ສຶກສາອົງປະກອບທາງເຄມີ, ຄຸນຄ່າທາງທາດອາຫານ ແລະ ຄວາມສາມາດໃນການຍ່ອຍໄດ້ ຂອງວັດຖຸດິບອາຫານສັດ ຢູ່ພາກເໜືອ ຂອງ ສປປ ລາວ: ແຂວງຫຼວງພະບາງ ແລະ ໄຊຍະບຸລີ

ນາປະເສີດ ວົງສະຫງວນ[1], ບຸນເລີດ ສີວິໄລ[1], ດາວວີ ກອງມະນີລາ[1] ແລະ ສັງຄົມ ອົນທະປັນຍາ[2]

ບົດຄັດຫຍໍ້

ຈຸດປະສົງຂອງການຄົ້ນຄວ້າຄັ້ງນີ້ ເພື່ອສຶກສາເຖິງອົງປະກອບທາງເຄມີ, ຄຸນຄ່າທາງທາດອາຫານ ແລະ ຄວາມສາມາດໃນການຍ່ອຍໄດ້ ຂອງວັດຖຸດິບອາຫານສັດ ໂດຍໃຊ້ວິທີການວັດແທກປະລິມານທາດອາຍທີ່ເກີດຂຶ້ນ ໃນຫ້ອງປະຕິບັດການ. ການທົດລອງຄັ້ງນີ້ ໄດ້ນຳໃຊ້ຕົວຢ່າງທັງໝົດ 27 ຕົວຢ່າງ ເຊິ່ງແບ່ງອອກ ເປັນ 3 ກຸ່ມ ຄື: ກຸ່ມອາຫານຫຍາບ ໄດ້ແກ່ T7: ຫຍ້າຊ້າງ (*Pennisetum purpureum*), T9: ຫຍ້າຍຸງ (*Microstegium ciliatum*), T10: ເຂມ (*Bambusa spp.*), T11: ເລົ້າ (*Miscanthus floridulus*), T17: ແຝກ (*Cymbopogon nardus var.*), T18: ສ່າໄລ່, T38: ພາກຄວາຍ (*Eleusine indica*), T39: ພາກຄວາຍໃຫຍ່ (*Eleusine spp.*), T40: ກວາເຕມາລາ (*Tripsacum lascum*); ກຸ່ມ ອາຫານທາດ ຊຶ້ນໄດ້ແກ່ T21: ເຄືອຈີ້ຈ້ໍ, T23: ຫຍ້າຫຍຸບ (*Desmanthus virgatus*), T24: ເຄືອຜູ້ເຖົ້າໄຫ້ (*Centrose- ma spp.*), T25: ເຄືອຕົດໝາ (*Paederia linearis*), T27: ເຄືອມັນດ້າງຂາວ (*Ipomoea spp.*), T28: ເຄືອມັນດ້າງເຫຼືອງ (*Ipomoea batatas L.*), T29: ເຄືອຫຍ້າໜາມຊູດຮີດ (*Mimosa pigra L.*), T31: ເຄືອຖົ່ວເຄືອ (*Arechis spp.*), T34: ເຄືອຂອນ ແລະ ກຸ່ມຕົ້ນໄມ້ອາຫານສັດໄດ້ແກ່ T8: ປໍສາ (*Brous-sonetia papyrifera*), T13: ໃບໄລ່ (*Bambusa spp.*), T16: ໃບບົງ (*Bambusa spp.*), T19: ໃບກ້ວຍປ່າ (*Musa sapientum Linn.*), T22: ໃບສົມພົດ (*Bauhinia spp.*), T26: ໃບເດື່ອ (*Ficus spp.*), T32: ໃບປໍຫູ (*Broussonetia spp.*), T33: ໃບກະຖິນ (*Leucaena leucucephala*), T37: ໃບສົ້ມສ້ຽ (*Bauhinia malabarica Roxb.*). ທຸກຕົວຢ່າງຖືກສຸ່ມເກັບໂດຍເລືອກເອົາສ່ວນທີ່ ສັດກິນໄດ້ ຕາມພຶດຕິກຳການກິນຂອງສັດ. ນຳຕົວຢ່າງມາຕາກແດດໃຫ້ແຫ້ງ ແລະ ບົດໃນຂະໜາດ 1 ມມ. ຈາກນັ້ນ ນຳເຂົ້າຫ້ອງວິໄຈທາງດ້ານອົງປະກອບທາງເຄມີ ເພື່ອຫາທາດໄນໂຈຣເຈນ (ທາດຊຶ້ນ), ເຖົ່າລວມ, ທາດທີ່ລະລາຍໃນສານຟອກທີ່ເປັນກາງ (NDF), ທາດທີ່ລະລາຍໃນສານຟອກທີ່ເປັນກົດ (ADF). ອີກສ່ວນນຶ່ງນຳໄປຫາຄວາມສາມາດໃນການຍ່ອຍໄດ້ ໂດຍໃຊ້ວິທີການວັດແທກທາດອາຍ. ຜົນຂອງປະ

