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Effect of supplementing a diet based on maize, rice bran and cassava chip with three different improved forages on feed intake, digestibility and growth in rabbits

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Abstract

The effect of supplementing a diet based on a concentrate, containing maize, rice bran and cassava chip, with three different improved forages and with natural vegetation as a control on feed intake, digestibility and growth was studied in an on-station experiment with forty rabbits, New Zealand White x local breed, 20 males and 20 females, weaned at 5 weeks of age. The average initial weight of the rabbits was 787 (11.2) g. The rabbits were individually caged and randomly allocated to four treatment groups of 10 rabbits each. The groups were balanced for sex. The treatments were diets containing three different kinds of improved forages; Cassava hay, Stylo 184 and Guinea grass, which were fed *ad libitum* in the amount of 130% of the average daily forage consumption in the previous week. The control group was fed a local herb, *Spilanthes acmella Murr*. All rabbits were fed 35 g fresh ~30 g dry matter (DM) per day of the concentrate.

Total daily DM intake was significantly lower for the group supplemented with Guinea grass, 73 g/day compared to 90 g, 97 g and 93 g for the groups supplemented with Cassava hay, natural herbs and Stylo 184, respectively. The rabbits fed the natural herb had significantly higher growth rate, 18.2 g/day, than the rabbits fed Guinea grass or Cassava hay, 9.2 and 15.2 g/day, respectively, but not significantly different from rabbits fed Stylo 184, 16.9 g/day. DM digestibilities of the diets containing Cassava hay, Guinea grass or natural herb were not significantly different, 0.76 to 0.83, but significantly higher than of the Stylo 184 diet, 0.75. CP digestibility for the Cassava hay diet was similar to Stylo 184, but significantly higher than for the natural herb and Guinea grass diet.

Keywords: Intake, digestibility, live weight gain, Stylosanthes, Cassava hay and Guinea grass.

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1. Introduction

Rabbits in Laos are only raised in small-scale systems, in which high-cost inputs such as pig starter pellets or commercial concentrate feeds cannot be justified. The small backyard rabbitry therefore depends on local feed resources such as forages and native grasses, both of which can be collected close to the production site.

According to NRC (1977), growing rabbits require a minimum of 160 g crude protein (CP) and 65% total digestible nutrients (TDN) in the diet, corresponding to around 1 MJ per rabbit and day. According to the same publication, average content of CP in wheat bran satisfies the CP requirement of rabbits but not the TDN minimum. For maize bran there is no published information for rabbits.

Rabbits have a potential as meat-producing animals in the tropics, particularly on subsistence-type small farms. Such characteristics as small body size (thus low daily feed requirements), short generation interval, high reproductive potential, rapid growth rate and the ability to utilize forages and fibrous agricultural by-products are attributes in favour of rabbit production (Cheeke, 1986). In spite of these apparent advantages, rabbit production has not yet achieved its potential in the tropics.

The major nutritional requirements of rabbits of concern in small-scale tropical rabbit production are protein and energy. The rabbit is a small herbivore that has evolved a digestive tract uniquely suited to the utilization of herbage. The ability of rabbits to efficiently digest the protein in forages is associated with caecal fermentation and caecotrophy (Robinson et al., 1985).

The limiting nutritional factor in rabbit production in tropical areas is probably digestible energy. Feeding programs that incorporate culled bananas, plantains, cassava, and various tropical fruits, sugar cane products, and agricultural by-products such as rice bran and other grain-milling by-products should be developed. These materials are excellent sources of digestible energy, and can be used to supplement legume forages (e.g. tree legumes), which are good sources of protein.

According to Phengsavanh (1997) there were few forage species that were well adapted to the wide range of environmental conditions of Lao PDR. These species are *Andropogon gayanus* (Gamba grass), *Brachiaria spp, Panicum maximum* (Guinea grass) and *Stylosanthese guianensis* (Stylo CIAT 184).Of these species, only Gamba grass and Stylo 184 grow quite satisfactorily in the wet as well as long into the dry season, and are also suitable for feeding. However, *Brachiaria spp (B. brizantha, B. decumbens* and *B. ruziziensis)* are recommended to be avoided due to photosensitization and *Panicum maximum (*Purple guinea*)* can grow well only in the wet season and on quite fertile soils.

