GENETICS, BREEDING, AND MODELING

Consideration of Percentage of Milk Shipped for Calculation of Total Lactation Yields from Various Morning and Evening Plans of Milk Sampling

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ABSTRACT

Milk yield recorded on DHI test day was compared with data on milk shipped from Texas and Minnesota herds for an innovative DHI test plan referred to as alternate a.m.-p.m. without a timer. Controls were yields for test day and for milk shipped from official DHI herds in Texas, Illinois, Minnesota, and several northeastern US states. Herd milk yield for a test day as a percentage of milk shipped was considered to be an indicator of the accuracy of the DHI recording plans. Mean percentage of milk shipped was 103 for all plans and regions. When herd test days with missing values were excluded, the percentages of herd test days within 96 to 110% of milk shipped were 77 for Texas and 82 for Minnesota innovative plans and 82 for Texas, 82 for Minnesota, 79 for Illinois, and 81 for northeastern official plans. Analysis indicated that the percentage of milk shipped was consistent across herd sizes, data source, and milk yield.

Eight hypothetical testing plans were examined with or without adjustment of lactation yields for percentage of milk shipped. Estimates of variance components of lactation milk yields were computed and compared using a multitrait animal model. Adjustment of records for percentage of milk shipped would decrease mean milk yields by 3%, could result in better estimates of actual milk produced, but would have little effect on accuracy of genetic evaluations.
(**Key words**: genetic evaluations, innovative testing plans, accuracy, test day)

Abbreviation key: **AP-WOT** = testing plan of alternate a.m.-p.m. milking without a timer, **AP-WOT-MS** = AP-WOT with bulk tank comparison, **%MS** = test day yield as a percentage of milk shipped.

INTRODUCTION

The DHIA record-keeping plans denoted as official DHIA have traditionally had a DHI technician weigh and sample consecutive milkings during a 24-h period (14) that occurred approximately once a month. However, demand by dairy producers to lower testing costs, to increase the ability of DHI technicians to handle more herds and thereby increase their income, and efforts to reduce disruption of the normal milking routine have spurred investigations and implementations of alternative testing methods that have the credibility of official DHIA without compromising accuracy of the test.

A review by McDaniel (5) described alternative methods for DHI testing. One of these alternatives was the alternate a.m.-p.m. testing plan. Under this plan, monthly samples and milk weights are collected for only one milking per test day but alternate from a.m. to p.m. milking from month to month. Research (3, 4, 9, 12) indicated the need to record and correct for milking interval for a.m.-p.m. plans so that milk weights and samples represented a 24-h period. The National Cooperative DHI Programs Policy Board voted to use a.m.-p.m. as an official DHIA plan if previous milking times were confirmed with an electronic timing device. However, the required purchase of an electronic timer has discouraged some DHIA from promoting or offering the plan and some dairy producers from participating in the plan.

Records from the supervised DHIA testing plan of alternate a.m.-p.m. milking without a timer (**AP-WOT**), although not considered official by DHIA, have been included in USDA-DHIA genetic evaluations since July 1984. The percentage of cows enrolled in record-keeping plans used in USDA-DHIA genetic evaluations from AP-WOT increased from 7% in 1984 to 10% in 1991 (6). This increased participation tends to confirm increasing demand for testing plans with low costs while still allowing use of records for genetic evaluations.

Records for cows enrolled in innovative testing plans have received official DHIA status since December 1990 (Jill McGregor, May 18, 1995, personal communication). One of the first and most popular testing plans proposed by DHIA leaders was the supervised DHIA plan of alternate a.m.-p.m. without a

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timer but with a bulk tank comparison (**AP-WOT-MS**). This innovative plan requires two independent measures of total milk yield to be collected on test day for each herd. The first measure is the sum of the milk weights of individual cows. Before summation, milk weight of each cow was converted to a 24-h basis using the recorded milking interval (11). The second measure is the milk shipped from the bulk tank, calculated as the 3-d mean of the 24-h weights of bulk tank shipments prior to test day. The sum of the milk weights from individual cows is expressed as a percentage of the measurement of milk shipped and is referred to as the test day yield as a percentage of milk shipped (**%MS**), which was proposed as the variable denoting the accuracy of milk yields for herd test days.

Previously, Wiggans (15) investigated methods to estimate yields from a.m.-p.m. plans and proposed a procedure that utilized such bulk tank measurements for calculating 24-h milk weights for individual cows. Wiggans (15) indicated that the bulk tank weight should be augmented with the amount of milk withheld from shipment. Wiggans (15) also noted that %MS would force errors associated with a.m.-p.m. factors to be zero. However, if the amount of milk withheld from shipment is reported inaccurately, errors would still exist.