ລິມານທາດອາຍທີ່ເກີດຂຶ້ນທັງໝົດ (d) ສະແດງໃນຕາຕະລາງ 2 ເຫັນໄດ້ວ່າ ໃນກຸ່ມອາຫານຫຍາບ ຫຍ້າກວາເຕມາລາ (T40=182.81 ມລ) ມີຄ່າສູງສຸດ ແລະ ຫຍ້າແຝກ ມີຄ່າຕ່ຳສຸດ (T17=57.49 ມລ), ກຸ່ມທາດຊຶ້ນສູງສຸດ ແມ່ນເຄືອມັນດ້າງຂາວ (T27=119.84 ມລ ແລະ ຕ່ຳສຸດແມ່ນເຄືອຂອນ (T34=58.14 ມລ), ກຸ່ມຕົ້ນໄມ້ອາຫານສັດມີຄ່າສູງສຸດແມ່ນ ໃບກ້ວຍປ່າ (T19=138.07 ມລ), ຕ່ຳສຸດ ແມ່ນ ໃບກະຖິນ (T33=54.79 ມລ) ຕາມລຳດັບ.

ຄຳສັບທີ່ສຳຄັນ: *ວັດຖຸດິບອາຫານສັດ, ອາຫານຫຍາບ, ອາຫານທາດຊຶ້ນ, ຕົ້ນໄມ້ອາຫານສັດ, ການຍ່ອຍໄດ້ໃນຫ້ອງປະຕິບັດການ.*

[1]Dept. of Animal and Fisheries Science, Faculty of Agriculture, National University of Laos,
E-mail: viengsakounna@yahoo.com
[2]Dept. of Animal and Fisheries Science, Faculty of Agriculture, Suphanuvong University

THE STUDY OF CHEMICAL COMPOSITION AND NUTRITIVE VALUE OF ANIMAL FEED RESOURCE IN NORTHERN LAO PDR: LUANGPRABANG AND SAYABOURY PROVINCE

V. Napasirth[1], B. Sivilay[1], D. Kongmanila[1], and S. Inthapanya[2]

Abstract

The objectives of this study was to assess the chemical composition and kinetic of gas production of animal feed resources in the Northern of Laos by using in vitro gas technique. Twenty seven of feed sample were collected and divided in to three groups according to source of feedstuffs: group one roughage group there are T7: Xang (*Pennisetum purpureum*), T9:Yung *(Microstegium ciliatum),* T10: Kham *(Bambusa spp.)*, T11: Loa *(Miscanthus floridulus),* T17: Phaek *(Cymbopogon nardus var.)*, T18: Salai, T38: Pakhuay *(Eleusine indica)*, T39: Pakuay yai *(Eleusine spp.)*,T40: Kuaytemala *(Tripsacum lascum)*; group two protein group there are T21: Jijor, T23: Mayalab *(Desmanthus virgatus)*, T24: Phuthoahai *(Centrosema spp.)*, T25: Todma *(Paederia linearis)*, T27: Sweet potato white *(Ipomoea spp.)*, T28:Sweet potato yellow *(Ipomoea batatas L.)*, T29: Mimosa *(Mimosa pigra L.),* T31:Thuakhue *(Arechis spp.)*, T34: Khuekhon; and group three fodder tree group there are T8:Porsa *(Broussonetia papyrifera)*, T13: Lai (Bambusa spp.), T16: Bong (Bambusa spp.), T19:Wild banana leaves *(Musa sapientum Linn.)*, T22: Somphot *(Bauhinia spp.)*, T26: Due *(Ficus spp.)*, T32: Porhou (Broussonetia spp.), T33: Luecaena (Leucaena leucucephala), T37: Somseo (Bauhinia malabarica Roxb.). All of samples they were collected as a part of animal fed in natural condition. Ground through a 1 mm screen for the chemical analysis and evaluate kinetic of gas production by in vitro gas production technique. In the roughage group

it was found that the potential extent of gas production (d) shown in table 2 that expressed in ml as highest is T40 and lowest is T17 (182.81 ml, 57.49 ml) in roughage group; highest is T27 and lowest is T34 (119.84 ml, 58.14 ml) in protein group and highest is T19 and lowest is T33 (138.07 ml, 54.79 ml) in fodder group respectively.

Key words: Feedstuffs, Roughage, Protein, Fodder tree, *In vitro* gas production technique.

