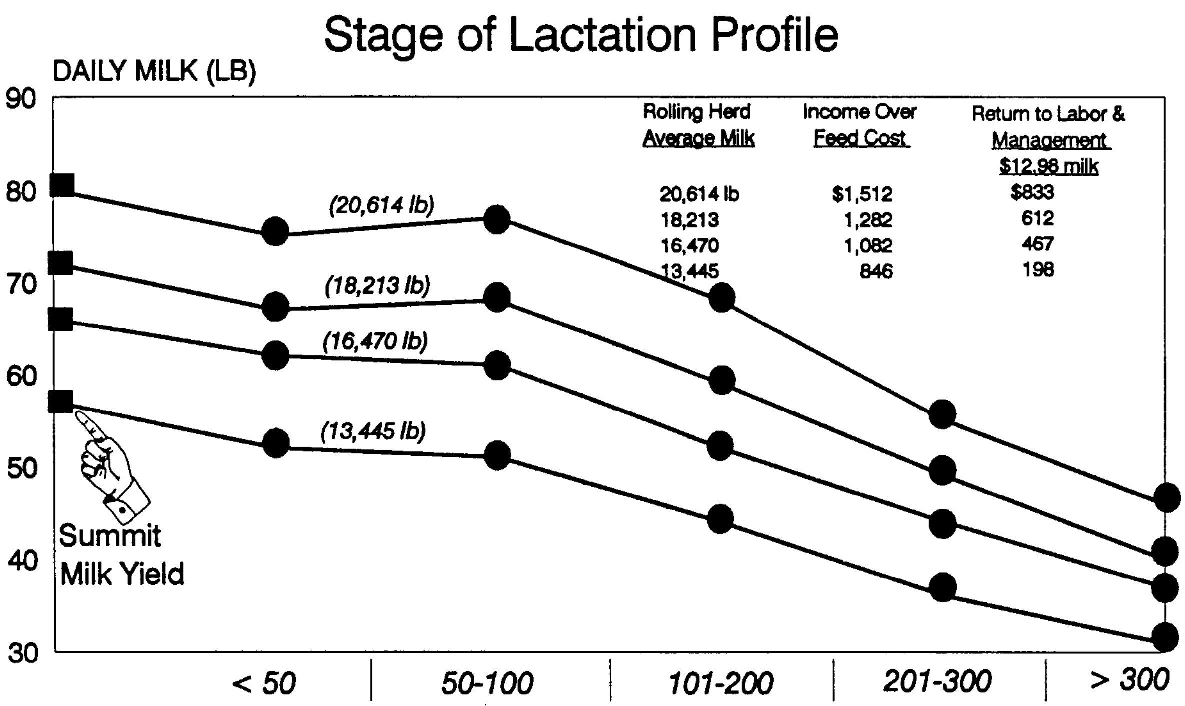

Figure 1. Summit Milk Yield (■), Lactation Profiles (0), and Income-over-feed Cost for Kansas Holstein Herds at Various levels of Rolling Herd Averages (Milk per Cow per Year)

BODY CONDITION SCORING: A MANAGEMENT TOOL

J. E. Shirley

Summary

Body condition scoring provides a tool to help the dairy herd manager evaluate his/her nutrition and management program. It takes time, has an associated cost, and will result in a positive economic return if one makes management changes suggested by the results. Body condition scoring done simultaneously with other herd events reduces the time required and provides the herd manager with coordinated information.

(Key Words: Body Condition Score, Management Tool, Dairy Cattle.)

Introduction

Dairy herd managers have used the concept of body condition observation as a management tool for many years. Early usage simply employed poor, moderate, and fleshy as descriptive terms, whereas today's dairymen use a number system in an effort to quantitate the amount of subcutaneous fat. Thus, body condition scoring is not a new, magical technique that will guarantee success but an improved way to apply an old concept.

The purpose of this discourse is to answer, within our current knowledge, the questions; 1) why you should body condition score and 2) when you should body condition score.

Body condition scoring takes time; therefore, it has an associated cost and should result in a positive economic return. The economic return will be realized only if you make management changes suggested by the results.

Reasons to Body Condition Score

1. Thin cows at parturition do not peak (milk yield) as high as cows in moderate condition.

2. Fat cows at parturition experience more calving problems and more metabolic problems, which translate into lower milk production.

3. A large decrease in body condition after calving may indicate that your feeding and management program for early lactation cows is inadequate.

4. Body condition is a good indicator of when a cow is ready to move from the high producer group to a lower producer group or when to change the amount of feed allocated in the parlor or from a computer-feeder.

5. Monitoring body condition and taking appropriate action will increase income.

Appropriate Times to Body Condition Score

Effective management decisions can be achieved if the manager has the appropriate information. Body condition scores taken at random times within a herd are often confusing and of limited value. The following general guidelines relative to when you should body condition score are based on herd events rather than specific dates. This approach allows the manager to analyze body condition in conjunction with other routine tasks without trying to fit another observation into an already crowded schedule.

1. Within 3 days after calving.

This provides a better estimate of body condition at the beginning of lactation than if you body score just before parturition. Observations before calving tend to be higher and more variable because of the presence of the calf and body fluids.

2. The first postpartum reproductive tract examination (approximately day 21 after calving).

Our records indicate that most cows reach their minimum body condition by this time and remain stable for the next 60 to 90 days, if they are healthy and the feeding program is adequate.

3. The first insemination (after 41 days postpartum).

Body condition score at this time will generally be close to the body condition score at day 25 if everything is in order. If the score is significantly less (.5), you need to adjust your early lactation feeding program or herd health program.

4. Before changing from the early lactation or high cow ration.

The most efficient time to increase body condition occurs during the first 60 days after peak milk yield. Change rations only after cows have reached a body condition score of 3+.

5. Dry off time.

Cows should have a body score of 3.25 to 3.75 at dry off time. Cows scoring less than 3.25 should receive additional energy during the dry period to improve their body condition to at least 3.25. Cows over 3.75 should receive long stem grass hay and minerals and vitamins with limited (2 to 3 lbs.) or no grain until they reach 3.75 or a maximum of 4.0. Cows in the optimum range should receive adequate nutrients to maintain body condition.

EFFECT OF PROCESSING OF SOYBEANS ON RELEASE OF FREE FATTY ACIDS AND SUBSEQUENT EFFECTS UPON FIBER DIGESTIBILITIES

P. V. Reddy, J. L. Morrill, and T. G. Nagaraja

Summary

Two in vitro experiments were conducted to determine the rates of lipolysis and biohydrogenation of fat from raw or processed soybeans and to examine subsequent effects upon fiber digestibilities. In experiment 1, substrates containing soy oil; raw soybeans; extruded soybeans; and soybeans roasted at 270,295, or 325 °F were incubated with ruminal contents for 2, 4, 6, 12, or 24 hr, and release of free fatty acids was measured. The fatty acids released from substrates containing soy oil, extruded soybeans, and raw or roasted soybeans reached maximums at 4, 6, and 12 hr incubations, respectively. Fatty acids in roasted soybeans were subjected to less biohydrogenation than those in raw or extruded soybeans, suggesting that fatty acids of roasted soybeans are protected partially from ruminal bacteria. At all incubation times, the substrates containing soy oil or extruded soybeans had lower and those containing roasted soybeans had higher fiber digestibilities.

(Key Words: Soybeans, Free Fatty Acids, Biohydrogenation, Fiber Digestibilities.)

Introduction

Full fat soybeans contain, on a dry basis, approximately 19% fat and 39% CP. The protein is considered to be of high quality, and the high fat content is attractive because of its ability to increase the energy density of a diet for animals having high energy requirements. The benefits of feeding heat-treated soybeans for dairy cows were attributed to minimizing activity of antinutritional factors and maximizing protein supply at the intestinal level.

Processing methods can influence utilization of soybeans by affecting release of free fatty acids (FFA). For example, the extrusion process ruptures the fat micelles within the soybean, which can allow a more rapid release of oil into the rumen. Roasting of soybeans, followed by steeping at elevated temperatures, can influence fatty acid release by protein and fat interactions. Antibacterial effects of FFA on fiber-digesting bacteria are well documented. The rates of release of fatty acids from whole soybeans and processed soybeans can be different and can affect fiber digestibilities.

The objectives of this experiment were to determine the rates of lipolysis and biohydrogenation of processed soybeans incubated in rumen contents and to examine subsequent effects upon fiber digestion.

Procedures

Experiment 1

Substrates for incubation were soybean meal plus soy oil; raw soybeans; soybeans roasted at 270, 295, or 325°F temperatures; and extruded soybeans; these were designated as control, RB, RSB-270, RSB-295, RSB-325, and ESB, respectively.

Half a gram of substrate was incubated in 40 ml of medium solution and 10 ml of inoculum in a 250-ml Erlenmeyer flask. The inoculum was prepared by collecting whole rumen contents from a rumen-fistulated Holstein steer and straining through two layers of cheesecloth. The incubation was conducted in a shaking water bath for 2,4,6,12, and 24 hr. The FFA released from substrates at different incubation times were extracted and analyzed by using Gas Liquid Chromatography.