Stylo 184 is a short-lived perennial legume (2 to 3 years) that grows into a small shrub with some woody stems. It is adapted to a wide range of soils and climates but is one of the few herbaceous legumes, which will grow well on infertile, acid soils. It will not grow on very alkaline soils (pH>8). Unlike earlier varieties of *S. guianensis* (eg. cv. Schofield, Cook and Graham) Stylo 184 has shown good resistance to the fungal disease anthracnose in Southeast Asia. It is usually grown as a cover crop, which is cut every 2 to 3 months. It effectively suppresses weeds and is a good feed supplement for most animals, including chickens, pigs and fish. Stylo 184 can be fed fresh or dried for hay and leaf meal. It does not tolerate being cut close to the ground since there are few buds on the lower stem for regrowth. This can be improved by making the first cut at 10 to 20 cm to encourage branching close to the ground. Subsequent cuts must be made higher (>25 cm) to ensure good regrowth (Horne and Stür, 1999). N concentrations of *Stylosanthes guianensis* range from 1.5 to 3%. Dry matter (DM) digestibility of young plant material lies between 60% and 70% but with increasing age and lignification this may be reduced to below 40% (Mannetje and Jones, 1992).

The advantage of cassava is that it can be grown in areas with an extended dry period. Where there are better conditions for plant growth, other crops are usually more profitable as a source of animal feed (Mui, 1994). Cassava is also an exploitive crop and growing it in monoculture leads to declines in soil fertility. When leaves are harvested at the same time as the roots, yields are in the range of 1 to 4 tons DM/ha (Ravindran, 1992). Leaf production can be enhanced by partial defoliation during the growing season. The biomass production for first and subsequent harvests shows the potential of this crop since this timing coincides well with the harsh dry season when access to natural grasses and herbs is limited. The high quality in terms of protein and content of digestible nutrients, together with high consumption rate (Ravindran 1992), proves that it is an excellent feed either for full feeding as cassava hay or as a supplement in crop-residue based diets

The aim of this experiment was to study the effect of supplementing a diet based on maize, rice bran and cassava chip with three different improved forages and with natural vegetation as a control on feed intake, digestibility and growth in rabbits. The hypothesis was that feeding cassava foliage hay and fresh forage from Stylo 184 or Guinea grass will result in similar growth performance in rabbits, superior to that from local herbs and grasses, when supplementing a diet based on rice bran, maize and cassava chips.

2. Materials and methods

2.1 Location and climate of the study area

The experiment was conducted at the Livestock Research Center, about 40 km from Vientiane, Laos. In this location the dry season starts early in November and continues until the end of April. The wet season runs from May to October. Annual rainfall is on average 1600 mm. Mean temperature is about 25 C^o. The experiment was carried out during the months June to August 2004.

2.2 Experimental feeds

The three different species of improved forages used in the experiment were Guinea grass, Stylo 184 and Cassava leaves. The native grass used as a control consisted mainly of one herb, *Spilanthes acmella Murr*. The feeds were collected from existing pastures of the Livestock Research Centre. Cassava leaves were harvested at the station 3 months after planting and were sun dried for 2 to 3 days. Stylo 184 and Guinea grass were harvested stepwise to assure a similar age of 40 to 45 days and development and were fed in fresh form. Fertilizer was applied after each harvest, 80 kg urea/ha and 60 kg phosphate/ha at each occasion. The pasture was divided into 10 plots and each plot provided enough feed for 4 days and was rotated. The feed was manually harvested twice per day in the morning at 06.00 h and in the afternoon at 15.30 h. The Stylo 184 was cut at 20 cm from the top at harvest and Guinea grass was chopped manually to about 20 cm length. Spilanthes was about 30 cm high at harvest and was fed whole.

