Annals of Tropical Research 35[1]:61-73(2013)

Performance of Growing Lambs as Influenced by Liquid Acid Whey Supplementation

Angie R. Poliquit and Serena L. Sanchez

Department of Animal Science, Visayas State University, Baybay City Leyte, 6521-A Philippines

ABSTRACT

Twelve male growing lambs were used in a randomized complete block design to determine the effects of feeding liquid acid whey (LAW) on the performance of the animal, its dry matter intake, nutrient digestibility, weight gain and ruminal pH. Animals received a diet consisting of Napier grass (*Pennisetum purpureum*, Schumacher). Treatments were Napier grass plus concentrate, Napier grass plus LAW and Napier grass plus concentrate plus LAW. Individual dry matter intake (DMI), biweekly weight gain (WG) and ruminal pH were measured. Diet digestibility was determined using the total collection method. Results showed that LAW increased ($p<0.05$) WG and diet digestibility (dry matter, organic matter and crude protein). Liquid acid whey had an average digestibility of 54.41% for dry matter, 83.94% for organic matter and 87.56% for crude protein. Ruminal pH two hours after feeding was stable for animals with LAW alone. However, DMI was similar ($p>0.05$) among treatments. It can be concluded that including LAW in the diet significantly improved WG, diet digestibility and ruminal pH without affecting DMI.

Keywords: lamb, acid whey, supplement, dry matter intake, ruminal pH, digestibility

Correspondence: A. R. Poliquit *Address:* Department of Animal Science, Visayas State University, Baybay City, Leyte, 6521-A Philippines *Tel:* 563-7125 *Email:* angiepoliquit@ymail.com
DOI: 10.32945/atr3515.2013

INTRODUCTION

Most of the farmers raise their sheep in extensive system without providing any supplementation. Usually, this type of production system causes reduced growth rate and poor reproductive performance in sheep, which in turn results in severe economic loss (Kabir *et al.*, 2004). Although majority of the nutrients required by sheep are from forages, when these forages are not available or are insufficient in protein and energy needed to support desirable performance, supplement should be provided. Supplements provide the energy, protein, vitamins and minerals required by sheep to achieve its desired level of performance with the goal of either adding nutrients in the forage consumed or increasing forage intake to fill the voids between nutrient demand and nutrients provided by the forage (Machen, 2005). The amount of supplementation used is determined by the type and quality of forages given, and is also dependent on accessibility of cheap good quality supplements.

One of the potential supplements in animal feeding both for monogastric and polygastric animals is the liquid whey. It is the liquid residue of cheese and casein production which comprises 80-90% of the total volume of milk and contains about half of the nutrients in the original milk comprising soluble protein, lactose, vitamins and minerals (Bylund, 1995).

The study aimed to discover the effect of liquid acid whey as supplement in growing lambs on the dry matter intake, growth performance, nutrient digestibility and ruminal pH.

MATERIALS AND METHODS

Collection and Storage of Liquid Acid Whey

Liquid acid whey was obtained from the Milk Processing Area of Philippine Carabao Center (PCC) at VSU. The collected liquid acid whey was immediately stored and cooled down to about 5°C to temporarily stop bacterial growth (Bylund, 1995).

Preparation of Liquid Acid Whey as Supplement

The stored whey was allowed to cool at room temperature for pH determination using Jenco pH pen. The pH pen was immersed for 5 min in a well-mixed whey sample before getting the value (Figure 1). Testing of pH was done daily prior to feeding to assure similar pH value of whey throughout the study. Whey was given daily in the morning as drench at 30% of the total dry matter intake of the animal.

Figure 1. Preparation and pH testing of liquid acid whey

Preparation of Concentrate Ration

A ground concentrate ration that was formulated to be used in the study was processed (ground and thoroughly mixed) from the VSU Feed Mill. Concentrate was given at 1.0% of the bodyweight of the animal.

Feed and chemical compositions of concentrate ration are presented in Tables 1 and 2, respectively.

Table 1. Feed composition of concentrate ration (as-fed) for growing lambs

)ÆB≤• §◎Æ¥	Amount (kg)	Percent of Mix
Corn, yellow (local)	12.617	11.547
Rice Bran, D_1	94.597	86.571
Limestone	[illegible]	1.401
Salt	0.526	0.481
Total	109.271	100.000

Nutrient requirement of growing lambs: 0.56 kg DMI, 0.38 kg TDN, 58 g CP, 2.9 g Ca and 1.9 g Total P (PHILSAN, 2003).