The objectives of this research were 1) to examine statistical properties of the %MS and to determine whether these properties differed with herd size and production, 2) to determine whether statistical properties of %MS differed for herds enrolled in the innovative AP-WOT-MS compared with herds enrolled in the official DHIA testing plans, and 3) to determine whether adjustment of test day yields for %MS would increase the accuracy of genetic evaluations.

DATA

Six data files from Minnesota, Texas, Illinois, and the northeastern US states were utilized in this study. Each of the four sources of data contained different amounts of information. Variables included in each data file are shown in Table 1.

Minnesota

Test day data spanned December 1989 through May 1992, were from 896 Minnesota herd test days, and were obtained from the Minnesota Dairy Records Processing Center. Data consisted of herds that had switched from alternate a.m.-p.m. testing with a timer to the innovative AP-WOT-MS testing plan These data were split into two files: 1) test day data prior to initiation of AP-WOT-MS (Minnesota 1) and 2) test day data during participation in AP-WOT-MS (Minnesota 2).

For both data files, previous and test day milking times were used to calculate the interval preceding the measured milking and to compute factors as in the study by Shook et al. (12) to calculate test day milk yields. Test day milk yields for individual cows were summed within herd test day to give the milk yields for herd test days. The %MS was calculated as sum of milk yields for herd test days multiplied by 100 and divided by the amount of milk shipped daily.

Texas

Test day data from May 1991 through June 1992 from 5782 Texas herd test days were obtained from the North Carolina Dairy Records Processing Center. Herds participating in the innovative AP-WOT-MS (Texas 1) consisted of 890 of these herd test days.

TABLE 1. Variables included in each of the data files.

Variable	Data files			
	Minnesota	Texas	Northeastern	Illinois
Herd code	Yes	Yes	Yes	Yes
Test date	Yes	Yes	Yes	Yes
Testing method code	Yes	Yes	Yes	Yes
Previous milking times	Yes	No	Yes	No
Test day milking times	Yes	No	Yes	No
Milk weights for individual cows	Yes	No	Yes[1]	No
Herd size	Yes	Yes	Yes	Yes
Amount of milk shipped daily	Yes	Yes	Yes	Yes
Sum of milk yields for herd test days	Yes[2]	Yes	Yes[2]	Yes
Annual rolling herd average of milk yield	No	Yes	No	Yes
Amount of milk withheld from shipping on test day	No	No	No	Yes

[1]Milk weights provided separately for a.m. and p.m. milkings.

[2]Calculated from individual cow milk weights that were provided.

The other herd test days were herds participating in official DHIA plans (Texas 2). Sum of milk yields for herd test days and amount of milk shipped were used as previously stated to compute %MS.

Northeastern

Test day data from April 1991 through June 1992 from 2400 herd test days enrolled in official DHIA-type-test plans, 00 and 20, from several northeastern US states were obtained (Northeastern). For each cow, the summed milk weights from measured milkings were the milk yield for cow test days. Milk yields for individual cow test days summed within herd test days were the milk yields for herd test days. Sum of milk yields for herd test days was multiplied by 100 and divided by the amount of milk shipped, resulting in %MS.

Illinois

Test day data from January 1992 through May 1992 from 4172 Illinois herd test days enrolled in official DHIA plans were obtained from the Iowa Dairy Records Processing Center (Illinois). Sum of milk yields for herd test days and amount of milk shipped were used as previously stated to compute %MS. The amount of milk withheld from shipping on test day was multiplied by 100 and divided by sum of milk yields for herd test days and was termed the percentage of milk withheld from shipping.

METHODS

Analysis of Herd Test Day %MS

Frequency distribution of %MS was examined separately for each of the six data files (Minnesota 1, Minnesota 2, Texas 1, Texas 2, Northeastern, Illinois). Frequency distributions were examined with and without herd test days with missing %MS. Herd test days with missing %MS occurred because of failure to record amount of milk shipped. Herd test days with missing %MS were included because recording of %MS was a requirement for participation in the innovative testing plan examined in this study. For the Illinois data, the frequency distribution of percentage of milk withheld from shipping was examined as well.