Rice bran and maize was purchased from the local market and cassava chips were bought from farmers and chopped manually into pieces of 2-3 mm then sun dried for 4-5 days and was mixed to a concentrate with rice bran and maize as a basal diet. The concentrate consisted of maize, 303 g, rice bran, 496 g, cassava chip, 192 g, salt 4 g and premix, 4 g, per kg feed and was planned to have a CP content of 93.7 g/kg DM.

2.3 Animals and management

Forty rabbits, New Zealand White x local breed, 20 males and 20 females, weaned at 5 weeks of age were used in the experiment. The rabbits were bought from a factory producing vaccines in Nongthang about 8 km from Vientiane. The average initial body weight (BW) of the rabbits was 787 (11.2) g. They were treated against endo-parasites with coopane, a brand of piparazine, at the rate of 2 g per litre of water.

The rabbits were individually caged and fed. The feeding troughs were divided into two sections in order to separate the feedstuffs and water was provided *ad libitum*. The animals were fed twice per day at 7.00 h and 16.30 h. The forage was provided first followed by the basal diet.

Continuous observations, mainly at midday (12:00h) and at evening (18:00h) were done to confirm the permanent availability of feed and water.

2.4 Experimental design

A completely randomised design was used and the animals were allocated to four treatment groups of 10 rabbits each. The groups were balanced for sex, with 5 males and 5 females in each group. The treatments were diets containing three different kinds of improved forages; Cassava hay, Stylo 184 and Guinea grass, which were fed *ad libitum* in the amount of 130% of the average forage consumption per day in the previous week and 35 g fresh (~30 g DM) per day of the basal diet, the same for all rabbits. The amount of basal diet to be fed was checked during the adaptation period to fix an appropriate level and was increased when the rabbits were growing. The control group was fed the same basal ration and a native herb *(Spilanthes acmella Murr)* fed fresh *ad libitum*. Expected DM intake was around 50 to 60 g/kg BW (NRC, 1977).

2.5 Digestibility

Faeces were collected for determination of digestibility from 5 animals on each diet every morning before feeding on day 21 to day 27 of the experiment. The animals stayed in their usual cages and the faeces were collected with a net attached to the cage. During the collection period the faeces were wrapped in a plastic bag and stored in a refrigerator and total faeces voided were weighed. The faeces were sampled for each animal every day and then pooled for the 7-day collection period dried, ground and stored until further analysis.

2.6 Data collection and analysis

The chemical composition of the feeds was determined before the experiment in order to formulate the diets. Samples of feed were then taken once every week during the experiment and were pooled to 1 sample per 2 weeks.

The feed consumption was recorded and feed refusals of the native herb, Cassava hay, Stylo 184 and Guinea grass were collected from individual animals and weighed every day in the morning before feeding and then pooled together for each treatment for 2 weeks. To be able to record the feed intake the DM of the fresh feeds offered and the refusals were checked with a microwave oven every day if the variation in humidity was high, otherwise 2 times per week.

The samples were analysed for DM and ash according to standard methods of AOAC (1980). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined by the methods of Van Soest and Robertson (1985). N was analysed by the Kjeldahl method and CP was calculated as Nx6.25. The samples of DM, N, and ash were analysed in the Livestock and Fisheries Department. NDF and ADF were analysed in the Animal Nutrition Research Center, Khon Kaen University, Thailand.

The animals in the experiment were weighed when the experiment started and then once per week at 07.00 h before feeding. The experiment lasted 70 days.

2.7 Statistical analyses

The data from the experiment were analysed statistically by a variance analysis using the General Linear Model (GLM) of the Minitab Software version (Release 13.31 Minitab, 2000). Treatment means which showed significant difference at the probability level of $P<0.05$ were compared using Tukey’s pairwise comparison procedures.