Table 2. Chemical composition (%) of concentrate ration for growing lambs

$ ≤π - °¥•≤	Ash	Crude Protein	Ether Extract	Crude Fiber
13.74	15.60	9.09	3.24	19.81

Experimental Design and Treatments

Twelve male growing lambs of the same breed (½ Merino: ¼ Dorset: ¼ Damara), at about five months old, were assigned to the dietary treatments following the Randomized Complete Block Design (RCBD). The following treatments had four replicates each: T_1 - *Ad libitum* Napier grass soilage, with concentrate supplement at 1.0% of body weight (DM basis); T_2 - *Ad libitum* Napier grass soilage, drench with liquid acid whey at 30% of dry matter intake; and T_3 - *Ad libitum* Napier grass soilage, drench with liquid acid whey at 30% of dry matter intake plus concentrate supplement at 1.0% of body weight (DM basis).

Feeding and Management of Experimental Animals

Cleaning and disinfection of the experimental site were done two weeks before confining the animals to prevent and control outbreak of diseases. Lambs were dewormed subcutaneously with Ivermectin at 0.02 ml per kg bodyweight (1 ml per 50 kg bodyweight) and were given intramuscular injection of vitamin AD_3E at 3 to 5 ml per head prior to the start of the experiment. Lambs were individually penned using bamboo slats and coconut lumber. Each pen was provided with feeding trough and waterer which were placed where they were accessible to the animal. Lighting was provided continuously. Fecal waste was collected and disposed regularly.

Growing lambs were fed through cut-and carry with Napier grass. Feeding was done twice a day at 7:00 A.M. and at 3:00 P.M for 90 days. Prior to the feeding trial, the animals were conditioned for a period of 14 days for adaptation. Drinking water was given to the animals *ad libitum*. Lambs' biweekly weights were also recorded.

Collection of Rumen Fluid

Rumen fluid was collected two hours before and after feeding and supplementation by means of human stomach tube (fringe 18 x 125 cm) inserted to the mouth of the animal. The collected fluid which was used for the determination of ruminal pH was done monthly (Figure 2).

Figure 2. Insertion of stomach tube for collection of rumen fluid for pH determination

Digestibility Trial

After the feeding trial, digestibilities of the diet were determined by the total fecal collection method. Feed refusals and feces were collected daily for 5 consecutive days from each animal. Feces were collected using a collection bag which was attached to the body of the animal by means of a harness(Figure 3).

Figure 3. Collection of feces from lambs for diet digestibility determination

Laboratory Analyses

Liquid acid whey sample was analyzed for ash, crude protein (CP), and ether extract (EE) according to the AOAC (1990). Total solids of whey were determined through gravimetric method. The pH of whey was determined by immersing a Jenco pH pen for 5 minutes in the sample.

Concentrate ration was subjected to proximate analysis for the determination of dry matter (DM), ash, CP, crude fiber (CF) and EE according to the AOAC (1990).

Napier grass and feces were analyzed for DM, ash, and CP according to the AOAC (1990). Digestibilities of nutrients were calculated as the difference between nutrient intake and fecal excretion of nutrients.

Data Analysis

Data gathered were analyzed by two-way analysis of variance (ANOVA). Comparison of treatment means was done using Tukey's Honestly Significant Difference (HSD) Test of Statistical Package for the Social Sciences (SPSS) version 16 computer package.

RESULTS AND DISCUSSION

Dry Matter Intake (DMI) of Napier Grass

Actual dry matter intakes of Napier grass, given in Table 3, were not statistically different (p>0.05) among treatments, which suggest that liquid acid whey had no negative effect on the palatability of forage, thus, intakes of lambs were not depressed.

Studies of Ben Salem and Fraj (2007) showed that feeding of liquid acid whey to Holstein dairy cows resulted to the increase of dry matter intake. However, other studies reported no effects on cows' dry matter intake when liquid whey or whey products replaced part of the concentrate diet (Remond *et al.*, 1978 and Coulon *et al.,* 1979 as cited by Ben Salem and Fraj, 2007).

