and 4.5%; $P<0.01$), and decreased DE intake 20.5% ($P<0.01$). Holsteins had similar digestibility of DM and GE, but had greater DE intake ($P<0.01$) when compared to British steers. Change in DM digestibility was negatively correlated to change in DMI (r = -0.48; $P<0.01$) for LF vs HF within British steers, but not Holsteins ($P=0.42$). There were fiber level × breed interactions for digestibility of NDF and ADF ($P<0.10$). When comparing Holstein to British steers, digestibility of NDF and ADF was 4.1 and 3.4% lower for LF, but was only 1.1 and 0.6% lower for HF, respectively. Results from this trial suggest that high NDF corn silage diets may reduce intake of both British and Holstein steers by physical fill, and this reduction in DMI continues as steers increase in body weight from 240 to 330 kg.

Key Words: Fiber Level, Physical Fill, Male-sterile Corn

ASAS/ADSA Ruminant Nutrition: Fiber

821 Measuring neutral detergent fiber in feeds and forages.

D. R. Mertens*[1] and D. Sauvant[2], [1]*US Dairy Forage Research Center, Madison, WI,* [2]*INRA-Institut National Agronomique, Paris-Grignon.*

Neutral detergent fiber (NDF) is an important characteristic for measuring the nutritive value of feeds and forages. For ruminants, fiber can be defined as the indigestible or slowly-digesting components of feeds that occupy space in the gastrointestinal tract, which indicates that fiber can be determined only by the animal. Measurement of fiber is a compromise between the theoretical concept and the utility of using chemical methods to isolate and measure fractions that closely resemble it. The method used to isolate it, in effect, defines a specific type of fiber; therefore, it follows that fiber methods must be followed exactly to obtain results that are valid and reproducible. The NDF method was originally designed to measure fiber in forages and has acquired the reputation of being variable and difficult to use with other feeds. However, the greatest source of variability in NDF is related to various modifications and alternative procedures. In addition, laboratories sometimes modify fiber methods for convenience or speed without understanding how these changes affect results. Many factors can affect the determination of fiber and it is important to understand the conditions and steps in fiber methods that must be followed closely to obtain accurate results. Among these are: subsampling, drying, grinding and amount of the sample, standardization of reagents, pretreatment with acetone, removal of starch and nitrogen contamination, timing and temperature of refluxing, soaking, washing and transferring of fibrous residues, type of filtration vessel, method of weighing, and correction for ash or protein. Use of heat-stable amylase to remove starches and sulfite or proteases to remove nitrogen have significant impact on NDF determinations. They also affect soluble carbohydrate estimates that are calculated by difference. The amylase-treated NDF (aNDF) method, which uses both amylase and sulfite, solves most of the problems associated with measuring NDF, and with appropriate modifications can be used to measure fiber in protein, starch, pectin and fat-containing materials.

Key Words: Fiber methods, NDF, Feed evaluation

822 Fiber requirements for finishing beef cattle - a commercial feedlot perspective.

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It is generally accepted that dietary fiber is necessary in diets for finishing beef cattle to maximize net energy intake above maintenance and to lessen the risk of metabolic disorders. Fiber functions primarily to assist in maintaining ruminal pH above a critical threshold. Therefore, fiber requirements must be considered in the context of the physical nature of the fiber, fermentability of diet organic matter and meal size and frequency. Finishing diets typically contain only minimal fiber (5 to 15% roughage on a DM basis) and a high concentration of readily fermentable organic matter, which magnifies the importance of feeding management for influencing feed intake patterns to minimize daily fluctuations in ruminal pH. Concepts used to optimize NDF in diets for lactating dairy cows may be useful for refining fiber requirements for feedlot cattle but have not been tested extensively. Progress in this area is hindered by a lack of consensus on appropriate response criteria for assessing fiber status and a paucity of fiber equivalency values for diet formulation. Effects of fiber source, fiber level or organic matter fermentability treatments on rate of gain might be a practical indicator of fiber adequacy under research conditions due to the direct relationship between rate of gain and net energy intake. Because particle size distribution is a major determinant of fiber effectiveness, establishing the critical particle length for fiber in finishing diets and a more complete catalogue of particle size distributions and variation in common diet ingredients would be useful. Economic and operational realities continually provide incentives to minimize fiber in finishing diets; the challenge is to develop procedures that will more precisely determine the minimum level that is compatible with production and economic objectives of specific feeding operations.