The following model was used in the experiment: $Y_{ij} = \mu + A_i + S_j + e_{ij}$ where Y_{ij} = growth or feed consumption, μ = overall mean, A_i = effect of diet, S_j = effect of sex and e_{ij} = random error

The results were also analysed by using a regression analysis to determine the relationship between CP intake and live weight gain. The model used was $Y_{ij}=a+bX_i+e_{ij}$ where Y is the live weight gain, a is the intercept, b is slope of Y_i against the corresponding value of X_i, X_i is the total CP intake or CP in g/kg DM intake, e_{ij} is the random error effect.

3. Results

The chemical composition of the homemade concentrate is presented in Table 1. The Cassava hay, Stylo 184 and Guinea grass were of good quality and contained 224 g, 200 g and 121 g CP/kg DM respectively. Spilanthes had lower CP content, 159 g/kg DM, than Cassava hay and Stylo 184. The ash content was higher in Spilanthes than in any of the other forages.

Table 1. Chemical composition of the feeds (mean and SD)

			g / kg DM				ME
	N	DM g/kg	CP	Ash	NDF	ADF	MJ
Maize	3	857 (4.8)	83 (4.1)	11 (4.9)	498 (9.6)	31 (6.7)	13.9
Rice bran	3	882 (7.5)	122 (5.0)	59 (5.6)	241 (6.7)	59 (3.8)	9.7
Cassava chip	3	869 (7.0)	199 (2.7)	20 (4.7)	189 (5.1)	42 (5.7)	14.6
Concentrate	3	878 (1.9)	110 (3.2)	47 (2.7)	324 (5.5)	53 (4.8)	11.8
Cassava hay	5	787 (3.3)	224 (3.8)	53 (6.4)	540 (3.4)	307 (22.0)	9.4
Guinea grass	5	230 (3.1)	121 (1.8)	52 (2.5)	712 (15.4)	445 (16.3)	9.4
Spilanthes S+L	5	178 (1.8)	159 (2.1)	71 (5.2)	514 (24.7)	409 (17.9)	11.0
Spilanthes S	5	130 (1.4)	91 (1.9)	69 (5.2)	552 (16.0)	491 (18.9)	-
Spilanthes L	5	190 (4.0)	211 (4.7)	71 (2.7)	477 (27.0)	329 (14.9)	-
Stylo 184 S+L	5	219 (2.7)	200 (2.7)	57 (1.9)	602 (24.5)	406 (29.7)	10.0
Stylo 184 S	5	190 (1.9)	170 (2.1)	56 (5.2)	632 (16.0)	509 (17.1)	-
Stylo 184 L	5	240 (6.8)	230 (4.7)	57 (2.7)	572 (27.0)	309 (14.9)	-

Concentrate=Basal diet; S= Stem; L= Leaves; [1]Table values

Table 2. Feed intake (least squares means (LS-means) and standard error (SE))

	Diet				
	CH	GN	SA	ST	SE
Feed intake, g DM/day					
Spilanthes					
Stem	0	0	31.3	0	0.55
Leaves	0	0	14.4	0	0.43
Stylo 184					
Stem	0	0	0	22.6	0.70
Leaves	0	0	0	18.4	0.61
Cassava hay	41.5	0	0	0	0.41
Guinea grass	0	28.3	0	0	0.97
Concentrate	49.3^{b}	45.1^{b}	50.9^{a}	52.0^{a}	1.16
DM intake, total	90.0^{a}	73.2^{b}	97.2^{a}	92.9^{a}	2.37
DM intake (g/kg BW)	69.6^{a}	64.9^{b}	74.3^{a}	70.8^{a}	1.41
DM intake (g/kg $W^{0.75}$)	74.2^{a}	66.9^{b}	79.5^{a}	75.8^{a}	1.51
CP intake (g/d)	13.2^{a}	8.6^{b}	12.5^{a}	13.4^{a}	0.32
CP intake g/kg DM	147^{a}	117^{c}	129^{b}	145^{a}	24
CP intake (g/$W^{0.75}$)	10.9^{a}	7.8^{b}	10.2^{a}	10.9^{a}	0.23
MJ ME/day	9.7^{ab}	7.9^{c}	11.0^{a}	10.2^{a}	0.25

