REFERENCES

Adesogan, A. T. 2005. Effect of bag type on the apparent digestibility of feeds in ANKOM Daisy ^{II} incubators. Anim. Feed Sci. Tcehnol. 119:333-344.

Aldrich, J. M., L. D. Muller, G. A. Varga, and L. D. Griel Jr. 1993. Nonstructural carbohydrate and protein effects on rumen fermentation, nutrient flow, and performance of dairy cows. J. Dairy Sci. 76:1091-1105.

Allen, M. S. 1997. Relationship between fermentation acid production in the rumen and the requirement for physically effective fiber. J. Dairy Sci. 80:1447-1462.

Allen, M. S. 1997. Relationship between fermentation acid production in the rumen and the requirement for physically effective fiber. J. Dairy Sci. 80:1447-1462.

Allen, M. S. 2000. Effects of diet on short-term regulation of feed intake by lactating dairy cows. J. Dairy Sci. 83:1598-1624.

Amos, H. E. 1986. Influence of dietary protein degradability and energy concentration on growth of heifers and steers and intraruminal protein metabolism. J. Dairy Sci. 69:2099-2110.

AOAC. 1990. Official Methods of Analysis. 15th ed. AOAC, Arlington, VA.

AOAC. 1997. Official Methods of Analysis. 16th ed. AOAC, Gaithersburg, MD.

AOAC. 2000. Official Methods of Analysis. 19th ed. AOAC international, Washington, DC.

Apori, S. O., F. B., Castro, W. J., Shand, and E. R., Ørskov. 1998. Chemical composition, in sacco degradation and *in vitro* gas production of some Ghanian browse plants. Anim. Feed Sci. Technol. 76:129-137.

Argyle, J. L., and R. L. Baldwin. 1989. Effects of amino acids and peptides on rumen microbial yields. J. Dairy Sci. 72:2017-2027.

Ariza, P., A. Bach, M. D. Stern, and M. B. Hall. 2001. Effects of carbohydrates from citrus pulp and hominy feed on microbial fermentation in continuous culture. J. Anim. Sci. 79:2713-2718.

Ash, R., and G. D. Baird. 1973. Activation of volatile fatty acids in bovine liver and rumen epithelium. Biochem. J. 136:311-319.

Atasoglu, C., A. Y. Guliye, and R. J. Wallace. 2004. Use of stable isotopes to measure de novo synthesis and turnover of amino acid-C and -N in mixed micro-organisms from the sheep rumen *in vitro*. Br. J. Nutr. 91:235-261.

Atasoglu, C., C. J. Newbold, and R. J. Wallace. 2001. Incorporation of ^{15}N ammonia by cellulolytic ruminal bacterial *Fibrobacter succinogenes* BL2, *Ruminococcus albus* SY3, and *Ruminococcus flavefaciens* 17. Appl. Environ. Microbiol. 67:2819-2822.

Atasoglu, C., C. Valdes, C. J. Newbold, and R. J. Wallace. 1999. Influence of peptides and amino acids on fermentation rate and de novo synthesis of amino acids by mixed micro-organisms from the sheep rumen. Br. J. Nutr. 81:307-314.

Bach, A., I. K. Yoon, M. D. Stern, H. G. Jung, and H. Chester-Jones. 1999. Effects of type of carbohydrate supplementation for lush pasture on microbial fermentation in continuous culture. J. Dairy. Sci. 82:153-160.

Bach, A., M. Ruiz Moreno, M. Thrune, and M. D. Stern. 2008. Evaluation of fermentation dynamics of soluble crude protein from three protein sourses in continous culture fermenters. J. Anim. Sci. 86:1364-1371.

Baldwin, R. L., and M. J. Allison. 1983. Rumen metabolism. J. Anim. Sci. 57 (Suppl.2):461-477.

Bauchop, T., and S. R. Elsden. 1960. The growth of microorganisms in relation to their energy supply. J. Gen. Microbiol. 23:457-469.

Bauman, D. E., and J. M. Griinari. 2001. Regulation and nutritional manipulation of milk fat: Low-fat milk syndrome. Livest. Prod. Sci. 70:15-29.

Beever, D. E. 1993. Rumen Function. In: Quantitative Aspects of Ruminant Digestion and Metabolism. J. M. Forbes and J. France (eds.). CAB International, New York.

Belasco, I. J. 1956. The role of carbohydrates in urea utilization, cellulose digestion and fatty acids formation. J. Anim. Sci. 15:496-508.

Bell, A.W. 1981. Lipid metabolism in liver and selected tissues and in the whole body of ruminant animals. In: Lipid Metabolism in Ruminant Animals. W. W. Christie (ed.). Pergamon Press, Oxford.

Ben-Ghedalia, D., E. Yosef, J. Miron, and Y. Est. 1989. the effect of starch-pectin-rich diets on quantitative aspects of digestion in sheep. Anim. Feed Sci. Technol. 24:289-298.

Bergman, E. N. 1990. Energy contributions of volatile fatty acids from the gastrointestinal tract in various species. Physiol. Rev. 70:567-590.

Blummel, M., and E. R. Ørskov. 1993. Comparison of *in vitro* gas production and nylon bag degradability of roughages in prediction of feed intake in cattle. Anim. Feed Sci. Technol. 40:109-119.

Blummel, M., A. A., Karsli, and J. R. Russell. 2003. Influence of diet on growth yields of rumen microorganism *in vitro* and *in vivo*: influence on growth yield of variable carbon fluxes to fermentation products. Br. J. Nutr. 90:625-634.

Boniface, A. N., R. M. Murray, and J. P. Hogan. 1986. Optimum level of ammonia in the rumen liquor of cattle fed tropical pasture hay. Proc. Aust. Soc. Anim. Pord. 16:151-154.

Boucher, S. E., R. S. Ordway, N. L. Whitehouse, F. P. Lundy, P. J. Kononoff, and C. G. Schwab. 2007. Effect of incremental urea supplementation of a conventional corn silage-based diet on ruminal ammonia concentration and synthesis of microbial protein. J. Dairy Sci. 90:5619-5633.

Brisson, G. J. 1956. On the routine determination of chromic oxide in feces. Can. J. Agric. Sci. 36:210-212.

Broderick, G. A., R. J. Wallace, E. R. Ørskov, and L. Hansen. 1988. Comparison of estimates of ruminal protein degradation by *in vitro* and *in situ* methods. J. Anim. Sci. 66:1739-1745.

Broderick, G. A., and N. R. Merchen. 1992. Markers for quantifying microbial protein synthesis in the rumen. J. Dairy Sci. 75:2618-2632.

Broderick, G.A. 1994. Quantifying forage protein quality. In: Forage Quality, Evaluation, and Utilization. G. C. Fahey, Jr., M. D. Collins, D. R. Mertens and L. E. Moser (eds.) American Soc. Agron., Madison, WI.

Broderick, G. A. and R. C. Cochran. 2000. *In vitro* and *in situ* methods for estimating digestibility with reference to protein degradability. In: Feeding Systems and Feed Evaluation models. M. K. Theodorou and J. France (eds.) CAB International, Wallingford.

Broderick, G. A., D. R. Mertens, and R. Simons. 2002. Efficacy of carbohydrate sources for milk production by cows fed diets based on alfalfa silage. J. Dairy Sci. 85:1767-1776.

Broderick, G. A., and W. J. Radloff. 2004. Effect of molasses supplementation on the production of lactating dairy cows fed diets based on alfalfa and corn silage. J. Dairy Sci. 87:2997-3009.

Broderick, G. A., N. D. Luchini, S. M. Reynal, G. A. Varga, and V. A. Ishler. 2008. Effect on production of replacing dietary starch with sucrose in lactating dairy cows. J. Dairy Sci. 91:4801-4810.

Broudiscou, L. P., A. Agbagla-Dobnani, Y. Papon, A. Cornu, E. Grenet, and A. F. Broudiscou. 2003. Rice straw degradation and biomass synthesis by rumen micro-organisms in continuous culture in response to ammonia treatment and legume extract supplementation. Anim. Feed Sci. Technol. 105:95-108.

Brown, V. E., C. Rymer, R. E. Agnew, and D. I. Givens. 2002. Relationship between *in vitro* gas production profiles of forages and *in vivo* rumen fermentation patterns in beef steers fed those forages. Anim. Feed Sci. Technol. 98: 13-24.

Buaphan S., V. Pattarajinda, M. A. Froetschel, M. Duangjinda, and Y. Opatpatanakit. 2008. Effects of replacing dietary starch with sugar on nutrient digestibility and gas production technique. In: The Proceeding of 13th Animal Science Congress of the Asian-Australasian Association of Animal production Societies, Hanoi, Vietnam.

Cabrita, A. R. J., A. J. M. Fonseca, R. J. Dewhurst, and E. Gomes. 2003. Nitrogen supplementation of corn silages: Assessing rumen function using fatty acid profiles of bovine milk. J. Dairy Sci. 86:4020-4032.

Cabrita, A. R. J., R. J. B. Bessa, S. P. Alves, R. J. Dewhurst, and A. J. M. Fonseca. 2007. Effects of dietary protein and starch on intake, milk production, and milk fatty acid profiles of dairy cows fed corn silage-based diets. J. Dairy Sci. 90:1429-1439.

Calsamiglia, S., A. Ferret, and M. Devant. 2002. Effects of pH and pH fluctuations on microbial fermentation and nutrient flow from a dual-flow continuous culture system. J. Dairy Sci. 85:574-579.

Cameron, M. R., T. H. Klusmeyer, G. L. Lynch, J. H. Clark, and D. R. Nelson. 1991. Effects of urea and starch on rumen fermentation, nutrient passage to the duodenum, and performance of cows. J. Dairy Sci. 74:1321-1336.

Carro, M. D., and E. L. Miller. 1999. Effect of supplementing a fibre basal diet with different nitrogen forms on ruminal fermentation andmicrobial growth in an in vitro semi-continuous culture system (RUSITEC). Br. J. Nutr. 82:149-157.

Casper, D. P., and D. J. Schingoethe. 1986. Evaluation of urea and dried whey in diets of cows during lactation. J. Dairy Sci. 69:1346-1354.

Casper, D. P., H. A. Maiga, M. J. Brouk, and D. J. Schingoethe. 1999. Synchronization of carbohydrate and protein sources on fermentation and passage rates in dairy cows. J. Dairy Sci. 82:1779-1790.

Cetinkaya, N., S. Yaman, and N. H. O. Baber. 2006. The use of purine derivatives/creatinine ratio in spot urine samples as an index of microbial protein supply in Yerli Kara crossbred cattle. Livest. Sci. 100:91-98.

Chamberlain, D. G., S. Robertson, and J. J. Choung. 1993. Sugars versus starch as supplements to grass silage: Effects on ruminal fermentation and the supply of microbial protein to the small intestine, estimated from the urinary excretion of purine derivatives, in sheep. J. Sci. Food Agric. 63:189-194.

Charmely, E. D., D. M. Veira, G. Butler, L. Aroeira, and H. C. V. Codagnone. 1991. The effect of frequency of feeding and supplementation with sucrose on ruminal fermentation of alfalfa silage given ad libitum or restricted to sheep. Can. J. Anim. Sci. 71:725-737.

Chaudhry, A. S., and A. J. F. Webster. 2001. Electrophoresis to determine the molecular weight distribution in soluble proteins from various foods and their rumen-resistant residues in cattle. J. Sci. Food Agric. 81:1087-1093.

Chenost, M., J. Aufrere, and D. Macheboeuf. 2001. The gas-test technique as a tool for predicting the energetic value of forage plants. Anim. Res. 50:349-364.

Chen, K. H., J. T. Huber, C. B. Theurer, D. V. Armstrong, R. C. Wanderley, J. M. Simas, S. C. Chan, and J. L. Sullivan. 1993. Effect of protein quality and evaporative cooling on lactational performance of Holstein cows in hot weather. J. Dairy Sci. 76:819-825.

Chen, X. B., A. T. Mejia, D. J. Kyle, and E. R. Ørskov. 1995. Evaluation of the use of purine derivatives:creatinine ratio in spot urine and plasma samples as an index of microbial protein supply in ruminants: studies in sheep. J. Agric. Sci. 125:137-143.

Chen, X. B., F. D. Hovell, E. R. Ørskov, and D. S. Brown. 1990. Excretion of purine derivatives by ruminants: Effect of exogenous nucleic acid supply on purine derivative excretion by sheep. Br. J. Nutr. 63:131-142.

Chen, X. B., M. C. N. Jayasuriya, and H. P. S. Makkar. 2004. Measurement and application of purine derivatives:creatinine ratio in spot urine samples of ruminants. In: Estimation of Microbial Protein Supply in Ruminants Using Urinary Purine Derivatives. H. P. S. Makkar and X. B. Chen (eds.). Kluwer Academic Publishers, Dordrecht.

Chen, X. B., Y. K. Chen, M. F. Franklin, E. R. Ørskov, and W. J. Shand. 1992. The effect of feed intake and body weight on purine derivative excretion and microbial protein supply in sheep. J. Anim. Sci. 70:1534-1542.

Cherney, D. J. R., J. H. Cherney, and L. E. Chase. 2003. Influence of dietary nonfiber carbohydrate concentration and supplementation of sucrose on lactation performance of cows fed fescue silage. J. Dairy Sci. 86: 3983-3991.

Chesson, A., and C. W. Forsberg. 1997. Polysaccharide degradation by rumen microorganisms. In: The Rumen Microbial Ecosystem. P. N. Hobson and C. S. Stewart (eds.) Chapman and Hall, London.