Experiment 2

Incubation conditions and substrates for incubation were the same as in Experiment 1 with the following exception: .5 g of ground alfalfa hay was added to each substrate in order to determine the effect of release rate of fatty acids on fiber digestibilities. The fiber determinations used the procedure outlined by Goering and Van Soest.

Results and Discussion

The least square means of FFA released from substrates during different incubation times are presented in Table 1. The FFA releases from control, ESB, and RB or RSB substrates reached their peaks at 4, 6, and 12 hr of incubation, respectively. Fairly rapid release of FFA from extruded soybeans is attributed to the fact that the process ruptured cell membranes and lead to higher availability of oil to external agents. Relatively slow release of FFA from raw or roasted soybeans could be due to intracellular location of oil or chemical changes taking place during the roasting process. As the roasting temperature increased from 270 to 325 °F, the release of FFA decreased at 2, 12, and 24 hr incubations.

Biohydrogenation of unsaturated C18 fatty acids is presented in Table 2. Biohydrogenation of C18:1 was higher for control and RB, medium for ESB, and low for RSB substrates, suggesting that fatty acids of RSB are protected partially from ruminal bacteria. Similar trends of biohydrogenation were observed for C18:2 in all the substrates. Biohydrogenations of all unsaturated C18 in control, RB, ESB, and RSB substrates were 77.8, 77, 67.2, and 55.5%, respectively.

The least square means of NDF and ADF digestibilities of substrates at different incubation times are presented in Table 3. At all incubation times, NDF digestibilities were lower for control and ESB substrates than for RSB substrates. The ADF digestibilities of substrates followed a similar trend.

In conclusion, the release of FFA was faster from substrates containing soy oil or extruded soybeans than from those containing raw or roasted soybeans. Fatty acids in roasted soybeans were less biohydrogenated than those in raw or extruded soybeans. High rates of lipolysis and FFA concentrations were linked to depression in fiber digestibilities for control and ESB substrates.

Table 1. Averages of Free Fatty Acids Released from Substrates during Incubation (n=5)

Incubation time, hr	Substrates[1]						Probabilities for contrast					
	Control	RB	ESB	RSB-270	RSB-295	RSB-325	Control vs Rest	RB vs ESB	RB vs RSB	ESB vs RSB	Roasting temperature: Linear	Roasting temperature: Quadratic
	-----mg/g substrate-----											
2	85.6	66.4	70.2	51.0	46.2	41.4	.01	.13	.01	.01	.01	.84
4	109.6	74.8	88.2	61.8	59.8	54.0	.01	.01	.01	.01	.16	.56
6	92.8	93.6	112.4	73.6	70.0	70.0	.01	.01	.01	.01	.13	.32
12	70.8	100.7	72.2	86.0	83.8	78.2	.01	.01	.01	.01	.01	.12
24	52.2	85.8	61.0	51.0	48.0	43.0	.01	.01	.01	.01	.01	.16

[1]Control = soybean meal plus soy oil; RB = raw soybeans; ESB = extruded soybeans; RSB-270, RSB-295, RSB-325 = soybeans roasted at 270, 295, and 325°F, respectively.

Table 2. Biohydrogenation of Unsaturated C 18 Fatty Acids during Incubation (n=5)

Fatty acid[2]	Substrates[1]						SEM
	Control	RB	ESB	RSB-270	RSB-295	RSB-325	
	%						
18:1[3]	75.5[a]	74.2[a]	64.9[b]	55.3[c]	52.6[c]	50.2[c]	1.8
18:2	80.8[a]	79.8[a]	66.4[b]	58.3[c]	56.6[c]	53.8[c]	1.1
Total C18[4]	77.8[a]	77.0[a]	67.2[b]	58.7[c]	55.4[c]	52.3[c]	1.7

[abc]Means with different superscripts in the same row differ ($P < .05$).
[1]Control = soybean meal plus soybean oil; RB = raw soybeans; ESB = extruded soybeans; RSB-270, RSB-295, RSB-325 = soybeans roasted at 270, 295, and 325°F, respectively.
[2]C18:3 not listed because of its low content in substrates.
[3]Number of carbons:number of double bonds.
[4]C18:1 + C18:2 + C18:3.

Table 3. Averages of NDF and ADF Digestibilities of Substrates Used in Experiment 2 (n=4)

Incubation time, hr	Substrates[1]						Probabilities for contrast					
	Control	RB	ESB	RSB-270	RSB-295	RSB325	Control vs Rest	RB vs ESB	RB vs RSB	ESB vs RSB	Roasting temperature: Linear	Roasting temperature: Quadratic
	---------- % ----------											
NDF digestion												
2	8.2	11.4	7.9	11.6	13.9	12.7	.01	.01	.04	.01	.16	.01
4	10.2	18.5	13.2	17.5	19.9	19.2	.01	.01	.39	.01	.01	.01
6	12.1	20.1	16.0	21.0	22.7	21.1	.01	.01	.10	.01	.99	.04
12	18.7	24.4	20.1	26.6	30.2	24.9	.01	.01	.11	.01	.02	.01
24	41.1	56.4	52.4	55.9	56.8	55.7	.01	.02	.68	.01	.94	.92
ADF digestion												
2	5.1	9.2	7.1	9.4	9.7	9.6	.01	.01	.13	.01	.43	.48
4	8.6	15.1	10.5	14.8	15.6	16.1	.01	.01	.27	.01	.01	.62
6	11.1	17.2	12.0	18.1	18.0	18.1	.01	.01	.10	.01	.98	.78
12	15.5	20.4	19.1	21.1	21.9	21.0	.01	.01	.13	.01	.58	.09
24	36.4	51.2	48.2	52.1	53.2	54.1	.01	.01	.14	.01	.01	.01

[1]Control = soybean meal plus soy oil; RB = raw soybeans; ESB = extruded soybeans; RSB-270, RSB-295, RSB-325 = soybeans roasted at 270, 295, and 325°F, respectively.

EFFECT OF ROASTING SOYBEANS AND CORN ON DAIRY CALF PERFORMANCE

I.E. O Abdelgadir, J. L. Morrill, A. M. Feyerherm[1] and J. J. Higgins[1]

Summary

To evaluate the effect of roasting soybeans and corn on performance of young dairy calves, newborn Holstein calves (n= 132) were blocked by sex and birth date and randomly assigned to one of six isonitrogenous calf starters. The starters were formulated using soybean meal or soybeans roasted at 280 or 295 °F. Each of these protein sources was used with either raw corn or corn roasted at 280°F. Diets were offered ad libitum from .5 to 8 wk of age. Calves were fed milk at 4% of birth weight twice daily and weaned when they consumed 1.5 lb of starter per day for 3 consecutive days. Soybeans roasted at 295 °F resulted in improved overall calf performance. Roasted corn enhanced performance of calves fed soybean meal but did not alter performance of those fed soybeans roasted at 280 °F and depressed performance of calves fed soybeans roasted at 295 °F. These effects were more pronounced during the postweaning period (6 to 8 wk). These results demonstrate the importance of nutrient interactions in young dairy calves, especially when processed grains are fed.

(Key Words: Dairy Calves, Starters, Soybeans, Corn, Roasting.)

Introduction

Previous research at Kansas State University has shown superior performance when young dairy calves were fed whole soybeans processed at optimum conditions. Other research has demonstrated the beneficial effect of roasting corn for finishing beef cattle. Little information about the value of roasted corn as a major ingredient in calf starters is available. Information about how protein and carbohydrate sources interact when fed to the young dairy calf is also lacking. The objectives of this study were to evaluate the effects of roasting soybeans and corn and to study possible interactions between the two feed sources when fed to young dairy calves.

Procedures

Newborn Holstein calves (n= 132) were fed colostrum as soon as possible after birth and moved to 4 x 4 ft wood hutches bedded with straw. They were blocked by sex and birth date, and calves within each block were randomly assigned to one of six pelleted isonitrogenous starters made by using either soybean meal (SBM) or soybeans roasted using a Jet-Pro Roaster® (Jet-Pro Co., Atchison, Ks) to an exit temperature of 280°F (SB280) or 295°F (SB295). Each of these protein sources was used with either raw corn or corn roasted to an exit temperature of 280°F to make the six dietary treatments (Table 1). Whole milk was fed at 4% of birth weight twice daily, and starter and water were available free choice until the end of the trial at wk 8. Calves were weaned when they daily consumed 1.5 lb of starter for 3 consecutive days, provided that they were not less than 3 wk of age

[1]Department of Statistics.

and had gained ≥ 10 lb body weight since birth. They were observed daily for general appearance and consistency of their feces. Starter consumption and body weight were recorded weekly. Heart girth and wither height were recorded at the start and end of the experiment. Body condition score (1, thin to 5, fat) was recorded at the end of the trial.