Analysis of covariance (10) was used to test for significance ($P < 0.10$) of data source and of the herd size on the percentage of milk shipped (Model [1]):

$$Y_{ij} = \mu + d_i + \beta s_{ij} + d_i s_{ij} + e_{ij} \quad [1]$$

where

Y_{ij} = percentage of milk shipped for herd test day j within data source i,
μ = overall mean,
d_i = effect of data source i,
βs_{ij} = regression of y on herd size,
$d_i s_{ij}$ = interaction of herd size and data source, and
e_{ij} = unexplained residual.

The interaction between herd size and data source was examined, and, if significant, then herd size was nested within data source (Model [2]).

$$Y_{ij} = \mu + d_i + \beta_i s_{ij} + e_{ij} \quad [2]$$

where

Y_{ij} = percentage of milk shipped for herd test day j within data source i,
μ = overall mean,
d_i = effect of data source i,
$\beta_i s_{ij}$ = regression of y on herd size nested within data source i, and
e_{ij} = unexplained residual.

The orthogonal contrast between the innovative AP-WOT-MS plan from Texas and Minnesota and the official DHIA plans in Illinois, Minnesota, New York, and Texas, was examined.

Another model for analysis of covariance (10) was examined using only the data from Illinois and Texas and including annual rolling herd average of milk yield as well as herd size. Model [3] was identical to Model [1] except that annual rolling herd average of milk yield was also included. Interactions of covariables and data source were examined.

$$Y_{ij} = \mu + d_i + \beta_1 s_{ij} + \beta_2 m_{ij} + d_i s_{ij} + d_i m_{ij} + e_{ij} \quad [3]$$

where

Y_{ij} = percentage of milk shipped for herd test day j within data source i,
μ = overall mean,
d_i = effect of data source i,
$\beta_1 s_{ij}$ = regression of y on herd size,
$\beta_2 m_{ij}$ = regression of y on annual rolling herd average of milk yield,
$d_i s_{ij}$ = interaction of herd size and data source,
$d_i m_{ij}$ = interaction of annual rolling herd average of milk yield and data source, and
e_{ij} = unexplained residual.

If interactions were significant, then covariables were modeled as nested within data source (Model [4]):

$$Y_{ij} = \mu + d_i + \beta_{1i}s_{ij} + \beta_{2i}m_{ij} + e_{ij} \quad [4]$$

where

Y_{ij} = percentage of milk shipped for herd test day j within data source i,
μ = overall mean,
d_i = effect of data source i,
$\beta_{1i}s_{ij}$ = regression of y on herd size within data source i,
$\beta_{2i}m_{ij}$ = regression of y on annual rolling herd average of milk yield within data source i, and
e_{ij} = unexplained residual.

Herd test days with <10 cows were removed prior to analyses. Herd test days with %MS <70% or >130% were considered errors and removed prior to all statistical analyses. Errors of this magnitude could occur because of erroneous recording of 24-h milk yield shipped daily (i.e., only 12 h of milk yield shipped daily, 48 h of milk yield shipped daily, milk yield for split herds in one bulk tank, etc.) and were considered to be outliers.

Multiple regression (10) was used to test for significance ($P < 0.10$) of herd size and rolling herd average of milk yield on the percentage of milk withheld from shipping.

Means and standard deviations of %MS were examined separately for each of the six data files. For each data file, herd test days were arbitrarily stratified into herd size classes. Herd size classes were defined as class 1, 10 to 60 cows; class 2, 61 to 100 cows; and class 3, >100 cows. Means and standard deviations were computed for each herd size class. For the Illinois and Texas data, herd test days were stratified into herd production classes. Means and standard deviations were calculated for each production class. Herd production classes were defined as class 1, <6804 kg; class 2, 6804 to 7710 kg; class 3, 7711 to 8618 kg; class 4, 8619 to 9525 kg; and class 5, >9525 kg. Means and standard deviations by herd size and production classes indicated the effect of these variables on %MS.

Analysis of Adjusting Test Day Milk Yields for %MS

Individual a.m. and p.m. milk weights from the Northeastern data were used to calculate lactation yields of cows that would represent several types of testing plans:

1. Traditional testing plan where both a.m. and p.m. milk yields are measured and used to compute test day yield.
2. Identical to plan 1 except that test day yield is then adjusted by the inverse of %MS calculated for this plan.
3. Alternate a.m.-p.m. plan by which the a.m. milk weight is measured one month and the p.m. weight is measured the next month. The individual milk weight is used to calculate the test day yield using a.m.-p.m. factors developed by Shook et al. (11).
4. Identical to plan 3 except that test day yield is then adjusted by the inverse of %MS calculated for this plan.
5. An a.m.-a.m. plan in which only the a.m. milk weight is measured every month. The individual milk weight is used to calculate the test day yield using a.m.-p.m. factors developed by Shook et al. (11).
6. Identical to plan 5 except that test day yield is then adjusted by the inverse of %MS calculated for this plan.
7. A p.m.-p.m. plan in which only the p.m. milk weight is measured every month. The individual milk weight is used to calculate the test day yield using a.m.-p.m. factors developed by Shook et al. (11).
8. Identical to plan 7 except that test day yield is then adjusted by the inverse of %MS calculated for this plan.