Chester-Jones, H., M. D. Stern, H. M. Metwally, J. G. Linn, and D. M. Ziegler. 1991. Effects of dietary protein-energy interrelationships on Holstein steer performance and ruminal bacterial fermentation in continuous culture. J. Anim. Sci. 69:4956-4966.

Chizzotti, F. H. M, O. G. Pereira, L. O. Tedeschi, F. S. C, Valadares, M. L. Chizzotti, M. I. Leao, and D. H. Pereira. 2008. Effects of dietary nonprotein nitrogen on performance, digestibility, ruminal characteristics, and microbial efficiency in crossbred steers. J. Dairy Sci. 86:1173-1181.

Clark, J. H., T. H. Klusmeyer, and M. R. Cameron. 1992. Microbial protein synthesis and flows of nitrogen fractions to the duodenum of dairy cows. J. Dairy Sci. 75:2304-2323.

Cotta, M. A. 1988. Amylolytic activity of selected species of ruminal bacteria. Appl. Environ. Microbiol. 54:772-776.

Craig, W. M., B. J. Hong, G. A. Broderick, and R. J. Bula. 1984. *In vitro* inoculum enriched with particle-associated microorganisms for determining rates of fiber digestion and protein degradation. J. Dairy Sci. 67: 2902-2909.

Craig, W. M., D. R. Brown, G. A. Broderick, and D. B. Ricker. 1987. Post-prandial compositional changes of fluid- and particle-associated ruminal microorganisms. J. Anim. Sci. 65:1042-1048.

Cruz Soto, R., S. A. Muhammed, C. J. Newbold, C. S. Stewart, and R. J. Wallace. 1994. Influence of peptides, amino acids and urea on microbial activity in the rumen of sheep receiving grass hay and on the growth of rumen bacteria *in vitro*. Anim. Feed Sci. Technol. 49:151-161.

Cyriac, J., A. G. Rius, M. L. McGilliard, R. E. Pearson, B. J. Bequette, and M. D. Hanigan. 2008. Lactation performance of mid-lactation dairy cows fed ruminally degradable protein at concentrations lower than National Research Council recommendations. J. Dairy Sci. 91:4704-4713.

Czerkawski, J. W. and G. Breckenridge. 1969. Fermentation of various soluble carbohydrates by rumen micro-organisms with particular reference to methane production. Br. J. Nutr. 23:925-937.

Czerkawski, J. W., and G. Breckenridge. 1977. Design and development of a long-term rumen simulation technique (Rusitec). Br. J. Nutr. 38: 371-389.

Dann, H. M., C. S. Ballard, R. J. Grant, K. W. Cotanch, M. P. Carter, and M. Suekawa. 2006. Effects of glutamate on microbial efficiency and metabolism in continuous culture of ruminal contents and performance of mid-lactation dairy cows. Anim. Feed Sci. Technol. 130:204-224.

Dansky, L. M., and F. W. Hill. 1952. Application of the chromic oxide indicator method to balance studies with growing chickens. J. Nutr. 47:449-459.

Dawson, K. A., M. A. Rasmussen, and M. J. Allison. 1997. Digestive disorders and nutritional toxicity. In: The Rumen Microbial Ecosystem. P. N. Hobson and C. S. Stewart (eds.). Chapman and Hall, London.

DeFrain, J. M., A. R. Hippen, K. F. Kalscheur, and D. J. Schingoethe. 2004. Feeding lactose increases ruminal butyrate and plasma β- hydroxybutyrate in lactating dairy cows. J. Dairy Sci. 87:2486-2494.

DeFrain, J. M., A. R. Hippen, K. F. Kalscheur, and D. J. Schingoethe. 2006. Feeding lactose to increase ruminal butyrate and the metabolic status of transition dairy cows. J. Dairy Sci. 89:267-276.

Dehareng, D., and J. M. Godeau. 1989. Polyethylene glycol dilution curves: A comparison of apparent ruminal liquid volumes and dilution rates estimated from either ruminal or duodenal fluid samples of Friesan cows. J. Anim. Physiol. Anim. Nutr. 62:268-272.

Delahoy, J. E., L. D. Muller, F. Bargo, T. W. Cassidy, and L. A. Holden. 2003. Supplemental carbohydrate sources for lactating dairy cows on pasture. J. Dairy Sci. 86:906-915.

DelCurto, T., R. C., Cochran, D. L., Harmon, A. A., Beharka, K. A., Jacques, G., Towne, and E. S., Vanzant. 1990. Supplementation of dormant tallgrass-prairie forage. I. Influence of varying supplemental protein and (or) energy levels on forage utilization characteristics of beef steers in confinement. J. Anim. Sci. 68:515-531.

DePeters, E. J, and J. P. Cant. 1992. Nutritional factors influencing the nitrogen composition of bovine milk: A review. J. Dairy Sci. 75:2043-2070.

DePeters, E. J., J. G. Fadel, and A. Arosemena. 1997. Digestion kinetics of neutral detergent fiber and chemical composition within some selected by-product feedstuffs. Anim. Feed Sci. Technol. 67:127-140.

Devant, M., A. Ferret, J. Gasa, S. Calsamiglia, R. Casals. 2000. Effects of protein concentration and degradability on performance, ruminal fermentation and nitrogen metabolism in rapidly growing heifers fed high concentrate diets from 100 to 230 kg body weight. J. Anim. Sci. 78:1667-1676.

De Veth, M. J., and E. S. Kolver. 2001. Diurnal variation in pH reduces digestion and synthesis of microbial protein when pasture is fermented in continuous culture. J. Dairy Sci. 84:2066-2072.

Dewhurst, R. J., D. Hepper, and A. J. F. Webster. 1995. Comparison of *sacco* and *in vitro* techniques for estimating the rate and extent of rumen fermentation of a range of dietary ingredients. Anim. Feed Sci. Technol. 51:211-299.

Dijkstra, J., H. Boer, J.V. Bruchem, M. Bruining, and S. Tamminga. 1993. Absorption of volatile fatty acids from the rumen of lactating dairy cows as influenced by volatile fatty acid concentration, pH and rumen liquid volume. Br. J. Nutr. 69:385-396.

Dryhurst, N., and C. D. Wood. 1998. The effect of nitrogen source and concentration on *in vitro* gas production using rumen micro-organisms. Anim. Feed Sci. Technol. 71:131-143.

Dwayne, R. B., and D. D. Redfearn. 1997. Plant limitations to fiber digestion and utilization. J. Nutr. 1997. 127:8145-8185.

Firkins, J. L. 1996. Maximizing microbial protein synthesis in the rumen. J. Nutr. 126:1347-1354.

Firkins, J. L., L. L. Berger, N. R. Merchen, G. C. Fahey, and R. L. Mulvaney. 1987. Ruminal nitrogen metabolism in steers as affected by intake and dietary urea concentration. J. Dairy Sci. 70:2302-2311.

Firkins, J. L., W. P. Weiss, and E. J. Piwonka. 1992. Quantification of intraruminal recycling of microbial nitrogen using nitrogen- 15. J. Anim. Sci. 70:3223-3229.

Fondevila, M., A., Barrios, J. Urdaneta, J., Balcells, and C., Castrillo. 2002. Gas production from straw incubated *in vitro* with different levels of purified carbohydrates. Anim. Feed Sci. Technol. 101:1-15.

Friggens, N. C., J. D. Oldham, R. J. Dewhurst, and G. Horgan. 1998. Proportions of volatile fatty acids in relation to the chemical composition of feeds based on grass silage. J. Dairy. Sci. 81:1331-1344.

France, J., and R. C. Siddons, 1993. Volatile fatty acid production. In: Quantitative Aspects of Ruminant Digestion and Metabolism. J. M. Forbes and J. France (eds.). CAB International, New York.

Gabler, M. T., and A. J. Heinrichs. 2003. Altering soluble protein and potentially rumen degradable protein for prepubertal Holstein heifers. J. Dairy Sci. 86:2122-2130.

Galo, E., S. M. Emanuele, C. J. Sniffen, J. H. White, and J. R. Knapp. 2003. Effects of a polymer-coated urea product on nitrogen metabolism in lactating Holstein dairy cattle. J. Dairy Sci. 86:2154-2162.

Garrett, E. 1996. Subclinical rumen acidosis:clinical signs and diagnosis in dairy herds. Large animal Veterinarian. November/December.

Getachew, G., P. H. Robinson, E. J. DePeters, and S. J. Taylor. 2004. Relationships between chemical composition, dry matter degradation and *in vitro* gas production of several ruminant feeds. Anim. Feed Sci. Technol. 111:57-71.

Getachew, G., E. J. DePeters, P. H. Robinson, and J. G. Fadel. 2005. Use of an *in vitro* rumen gas production technique to evaluate microbial fermentation of ruminant feeds and its impact on fermentation products. Anim. Feed Sci. Technol. 123-124:547-559.

Gleghorn, J. F., N. A. Elam, M. L. Galyean, G. C. Duff, N. A. Cole, and J. D. Rivera. 2004. Effects of crude protein concentration and degradability on performance, carcass characteristics, and serum urea nitrogen concentrations in finishing beef steers. J. Dairy Sci. 82:2705-2717.

Goering, H. K., and P. J. Van Soest. 1970. Forage Fiber Analyses (Apparatus, Reagents, Procedures, and Some Applications). Agric. Handbook No. 379. ARS-USDA, Washington, DC.

Golombeski, G., L., K. F. Kalscheur, A. R. Hippen, and D. J. Schingoethe. 2006. Slow-release urea and highly fermentable sugars in diets fed to lactating dairy cows. J. Dairy Sci. 89:4395-4403.

Gradel, C. M., and B. A. Dehority. 1972. Fermentation of isolated pectin and pectin from intact forages by pure cultures of rumen bacteria. Appl. Micro. 23:332-340.

Grant, R. J., and D. R. Mertens. 1992a. Development of buffer systems for pH control and evaluation of pH effects on fiber digestion *in vitro*. J. Dairy Sci. 75:1581-1587.

Grant, R. J., and D. R. Mertens. 1992b. Impact of *in vitro* fermentation techniques upon kinetics of fiber digestion. J. Dairy Sci. 75:1263-1272.

Grant, R. J., and D. R. Mertens. 1992c. Influence of buffer pH and raw corn starch addition on *in vitro* fiber digestion kinetics. J. Dairy Sci. 75:2762-2768.

Griswold, K. E., W. H. Hover, T. K. Miller, and W. V. Thayne. 1996. Effect of form of nitrogen on growth of ruminal microbes in continuous culture. J. Anim. Sci. 74:483-491.

Griswold, K. E., G. A. Apgar, J. Bouton, and J. L. Firkins. 2003. Effects of urea infusion and ruminal degradable protein concentration on microbial growth, digestibility, and fermentation in continuous culture. J. Anim. Sci. 81:329-336.

Haig, P. A., T. Mutsvangwa, R. Spratt, and B. W. McBride. 2002. Effects of dietary protein solubility on nitrogen losses from lactating dairy cows and comparison with predictions from the Cornell Net-Carbohydrate and Protein System. J. Dairy Sci. 85:1208-1217.

Hall, G., E. W. Cheng, W. H. Hale, and W. Burroughs. 1954. Chemical and enzymatic preparations of protein hydrolyzates stimulatory to cellulose digestion by rumen microorganisms. J. Anim. Sci. 13:985. (Abstr.).

Hall, M. B. 2002. Working with sugars (and molasses). In: Proceedings from the 13th Annual Florida Ruminant Nutrition Symposium. Gainesville, FL.

Hall, M. B., and C. Herejk. 2001. Differences in yields of microbial crude protein from *in vitro* fermentation of carbohydrates. J. Dairy Sci. 84:2486-2493.

Hall, M. B., and G. B. Huntington. 2008. Nutrient synchrony: Sound in theory, elusive in practice. J. Anim. Sci. 2008. 86 (E. Suppl.):E287-E292.

Hall, M. B., and P. J. Weimer. 2007. Sucrose concentration alters fermentation kinetics, product, and carbon fates during *in vitro* fermentation with mixed ruminal microbes. J. Dairy Sci. 85:1467-1478.

Hatfield, R. D., and P. J. Weimer. 1995. Degradation characteristics of isolated and in situ cell wall lucerne pectic polysaccharides by mixed ruminal microbes. J. Sci. Food Agric. 69:185-196.

Hedqvist, H., and P. Uden. 2006. Measurement of soluble protein degradation in the rumen. Anim. Feed Sci. Technol. 126:1-21.

Heldt, J. S., R. C. Cochran, G. L. Stokka, C. G. Farmer, C. P. Mathis, E. C. Titgemeyer, and T. G. Nagaraja. 1999. Effects of different supplemental sugars and starch fed in combination with degradable in take protein on low- quality forage use by beef steers. J. Anim. Sci. 77:2793-2802.

Henning, P. H., D. G. Steyn, and H. H. Meissner. 1991. The effect of energy and nitrogen supply pattern on rumen bacterial growth *in vitro*. Anim. Prod. 53:165-175.

Henning, P. H., D. G. Steyn, and H. H. Meissner. 1993. Effect of synchronization of energy and nitrogen supply on ruminal characteristics and microbial growth. J. Anim. Sci. 71:2516-2528.

Herold, D., T. J. Klopfenstein, and M. Klemesrud. 1996. Evaluation of animal byproducts for escape protein supplementation. In: Nebraska Beef Cattle Reports. University of Nebraska, Lincon.