Results and Discussion

Total weight gain and feed consumption, height increase, and weaning age are shown in Table 2. Overall performance of calves on SB295 starter was superior to those on the SBM starter. Similar results were reported by Reddy et. al., using soybeans processed with the same method (Dairy Day 1992, Report of Progress 666, Kansas Agricultural Experiment Station). Increasing the roasting temperature from 280 to 295 °F improved feed consumption, weight gain, and height increase and reduced weaning age. Heifer calves consumed more feed than bull calves, 114 vs 101 lb for the entire trial ($P < .05$), but bull calves gained more height, 3.4 vs 2.9 in ($P<.05$).

Performance of those calves weaned at ≤ 37 days of age (n= 122) from wk 6 to wk 8 is shown in Table 3. An interaction ($P< .05$) occurred between the protein source (SBM, SB280, or SB295) and type of corn. Considering most variables measured in this experiment, the starter containing SB295 and raw corn would be considered the superior diet. Average daily gain was superior when roasted corn was used with SBM, not different when it was used with SB280, and lower when it was used with SB295. Feed intake was not different. The same pattern was observed for gain:feed ratio and energetic efficiency expressed as Mcal ME/lb of gain. Roasted corn did not affect body condition score when used with SBM, whereas a significant improvement was observed when it was used with SB280. Roasted corn depressed the body condition score when used with SB295. Over this postweaning period, performance of calves on SBM and roasted corn was similar to performance on SB295 and raw corn, but they tended to have a better energetic efficiency because of the former’s lower energy content compared to the SB295 and raw corn starter. A benefit of the SB295 and raw corn starter was that calves were weaned earliest.

The results of this study indicated the importance of interaction between protein and carbohydrate sources, especially when processed ingredients are used in calf starters. These interactions are more evident during the postweaning period, when the young calf is starting to become a functional ruminant. The results also demonstrate the need for a more precise characterization of nutrient requirements of ruminants including the weaned dairy calf.

Table 1. Ingredient and Chemical Composition of Calf Starters

	Starters[1]					
	Soybean meal		SB280[2]		SB295[2]	
Ingredient	Raw corn	Roasted corn	Raw corn	Roasted corn	Raw corn	Roasted corn
	%					
Corn, raw	40.53	-	37.28	-	37.34	-
Corn, roasted	-	39.20	-	36.00	-	36.08
Soybean meal	-	-	15.22	15.56	-	-
SB280[2]	-	-	18.06	18.44	-	-
SB295[2]	-	-	-	-	17.90	18.26
Alfalfa, ground	19.64	20.08	19.62	20.23	19.85	20.29
Oats, rolled	14.88	15.24	15.24	15.36	15.06	15.38
Molasses	7.00	7.20	7.12	7.28	7.16	7.30
Trace mineralized salt	.18	.18	.18	.18	.18	.18
Limestone	.72	.72	.68	.68	.68	.68
Vitamin mix[3]	.15	.15	.15	.15	.15	.15
Coccidiostat[4]	1.32	1.32	1.32	1.32	1.32	1.32
Dicalcium phosphate	.36	.36	.36	.36	.36	.36
Chemical analyses, %						
DM	83.9	84.6	83.6	84.00	81.4	82.8
CP[5]	17.0	17.4	16.6	16.8	16.4	17.1
ADF[5]	12.8	12.0	11.7	12.0	10.9	11.0
NDF[5]	24.5	29.1	30.7	28.0	24.0	34.5
Ether extract[5]	3.9	3.7	6.3	5.8	5.2	5.2

[1]As fed basis.
[2]Soybeans identified by roasting temperature.
[3]Provided 1000 IU vitamin A, 140 IU vitamin D, and 32 IU vitamin E per lb feed.
[4]Deccox (0.5%), provided 30 mg per lb feed.
[5]Dry matter basis.

Table 2. Effect of Protein Source on Total Weight Gain, Total Feed Intake, Height Increase, and Weaning Age

Item	Protein source			
	SBM[1]	SB280[2]	SB295[2]	SEM
Total wt gain, lb	58.4[b]	63.4[a]	66.4[a]	2.2
Total feed intake, lb	101.5	107.5	114.5	4.7
Height increase, in	2.9[b]	3.0[b]	3.5[a]	.5
Weaning age, days	32.5[b]	31.5[ab]	29.4[a]	.9

[a,b]Means within a row with different superscripts differ ($P < .05$).
[1]Soybean meal.
[2]Soybeans identified by roasting temperature.

Table 3. Average Daily Gain (ADG), Average Feed Intake (AFI), Gain:Feed Ratio, Energetic Efficiency, and Body Condition Score (BCS) of Calves from 6 to 8 wk

Item	Soybean Meal		SB280[1]		SB295[1]		SEM
	Raw corn	Roasted corn	Raw corn	Roasted corn	Raw corn	Roasted corn	
ADG, lb	1.8[ab]	2.1[a]	1.9[ab]	1.9[ab]	2.1[a]	1.7[b]	.1
AFI, lb	4.6	4.6	4.3	4.5	4.6	4.2	.2
Lb gain:lb feed	.39[b]	.46[a]	.44[ab]	.43[ab]	.46[a]	.41[ab]	.02
Mcal ME/lb gain	3.64[ab]	2.99[a]	3.32[ab]	3.49[ab]	3.18[a]	3.81[b]	.25
BCS	2.8[ab]	2.9[ab]	2.5[b]	3.1[a]	3.3[a]	2.6[b]	.2

[a,b]Means within a row with different superscripts differ ($P < .05$).
[1]Soybeans identified by roasting temperature.

EVALUATION OF SPRAY-DRIED WHEAT GLUTEN AS A COMPONENT OF CALF STARTERS

H. Terui, J. L. Morrill, and M. Yashima[1]

Summary

Holstein calves (n =52) were on experiment from birth to 10 wk of age. Control calves were fed starters containing soybean meal as the protein supplement. The other calves were fed starters in which part of the soybean meal was replaced by spray-dried wheat gluten. Bull calves fed starters containing wheat gluten consumed more starter during the third and fourth week and gained more weight during the third week than control calves, but overall differences in weight gain or feed intake were not significant, nor was there a significant carryover effect when all calves were fed the same diet.

(Key Words: Calves, Calf Starters, Wheat Gluten, Protein.)

Introduction

In recent research at Kansas State University, nursery pigs showed a significant improvement in performance when spray-dried wheat gluten (SDWG) was included at 6-8% of their diet. Also, a carryover effect occurred, i.e. pigs that had been fed SDWG performed better than control pigs when both groups were fed a common diet.

The objectives of this study were to evaluate the effect of partial replacement of soybean meal by SDWG in starters for pre-weaned dairy calves and to determine if postweaned calves showed a carryover effect.

Procedures

Holstein calves (n =62) were blocked by date of birth and sex, and calves from each block were randomly assigned to control or treatment groups. All calves were fed colostrum or transition milk for 3 days after birth, then milk at 8% of birth weight until weaning. The calves were housed in individual hutches bedded with straw. Water was always available, except during freezing weather when it was available for at least 1 hour twice daily. The calves were weaned when they consumed at least 1.5 lb starter on 3 consecutive days, provided they were healthy, at least 4 weeks of age, and had gained at least 10 pounds since birth.

Calves assigned to the control group were fed the control diet until they were 7 weeks of age; calves in the treatment group were fed a diet containing wheat gluten to 7 weeks of age. From then until the end of the experiment at 10 wk of age, all calves were fed the common starter. The compositions of the starters are shown in Table 1. Starter was always available and was fed in small amounts at first to ensure freshness. Additions and removal of starter were measured to allow determination of consumption. Periodic samples of the starters were collected and composite for analysis.

Body weights of the calves were measured weekly, and heights at withers were measured at the beginning, at 7 wk of age, and at the end of the experiment.

[1]Department of Chemical Engineering

Results and Discussion

Four of the calves assigned to the experiment died and six were removed because of sickness. Neither of these problems was a result of the experimental treatments. Weight gains and feed intake are shown by weeks in Table 2. Male calves fed starters containing wheat gluten consumed more feed during weeks 3 and 4 and gained more weight during week 3 than calves fed starters without wheat gluten. However, overall differences were not significant. Average daily gains for weeks 1-5, when most calves were consuming milk and starter, and for weeks 8-10, when calves were consuming only starter, and for the entire period are shown in Table 3. Treatment caused no differences in any of these measurements. Differences in height at withers were not significant.

Feed efficiencies, expressed as weight gain per unit feed, for weeks 8-10 were .37 for male calves not fed wheat gluten and .38 for male calves fed wheat gluten (SE .01). Corresponding values for female calves were .34 for calves not fed wheat gluten and .35 those fed wheat gluten (SE .02). Neither of these differences was significant.

Potentially, a particular protein can be more valuable than one it replaces by providing an improved amino acid balance, by having a different rumen escape potential, by increasing palatability, by having less antinutritional factors, or for other reasons. Amino acid composition of a protein that is degraded in the rumen is less important, because the amino acids are, to a large extent, synthesized into bacterial protein. For this reason, amino acid composition of protein fed to ruminants is less important than that of protein fed to nonruminants, and this may be an explanation for the difference in response between pigs and calves. Because milk provides a very good source of protein that bypasses the rumen, quality of protein in dry feed is less important before weaning.