[1]Dept. of Animal and Fisheries Science, Faculty of Agriculture, National University of Laos, E-mail: viengsakounna@yahoo.com

[2]Dept. of Animal and Fisheries Science, Faculty of Agriculture, Suphanuvong University

Introduction

Feed is important for animal production that include 60 – 70 % of total cost, product from the animal such as meat, milk, and eggs demand from domestic consumption and exportation (FAO, 2001). In Lao PDR. also increase demand source of protein. The main of protein source in Laos from the cattle production because farmer they have reared as long as. But cattle production system in Lao raised with free range depend on the natural surroundings, there are many source of feed for animal production in Laos especially for ruminant. Feed that important for the animal production system now a days the feed system should be developed.

Materials and Methods

Feedstuffs sample preparation and chemical analysis

Twenty four samples were collected from Luangprabang and Sayaboury provinces in the northern Lao PDR. on August 2007, All of sample were ground through a 1 mm screen and separated into two parts. The first samples were used to determine chemical composition including dry matter (DM), ash, crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF) (Van Soest *et al*., 1991; Chhay Ty and Julio Ly, 2001). The second part of samples were used to evaluate kinetics of gas production and degradation characteristics using in vitro gas production technique. This part of the samples were divided into three groups based on the source of feedstuffs first group there are T7: Elephant grass *(Pennisetum purpureum)*, T9: Yung *(Microstegium ciliatum)*, T10: Kham *(Bambusa spp.)*, T11: Loa *(Miscanthus floridulus)*, T17: Phaek *(Cymbopogon nardus var.)*, T18: Salai, T38: Pakhuay *(Eleusine indica)*, T39: Pakuay yai *(Eleusine spp.),* and T40: Kuaytemala *(Tripsacum lascum);* second group there are T21: Jijor, T23: Mayalab *(Desmanthus virgatus)*, T24:Phuthoahai *(Centrosema spp.)*, T25: Todma *(Paederia linearis)*, T2: Sweet potato white *(Ipomoea spp.)*, T28: Sweet potato yellow *(Ipomoea batatas L.)*, T29: Mimosa *(Mimosa pigra L.)*, T31: Thuakhue *(Arechis spp.)*, T34: Khuekhon; and third group there are T8: Porsa *(Broussonetia papyrifera)*, T13: Lai *(Bambusa spp.)*, T16: Bong *(Bambusa spp.)*, T19:Wild banana leaves *(Musa sapientum Linn.)*, T22: Somphot *(Bauhinia spp.)*, T26: Due (Ficus spp.), T32: Porhou *(Broussonetia spp.),* T33: Luecaena *(Leucaena leucucephala)*, T37: Somseo *(Bauhinia malabarica Roxb.)*. All of samples they were collected as a part of animal fed in natural condition.

Experimental design

The experimental design was completely randomized (four replicates per treatment). Mixed rumen fluid inoculums were obtained from six Native cattle with average weight 180 kg. All steps during the rumen fluid transfer and incubation period were strict anaerobic condition. Rumen fluid inoculums were removed early morning before feeding under stomach tube (Suction by vacuum pump). All of animals were free grazing by natural grass to adapted rumen ecology. Approximately 0.5 g of the feed sample on fresh matter basis was put into 50 ml of serum bottle and injected 40 ml of rumen fluid medium. The bottle was sealed and incubated in a hot air oven at 39 °C (Applied by Sommart *et al*., 2000). Gas production characteristic from the fermentation of feed stuffs was measured in every hour for first 12 hrs after incubate, every 3 hrs for 24 hrs after incubate, every 6 hr for 78 hrs after incubate and the last time at 96 hrs after incubate and described the kinetics of fermentation based on the modified exponential model y=a+b[1-Exp (-ct)] (Ørskov and McDonal, 1979), were a = the intercept which ideally reflects the fermentation of soluble fraction, b = the fermentation of the insoluble fraction, c = rage of gas production and y = gas production at the time ' t ' and d=.potential extent of gas production.

Statistical analysis

The data were analyzed according to the ANOVA model by Statistic Analysis System, (SAS, 1996) version 6.12. Means were separated by Duncan New's Multiple Rang Test. The level of significant was determined at $p<0.05$.

Results and Discussion

Chemical composition of feedstuffs

The results of chemical composition of feedstuffs are shown in table 1. That founded the crude protein content of the roughage group ranged from 6.06–10.56 % (Elephant grass and Kham). Crude protein content of elephant grass was lower but NDF, ADF were higher than that reported by Department of Livestock Development (2004). The crude protein, NDF of Kuaytemala were lower and ADF higher than that reported by Department of Livestock Development (2004), protein content of Pakkuay grass was lower than reported by Napasirth *et al*. (2005. The crude protein content of feedstuffs in protein group ranged from 11.21-22.05 %. Mimosa was highest and Jijor was lowest. Protein content of Mimosa and Mayalab were lower than reported by Department of Livestock Development (2004) but not high different. The crude protein content of fodder tree group ranged from 8.06-22.58 %.