$^{a, b, c}$ Means within rows with different superscripts differ significantly ($P<0.05$)
CH=Cassava hay, GN=Guinea grass, SA=*Spilanthes acmella* and ST=Stylo 184,

Daily feed intake is presented in Table 2. The rabbits fed Stylo 184 and Spilanthes consumed more stem than leaves. The rabbits fed Cassava hay and Guinea grass had significantly lower intake of concentrate than the rabbits given diets of Spilanthes and Stylo 184. However, only the group fed Guinea grass had significantly lower total DM intake, DM intake in g/kg BW and in g/$W^{0.75}$. CP intake in percent of DM intake ranged from 117 g/kg DM for rabbits fed Guinea grass to 147 g/kg DM for rabbits fed Cassava hay.

The live weight gain in g/day is presented in Table 3 and accumulated weight gain in Diagram 1. There were significant differences in live weight gain among the treatments. The rabbits fed Spilanthes had significantly higher growth rate than the rabbits fed Guinea grass or Cassava foliage but not significantly different from rabbits fed Stylo 184.

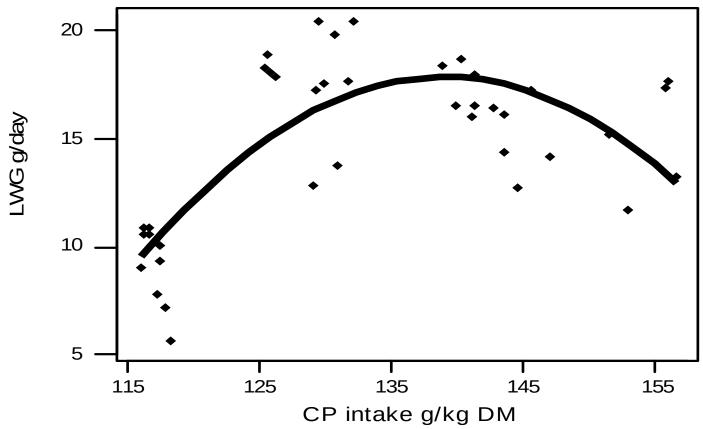

Diagram 1. The effect of feeding Guinea grass, Cassava hay, Stylosanthes CIAT 184 or *Spilanthes acmella Murr* on growth performance.

Table 3. Initial weight, live weight gain and feed conversion ratio

	Diet				
Items	CH	GN	SA	ST	SE
Initial weight, g	744	805	800	771	11.4
Final weight, g	1753[b]	1454[c]	1920[a]	1830[ab]	41.3
Live weight gain (g/day)	15.2[b]	9.2[c]	18.2[a]	16.9[ab]	0.63
FCR-DM (g DM/g LWG)	6.0[b]	8.2[a]	5.4[b]	5.5[b]	0.29
FCR-CP (g CP/g LWG)	0.9[a]	1.0[b]	0.7[a]	0.8[a]	0.04

[a, b, c] Means within rows with different superscripts differ significantly ($P<0.05$)
CH=Cassava hay; GN=Guinea grass; SA=*Spilanthes acmella Murr;* ST=Stylo 184.

In Diagram 2 the relation between total CP intake (X) and live weight gain (Y) is shown. The regression line is represented by the mathematical equation:
$Y= 1.4644x-2.5933$ ($R^2=0.66$).

