Optimizing Sampling Practices at NYS Dairy Farms

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Introduction

Current standard forage sampling practices may not yield samples that accurately represent the quality of the delivered forages in dairy diets. Sampling frequency, number of samples, and allowed deviation in the change of forage quality (Control limits) can be optimized according to the farm characteristics to improve interpretation of forage samples and diet accuracy. For a period of 16 weeks in the winter of 2020 and spring of 2021, we collected corn silage and haylage samples in duplicate, 3 days per week before diet mixing from 8 NYS dairy farms with 3 silage storage methods (bunker, bag, and drive over pile). Lactating herd size was recorded to be used as an input in the optimization analysis. We also recorded the change of the volume of each silo, the sampling date, and identified spatially explicit methods to define the field(s) of origin of the silage within the bags (1 dimensional) and bunker silages (2 dimensional) to estimate feeding rate (ft/d and ft^3/d) and feeding time for each field of origin (days per field of origin). The herd size records and the field-of-origin feeding time (average feeding d/field) were used as inputs in the renewal reward model (RRM) described by St-Pierre and Cobanov (2007) to define the farm size and in-control time parameters for each farm, respectively. Then, we applied a genetic algorithm optimization method using the RRM as objective function to estimate the optimum sampling frequency, sample number, and control limits of each farm. In our study context, the in-control time parameter refers to the length of time haylage and corn silage quality stays stable without a major change. The objective of this study is to develop a method to increase sampling efficiency and diet accuracy by optimizing sampling practices at eight different NYS case study dairy farms.

Main Findings

Feedout data records reported in table 1 show a small-scale farm A (±118 cows) and large-scale farm B (±1,229 cows) using bags and medium-scale farm C (±517 cows) and D (±656 cows) using bunkers for haylage and corn silage. The feeding rate (ft^3/d) of farm A and C was lower than B and D for haylage and corn silage. The feeding rate (ft^3/d) of all farms was related to the farm size, ensiling method, bag and bunker dimensions, and forage type. Field-of-origin feeding time (d/field) not only depends on feeding rate (ft/d) and (ft^3/d), and silage face area (ft^2/d), but also depends on the field area and number of fields harvested per farm.

St-Pierre and Cobanov (2007) identify in-control time of the RRM as one of relevant parameters for optimizing sampling practices. They proposed 30 days as the in-control time parameter for the RRM based on expert opinion. However, in a previous study, our mixed-model analysis of the haylage and corn silage at harvest and feedout identified field-of-origin as a primary contributor to variation in forage composition. Thus, haylage and corn silage composition is expected to change with the field of origin. For this reason, we propose the average field-of-origin feeding time (d/field) as in-control time (d) parameter of the RRM.

Table 1. Farm herd size, ensiling method, feeding rates, and silage area of sampled haylage and corn silage.

Ingredient	Farm	Number of cows	Ensiling type	Feeding rate (ft/d)	Silage face area (ft^2)	Feeding rate (ft^3/d)	Field-of-origin feeding time (d/field)
Haylage	A	118	Bag	1.7	64	109	7 (1 - 16)
	B	1229	Bag	3.7	154	554	4 (1 - 13)
	C	517	Bunker	1.0	271	301	13 (5 - 16)
	D	656	Bunker	1.7	518	601	6 (1 - 2)
Corn Silage	A	118	Bag	3.4	64	215	18 (5 - 33)
	B	1229	Bag	11.4	154	1762	6 (1 - 13)
	C	517	Bunker	1.3	438	632	7 (1 - 24)
	D	656	Bunker	0.8	1251	1,131	6 (1 - 13)