For each of the eight plans examined, 305-d lactation yields for each cow were calculated as described by Wiggans and Dickinson (16). Records <305 d in length were projected to 305-d yields (18). Next, lactation milk yield were standardized for age and month of calving (8). Means and standard deviations of mature equivalent milk yields were compared across simulated test plans. Estimates of variance components for each of the eight measurements of lactation milk yield were computed (I. Misztal, 1994, unpublished data) from a multitrait animal model. The animal model included the fixed effect of herd-year-management group and a random animal effect with two unknown parent groups. Management groups were defined to mimic current definitions for management group used for genetic evaluations by USDA Animal Improvement Programs Laboratory (17), but registered and grade cows were not stratified separately. Estimates of animal additive genetic and residual variance components were compared to determine the effect of adjusting for percentage of milk shipped on the accuracy of genetic evaluations.

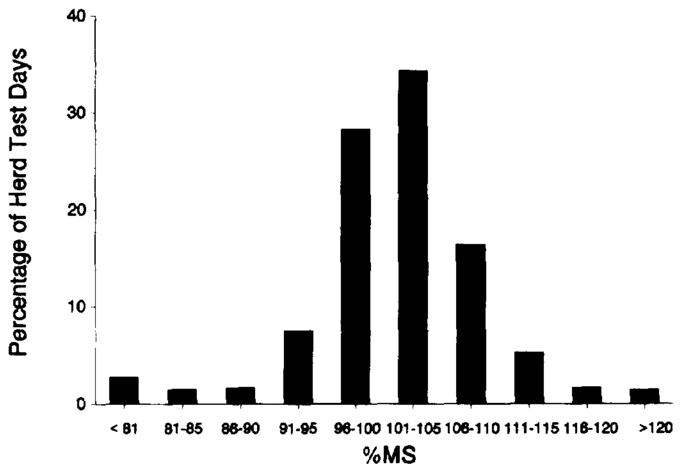

Figure 1. Frequency distribution of test day yield as a percentage of milk shipped (%MS) for herd test days for Illinois enrolled in official DHIA testing plans.

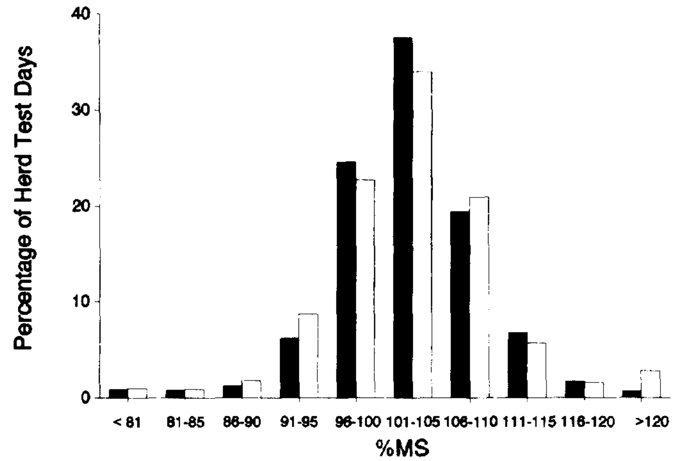

Figure 3. Frequency distribution of test day yield as a percentage of milk shipped (%MS) for herd test days for Texas enrolled in official (■) and innovative (□) DHIA testing plans.

RESULTS AND DISCUSSION

Percentage of herd test days with missing %MS was 9%. Missing %MS varied by data file (Minnesota 1 = 3%, Minnesota 2 = 0%, Texas 1 = 18%, Texas 2 = 13%, Northeastern = 7%, and Illinois = 0%). Examination of data with a higher percentage of missing %MS indicated that most missing values occurred early and that missing values were less of a problem later in the data, which suggested a problem in capturing this information when AP-WOT-MS was initiated. Frequency distributions of %MS for the remaining herd test days are shown in Figures 1, 2, 3, and 4. Examination of the distribution of %MS values across all six data files indicated a uniform normal distribution with a central tendency around 103%. Observations that were <81% were mostly clustered around 50%, which suggested that milk yield from 2 d rather than milk yield from 1 d was reported as the daily amount of milk shipped. Percentage of herd test days with 96 to 110 %MS were 77 for Texas 1, 82 for Texas 2, 79 for Illinois, 81 for Northeastern, 82 for Minnesota 1, and 82 to Minnesota 2 when records with 0 %MS were excluded. Observations that were >120% were generally clustered around 200%, which suggested that milk yield from one milking rather