Table 1: Chemical composition of feed stuffs

	Feed stuffs	DM (%)	Ash	OM	CP	NDF	ADF	TDN*
			---------- % DM basis ----------					
I. Roughage group								
T7	Elephant grass	29.03	7.94	92.06	6.05	73.14	45.55	50.59
T9	Yung	32.35	9.11	90.89	6.19	67.33	44.37	51.94
T10	Kham	26.37	10.12	89.88	10.56	69.11	62.18	31.64
T11	Loa	37.50	7.60	92.40	6.13	76.70	51.62	43.68
T17	Phaek	32.39	5.07	94.93	9.53	46.18	49.80	45.75
T18	Salai	21.83	11.97	88.03	6.80	64.27	43.06	53.43
T38	Pakhuay	25.00	16.79	83.21	8.87	66.54	41.67	55.02
T39	Pakuay yai	21.33	12.58	87.42	10.41	60.70	34.21	63.52
T40	Kuaytemala	16.09	11.57	88.43	7.76	59.00	33.39	64.45
II. Protein group								
T21	Jijor	4.98	8.28	91.72	11.21	47.98	52.68	42.47
T23	Mayalab	15.13	5.98	94.02	16.29	36.45	38.74	58.36
T24	Phuthoahai	16.66	5.88	94.12	13.53	51.37	37.34	59.95
T25	Todma	1.09	10.14	89.86	12.55	51.65	23.14	76.14
T27	Sweat potato white	3.28	15.68	84.32	15.74	32.70	49.86	45.68
T28	Sweat potato yellow	5.45	18.34	81.66	20.94	45.06	28.50	70.04
T29	Mimosa	12.99	7.46	92.54	22.05	39.65	35.70	61.82
T31	Thuakhue	35.21	9.61	90.39	11.35	45.22	33.96	63.81
T34	Khuekhon	29.38	9.82	90.18	11.94	53.39	48.13	47.66
III. Fodder trees group								
T8	Porsa	28.51	15.15	84.85	22.58	32.19	23.07	76.22
T13	Lai	48.81	12.85	87.15	13.25	74.21	51.33	44.01
T16	Bong	34.71	14.00	86.00	13.18	72.74	23.85	75.33
T19	Wild banana	7.10	18.78	81.22	16.24	54.35	41.31	55.43
T22	Somphot	17.97	8.05	91.95	11.29	35.71	44.80	51.46
T26	Due	9.30	16.67	83.33	16.90	48.50	48.64	47.07
T32	Porhou	33.13	10.16	89.84	10.53	46.97	43.43	53.01
T33	Luecaena	36.08	5.16	94.84	18.49	64.76	58.80	35.49
T37	Somseo	40.78	9.64	90.36	8.06	79.90	41.01	55.78

DM=dry matter, OM= organic meter, CP= crude protein, NDF= neutral detergent fiber, ADF= acid detergent fiber, OM= organic meter, TDN= total digestible nutrient (TDN (roughage)=4.898+(89.796 x NEL); NEL=1.0876-(0.127 x %ADF); TDN (legume)= 4.898+(89.796 x NEL); NEL=1.044-(0.0119 x %ADF) (Department of Livestock Development, 2004)

Gas production characteristic of the feedstuffs

The gas production from the fermentation of feedstuffs was measured 1 to 96 hrs. The in vitro gas test adapted to describe kinetic of fermentation that were based on the modified exponential model y=a+b[(1-Exp(-ct)] (∅rskov and McDonal. 1979). Gas production characteristic of feedstuffs present in Table 2 and Figure 1, 2 and 3. A comparison of the gas production characteristic of different treatments indicated significant differences between treatments ($p<0.05$). The intercept value (a) for roughage group ranged from -7.515 to -2.449 ml; for protein group ranged -9.154 to -1.575 ml and for fodder tree group ranged from -8.677 to -1.387 ml. The intercept value (a) were negative in the incubation, these data suggested that a lag phase due to delay in microbial colonization of the substrate may occur in the early state of incubation. It is well known that the value for absolute (a), describe ideally, reflects the fermentation of the soluble fraction. The gas value of asymptote (b) describe that the fermentation of the insoluble fraction. The fermentation of insoluble fraction of roughage group, protein group and fodder group were found that the ranged from 55.05 to 175.47 ml; 56.56 to 110.69 ml and 52.55 to 126.01 ml, respectively. The rate of gas production (c) was ranked from fastest to lowest in the Table 2 showed that the rate of gas production of feedstuffs ranged from 0.0067 to 0.0230 %/hr in roughage group; from 0.0213 to 0.0364 %/hr in protein group and from 0.0109 to 0.0302 %/hr, respectively. The potential extent of gas production (d) ranged from 57.49 to 182.81 ml in roughage group, from 58.14 to 119.84 ml in protein group and from 54.79 to 138.07 ml in fodder group, respectively.

