Group feeding economics-milking the feed margin

Dr. Albert DeVries | University of Florida | devries@ufl.edu

Notes:
Paper and PowerPoint Slides on following pages

Group feeding economics - Milking the feed margin

Albert De Vries, Carlos Nino de Guzman, Diwakar Vyas

Department of Animal Sciences, University of Florida

Contact: devries@ufl.edu

Introduction

Most dairy farms in the US feed total mixed rations (TMR) to groups of cows. A TMR has been defined as "a quantitative mixture of all dietary ingredients, blended thoroughly enough to prevent separation and sorting, formulated to specific nutrient content, and offered ad libitum" (Coppock et al., 1981). This paper aims to discuss 2 aspects of TMR feeding. First, there is a brief review of the principles of feeding one versus multiple TMR to lactating cows, and the impact on the feed margin (=milk income minus feed cost, or IOFC). Second, there are estimates of the increased cost of loading, mixing and delivering multiple TMR. The benefits of feeding multiple TMR may or may not be greater than the extra cost as the analysis will show.

Nutritional grouping of the lactating cow

The practice of feeding TMR to dairy cows appears to have taken off in the 1950s (Schingoethe, 2017). Prior to feeding TMR, the common practice was to add concentrates on top of forages. This allowed some level of feeding the individual cow based on her requirements. The advent of group feeding a TMR was influenced by the advent of milking in parlors, increasing herd sizes and free stall housing.

Schingoethe (2017) lists advantages and disadvantages of TMR feedings. While the advantages of TMR feeding far outweigh the disadvantages, one apparent disadvantage remains that dairy cows in a herd have wide ranging nutrient requirements that cannot be individually met with group feeding. Indeed, application of the TMR system, decades ago, was at first resisted because "dairy nutritionists felt that it had limited application because of the wide range in energy requirements within any herd." (Coppock et al., 1981).

Today, the individual nutrient requirements of dairy cattle varying in physiological status such as milk production, body weight, age, and reproductive status etc. appear to be well understood. The main limiting factors are energy and protein densities. A higher nutrient dense diet is typically more expensive. What is less well understood is how cows respond when they are fed a ration (diet) that deviates from her individual nutrient requirements. Cows fed a TMR in the group are either overfed or underfed, both which have costs. Overfed cows produce milk at their maximum capacity, but are less efficient users of protein, may get fat and less healthy. Underfed cows produce less milk than their maximum capacity and/or may mobilize more body fat.

The challenge for group feeding is to formulate the ration that minimizes the sum of both costs. Some 40 years ago this question led to the development of lead factors (Stallings and McGilliard, 1984) with the outcome that the ration should overfeed approximately 83% of the herd (and underfeed 17%) in terms of energy and protein. In a heterogenous group, such as when one ration is fed to all cows, there are

many cows that have nutrient requirements that deviate much from the nutrient density of the ration that is fed.

Nutritional grouping is a practice to put lactating cows with similar nutrient requirements together and offer them a ration formulated for the more homogenous cows in that group. Nutritional grouping can be beneficial by saving feed costs, improving productivity and herd health, and increases nutrient emissions to the environment (Cabrera and Kalantari, 2016; Barrientos-Blanco et al., 2022).

More than a dozen studies have investigated the economics of nutritional grouping. These studies looked at how many different TMR should be fed to lactating cows, and what the best ways are to group cows. The criterion of how to group cows affects the economics of how many rations to feed. The largest advantage of nutritional grouping was found with a method called "cluster" grouping, where cows are grouped based on a formula that combines similarity for net energy of lactation and crude protein (McGilliard et al., 1983). More recently, Wu et al. (2019) proposed a marginally better, but also much more complex method called OptiGroup to group cows.

A review of 7 studies (Cabrera and Kalentari, 2016), and converting the results into 2025 dollars, showed an advantage of feeding 2 vs 1 TMR to all lactating cows ranging from +$29 to +$152 (mean +$75) in IOFC per cow per year. Going from 2 to 3 TMR increased the IOFC per cow per year by another $11 to $71 (mean +$42). Thus, from 1 to 2 rations is worth more than from 2 to 3 rations which illustrates the reduced marginal value when another ration is added.