Table 3. Monthly dry matter intake (kg) of lambs fed with Napier grass

4≤•°¥≠•Æ¥	First Month^{ns}	Second Month^{ns}	Third Month^{ns}
T_1 – Concentrate	35.50	40.86	43.92
T_2 - Liquid Acid Whey (LAW)	39.38	46.68	49.77
T_3 - Concentrate + LAW	31.33	37.22	39.66
p-value	0.291	0.261	0.181

Apparent Digestibility of Nutrients

Supplementing whey alone to growing lambs had a significant effect (p<0.05) on the apparent digestibilities of dry matter, organic matter, and crude protein. Results on nutrient digestibility of dry matter, organic matter and crude protein are presented in Tables 4, 5, and 6, respectively.

Lowest digestibility values were obtained from concentrate. Digestibility values for whey were highest among treatments. Anderson (1975) reported that the dry matter digestibility of whey in ruminants is excellent amounting to 87% when whey constitutes 30% of the total feed intake. Digestibility is associated with ruminal pH. Fuller (2004) noted that when rumen pH falls below 6.0, cellulolytic bacteria cannot digest the forage component of the ration.

Table 4. Dry Matter Digestibility (%) of Feeds

4≤•°¥≠•Æ¥	DM Intake (kg)	DM Excreted (kg)	DM Digestibility (%)
T_1 – Concentrate	2.91	1.86	36.14[c]
T_2 - Liquid Acid Whey (LAW)	3.02	1.38	54.41[a]
T_3 - Concentrate + LAW	3.01	1.50	50.09[b]
p-value			0.002

Figures with different letter superscripts are significantly different at Tukey's HSD at 0.05 level

Table 5. Organic Matter Digestibility (%) of Feeds

4≤•°¥≠•Æ¥	OM Intake (kg)	OM Excreted (kg)	OM Digestibility (%)
T_1 – Concentrate	2.34	0.71	69.46[c]
T_2 - Liquid Acid Whey (LAW)	3.27	0.53	83.94[a]
T_3 - Concentrate + LAW	2.36	0.57	75.89[b]
p-value			0.003

Figures with different letter superscripts are significantly different at Tukey's HSD at 0.05 level

Table 6. Crude Protein Digestibility (%) of Feeds

4≤•°¥≠•Æ¥	CP Intake (kg)	CP Excreted (kg)	CP Digestibility (%)
T_1 – Concentrate	1.37	0.29	78.51[c]
T_2 - Liquid Acid Whey (LAW)	1.91	0.24	87.56[a]
T_3 - Concentrate + LAW	1.38	0.24	82.79[b]
p-value			0.003

Figures with different letter superscripts are significantly different at Tukey's HSD at 0.05 level

Cumulative Weight Gain (CWG) of Lambs

Weight gain of lambs with whey supplementation significantly increased ($p<0.05$) the first, second, fourth and fifth biweekly gains, as shown in Table 7. Total weight gain is highest for lambs supplemented with whey, followed by whey plus concentrate.

Studies conducted by Herold and Szabó (1990) reported that when calves were fed with whey, an increase in weight gain by 20-25% was observed. In studies of Welch and Nilson (1973), steers fed with liquid whey free choice consumed 28 to 31% of their dry matter as whey and gained weight as rapidly as those fed with control ration. Anderson (1975) stated that the nitrogen in whey is converted in the rumen into microbial protein, which is the principal source of amino acids and has a good balance of essential amino acids. Metabolizable protein, mostly from the supply of microbial true protein, is needed by the animal for productivity such as growth.

Increase in weight gain is correlated to increase in dry matter intake and nutrient digestibility.

Table 7. Cumulative biweekly weight gain (kg) of lambs

4≤•°¥≠•Æ¥	First	Second	Third	Fourth	Fifth
T_1 – Concentrate	0.35[b]	0.75[b]	1.00	1.00[b]	0.80[b]
T_2 - Liquid Acid Whey (LAW)	0.55[a]	0.95[b]	1.35	1.35[a]	1.05[a]
T_3 - Concentrate + LAW	0.25[b]	0.90[ab]	1.15	1.05[b]	0.90[ab]
p-value	0.002	0.043	0.175	0.023	0.009

Figures with different letter superscripts are significantly different at Tukey's HSD at 0.05 level

Ruminal pH

Results for ruminal pH are presented in Table 8. Ruminal pH before feeding for the first and third months showed significant result ($p<0.05$). Ruminal pH for whey alone showed lowest value among treatments with stable results for second and third month. Ruminal pH after feeding showed significant results ($p<0.05$). Lambs with whey supplement had similar ruminal pH value from first to third month with 7.0 pH value. Result showed that ruminal pH for lambs with concentrate supplement had the lowest value among treatments.

