Grass vs. Legume Forages for Dairy Cattle

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Alfalfa is the primary forage fed to lactating dairy cows; however, there is renewed interest in utilizing grass forages in lactating dairy cow diets particularly because of farm nutrient management issues. Yield and perceived quality is generally lower for grass species compared to legumes while other agronomic factors (e.g., longer stand life, requirement for nitrogen fertilizer and more tolerance of manure spreading, allows for greater and more frequent manure application than on alfalfa) may make grasses more desirable. Grasses may also complement diets with high levels of co-products from the ethanol and food industries better than legumes because grasses are generally moderate to low in crude protein (CP) compared to alfalfa and most co-products contain a significant amount of CP.

The purpose of this article is to review some results and limitations of previous lactation studies that have compared the feeding value of grass and legume forages and provide information on nutritional and cell wall differences between grasses and legumes in order to better understand the utilization of these forages by dairy cows.

HOW DO DAIRY COWS PERFORM WHEN FED GRASS VS. LEGUME DIETS?

As shown in Table 1, comparing legumes to grasses in lactation studies is confounded by the neutral detergent fiber (NDF) differences between the two species. Grasses generally contain more NDF (Table 2) and, therefore, when diets are formulated to contain an equal amount of forage DM, the total dietary NDF concentration will be higher for diets containing grasses compared to legumes. Increasing dietary NDF concentration most often has a negative impact on the amount of DM consumed by lactating dairy cows (Allen, 2000) which generally translates into reduced milk production. The studies reported in Table 1 all had the grass forage higher in NDF compared to the alfalfa fed within the study, but DM intake of cows and milk production was not always compromised by a higher NDF content in the forage. Jung and Allen (1995) reported the impact of NDF concentration on rumen fill is not always consistent, as it is also influenced by the chemical composition and digestibility of the NDF fraction and particle size.

Table 1. *Lactation studies comparing legume and grass forages.*

Reference	Forage Source[1]	Forage: Concentrate	Forage NDF %DM	Diet NDF %DM	DMI lb/day	3.5% FCM lb/day
Broderick et al., 2002	A	51:49	43.5	27.8	55.4[a]	83.6[a]
	PR	40:60	49.5	27.7	37.0[b]	68.9[b]
Cherney et al., 2004	A	62:38	40.6	27.0	56.2	90.2[a]
	O[2]	54:46	51.3	27.9	59.5	83.1[ab]
	O[3]	51:49	49.2	32.3	49.2	76.9[b]
	F[2]	59:41	45.0	28.8	59.1	91.9[a]
	F[3]	48:52	55.1	32.0	50.0	86.4[ab]
Hansen et al., 1991	A	60:40	49.6	38.5	44.9	59.5
	A	50:50	49.6	32.1	44.5	65.6
	A	40:60	49.6	25.7	45.8	68.3
	B	60:40	63.6	47.2	46.1	65.0
	B	50:50	63.6	39.2	45.4	68.6
	B	40:60	63.6	31.1	45.6	69.0
Hoffman et al., 1998	A	70:30	43.8	35.7	49.5[a]	71.4[a]
	PR	68:32	46.8	37.1	44.7[b]	69.4[b]
Weiss, 1995	A	59:41	44.7	38.6	46.7	62.5
	O	59:41	51.1	41.4	43.6	61.2
Weiss and Shockey, 1991	A	60:40	40.1	30.6	49.3	51.7
	A	40:60	40.1	25.6	51.0	52.4
	O	60:40	52.5	39.1	45.1	52.4
	O	40:60	52.5	30.9	48.0	51.3

[1]A-alfalfa, B-brome grass, O-orchardgrass, F-tall fescue, PR-perennial ryegrass
[2,3] Denotes first and second cuttings, respectively
[a,b] - uncommon superscripts within a study differ p< 0.05