These 7 studies were done using different grouping methods including by cluster, OptiGroup, net energy of lactation, and days in milk. The grouping method can have an important impact on the value of nutritional grouping: grouping by cluster was the most valuable, followed by dairy merit and days in milk. Nutritional grouping by test day milk had the smallest increase in IOFC (Cabrera and Kalentari, 2016).

Although there is an interesting increase in IOFC by moving from 1 to 2 to 3 different TMR in lactating cows, nutritional grouping is not that common in practice. In a survey held a decade ago (Contreras-Govea et al., 2015), 58% of the surveyed dairy farms in Wisconsin and Michigan used the same ration for all lactating cows. The most important nutritional grouping strategy, when fed at least 2 rations, was to provide a different TMR to fresh cows compared to the other lactating cows in the herd. Stage of lactation post fresh and milk production level were also criteria considered important for nutritional grouping. There was a strong consensus among the survey respondents that more than 1 ration was needed to feed a herd of lactating cows. However, the main reason why nutritional grouping was not used (or not used more) was the desire to keep feeding simple. The observation that cows drop in milk when moved to a different group was another important reason for limiting nutritional grouping.

Our personal observation is that in the Southeast some large herds feed only one ration to all lactating cows. One reason is that these producers are not convinced that cows respond much better to feeding different diets. A reason may be lower quality forages and therefore less clarity on how cows respond to diets that have a different nutrient density. The desire to keep feeding simple but consistent is another reason for having one ration.

Increased cost of loading, mixing and delivering multiple TMR

The studies summarized above showed an increase in IOFC from nutritional grouping that may be of interest to dairy producers. Those studies did not include any extra cost associated with formulating and delivering different TMR (other than the cost of the feed itself).

Nutritional grouping adds complexity to feeding dairy cows, with the increased risk of mistakes. Some mistakes that come to mind include mixing the wrong TMR and feeding the wrong TMR to the wrong group. We do not know how likely these mistakes are and what their economic consequences would be.

For our economic analysis, we did include the cost of increased TMR variability and an increased number of loads (trips). It is often thought that low day to day variation in the ration is important for dairy cows. However, Weiss and St-Pierre (2024) conducted a review of the literature and large nutrient composition databases and concluded that current data do not show any negative effects when rations reasonably vary from day to day if, when averaged over a few days, the nutrient composition meets ration specifications.

Bach (2024) found that dairy producers consistently overmix energy grains, grain silages, hays, and protein sources, whereas nongrain silages, molasses, minerals, and straw are added in lower amounts than expected. Divergence in the total amount of TMR (because some ingredients are added in excess) was weakly but quadratically correlated with milk yield, showing a reduced milk yield with greater deviation from the formulated ration.

Nutritional grouping could lead to feeding smaller loads of TMR when the one full load of the TMR mixer holds enough TMR to feed more than 1 pen. If one pen would be fed a separate TMR, the mixer fill may be significantly less than the maximum mixer volume. When this is the case, we might assume that mixing errors increase and perhaps, as Bach (2024) showed, milk production and IOFC are decreased.

Associated with potentially feeding smaller loads, national grouping could simply lead to more loads (trips) being made and delivered to feed different rations to different pens. We assumed operating cost of the TMR mixer and loader of $100 per hour (Carrasquillo-Mangual, 2020) and 40 minutes to load, mix and deliver a TMR load (Karszes and Howlett, 2016). Now we are ready to compare the benefit of nutritional grouping with the potentially added cost of delivery and mixing errors.

Effect of nutritional grouping on mixer cost and errors

We built a spreadsheet that included number of post fresh lactating cows, pounds of TMR fed per cow per feeding, number of feedings per day, pen size based on 3x milking, and maximum TMR mixer capacity. Then we varied number of rations from 1 to 4. When more rations were fed, we assumed that the number of pens (cows) receiving the same ration was as equal as possible. For example, if we had 7 pens and 3 rations, then we assumed 3 pens with one ration, 2 pens with the next ration, and 2 pens with the third ration. Collectively, the math in the spreadsheet determined the number of TMR mixer loads and the average mixer fill percentage.