Optimum sampling practices estimated by optimizing the RRM were different for each farm when we set the in-control time equal to the average field-of-origin feeding time (d/field) and farm herd size equal to the average lactating cow number (Table 2). Consistent with the number of samples proposed by St-Pierre and Cobanov (2007), our results suggest the optimum number of samples is 2 samples per sampling time for all farms, ensiling methods, and forage ingredients. A larger number of cows and shorter in-control time increased the optimum sampling frequency. The optimum sampling frequencies using the field-of-origin feeding time to parameterize the RRM were consistent with sampling frequencies suggested by St-Pierre and Cobanov (2007). However, the optimum control limits were lower than the proposed by St-Pierre and Cobanov (2007). Lower control limits increase the number of samples out of the stable composition range and but could yield more accurate and consistent diets. Total quality cost ($/d) in table 2 refers to the sum of the costs required to collect samples, sample analyze sample composition, and adjust diets, as well as expected changes in milk production. Consistent with St-Pierre and Cobanov (2007), the total quality cost ($/d) increased with the increase of herd size. However, the total quality cost estimated using the field-of-origin feeding time were higher than the total quality cost estimated by St-Pierre and Cobanov (2007). This result is due to the shorter in-control time inputs that we estimated based on the expected frequency of changing the field-of-origin.

Take Home Message

The optimal number of samples for each farm, regardless to the herd size, field feeding time, ensiling method, and type of forage is 2 samples per sampling time. Optimal sampling frequency increases with the increase in the herd size. Shorter values for the in-control parameter decreases the allowed deviation in the change of forage quality. Our estimates of the field-of-origin feeding time suggest that these values vary between farms and support farm specific estimates for the in-control time parameter needed by the RRM model.

Table 2. Optimum estimates and range of in-control time, number of samples, control limits, and total quality cost calculated with three different optimization methods in farms with different lactating herd sizes and two ensiling methods.

Herd Size and in-control time data source	Ingredient	Farm	Number of cows	Ensiling method	In-control time (d)	Number of samples	Sampling frequency (d)	Control limits (SD)	Total quality cost ($/d)
NYS Farms	Haylage	A	118	Bag	7 (1 - 16)	2 (1 - 2)	14 (12 - 19)	0.56 (0.00 – 1.11)	$67 ($59 - $76)
		B	1229	Bag	4 (1 - 13)	2 (1 - 2)	3 (2 - 3)	0.80 (0.00 - 1.04)	$574 ($451 - $777)
		C	517	Bunker	13 (5 - 16)	2 (2 - 2)	4 (4 - 5)	0.99 (1.00 - 1.20)	$229 ($196 - $275)
		D	656	Bunker	6 (1 - 2)	2 (1 - 2)	4 (3 - 4)	0.84 (0.38 - 1.07)	$312 ($265 - $377)
	Corn Silage	A	118	Bag	18 (5 - 33)	2 (1 - 2)	13 (12 - 19)	0.86 (0.00 - 1.16)	$58 ($47 - $76)
		B	1229	Bag	6 (1 - 13)	2 (1 - 2)	3 (2 - 3)	0.80 (0.00 – 1.04)	$574 ($451 - $777)
		C	517	Bunker	7 (1 - 24)	2 (2 - 2)	5 (4 - 5)	0.95 (0.00 – 1.21)	$227 ($171 - $340)
		D	656	Bunker	6 (1 - 13)	2 (1 - 2)	4 (3 - 7)	0.75 (0.00 - 1.10)	$324 ($258 - $427)
St-Pierre and Cobanov (2007)	All forage ingredients	A	118	Bag	30	2 (-)	13 (-)	1.14 (-)	$48 (-)
		B	1229	Bag	30	2 (-)	3 (-)	1.32 (-)	$338 (-)
		C	517	Bunker	30	2 (-)	5 (-)	1.26 (-)	$158 (-)
		D	656	Bunker	30	2 (-)	5 (-)	1.11 (-)	$194 (-)

References

St-Pierre, N. R. and B. Cobanov. 2007. A Model to Determine the Optimal Sampling Schedule of Diet Components1. Journal of Dairy Science 90(12):5383-5394.