Key Words: Feedlot Cattle, Fiber Requirements, Effective Fiber

823 Digestible fiber from forages for lactating cows.

M. S. Allen*, M. Oba, and J. A. Voelker, *Michigan State University, East Lansing.*

Coarse dietary fiber benefits lactating cows through selective retention of digestible organic matter in the rumen, more consistent supply of absorbed fuels within a day, and moderation of ruminal pH. However, energy density of neutral-detergent fiber (NDF) is lower and forage NDF is more filling than other dietary components; diets with high forage NDF can reduce energy intake by mechanisms related to ruminal distention. Forage NDF that is highly digestible is less filling and allows greater energy intake. Distention becomes a dominant mechanism limiting feed intake as milk yield increases, thus response to increased in vitro NDF digestibility is positively related to milk yield of cows. Maximum extent of digestion of forage NDF is negatively related to NDF lignification and is determined by environmental conditions during growth, plant genetics, and maturity at harvest. Digestibility of NDF in vivo is further determined by ruminal retention time and rate of digestion. Rate of NDF digestion is limited by low ruminal pH, high starch diets, and availability of nutrients for microbial growth. Although digestibility of forage NDF measured in vitro or in situ is positively related to feed intake and milk yield within a forage family, grass NDF digests and passes from the rumen more slowly than legume NDF and is therefore more filling despite its generally higher digestibility. Digestibility of NDF measured in vitro or in situ is negatively related to the filling effects of NDF, but is not necessarily an index of energy content. Forages with higher in vitro NDF digestibility allow greater DMI for cows with fed intake limited by physical fill, but reduced ruminal retention time decreases differences in NDF digestibility in vivo. Although DMI and NDF digestibility are positively related, DMI by cows is less limited by distension in the gastrointestinal tract as NDF digestibility increases, and therefore diminishing returns are expected for DMI. This presentation will discuss factors affecting NDF digestibility of forages, measurement and prediction of NDF digestibility, and benefits of highly digestible forage NDF.

Key Words: NDF digestibility, lactating cows, forage

824 Empirical modeling of ruminal pH from dietary NDF and mean particle size.

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Accurate prediction of rumen pH is a challenge in ruminant nutrition. Numerous experiments have studied some aspects of the effects of the chemical and physical characteristics of fiber on ruminal pH. The results of these studies were combined for a meta-analysis of fiber-related factors affecting ruminal pH. Two databases were compiled, the first one consisted of trials where NDF content was the experimental factor and its mean value was <50% DM (35 publications, 46 experiments, 120 treatments; NDF = 32.2 6.2% DM (mean standard deviation or sd). The second database consisted of data from experiments where dietary mean particle size (MPS) was the primary experimental factor (12 publications, 19 experiments, 51 treatments; MPS = 2.59 1.48 mm). Ruminal pH were similar between the two bases (pH = 6.16 0.30, n = 120 and pH = 6.25 0.32, n = 51). A GLM model of variance-covariance was used for statistical analysis that allowed relationships

across (global) and within (local) experiments to be investigated. Variance analysis was between experiments, and covariates were either NDF content or MPS. The interactions between experiments (E) and covariates were also tested (either E*NDF or E*MPS). For the NDF database, the interactions between experiments and NDF were significant (pH = 5.25 + 0.028 NDF + E*NDF, n = 120, R2 = 0.98, rsd = 0.09). The response of pH to dietary NDF was greater when the experimental mean ruminal pH was low than when experimental pH was high. For instance, dpH/dNDF = 0.037 when mean pH = 5.8 and = 0.018 when mean pH = 6.5. There were also significant interactions between experiments and MPS (pH = 5.67 + 0.24 MPS + E*MPS, n = 51, R2 = 0.98, rsd = 0.07). The pH response to MPS variation was more pronounced in experiments when mean pH was low. For instance, dpH/dMPS = 1.14 when mean pH = 5.8 and = 0.21 when mean pH = 6.5. These analyses indicate that both NDF and MPS influence ruminal pH and that the sensitivity of rumen pH to these two factors is greater when rumen pH is less that 6.0.