Herrera-Saldana, R., R. Gomez-Alarcon, M. Torabi, and J. T. Huber. 1990. Influence of synchronizing protein and starch degradation in the rumen on nutrient utilization and microbial protein synthesis. J. Dairy Sci. 73:142-148.

Hightstreet, A., P. H. Robinson, J. Robinson, and J. G. Garrett. 2010. Response of Holstein cows to replacing urea with a slowly rumen released urea in a diet high in soluble crude protein. Livest. Sci. 129:179-185.

Hill, T. M., S. P. Schmidt, R. W. Russell, E. E. Thomas, and D. F. Wolfe. 1991. Comparison or urea treatment with established methods of sorghum grain preservation and processing on site and extent of starch digestion by cattle. J. Anim. Sci. 69:4570-4576.

Holden, L. A. 1999. Comparison of methods of *in vitro* dry matter digestibility for ten feeds. J. Dairy Sci. 82:1791-1794.

Hoover, W. H. 1986. Chemical factors involved in ruminal fiber digestion. J. Dairy Sci. 69:2755-2766.

Hoover, W. H., and S. R. Stokes. 1991. Balancing carbohydrates and proteins for optimum rumen microbial yield. J. Dairy Sci. 74:3630-3644.

Hoover, W. H., and T. K. Miller-Webster. 1998. Role of sugars and starch in ruminant fermentation. In: Proceeding of Tri-State Dairy Nutrition Conf., Ft. Wayne, IN.

Hoover, W. H., and T. K. Miller-Webster. 2001. The contribution of sugars to rumen fermentation and milk production. In: The Proceeding of 42nd Annual New England Dairy Feed Conference, West Lebanon, NH, pp.1-24. *Cited* in D. J. R Cherney, J. H. Cherney, and L. E. Chase. Influence of dietary nonfiber carbohydrate concentration and supplementation of sucrose on lactation performance of cow fed fescue silage. J. Dairy Sci. 86:3983-3991.

Hoover, W. H., B. A. Crooker, and C. J. Sniffen. 1976. Effects of differential solid-liquid removal rates on protozoa numbers in continuous cultures of rumen contents. J. Anim. Sci. 43:528-534.

Hoover, W. H, C. Kincaid, and G. Varga. 1984. Effects of solids and liquid flows on fermentation in continuous cultures. IV. pH and dilution rate. J. Anim. Sci. 58: 692.

Hoover, W. H., C. Tucker, J. Harris, C. J. Sniffen, and M. B. de Ondarza. 2006. Effects of nonstructural carbohydrate level and starch:sugar ratio on microbial metabolism in continuous culture of rumen contents. Anim. Feed Sci. Technol. 128:307-319.

Hristov, A., and G. A. Broderick. 1994. *In vitro* determination of ruminal protein degradability using [15N]-ammonia to correct for microbial nitrogen uptake. J. Anim. Sci. 72:1344-1354.

Hristov, A. N., and J. K. Ropp. 2003. Effect of dietary carbohydrate composition and availability on utilization of ruminal ammonia nitrogen for milk protein synthesis in dairy cows. J. Dairy Sci. 86:2416-2427.

Hristov, A. N., J. K. Ropp, K. L. Grandeen, S. Abedi, R. P. Etter, A. Melgar, and A. E. Foley. 2005. Effect of carbohydrate source on ammonia utilization in lactating dairy cows. J. Anim. Sci. 83:408-421.

Huber, J. T., and L. J. R. Kung. 1981. Protein and nonprotein nitrogen utilization in dairy cattle. J. Dairy Sci. 64:1170-1195.

Huhtanen, P., and H. Khalili. 1992. The effect of sucrose supplements on particleassociated carboxymethylcellulase (EC 3.2.1.4) and xylanase (EC 3.2.1.8) activities in cattle given grass-silage-based diet. Br. J. Nutr. 67:245-255.

Huhtanen, P., and H., Khalili, 1991. Sucrose supplements in cattle given grass silage based-diet. 3. Rumen pool size and digestion kinetics. Anim. Feed Sci. Technol. 33:275-287.

Huhtanen, P., and S. Robertson. 1988. The effect of dietary inclusion of starch, sucrose and xylose on the utilization of dietary energy in sheep. Anim. Feed Sci. Technol. 21:11-21.

Hungate, R. E. 1966. The Rumen and its Microbes. Academic Press, New York.

Huntington, G. B. 1989. Hepatic urea synthesis and site and rate of urea removal from blood of beef steers fed alfalfa hay or a high concentrate diet. Can. J. Anim. Sci. 69:215-223.

Huntington, J. A., and D. I. Givens. 1995. The in situ technique for studying the rumen degradation of feeds: a review of the procedure. Nutri. Abstr. Rev. 65:63-93.

Huntington, G. B. 1997. Starch utilization by ruminants: from basics to the bunk. J. Anim. Sci. 75:852-867.

IAEA- TECDOC-945. 1997. Estimation of Rumen Microbial Protein Production from Purine Derivatives in Urine, IAEA, Publication.

Jarvis, M. C. 1984. Structure and properties of pectin gels in plant cell walls. Plant Cell and Environ. 7:153-164.

Jenness, R., and S. Patton. 1959. Principles of Dairy Chemistry. John Wiley and Sons, New York, NY.

Jones, D. F., W. H. Hoover, and T. K. Miller-Webster. 1998. Effects of concentrations of peptides on microbial metabolism in continuous culture. J. Anim Sci. 76: 611-616.

Kajikawa, H., M. Mitsumori, K. Tajima, and M. Kurihara. 2005. Amino acids antagonistic to the amino acids inhibitory for growth rate of mixed ruminal bacteria. J. Dairy Sci. 88:2601-2603.

Kalscheur, K. F., R. L. Baldwin VI, B. P. Glenn, and R. A. Kohn. 2006. Milk production of dairy cows fed differing concentrations of rumen-degraded protein. J. Dairy Sci. 89:249-259.

Kaneko, J. J. 1997. Carbohydrate metabolism and its diseases. In: Clinical Biochemistry of Domestic Animals. J. J. Kaneko, J. W. Harvet, and M. L Bross (eds.). Academic Press, London.

Kang-Meznarich, J. H., and G. A. Broderick. 1981. Effects of incremental urea supplementation on ruminal ammonia concentration and bacterial protein formation. J. Anim. Sci. 51:422-431.

Kanjanapruthipong, J., and R. A. Leng. 1998. The effects of dietary urea on microbial populations in the rumen of sheep. Asian-Aust. J. Anim. Sci. 11:661-672.

Karsli, M. A., and J. R. Russell. 2002. Effect of source and concentrations of nitrogen and carbohydrate on ruminal microbial protein synthesis. Turk. J. Vet. Anim. Sci. 26:201-207.

Kebreab, E., J. France, J. A. N. Mills, R. Allison, and J. Dijkstra. 2002. A dynamic model of N metabolism in the lactating dairy cow and an assessment of impact of N excretion on the environment. J. Anim. Sci. 80:248-259.

Kertz, A. F., L. R. Prewitt, A. G. Lane, and J. R. Campbell. 1968. Effect of dietary protein intake on creatinine excretion and the creatinine-nitrogen ratio in bovine urine. J. Anim. Sci. 30:278-282.

Kertz, A. F., M. K. Koepke, L. E. Davidson, N. L. Betz, J. R. Norris, L. V. Skoch, B. R. Rords, and D. T. Hopkins. 1989. Factors influencing intake of high urea-containing rations by lactating dairy cows. J. Dairy Sci. 65:587-604.

Khalili, H., and P. Huhtanen. 1991. Sucrose supplements in cattle given grass silage based diet. Digestion of organic matter and nitrogen. Anim. Feed Sci. Technol. 33:247-261.

Kim, K. H., J. Choung, and D. G. Chamberlain. 1999b. Effects of varying the degree of synchrony of energy and nitrogen release in the rumen on the synthesis of microbial protein in lactating dairy cows consuming a diet of grass silage and a cereal-based concentrate. J. Sci. Food Agric. 79:1441-1447.

Kim, K. H., S. S. Lee, and K. J. Kim. 2005. Effect of intraruminal sucrose infusion on volatile fatty acid production and microbial protein synthesis in sheep. Asian-Aust. J. Anim. Sci. 18:350-353.

Kim, K. H., Y.G. Oh, J. J. Choung and D. G. Chamberlain. 1999a. Effects of varying degrees of synchrony of energy and nitrogen release in the rumen on the synthesis of microbial protein in cattle consuming grass silage. J. Sci. Food Agric. 79:833-838.

Kim, K. H., S. S. Lee, B. T. Jeon, and C. W. Kang. 2000. Effects of the pattern of energy supply on the efficiency of nitrogen utilization for microbial protein synthesis inthe non-lactating cows consuming grass silage. Asian-Aust. J. Anim. Sci.13:962-966.

Kitessa, S., P. C. Flinn, and G. G. Irish. 1999. Comparison of methods used to predict the *in vivo* digestibility of feeds in ruminants. Aust. J. Agric. Res. 50:825-841.

Kotb, A. R., and T. D. Luckey. 1972. Markers in nutrition. Nutrition Abtracts and Reviews. 42:813-845.

Krishnamoorthy, U. T., V. Muscato, C. J. Sniffen, and P. J. Van Soest. 1982. Nitrogen fractions in selected feedstuffs. J. Dairy Sci. 65:217-225.

Krishnamoorthy, U., C. J. Sniffen, M. D. Stern, and P. J. Van Soest. 1983. Evaluation of a mathematical model of rumen digestion and an *in vitro* simulation of rumen proteolysis to estimate the rumen-undegraded nitrogen content of feedstuffs. Br. J. Nutr. 50:555-568.

Krishnamoorthy, U., H., Steingass, and K. H., Menke. 1991. Preliminary observation on the relationship between gas production and microbial protein synthesis *in vitro*. Arch. Anim. Nutr. 5:521-526.

Kunkle, W. E., J. T. Johns, M. H. Poore, and D. B. Herd. 2000. Effects of carbohydrate source, feed additives and feeding systems on response to supplements for cattle fed forage based diets. In: The Proceeding of 11th Annual Florida Ruminant Nutrition Symposium, University of Florida, Gainesville, FL.

Lean, I. J., T. K. Miller-Webster, W. Hoover, W. Chalupa, C. J. Sniffen, E. Evans, E. Block, and A. R. Rabiee. 2005. Effects of BioChlor and Fermenten on microbial protein synthesis in continuous culture fermenters. J. Dairy Sci. 88: 2524-2536.

Lees, J. A., J. D. Oldham, W. Haresign, and P. C. Garnsworthy. 1990. The effect of patterns of rumen fermentation on the response by dairy cows to dietary protein concentration. Br. J. Nutr. 63:177-186.

Leiva, E., M. B. Hall, and H. H. Van Horn. 2000. Performance of dairy cattle fed citrus pulp or corn products as sources of neutral detergent-soluble carbohydrates. J. Dairy Sci. 83:2866-2875.

Leng, R. A. 1970. Formation and production of volatile fatty acids in the rumen. In: Physiology of Digestion and Metabolism in the Ruminant. A.T. Phillipson, (ed.). Oriel Press. Newcastle-upon-Tyne.

Leng, R. A., and J. V. Nolan. 1984. Nitrogen metabolism in the rumen. J. Dairy Sci. 67:1072-1089.

Losada, H., and R. Alderete. 1977. Effect of cassava root meal and urealevel on the performance of steers grazed on poor quality pasture with free access to molasses. Trop. Anim. 4:47-50.

Lou, J., K. A. Dawson, and H. J. Strobel. 1997. Glycogen formation by the rumen bacterium *Prevotella ruminicola*. Appl. Environ. Microbiol. 63:1483-1488.

Lykos, T., G. A. Varga, and D. Casper. 1997. Varying degradation rates of total nonstructural carbohydrates: Effects on ruminal fermentation, blood metabolites, and milk production and composition in high producing Holstein cows. J. Dairy Sci. 80:3341-3355.

Mabjeesh, S. J., M., Cohen, and A., Arieli. 2000. *In vitro* methods for measuring the dry matter digestibility of ruminant feedstuffs: comparison of methods. J. Dairy Sci. 83:2289-2294.

Madsen, J., Hvelplund, T., Weisbjerg, M.R., Bertilsson, J., Spörndly, R., Olsson, I., Harstad, O.M., Volden, H., Tuori, M., Varvikko, T., Huhtanen, R., Olafsson, B.L., 1995. The AAT-PBV protein evaluation system for ruminants. A revision. Norwegian J. Agric. Sci. Suppl. 19:1-37.

Maeng, W. J., C. J. Van Nevel, R. L. Baldwin, and J. G. Morris. 1976. Rumen microbial growth rates and yields: Effect of amino acids and protein. J. Dairy Sci. 59:68.

Maiga, H. A., D. J. Schingoethe, and F. C. Ludens. 1995. Evaluation of diets containing supplemental fat with different sources of carbohydrates for lactating dairy cows. J. Dairy Sci. 78:1122-1130.

Mandebvu, P., J. L. Klingener, D. D. LaCoss, C. S. Ballard, C. J. Sniffen, and S. R. Kramer. 2001. Effects of source and level of nitrogen, and changing buffer/ruminal fluid at 48 h on *in vitro* digestion of feedstuffs. J. Dairy Sci. 93: 43-54.