More research is needed to determine if there is an advantage of feeding wheat gluten to weaned calves. To maximize the potential for benefit from an improved animo acid balance using wheat gluten, the amount of wheat gluten protein escaping rumen degradation and the amino acid composition of the specific fraction escaping rumen degradation should be determined. Also, the increased feed consumption by bull calves fed wheat protein, which was significant in weeks 3 and 4, should be explored more fully. Dry feed consumption is very important in the young calf, because dry feed is responsible for rumen development. Wheat gluten has a desirable effect as a pellet binder, which is important because calf starters are often pelleted and pellet quality is often a problem.

Table 1. Ingredient and Chemical Composition of Calf Starters

	Diets[1]		
Item	Control	Treatment	Common
Ingredient		%	
Alfalfa pellets	9.6	9.6	9.6
Corn, rolled	50.0	50.0	45.6
Oats	19.8	19.8	19.8
Molasses, liquid	5.2	5.2	5.2
Supplement	15.4	15.4	19.8
		Composition of Supplement	
Ingredient		%	
Corn	3.4	26.0	…
Soybean meal	79.9	27.3	85.8
Limestone	6.7	6.7	5.1
Salt, trace mineral	1.7	1.7	1.4
Deccox®[2]	5.7	5.7	76.0
Cellulose	.9	…	…
Wheat gluten	…	30.0	…
Dicalcium phosphate	…	.9	…
Vitamins A, D, and E[3]	1.7	1.7	1.7
Chemical analysis of diets, %			
DM	86.8	86.8	86.6
CP[4]	15.8	15.7	17.7
ADF[4]	9.3	8.6	9.6
NDF[4]	15.2	15.5	14.8

[1]As-fed basis.
[2]Provided 30 mg of decoquinate per lb finished diet.
[3]Provided 1000 IU vitamin A, 140 IU vitamin D, 32 IU vitamin E per lb finished diet.
[4]DM basis.

Table 2. Weekly Feed Intake and Weight Gain

Item Diets	Week 1	2	3	4	5	6	7	8	9	10	Overall
Feed Intake											
Male Calves	lb										
Control diet	0.8	1.7	4.6[a]	13.2[a]	24.8	32.8	36.3	43.2	48.7	52.9	259.1
Treatment diet	1.2	3.6	7.7[b]	15.9[b]	26.0	33.3	38.6	44.4	49.8	53.9	274.4
SE	.2	.4	.8	1.8	1.8	2.0	1.7	1.8	2.2	2.4	11.3
Female Calves											
Control diet	1.0	2.1	5.3	11.0	20.2	29.2	35.6	40.9	44.0	49.7	239.0
Treatment diet	1.0	3.0	6.1	12.6	19.0	27.4	33.1	40.6	46.2	51.3	245.0
SE	.3	.4	1.2	2.2	3.4	2.8	2.5	2.3	2.3	2.1	16.0
Weight Gain											
Male Calves											
Control diet	0.8	5.2	7.9[c]	12.7	12.2	15.2	14.2	17.2	19.2	17.2	121.7
Treatment diet	1.9	6.8	11.2[d]	9.6	10.9	16.5	14.2	17.8	20.2	18.5	127.5
SE	.9	.9	1.2	1.8	1.6	1.7	1.2	1.4	1.8	2.1	5.5
Female Calves											
Control diet	0.8	4.8	6.8	10.7	13.1	14.4	13.6	14.9	14.8	16.7	110.4
Treatment diet	0.8	4.6	8.5	10.4	10.8	13.0	13.6	17.1	17.4	13.8	110.0
SE	1.0	1.2	1.5	1.6	1.6	1.8	2.0	1.4	1.5	1.6	8.1

[a,b]Means within the same column, within response, with different letters differ ($P<0.05$)
[c,d]Means within the same column, within response, with different letters differ ($P<0.10$)

Table 3. Average Weight Gains during Certain Periods

Group	Average daily gains, lb: Weeks 1-5	Weeks 8-10	Overall
Male Calves			
Control	1.11	2.55	1.74
Treatment	1.15	2.70	1.82
SE	.14	.08	.12
Female Calves			
Control	1.03	2.21	1.58
Treatment	1.00	2.30	1.57
SE	.11	.08	.16

HIGH QUALITY ALFALFA IN SHORT SUPPLY---NOW WHAT?

J. R. Dunham

Summary

Wetter than normal growing and harvesting conditions have resulted in a short supply of high quality alfalfa. Because forage quality affects milk production in early lactation cows, dairy farmers are encouraged to consider other alternatives to feeding low quality alfalfa to high-producing dairy cows.

(Key Words: Alfalfa Quality, Alfalfa Prices, By-products, Relative Feed Value.)

Introduction

High quality alfalfa is an important ingredient in most dairy rations in Kansas because it is an excellent source of protein and highly digestible fiber. However, the quality of the alfalfa crop of 1993 is lower than normal because of the wet conditions during the growing and harvesting period. These conditions delayed harvesting; and, in many situations, caused field losses of leaves before the crop could be put into storage as either hay or haylage. Late maturity and leaf loss results in high-fiber, low-protein alfalfa that is less digestible. Thus, the quality of much of the alfalfa crop is lower than normal.

High quality alfalfa is usually considered to have a Relative Feed Value (RFV) greater than 140. A lot of alfalfa will have an RFV of 170 to 180. Because RFV is determined by the contents of acid detergent fiber (ADF) and neutral detergent fiber (NDF), much of this year's alfalfa will have an RFV of less than 140.

Because forage quality impacts performance, especially of early lactation cows, dairy farmers are encouraged to consider some alternatives to feeding low quality alfalfa.

Alternatives

Minimize Hay Feeding. Because corn silage should be plentiful, feeding herds corn silage should minimize the amount of alfalfa fed. Rations composed of large amounts of corn silage usually require some hay to keep the dry matter content of the ration above 50 percent. A general rule of thumb is to feed at least 5 lb of dry hay with high corn silage rations.

Producers feeding herds mostly alfalfa hay or haylage should consider feeding minimum amounts of forage and maximum amounts of grain and other by-products.

For normal rumen function, the total ration should contain a minimum of 27 percent NDF or 17 percent ADF. By-products such as whole cotton seeds and soy hulls could be substituted for alfalfa to maintain adequate fiber.

Dairy farmers are encouraged to work closely with a nutritionist when formulating rations with minimum fiber. Care should be taken to buffer low fiber rations.

The amounts of by-products that may be substituted for forages are restricted. Because of the high fat content of whole cotton seeds, 6 lb per hd per day is the maximum recommended. Soy hulls should be restricted to about 5 lb per hd per day because the fiber length is short.

Split the Herd. Where practical, herds could be split into early lactation and later lactation groups for feeding purposes. Because forage quality is more critical for early lactation cows, the high quality alfalfa could be allocated to them and the lower quality alfalfa to cows late in lactation.

Purchase High Quality Alfalfa. Just because a dairy farmer produces low quality alfalfa does not mean that it has to be fed on that farm. If all of the low quality alfalfa cannot be utilized by heifers and cows in late lactation, consider selling it to farmers with other classes of livestock and purchasing high quality hay.

Although high quality alfalfa will be relatively expensive this year, it can be a valuable ingredient for high-producing dairy herds. Table 1 shows the value of alfalfa hay for dairy rations as determined by K-State computer programs (HayPrice and Lact-Cow) . Price comparisons were made with corn and soybean meal priced at $4.50/cwt and $12.00/cwt, respectively. Average quality alfalfa hay was priced at $85.00/ton.

Table 1 shows that a difference of $35.36/ton between the lowest and highest quality alfalfa. This value is based strictly upon the difference in nutrient content. The high quality hay would be worth even more if the effect of feeding it on milk production could be calculated.

Table 1. Value of Alfalfa Hay with Various Nutritional Contents

ADF %	NDF %	RFV	Protein %	Value
40	50	107	16.0	$77.64
37	47	119	17.5	$86.48
34	44	132	19.0	$95.32
31	41	147	20.5	$104.16
28	38	164	22.0	$113.00

INCIDENCE OF DIGITAL PAPILLOMATOSIS ("HAIRY WARTS") IN A DAIRY HERD. RESPONSE TO SURGERY AND AUTOGENOUS VACCINATION

J. Gaines, J. Galland, J. Leedle, R. Basaraba and D. Anderson[1]

Summary

Digital papillomatosis (hairy warts) was diagnosed in a dairy herd with a high level of lameness (20%). Warts ranged from mild to moderate to severe, with severity increasing with length of lactations. All milking cows (100%) had at least mild lesions. Cows with severe lesions were more likely to be lame. Severity of lesions had no influence on 305-day ME milk production, days open, or somatic cell counts. Cows in milk more than 150 days and lame produced 3 kg less milk per day than cows that were not lame. Almost all warts were in the interdigital cleft near the heel of the rear feet. A few cows had lesions in the front of the interdigital cleft or on the front feet. No viral particles were observed or isolated. A new, Gram-negative, motile, facultatively anaerobic, spiral-shaped bacteria was isolated from one lesion. The cellular fatty acid profile of this bacterium had no match to any other known bacteria in any of three computer databases examined.

