Northern New York Agricultural Development Program
2013 FINAL REPORT

Economical Substitutes in Northern New York for Corn Grain in Dairy Cow Diets

Project Leader(s):
Rick Grant, Kurt Cotanch, and Katie Ballard
William H. Miner Agricultural Research Institute
1034 Miner Farm Road
Chazy, NY 12921

Contact information for Rick Grant:
Phone: 518-846-7121 x116
Fax: 518-846-8445
Email: grant@whminer.com

Collaborators:
Regional agri-business and feed industry personnel accessed via Northeast Ag and Feed Alliance membership

Background:

High Corn Prices. Since 2007 the price of corn grain in the US has been higher than at any time during the previous 30 years. Forecasts are for the corn price to remain between approximately $4.00 and $7.00 per bushel in the future. Although corn and other feed prices will continue to fluctuate, dairy rations are now being formulated in a new era of substantially higher feed prices.

Feeding Low Starch Diets – Do They Work? Higher corn prices are driving a trend toward lower starch content of dairy rations. Cornell University published results of a field survey in 2007 showing that high-producing dairy herds in the northeastern US and upper Midwest fed rations that ranged between 21 and 30% starch. Clearly, high milk production can be obtained with either lower or higher dietary starch as long as the ration is properly formulated. We know that dairy cows and rumen microbes do not have an actual starch requirement. Rather, the rumen microbes require adequate fermentable carbohydrates (starch, sugars, soluble fiber, and digestible fiber) to provide energy for microbial protein synthesis and milk production. Research conducted during the past five years at Miner Institute and elsewhere demonstrates that diets ranging from 18 to 26% starch can be successfully fed to dry cows, fresh cows, and early to mid- lactation cows without compromising any aspect of performance. In fact, lower starch diets (18 to 21%) actually enhance performance of fresh cows.

The Key to Making Lower Starch Diets Work. With high corn prices, we try to feed more forage and less grain. This approach only works if there is a consistent supply of high quality forage – a major constraint on many regional farms due to weather and management challenges. If forage quality is not high quality, then feeding high-forage diets will limit energy available to the cow, feed intake and milk production will suffer, feed efficiency will be reduced, and the real cost of production rises. So, on many farms we end up feeding more grain and less forage, but now the strategy turns to greater use of nonforage sources of fiber (NFFS; "byproducts") that contain fermentable carbohydrates (such as sugars, pectin, digestible NDF) that can replace expensive corn starch.

Replacing corn with NFFS that have optimal carbohydrate fermentability is the key to successfully feeding lower starch diets. Any starch remaining in the diet – from either corn silage or corn grain - must be processed for maximal digestion by the cow. Then, we must complement that starch with the appropriate amount of other fermentable carbohydrates from various NFFS byproducts. Research conducted during the past three years at University of Wisconsin indicates that byproducts that do not contain much fermentable carbohydrates (such as whole cottonseed) cannot effectively replace corn starch in the diet – milk production and feed efficiency drop. But NFFS such as soybean hulls, beet pulp, and wheat midds work well because they do contain sufficient fermentable carbohydrates like sugar, pectin, soluble fiber, and digestible NDF.

A new laboratory technique has been developed (called Fermentrics and conducted by Dairyland Lab in Arcadia, Wisconsin) that characterizes feed carbohydrate fermentability, feed digestibility, rumen digestion efficiency, and predicts rumen microbial protein production. These data will be critical for choosing the appropriate NFFS and other byproducts and for properly formulating the reduced-corn ration. To-date no comprehensive analysis of byproducts that can replace corn grain has been done using this new approach.

A Low-Starch Strategy for the Northern New York Dairy Industry. In Northern New York we may be able to take advantage of regional opportunities for purchasing good buys on NFFS. Even though we are a long way from the Midwestern US and other locations where many NFFS are produced, the North Country has under-appreciated opportunities due to the Saint Lawrence Seaway, proximity to the Canadian border, and other unique transportation and geographical factors. One important factor is our close proximity to substantial corn acreage in Quebec that requires little shipping cost versus many other regions of the country. Distillers grains, wet brewers grains, and malt sprouts produced in Quebec and gluten feed in Ontario are all competitively priced in Northern New York. Large storage facilities on the St. Lawrence River have provided storage and availability of citrus pulp and whole cottonseed. In addition to river shipping, occasionally rail cars and truckloads may be purchased. Bakery byproducts from New England are also potentially economical.

The Bottom Line. A comprehensive survey and inventorying of the availability of byproducts in this region have not been done, but the prevailing cost of corn makes it imperative that we do so now. We need to know the most likely NFFS byproducts that will be used in various regions of Northern New York and the nutrient profiles and carbohydrate fermentability of these products.