We found for example that on a dairy farm with 1000 lactating cows and a TMR mixer capacity of 12,000 pounds, the cost to deliver 1 or 2 rations did not vary. To feed 3 rations increased the cost by $90 per cow per year and feeding 4 rations increased the cost by $164 per cow per year. With 3000 cows, the cost of feeding 2, 3, or 4 rations did not vary and were $36 per cow per year above feeding 1 ration.

Approximately half of these extra costs were due to delivering more TMR loads while the remainder was due to extra cost allocated from more variability in the ration fed because of smaller loads.

These increases in the cost of making more loads and the greater variability of the ration need to be compared with the IOFC increases due to nutritional grouping. A casual observation suggests that the benefits and delivery costs of nutritional grouping may cancel each other out depending on TMR mixer size relative to pen size. Further analyses are strongly recommended.

The TMR mixer spreadsheet is available from the first author upon request.

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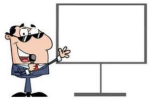
Albert De Vries
Department of Animal Sciences
University of Florida
Gainesville, FL 32611
devries@ufl.edu

UF IFAS UNIVERSITY of FLORIDA

Western Dairy Management Conference, Reno, Nevada. March 31-April 3, 2025

Overview

1. Nutritional grouping principles
2. Economic benefits of nutritional grouping
3. Are producers feeding multiple rations?
4. TMR mixer cost
5. Mixing errors
6. Effect of nutritional grouping on mixer cost and errors
7. Summary



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Terminology

- Group feeding = nutritional grouping = feeding different rations
- Feed margin
  = Milk sales - feed cost
  = Income over feed cost
  = IOFC (per cow per year)
- Total mixed ration = diet = recipe
- TMR *mixer* = TMR wagon

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Nutritional grouping principles

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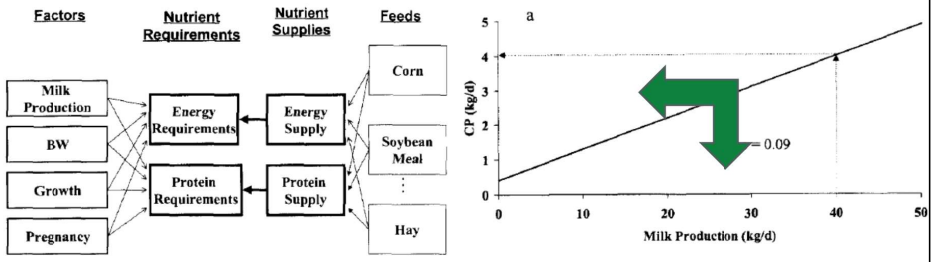
St-Pierre and Thraen (1999). J. Anim. Sci. Vol. 77, Suppl. 2 / J. Dairy Sci. Vol. 82, Suppl. 2

Nutrient requirements system



- Inputs: Physiological status cow, for example milk production
- Outputs: How many nutrients are required (energy, protein, …)

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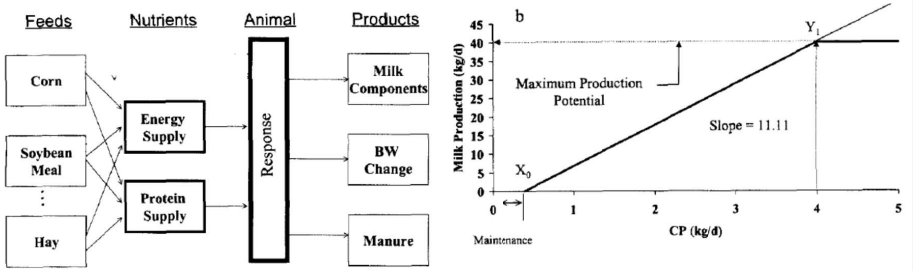
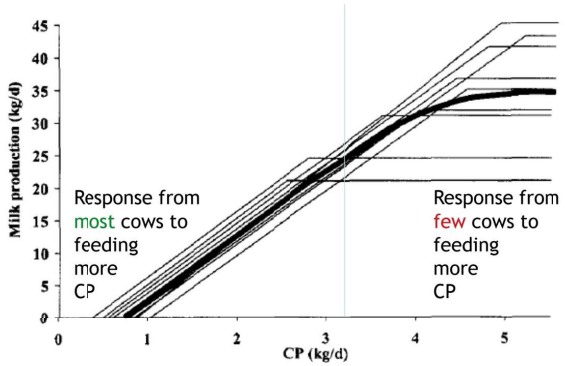
Production response system (one cow)