Cows with severe lesions were assigned randomly to one of four groups: Group 1: surgical removal and autogenous vaccination; Group 2: surgical removal only; Group 3: autogenous vaccination only, and Group 4: control. Neither surgical removal nor autogenous vaccination had a significant effect on wart severity, lameness, or milk production when cows were inspected 10 wk later. Contemporary evaluation of 249 herdmates revealed a substantial number of severely affected cows naturally improved. Of 25 severely affected herd contemporaries, only 8 were severely affected 10 wk later. Evidently, natural improvement of lesions is a common phenomenon with "hairy warts."

(Key Words: Bovine, Lameness, Digital Papillomatosis.)

Introduction

Hairy warts were first described in Italy, and outbreaks have been reported in England, the Netherlands, and the United States. The disease appears to cause lameness and severe reductions in milk production (20-50%). As many as 70% of cows have warts in affected herds. The cause is unknown. Efforts to isolate and identify a virus have been unsuccessful. Numerous spirochetes are observed in the lesions, however, and positive responses to treatment with disinfectant solution, antibiotics, surgical removal, and vaccination have been reported. An outbreak of digital papillomatosis occurred in a dairy in the U. S. A..

The objectives of this study were to determine prevalence and severity of warts, effect of the disease on productivity and lameness, etiology, and response to removal and vaccination.

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Procedures

All lactating cattle were inspected as they were milked in the parlor. The parlor was a herringbone design with eight cows on each side. The heels of the rear feet of the cattle first were rinsed with a wash hose, then examined with a flashlight. The lesions were rated as mild, moderate, or severe. A mild lesion was one with slight reddening and ulcerations present only in the interdigital cleft of the heels. Moderate lesions had active granulation occurring with ulceration. Severe lesions were growths (at least 4 cm in diameter) with frond-like projections (Figure 1). As cows exited the parlor, body condition score and lameness were assessed. DHIA had tested the cows for milk production during the week prior to the second visit. These production records were obtained for analysis.

Only cows severely affected (growths at least 4 cm with frond-like projections) were enrolled in the removal and vaccination trial. A total of 28 severely affected cows was selected. These cows were assigned randomly to four groups: 1) surgical removal and autogenous vaccination; 2) surgical removal with no autogenous vaccination; 3) no surgical removal with autogenous vaccination; and 4) no treatment.

Surgical removal was accomplished by restraining the cow in a foot trimming chute. The size of the warts removed resulted in a large wound, which we were not able to suture closed. The cow was then bandaged, and the wound healed by scarring.

An autogenous vaccine was produced by homogenizing the warts in saline (20% weight to volume solution) and allowing the cellular debris to sediment, then adding 0.5 % formalin as a preservative. Cows were vaccinated by injecting 1 ml of the vaccine intradermally and 15 ml intramuscularly.

These cows were inspected for warts and lameness 3 wk after surgical removal and vaccinated at that time. They were again inspected for warts and lameness 7 wk after removal. Milk production records were collected during the week prior to removal and at week 10. Herd contemporaries were inspected for lameness and severity of warts at the time of surgical removal and 10 wk later. The effect of removal and autogenous vaccination on lameness and recurrence were analyzed by the use of contingency tables. Analysis of co-variance was used to determine the effect of removal or vaccination on milk production.

Results

All cattle were affected to some degree. Severity was associated with lameness ($P < .001$; Table 1), and a substantial number of cows were lame (n =72). Severity did not increase as lactation number increased (Table 2). However, the prevalence of lameness did increase as lactation number increased ($P < .01$; Table 2). Severity increased as days in milk increased ($P < .001$; Table 3), though the prevalence of lameness did not (Table 3). Mature equivalent 305 day milk yield, somatic cell count, and days open did not vary by severity (Table 4) or lameness (Table 4). Body condition score was affected by lameness (Table 4) but not by severity (Table 4). Cows milking less than 150 days that were lame showed no decrease in milk production. Cows milking more than 150 days and lame had a reduction of 2.94 kg of milk per day, compared to cows that were milking more than 150 days but were not lame.

In the experiment, 23 of the 28 cows were available for inspection 10 wk later. The remaining cows had been culled. Two were sold for dairy purposes, one was culled for failure to conceive, one died, and one was culled for low production. Of these 5 cows, one had received autogenous vaccination and two had warts surgically removed.

The results of surgical removal and vaccination on severity and lameness are shown in Table 5. Neither surgical removal or autogenous vaccination had a significant effect on number of cows severely affected or lame when cattle were inspected 10 wk later. Surgical removal resulted in 33% of cows severely affected and 17% of cows lame 10 wk later, which was the same as the controls. Accordingly, the effect on milk production of vaccination or removal was not significant.

Table 1. Prevalence of Interdigital Papillomatosis and Lameness in a Dairy Herd

Category	N	%	Lame %	Relative risk lameness
None	0	0	0	—
Medium	178	54	16	1.0
Moderate	92	28	10	1.0
Severe	50	15	52	1.80*
Bandaged	12	3.6	33	—
Total	332	100	**20.5**	—

*Severity was associated with lameness (P< .001).

Table 2. Distribution of Severity of Interdigital Papillomatosis and Lameness by Lactation

	Lactation number				
Severity	1	2	3	>3	Total
Mild	64%	46%	52%	51%	56%
Moderate	24%	34%	28%	31%	29%
Severe	12%	20%	20%	18%	15%
% Lame	12	22	30	25	20

*Severity did not increase as lactation number increased.
*Prevalence of lameness increased as lactation number increased (P<.01).

Table 3. Severity of Digital Papillomatosis by Days in Milk in a Dairy Herd

	Days in Milk			
Severity	< 100	100-200	> 200	Total
Mild	72%	40%	60%	56%
Moderate	21%	41%	21%	28%
Severe	9%	19%	19%	16%
% Lame	12.5	20	24	

*Severity increased as days in milk increased (P< .001).
*Lameness did not increase as days in milk increased.

Table 4. Influence of Lameness and Severity of Hairy Warts on 305-day ME, Somatic Cell Count (SCC), Body Condition Scores (BCS), and Days Open

Severity	305 d ME (kg)	SCC (1000)	BCS	Days open
Mild	10318	192	2.7	139
Moderate	10795	107	2.7	130
Severe	10318	157	2.7	154
Bandaged	9717	313	2.5	115
Lameness				
No	10464	185	2.7	134
Yes	10214	134	2.6	145

Table 5. Effect of Surgical Removal and Autogenous Vaccination of Digital Papillomatosis on Wart Severity and Lameness 10 weeks after Removal

Treatment	No. severe	No. mild	No. lame	No. not lame
Removal and Vaccination	4	3	2	5
Removal only	0	5	0	5
Vaccination only	2	4	1	5
No treatment	2	3	0	5

Dr. Deryck Read of California Veterinary Diagnostic Laboratory confirmed the lesions as those of digital papillomatosis. The lesions were similar to those he has seen from California, New York, Michigan, Great Britain, and the Netherlands.

No viral particles were isolated or observed with electron microscopy. A new, Gram-negative, motile, facultatively anaerobic bacteria was isolated from a representative lesion. The cellular fatty acid profile of the bacterium was determined and then compared to profiles of known bacteria in three different databases. No match occurred.

Discussion

This disease has been reported in New York, Great Britain, the Netherlands, and Italy. The characteristic lesion is an epithelial papilloma. Workers in California have observed a spirochete, and we have isolated a gram-negative, facultatively anaerobe bacterium in the lesion. Attempts at viral isolation have been unsuccessful, and electron microscopy techniques have not demonstrated a virus.

Although reports from the field indicate an increasing prevalence, little is actually known of the epidemiology of this disease. Mild to moderate effects on productivity have been reported. In this herd, the prevalence was very high. Severity increased as lactation length increased, and the rate of lameness increased with severity. Because all cows were affected, we cannot make any conclusions as to the effect on productivity. However, neither severe lesions or lameness significantly changed SCC, 305-day ME milk, or days open. Lame cows had a slight reduction in body condition score. Severity increased as days in milk increased, as did lameness. However, the prevalence of lameness was high in this herd (20%), and higher than most surveys of lameness in dairy cows. Lameness did reduce milk production by 3.0 kgs but only in cows milking for more than 150 days.

Neither surgical removal nor autogenous vaccination had a significant effect on lesion resolution, lameness, or milk production (Tables 5). Lesion severity regressed naturally on a number of cows without intervention. All lactating cows in this herd were inspected at the onset of this study and also at the completion. Of 249 cows not included in the random trial, 10% (n =25) were severe at the initial observation, and 20% were severe 10 wk later. However, only 8 of 25 severely affected cows at the first observation had severe lesions 10 wk later. A similar phenomenon was observed with lameness. Of 41 cows lame initially, only 11 were lame at the final observation, and 31 cows that were not lame initially developed lameness by the final observation. Therefore, even with a larger sample size, it is unlikely that the intervention used here would show a significant effect.

