Voluntary Feed Intake in Goats of Foliages with varying pH Levels from Selected Trees and Shrubs

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Abstract- The quality of forage affects consumption, nutrient intake, and the resulting animal performance. Voluntary intake of tree/shrub forages as affected by their pH levels was investigated using 24 heads of goat. Several forages were analyzed for their pH level and were categorized as low (3.25-4.50) medium (4.51-5.76) and high (5.76-up) pH levels. Two samples in each category were used and was set-up in a randomized complete block design (RCBD). Voluntary feed intake (VFI) was established by adding 20% of the days offering based on previous days intake. The six (6) forages tested were Kakawate (*Gliricidia sepium*), Madre de agua (*Trichanthera gigantea*), Acacia (*Samanea saman*), Gmelina (*Gmelina arborea*), Robles (*Cassia siamea*) and Santol (*Sandoricum koetjape*). Forages with high pH levels that approximate the ideal level of ruminal pH such as Kakawate and Madre de agua, followed by Gmelina, had significantly higher intakes of dry matter (DM) both in actual amount and as percent body weight, organic matter (OM) and neutral detergent fiber (NDF) than those with low pH levels. Voluntary intake of crude protein (CP) among forages tested appeared to be not dependent on pH level. High pH level forages appeared to have a great potential as ruminant feed showing high levels of voluntary intake.

Index Terms- pH level, rumen fermentation, tree/shrub forages, Voluntary Feed Intake (VFI).

I. INTRODUCTION

Goat farming plays a significant role in poverty alleviation in the countryside. It is an attractive enterprise to many small hold farmers in the Philippines because aside from its minimal expense, it does not demand high capital investment for maintaining better production efficiency. Sixty-three percent of the world's total meat consumption can be credited to goat's meat (Laudan, 2008). The increasing demand for goat meat in the local market encourages raisers to produce more, thus, more backyard farmers are becoming big entrepreneurs.

A goat's natural diet is the foliage from grasses, legumes, trees and shrubs. The forage species that they subsist on can be found in pasture gardens, live fences, hedgerows of contour farms, plantation crops or in sylvo-pastoral systems. According to Nowak (2008), sylvo-pastoral systems can offer an economically smart timber-livestock production package for farmers by providing annual income from meat goats and sustainable browse systems and timber from trees (Devendra and Burn, 1983).

Variances in the voluntary forage intake are undeniably the main dietary factor determining level and efficiency of ruminant production. Voluntary intake is affected by animal aspects, environment and plant/forage factors. Animal nutrition is dependent on one of the animal factors affecting, the animal's nutritive requirement (Allison, 1985). While environment affects voluntary intake in such a way that an environment is full of stress factor that causes fatigued in seeking, ingesting, chewing and ruminating their feed (Preston and Leng, 1997).

Forage quality is an expression of a characteristic that refers to how well animals eat a forage and how efficiently the nutrients in the forage are changed into animal products (Fulgueira et al., 2007). Thus the greatest measure of forage quality is the productivity of animal, which is affected by feed and nutrient intake, digestibility and utilization efficiency (Fulgueira et al., 2007). However, some forages are rejected because of its indigestible lignin, unwanted smell (Preston and Leng, 1997), secondary metabolites such as tannin content or because of the forage pH level (Cherney, 2000; Ba and Ngoan, 2003) . That the quality of roughage reveals a close relationship with rumen environment, microbes and fermentation patterns (Wanapat, 2000). And the pH level of the forage is reflected to be a parameter that best defines the quality and fermentation rate, and successful conservation of forages with moisture contents higher than 65% (Fulgueira et al., 2007).