Table 2: Gas production characteristic parameter

	Items	Gas production characteristic			
		a (ml)	b (ml)	c (%/hr)	d (ml)
I. Roughage group					
T7	Elephant grass	-5.678 bc	139.43 ab	0.0169 abc	145.11 ab
T9	Yung	-7.473 c	131.38 ab	0.0230 a	138.85 ab
T10	Kham	-5.423 bc	126.24 ab	0.0143 bc	131.66 ab
T11	Loa	-3.636 ab	173.39 a	0.0067 d	177.03 a
T17	Phaek	-2.449 a	55.05 c	0.0213 ab	57.49 c
T18	Palai	-6.101 bc	113.54 b	0.0198 ab	119.64 b
T38	Pakhuay	-7.515 c	129.44 ab	0.01827 ab	136.95 ab
T39	Pakuay yai	-7.190 c	152.12 ab	0.0145 bc	159.31ab
T40	Kuaytemala	-7.342 c	175.47 a	0.0101 cd	182.81a
II. Protein group					
T21	Jijor	-4.503 abc	77.01 bcd	0.0285 ab	81.51 bcd
T23	Mayalab	-3.940 ab	89.56 abc	0.0237 b	94.19 abc
T24	Phuthoahai	-2.524 ab	63.96 cd	0.0255 b	66.49 cd
T25	Todma	-7.282 dc	92.96 abc	0.0360 a	100.24 abc
T27	Sweat potato white	-9.154 d	110.69 a	0.0280 ab	119.84 a
T28	Sweat potato yellow	-8.967 d	91.91 abc	0.0364 a	100.88 abc
T29	Mimosa	-5.368 bc	88.82 abc	0.0259 b	94.19 abc
T31	Thuakhue	-7.582 dc	101.13 ab	0.0292 ab	108.71 ab
T34	Khuekhon	-1.575 a	56.56 d	0.0213 b	58.14 d
III. Fodder trees group					
T8	Porsa	-8.677 c	122.44 a	0.0275 ab	131.11 a
T13	Lai	-1.387 a	85.65 ab	0.0108 b	100.89 ab
T16	Bong	-2.633 ab	101.82 ab	0.0109 b	104.46 ab
T19	Wild banana	-5.861 bc	132.21 a	0.0143 ab	138.07 a
T22	Somphot	-1.520 a	80.59 ab	0.0169 ab	83.18 ab
T26	Due	-4.680 abc	96.21 ab	0.0302 a	100.89 ab
T32	Porhou	-7.430 c	107.72 ab	0.0244 ab	115.15 ab
T33	Luecaena	-2.240 ab	52.55 b	0.0197 ab	54.79 b
T37	Somseo	-7.674 c	126.01 a	0.0186 ab	133.69 a

a = intercept (ml), b= the volume of gas at asymptote (ml), c = rate of gas production (%/hr.), d = |a| + b (potential extent of gas production, ml); a, b, c, d mean with in the same column with different superscripts differ significantly ($p<0.05$).

Gas volume of feedstuffs

The results indicate that cumulative gas volume at 12, 24, 36, 48, 72 and 96 hr after incubation were significantly different ($p<0.05$) between treatments and curve of cumulative gas production for each treatments are presented in Figure 1, 2 and 3. It can be seen that the gas production reach a plateau after 96 hrs fermentation of each feedstuffs. These finding indicate that substrate fractions and degradabilities of each feedstuffs are different. Gas production is directly proportional to substrate degradation rate (Dhanoa *et al*., 2000). Additionally, kinetic of gas production is dependent on the relative proportion of soluble, insoluble but degraded., and undegradable particles of the feed (Getachew *et al*., 1998). Menke *et al*. (1979) suggested that the gas volume at 24 hrs after incubation has a relationship with metabolizable energy in feedstuffs.