- Inputs: Levels of nutrients (energy, protein, …)
- Outputs: Physiological status, for example milk production

6

Production response system (9 cows)



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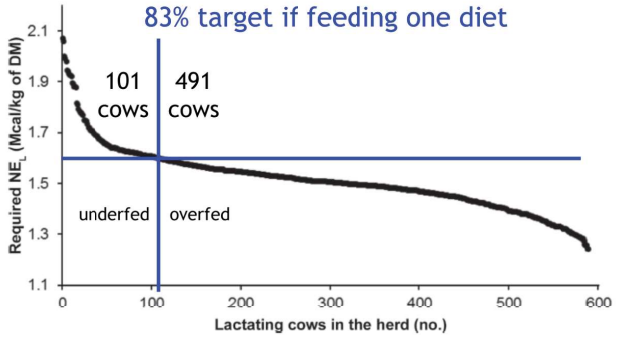
Example: Net Energy of Lactation requirement for 592 cows

A. S. Kalantari, L. E. Armentano, R. D. Shaver, and V. E. Cabrera. J Dairy Sci. 99:1672 (2016)



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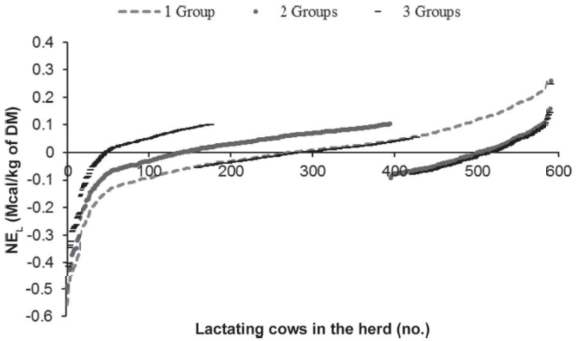
Dr. Albert DeVries | University of Florida | devries@ufl.edu

Difference between provided and required NEL concentration under 1, 2, or 3 nutritional groups based on the diet offered at the average NEL concentration of the group

A. S. Kalantari, L. E. Armentano, R. D. Shaver, and V. E. Cabrera. J Dairy Sci. 99:1672 (2016)



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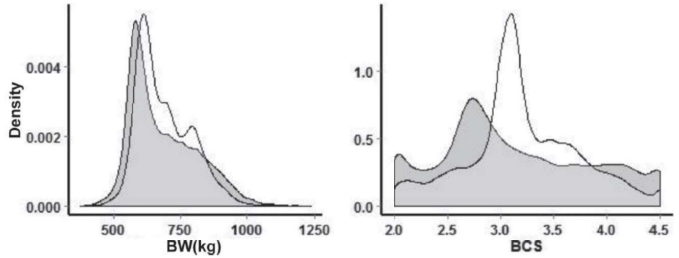
Do cows fed multiple rations get less fat?