The rumen pH affects not only fermentation products, but also the growth rates of bacteria (Hobson, 1972). Low pH grain or forage derived products (e.g., initially low pH grain silage or haylage) can cause rumen pH problems such as clinical or subclinical acidosis (Williams, 2010). When ruminal pH decreases below uncomfortable level, fiber digestion declines dramatically and, therefore, decreases voluntary feed intake (Beauchemin, 2011). The characteristic of feedstuffs such as pH, starch content and availability, moisture, crude protein and fat content, can have a marked effect on VFA, ruminal pH, and microbial protein production, and eventually growth of the animal (Wanapat, 2000). Since rumen pH plays an important role in rumen fermentation, the pH level of the forage must be connected to its acceptability or voluntary intake and as it triggers changes in ruminal pH. There is, therefore, a need to determine the relationship between pH level and voluntary intake of foliage from shrubs and trees in goats.

II. METHODOLOGY

A. Measurement of Foliage pH

Fresh leaves from different trees and shrubs forages were individually placed in a blender and homogenized for easy extraction of the juice. The juice was collected and placed in clean container for pH determination. Right after pH determination, the forages were categorized according to the pH levels as low, medium and high (Table I). Two samples in each category were selected for the experiment on acceptability.

Table I. The pH Levels of Different Trees and Shrubs Tested

Categories	Tree Leaves	Scientific Name	pH levels
Low (pH 3.25-4.50)	**Robles**	***Cassia siamea***	**3.73**
	Santol	***Sandoricum koetjape***	**3.45**
	Mango	*Mangifera indica*	4.38
	Talisay	*Terminalia catappa*	4.38
Medium (pH 4.51-5.76)	Kalumpit	*Terminalia microcarpa*	4.89
	Pili	*Canarium ovatum*	4.94
	Mahogany	*Swietenia mahagoni*	5.18
	Molave	*Vitex parviflora*	5.19
	Alagaw	*Premna odorata*	5.24
	Caimito	*Chrysophyllum cainito*	5.45
	Acacia	***Samanea saman***	**5.43**
	Pagatpat	*Sonneratia alba*	5.50
	Duranta	*Duranta erecta*	5.56
	Gmelina	**Gmelina arborea**	**5.69**
	Jackfruit	*Artocarpus heterophyllus*	5.72
High (pH 5.76- up)	Gumamela	*Hibiscus rosa-sinensis*	5.80
	Kakawate	***Gliricidia sepium***	**7.06**
	Mulberry	*Morus sp.*	7.16
	Thrichanthera	***Trichanthera gigantea***	**7.47**

B. Preparation of Experimental Area and Test Animals

The experiment on acceptability used open-top metabolism cages (Bestil, 2009, Bestil, 1985) to accurately measure voluntary feed intake. The individual cages were cleaned and disinfected prior to the placing of animals. The goats, aging about 5-8 months old, were dewormed before the conduct of the study to combat internal parasitism.

C. Treatments and Experimental Design

Randomized complete block design (RCBD) was used in the study with sex/ breed/ age combination of the experimental animals and site of the experiment as basis for blocking. Each treatment was replicated four times.

The following treatments were applied to growing goats based on the results of the analysis of pH content:

Forage species 1 – Kakawate (high pH)
Forage species 2 - Trichanthera (high pH)
Forage species 3 - Acacia (medium pH)
Forage species 4 – Gmelina (medium pH)
Forage species 5 – Robles/Tadios (low pH)
Forage species 6 – Santol (low pH)

D. Measurement of Acceptability

There are many factors governing acceptability of forages which may include: a) physical, b) chemical interacting with c) animal factors. Overall acceptability was measured in terms of voluntary intake where test forages were offered ad libitum by giving 15-20% allowance based on the previous day's intake (Bestil, 2009, Bestil, 1985).

E. Laboratory Analyses

Samples of the foliage's (leaves) were analyzed according to the established protocol of AOAC (1990). Cell wall components (NDF) were determined according to the method of Van Soest et al., (1991). DM content was analyzed in the laboratory using a convection oven set at 100^0 Celsius for about 24 hours (Bestil, 2009). Organic matter (OM) was determined by ashing leaves in a muffle furnace at 550^0 Celsius for 6 hours. Crude protein was analyzed by micro-kjeldahl method and calculated as N x 6.25 by AOAC (1990).