Mansfield, H. R., M. D. Stern, and D. E. Otterby. 1994. Effects of beet pulp and animal by-products on milk yield and *in vitro* fermentation by rumen microorganisms. 77:205-216.

Maeng, W. C., C. J. Van Nevel, R. L. Baldwin, and J. G. Morris. 1976. Rumen microbial growth rates and yield: effect of amino acids and protein. J. Dairy Sci. 59:68-79.

Maeng, W.J., and Baldwin, R.L. 1976a. Factors influencing rumen microbial growth rates and yields: Effect of amino acid additions to a purified diet with nitrogen from urea. J. Dairy Sci. 59:648-655.

Maeng, W. J., and R. L. Baldwin, 1976b. Factors influencing rumen microbial growth rates and yields: Effects of urea and amino acids over time. J. Dairy Sci. 59:643-647.

Mahadevan, S., F. D. Sauer, and J. D. Erfle. 1987. Preparation of protease from mixed rumen microorganisms and its use for the *in vitro* determination of the degradability of true protein in feedstuffs. Can. J. Anim. Sci. 67:55-64.

Marounek, M., and D. Duskova. 1999. Metabolism of pectin in rumen bacteria *Butyrivibrio fibrisolvens* and *Prevotella ruminicola*. Appl. Micro. 29:429-433.

Marten, G. C., J. L. Halgerson, and D. A. Sleper. 1988. Nearinfrared reflectance spectroscopy evaluation of ruminal fermentation and cellulase digestion of diverse forages. Crop Sci. 28:163-167.

Matheron, C., A. M. Delort, G. Gaudet, T. Liptaj, E. Forano. 1999. Interaction between carbon and nitrogen metabolism in *Fibrobacter succinogenes* S85. A 1H and 13C NMR study. Appl. Environ. Microbiol. 65:1941-1948.

Maynard, L. A., and J. K. Loosli. 1975. Animal Nutrition (6th ed.). McGraw-Hill book company, New York.

Maynard, L. A., J. K. Loosli, H. F. Hintz, and R. G. Warner. 1979. Digestive processes in different species. In: Animal Nutrition. McGraw-Hill Inc., New York.

McAllan, A. B., and R. H. Smith. 1974. Bacterial carbohydrates formed in the rumen and their contribution to digesta entering the duodenum. Br. J. Nutr. 31:77-88.

McAnally, R.A. 1944. The determination of total volatile fatty acids in blood. J. Exp. Biol. 20:130-131.

McCormick, M. E., D. D. Redfearn, J. D. Ward, and D. C. Blouin. 2001. Effect of protein source and soluble carbohydrate addition on rumen fermentation and lactation performance of Holstein cows. J. Dairy Sci. 84:1686-1697.

McDonald, P., R. A. Edwards, J. F. D. Greenhalgh, and C. A. Morgan. 1995. Animal Nutrition. Addison Wesley Longman Ltd. Essex.

Mehrez, A. Z., E. R. Ørskov, and I. McDonald. 1977. Rates of rumen fermentation in relation to ammonia concentration. Br. J. Nutr. 38:437-443.

Melville, S. B., T. A. Michel, and J. M. Macy. 1988. Regulation of carbon flow in *Selenomonas ruminantium* grow in glucose-limited continuous culture. J. Bacteriol. 170:5305-5311.

Meng, Q., M. S. Kerley, P. A. Ludden, and R. L. Belyea. 1999. Fermentation substrate and dilution rate interact to affect microbial growth and efficiency. J. Anim. Sci. 77:206-214.

Menke, K. H., and H., Steingass. 1988. Estimation of the energetic feed value obtained from chemical analysis and gas production using rumen fluid. Anim. Res. Dev. 28:7-55.

Menke, K. H., L. Raab, A. Salewski, H. Steingass, D. Fritz, and W. Schneider. 1979. The estimation of digestibility and metabolizable energy content of ruminant feedstuffs from the gas production when they are incubated with rumen liquor *in vitro*. J. Agric. Sci. 193:217-225.

Mentink, R. L. P. C. Hoffman, and L. M. Bauman. 2006. Utility of Near-Infrared Reflectance Spectroscopy to predict nutrient composition and *in vitro* digestibility of total mixed rations. J. Dairy Sci. 89:2320-2326.

Merry, R. J., A. B. McAllan, and R.H. Smith. 1990. *In vitro* continuous culture studies on the effect of N source on rumen microbial growth and fibre digestion. Anim. Feed Sci. Technol. 31:55-64.

Mertens, D. R., and J. R. Loften. 1980. The effect of starch on forage fiber digestion kinetics *in vitro*. J. Dairy Sci. 63:1437-1446.

Milton C. T., R. T. Brandt, and E. C. Titgemeyer 1997. Urea in dry-rolled corn diets: Finishing steer performance, nutrient digestion, and microbial protein production. J. Anim Sci. 75:1415-1424.

Miron, J., E. Yosef, D. Ben- Ghedalia, L. E. Chase, D. E. Bauman, and R. Solomon. 2002. Digestibility by dairy cows of monosaccharide constituents in total mixed ration containing citrus pulp. J. Dairy Sci. 85:89-94.

Moloney, A. P., A. A. Almiladi, M. J. Drennan, and P. J. Caffrey. 1994. Rumen and blood variables in steers fed grass silage and rolled barley or sugar cane molasses-based supplements. Anim. Feed Sci. Technol. 50:37-54.

Mould, F. L., and E. R. Ørskov. 1983. Manipulation of rumen fluid pH and its influence on cellulolysis *in sacco*, dry matter degradation and the rumen microflora of sheep offered either hay or concentrate. Anim. Feed Sci. Technol. 10:1-14.

Mould, F. L., E. R. Ørskov, and S. O. Mann. 1984. Associative effects of mixed feeds. I. Effect of type and level of supplementation and the influence on the rumen fluid pH on cellulolysis *in vivo* and dry matter digestion on various roughages. Anim. Feed Sci. Technol. 10:15-30.

Murphy, J. J. 1999. The effects of increasing the proportion of molasses in the diet of milking dairy cows on milk production and composition. Anim. Feed Sci. Technol. 78:189-198.

Nagaraja, T. G., and E. C Titgemeyer. 2007. Ruminal acidosis in cattle: the current microbiologycal and nutritional outlook. J. Dairy Sci. 90:E17-E38.

Newbold, J. R., and S. R. Rust. 1992. Effect of asynchronous nitrogen and energy supply on growth of ruminal bacteria in batch culture. J. Anim. Sci. 70:538-546.

Nocek, J. E. 1988. In situ and other methods to estimate ruminal protein and energy digestibility: Review. J. Dairy Sci. 71:2051-2069.

Nocek, J. E., and J. B. Russell. 1988. Protein and energy as an integrated system. Relationship of ruminal protein and carbohydrate availability to microbial synthesis and milk production. J. Dairy Sci. 71:2070-2107.

Nocek, J. E., and S. Tamminga. 1991. Site of digestion of starch in the gastrointestinal tract of dairy cows and its effect on milk yield and composition. J. Dairy Sci. 74:3598-3629.

Nocek, J. E. 1997. Bovine acidosis: Implications on laminitis. J. Dairy Sci. 80:1005-1028.

Nombekela, S. W. and M. R. Murphy. 1995. Sucrose supplementation and feed intake of dairy cows in early lactation. J. Dairy Sci. 78:880-885.

Nombekela, S. W., M. R. Murphy, H. W. Gonyou, and J. I. Marden. 1994. Dietary preferences in early lactation cows as affected by primary tastes and some common feed flavors. J. Dairy Sci. 77:2393-2399.

NRC. 1989. Nutrient Requirements of Dairy Cattle. 6th rev. ed. National Academy Press, Washington, DC.

NRC. 1996. Nutrient Requirements of Beef Cattle. 7th rev. ed. National Academy Science Washington, DC.

NRC. 2001. Nutrient Requirements of Dairy Cattle. 7th rev. ed. National. Academy Science Washington, DC.

OAE. 2011, Forcasting result of livestocks by whole kingdom, crop year 2011, Office of Agricultural Economic, Ministry of Agricultural and Cooperatives, Bangkok, Thailand, .

Oba, M., and M. S. Allen. 2003. Effects of diet fermentability on efficiency of microbial nitrogen production in lactating dairy cows. J. Dairy Sci. 86:195-207.

Obara, Y., and D. W. Dellow. 1993. Effects of intraruminal infusions of urea, sucrose or urea plus sucrose on plasma urea and glucose kinetics in sheep fed chopped lucerne hay. J. Agric. Sci. (Camb.). 121:125-130.

Oliveira, A. S., R. F. D.Valadares, S. C. Valadares Filho, P. R. Cecon, L. N. Renno, A. C. Queiroz, , and M. L. Chizzotti. 2001. Microbial protein production, purine derivatives and urea excretion estimate in lactating dairy cows fed isoprotein diets with different non-protein nitrogen compounds levels. Rev. Bras. Zootec. 30:1621-1629.

Oltjen, R. R., James Bond, R. J. Gerrits, and L. A. Johnson. 1971. Growth and reproductive performance of bulls and heifers fed purified and natural diets. V. Free amino acids in the semen and blood plasma (puberty to 148 weeks of age). J. Anim. Sci. 33:60.

O'Mara, F. P., J. J. Murphy, and M. Rath. 1997. The effect of replacing dietary beet pulp with wheat treated with sodium hydroxide, ground wheat, or ground corn in lactating cows. J. Dairy Sci. 80:530-540.

Ordway, R. S., V. A. Ishler, and G. A. Varga. 2002. Effects of sucrose supplementation on dry matter intake, milk yield, and blood metabolites of periparturient Holstein dairy cows. J. Dairy Sci. 85:879-888.

Ørskov, E.R., and I. McDonald. 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. J. Agric. Sci. (Camb). 92:499-503.

Osborne, V. R., K. E. Leslie, and B. W. McBride. 2002. Effect of supplementing glucose in drinking water on the energy and nitrogen status of the transition dairy cows. Can. J. Anim. Sci. 82:427-433.

Otto, G., T. Hemme, S. Rojanasthien, and J. Younggad. 2006. The economicof milk production in Chiang Mai, Thailand, with particular emphasis on small-scale producers. International Farm Comparison Network (IFCN), FAO.

Owens, F. N., and W. G. Bergen. 1983. Nitrogen metabolism of ruminant animals: Historical perspective, current understanding and future implications. J. Anim. Sci. 57 (Suppl. 2):498-518.

Owens, F.N., R.A. Zinn, and Y.K. Kim. 1986. Limits to starch digestion in the ruminant small intestine. J. Anim. Sci.63:1634-1648.

Owens, V.N., K.A. Albrecht, R.E. Muck, and S.H. Duke. 1999. Protein degradation and fermentation characteristics of red clover and alfalfa silage harvested with varying levels of total nonstructural carbohydrates. Crop Sci. 39:1873-1880.

Pattarajinda, V., and M. Duangjinda. 2006. Dairy Feed and Least Cost Feed Formulation Program. Dept. Animal Science. Faculty of Agriculture, Khon Kaen Universitry.

Pan, J., T. Suzuki, S. Koike, K. Ueda, Y. Kobayashi, K. Tanaka, and M. Okubo. 2003. Effects of urea infused into the rumen on liquid- and particle-associated fibrolytic enzyme activities in steers fed low quality grass hay. Anim. Feed Sci. Technol. 104:13-27.

Pell, A.N., and Schofield, P. (1993) Computerized monitoring of gas production to measure forage digestion *in vitro*. J. Dairy Sci. 76:1063-1073.

Penner, G. B., K. A. Beauchemin, and T. Mutsvangwa. 2007. Severity of ruminal acidosis in primiparous Holstein cows during the periparturient period. J. Dairy Sci. 90:365-375.

Penner, G. B., and M Oba. 2009. Increasing dietary sugar concentration may improve dry matter intake, ruminal fermentation, and productivity of dairy cows in the postpartum phase of the transition period. J. Dairy Sci. 92:3341-3353.

Penner, G. B., L. L. Guan, and M. Oba. 2009. Effect of feeding fermenten on ruminal fermentation in lactating Holstein cows fed two dietary sugar concentrations. J. Dairy Sci. 92:1725-1733.

Perdok, H., and R. A. Leng. 1989 Rumen ammonia requirements for efficient digestion and intake of straw by cattle . In: The Roles of Protozoa and Fungi in Ruminant Digestion. J. V. Nolan, R. A. Leng, and D. I. Demeyer (eds.). Penambul Books, Armidale.

Pimpa, O., and J. B.Liang. 2004. Estimation of microbial protein supply of lactating dairy cows under smallholder farms in North-East Thailand using urinary purine derivative technique. In: Estimation of Microbial Protein Supply in Ruminants Using Urinary Purine Derivatives. H. P. Makkar, and S., Chen, X. B. (eds.), Kluwer Academic Publishers, Dordrecht.

Piwonka, E. J., J. L. Firkins, and B. L. Hull. 1994. Digestion in the rumen and total tract of forage-based diets with starch or dextrose supplements fed to Holstein heifers. J. Dairy Sci. 77:1570-1579.

Piwonka, E. J., and J. L. Firkins. 1996. Effect of glucose fermentation on fiber digestion by ruminal microorganisms *in vitro*. J. Dairy. Sci. 79:2196-2206.

Piwonka, E. J., J. L. Firkins, and B. L. Hull. 1994. Digestion in the rumen and total tract of forage-based diets with starch or dextrose supplements fed to Holstein heifers. J. Dairy Sci. 77:1570-1579.