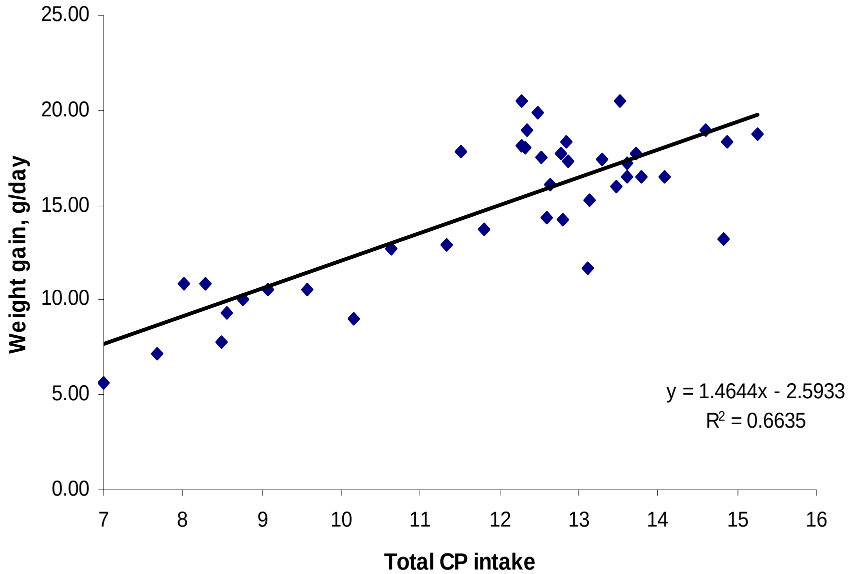

Diagram 2. Relationship between total CP intake, g/day and weight gain, g/day

Diagram 3 shows the relation between CP intake in g/ kg DM intake and live weight gain: Y = -286.7 + 4.38 x - 0.016x^2 + (R^2=0.58).

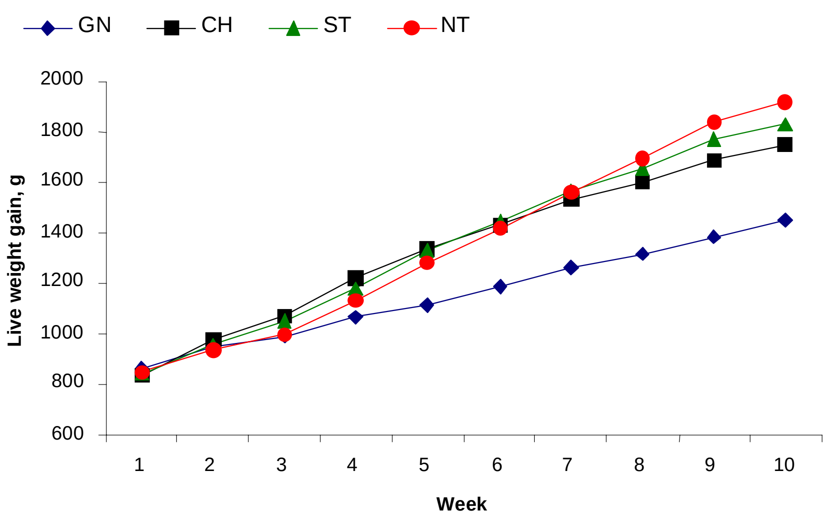

Diagram 3. Relationship between CP intake in g/kg DM and live weight gain g/day.
(Y= -286.17+4.38X+0.016X^2, 4.38X P<0.001; 0.016X^2 P<0.001; R^2=0.58)

The nutrient intake and digestibilities determined during the 7-day digestibility trial are presented in Table 4. The highest DM intakes were obtained with the Stylo 184 and Cassava hay diets. There were no significant differences between the DM intakes of the rabbits on Stylo 184, Cassava hay and the Guinea grass diets. Intake of Spilanthes was significantly lower than for the other diets. Rabbits on the Cassava hay diet consumed significantly more CP in comparison to any of the other diets. The native herb and Guinea grass were similar concerning the amount of CP consumed.