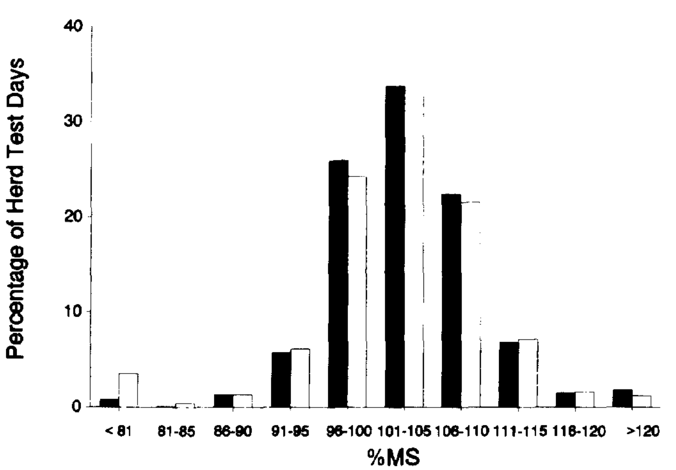

Figure 2. Frequency distribution of test day yield as a percentage of milk shipped (%MS) for herd test days for Minnesota prior to (■) and during (□) enrollment in innovative DHIA testing plan.

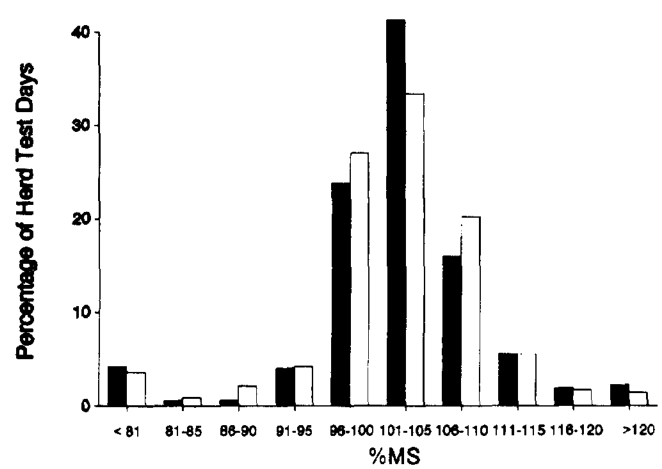

Figure 4. Frequency distribution of test day yield as a percentage of milk shipped (%MS) for herd test days for the northeastern US enrolled in official DHIA testing plans: 0 (■) and 20 (□).

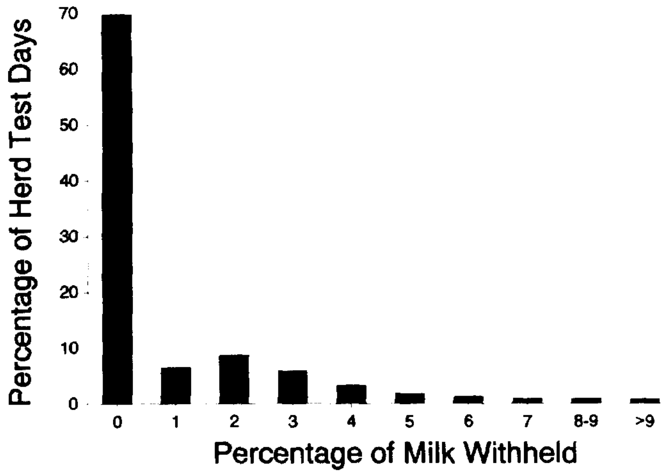

Figure 5. Frequency distribution of percentage of milk withheld from shipping for herd test days for Illinois enrolled in official DHIA testing plans.

TABLE 3. Analysis of covariance from a model with the dependent variable of test day yield as percentage of milk shipped and independent variables of data file and herd size within data file.[1]

Source	df	*F*	*P* > *F*
Data file	5	2.20	0.0511
Herd size (data file)	6	2.20	0.0583

[1]R^2 = 0.0019; root MSE = 6.4.

than milk yield from 1 d was reported as the daily amount of milk shipped.