Piva, G., and F. Masoero. 1996. Carbohydrates with different ruminal fermentability: starch and fibrous fractions. Zoot. Nutr. Anim. 22:215-229.

Poos, M. I., L. S. Bull, and R. W. Hemken. 1979. Supplementation of diets with positive and negative urea fermentation potential using urea or soybean meal. J. Anim. Sci. 49: 1417-1426.

Prasad, C. S., C. D. Wood, and K. T. Sampath. 1994. Use of *in vitro* gas production to evaluate rumen fermentation of untreated and urea treated finger millet straw (Eleusine coracana) supplemented with different levels of concentrate. J. Sci. Food Agric. 65:457-464.

Prevot, S., J. Senaud, J. Bohatier, and G. Prensier. 1994. Variation in the composition of the ruminal bacterial microflora during the adaptation phase in an artificial fermenter (Rusitec). Zool. Sci. 11:8718-8287.

Reynal, S. M., and G. A. Broderick. 2005. Effect of dietary level of rumen-degraded protein on production and nitrogen metabolism in lactating dairy cows. J. Dairy Sci. 88:4045-4064.

Ribeiro, C. V. D. M., S. K. R. Karnati, and M. L. Eastridge. 2005. Biohydrogenation of fatty acids and digestibility of fresh alfalfa or alfalfa hay plus sucrose in continuous culture. J. Dairy Sci. 88:4007-4017.

Robinson, P. H., M. Campbell, Mathews, and J. G. Fade. 1999. Influence of storage time and temperature on *in vitro* digestion of neutral detergent fibre at 48 h, and comparison to 48 h *in sacco* neutral detergent fibre digestion. Anim. Feed Sci. Technol. 80:257-266.

Rode, L. M., and L. D. Satter. 1988. Effect of amount and length of alfalfa hay in diets containing barley or corn on site of digestion and rumen microbial protein synthesis in dairy cows. Can. J. Anim. Sci. 68:445-454.

Rodriguez, L. A., C. C. Stallings, J. H. Herbein, and M. L. Mcgilliard. 1997. Diurnal variation in milk and plasma urea nitrogen in Holstein and Jersey cows in response to degradable dietary protein and added fat. J. Dairy Sci. 80:3368-3376.

Rogmanolo, D., C. E. Polan, and W. E. Barbeau. 1994. Electrophoretic analysis of ruminal degradability of corn proteins. J. Dairy. Sci. 77:1093-1099.

Rooke, J. A., N. H. Lee, and D. G. Armstrong. 1987. The effects of intraruminal infusions of urea, casein, glucose syrup and a mixture of casein and glucose syrup on nitrogen digestion in the rumen of cattle receiving grass-silage diets. Br. J. Nutr. 57:89-98.

Rooney, L. W., and R. L. Pflugfelder. 1986. Factors affecting starch digestibility with special emphasis on sorghum and corn. J. Anim. Sci. 63:1607-1623.

Russell, J. B. 1993. Glucose toxicity in Prevotella ruminicola: methylglyoxal accumulation and Its effect on membrane physiology. Appl. Environ Microbiol. 59:2844-2850.

Russell, J. B. 1998. Strategies that ruminal bacteria use to handle excess carbohydrate. J. Anim. Sci. 76:1955-1963.

Russell, J. B. 2002. Rumen microbiology and its role in ruminant nutrition. *Cited* in L. A. Carver. 2007. Sugar aids lactating dairy cattle production. Feed stuffs. 79: 1-3.

Russell, J. B., and C. J. Sniffen. 1984. Effect of carbon-4 and carbon-5 volatile fatty acids on growth of mixed rumen bacteria *in vitro*. J. Dairy Sci. 67: 987-994.

Russell, J. B., and D. B. Dombrowski. 1980. Effect of pH on the efficiency of growth by pure cultures of rumen bacteria in continuous culture. Appl. Environ. Microbiol. 39:604-610.

Russell, J. B. and H. J. Strobel. 1993. Microbial energetics. In: Quantitative Aspects of Ruminant Digestion and Metabolism. J. M. Forbes and J. France (eds.). CAB International, Wallingford, UK, pp. 165-186.

Russell, J. B. and T. Hino. 1985. Regulation of lactate production in *Streptococcus bovis*. J. Dairy Sci. 68:1712-1721.

Russell, J. B., J. D. O'Connor, D. G. Fox, P. J. Van Soest, and C. J. Sniffen. 1992. A Net Carbohydrate and Protein system for Evaluating Cattle Diets: I. Ruminal Fermentation. J. Anim. Sci. 70:3551-3561.

Sannes, R. A., M. A. Messman, and D. B. Vagnoni. 2002. Form of rumen-degradable carbohydrate and nitrogen on microbial protein synthesis and protein efficiency of dairy cows. J. Dairy Sci. 85: 900-908.

Sanson, D. W., D. C., Clanton, and I. G., Rush. 1990. Intake and digestion of low-quality meadow hay by steers and performance of cows on native range when fed protein supplements containing various levels of corn. J. Anim. Sci. 68: 595-603.

Santos, F. A. P., J. E. P. Santos, C. B. Theurer, and J. T. Huber. 1998. Effects of rumen-undegradable protein on dairy cow performance: A 12-year literature review. J. Dairy Sci. 81:3182-3213.

SAS. 1996. The SAS system, Version 6.2, SAS Institute, Inc., Cary, NC.

Satter, L. D., and L. L. Slyter. 1974. Effect of ammonia concentration on rumen microbial protein production *in vitro*. Br. J. Nutr. 32:199-208.

Schingoethe, D. J. 1991. Protein quality and amino acid supplementation in dairy cattle. In: The Proceeding of Southwest Nutrition Management Conference, Tempe, AZ.

Schwab, C.G. 1996. Rumen-protected amino acids for dairy cattle: Progress towards determining lysine and methionine requirements. Anim. Feed Sci. Technol. 59:87-101.

Schwab, C. G., C. K. Bozak, N. L. Whitehouse, and M. M. A. Mesbah. 1992. Amino acid limitation and flow to duodenum at four stages of lactation. 1. Sequence of lysine and methionine limitation. J. Dairy Sci. 75:3486-3502.

Schwingel, W. R., and D. B. Bates. 1996. Use of sodium dodecyl sulfate polyacrylamide gel electrophoresis to measure degradation of soluble soybean proteins by *Prevotella ruminocola* GA33 or mixed ruminal microbes *in vitro*. J. Anim. Sci. 74:475-482.

Seymour, W. M., D. R. Campbell, and Z. B. Johnson. 2005. Relationships betweenrumen volatile fatty acid concentrations and milk production in dairy cows: A literature study. Anim. Feed Sci. Technol. 119:155-169.

Shi, Y., and P. J. Weimer. 1992. Response surface analysis of the effects of pH and dilution rate on Ruminococcus flavefaciens FD-1 in cellulose-fed continuous culture. Appl. Environ. Microbiol. 58:2583-2591.

Shriver, B. J., W. H. Hoover, J. P. Sargent, R. J., Crawford, J. R., and W. V. Thayne. 1986. Fermentation of a high concentrate diet as affected by ruminal pH and digesta flow. J. Dairy Sci. 49:413-419.

Silva, R. M. N., R. F. D. Valadares, S. C. Valadares Filho, P. R. Cecon, L. N. Renno, and R. M. L.Veras. 2001. Urea for dairy cows: estimates of urinary volume, microbial production and urea excretion. Rev. Bras. Zootec. 30:1948-1957.

Sinclair, L. A., P. C. Garnworthy, J. R. Newbold, and P. J. Buttery. 1995. Effect of synchronizing the rate of dietary energy and nitrogen in diets with a similar carbohydrate composition on rumen fermentation and microbial protein synthesis in sheep. J. Agric. Sci. 124:463-472.

Slyter, L. L., R. R. Oltjen, D. L. Kern, and F. C. Blank. 1970. Influence of type and level of grain and diethylstilbestrol on the rumen microbial population of steers fed all concentrate diets. J. Anim. Sci. 31:996-1002.

Smith, W. R., I. Yu, and R. E. Hungate. 1973. Factors affecting cellulosis by *Ruminococcus albus*. J. Bacteriol. 114:729-737.

Sniffen, C. J., J. D., O'Connor, P. J., Van Soest, , D. G., Fox, and J. B., Russell. 1992. A net carbohydrate and protein system for evaluating cattle diets. II. Carbohydrate and protein availability. J. Anim. Sci. 70:3562-3577.

Sniffen, C. J., J. D. O'Connor, P. J. Van Soest, D. G. Fox, and J. B. Russell. 1992. A net carbohydrate and protein system for evaluating cattle diets. II. Carbohydrate and protein availability. J. Anim. Sci. 70:3562-3577.

Sniffen, C. J., J. B. Russell, and P. J. Van Soest. 1983. The influence of carbon source, nitrogen source and growth factors on rumen microbial growth. In: The Proceeding of Cornell Nutrition Conference for Feed Manufacturers, Cornell University, Ithaca, NY.

Sniffen, C. J., and P. H. Robinson. 1987. Microbial growth and flow as influenced by dietary manipulations. J. Dairy Sci. 70:425.

Sniffen, C. J., J. D. O'Connor, P. J. Van Soest, D. G. Fox, and J. B. Russell. 1992. A net carbohydrate and protein system for evaluating cattle diets: II. Carbohydrate and Protein availability. J. Anim. Sci. 70:3562-3577.

Solomon, R., L. E. Chase, D. Ben-Ghedalia, and D. E. Bauman. 2000. The effect of nonstructural carbohydrate and addition of full fat extruded soybeans on the concentration of conjugated linoleic acid in the milk fat of dairy cows. J. Dairy' Sci. 83:1322-1329.

Stern, M.D., and W.H. Hoover. 1979. Methods for determining and factors affecting rumen microbial protein synthesis: a review. J.Anim. Sci. 49:1590-1603.

Stern, M. D. 1986. Efficiency of microbial protein synthesis in the rumen. In: The Proceeding of Cornell Nutrition Conference for Feed Manufacturers, Cornell University, Ithaca, NY.

Stern, M. D., A. Bach, and S., Calsamiglia, 2006. New concepts in protein nutrition of ruminants. In: 21st Annual Southwest Nutrition and Management Conference. Tempe, AZ.

Stern, M. D., A. Bach, and S., Calsamiglia, 1997. Alternative techniques for measuring nutrient digestion in ruminants. J. Anim. Sci. 75:2256-2276.

Stewart, C. S., H. J. Flint, and M. P. Bryant. 1997. The rumen bacteria. In: The Rumen Microbial Ecosystem. P. N. Hobson and C. S. Stewart (eds.), Chapman and Hall, London.

Stewart, C. S., and M. P. Bryant. 1988. The rumen bacteria In: The Rumen Microbial Ecosystem. P. N. Hobson (ed.), Elsevier Appl. Sci., London.

Stokes, S. R., W. H. Hoover, T. K. Miller, and R. P. Manski. 1991. Impact of carbohydrate and protein level on bacterial metabolism in continuous culture. J. Dairy Sci. 74:860-870.

Storm, E., D. S. Brown, and E. R. Ørskov. 1983. The nutritive value of rumen microorganisms in ruminants. 3. The digestion of microbial amino and nucleic acids in, and losses of endogenous nitrogen from, the small intestine of sheep. Br. J. Nutr. 50:479-485.

Stouthammer, A. H., and C. Bettenhausen. 1973. Utilisation of energy for growth and maintenance in continuous and batch cultures of microorganisms. Biochim. Biophys. Acta. 301:53-70.

St-Pierre, N. R. 2001. Invited review: Integrating quantitative findings from multiple studies using mixed model methodology. J. Dairy Sci. 84:741-755.

Streeter, M. N., D. G. Wagner, F. N. Owens, and C. A. Hibberd. 1991. The effect of pure and partial yellow endosperm sorghum grains hybrids on site and extent of digestion in beef steers. J. Anim. Sci. 69:2571-2584.

Strobel, H. J., and J. B. Russell. 1986. Effect of pH and energy spilling on bacterial protein synthesis by carbohydrate-limited cultures of mixed rumen bacteria. J. Dairy Sci. 69: 2941-2947.

Susmel, P., M. Spanghero, B. Stefanon, and C. R. Mills, 1995. Nitrogen balance and partitioning of some nitrogen catabolites in milk and urine of lactating cows. Livest. Prod. Sci. 44:207-219.

Sutoh, M., Y. Obara, and S. Miyamoto. 1996. The effect of sucrose supplementation on kinetics of nitrogen, ruminal propionate and plasma glucose in sheep. J. Agric. Sci. (Camb.) 126:99-105.

Sutton, J. D. 1979. Rumen function and the utilization of readily fermentable carbohydrates by dairy cows. Trop. Anim. Prod. 4:1-12.

Sutton, J. D. 1989. Altering milk composition by feeding. J. Dairy Sci. 72:2801-2814.

Tamminga, S. 1979. Relation between different carbohydrates and microbial synthesis of protein. Institute for Livestock Feeding and Nutrition (Rep. No. 130):31.

Tamminga, S. 2006. The effect of the supply of rumen degradable protein and metabolizable proteinon negative energy balance and fertility in dairy cows. Anim. Reprod. Sci. 96:227-239.

Tamminga, S., W. M. Van Straalen, A. P. J Subnel, R. G. M Meijer, A. Steg, C. J. G. Wever, and M. C. Blok. 1994. The Dutch protein evaluation system: the DVE/OEB-system. Livest. Prod. Sci. 40, 139-155.