Key Words: Rumen, pH, Fiber

825 Effect of different particle size distribution of oat silage on feeding behavior and productive performance of dairy cattle. C. Leonardi*, L.E. Armentano, and K.J. Shinners, *University of Wisconsin-Madison*.

Twenty lactating Holstein cows (5 primiparous and 15 multiparous) were used in an incomplete Latin Square, with five treatments and three periods of 21 days each. Diets contained 25% corn silage, 25% oat silage and 50% grain mix (DM basis). The five treatments tested in the experiment were: Long Oat Silage (LOS), Medium Oat Silage (MOS), Fine from Long Oat Silage (FLOS), Fine from Medium Oat Silage (FMOS), and Half LOS plus half FLOS (LFLOS). LOS and MOS silages were obtained directly in the field (2 vs. 8 knifes on the harvester). FLOS and FMOS were obtained by chopping LOS and MOS just prior to feeding. The mean particle size (MPS) of the diets was 4.35, 4.46, 5.19, 5.39, and 6.68 mm for FMOS, FLOS, MOS, LFLOS, and LOS respectively. MOS was designed to provide similar MPS of LFLOS, but narrower particle size distribution. Sorting is expressed as (MPS of the intake/ MPS of the diet) x100. Treatments were tested for linear and quadratic response, utilizing the MPS of the intake to calculate the contrast coefficients. No quadratic response was observed. The primary effect was a linear decrease of DMI, milk yield, and milk protein yield with longer oat silage. Feeding longer particle size increased time spent eating, ruminating and chewing per kg of DMI. Increasing particle size increased sorting. LFLOS was similar to MOS with the possible exception of eating time.

	Trt[1]							Contrast	
	FMOS	FLOS	MOS	LFLOS	LOS	SEM	L[2]	1vs2	3vs4
	1	2	3	4	5				
DMI, kg/d	22.1	22.0	21.7	21.1	20.4	.5	<.01	.92	.30
Milk yield, kg/d	39.4	40.3	39.0	39.1	38.2	.9	<.01	.20	.87
Protein, g/d	1075	1095	1059	1060	1026	26	<.01	.36	.98
Fat, g/d	1305	1340	1312	1257	1283	41	.18	.39	.15
Eating, min/kd DMI	10.5	11.1	11.4	12.8	13.4	.7	<.01	.53	.11
Ruminating, min/kg DMI	25.1	24.5	25.6	26.2	28.0	.9	<.01	.51	.46
Chewing, min/kg DMI	35.4	35.7	37.1	39.3	41.5	1.2	<.01	.81	.13
Intake MPS/ diet MPS, %	99.4	98.4	97.3	96.1	93.5	var[3]	<.01	<.01	.54

[1]T= Treatments.[2]L= Linear; [3]var=variance. Treatments presented unequal variance. In the statistical analysis the variance was grouped for FLOS and FMOS, and for MOS, FLFOS, and LOS. The SEM was .4 for FLOS and FMOS, and 1.2 for MOS, FLFOS, and LOS.

Key Words: Oat silage, Particle size

826 Partitioning in vitro digestibility of corn silages of different particle sizes. D.R. Mertens*[1] and G. Ferreira[2], [1]*US Dairy Forage Research Center, Madison, WI*, [2]*Universidad Catolica Argentina, Buenos Aires*.