727 cow herd including 592 cows in nutritional groups

1 nutritional group = 1 ration
3 nutritional groups = 3 rations



Kalantari et al. J Dairy Sci. 99:1672 (2016)

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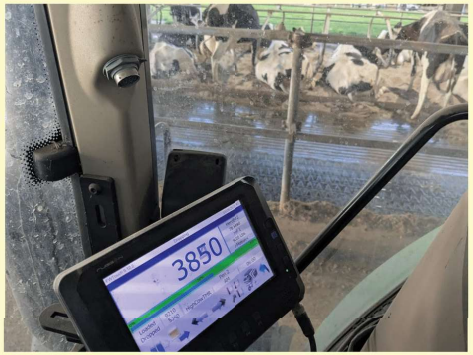
Economic benefits of nutritional grouping



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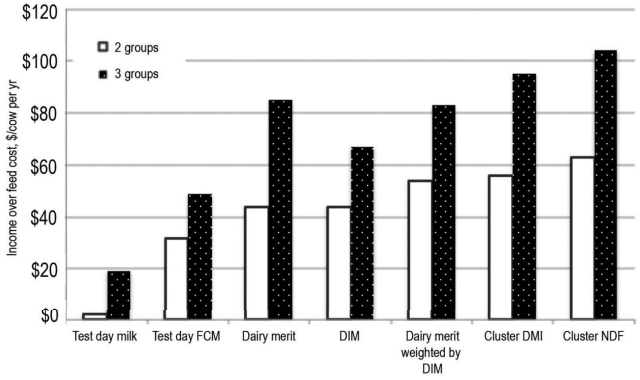
Increase in IOFC due to the optimal grouping criteria for a herd producing 10,000 kg/cow per year. 2 or 3 groups.

Adapted from Williams and Oltenacu (1992) by Cabrera and Kalantari (2016)

Grouping

Dairy merit = 100 × 4% Fat Corrected Milk / metabolic Body Weight

Cluster = simultaneous requirements of protein and energy



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Summary of economics of feeding multiple diets

IOFC\cow\year, results in 2025 dollars

Study	Type	Grouping	IOFC\cow\year difference, #diets		
			3 vs 1	3 vs 2	2 vs 1
Smith+ 1978	Field	DIM			$152
Williams+ 1992	Simulation	Cluster		$71	
St-Pierre+ 1999	Simulation	Cluster	$149	$64	$85
Earleywine 2001	Simulation	DIM	$80		$69
Cabrera+ 2014	Simulation	NEL	$63	$34	$29
Kalantari+ 2016	Simulation	Cluster	$62	$11	$52
Wu+ 2019	Simulation	OptiGroup	$89	$29	$60

Adapted from: Cabrera & Kalantari (2016) + Wu et al. (2019)

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Feeding lower nutrient dense rations

"Cows respond by producing less milk"

"Cows compensate by eating more"

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Are producers feeding multiple rations?

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Survey: *Reasons* for feeding groups of lactating cows

	Wisconsin	Michigan	Michigan
Herd size	≥200	≥200	<200
N	196	59	152
Fresh vs. all other lactating cows	4.5	4.5	3.4
Stage of lactation for nonfresh cows	3.4	4.1	3.5
Milk production level	3.3	3.9	3.7
Health issues	3.2	3.4	3.1
Parity (lactation number)	3.1	3.5	3.1
Body condition score	3.1	3.1	3.5
Reproductive status	2.9	3.2	3.1
I don't feed different diets due to constraints	2.0	1.8	2.6
I don't believe that more than one diet is needed	1.8	1.6	2.3

5 = strongly agree, 1 = strongly disagree

Contreras-Govea et al. (2015). J. Dairy Sci. 98:1336

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Survey: *Constraints* to feeding groups of lactating cows

	Wisconsin	Michigan	Michigan
Herd size	≥200	≥200	<200
N	196	59	152
Desire to keep it simple	3.2	3.0	3.8
Milk drops when cows are moved to different groups	3.4	3.2	3.1
Current farm facilities do not allow it	2.4	2.5	3.9
Conflicts with grouping for reproductive purposes	2.8	2.6	2.9
Not enough labor or personnel to handle it	2.2	2.3	3.3
I don't believe more than 1 feeding group is needed	2.3	2.0	2.8
Nutritionist does not want to	2.3	2.1	2.5