Terry, R. A., J. M. A. Tilley, and G. Outen. 1969. Effect of pH on cellulose digestion under *in vitro* conditions. J. Sci. Food Agric. 20:2023-2031.

Thanh, V. T. K., D. T. Phuong, T. T. T. Hong, P. T. Luu, N. M. Dung, H. Q. Hung, and E. R. Ørskov. 2004. Comparison of purine derivatives and creatinine in plasma and urine between local cattle and buffaloes in Vietnam. In: Estimation of Microbial Protein Supply in Ruminants Using Urinary Purine Derivatives. H. P. Makkar, and S., Chen, X. B. (eds.), Kluwer Academic Publishers, Dordrecht.

Theodorou, M. K., B. A. Williams, M. S. Dhanoa, and A. B. McAllan. 1991. A new laboratory procedure for estimating kinetic parameters associated with the digestibility of forages. In: The Proceeding of Int. Symp on Forage Cell Wall Structure and Digestibility, October 1991. USDA-ARS, Wisconsin.

Therion, J. J., A. Kistnor, and J. H. Kornelius. 1982. Effect of pH on growth rates of rumen amylolytic and lactilytic bacteria. Appl. Environ. Microbiol. 44:428-434.

Thomas, G. J. 1960. Metabolism of the soluble carbohydrates of grasses in the rumen of the sheep. J. Agric. Sci. 54:360-372.

Tilley, J. M. A., and R. A. Terry. 1963. A two-stage technique for the *in vitro* digestion of forage crops. J. Br. Grassl. Soc. 18:104-109.

Todorov, N., S. Atanassova, D. Pavlov, and R. Grisorova. 1994. Prediction of dry matter and protein degradability of forages by near infrared spectroscopy. Livest. Prod. Sci. 39:89-91.

Tomerska, H. 1971. Decomposition of pectin *in vitro* by pure strains of rumen bacteria. Acta Microbiol. Polon. 22:63-69.

Topps, J. H., and Elliott, R. C., 1965. Relationships between concentrations of ruminal nucleic acid and excretion of purine derivative by sheep. Nature 205:498-499.

Trevaskis, L. M., W. J. Fulkerson, and J. Gooden. 2001. Provision of certain carbohydrate-based supplements to pasture-fed sheep, as well as time of harvesting of the pasture, influences pH, ammonia concentration and microbial protein synthesis in the rumen. Aust. J. Exp. Agric. 41:21-27.

Trevaskis, L. M., W. J. Fulkerson, and K. S. Nandra. 2004. Effect of time of feeding carbohydrate supplements and pasture on production of dairy cows. Livest. Prod. Sci. 85:275-285.

Tyrrell, H. F., and J. T. Reid. 1965. Prediction of the energy value of cows milk. J. Dairy Sci. 48:1215-1223.

USDA. 2011. World agriculture supply and demand estimates. United State Department of Agriclture, April 8, 2011.

Vagnoni, D. B., G. A. Broderick, M. K. Clayton, and R. D. Hatfield. 1997. Excretion of purine derivatives by Holstein cows abomasally infused with incremental amounts of purines. J. Dairy Sci. 80:1695-1702.

Valadares, R. F. D., G. A. Broderick, S. C. Valadares Filho, and M. K. Clayton. 1999. Effect of replacing alfalfa silage with high moisture corn on ruminal protein synthesis estimated from excretion of total purine derivatives. J. Dairy Sci. 82: 2686-2696.

Vallimont, J. E., F. Bargo, T. W. Cassidy, N. D. Luchini, G. A. Broderick, and G. A. Vargar. 2004. Effect of replacing dietary starch with sucrose on ruminal fermentation and nitrogen metabolism in continuous culture. J. Dairy Sci. 87: 4221-4229.

Van der Linden, Y., N. O. Van Gylswyk, and H. M. Schwartz. 1984. Influence of supplementation of corn stover with corn grain on the fibrolytic bacteria in the rumen of sheep and their relation to the intake and digestion of fiber. J. Anim. Sci. 59:772-783.

Van Horn, H. H., M. B. Olayiwole, C. J. Wilcox, Barney Harris Jr., and J. M. Wing. 1976. Effects of housing, milk, feeding management, and ration formulation on calf growth and feed intake. J. Dairy Sci. 59:924-929.

Van Houtert, M. F. J. 1993. The production and metabolism of volatile fatty acids by ruminants fed roughages, a review. Anim. Feed Sci. Technol. 43:189-225.

Van Kessel, J. A., and J. B. Russell. 1996. The effect of pH on ruminal methanogenesis. FEMS Microbiol. Ecol. 20:205-210.

Van Keulen, J., and B. A. Young. 1977. Evaluation of acid-insoluble ash as a nutral marker in ruminant digestibility studies. 44:282-287.

Van Soest P. J., J. B. Robertson, and B. A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74:3583-3597.

Van Soest, P. J. 1994. Nutritional Ecology of the Ruminant (2nd ed.). Cornell University Press. Ithaca, NY.

Van Soest, P. J. 2006. Rice straw, the role of silica and treatments to improved quality. Anim. Feed Sci. Technol. 130:137-171.

Van Soest, P. J. and J. B. Robertson. 1985. Analysis of Forages and Fibrous Foods - A laboratory manual for Animal Science 613. Cornell University, Ithaca, NY.

Varga, G. A., W. H. Hoover, L. L. Junkins, and B. J. Shriver. 1988. Effects of urea and isoacids on *in vitro* fermentation of diets containing formaldehyde-treated or untreated soybean meal. J. Dairy Sci. 71:737-747.

Virtanen, A. I. 1966. Milk production of cows on protein-free feed. Science. 153:1603-14.

Voelker, J. A., and M. S. Allen. 2003. Pelleted beet pulp substituted for high-moisture corn: 1. Effects on feed intake, chewing behavior and milk production of lactating dairy cows. J. Dairy Sci. 86:3542-3552.

Vogel, K. P., J. F., Pedersen, S. D., Masterson, and J. J., Toy. 1999. Evaluation of a filter bag system for NDF, ADF, and IVDMD forage analysis. Crop Sci. 39: 276-279.

Voelker, J. A., and M. S. Allen. 2003. Pelleted beet pulp substituted for high-moisture corn: 3. Effects on ruminal fermentation, pH and microbial protein efficiency in lactating dairy cows. J. Dairy Sci. 86:3562-3570.

Varga, G. A. 2003. Soluble carbohydrates for lactating dairy cows. In: The Proceeding of Tri-State Dairy Nutrition Conference. Wayne, IN.

Varga, G.A., and P. Kononoff. 1999. Dairy rationing using structural and nonstructural carbohydrates: from theory to practice. In: The Proceeding of Southwest Nutrition Conference. Phoenix, AZ.

Wanapat, M., and O. Pimpa. 1999. Effect of ruminal NH_3-N levels on ruminal fermentation purinederivatives, digestibility and rice straw intake in swamp buffaloes. Asian-Aust. J. Anim. Sci. 12:904-907.

Weekes, T. E. C. and A. J. F. Webster. 1975. Metabolism of propionate in the tissues of the sheep gut. Br. J. Nutr. 33:425-438.

Whittet, K.M., 2004. Factors affecting the variability in urinary creatinine and purine derivative excretion in beef cattle. M.S. Dissertation. University of Nebraska, Lincoln, NE.

Wilman, D., and A., Adesogan. 2000. A comparison of filter bag methods with conventional tube methods of determining the *in vitro* digestibility of forages. Anim. Feed Sci. Technol. 84:33-47.

Wing, J. M., H. H. Van-Horn, S. D. Sklare, and B. Harris Jr. 1988. Effects of citrus molasses distillers solubles and molasses on rumen parameters and lactation. J. Dairy Sci. 71:414-420.

Wolin, M. J. 1960. A theoretical rumen fermentation balance. J. Dairy Sci. 43:1452-1452.

Yooyuenyong, W., K. Harinthranon, P. Tungjaipattana, N. Nijthavorn, W. Tisayathikom, N. Kulpreedarat, and N. Jutikitdecha. 2003. Manual of Practice "Standard Inspection for Dairy Farms and Production of Raw Milk in Thailand, 1999" for Farm Standard Certification Inspectors, P-DAINS- 001, Effective from 1 April 2003. Bureau of Livestock Standard and Certification, Department of Livestock Development, Bangkok, pp.10-26. (In Thai)

Zanton, G. I., M. T. Gabler, and A. J. Heinrichs. 2007. Manipulation of soluble and rumen-undegradable protein in diets fed to postpubertal dairy heifers. J. Dairy Sci. 90:978-986.

Zinn, R. A. 1991. Comparative feeding value of steam-flaked corn and sorghum in finishing diets supplemented with or without sodium bicarbonate. J. Anim. Sci. 69:905-916.

Zinn, R. A. 1995. Protein level, source, and non-protein nitrogen for feedlot cattle. In: The Proceedings of Plains Nutrition Council Symposium, Amarillo, TX. pp. 16-37.

Zinn, R. A., and F. N. Owens. 1986. A rapid procedure for purine measurement and its use for estimating net ruminal protein synthesis. Can. J. Anim. Sci. 66: 157-166.

Zinn, R. A., and F. N. Owens. 1993. Ruminal escape protein for lightweight feedlot calves. J. Anim. Sci. 71:1677-1687.

Ziolecki, A., H. Tomerska, and M. Wojciechowicz. 1972. Pectinolytic activity of rumen *Streptococci*. Acta Microbiol. 4:183-188.

Zubay, G. L. 1998. Biochemistry (4^{th} ed.). The McGraw-Hill Companies, New York.

APPENDICES

APPENDICES A

PUBLICATIONS

Buaphan Sirirat, V. Pattarajinda, M.A. Froetschel, M. Duangjinda, and Y. Opatpatanakit 2008. Effects of replacing dietary starch with sugar on nutrient digestibility and gas production technique. In: The Proceedings of the 13th Animal Science Congress, Asian-Asustralasian Association of Animal production Societies, September 22-26, Hanoi, Vietnam.

Buaphan Sirirat, Virote Pattarajinda, Monchai Duangjinda, and Yanin Opatpatanakit 2010. Effects of varying soluble protein and sugar concentration on ruminal fermentation and nutrients digestibility in crossbred steers. In: Proceedings of the 14th AAAP Animal Science Congress, Asian-Asustralasian Association of Animal production Societies, August 23-27, Taiwan, R.O.C.

Buaphan, S., M. A. Froestschel, V. Pattarajinda, M. Duangjinda, and Y. Opatpatanakit, 2011. Impact of forage variety and maturity at stage of harvest on *in vitro* rumen fermentation and microbial protein production. (Accepted for the 3rd International Conference on Sustainable Animal Agriculture for Developing Countries, July 26-29, 2011, Nakhonratchasima, Thailand).

Ross, C. L., M. A. Froetschel, S. Buaphan, S. Chinnasamy, and K. C. Das. 2010. Methane production, fermentation patterns and protozoa numbers *in vitro* as related to sources of rumen fluid from different cattle feeding systems and animal waste substrate digestion. J. Dairy Sci. Vol. 93, E-Suppl. 1: 509.

Sirirat Buaphan, and Virote Pattarajinda. 2008. Effect of replacing dietary starch with sugar on in vitro dry matter and fiber digestion. In: The Proceedings of 4th Animal Science/ Animal Husbandry Conference, January 25, Khon Kaen University, Khon Kaen.

Sirirat Buaphan, Virote Pattarajinda, Mark. A., Froetschel, Monchai Duangjinda, and Yanin Opatpatanakit. 2010. Quantifying *in vitro* microbial protein synthesis response to soluble carbohydrate feeding. In: The Proceedings of RGJ-Ph.D. Congress XI on "Research Towards Sustainability". April 1-3, 2010. Jomtien Plam Beach Resort, Pattaya, Chonburi, Thailand. pp. 319.

Sirirat Buaphan, Virote Pattarajinda, M.A. Froetschel, Monchai Duangjinda, and Yanin Opatpatanakit, 2008. Effects of replacing dietary starch with sugar on nutrient digestibility and gas production. Naresuan Agriculture J. Vol. 11 (suppl.): 457-462.

Sirirat Buaphan, Virote Pattarajinda, M.A. Froetschel, Monchai Duangjinda, and Yanin Opatpatanakit. 2011. The effects of soluble protein and sugar concentration on ruminal fermentation and nutrients digestibility in crossbred steers. J. Anim and Vet Adv. Vol. 10 (13): 1724-1730.

Virote Pattarajinda, and Sirirat Buaphan. 2009. Sweeten feed. J. Dairy. January-March, 2009, 26: 36-41. (In Thai).

APPENDICES B

LAB PROCEDURE

In Vitro Digestibility using the DAISY ^{II} Incubator (ANKOM Method)

1. Reagents

(a) Buffer Solution A:

	g/l
KH_2PO_4	10.0
$MgSO_4 7H_2O$	0.5
NaCl	0.5
$CaCl_2 2H_2O$	0.1
Urea (reagent grade)	0.5

(b) Buffer Solution B:

	g/l
Na_2CO_3	15.0
$Na_2S 9H_2O$	1.0

(c) Neutral Detergent Solution

2. Apparatus

(a) ANKOM DAISY^{II} Incubator

(b) Filtration device - F57 Filter Bags.

(c) Impulse bag sealer - 1915/1920 Heat Sealer.