Table 3: Gas production characteristic parameter

Items	Gas production (ml/0.5 gDM substrate)					
	12 hr	24 hr	36 hr	48 hr	72 hr	96 hr
I. Roughage group						
T7 Elephant grass	16.901ab	40.265 ab	58.833 ab	74.329 a	92.13 a	99.56 a
T9 Yung	18.692 a	47.807 a	65.051 a	77.347 a	92.85 a	99.14 a
T10 Kham	10.677 bc	29.821 bc	43.749 bc	57.403 ab	73.02 ab	78.92 ab
T11 Loa	7.347c	18.239 c	30.309 cd	42.507 bc	59.81 b	68.00 b
T17 Phaek	7.911c	16.641 c	23.948 d	30.450 c	36.55 c	39.13 c
T18 Palai	13.297 abc	34.397 ab	48.890 ab	60.080 ab	71.37 ab	76.50 ab
T38 Pakhuay	11.837 bc	37.504 ab	54.540 ab	68.587 a	84.63 a	91.05 ab
T39 Pakuay yai	13.774 abc	29.322 bc	55.815 ab	70.851 a	90.74 a	98.99 a
T40 Kuaytemala	7.536 c	30.341 bc	48.879 ab	63.816 a	84.89 a	94.89 a
SEM	1.98	4.80	5.16	6.12	7.17	7.77
II. Protein group						
T21 Jijor	13.357 b	31.118 bc	41.476 bc	49.259 bcd	57.241 bcd	60.408 bcd
T23 Mayalab	17.637 ab	35.751abc	46.330 abc	55.549 abc	66.732 abc	71.884 abc
T24 Phuthoahai	13.823 b	27.784 c	36.475 bc	43.317 cd	51.117 cd	54.675 cd
T25 Todma	25.600 a	52.113 a	62.100 a	70.089 a	77.145 ab	79.874 ab
T27 Sweat potato white	15.992 b	45.357 ab	61.036 a	71.307 a	80.472 a	83.805 a
T28 Sweat potato yellow	19.139 ab	49.739 a	60.042 a	67.592 ab	74.045 ab	76.515 ab
T29 Mimosa	17.171 ab	38.367 abc	49.722 ab	58.271 abc	68.818 abc	73.091 abc
T31 Thuakhue	18.230 ab	47.955 a	61.697 a	70.424 a	79.427 a	83.141 a
T34 Khuekhon	11.877 b	21.888 c	28.695 c	35.102 d	43.244 d	47.247 d
SEM	2.64	5.20	5.78	6.15	6.55	6.74
III. Fodder trees group						
T8 Porsa	20.534 a	52.130 a	66.09 a	77.45 a	90.28 a	95.09 a
T13 Lai	6.385 c	13.966 d	20.48 d	27.40 d	37.51 d	43.04 d
T16 Bong	6.932 c	16.432 d	25.01 cd	34.52 cd	44.95 d	51.02 d
T19 Wild banana	10.704 bc	31.503 bcd	45.82 abc	59.48 abc	75.28ab c	81.31 abc
T22 Somphot	11.681 bc	22.520 cd	30.96 cd	38.15 cd	47.84 cd	52.96 cd
T26 Due	13.030 bc	25.158 bcd	34.89 bcd	44.26 bcd	57.31 bcd	61.25 bcd
T32 Porhou	15.218 ab	42.094 ab	57.97 ab	69.29 ab	79.65 ab	82.72 abc
T33 Luecaena	8.667 bc	20.154 d	26.34 cd	32.13 d	38.80 d	41.69 d
T37 Somseo	13.011 bc	38.648 abc	55.74 ab	69.22 ab	84.97 ab	90.71 ab
SEM	2.04	5.72	7.43	8.42	9.29	9.59

a, b, c, d mean with in the same column with different superscripts differ significantly ($p<0.05$).