Frequency distribution of the percentage of milk withheld from shipping for the Illinois data is in Figure 5. Seventy percent of all herd test days had no milk withheld from shipping on test day. Twenty-one percent of the herd test days had between 1 and 3% of milk withheld from shipping on test day. Less than 0.8% of the herd test days had >9% of milk withheld from shipping on test day; the extreme test day had 32% of milk withheld. Mean percentage of milk withheld from shipping for the Illinois data was 1%. The high percentage of herd test days having <4% of milk withheld from shipping and the mean of 1% of milk withheld from shipping indicated that milk withheld from shipping accounted for only a portion of the differences in %MS.

Overall means and standard deviations of %MS by data file are in Table 2. The 12,164 herd test days averaged 102.9 %MS with standard deviation of 6.4 %MS. Means and standard deviations of %MS were consistent across the six data files; means ranged from 102.5 to 103.1 %MS, and standard deviations ranged from 5.8 to 7.2 %MS. These results agreed with those of Cady et al. (1), who examined 3560 test days from Washington and found a mean of 103.1 and a standard deviation of 5.1 for %MS. The 103 %MS indicated that a dairy producer was credited with 3% more milk on test day than was shipped. If the percentage of milk withheld from shipping from the Illinois data was typical of the US, then dairy producers averaged 2% more milk on test day than on other days. A possible reason for this extra 2% of milk yield on test day was that test day yields represented >24 h of milk. A lengthened milking interval on test day because of slower milking (i.e., more machine stripping of cows and sampling by technician) could explain increased milk yields on test day. Prior knowledge of when the DHIA technician would be testing (to permit changing the milking interval prior to the first milking on test day) could explain some of the extra milk yield on test day as well. On-farm use of milk for calves, other animals, or human consumption decreased the amount of milk shipped and contributed to %MS being >100%. Inaccuracies in recorded values of the amount of milk shipped would cause %MS to differ from 100%. Such inaccuracies could arise from human errors in measuring bulk tank weights or improper calibration of the bulk tank.

There was concern that test day milk yields would be overestimated for cows in herds enrolled in the

TABLE 2. Means and standard deviations of test day yield as percentage of milk shipped by data source and overall.

Data	n	$\overline{X}$	SD
Illinois	4009	103.1	6.7
Minnesota 1	822	103.0	6.0
Minnesota 2	881	103.1	5.8
Northeastern	2125	102.8	6.1
Texas 1	3989	102.7	6.2
Texas 2	788	102.5	7.2
Overall	12,614	102.9	6.4

TABLE 4. Analysis of covariance from a model with the dependent variable of test day yield as percentage of milk shipped and independent variables of data file, herd size, and annual rolling herd average of milk yield.[1]

Source	df	*F*	*P* > *F*
Data file	2	3.07	0.0464
Herd size	1	0.25	0.6144
$\overline{X}_{Milk}$	1	2.99	0.0836

[1]R^2 = 0.0013; root MSE = 6.5.

TABLE 5. Analysis of variance from a model with the dependent variable of percentage of milk withheld from shipping and independent variables of herd size and annual rolling herd average of milk yield.[1]

Source	df	F	$P > F$
Herd size	1	4.26	0.0392
$\overline{X}_{Milk}$	1	11.20	0.0006

[1]R^2 = 0.0033; root MSE = 1.9.

innovative AP-WOT-MS, because milking intervals would be longer than reported. For this reason, %MS was required for comparison with herd test days on official plans. There was also concern that %MS might vary by herd size and herd production. Differences between data file, herd size, and interaction between them was tested using Model [1], and the interaction was significant. Therefore, Model [2] was utilized instead, and results are presented in Table 3. Data source and herd size nested within data source were significant ($P < 0.10$) but explained little of the variation in %MS for herd test days ($R^2 = 0.002$). The orthogonal contrast comparing %MS from AP-WOT-MS to %MS from official DHIA data was not significant ($P > 0.10$). This result suggests that milking intervals reported to DHIA technicians on test day for the innovative plan must have been as accurate as those from the official plans.

Results from the analysis of covariance used to test the effect of annual rolling herd average of milk yield, herd size, and data source on the Illinois, Texas 1, and Texas 2 data are shown in Table 4. Interaction of herd size and data source and interaction of annual rolling herd average of milk yield and data source were not significant, so Model [3] was used. Herd size was not significant ($P > 0.10$), but data source and annual rolling herd average were significant ($P < 0.10$); still, the R^2 of 0.001 was small, indicating that these variables explained very little of the variation in %MS.