Future research plans call for continued investigation of the epidemiology of this disease. We are looking for afflicted herds Please contact the authors if you know of such herds. Furthermore, we plan on pursuing investigations as to the relevance of the gram-negative bacteria we isolated.

Figure 1. A Severe Lesion of Digital Papillomatosis on the Heel of the Rear Foot of a Dry Third Lactation Holstein Cow. The Lesion Was 6 cm Across and Had Numerous Epidermal Projection "Fronds". This Cow Had a Mild Lameness at the Time This Picture Was Taken.

USE OF MILK PROGESTERONE AND $PGF_{2}\alpha$ IN A SCHEDULED INSEMINATION PROGRAM

J. S. Stevenson and J. R. Pursley

Summary

Holstein cows milked twice daily were assigned to be inseminated at their first detected estrus (control) after 42 days in milk or received $PGF_{2}\alpha$ (PG) after 42 days, if they had a high milk progesterone (P_4) test on any of 3 consecutive Mondays until first inseminated. Milk P_4 tests and injections of PG were given on Mondays, and most of the breeding occurred on Thursdays and Fridays. The proportion of cows inseminated within 21 days of the beginning of the breeding period was greater in the milk P_4 + PG group (52.8%) than in the control (38.9%). Compared to controls, use of PG reduced days to first service by 12.2 ± 3.1 d, calving intervals by 23.3 ± 8.9 d, rate of reproductive culling, and cost per pregnancy. We concluded that using PG as a management tool in an AI program is warranted and cost effective. However, the milk P_4 test would not be justifiable unless its cost were significantly lower than the cost of a weekly injection of PG.

(Key words: $PGF_{2}\alpha$, Progesterone, AI.)

Introduction

Inefficient detection of estrus in dairy herds where AI is practiced contributes to a significant reduction in reproductive performance and potential milk yield. Although accuracy of detection of estrus may approach 90%, the proportion of all cows detected in estrus (efficiency) is much lower, around 50%. Prolonged intervals to first service resulting from inadequate detection of estrus contribute significantly to unacceptably long calving intervals. The two factors are highly correlated, because a l-day reduction in the interval to first service decreased calving interval by .86 day. Furthermore, nearly three times more variation was accounted for by days lost because of missed periods of estrus and total days open than by days lost because of conception failure and total days open.

Timely insemination of dairy cows at first service is enhanced through the use of $PGF_{2}\alpha$ (PG). Intervals to conception were reduced by as much as 3 wk when cows were treated with PG after detection of a palpable corpus luteum (CL) compared to those cows in which PG was not used. An alternative to palpation of a CL is the use of an on-farm milk progesterone (P_4) test to diagnose the presence of a CL when milk P_4 is high. Administering injections of PG on Monday mornings without prior assessment of CL or P_4 status also was effective in reducing intervals to first service compared to injecting PG based on palpation of a CL. Not only were more periods of estrus in cows synchronized or grouped together for weekly AI when PG was used, but the efficiency of detected estrus improved because the number of mounts increased when up to four or more cows were in estrus simultaneously.

The objective of our study was to determine whether the use of a milk P_4 test is warranted for identification of cows eligible for treatment with PG in a weekly scheduled AI program, based on the achieved reproductive efficiency and cost effectiveness compared to those for cows not receiving PG before first service.

Procedures

The study was conducted over 2 yr in Holstein cows that were housed in outside concrete lots with sheltered free stalls and fed a total mixed diet to meet or exceed NRC requirements for lactating cows. Cows were milked twice daily in a parlor and observed twice daily for signs of estrus. Reproductive tracts of cows were palpated per rectum before 42 days postpartum to determine breeding eligibility. Any cow with obvious uterine infection or other health complications was not assigned to the experiment. Uterine palpations were performed between 42 and 56 days after the last insemination to determine pregnancy status and confirmed by subsequent calving dates.

Cows were grouped together into 3-wk breeding clusters according to calving dates. Each breeding cluster was comprised of cows that were 42 to 63 days in milk. Cows were assigned randomly but unequally to two treatment groups. Control cows (n = 72) were untreated and inseminated at their first detected estrus after 42 days in milk, whereas cows (n = 127) assigned to the treatment group (milk P_4 + PG) were handled as described below.

Once a breeding cluster was formed, with the freshest cow at least 42 days in milk, a Monday morning milk sample was collected from all cows. Poststripping milk was collected directly into antibody-coated tubes and stored in a refrigerator at 5 °C for up to 6 h. Samples were brought to room temperature before P_4 was determined by a commercially available, qualitative, milk P_4 test (Accufirm®, ImmuCell, Portland, ME), with the aid of a hand-held spectrophotometer used to compare color intensities of test samples and the within-batch standard. When milk P_4 was high, cows in the treatment group (milk P_4 + PG) were injected with 25 mg PG (Lutalyse®, The Upjohn Company, Kalamazoo, MI) on Monday afternoon. If milk P_4 was low, cows were retested on the following Monday. Once treated cows were inseminated upon detected estrus, the sampling procedure was terminated. No cow was tested or injected more than three times. If a cow had not been inseminated at the end of test wk 3, first service was made at the first detected estrus without further use of PG.

Results and Discussion

Intervals to first service, pregnancy rate at first service, and the 2l-day insemination rate are summarized in Table 1. The milk P_4 + PG treatment reduced (P<.01) postpartum interval to first service by 12.2 ± 3.1 days (X ± SE) compared to the control. Pregnancy rate to first service was unaffected by treatment, although it was numerically higher in the milk P_4 + PG treatment group. This trend probably occurred because fewer cows in the treated group were inseminated in the 40- to 60-day postpartum period when fertility is lower than at later postpartum intervals. The 21-day insemination rate was higher (P = .053) in the treated than control group, with an average of 52.8% of the cows in each cluster group inseminated after 3 wk, whereas only 38. 9% of the controls were inseminated during the same interval.

Actual calving intervals, pregnancy rates at 120 days in milk, and overall pregnancy rate are summarized in Table 1. Although the proportion of cows conceiving at the end of the experiment (73.4%) was unaffected by treatments,_ calving intervals were 23.3 ± 8.9 days (X ± SE) shorter (P = .068) in the milk P_4 + PG treatment group than in controls. Pregnancy rate by 120 days in milk was not different but numerically favored the treated cows.

Reasons for disposal of 26.6% of the cows in our experiment were many. Amount of culling was similar between groups, except in the categories of low milk production and reproductive problems. Fewer (P< .05) treated than control cows (33 vs 56%) were culled for reproductive problems, which allowed a greater ($P<.05$) proportion of voluntary culling for low milk production in the treated than the control group (33 vs 12%).

We attempted to examine the cost effectiveness of our two treatments relative to the cost of each pregnancy achieved. Cost comparisons for our two treatments and for two other PG systems recently reported in the literature are summarized in Table 2. The latter two programs involved either weekly injections of PG on Monday mornings, without prior assessment of CL or P_4 status, or injections of PG based on detection of a CL by weekly palpation of the ovaries. Costs were estimated to approach realistic values for milk P_4 tests, PG, and individual palpations of cows.

An additional cost was added to our control group because of its longer calving interval. The cost of days open beyond 365 days (12-mo calving interval) has been reported to range from $.25 to $4.68 per day open beyond 85 d. For controls, we conservatively used the estimate of $1 per day open beyond the number achieved in the milk P_4 + PG group, for a total of $23.30 per pregnancy. The cost per pregnancy in controls was $30.32 compared to a lower cost of $20.59 for the treated cows. To make the cost per pregnancy equal in our two treatment groups, the cost of 1 day open beyond 85 days would have to equal only $.35.

In comparison, similar estimates of cost per pregnancy in a previous study were $17.69 for weekly Monday morning injections of PG and $14.14 for palpation + injections of PG (Table 2). Median days open were 97 and 110 days for the two previous groups, which were similar to that in our milk P_4 + PG group (mean = 101 d). Although the absolute costs will vary geographically, the relative ranking of costs is probably correct. In addition, the cost of our milk P_4 + PG treatment would have been more, if the number of milk tests and subsequent injections of PG had not been limited to three. In the previous report, the use of PG was limited only by occurrence of first inseminations or culling of the cow from the herd. Thus, the number of injections of PG per pregnancy was 3.6 compared to 1.4 in our milk P_4 + PG group (Table 2). The milk P_4 test + injection of PG is cost-effective when compared to our control within the given rates of detected estrus and level of fertility in our herd. Furthermore, the PG schemes described in the previous study probably are more cost-effective than either of our treatments.