In vitro apparent (IVDMD) and true DM disappearances (IVDMT - using neutral detergent extraction) of 32 diverse corn silages were determined to partition digestion into in vitro digestible NDF (IVdNDF) and digestible neutral detergent solubles (IVdNDS) and to study the factors affecting these fractions. Dried silages were fermented whole or after grinding through 4 or 1-mm screens for 24 h in a rotating jar in vitro system. For whole silages, ranges in variables were: IVDMD, 45-78%; IVDMT, 59-83%; IVdNDF, 5-30%; and IVdNDS, 24-63%. Results for 4 and 1-mm ground silages were similar and ranges were: IVDMD, 59-82%; IVDMT, 68-85%; IVdNDF, 10-33%; and IVdNDS, 37-68%. Range in estimated TDN by the NRC summative equation (63-75%) were narrower than IVDMD. Digestible NDF accounted for 10 to 50% of IVDMD regardless of physical form, indicating that neutral detergent solubles (NDS) were the primary contributor to DM digestibility. When corrected for ash, the relationship between IVdNDS and NDSom had a slope 0.98 and intercept of zero for 1 and 4-mm silages with $R^2 > 0.95$. The relationship for whole forages was similar, but R^2 were lower and residuals were large. For 1 and 4-mm silages, R^2 were improved by the addition of total starch and IVDMD of corn grain, indicating that starch affects IVdNDS. Residual deviations were reduced for whole silages by including the proportion of DM in starch from particles >4.75 mm and silage DM. For all materials, IVdNDF was related to aNDF or aNDFom and ADL or the ratio of ADL:aNDF. For 1-mm silage, IVdNDF = 0 + .6[aNDF- 4.5(ADL)], RMSE = 2.14. The regression coefficient for aNDF was similar for 4-mm and whole silages, but the coefficient for ADL was larger (5.1 to 8.2). The TDN summative equation agreed with 4-mm IVDMD; however, it tended to over predict dNDF and under predict dNDS (dCP + dNFC + dEE) compared with IVdNDF or IVdNDS. Improved equations for predicting corn silage digestibility will require coefficients for starch content, particle size and availability and refined relationships between ADL and dNDF.

Key Words: TDN, Fiber, Digestibility

827 Effects of pretrial milk yield on feed intake, production, and feeding behavior responses to forage particle size by lactating cows. G. M. Burato*[1], J. A. Voelker[2], and M. S. Allen[2], [1]*University of Padova, Italy*, [2]*Michigan State University, East Lansing, MI*.

Forage particle size can affect dry matter intake, chewing activity, digestibility, and yield and composition of milk for lactating cows. However, it is not known if cows varying in milk yield respond differently to differences in particle size of forages in their diets. Thirty-two Holstein cows (152 ± 78 DIM; 684 ± 71 kg BW; 2.79 ± 0.66 BCS; mean ± SD) received two diets according to a crossover design with 16 d periods. Milk yield averaged 36.6 kg/d and ranged from 24.1 to 49.3 kg/d for the 14 d prior to initiation of treatments. Diets had similar composition (DM basis: 30.8% NDF, 20.9% ADF, 19.8% CP, 23.4% starch) and differed only in the particle size of alfalfa hay (28% of dietary DM). The long diet (L) contained coarsely chopped alfalfa hay, whereas the same hay was chopped twice through a hammer mill (3.2 cm mesh screen) before being included in the short diet (S). Both diets were offered ad libitum (5% orts) as a TMR. Different DM percentages were found for L and S diets on upper (11 vs. 0%) and middle sieves (32 vs 35%) and in the bottom pan (57 vs. 65%) of the Penn State separator. Treatments had no effect on DMI, milk yield, milk fat, milk protein, change in BW or BCS, or on total chewing or rumination time per day. Eating time increased for L treatment (229 vs. 202 min/d, $P < 0.001$). Cows across the range of milk yield responded similarly to treatments. No effects of pre-trial milk yield on response to diet particle size (L-S) were observed for DMI, milk yield, or percentages of milk components. The ratio between the NDF retained by each sieve of the Penn State separator for orts and the corresponding fraction in the original diet showed that selection against coarse NDF (upper plus middle sieves) increased with pre-trial milk yield for the L diet ($R^2 = 0.23$, $P = 0.02$). This feeding behavior response reduced the original difference in particle size between the experimental diets. Selective feeding behavior, as well as the relatively high dietary NDF concentration used in this experiment, resulted in no effect of diet particle size on feed intake and milk production.

Key Words: Lactating Cows, Forage Particle Size, Feed Selection Activity

828 In situ digestibility and ruminal retention time of feed particles with functional specific gravity higher or lower than 1.02. A. N. Hristov*[1], S. Ahvenjarvi[2], P. Huhtanen [2], and T. A. McAllister[3], [1]*Department of Animal and Veterinary Sci., University of Idaho, Moscow, ID 83844-2330,* [2]*MTT Agrifood Research Finland, FIN31600 Jokioinen,* [3]*Agriculture and Agri-Food Canada, Lethbridge Research Centre, Lethbridge, AB T1J 4B1.*