F. Data Gathered and Analysis

1. pH level of the foliage/forage
2. Ruminal pH of goats
   This was done by collecting rumen fluid through stomach tubing.
3. Nutrient composition:
   a. % DM
   b. % CP
   c. %OM
   d. % NDF
4. Voluntary Dry Matter Intake (DMI)
   DMI, kg = [(Feed given × DM of given) – (Feed refused × DM of refused)]
5. Dry Matter Intake as % Body Weight)
   DMI is computed to account the variations in body size affecting voluntary DMI.

$$\text{DMI, BW} = \frac{\text{Dry Matter Intake, kg}}{\text{Liveweight, kg}}$$

6. Nutrients (OM, CP, NDF) intake
   Nutrient intake, kg = DMI x % nutrient of the feed

G. Data Analysis

Data was analyzed using two-way ANOVA. Comparison of treatment means were done by Least Significant

Difference (LSD) test using the Statistical Package for Social Sciences (SPSS) ver. 15 and Statistic 6.

III. RESULTS AND DISCUSSIONS

Voluntary Dry Matter Intake of Tree/Shrub Forages with Varying pH Levels

The voluntary dry matter intake (DMI) of goats fed with different tree/shrub forages with varying pH and crude protein levels is presented in Table II. It was noted that the crude protein content of the forage did not show a definite pattern of effects on voluntary intake, while pH content did. Daily DMI showed significant difference and forages having highest pH level that approximate the ideal rumen pH of 5.5 to 7.0 for faster microbial growth and better fiber digestion (Solaiman, 2010) had significantly higher DM intake. Kakawate and Trichanthera with high pH levels obtained the highest voluntary intake followed by Gmelina with pH level 5.69 (medium), while Robles, Santol and Acacia had the lowest voluntary intake among the forages tested.

When voluntary dry matter intake of forages from trees/shrubs of varying pH contents was expressed as percent body weight to account for differences in body size affecting voluntary intake, results showed a similar pattern of differences as that of dry matter intake. Forages of high pH levels such as Kakawate and Trichanthera had significantly higher values than forages with medium and low pH levels (Table II).

Table II. Voluntary Feed Intake and Dry Matter Intake of Goats Fed with Different Trees/ Shrub with Varying pH Contents

Treatments	pH Levels	CP (%)	pH content	DMI (Kg)	DMI (% BW)
Kakawate *Gliricidia sepium*	High pH	19.76	7.06	0.80a	5.41a
Trichanthera *Trichanthera giganthea*		18.95	7.47	0.79a	6.05a
Acacia *Samanea saman*	Medium pH	26.71	5.43	0.31d	2.48c
Gmelina *Gmelina arborea*		16.74	5.69	0.55b	4.27b
Robles/Tadios *Cassia siamea*	Low pH	16.53	3.73	0.30d	2.50c
Santol *Sandoricum koetjape*		8.07	3.45	0.50c	3.87b
p-value				0.000**	0.000**

Means of the same letter superscripts within a column are not significantly different

The intake of Santol and Robles forages with low pH level may have decreased the rumen pH (Wanapat, 2000) and when ruminal pH decreases below 6.0, fiber digestion declines dramatically, causing decreases in voluntary feed intake (Beauchemin, 2011).

However, it should not be construed that all forages having high pH are highly acceptable to ruminants because too acidic or too basic rumen environment will cause the microbial enzymes to decrease their effectiveness, potentially stopping them from functioning altogether and consequently causing fermentation failure (Beauchemin, 2011).

Although Acacia has a pH level falling within the ideal pH range of 5.5-7.0 (Solaiman, 2010), voluntary intake was low, and the most likely explanation would be the presence of secondary metabolites that affected the acceptability of the forages. Intake of plant secondary metabolites at high level reduces the nutrient utilization, feed efficiency and animal productivity (Cherney, 2000). Other factors also influence acceptability and voluntary feed intake. The smell is often the most important factor that affects feed intake especially of forages with low pH as they give off an acidic or sour smell from volatile materials when stored for two or more days. This makes them unpalatable to the animals (Preston and Leng, 1997).