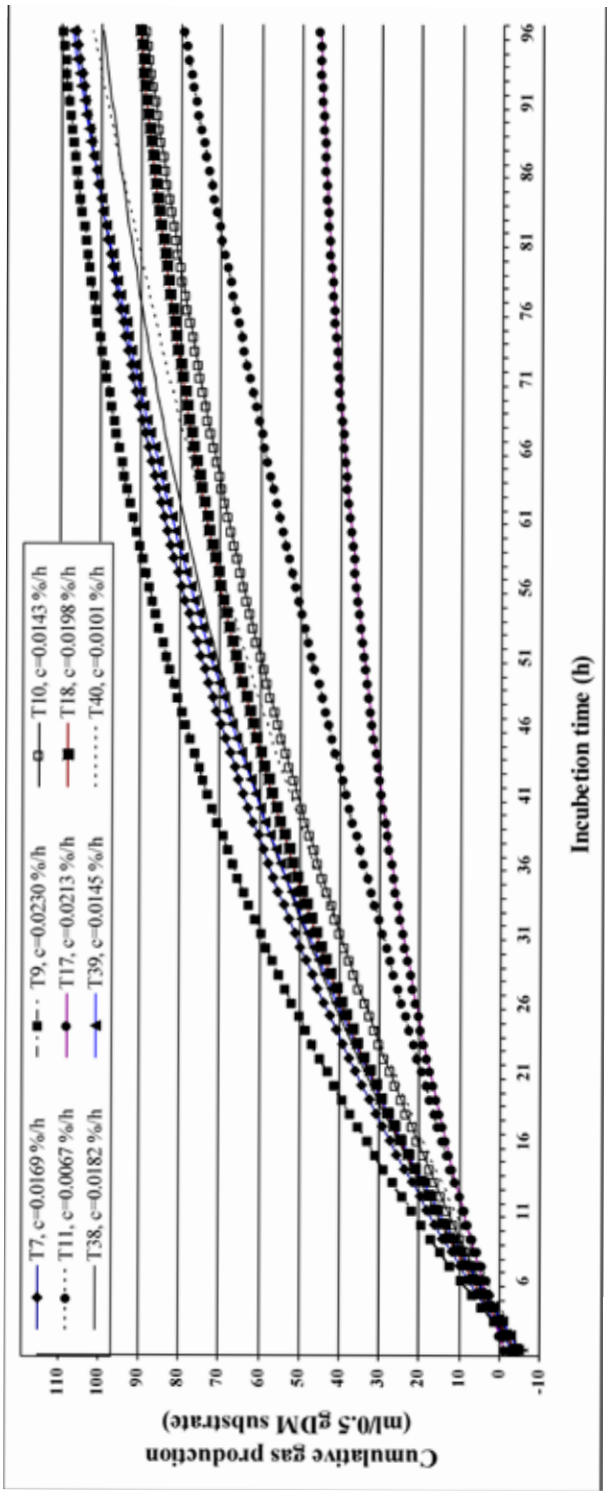

Plate 1: Cumulative gas volume of roughage group, estimated by y=a+b[1-Exp(-ct)] (ml/0.5 gDM substrate) throughout 96 hrs.

T7: Elephant grass *(Pennisetum purpureum)*, T9: Yung *(Microstegium ciliatum)*, T10: Kham *(Bambusa spp.)*, T11: Loa *(Miscanthus floridulus)*, T17: Phaek *(Cymbopogon nardus var.)*, T18: Salai, T38: Pakhuay *(Eleusine indica)*, T39: Pakuay yai *(Eleusine spp.)*, and T40: Kuaytemala *(Tripsacum lascum)*.

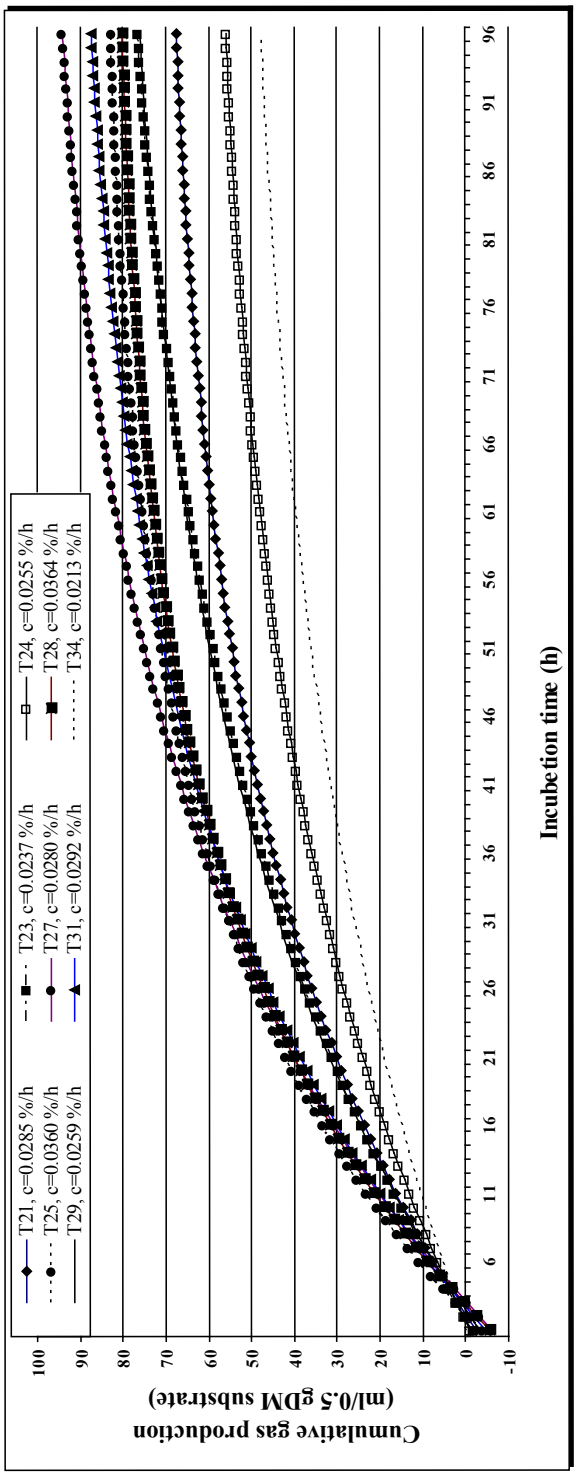

Plate 2: Cumulative gas volume of protein group, estimated by y=a+b[1-Exp(-ct)] (ml/0.5 gDM substrate) throughout 96 hrs.
T21:Jijor, T23:Mayalab *(Desmanthus virgatus)*, T24:Phuthoahai *(Centrosema spp.)*, T25:Todma *(Paederia linearis)*, T27:Sweet potato white *(Ipomoea spp.)*, T28:Sweet potato yellow *(Ipomoea batatas L.)*, T29:Mimosa *(Mimosa pigra L.)*, T31:Thuakhue *(Arechis spp.)*, T34: Khuekhon.