Ruminal content was separated into particles with functional specific gravity (SG) higher or lower than 1.02 (HP and LP, respectively) and their mean ruminal retention times (MRT) and indigestible neutral detergent fiber (INDF) concentrations were compared. Whole ruminal contents from two lactating cows fed an all-grass silage diet were separated into HP and LP in NaCl solution (SG = 1.02) and washed through a 200-micron mesh (HP and LP) and a 38-micron mesh (HP only). Whole grass silage (WGS) was labeled with lanthanum, HP with erbium and LP with dysprosium. In a crossover study with four Ayrshire cows and two diets (100% grass silage and 50% grass silage:50% concentrate), labeled HP, LP and WGS were pulse dosed simultaneously into the rumen and whole ruminal contents were sampled 20 times over the next 72 h to determine markers MRT. Fractions arising from wet-sieving HP and LP were incubated in situ to determine INDF contents. Diet did not affect ($P > 0.05$) ruminal MRT of labeled particles. The MRT of LP (22.5 h) was shorter than that of WGS (29.2 h, $P < 0.05$) or HP (28.8, trend at $P < 0.1$). The 0.038-, 0.08-, 0.16-, 0.315- and 0.63-mm sieves retained more ($P < 0.05$) dry matter from HP than from LP; the 2.5-mm sieve retained more ($P < 0.05$) from LP than from HP. Except for 0.16 mm, all sieve fractions from HP contained more ($P < 0.05$) INDF than those from LP. Overall, HP had higher ($P < 0.05$) INDF content than LP (45.3 vs 41.8%). Across SG, INDF content increased ($P < 0.05$) with increasing sieve size up to 0.63 mm, and was lower ($P < 0.05$) in particles larger than 2.5 mm. This study indicates that ruminal particles with SG higher than 1.02 have higher INDF content and tend to reside longer in the rumen than those with SG less than 1.02.

Key Words: Ruminal Particles, Specific Gravity , Digestibility

829 Differences among carbohydrates in yields of crude protein from in vitro fermentation with mixed ruminal microbes. M. B. Hall*[1] and C. Herejk[1], [1]*Dept. of Animal Sciences, University of Florida.*

The yield of microbial crude protein (CP) from carbohydrate fermentations was examined using trichloroacetic acid (TCA) precipitation of batch cultures. The medium contained ammonium bicarbonate, casein acid hydrolysate, and cysteine hydrocholoride as nitrogen sources. Isolated bermudagrass neutral detergent fiber (iNDF) and 60:40 blends of iNDF and sucrose (Suc), citrus pectin (Pec), or corn starch (Sta) (375 mg of substrate organic matter (OM)/vial) were fermented in vitro in two separate fermentation runs with mixed ruminal microbes. Three fermentation tubes for each substrate were destructively sampled at 0, 4, 8, 12, 16, 20, and 24 h. Fermented samples were precipitated at a concentration of 19.4% TCA, and filtered to collect unfermented iNDF and precipitate. Collected residues were analyzed for CP as Kjeldahl N x 6.25. Microbial CP (TCACP) was estimated as TCA-precipitated CP corrected for the TCA-precipitated CP content of substrates at 0 h, and the mean of fermentation blanks from each hour. Medium pH did not decline below 6.49 in any fermentation tube. Heterogeneity of regression analysis of TCACP yield over time for iNDF vs. other substrates, Pec + Sta vs. Suc, and Pec vs. Sta indicated that the compared curves were not parallel ($P < 0.05$). The patterns of TCACP yield over time were cubic for iNDF and Suc, and quartic for Pec and Sta. The maximal yields of TCACP predicted from the regressions were Sta: 34.0 mg at 15.6 h, Pec: 29.9 mg at 13.5 h, Suc: 25.5 mg at 12.5 h, and iNDF:13.6 mg at 19.3 h. Comparisons of maximal yields based on the hour in which the measured mean yield was greatest for each substrate in each fermentation indicated that starch > sucrose = pectin > iNDF ($P < 0.05$). All substrates showed increases in TCACP to their maxima, followed by declines in TCACP. This likely reflects the relative dominance of microbe production or degradation about the point of substrate limitation. Unlike other substrates, Suc had no detectable lag, and presented a much flatter TCACP yield curve than the other non-NDF carbohydrates (NFC). The NDF and NFC carbohydrates examined differed in both yield and pattern of yield over time of TCACP.