(d) Thermos

(e) ANKOM $^{200/220}$ Fiber Analyzer

3. Procedure

Preparation of Filter Bags and Sample: Pre-rinse F57 filter bags in acetone for three to five minutes and completely air-dry. The acetone rinse removes a surfactant that inhibits microbial digestion. Weigh each F57 filter bag and record weight (W_1). Zero the balance and weigh 0.25g of sample (W_2) directly into filter bag. NOTE: For 48 hr studies a sample size of 0.5 g is acceptable. Heat seal bag closed and place in the digestion jar (up to 25 samples per jar). Samples should be evenly

distributed on both sides of the digestion jar divider. Include at least one sealed blank bag for correction factor (C_1).

Preparation of (combined) Buffer Solution: (For each digestion jar)

a) Pre-warm at 39°C both buffer solutions (A & B). In separate container add ~266 ml of solution B to 1330 ml of solution A (1:5 ratio). The exact amount of A to B should be adjusted to obtain a final pH of 6.8 at 39°C. No further adjustment of pH is necessary. Add 1600 ml of combined A/B mixture to each digestion jar.

b) Place the digestion jars with samples and buffer solution into Daisy^{II} Incubator and turn on heat and agitation switches. Allow temperature of digestion jars to equilibrate for at least twenty to thirty minutes.

Preparation of Inoculum and Incubation:

1. Preheat two 2 l thermos bottles by filling with 39°C water. Empty heated water just prior to collection of rumen inoculum. Using the appropriate collection procedure, remove at least 2000 ml of rumen inoculum and place in thermos. Include approximately two "fistfuls" of the fibrous mat from the rumen with your collection in one thermos.

2. Preheat a blender by filling with 39°C water. Empty the heated water just prior to pouring the rumen inoculum from the thermos into the blender. Purge the blender container with CO_2 gas and blend at a high speed for 30 seconds. The blending action serves to dislodge microbes that are attached to the mat and assure a representative microbial population for the *in vitro* fermentation. Filter the blended digesta through four layers of cheesecloth into a five-liter flask (pre-heated 39°C). Filter the remaining rumen fluid in the other thermos through four fresh layers of cheesecloth into the same five-liter flask. NOTE: Allow for extra cheesecloth around the edges to facilitate squeezing contents of filtered mat. The flask should be continually purged with CO_2 and continued during the transfer of the inoculum.

3. Remove one digestion jar from the Daisy ^{II} Incubator and add the 400ml of inoculum to the buffer solution and samples. Purge the digestion jar with CO_2 gas for thirty seconds and secure lid.

4. Repeat process for all digestion jars to be used. NOTE: Do not allow CO_2 gas to bubble through the buffered inoculum, rather use the CO_2 to form a gaseous blanket over the contents of the jar.

5. Incubate for 48 hours. The DAISY^{II} Incubator will maintain a temperature of 39.5°C ± 0.5. If temperature of jars varies greater than one degree then move incubator to a warmer location or place blanket or similar insulator over incubator.

6. At completion of incubation, remove jars and drain fluid. Rinse bags thoroughly with cold tap water until water is clear. Use a minimum of mechanical agitation.

7. When determining True Digestibility it is necessary to remove microbial debris and any remaining soluble fractions using Neutral Detergent Solution. After rinsing the bags in water place them in the ANKOM $^{200/200}$ Fiber Analyzer and follow the procedure for determining NDF. Record the post *in vitro* NDF weight as WB3B. NOTE: Bags can be stored in the refrigerator or freezer until NDF determinations can be performed.

4. Calculations:

$$\% \text{ IVDMD} = 100 - (W_3 - (W_1 \times C_1)) \times 100 \div (W_2 \times DM)$$

Where: W_1 = Bag tare weight

W_2 = Sample weight

W_3 = Final bag weight after In Vitro and sequential ND treatment

C_1 = Blank bag correction (final oven-dried weight ÷original blank bag weight

5. References

Robinson, P. H., M. Campbell, Mathews, and J. G. Fade. 1999. Influence of storage time and temperature on in vitro digestion of neutral detergent fibre at 48 h, and comparison to 48 h in sacco neutral detergent fibre digestion. Anim. Feed Sci. Technol. 80:257-266.

Neutral Detergent Fiber in Feeds (Filter Bag Technique)

1. Apparatus

1. Analytical Balance (capable of weighing down to 0.1 mg).

2. Oven: capable of maintaining a temperature of 102±2°C).

3. Digestion instrument: capable of performing the digestion at 100 ± 0.5°C and maintaining a pressure of 10-25 psi). The instrument must also be capable of creating a similar flow around each sample to ensure uniformity of extraction (ANKOM200, 65 rpm agitation, ANKOM Technology).

4. Filter bags: constructed from chemically inert and heat resistant filter media), capable of being heat sealed closed and able to retain 25 micron particles while permitting rapid solution penetration (F57, ANKOM Technology).

5. Heat sealer: sufficient for sealing the filter bags closed to ensure complete closure (1915, ANKOM Technology).

6. Desiccator pouch: collapsible sealable pouch with desiccant inside that enables the removal of air from around the filter bags (MoistureStop Weigh Pouch, ANKOM Technology).

7. Marking pen: solvent and acid resistant (F08, ANKOM Technology).

2. Reagents

1. Neutral Detergent Solution, add 30.0 g Sodium dodecyl sulfate, USP; 18.61g Ethylenediaminetetraacetic disodium salt, dihydrate; 6.81 g Sodium borate; 4.56 g Sodium phosphate dibasic, anhydrous; and 10.0 ml Triethylene glycol, in 1 l distilled H_2O. Check pH range to 6.9 to 7.1. Agitate and heat to aid solution.

2. Alpha-amylase (Heat-stable bacterial alpha amylase: activity = 17,400 Liquefon Units / ml) (FAA, ANKOM Technology).

3. Sodium sulfite (Na2SO3, anhydrous.

3. Preparation of sample

Grind samples in a centrifugal mill with a 2 mm screen or cutter type (Wiley) mill with a 1 mm screen. Samples ground finer may have particle loss from the filter bags and result in low values.

4. Procedure

1. Use a solvent resistant marker to label the filter bags. Weigh filter bag (W_1) and zero balance. Do not pre-dry filter bags; any moisture will be accounted for by the blank bag correction.

2. Weigh 0.45-0.55 g of prepared sample (W_2) directly in filter bag. Avoid placing the sample on the upper 4 mm of the bag.

3. Using a heat sealer, completely seal the upper edge of the filter bag within 4 mm of the top. Use sufficient heat to completely seal the filter bag and allow enough cool time (2 sec) before removing the bag from the heat sealer.

4. Weigh one blank bag and include in run to determine blank bag correction (C_1).

5. Place a maximum of 24 bags into the Bag Suspender. All nine trays should be used regardless of the number of bags being processed. Place three bags per tray and then stack trays on center post with each level rotated 120 degrees. Insert the Bag Suspender with bags into the fiber analyzer vessel and place the weight on top to keep it submerged. Prior to inserting the Bag Suspender, if the vessel temperature is warm from a previous run, add cold water and exhaust.

6. When processing 24 sample bags, add 1900- 2000 ml of ambient ND solution to the fiber analyzer vessel. If processing less than 20 bags, add 100 ml/bag of ND solution (use minimum of 1500 ml to ensure Bag Suspender is covered). Add 20 g (0.5 g/50ml of ND solution) of sodium sulfite and 4.0 ml of alpha-amylase to the solution in the vessel.

7. Turn Agitate and Heat on and confirm agitation. Set timer for 75 min and close lid. 9. At end of extraction, turn Heat and Agitate off. Open the drain valve (slowly at first) and exhaust hot solution before opening lid. The solution in the vessel is under pressure. The exhaust valve needs to be opened to release the pressure and solution prior to opening the lid.

8. After the solution has been exhausted, close the exhaust valve and open the lid. Add 1900ml of (70-90°C) rinse water and 4.0 ml of alpha-amylase to the first and second rinses. Turn Agitate on and rinse for 5 min. The lid may be sealed with the Heat on or left open with the Heat off. Repeat hot water rinses a total of three times.

9. When the rinsing process is complete remove the samples. Gently press out excess water from bags. Place bags in a 250 ml beaker and add enough acetone to cover bags and soak for 3-5 min. 12. Remove bags from acetone and place on a wire screen to air-dry. Completely dry in oven at 102±2°C (most ovens will complete drying within 2-4 hrs). Do not place bags in the oven until acetone has completely evaporated.

10. Remove bags from oven, place directly into a desiccator container. Cool to ambient temperature and weigh bags (W_3).

5. Calculations

$$\% \text{ NDF (as-received basis)} = \frac{(W_3 - (W_1 \times C_1)) \times 100}{W_2}$$

Where: W_1 = Bag tare weight

W_2 = Sample weight

W_3 = Dried weight of bag with fiber after extraction process

C_1 = Blank bag correction (final oven dried weight ÷original blank bag weight)

6. Notes

Caution: Powdered chemicals will irritate the mucous membranes. A dust mask and gloves should be worn when handling this chemical. Acetone is extremely flammable. Avoid static electricity and use a fume hood when handling.

7. References

Robinson, P. H., M. Campbell, Mathews, and J. G. Fade. 1999. Influence of storage time and temperature on in vitro digestion of neutral detergent fibre at 48 h, and comparison to 48 h in sacco neutral detergent fibre digestion. Anim. Feed Sci. Technol. 80:257-266.

Acid Detergent Fiber in Feeds (Filter Bag Technique)

1. Apparatus

1. Analytical Balance (capable of weighing 0.1 mg).

2. Oven, maintaining a temperature of 102 ± 2°C.

3. Digestion instrument (capable of performing the digestion at 100±0.5°C and maintaining a pressure of 10-25 psi). The instrument must also be capable of creating a similar flow around each sample to ensure uniformity of extraction (ANKOM^{200}, 65 rpm agitation, ANKOM Technology).

4. Filter bags (F57, ANKOM Technology).

5. Heat sealer: sufficient for sealing the filter bags closed to ensure complete closure (1915, ANKOM Technology).

6. Desiccator.

7. Marking pen (solvent and acid resistant; F08, ANKOM Technology).

2. Reagents

Acid Detergent Solution: add 20g cetyl trimethylammonium bromide (CTAB) to 1 l of 1*N* H_2SO_4 previously standardized (premixed chemical solution available from ANKOM). Agitate and heat to aid solution.

3. Preparation of sample

Grind samples in a centrifugal mill with a 2 mm screen or cutter type (Wiley) mill with a 1 mm screen. Samples ground finer may have particle loss from the filter bags and result in low values.

4. Procedure

1. Use a solvent resistant marker to label the filter bags. Weigh filter bag (W_1) and zero balance.

2. Weigh 0.45-0.55 g of prepared sample (W_2) directly in filter bag. Avoid placing the sample on the upper 4 mm of the bag.

3. Using a heat sealer, completely seal the upper edge of the filter bag within 4 mm of the top.

4. Weigh one blank bag and include in run to determine blank bag correction factor (C_1).

5. Place a maximum of 24 bags into the Bag Suspender. All nine trays should be used regardless of the number of bags being processed. Place three bags per tray and then stack trays on center post with each level rotated 120 degrees. Insert the Bag Suspender with bags into the fiber analyzer vessel and place the Bag Suspender weight on top to keep it submerged.

6. When processing 24 sample bags, add 1900-2000 ml of ambient temperature AD solution to the fiber analyzer vessel. If processing less than 20 bags, add 100 ml/bag of AD solution (use minimum of 1500 ml to ensure Bag Suspender is covered).

7. Turn Agitate and Heat ON and confirm agitation. Set timer for 60 min and close lid.

8. At end of extraction, turn Heat and Agitate off. Open the drain valve (slowly at first) and exhaust hot solution before opening lid.

9. After the solution has been exhausted, close the exhaust valve and open the lid. Add 1900-2000ml of (70-90°C) rinse water. Turn Agitate on and rinse for 5 min. The lid may be sealed with the Heat on or left open with the Heat off. Repeat 5 min. hot water rinses a total of three times or until water is neutral pH.

10. When the rinsing process is complete remove the samples. Gently press out excess water from bags. Place bags in a 250 ml beaker and add enough acetone to cover bags and soak for 3-5 min.

11. Remove bags from acetone and place on a wire screen to air-dry. Completely dry in oven at 102 ± 2°C (most ovens will complete drying within 2-4 hrs).Do not place bags in the oven until acetone has completely evaporated.

12. Remove bags from oven, place directly into a collapsible desiccant pouch and flatten to remove air. Cool to ambient temperature and weigh bags.

5. Calculations

$$\% \text{ ADF (as-received basis)} = \frac{(W_3 - (W_1 \times C_1)) \times 100}{W_2}$$

Where: W1 = Bag tare weight

W2 = Sample weight

W3 = Dried weight of bag with fiber after extraction process

C1 = Blank bag correction factor (final oven dried weight ÷original blank bag weight t)

6. References

Robinson, P. H., M. Campbell, Mathews, and J. G. Fade. 1999. Influence of storage time and temperature on in vitro digestion of neutral detergent fibre at 48 h, and comparison to 48 h in sacco neutral detergent fibre digestion. Anim. Feed Sci. Technol. 80:257-266.

Determination of Soluble Crude Protein in feedstuffs

1. Principle

The dried and milled sample is extracted with a borate-phosphate buffer pH 6.75 at 39°C for 1 hour. After centrifugation the soluble crude protein (SP) in the supernatant is determined using Kjeldahl or other suitable methods for total nitrogen determination. For silage samples the content of ammonium nitrogen should also be determined as a correction for loss of crude protein as ammonium nitrogen during drying is needed in the calculation of SP.