Methods:
Using the membership data base of the Northeast Ag and Feed Alliance, we identified nutritionists and feed industry personnel who feed dairy cows within the 6 counties in Northern NY. A survey was developed and phone interviews conducted with the personnel identified as feeding cows in Northern New York (n = 14 people). Primary questions for this phone survey were: 1) approximately how many cows do you feed, by county, in the 6-county region, 2) how have your recommendations for ration corn grain and starch content changed over the last five years, 3) what NFFS byproducts do you currently use, 4) where are these NFFS sourced, and 5) are some NFFS byproducts especially good buys in regions of Northern New York?

We collected representative samples of each NFFS byproduct that reflected the expected variation in nutrient composition for each feed. Collection of samples by industry personnel was coordinated through Miner Institute.

Samples were sent to Dairyland Labs (Arcadia, WI) for complete Fermentrics analysis that included: digestion rates for slow- and fast-fermenting carbohydrates, rumen digestion efficiency, feed digestibility, and microbial protein production. These data will be useful for proper formulation of lower starch diets and prediction of intake and milk production response. We have found good agreement between the Fermentrics analysis and actual measured cow response to diet in previous research studies conducted at Miner Institute that evaluated sources of dietary carbohydrate (forage NDF versus non-forage NDF and starch level).

The compositional data were summarized and used to create a data base that can be shared with all segments of the dairy industry in Northern New York. Use of this information will allow dairy farmers to consistently feed lower starch diets using the most economical and nutritionally effective feed replacements for corn grain.

Results:
Based on the phone interviews of the regional nutritionists, the following byproduct feeds were selected as being most commonly available feeds in Northern New York: snaplage, soybean hulls, wheat midds, red dog, citrus pulp, beet pulp, distillers grain plus solubles, corn gluten feed, whole cottonseed, and dried whey. Snaplage was chosen for inclusion because of the current interest in it as an alternative to high-moisture shelled corn or corn silage. Additionally, we also analyzed canola meal and soybean meal, steam flaked corn, and corn meal (as the standard feed component). A summary of the phone survey results is summarized in Table 1.

Fermentrics is a new laboratory method that uses a batch-culture, rumen-fluid, gas-fermentation system combined with mathematical curve-peeling techniques allowing for the differentiation of rapid and slowly fermenting carbohydrate pools in individual feedstuffs or TMR samples. The rate and extent of organic matter degradation can be determined by monitoring gas produced during fermentation. This allows for a direct approach to determining carbohydrate pools (B_1, B_2, B_3) and digestion rates to accurately populate feed libraries in ration-balancing software such as the Cornell Net Carbohydrate Protein System.

Table 2 summarizes the protein fractions of the feed samples. As expected, there is a considerable range in protein content among the byproducts, but they are all low in ADFIP and NDFIP which indicates that none of these feeds suffers from unavailable protein. The soluble protein measured using buffers in the lab, or with in vitro microbial digestion, shows a wide range. This range in protein and microbial-soluble protein can be easily accommodated during ration formulation as long as accurate values exist to enter into the ration balancing software – which this report provides.

Table 3 summarizes the carbohydrate composition of these same byproduct feeds. Compared with corn, there is considerable variation in fiber, starch, and sugar content among the feeds. Some byproducts such as soybean hulls are very high in NDF while others such as wheat midds and red dog contain considerable starch. Citrus and beet pulp are higher in sugars than the other byproducts. Ether extract is variable, but generally low for these feeds except for whole cottonseed and distillers grains (which may be variable depending on source).

Table 4 provides the organic matter digestibility for these same feeds and they all compare favorably to corn grain except for soybean hulls which are substantially lower. This reflects the high NDF content of the soybean hulls; it is important to note that many dairy feeding studies have found that soybean hulls, despite their high fiber content, are a good source of fermentable carbohydrates and energy to the dairy cow. The predicted energy content of these feeds generally tracks with the organic matter digestibility.

Table 5 provides the macromineral content of the feeds for use in ration formulation when replacing corn with these byproducts.

Table 6 shows the microbial biomass production for each feed and the ranking relative to corn meal. Microbial biomass production (MBP) is measured directly by analyzing the substrate that remains after 48 hours of incubation with a NDF analysis (w/o amylase or sodium sulfite). The difference between the weight of the substrate before and after NDF analysis is the microbial biomass. *Higher MBP is the "gold standard Fermentrics parameter" associated with higher milk production*.