Information from the multiple regression analysis used to test the effect of herd size and annual rolling herd average of milk yield on the percentage of milk withheld from shipping in the Illinois data is presented in Table 5. Both herd size and annual rolling herd average of milk yield were significant (P

TABLE 6. Means and standard deviations of test day yield as a percentage of milk shipped (%MS) by data source and herd size class.[1]

Data file	Herd size $\overline{X}$	Herds	%MS $\overline{X}$	%MS SD
	(no. cows)	(no.)		
Illinois				
Class[1] 1	40	2572	103.1	7.2
Class 2	77	1091	102.7	5.7
Class 3	132	346	103.9	6.1
Minnesota 1				
Class 1	41	658	103.1	6.0
Class 2	73	164	102.9	6.0
Minnesota 2				
Class 1	40	703	103.2	5.9
Class 2	72	178	102.8	5.6
Northeastern				
Class 1	44	842	103.3	6.8
Class 2	77	721	103.4	5.5
Class 3	177	562	101.5	5.7
Texas 1				
Class 1	45	549	102.5	6.5
Class 2	80	993	102.6	6.4
Class 3	215	2447	102.8	6.1
Texas 2				
Class 1	42	98	103.5	8.1
Class 2	81	131	102.4	8.3
Class 3	317	559	102.3	6.7
Overall				
Class 1	42	5422	103.1	6.8
Class 2	78	3278	102.8	6.0
Class 3	217	3914	102.6	6.1

[1]Herd size class: 1 = 10 to 60 cows, class 2 = 61 to 100 cows, and class 3 = >100 cows.

TABLE 7. Means and standard deviations of mature equivalent for milk yields calculated under eight testing plans.

Plan	Mature equivalent milk yield	
	$\bar{X}$	SD
	(kg)	
Traditional	9321	1796
Adjusted[1] traditional	9188	1799
a.m.-p.m.	9329	1827
Adjusted a.m.-p.m.	9195	1829
a.m.-a.m.	9270	1827
Adjusted a.m.-a.m.	9197	1833
p.m.-p.m.	9391	1850
Adjusted p.m.-p.m.	9183	1827

[1]Yields corrected for test day yield as a percentage of milk shipped.

TABLE 8. Estimates of residual and genetic variance components for the eight measures of lactation milk yields calculated under the different testing plans.

Plan	Variance Components	
	Residual	Genetic
	(kg)	
Traditional	4,104,599	844,144
Adjusted[1] traditional	3,978,500	824,639
a.m.-p.m.	4,337,295	872,267
Adjusted a.m.-p.m.	4,197,587	832,351
a.m.-a.m.	4,272,430	842,783
Adjusted a.m.-a.m.	4,196,680	841,422
p.m.-p.m.	4,416,674	908,555
Adjusted p.m.-p.m.	4,195,772	855,484

[1]Yields corrected for test day yield as a percentage of milk shipped.

< 0.10); however, the R^2 was only 0.003, indicating that these variables explained little of the variation in the percentage of milk withheld from shipping.

Table 6 contains overall means and standard deviations of the %MS by herd size class as well as data source. Herd size classes were defined as class 1, 10 to 60 cows; class 2, 61 to 100 cows; and class 3, >100 cows. Mean %MS decreased slightly from the smallest to the largest herd size class. However, the trend for %MS to decrease with herd size class was not consistent within data source. Means and standard deviations of the %MS by herd production class was examined but are not provided. Results from this analysis indicated only a slight increase in mean %MS as herd yield increased.

A number of hypothetical testing plans that would use either one or both of the test day samples were examined with or without adjustment for %MS. Means and standard deviations of mature equivalent milk yields that would be calculated under eight different plans are in Table 7. The mean length of lactation was 175 d for the 5637 cows examined. The shorter than expected lactation length and the lower than expected number of cows resulted because the span for test day data was only from April 1991 through June 1992 and because lactations were required to have a test day within the first 75 d of lactation. Means ranged from 9270 to 9391 kg for the testing plans that did not adjust for %MS. A proposed p.m.-p.m. testing plan had the highest mean for mature equivalent milk yield, and a proposed a.m.-a.m. plan had the lowest mean for mature equivalent milk yield. Larger mean yields from a p.m.-p.m. plan could be caused by an inaccurate indication of preceding milking time because generally the p.m. milking is the first milking measured on test day. Means ranged from 9183 to 9197 kg for testing plans that adjusted for %MS. Adjustment for %MS caused means for mature equivalent milk yields to be more uniform across testing plans. Uniformity of calculation of lactation milk yields across testing plans should be important to dairy producers who base management decisions (i.e., purchase of replacement cows and heifers) on phenotypic lactation milk yields. Improved accuracy of test day milk yield from the adjustment of %MS would also be important to dairy producers who base feeding decisions for individual cows on test day milk yields.