The accuracy of the milk P_4 test was good at 87.4%, but its high rate of false positive tests (52. 8%) resulted in cows receiving **$PGF_{2\alpha}$** that did not have a functional CL. The palpation method is also not error free, because one review, which summarized 402 palpations in four separate studies confirmed by concentrations of P_4 in serum, reported that accuracy of diagnosing a functional CL (actively producing P_4) was 82%, whereas the accuracy of diagnosing a cow without a functional CL was only 70%. Because the costs of inaccurate milk P_4 tests and individual palpations are included in Table 2, improving accuracy of either method of assessing CL status should reduce the estimated cost per pregnancy. Assuming 100% accuracy and eliminating the high rate of false positive tests, the cost per pregnancy of the milk P_4 test would have decreased by $1.63, making it more comparable in cost ($18.96) to the weekly PG system ($17.69). The obvious problem in cost comparisons for the milk P_4 test and the weekly injections of PG is that their costs are similar. Achieving a greater accuracy by milk P_4 testing and reducing the cost of administering injections of PG to cows without a CL would require the cost of the milk test to be significantly lower than its current price. Even when the number of injections of PG in the weekly scheme was nearly 3 x that for the milk P_4 + PG treatment or that for the palpation + PG (Table 2), the weekly injection system seemed to be cost effective.

Using PG as a tool to control the onset of estrus is warranted in a dairy AI program, because it reduces days to first service, calving intervals, rate of reproductive culling, and cost per pregnancy. However, the additional use of the milk P_4 test probably is not justifiable in this application unless its cost is significantly lower than the cost of a weekly injection of PG.

Table 1. Reproductive Performance of Dairy Cows Given Weekly Injections of Prostaglandin $F_2\alpha$ (PG) versus Using No PG (Control)

	Treatment			
Trait	Control	Milk P_4 + PG	SE	P value
No. cows	72	127	—	—
Days to first service	83.6	71.4	3.1	.006
First-service pregnancy rate, %	34.7	41.7	–	.257
Percentage bred once in first 21 d	38.9	52.8	–	.053
Calving interval	406.4	383.1	8.9	.068
Pregnant by 120 d, %	62.3	72.0	–	.174
Overall pregnancy rate, %	73.6	73.2	–	.993

Table 2. Cost Comparison for Breeding Programs Involving Only Visual Detection of Estrus (Control), Milk Progesterone (P_4) + Prostaglandin $F_2\alpha$ (PG), Weekly Blind Injections of PG, and Palpation + PG.

	Treatment			
Item	Control	Milk P_4 + PG	Weekly PG	Palpation + PG
No. cows assigned	72	127	184	188
No. pregnancies	53	93	156	154
Cost of milk P_4 ($3 each)	o	864	0	0
Cost of PG ($3 each)	o	399	1665	507
No. of injections/pregnancy	o	1.4	3.6	1.1
Cost of palpations ($2 each)	372	652	1094	1670
Cost of longer days open ($1/d)	1235	0	0	0
Total costs, $	1607	1915	2759	2177
Cost/pregnancy, $	30.32	20.59	17.69	14.14

Dairy Day 1993

AFLATOXINS: CONTAMINATION OF ANIMAL FEEDS AND FOOD PRODUCTS

R. K. Phebus

Summary

Mycotoxins are toxic chemicals produced by certain species of molds during their growth on numerous substrates. Molds can invade the food and feed supply at various points throughout production, storage, processing, and distribution. Of most concern are the aflatoxins, which are highly toxic and classified as *probable human carcinogens.* Aflatoxins are often associated with crops that have undergone stress or feeds and foods that have been stored improperly. Tremendous economic implications are associated with regulation, testing, and loss of agricultural products from aflatoxin contamination. Dairy cattle excrete a portion of consumed aflatoxins into milk, thus, leading to a strict action level of 0.5 ppb in fluid milk. Several types of processed food products have been demonstrated to be occasionally contaminated with these toxins.

(Key Words: Aflatoxins, Molds, Carcinogens, Toxins, Federal Regulations.)

What Are Aflatoxins?

Mycotoxin is the general term for a wide range of chemical toxins produced by numerous species of fungi (molds). Aflatoxins are a particular class of mycotoxin produced by three species of the mold *Aspergillus.* Over 10 forms of aflatoxins have been identified differing only by a slight change in the molecule's chemical structure; however, these forms have different associated toxicities. The B and G forms of the toxin are predominantly produced in agricultural crops in the field or during storage. These toxins have very high toxicities as demonstrated in several species of test animals. Other structural forms of aflatoxins are produced during metabolism of ingested aflatoxins by animals. These metabolic forms have various levels of toxicity. Aflatoxin M is found in milk secreted by lactating animals and is relatively toxic compared to the other forms.

Toxicity to Humans and Animals

Aflatoxins are extremely toxic to most species of animals. Acute (immediate effect) toxicities occur as a consequence of ingestion of high levels of the toxins in a contaminated food or feed. This would be an unlikely occurrence in the United States for humans; however, it has occurred in developing countries because of lack of food and starvation. Livestock would be more prone to acute toxicity effects, and symptoms would include reduced feed consumption, dramatic drops in milk production, weight loss, liver damage, and even death.

A more common problem with prolonged exposure to aflatoxins is chronic (long-term) toxicity. The predominant organ affected in most species is the liver, where degeneration and cancer are often observed. Aflatoxin B_1 is one of the most potent carcinogens known to man. Other chronic effects include reduced feed efficiency, immunosuppression, and reproductive problems. Research has shown that giving dairy cattle feeds contaminated with 120 ppb aflatoxin over a prolonged period of time resulted in a reduction in breeding efficiency, birth of smaller calves, diarrhea, acute mastitis, respiratory disorders, prolapsed rectums, hair loss, and reduced feed consumption. After removal of aflatoxin from the animals' diets, milk production increased 28%. Obviously, severe economic implications can result from aflatoxin contamination of livestock feeds.

Occurrence and Regulation

Mycotoxins can contaminate many foods and feeds prior to harvest and/or during storage. Several crops can become contaminated in the field, with corn, peanuts, cottonseed, and nuts having the highest risks of becoming toxic. Also at some risk are raisins, figs, and spices. During storage, other crops normally resistant to field contamination can become infested, if environmental conditions are appropriate for mold growth. These include soybeans, grain sorghum, millet, wheat, oats, barley, and rice. Finally, aflatoxins can be secreted into raw milk by lactating dairy animals as aflatoxin M. Approximately 1% of the total aflatoxins ingested by dairy cattle is excreted in the animals' milk.

Aflatoxin in raw agricultural products can lead to contamination of processed foods. Aflatoxin is very stable to most of the processing technologies including retort and pasteurization. Therefore, the toxin can be carried into processed foods derived from these commodities. Some processed foods that have been implicated include peanut butter, corn, hominy, spaghetti, flour, milk, nonfat dry milk, and cheddar cheese.

In the United States, aflatoxins are the only mycotoxins formally regulated. The Food and Drug Administration has set guidelines for acceptable levels of these "unavoidable contaminants" in foods and animal feeds. Foods for human consumption can contain no more than 20 ppb and milk no more than 0.5 ppb of aflatoxin M_1. Other countries have different action levels for foods contaminated with these toxins, which often leads to difficulties in world trade. Currently, the international community is considering lowering the level of permissible aflatoxin M_1 in milk to 0.05 ppb.

Animal feeds have a general action level of 20 ppb. For cottonseed meal and corn used for feedlot cattle, the limit is 300 ppb. Corn intended for finishing swine cannot contain more than 200 ppb. Corn for breeding animals and mature poultry has an aflatoxin limit of 100 ppb.

Dairy Day 1993

RAW MILK QUALITY - MILK FLAVOR

H.A. Roberts

Summary

Flavor control in market milk begins on the farm and continues through the processing plant and into the home of the consumer. Flavor control is directly or indirectly related to the health of the cow, the feeding of the cow, the cleaning and sanitizing of utensils, the cooling of the milk, transportation to the processing plant, and all the steps in processing and distribution of the milk.

Consumers judge the quality of milk largely by taste and appearance. Therefore, it is important that each load of milk be checked for off-flavors before it is loaded on the tank truck and again when it is received at the processing plant.

Learning to recognize and distinguish certain characteristics of each possible off-flavor that may be present in milk is important. This will help the dairyman and the fieldman in tracing the source of any off-flavors in milk and assist in reducing or eliminating the cause.

At the end of this article, you will find a chart explaining some of the milk flavor defects, possible causes, and preventions. Cut this page out and place it near your milk tank for reference.

Introduction

Milk Flavor: Milk normally has a slightly sweet flavor. Occasionally, certain undesirable off-flavors and odors such as salt, bitter, acid, rancid, and feed, occur. The causes of milk flavors are numerous. Some are due to feed, others are due to physiological processes of the cow that upset the normal balance of milk constituents and result in the excretion or secretion of substances that cause off-flavors. Sometimes the flavors are due to bacterial contamination which results from poor care of utensils, improper handling and cooling of milk, etc.

The common off-flavors found in milk can be classified in three basic categories -- the ABC's of off-flavor development. These are absorbed, bacterial and chemical. Some off-flavors, however, can be caused by more than one of these actions. Consequently, some are listed in more than one category.