5 = strongly agree, 1 = strongly disagree

Contreras-Govea et al. (2015). J. Dairy Sci. 98:1336

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TMR mixer cost

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Cost of Loading, Mixing, & Delivering Feed New York State, 2014-2015

Jason Karszes
Ashley Howlett

26 farms
Average 1199 mature cows

www.usinflationcalculator.com
$1.00 in 2014 =
$1.34 in 2025

http://publications.dyson.cornell.edu/outreach/extensionpdf/2016/Cornell-Dyson-eb1610.pdf

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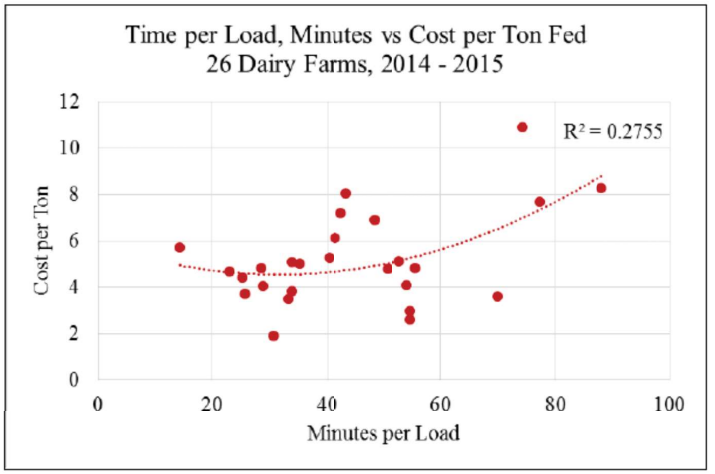

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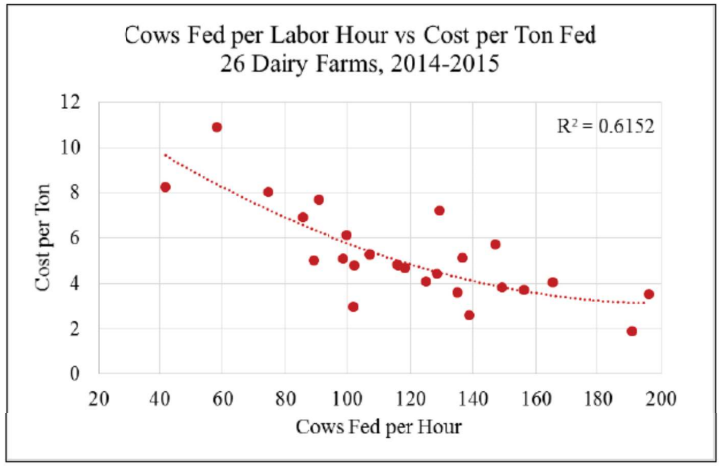

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Feed Delivery Summary Statistics
26 Farms, Each Row Sorted Independently
2014-2015

	Average	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Tons Fed per Labor Hour	8.30	4.60	7.30	8.97	12.84
Loads per Labor Hour	1.31	0.77	1.08	1.37	2.07
Cows Fed per Labor Hour	119.09	76.90	107.19	130.12	167.37
Total Cost Per Labor Hour	$37.81	$28.95	$35.39	$39.55	$48.53
Fuel per Load, Gallons	2.89	1.63	2.21	2.86	5.07
Fuel per Ton, Gallons	0.45	0.27	0.35	0.43	0.77
Average Load Size, Tons	6.99	3.75	5.48	7.80	11.34
% Of Mixer Capacity	65.34%	50.36%	59.43%	68.49%	85.05%
Cost per Worker Equivalent	$44,623	$37,297	$41,329	$45,340	$55,626
Calculated Length of Feeding, 1 Person, Hours	10.2	4.6	8.3	11.0	17.9
Time per Load, Minutes	45	25	36	49	70
Cost per Gallon, Fuel	$2.06	$2.00	$2.00	$2.05	$2.19
Loader Size, Average, Yards	*3.77*	*1.93*	*3.39*	*4.44*	*5.50*
Investment per Ton Fed	$9.75	$4.57	$8.19	$11.01	$15.88
Truck/Tractor & Mixer	$5.35	$2.75	$4.26	$6.12	$8.56
Loader	$4.40	$1.82	$3.93	$4.89	$7.32