Table 6 also summarizes the rates of carbohydrate B1 and B3 fermentation. Carbohydrate pool specific digestion rates are the calculated maximum rates of degradation per hour for the B1 and B3 carbohydrate pools as defined by models like CNCPS or CPM. It should be recognized that strict definitions of B-pool constituents (e.g. B1 is only starch) cannot be adhered to with this type of analytical tool given the heterogeneous nature of nutrients which can exist in both the fast and slow pools. However, Fermentrics B-pool rate estimates do allow nutritionists more realistic values than "book values" contained in feed libraries or NDF digestion rates calculated from NDF, lignin and single time-point NDF digestibility assays.

These rates may be inputted into nutrition models to provide more accurate formulations when replacing corn with byproduct feeds.

Conclusions/Outcomes/Impacts:
This study provides a set of compositional information for the byproducts commonly available in Northern New York that are used to replace dietary corn grain. This information can be inputted into ration formulation software based on models such as CNCPS that require rates of carbohydrate digestion. Also, the relative ranking of the various feeds may be used to decide which feeds do the best job of replacing corn meal on a starch basis or on a microbial production basis. Because byproduct feeds are inherently variable in nutrient composition, additional feed sampling and analyses may result in greater accuracy of compositional values for ration formulation.

The bottom line is that this information provides an initial data base that allows for more accurate ration formulation using corn substitutes which will result in rations that elicit better cow productivity.

Outreach:
Outcomes of this study will be shared with the 6-county dairy industry by: 1) a series of on-farm meetings developed collaboratively between Miner Institute and Cornell Cooperative Extension (envision 4 meetings: Watertown, Canton, Malone, and Plattsburgh regions to occur in 2014); 2) results will be summarized and reported in regional Extension newsletters and the Miner Farm Report; and 3) the information will also be made available on the Miner Institute web site.

Person to contact for more information:
Rick Grant
William H. Miner Agricultural Research Institute
1034 Miner Farm Road
Chazy, NY 12921
grant@whminer.com
518-846-7121

<u>Table 1. Summary of responses to nutritionist phone survey</u>.

- **Approximate number of dairy cows fed by county:**

Essex	300
Clinton	6,000
Franklin	3,500
St. Lawrence	8,500
Lewis	6,500
Jefferson	8,000

- **How have your recommendations for ration starch changed during past 5 years?**

	(% of respondents)
Typical ration starch % has decreased 2 to 4%-units	100
Do I keep a minimum % starch in ration?	100
▪ 22% or more	42
▪ 20-22%	50
▪ Less than 20%	8
Feed byproducts in place of corn if economical	100
Feed higher forage diets	100
▪ 5-10% more forage	64
▪ 10-20% more forage	29
▪ More than 20% more forage	7

- **What byproducts do you currently use most frequently?**

	(% of respondents)
Soybean hulls	100
Distillers grains/solubles	100
Wheat midds	78
Beet pulp	71
Citrus pulp	50
Corn gluten feed	64
Red dog	29
Whole cottonseed	93
Dried whey	29

- **What byproducts can be "good buys" for Northern New York?**

	(% of respondents)
Distillers grains	100
Wet brewers grains	21
Malt sprouts	8
Corn gluten feed	50
Citrus pulp	71
Whole cottonseed	100
Bakery byproducts	29

Table 2. Protein fractions measured using Fermentrics analysis.

Feed	DM, %	CP, % of DM	ADFIP, % of DM	NDFIP, % of DM	Soluble protein, % of CP	SP Bacterial % of CP[1]
Corn meal	85.9	8.5	0.5	1.4	23.4	27.7
Corn steam-flaked	84.8	7.4	0.5	1.2	22.9	28.9
Snaplage	64.8	7.6	0.2	1.2	34.1	60.0
Soybean hulls	91.9	9.5	1.0	3.9	24.6	23.1
Wheat midds	87.1	18.4	0.7	3.4	40.6	38.8
Red dog	88.3	18.7	0.5	1.6	42.2	48.0
Citrus pulp	89.0	7.7	0.9	2.2	39.8	37.7
Beet pulp	88.1	9.0	1.5	5.2	15.4	21.2
Corn gluten feed	87.3	23.9	0.9	3.8	51.4	50.0
Distillers grains+sol	88.3	32.5	5.5		16.6	20.0
Soybean meal	89.6	51.7	0.6	1.1	20.2	29.1
Canola meal	89.3	42.9	2.7	4.2	25.5	28.0
Cottonseed, whole	91.8	19.8	1.7	1.8	35.7	39.5
Whey, dried	95.3	4.5	---	---	91.4	100.0

[1]Soluble protein by microbial analysis is the amount of crude protein degraded in 3 hours of sample incubation divided by the total crude protein of the sample.

Table 3. Carbohydrate, lignin and ether extract composition measured using Fermentrics.