Estimates of components of residual and genetic variance for the eight measures of lactation milk yields are presented in Table 8. In Table 9, heritability estimates are on the diagonal, and estimates of genetic and phenotypic correlations are above and below the diagonal, respectively. Both residual and genetic components of variance decreased proportionately with the adjustment for %MS, resulting in little change in heritability estimates. Heritability estimates ranged from 0.165 to 0.172 and were low compared with those of other studies (2, 17). The low heritability estimates were most likely caused by the short mean length of lactation (13). Genetic correlations for the eight measures of mature equivalent milk yields ranged from 0.94 to 1.00. Phenotypic correlations ranged from 0.90 to 1.00. Similarity of heritability estimates and similarity of correlations for the eight plans indicated that adjustment for %MS and method of testing would have limited effect on the accuracy of genetic evaluations. There would be only limited improvement in accuracy of genetic evaluations by adjusting test day milk yields (and consequently lactation milk yields) for %MS because, generally, cows in the same management group would

TABLE 9. Estimates of heritability (diagonal), genetic (above diagonal), and phenotypic correlations (below diagonal) for the eight measures of lactation milk yields calculated under different testing plans.

	Traditional	Adjusted traditional	a.m.-p.m.	Adjusted a.m.-p.m.	a.m.-a.m.	Adjusted a.m.-a.m.	p.m.-p.m.	Adjusted p.m.-p.m.
Traditional	0.171	1.00	1.00	1.00	0.99	0.99	0.98	0.98
Adjusted[1] traditional	1.00	0.172	1.00	1.00	0.99	0.99	0.98	0.98
a.m.-p.m.	0.98	0.97	0.167	1.00	0.98	0.98	0.98	0.99
Adjusted a.m.-p.m.	0.98	0.98	1.00	0.165	0.96	0.96	0.99	0.99
a.m.-a.m.	0.98	0.98	0.96	0.96	0.165	1.00	0.94	0.95
Adjusted a.m.-a.m.	0.98	0.98	0.96	0.96	1.00	0.167	0.94	0.95
p.m.-p.m.	0.97	0.97	0.95	0.95	0.90	0.90	0.171	1.00
Adjusted p.m.-p.m.	0.97	0.97	0.95	0.95	0.90	0.91	1.00	0.169

[1]Yields corrected for test day yield as a percentage of milk shipped.

be affected by the same %MS. However, some error could be reduced for herds in which %MS varied from month to month and for cows, arbitrarily assigned to a management group, that initiated lactations during widely separated months (e.g., those herds with small herd size). For herds in which %MS varied dramatically from month to month, those cows that were culled from the herd have their records projected based on the %MS for last test days, which causes error in the projections and in the comparisons of management groups. Notification of herds in which %MS varied dramatically from month to month might have management value because unrecognized problems could be identified and addressed.

CONCLUSIONS

Examination of the frequency distribution of %MS revealed a normal distribution centered around 103%. Frequency distributions of %MS were similar for the innovative AP-WOT-MS and for the official DHIA plans examined. Information reported from the Illinois data on the amount of milk withheld from shipping on test day suggested that one-third of the mean (3%) for excess milk yield on test day could be due to milk withheld from shipping (i.e., milk with antibiotic residue). Increased time to complete milkings on test day because of either collection of component samples by the DHIA technician or increased machine stripping of cows could have also increased milk yields on test days. No significant differences were found in %MS between AP-WOT-MS and the official DHIA plans. Monitoring of %MS should help to ensure that correct milking intervals have been reported to the DHIA technician. Further, monitoring of %MS should help detect previously unknown problems associated with collection of test day milk yields (i.e., accuracy of milk meters) and measurement of milk shipped (i.e., improperly calibrated bulk tanks). Herd size and annual rolling herd average for milk yield explained few differences in %MS for herd test days. Mean of ME milk yields across the eight different testing plans indicated that adjustment of test day milk yields for %MS would improve the comparison of lactation records across testing plans. Estimates of variance component calculated from lactation milk yields adjusted for %MS were lower; however, estimates of residual and genetic variances were equally reduced, resulting in no difference in heritability estimates between milk yields adjusted for %MS versus unadjusted. As %MS become more readily available in databases, further examination will be needed to monitor how well %MS reflects the true accuracy of each herd's records.

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