(1) Absorbed - feed, barny, cowy, unclean, weedy, foreign
(2) Bacterial - acid, malty, unclean, putrid
(3) Chemical - cowy (ketosis), rancid, oxidized, sunlight, foreign

Absorbed flavor defects can develop before, during, and after milking.

Bacterial degradation generally results from contact of the milk with improperly washed or sanitized equipment; external contamination from dirty teats, etc.; and improper cooling.

Chemical defects can occur both before and after milking. The cowy flavor is the result of the animal suffering from acetonemia or ketosis. Because of their genetic makeup, the feed consumed, or the stage of lactation, certain cows can produce milk that is spontaneously susceptible to rancidity or oxidation. Most rancid and oxidized flavors, however, are induced by poor handling techniques or faulty equipment after milking. A foreign flavor can be caused by medications, a reaction to pesticides, disinfectants, or any number of contaminants.

Flavor Defects: The flavor of normal whole milk is pleasantly sweet, possessing neither a foretaste nor an aftertaste other than that imparted by the natural richness. Many beginners make a mistake of expecting a sample of good flavored milk to have a "taste". The beginner should remember that when milk does possess a so-called taste, something is usually wrong with the flavor.

Bitter

Description: Bitter flavor can be detected by taste only. There is no odor. Reaction time is slow, and taste persists long after the sample has been expectorated.

Cause: This defect can be caused by stripper cows, bacteria action or certain feeds.

Foreign

Description: Foreign or disinfectant flavor in milk can be detected by the sense of smell or may not be noted readily except when the sample is tasted. A strong aftertaste will be noted.

Cause: Foreign defect occurs when any seriously objectionable flavor foreign to milk, such as fly spray, paint, kerosene, creosote, or a medicinal substance, which may have gotten into the milk or been absorbed by it, renders the milk unpalatable or unfit for use. A residue of strong chlorine or other similar solution, if left in equipment, is absorbed by the milk, imparting a flavor characteristic of the disinfectant.

Feed

Description: Feed flavor is characteristic in that it is aromatic and somewhat pleasant and can be readily detected by the sense of smell. The feed flavors disappear quickly, leaving the mouth clean.

Cause: Many feeds affect the flavor of milk by transmission of their flavor through the cow. Feed flavors are caused by feeding silage and certain pasture grasses.

Flat-Watery

Description: Because this defect is not associated with an odor, the sense of smell furnishes no indication of its presence. When milk is tasted, the flatness is apparent soon after the sample reaches the tongue. A very slight oxidized flavor may suggest a flat taste. It resembles normal milk that has been partially diluted with water, even though this may not have been done.

Cause: This is an uncommon flavor, and its source is difficult to determine. It can be caused by low levels of total solids in the milk or by water added to the milk. Note: It is against the law to dilute milk with water.

Onion or Garlic

Description: This defect is very easy to recognize by its characteristic pungent odor and persistent taste.

Cause: This is an obnoxious weed flavor and is not classified as one of normal feed flavors. Milk from cows that have been eating wild garlic or onion will have this defect.

High Acid

Description: The high acid flavor is easily detected by both the senses of smell and taste. The sense of smell detects this odor easily. High acid milk conveys to the tongue a peeling effect, leaving both the tongue and the mouth with a feeling of cleanliness.

Cause: Normal bacterial growth from unsanitary milking practices, unclean utensils, and poor cooling cause this defect.

Oxidized-Cardboard

Description: This flavor is characterized by a "quick" taste reaction when the sample is taken into the mouth and by its relatively short adaptation time. The defect can be detected also by the odor. The flavor is quite pungent in advanced stages, but it is not persistent after the sample is expectorated.

Cause: This defect is caused when milk comes into contact with such metals as copper and iron. It also develops in milk that is left in the sun for a short time. It may be noticed in raw milk in winter months or dry lot feeding.

Rancid (Lipolytic)

Description: The rancid flavor can be detected both by the sense of smell and taste. The flavor is disagreeable and often exhibits a soapy characteristic. It may also resemble a spoiled nut meat that has turned dark in color.

Cause: Rancidity is caused by the hydrolysis of milk fat by the enzyme lipase when conditions are favorable. This results in the liberation of volatile acids, especially butyric. Milk from cows in late lactation usually develop rancidity quite rapidly because of a higher lipase titer. Rancidity is enhanced by extreme agitation of milk, the dumping together of night and morning's milk, and the mixing of raw and homogenized milk. Pasteurization destroys the enzyme.

Salty

Description: The sense of smell is valueless in detecting this flavor, because as there is no odor from salty milk. The salty flavor can be perceived quickly upon placing the sample into the mouth. Salty milk gives a cleansing feeling to the mouth.

Cause: Salty flavor can be present in milk from cows in the late stages of lactation and is often characteristic of milk from cows infected with mastitis.

Unclean

Description: This flavor seldom appears to a pronounced degree in milk. Its presence can be noted by failure of the mouth to clean up after expectorating the sample.

Cause: This defect can result from inadequate washing or sanitizing of tanks, pails, pipelines, or milking machines. It develops from the activity of certain types of bacteria in milk. This flavor also could be present as a result of cows drinking unclean water.

Malty

Description: This flavor can be readily detected by either the sense of smell or taste. Malty flavor is suggestive of malt, walnut, maple, or Grapenut flavor.

Cause: This is not a common flavor, but it may be encountered in milk not properly cooled. Certain bacteria from improperly cleaned equipment, especially milking machines, can contaminate milk.

PRODUCER MILK FLAVOR CHART

Milk of good flavor has a pleasant, slightly sweet taste and no odor.

Off-flavor	Possible Causes	Prevention
OXIDIZED cardboardy	Exposure to "white metal," worn tinned, or rusty surfaces on milk-handling equipment	Use stainless steel, glass, plastic, or rubber on all milk contact surfaces
	Winter or dry lot feeding	Provide green feed
	Exposure to daylight or artificial light	Protect from artificial light and daylight
	Copper or iron in water supply	Water treatment may be necessary
RANCID bitter soapy	Late lactation (over 10 months) or low producing cows	Discard milk from low producing or late lactation cows
	Excessive agitation or foaming of raw milk	Keep fittings tight and air admission to a minimum Avoid risers and don't run milk pumps in starved condition
	High blend temperatures	Cool milk to at least 40°F and hold
FEED OR WEED unnaturally sweet aromatic	Eating, or inhaling odors of, strong feeds (grass or corn silage, green forage, wild onion or other weeds) prior to milking	Feed after milking Ventilate barn Withhold objectionable feed or remove cows from pasture 2 to 4 hours prior to milking Store silage carts out of barn
	Sudden feed changes	Change feed gradually
UNCLEAN barny cowy	Damp, poorly ventilated barns	Keep barns clean and well ventilated
	Dirty cows or barn	Clean cows or barn
	Dirty milk-handling equipment	Clean and sanitize all milk-handling equipment
	Improper preparation and milking	Wash and dry cow's udder prior to milking; handle milker to avoid sucking up bedding
	Cows with ketosis (acetonemia)	Withhold milk, treat cows
MALTY OR HIGH ACID Grapenut-like sour	Dirty milk-handling equipment	Clean milk-handling equipment after each use Sanitize milk-handling equipment prior to use
	Slow or insufficient cooling	Promptly cool milk to 40°F and hold
OTHER OFF-FLAVORS		
Medicinal	Medications, insecticides	Use according to directions Use odorless medications
Disinfectant	Certain disinfecting or sanitizing agents	Avoid strong smelling disinfectants Use sanitizers properly
Salty	Mastitis, late lactation cows	Discard milk
Flat	Low total solids	Evaluate feeding program Thoroughly drain equipment before use

Source: Cooperative Extension Services of New Jersey, New York, Pennsylvania.

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BIOLOGICAL VARIABILITY AND CHANCES OF ERROR

Variability among individual animals in an experiment leads to problems in interpreting the results. Although the cattle on treatment X may have produced more milk than those on treatment Y, variability within treatments may indicate that the differences in production between X and Y were not the result of the treatment alone. Statistical analysis allows us to calculate the probability that such differences are from treatment rather than from chance.

In some of the articles herein, you will see the notation "$P < .05$". That means the probability of the differences resulting from chance is less than 5%. If two averages are said to be "significantly different", the probability is less than 5% that the difference is from chance or the probability exceeds 95% that the difference resulted from the treatment applied.

Some papers report correlations or measures of the relationship between traits. The relationship may be positive (both traits tend to get larger or smaller together) or negative (as one trait gets larger, the other gets smaller). A perfect correlation is one (+1 or -l). If there is no relationship, the correlation is zero.

In other papers, you may see an average given as $2.5 \pm .1$. The 2.5 is the average; .1 is the "standard error". The standard error is calculated to be 68% certain that the real average (with unlimited number of animals) would fall within one standard error from the average, in this case between 2.4 and 2.6.

Using many animals per treatment, replicating treatments several times, and using uniform animals increase the probability of finding real differences when they exist. Statistical analysis allows more valid interpretation of the results, regardless of the number of animals. In all the research reported herein, statistical analyses are included to increase the confidence you can place in the results.

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