The study of Cherney et al. (2004) supports this, as the first- cutting of both orchardgrass and fescue had a significantly higher (20-25% units) NDF digestibility than the first- cutting alfalfa (48% NDF digestibility), but milk production and DM intake were not different between diets containing orchardgrass, fescue or alfalfa. The second-cuttings of orchardgrass and fescue were similar in NDF digestibility to alfalfa. Cows fed diets containing these forages were lower in DM intake and milk production than cows fed the alfalfa diet. Similarly, the study of Weiss and Shockey (1991) reported no difference in milk production or DM intake when comparing orchardgrass with 52% NDF to alfalfa with 40% NDF, but NDF digestibility of the orchardgrass was 75% compared to 49% for the alfalfa. Unfortunately, none of the studies in Table 1 reported a forage particle size.

When diets are formulated to contain similar forage NDF concentrations, less forage and more concentrate is required in grass as compared to legume diets. Unless concentrate inclusion reaches levels that depress rumen function, a lower forage-to-concentrate ratio typically will increase milk production. Therefore, milk production on grass diets should generally equal or exceed milk production on legume diets. This is due to the lowered forage-to-concentrate ratio and generally higher energy (concentrate) intake of the grass containing diet when formulated for equal NDF. The study by Broderick et al. (2002) clearly illustrates how formulating for an equal dietary NDF concentration increases the concentrate amount in grass diets compared to legume diets, but refutes the premise milk production and DM intake increase with increasing concentrate feeding (Table 1). In the study by Cherney et al. (2004), lactation diets containing alfalfa, orchardgrass or tall fescue silage were balanced to provide a similar amount of forage NDF as a percent of body weight (0.95% of BW). This resulted in forage inclusion levels of 62, 54, 51, 59 and 48% for alfalfa, orchardgrass first- and second-cutting and tall fescue first- and second-cutting, respectively. No difference was reported in DM

intake or milk yield for cows fed alfalfa, first-cutting orchardgrass or first-cutting tall fescue silage, but lowered milk production and DM intake were reported for cows fed the second-cutting grass silages. The second-cutting grass diets had the lowest amount of forage in diet DM and yet cows produced the lowest amount of milk. The lactation studies of Hansen et al. (1991) and Weiss and Shockey (1991) directly compared grass and legume forage diets formulated on a forage to concentrate ratio basis, ranging from 40:60 to 60:40 and found no significant differences between treatments in DM intake or milk production due to forage type or amount of concentrate included in the diet.

Based on the studies reported in Table 1, how to formulate grass based diets to optimize lactation performance isn't well understood. In some cases, grass forages result in similar or superior lactation performance to legume forages. In others, performance is considerably depressed when grasses are fed? Such deviations in performance are most likely the result of variation in nutrient content and digestibility as affected by forage maturity, leaf-to-stem ratio and cell wall structure. The following sections will discuss these differences between grass and legume forages.

Table 2. *Nutrient profile summary of legume and grass hays and haylages from Dairyland Laboratories in Arcadia, WI, for 2006 and 2007.*