Total ruminal pH value before feeding for whey was observed to be lowest among treatment which could be attributed to the DM intake of the animal. At a higher level of DM intake, the pH of the rumen is lower (Robinson *et al.,* 1986; Madsen and Hvelplund, 1988; Zhao *et al.,* 1993). Hutjens (1997) noted that rumen pH can drop as more substrates, such as starch, are available for microbial use increasing acid production. Higher feed intake leads to more fermentation acids produced in the rumen, which is not compensated by increased salivary secretions associated with increased chewing (Maekawa *et al.*, 2002b).

A small difference in ruminal pH value for whey before and after feeding was observed. According to Hutjens (1997), wet rations can reduce rumen pH due to less saliva production to wet the feed for swallowing in which less chewing is needed to reduce particle size, thereby, lowering rumination time. Lactose in whey is broken down rapidly by bacteria and protozoa in the rumen and is converted into lactic acid which influences ruminal pH (Thivend, 1978).

On the average, ruminal pH values before supplementation were higher compared to pH values after supplementation. Ruminal pH declines following a meal, the drop depending partly on the initial pH (Maekawa *et al.*, 2002a; Nocek *et al*., 2002). The pH of the rumen can vary from more than 7.0 on a roughage diet to less than 5.0 on a high grain diet (Russell and Dombrowski, 1980; Erfle *et al.*, 1982; Erdman, 1988). In an experiment conducted by Susmel *et al.* (1995) on six rumen fistulated, nonlactating Simmental cows, whey used alone caused a lower rumen pH at 1.5 and 3 hours after the morning meal. Ruminal pH generally continues to decline after feeding with the lowest rumen pH usually occurring 4-6 hours after feeding (Lindberg, 1981; Madsen and Hvelplund, 1988).

Erdman (1988) reported that the method of sampling has likewise an effect on rumen pH as rumen fluid samples by stomach tube tend to have a higher pH than those taken via a rumen fistula. The site of sampling and the time of post feeding probably have more extensive effects on rumen pH than molar proportions of VFA (Erdman, 1988).

Table 8. Monthly ruminal pH two hours before and after supplementation in lambs

4≤•°¥≠•Æ¥	1st Month		2nd Month		3rd Month	
	Before	After	Before	After	Before	After
T_1 - Concentrate	7.4^{b}	6.8^{a}	7.2	6.9^{a}	7.0^{a}	6.8^{a}
T_2 - Liquid Acid Whey (LAW)	7.2^{a}	7.0^{b}	7.1	7.0^{b}	7.1^{b}	7.0^{b}
T_3 - Concentrate + LAW	7.4^{b}	7.2^{c}	7.2	7.0^{b}	7.3^{c}	6.9^{a}
p-value	0.006	0.001	0.178	0.037	0.000	0.000

Figures with different letter superscripts are significantly different at Tukey's HSD at 0.05 level

Chemical Composition of Liquid Acid Whey

Chemical composition of liquid acid whey is presented in Table 9.

Table 9. Chemical composition (%) of liquid acid whey

∝(	Water	Total Solids	Ash	Crude Protein	Ether Extract	Nitrogen-Free Extract
4.8	88.78	11.22	1.47	0.76	0.21	8.78

In obtaining nitrogen-free extract (NFE), crude fiber (CF) is estimated at 0%

CONCLUSION AND RECOMMENDATIONS

Based on the results, it can be concluded that whey can be an economical alternative for concentrate in lamb rations without any negative effects on dry matter intake, ruminal pH, nutrient digestibility and weight gain.

A practical recommendation would be to collect rumen fluid for pH determination via rumen fistula and to determine ruminal pH 4-6 hours after feeding and supplementation to further examine changes in pH. It would be more reliable to collect rumen fluid via rumen fistula to really determine the exact ruminal pH value.

Research should continue to clearly determine optimum levels of whey to be used with different basal diets and develop studies on liquid acid whey with probiotics.

ACKNOWLEDGMENT

The authors would like to express their heartfelt gratitude to the Accelerated Science and Technology Human Resource Development Program–National Science Consortium (ASTHRDP-NSC) of DOST.