2. Reagents Only use reagents of recognized analytical grade

2.1 $NaH_2PO_4H_2O$

2.2 $Na_2B_4O_710H_2O$

2.3 Water: Distilled or deionised water

2.4 Borate-phosphate buffer (modified from Licitra et al., 1996), pH 6.75 ± 0.05. Dissolve in 900 ml of water 12.2 g of sodium dihydrogen phosphate and 8.91 g of sodium tetraborate. Check the pH with a pH-meter and if necessary adjust pH. Dilute in a 1000 ml volumetric flask to the mark with water. Prepare fresh buffer solution daily

2.5 Sulfuric acid, ρ20 1.84 g/ ml

2.6 Catalyst: Kjeltabs CF 5 g ($CuSO4 \cdot 5H2O$: Approximately 0.10 g Cu/ tablet, Thompson & Capper Ltd.) or equivalent.

2.7 Titrant for the auto-burette in the Kjeltech apparatus (0.1 mol/l HCl).

3. Apparatus

3.1 Analytical balance capable of weighing to the nearest 1 mg

3.2 Centrifuge test tubes, 50 ml, with lid

3.3 Dispenser or pipette 50 ± 0.5 ml

3.4 Water bath, thermostated at 39 ± 0.5°C (or incubating chamber, 39 ± 0.5°C)

3.5 Glass rods

3.6 Centrifuge suitable for the centrifuge tubes and capable of spinning at 3000 g (values of g is given for the bottom of the test tubes)

3.7 Pipette 20 ± 0.2 ml

3.8 Kjeldahl equipment or other equipment for total nitrogen determination in liquids

3.9 Heating block suitable for digestion of the samples

3.10 pH-meter, calibrated and capable of measuring pH to the nearest 0.01 pH unit

4. Sample preparation

The samples are dried as specified for the NorFor samples (< 60°C) and ground on a hammer mill to pass a 1 mm sieve.

5. Procedure

5.1 Weigh approximately 1.5 g of the test sample to nearest 1 mg in a centrifuge tube (See note 6.1).

5.2 Add 50 ± 0.5 ml borate-phosphate buffer, pre-heated to 39 °C in water bath, to the samples (See note 6.2)

5.3 A blank sample of 50 ml borate-phosphate buffer should be included in each series of samples

5.4 To hydrate the sample, mix the sample gently with e.g. a glass rod. Then put the lid on the tube and shake the sample thoroughly.

5.5 Incubate in a water bath or an incubating chamber at 39 ± 0.5 °C for 1 h ± 5 minutes. Shake the tubes manually every 15th minute.

5.6 Centrifuge the tubes at 3000 × g for 10 min (see note 6.3).

5.7 Pipette 20 ± 0.2 ml of the supernatant and transfer to Kjeldahl tubes.

5.8 Add salt/catalyst and the volume of sulphuric acid to the tubes according to the standard procedure in the lab. Some feed samples foam extensively when the acid is added. Foaming during digestion in the Kjeldahl analysis can be reduced if the acidified samples are allowed to stand at room temperature for 1-2 hours or over night.

5.9 Increase the temperature of the digestor stepwise, to prevent foaming of the samples. Do not include the time it takes to reach working temperature in the total digestion time.

5.10 Analyse the nitrogen content by Kjeldahl distillation.

5.11 Calculate the content of soluble crude protein

6. Notes

6.1 In the procedure 1.5 g sample and 50 ml buffer is recommended. If using the common 50 ml centrifuge tubes from Falcon, NUNC, Greiner etc the tube will be very full when using 50 ml of buffer and the shaking might be a problem. The recommendation is then to use 1.2 g sample and 40 ml of buffer. Depending on the facilities in the lab other multiples of this sample:buffer ratio could be used, e.g. 3 g of sample and 100 ml buffer.

6.2 Analytical steps 5.2-5.8 (sulfuric acid addition) should be performed in sequence without interruption.

6.3 Some insoluble particles (containing trapped air), particularly from forages may float on the surface after centrifugation, but if the supernatant is carefully pipetted the insoluble matter will not cause contamination. The particles may be removed with a spoon or a paper tissue. If still a problem the supernatant can carefully be poured into a beaker through a tea-strainer and then pipetted.

7. Calculations

The content of soluble crude protein per kg crude protein is calculated according to:

$$\frac{(V_1-V_0) \times c \times 14.007 \times 6.25 \times V_2 \times 1000}{m \times CP \times V_3}$$

Where:

V_0 = volume (ml) of HCl used for titration of blank sample

V_1 = volume (ml) of HCl used for titration of sample

V_2 = volume (ml) of buffer added in step 5.2

V_3 = volume (ml) of extract pipetted in step 5.7

c = concentration of titrant (mol/l)

m = sample size (g)

14.007 = MW for nitrogen (g)

6.25 = Factor for conversion of nitrogen content to crude protein

8. References

Krishnamoorthy, U. T., V. Muscato, C. J. Sniffen, and P. J. Van Soest. 1982. Nitrogen fractions in selected feedstuffs. J. Dairy Sci. 65: 217-225.

Licitra, G., T.M., Hernandez, P.J., Van Soest. 1996. Standardization of procedures for nitrogen fractionation of ruminant feeds. Anim. Feed Sci. Technol. 51: 347-358.

Sugar (Reducing sugar invert sugar and sucrose) in food

1. Principle: sugars having free aldehyde and/or ketone groups can react as a weak reducing agent and are termed reducing sugar. In boiling alkaline solution of cupper salt (such as Feling's solution) with a solution of reducing sugar, copper (II) can be reduced to copper (I) and the red precipitate of cuprous oxide is formed. The weight of reducing sugar is equivalent to the weight of cuprous oxide, can be obtained from Munson-Walker table. Sucrose is a disaccharide and can be hydrolyzed with acid to yield two monosaccharides, glucose and fructose. These monosaccharides are reducing sugars.

2. Modification

This method is modified as follows.

2.1 For inversion, using 5 ml conc HCl to hydrolyze (in water bath) at 65-70 ^{o}C for 15 min.

2.2 Use carrez I and carrez II solution in place of saturated lead acetate solution as clarifying agent.

2.3 Use 40 % sodium hydroxide solution in place of concentrated sodium hydroxide solution.

2.4 Volume of test solution is 250 ml in place of 200 ml.

3. Reagents

3.1 Copper sulfate solution (Fehling A solution): dissolve 34.639g $CuSO_4.5H_20$ in distilled water, dilute to 500 ml with distilled water in volumetric flask and filter through filter paper Whatman no. 41.

3.2 Alkaline tartrate solution (Fehling B solution): dissolve 173 g potassium sodium tartrate. $4H_2O$ (Rochelle salt) and 50 g sodium hydroxide in distilled water, dilute to 500 ml with distilled water in volumetric flask, let stand for 2 days and filter through filter paper Whatman no. 541.

3.3 Fehling's solution is prepared by mixing equal volumes of Fehling A solution and Fehling B solution immediately before use.

3.4 Hydrochloric acid, conc.

3.5 Carrez I solution: dissolve 3.60 g $K_4Fe(CN)_6.3H_2O$ in 100 ml distilled water.

3.6 Carrez II solution: dissolve 7.20 g $ZnSO_4.7H_2O$ in 100 ml distilled water.

3.7 Sodium hydroxide, 40 % (w/v).

3.8 Ethanol, 95 % (v/v)

4. Apparatus

4.1 Analytical balance, accurate to 0.1 mg.

4.2 Beaker, 50 and 400 ml.

4.3 Volumetric flasks, 100 and 250 ml.

4.4 Erlenmeyer flsk, 250 ml.

4.5 Pipettes, 5 and 25ml.

4.6 Graduated cylinder, 50 ml.

4.7 Suction flask, 500ml.

4.8 Sintered crucible.

4.9 Watch glass.

4.10 Hot plate

4.11 Filter paper Whatman no. 41 and 541.

4.12 Electrical air oven.

4.13 Disccator with effective desiccant.

5. Preparation of test sample

Solid sample: bring sample to room temperature, grind the laboratory sample and mix until homogeneous.

6. Procedure

6.1 Preparation of test solution.

6.1.1 Weigh sample (depends on the amount of reducing sugar) accurately in 50 ml beaker.

6.1.2 Quantitatively transfer to 250 ml volumetric flask and distilled water to about 2/3 volume.

6.1.3 Add 5 ml Carrez I solution and add 5 ml Carrez II solution. Shake vigorously after each addition then to volume.

6.1.4 Filter through filter paper Whatman no. 41 into 250 ml Erlenmeyer flask; discard the first 5 ml filtrate. Collect the filtrate for procedure (6.2 and 6.3).

6.2 Determination of reducing sugar.

6.2.1 Pipette 25 ml test sample solution (6.1.4) into 400ml beaker.

6.2.2 Add 25 ml distilled water and 50 ml Fehling's solution (3.3).

6.2.3 Cover with watch glass and keep on hot plate.

6.2.4 Heat to boil within 4 min, and continue boiling for exactly 2 min.

6.2.5 Filter through sintered crucible (previously dried in air oven at 100 ± 2°C for 30 minutes, cooled and weighed) by using suction and wash precipitate of cuprous oxide thoroughly with hot distilled water till alkaline free. Then rinse with about 5ml ethanol (3.8).

6.2.6 Dry sintered crucible with precipitate in air oven 100 ± 2°C for 30 min, cool in desiccator and weigh (W_1).

6.2.7 Carry on the blank as 10.2.1 to 10.2.6 by using distilled water in place of sample (W_2).

6.2.8 Calculate reducing sugar content as dextrose (W_3) from the weigh of Cu_2O precipitate obtained (W_1-W_2) and Munson-Walker table.

6.2.9 Calculate reducing sugar content as invert sugar (W_4) from the weight of Cu_2O precipitate obtained (W_1-W_2) and Munson-Walker table.

6.3 Determination of invert sugar.

6.3.1 Pipette 50 ml test sample solution (6.1.4) into 100 ml volumetric flask.

6.3.2 Add 5 ml conc. HCl little by little with shaking, hydrolyze at 65 - 70°C for 15 min in water bath (with continuously shake 3 min and let stand for 12 min).

6.3.3 Cool in cold distilled water bath after hydrolization finished.

6.3.4 Neutralize with sodium hydroxide (3.7) and dilute to volume.

6.3.5 Pipette 50 ml sample solution into 400 ml beaker.

6.3.6 Add 50 ml Fehling's solution (3.3), cover with watch glass and heat on hot plate to boil within 4 min. Continue boiling for exactly 2 minutes.

6.3.7 Filter through sintered crucible (previously dried in air oven at 100 ± 2°C for 30 minutes, cooled and weighed) by using suction and wash precipitate of cuprous oxide thoroughly with hot distilled water till alkaline free. Then rinse with about 5 ml ethanol.

6.3.8 Dry sintered crucible with precipitate in air oven at 100 ± 2°C for 30 min, cool in desiccator and weight (W_5).

6.3.9 Calculate total sugar content as invert sugar (W_6) from the weight of Cu_2O precipitate obtained (W_5-W_2) and Munson-Walker table.

7. Calculations

7.1 Reducing sugar as dextrose, g/100 g

$$= \frac{W_3 \times 250 \times 100}{25 \times \text{weight of sample}}$$

Where:

W_3 = weight of dextrose from Muson-Walker table (g).

7.2 Total sugar as invert sugar, g/100 g

$$= \frac{W_6 \times 100 \times 250 \times 100}{50 \times 50 \times \text{weight of sample}}$$

Where:

W_6 = weight of invert sugar from Muson-Walker table (g).

7.3 Sucrose, g/100 g

$$= \frac{(W_6\text{-}W_4) \times 100 \times 250 \times 100 \times 0.95}{50 \times 50 \times \text{weight of sample}}$$

Where:

W_4 = weight of reducing as invert sugar from Muson-Walker table (g).

W_6 = weight of invert sugar from Muson-Walker table (g).

8. References

AOAC. 2000. Official Method of Analysis of AOAC international 17th ed (method 925.35 (B)), Gaithersburg, MD, p.17.

CURRICULUM VITAE

Name: Ms. Sirirat Buaphan.

Date of birth: February 14, 1970.

Place of birth: Ubon Ratchathani, Thailand.

Home address: 3/273 Moo 6, Kamphaeng Saen District, Nakhon Phathom, 73140. Thailand.

Education:

Bachelor degree: Bachelor of Science (Agriculture), Faculty of Agriculture, Ubon Ratchathani University, Ubon Ratchathani, Thailand (1991-1994).

Master degree: Master of Science (Animal Science), Faculty of Agriculture, Kasetsart University, Bangkok, Thailand (1999-2002).

Doctoral degree: Ph.D (Animal Science), Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand (2006-2011).

Research involved:

Master degree research: Effect of increased contents of cassava chips in total mixed rations on thiocyanate, lactoperoxidase and microorganisms in raw milk of cows.

Doctoral degree research: Optimizing the availability of soluble protein and carbohydrate on ruminal fermentation, microbial protein synthesis and milk production of dairy cows fed low quality roughage.

Scholarship:

- Master degree study was funded by The Graduate School, Kasetsart University.
- Doctoral degree was funded by the Thailand Research Fund through the Royal Golden Jubilee Ph.D. Program.

Occupation: Researcher at Suwanvajokkasikit Aniamal Research and development Institue, Kasetsart University (1995-Present).