Nutrient	Legume Hay		Grass Hay	
	Average	SD[1]	Average	SD[1]
CP, %DM	19.8	2.36	10.2	3.11
Protein Solubility, %CP	32.7	4.13	19.6	7.57
ADF, %DM	31.8	3.77	39.1	5.22
NDF %DM	40.4	4.55	58.0	6.58
NDF Digestion, %NDF (48 hour)	44.3	4.83	48.1	7.87
IVTDM Digestion, % (48 hour)	77.8	3.21	69.7	6.98
Lignin , %DM	7.3	0.81	6.5	1.47
Fat, %DM	2.5	0.34	2.6	0.54
Sugar, %DM	8.7	2.22	10.0	3.85
Ash, %DM	10.9	1.28	9.6	2.31
Calcium, %DM	1.48	0.19	0.61	0.26
Phosphorus, %DM	0.29	0.04	0.23	0.06
Potassium, %DM	2.40	0.38	1.86	0.55
RFV	150	22.5	96	16.3
RFQ	150	24.8	100	24.8
	Legume Haylage		Grass Haylage	
CP, %	20.3	2.11	13.8	2.96
Protein Solubility, %CP	52.8	6.58	43.4	11.4
ADF, %	32.0	3.14	34.7	4.24
NDF, %	40.2	3.91	52.1	6.13
NDF Digestion, %NDF (48 hour)	52.6	4.50	53.2	7.32
IVTDM Digestion, % (48 hour)	81.2	3.00	75.7	5.49
Lignin, %	8.1	1.09	5.8	1.54
Fat, %DM	3.3	0.59	4.0	0.77
Sugar, %	5.3	1.29	5.5	1.44
Ash, %DM	11.1	1.61	9.9	2.06
Calcium, %	1.37	0.19	0.65	0.24
Phosphorus, %	0.34	0.04	0.33	0.05
Potassium, %	2.64	0.41	2.64	0.64
RFV	150	20.4	113	18.0
RFQ	173	26.7	126	21.0

[1]*Standard deviation, ± 1 SD from the average accounts for 66% of the analyzed values reported.*

NUTRIENT COMPOSITION

The nutrient composition of grasses and legumes is variable depending on many factors such as species, maturity, fertilization and soil fertility, growing environment and harvesting conditions. The nutrient profile of the legume and grass hay and haylages is from analyses conducted by Dairyland Laboratories on samples submitted in 2006 and 2007 classified as grass or legume species (Table 2). Average values indicate differences and similarities between grass and legume forages, but do not provide a comprehensive description of how grasses and legumes are different or similar in nutrient composition. The standard deviations give an indication of the greater variability in the nutrient content of samples identified as grass forage compared to legumes. The following brief discussion covers some of the similarities and differences in fiber, protein and mineral concentration that generally exist between grass and legume forages when compared at similar stages of maturity.

Fiber. Grasses contain higher concentrations of NDF and acid detergent fiber than legumes (Table 1). Higher fiber concentrations are found in both the leaf and stem fractions of grasses compared to legumes. Buxton and Redfearn (1997) compared forage species at similar maturity and reported leaves of alfalfa and red clover plants (mid-flowering maturity) were approximately 25% NDF and stems were 40-55% NDF. In contrast, the leaves and stems of tall fescue, smooth bromegrass and orchardgrass were approximately 50% and 70% NDF, respectively.

However, the digestibility of NDF at 48 hours as reported by Dairyland Laboratories is very similar between legume and grass forages. Due to the higher fiber content of grasses at similar stages of maturity, forage quality indexes (RFV and RFQ) will always be lower for grasses.

Protein. The CP concentration of legumes is higher than grasses. The majority of CP in fresh legumes or grasses is true protein with approximately 10 -15% as non-protein nitrogen (NPN; primarily peptides, free amino acids and nitrates). The amount of NPN increases, as a percent of the CP, when grasses are heavily fertilized with nitrogen or when either legumes or grasses are fermented (30-65% of CP) (Reid, 1994; NRC, 2001). In both hay and haylage, the solubility of protein tends to be higher in legumes than grasses.

Minerals. Legumes tend to accumulate more total macro- and micro-minerals and ash than grasses. Of the major minerals in forages, legumes contain two to three times the calcium found in grasses, while potassium and phosphorus concentration is only slightly higher or similar to grasses (Table 1). Across all forage species, the major factors that impact forage mineral composition include fertilizer application, stage of growth and environmental conditions (McDowell and Valle, 2000; Jukenvicius and Sabiene, 2007).

High levels of performance have been observed for cows fed either legume or grass forages when included as part of a typical total mixed diet with multiple ingredients. The standard advice to feed high quality (low fiber, high digestibility) forages to lactating dairy cows as part of appropriately balanced mixed diets still prevails. However, the criteria or parameters on which to formulate diets to optimize milk production from grasses is less well understood than it is for alfalfa or corn silages.