Feed	Lignin %	ADF, % of DM	NDF, % of DM	EE, % of DM	Sugar, % of DM	Starch % of DM
Corn meal	1.0	2.9	9.7	3.7	3.6	65.9
Corn steam-flaked	1.0	2.7	7.6	2.4	2.5	70.7
Snaplage	1.5	10.5	22.8	3.3	2.2	52.8
Soybean hulls	1.5	53.2	73.1	0.9	6.3	0.6
Wheat midds	3.9	13.4	42.1	4.9	9.3	17.6
Red dog	2.3	8.9	27.4	3.8	7.9	36.1
Citrus pulp	<0.1	18.5	22.4	2.5	19.5	1.0
Beet pulp	2.7	27.7	41.9	1.8	15.9	0.7
Corn gluten feed	1.7	12.2	40.0	4.7	6.5	12.2
Distillers grains+sol	4.5	13.9	26.8	12.5	5.7	2.1
Soybean meal	0.7	7.2	10.7	1.5	17.4	1.9
Canola meal	8.1	19.6	26.6	3.6	12.0	1.1
Cottonseed, whole	8.9	33.8	41.3	19.4	8.1	0.3
Whey, dried	---	---	---	0.9	96.1	0.2

Table 4. Digestibility and energy content determined using Fermentrics.

Feed	aOMD, % of DM	TDN, % of DM	NEL, Mcal/lb	NEM, Mcal/lb	NEG Mcal/lb
Corn meal	61.9	87.1	0.91	0.95	0.65
Corn steam-flaked	72.2	86.5	0.91	0.94	0.64
Snaplage	55.1	82.1	0.86	0.88	0.59
Soybean hulls	37.7	63.9	0.66	0.58	0.33
Wheat midds	59.1	71.7	0.74	0.75	0.48
Red dog	67.9	78.5	0.82	0.88	0.58
Citrus pulp	63.6	79.0	0.82	0.82	0.53
Beet pulp	64.8	68.4	0.70	0.64	0.37
Corn gluten feed	79.2	76.2	0.79	0.83	0.55
Distillers grains+sol	60.7	82.9	0.88	0.95	0.65
Soybean meal	72.2	80.5	0.84	1.06	0.74
Canola meal	70.3	69.0	0.71	0.80	0.52
Cottonseed, whole	29.9	83.4	0.87	0.93	0.63
Whey, dried	100.0	---	---	---	---

Table 5. Macromineral content measured using Fermentrics.

Feed	Ash, % of DM	Ca, % of DM	P, % of DM	K, % of DM	Mg % of DM
Corn meal	1.53	0.02	0.33	0.42	0.14
Corn steam-flaked	1.20	0.02	0.25	0.34	0.10
Snaplage	1.76	0.05	0.27	0.49	0.13
Soybean hulls	4.80	0.57	0.11	1.29	0.23
Wheat midds	5.90	0.13	1.28	1.27	0.58
Red dog	3.70	0.12	0.75	0.84	0.28
Citrus pulp	7.39	2.00	0.10	1.05	0.14
Beet pulp	6.41	1.27	0.08	0.30	0.25
Corn gluten feed	5.58	0.04	0.99	1.46	0.47
Distillers grains+sol	5.24	0.05	0.92	1.21	0.35
Soybean meal	7.05	0.31	0.69	2.14	0.29
Canola meal	7.42	0.69	1.14	1.36	0.61
Cottonseed, whole	4.22	0.20	0.71	1.15	0.42
Whey, dried	9.30	0.68	0.83	2.32	0.10

Table 6. Microbial biomass production (MBP), rate of starch and rate of NDF digestion measured using Fermentrics with ranking relative to MBP and starch content.

Feed	MBP mg/g	Relative MBP Ranking	B1 Rate of Digestion %/hour	B3 Rate of Digestion %/hour	Relative Starch Ranking
Corn meal	247	1.00	16.2	4.37	1.00
Corn steam-flaked	221	0.89	13.7	5.85	1.07
Snaplage	201	0.81	8.57	4.33	0.81
Soybean hulls	93	0.37	16.5	4.62	0.01
Wheat midds	120	0.49	24.2	2.30	0.27
Red dog	165	0.67	7.8	3.40	0.55
Citrus pulp	165	0.67	20.1	2.76	0.67
Beet pulp	147	0.60	6.6	3.34	0.60
Corn gluten feed	102	0.41	13.1	4.20	0.41
Distillers grains+sol	180	0.73	13.0	4.53	0.03
Soybean meal	187	0.76	9.0	4.62	0.03
Canola meal	145	0.59	11.1	5.07	0.02
Cottonseed, whole	91	0.37	8.1	5.16	0.00
Whey, dried	---	---	0.0	10.41	4.78