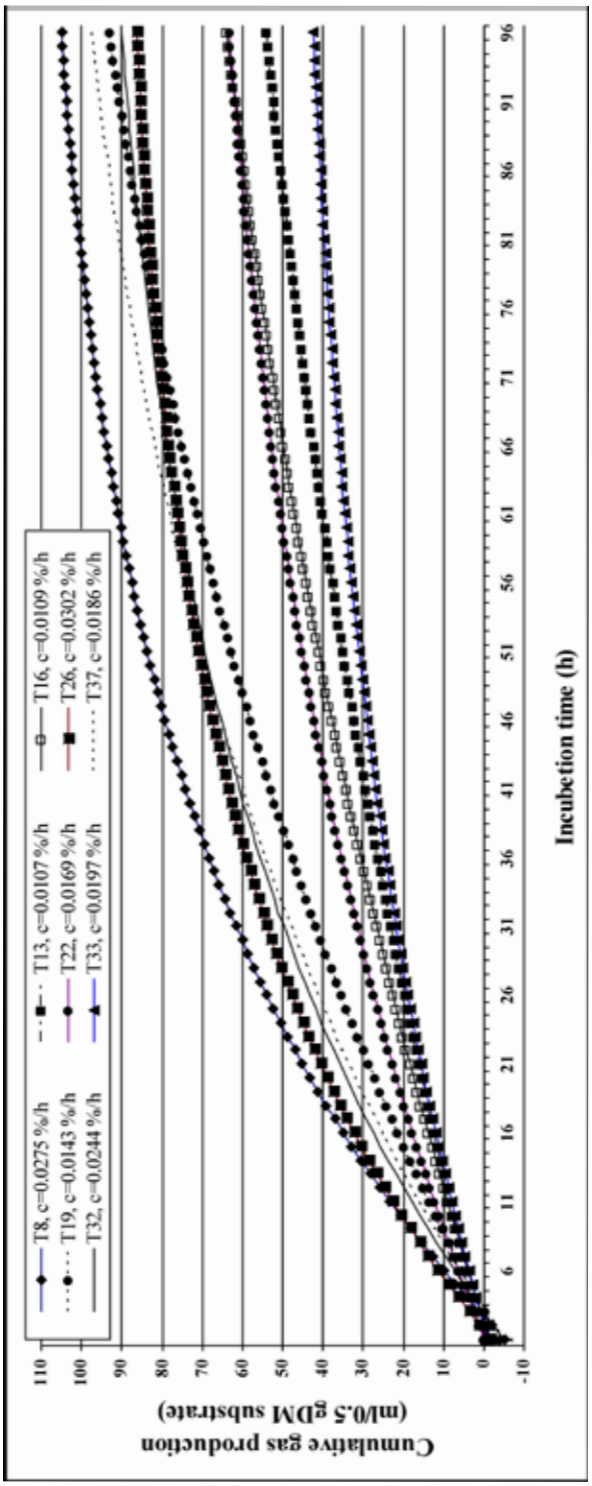

Plate 3: gas volume of fodder tree group, estimated by y=a+b[1-Exp(-ct)] (ml/0.5 gDM substrate) throughout 96 hrs.

T8:Porsa (Broussonetia papyrifera), T13:Lai (Bambusa spp.), T16:Bong (Bambusa spp.), T19:Wild banana leaves (Musa sapientum Linn.), T22:Somphot (Bauhinia spp.), T26:Due (Ficus spp.), T32:Porhou (Broussonetia spp.), T33:Luecaena (Leucaena leucucephala), T37: Somseo (Bauhinia malabarica Roxb.).

Acknowledgements

The authors would like to thank for Department of Livestock and Fisheries, Faculty of Agriculture National University of Laos, Janpan International Research Center for Agricultural Science (JIRCAS) project and Department of Agriculture and extension in Luangprabang and Sayaboury provinces for LAB facility, financial, data and sample supported. Special thanks to Department of Animal Science Faculty of Agriculture Khon Kaen University and Khon Kaen Animal Nutrition Research and Development Center for providing LAB facility.

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