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Total Cost per Ton: Loading, Mixing & Delivering TMR
26 Farms, Each Row Sorted Independently
2014-2015

	Average	Percent of Total	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Tons Fed per Day	88.38	-	34.20	49.67	84.95	142.15
Labor	$2.34	44%	$1.23	$1.80	$2.36	$4.16
Fuel & Utilities	$0.99	19%	$0.54	$0.72	$0.95	$1.83
Repairs	$0.57	11%	$0.29	$0.42	$0.66	$0.93
Total Operating Expense	$3.90	74%	$2.27	$2.99	$4.04	$6.55
Depreciation	$0.81	16%	$0.40	$0.66	$0.87	$1.37
Interest	$0.44	9%	$0.22	$0.40	$0.50	$0.67
Insurance	$0.04	1%	$0.00	$0.02	$0.04	$0.12
Total Ownership Expense	$1.30	26%	$0.65	$1.13	$1.45	$2.04
Total Cost, Loading, Mixing & Delivering Feed, per Ton	$5.20	100%	$3.15	$4.48	$5.31	$8.16

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Operating cost of mixer per hour

- Cornell study:
  - Deliver 8.30 TMR tons per hour
  - $5.20 per ton TMR delivered
  - Operating cost $5.20 x 8.30 = $43 per hour (2014)
  - Operating cost $43 x 1.34 = $58 per hour (2025)

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- Tractor
- Mixer
- Front-wheel loader

HOARD'S DAIRYMAN

NEWS BJZZ E-SOURCES IN HOARD'S BLOGS YOUTH BOOKSTORE

NUTRITION May 25 2020 08:00 AM

21 Total Shares

Are you mixing feed in the right spot?

Location can have a big impact on how well a TMR mixer can do its job.

BY MARTIN J. CARRASQUILLO-MANGUAL

- Operating cost $85 to $100 per hour

https://hoards.com/article-27862-are-you-mixing-feed-in-the-right-spot.html

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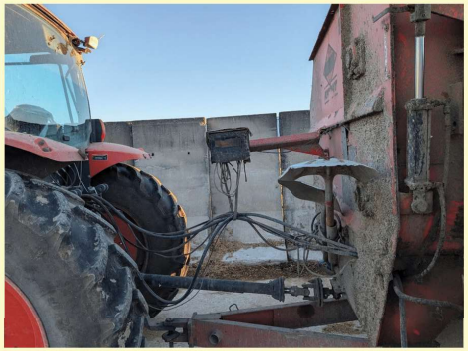
Mixing errors



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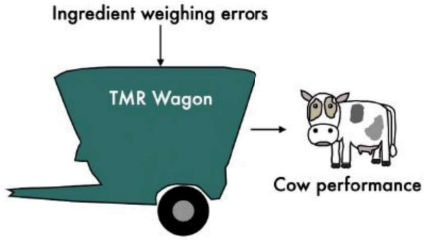
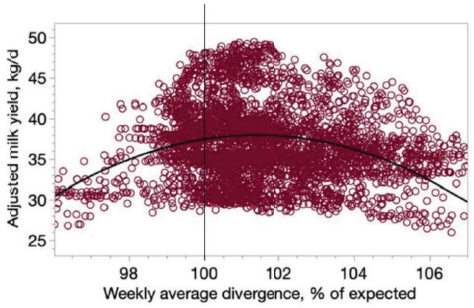
Mixing errors reduce milk production