REFERENCES

ANDERSON, M. J. 1975. Metabolism of liquid whey fed to sheep. Jour. Dairy Sci. **58(12)**: 1856-1859

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS. 1990. Official methods of analysis. 15th ed. AOAC, Washington DC. **73**: 953

BEN SALEM, M. AND M. FRAJ. 2007. The effects of feeding liquid acid whey in the diet of lactating dairy cows on milk production and composition. Jour. Cell and Anim. Biol. **1(1)**: 7-10

BYLUND, G.1995. Dairy Processing Handbook. Tetra Pak Processing Systems, Sweden. pp. 331-333

ERDMAN, R. A. 1988. Dietary buffering requirements of the lactating dairy cow: a review. J. Dairy Sci. **71**: 3246-3266

ERFLE, J. D., R. J. BOILA, R. M. TEATHER, S. MAHADEVAN, AND F. D. SAUER. 1982. Effect of pH on fermentation characterisitics and degradation of rumen microorganisms in vitro. J. Dairy Sci. **65**: 1457-1464

FULLER, M. F. 2004. The Encyclopedia of Farm Animal Nutrition. UK: CAB International. pp. 489-490

Herold, I. AND P. Szabó. 1990. Feeding curd-whey to cattle. Állattenyésztés és Takarmányozás **39(2)**: 177-186

HUTJENS, M. F. 1997. Alberta Dairy Management: Rumen Acidosis. Dairy Extension Advisory Group. pp. 1-2

KABIR, F., M. S. SULTANA, M. SHAHJALAL, M. J. KHAN, AND M. Z. ALAM. 2004. Effect of Protein Supplementation on Growth Performance in Female Goats and Sheep under Grazing Condition. Pakistan Journal of Nutrition **3 (4)**: 237-239

LINDBERG, J. E. 1981. The effect of basal diet on ruminal degradation of dry matter, nitrogenous compounds and cell walls in nylon bags: Roughages and cereals in various proportions. Swedish J. agric. Res. **11**: 159-169

MACHEN, R. 2005. Supplementation of Browsing/Grazing Goats. A Gathering of Goat Producers IV. p. 3

MADSEN, J. AND T. HVELPLUND. 1988. The influence of different protein supply and feeding level on pH, ammonia concentration and microbial protein synthesis in the rumen of the cows. Acta. Agric. Scand. **38**: 115-125

MAEKAWA, M., K. A. BEAUCHEMIN AND D. A. CHRISTENSEN. 2002a. Effect of concentrate level and feeding management on chewing activities, saliva production, and ruminal pH of lactating dairy cows. J. Dairy Sci. **85**: 1165-1175

MAEKAWA, M., K. A. BEAUCHEMIN AND D. A. CHRISTENSEN. 2002b. Chewing activity, saliva production, and ruminal pH of primiparous and multiparous lactating dairy cows. J. Dairy Sci. **85**: 1176-1182

NOCEK, J. E., J. G. ALLMAN AND W. P. KAUTZ. 2002. Evaluation of an indwelling ruminal probe methodology and effect of grain level on diurnal pH variation in dairy cattle. J. Dairy Sci. **85**: 422-428

PHILIPPINE SOCIETY OF ANIMAL NUTRITIONISTS. 2003. Feed Reference Standards. 3rd Ed. PHILSAN. pp. 78-194

ROBINSON, P. H., S. TAMMINGA, AND A. M. VAN VUUREN. 1986. Influence of declining level of feed intake and varying the proportion of starch in the concentrate on rumen fermentation in dairy cows. Livest. Prod. Sci. **15**: 173-189

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

SUSMEL, P., M. SPANGHERO, C. R. MILLS AND B. STEFANON. 1995. Rumen fermentation characteristics and digestibility of cattle diets containing different whey:maize ratios. Volume 53, Issue 1. Elsevier Inc. pp. 81-89

THIVEND, P. 1978. Use of whey in feeding ruminants with particular reference to pollution problems. pp. 1-9

WELCH, J. G. AND K. M. NILSON. 1973. Feeding liquid whey to dairy cattle. Jour. Dairy Sci. **56**: 681

ZHAO, J. Y., M. SHIMOJO AND I. GOTO. 1993. The effects of feeding level and roughage/concentrate ratio on the measurements of protein degradability of two tropical forages in the rumen of goats, using the nylon bag technique. Anim. Feed Sci. Technol. **41**: 261-269