Key Words: nonfiber carbohydrate, microbial protein, rumen fermentation

830 Endogenous N-losses in the digestive tract of dairy cows; influence of low digestible fiber. W.J.H. Van Gestel*[1], G. Hof[1], J. Dijkstra[1], and S. Tamminga[1], [1]*Wageningen Institute of Animal Sciences, Wageningen, The Netherlands .*

In dairy cattle, about 30 % of the excreted nitrogen in feces and urine is considered to be of endogenous origin. The amount of fecal endogenous N (EN) loss likely depends on amount and composition of the diet fed. In the Dutch DVE/OEB protein evaluation system, a fecal EN loss of 8 g N per kg indigestible dry matter (IDM) is expected This figure is derived from extrapolation of observed fecal N at various N-intake levels to a N-intake of 0. In this study, the influence of IDM passage on EN loss was investigated in a more direct way in a dose response set up, with IDM administered via two routes, and in two particle sizes. Four dairy cows, fitted with a dorsal rumen canula, were fed a basal ration of a mixture of grass- and maize silage, 1:1 on DM base, and concentrates according to individual requirements. In addition to this control diet (treatment 1), the animals received 3 kg of wheat straw as 0.5 mm particles infused in the abomasum (treatment 2) or orally (3) and as chopped straw orally (4) according to a 4x4 Latin square design. The extra fecal N, relative to the control, was corrected for indigestible N in the straw (ADIN, 1.51 g/kg DS) and undigested microbial N from straw fermented in the rumen (treatment 3 and 4), assuming that per kg unrecovered extra DM 24 g microbial N was produced, with a digestibility of 85%. The corrected extra N was considered the EN-loss due to the extra IDM. The addition of straw to the basal ration resulted in a significantly enhanced fecal excretion of DM (173% of the control) in treatment 2. The recovery of the extra DM was somewhat lower for treatment 3 and 4, due to rumen fermentation of the straw. There was a significant extra excretion of EN 3.4 - 6.0 (se 1.2) g per kg extra fecal IDM, which was also significantly lower than the expected value of 8 g per kg IDM. No significant differences were observed between treatments 2, 3 and 4. Therefore, EN loss due to IDM was not influenced by particle size and way of administration of the extra DM.

Key Words: Endogenous N, Dairy Cows, NDF

831 An investigation of feeding level effects on digestibility for diets based on grass silage and high fiber concentrates at two forage : concentrate ratios. F.J. Mulligan*, P.J. Caffrey, M. Rath, J.J. Callan, and F.P. O'Mara, *University College Dublin.*

The objective of this study was to investigate the effect of feeding level on diet digestibility at two forage : concentrate ratios for diets containing grass silage. Four rumen fistulated Holstein/Friesian steers were used in a latin square design comprising a 2 x 2 factorial arrangement of treatments. Treatments were maintenance (M) and 1.6-M feeding level and 500 or 850 g/kg dry matter (DM) soya hulls. Digestibility was determined by total collection and rate of digestion was determined in-sacco. Fractional soya hulls rumen outflow rate (k1p) and fractional solute rumen outflow rate (k1f) were determined using Cr-mordanted soya hulls and Co-EDTA. Increasing feeding level and soya hulls inclusion decreased the digestibility of diet DM, organic matter (OM), crude protein, neutral detergent fiber (NDF), acid detergent fiber (ADF) and gross energy (GE) ($P<0.01$). As the interaction of feeding level and forage : concentrate ratio was significant for GE digestibility ($P<0.05$), and approached significance for DM and OM digestibility ($P=0.06$, for both), the depression due to feeding level was greater for 850 g/kg DM soya hulls diets and the depression due to soya hulls inclusion was greater for the 1.6M diet. The rates of digestion of slowly degradable soya hulls DM ($P<0.05$) and NDF ($P=0.07$) and grass silage DM and NDF ($P=0.08$ and 0.09, respectively) were lower for high concentrate diets. Soya hulls k1p and k1f increased with feeding level but only the increase in k1f was significant ($P<0.01$). Diet OM, NDF and GE digestibility were positively related to rumen pH six hours after feeding ($P<0.01$; $R^2=0.50$ to 0.69). These results indicate that feeding level induced digestibility depressions are larger for high concentrate diets due to lower rumen pH values and lower rates of concentrate and forage digestion. These effects may cause important inaccuracies in rationing systems for ruminants.

Key Words: Digestibility, Intake, Forage : Concentrate Ratio