19,000 cows, 92 pens, 21 farms in Spain

Every mixing load of TMR + daily milk yield every cow

Bach 2024. https://doi.org/10.3168/jdsc.2023-0423

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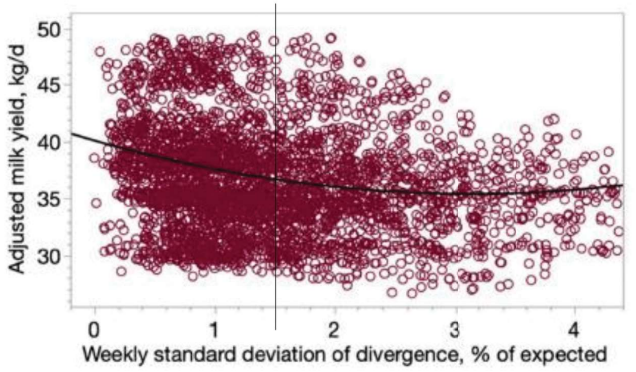
Mixing errors reduce milk production



Average daily divergence, %·pen/d	
Nongrain silages	98.5
Grain silages	101.8
Hays	102.3
Straw	99.4
Grains	101.2
Protein sources	101.8
Molasses	97.0
Minerals	96.9

Average 1.52 standard deviations

Bach 2024. https://doi.org/10.3168/jdsc.2023-0423

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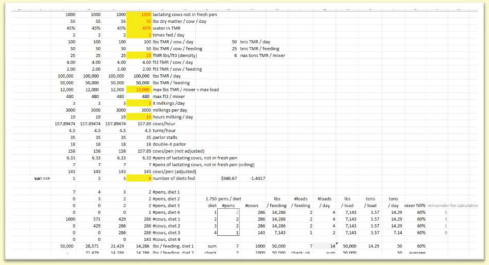
Group feeding economics-milking the feed margin

Dr. Albert DeVries | University of Florida | devries@ufl.edu

Effect of nutritional grouping on mixer cost and errors



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What-if-analysis

- Only post-fresh lactating cows
- Vary #rations from 1 to 4
- Assumptions:
  - Same number of cows in each pen
  - Rations distributed (approximately) equally across pens
  - TMR mixer load equally distributed across pens
- Spreadsheet available

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Analysis 1000 cows

- 1000 cows, 7 pens, 143 cows/pen
- 55 lbs dry matter/cow/day, fed 2x/day
- 12,000 lbs maximum TMR mixer load, 40 minutes to deliver one load

Number of rations fed	1	2	3	4
#Loads/day	10	10	12	14
Hours to mix and deliver TMR/day	6.67	6.67	8.00	9.33
lbs TMR/hour of feeding	15,000	15,000	12,500	10,714
Cost to deliver TMR/day	$667	$667	$800	$933
Extra cost to deliver TMR/cow/year	$0	$0	$49	$97
Average TMR mixer fill	83%	83%	69%	60%
Decrease in IOFC/cow/year	$0	$0	$42	$67
Increase in cost/cow/year	$0	$0	$90	$164

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Analysis 3000 cows

- 3000 cows, 7 pens, 429 cows/pen
- 55 lbs dry matter/cow/day, fed 2x/day
- 12,000 lbs maximum TMR mixer load, 40 minutes to deliver one load

Number of rations fed	1	2	3	4
#Loads/day	26	28	28	28
Hours to mix and deliver TMR/day	17.33	18.67	18.67	18.67
lbs TMR/hour of feeding	17,308	16,071	16,071	16,071
Cost to deliver TMR/day	$1,733	$1,867	$1,867	$1,867
Extra cost to deliver TMR/cow/year	$0	$16	$16	$16
Average TMR mixer fill	96%	89%	89%	89%
Decrease in IOFC/cow/year	$0	$19	$19	$19
Increase in cost/cow/year	$0	$36	$36	$36

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Group feeding economics-milking the feed margin

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Other cost of feeding multiple rations

- Feed wrong ration to wrong group?
- Make multiple prebatches?
- Nutritionist charges?
- Moving cows due to ration changes?

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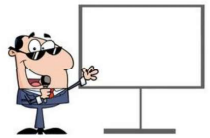
Summary. Nutritional grouping:

1. Increases feed margin (milk income over feed cost)
2. May increase cost of TMR delivery and feeding errors
3. Increased cost may be greater than increased feed margin

Thank you

devries@ufl.edu



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