Voluntary Intake of other Nutrients (OM, NDF and CP)

Table III presents the voluntary intake of organic matter (OM), neutral detergent fiber (NDF), and crude protein (CP) of goats fed with different tree/shrub forages with varying pH contents. There were significant differences in voluntary intake of OM and NDF as affected by the pH content of the forages. Although higher CP intake were obtained from forages containing high pH levels than those containing low pH, differences were insignificant and CP intake appeared to be largely affected by the CP content of forages rather than their pH contents.

Table III. Voluntary Intake of OM, NDF and CP of Goats Fed with Different Trees/Shrubs with Varying pH Contents

Treatments	Forage pH	DM (%)	OM (%)	NDF (%)	CP (%)	OMI (Kg)	NDFI (Kg)	CPI (Kg)
Kakawate	7.06	19	91.44	21.11	19.76	0.73^{a}	0.17^{b}	0.16
Trichantera	7.47	17	79.16	23.26	18.95	0.62^{b}	0.18^{a}	0.15
Acacia	5.43	40	94.20	37.79	26.71	0.30^{e}	0.12^{d}	0.25
Gmelina	5.69	24	93.20	20.77	16.74	0.52^{c}	0.12^{d}	0.09
Robles	3.73	42	90.81	30.02	16.83	0.26^{f}	0.08^{e}	0.05
Santol	3.45	28	88.74	26.46	8.07	0.44^{d}	0.13^{c}	0.04
p- value						*0.000***	*0.000***	*0.30^{ns}*

Means of the same letter superscripts within a column are not significantly different

The voluntary intake of OM and NDF showed a similar pattern of differences as that of DM intake (Table III). Forages having high pH levels, such as Trichanthera and Kakawate had significantly higher voluntary intakes of OM and NDF than forages with medium and low pH contents such as Santol, Robles, Gmelina and Acacia. Again, such differences can be attributed to differences in pH contents (Williams, 2010; Solaiman, 2010) presence of secondary metabolites (Cheema et al., 2011; Makkar, 2003) and the acid or sour smell of forage with low pH (Preston and Leng, 1997).

Changes in Rumen pH of Goats

Presented in Table IV is the rumen pH of goats obtained two (2) hours before and after feeding as affected by the varying pH levels of forages and its relationship to DM intake. It was observed that rumen pH of goats was slightly higher before feeding than after feeding. Table 4, also shows that rumen pH of goats fed with forages of varying pH levels were almost similar irrespective of the foliage pH level, although ruminal pH in goats fed with forages having high pH level had slightly higher values compared to those receiving forages with low to medium pH levels before and after feeding time. The study conducted by Beauchemin (2011) lends support to these results, showing that ruminal pH is high before the morning feeding because of intensive rumination and limited feed intake occurring at night. After feeding, however, rumen pH drops and the extent of this decline depends on the particle size and fermentability of the feed.

Table IV. Rumen pH of Goats before and after Feeding Forages from Different Trees/Shrubs of Varying pH Contents

Treatments	Forage pH	Rumen pH Before Feeding	Rumen pH After Feeding
Kakawate	7.06	7.68	6.92
Trichantera	7.47	8.18	7.15
Robles	5.43	7.25	6.55
Santol	5.69	7.15	6.45
Acacia	3.73	7.5	6.87
Gmelina	3.45	7.42	6.75

IV. CONCLUSION

Forages with high pH levels appeared to have great potential as ruminant feed, being more acceptable and showing high levels of voluntary intake for DM, OM and NDF. The forages tested that appeared to be more acceptable were Kakawate and Trichanthera with a pH level of 7.06 and 7.47 followed by Gmelina with pH level of 5.69 (medium).

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