Table 4. Feed intake and digestibility in rabbits fed different diets

Items	Diet				
	CH	*GN*	*SA*	*ST*	*SE*
Nutrient intake (g/day)					
DM	86.6^{a}	79.6^{a}	74.6^{b}	87.8^{a}	2.51
CP	13.7^{a}	9.7^{c}	9.5^{c}	12.2^{b}	0.27
NDF	36.0^{c}	47.6^{a}	27.1^{d}	39.5^{b}	0.91
ADF	13.9^{c}	18.5^{a}	13.0^{c}	17.0^{b}	0.52
Digestibility					
DM	0.828^{a}	0.758^{a}	0.825^{a}	0.754^{b}	0.018
CP	0.749^{a}	0.406^{b}	0.497^{b}	0.642^{ab}	0.040
NDF	0.501^{a}	0.371^{a}	0.459^{a}	0.357^{a}	0.044
ADF	0.371^{a}	0.150^{a}	0.289^{a}	0.165^{a}	0.074

[a, b, c, d] Means within rows with different superscripts differ significantly ($P<0.05$)
CH=Cassava hay; GN=Guinea grass; SA=*Spilanthes acmella Murr;* ST=Stylo 184.

DM digestibilities of the diets containing Cassava hay, Guinea grass or Spilanthes were not significantly different, but significantly higher than the Stylo 184 diet. CP digestibility for the Cassava hay diet was similar to Stylo 184, but significantly higher than for the Spilanthes and Guinea grass diet. NDF and ADF digestibilities however, were not significantly different among diets.

4. Discussion

The nutrient composition of Stylo 184 and Guinea grass used in this study are comparable with values of (Bamikole and Ezenwa 1999) and of those presented by Adegbola et al. (1985). The CP content was 224 g/kg DM for Stylo 184 compared to 190 g described by Phengsavanh (2003) also in Laos. The CP content of Guinea grass was 121 g/kg DM as compared to 96 g presented by Viengsavanh (2001). The CP content in the Cassava hay was high, 224 g/kg DM, due to the fact that only leaves were used to make the hay. The CP content in Cassava hay can vary from 170 to 340 g/DM (Rogers and Milner, 1963) depending mainly on the amount of stem in the hay. Chalong (2004) obtained 206 g CP/kg DM in cassava hay.

The rabbits fed the diet containing Stylo 184 consumed similar amounts of DM and CP as rabbits fed Spilanthes or Cassava hay but significantly higher amounts than the rabbits fed Guinea grass. Legume hays and foliages generally have higher CP content and higher intakes than grass, which is the reason why grass-legume mixtures are preferred to sole grass swards, fertilised or unfertilised (Ezenwa and Aken'Ova, 1998). The total DM intake was, however, high, from 65 to 74 g/kg BW, which was higher than expected. Rabbits should have grass or hay available at all times, preferably on a free choice basis. Most rabbits will graze selectively through a pile of hay, picking out the tastier bits. Offering of hay should be in small amounts regularly (2 or 3 times a day), rather than large amounts of hay occasionally Carbohydrates are the primary energy source in the diet of rabbits. Therefore, the need for carbohydrates is dictated by their energy requirement (Atkins, 1997)

The rabbits fed Stylo 184, Spilanthes and Cassava hay had a higher daily weight gain than the rabbits fed Guinea grass. There was a strong positive relationship between CP intake and daily weight gain, which could be expected. As shown in Diagram 3, however, the optimum level in this experiment was between 138.7 and 139.4 g CP/kg DM, which is lower than the recommendations by NRC (1977). High levels of protein were mainly consumed by rabbits fed Cassava hay. The reason why the growth rate decreased at higher levels of protein could be that the Cassava hay contained tannins and/or HCN, which at higher levels affected the growth rate negatively. The digestibility of DM for Cassava hay was, however, high, similar to Guinea grass and Spilanthes, while digestibility for CP was significantly higher for Cassava hay than for Guinea grass and Spilanthes but similar to Stylo 184. It could also be that the rabbits in this experiment did not have genetical capacity for higher growth rates and to break down CP and excrete N in the urine is an energy demanding process.

Energy consumed in the different diets, estimated from table values and from a plant with similar chemical composition as Spilanthes showed that the rabbits consumed around 1 MJ per day with the exception of the Guinea grass diet, 0.8 MJ/day.

5. Conclusion

When feeding growing rabbits a concentrate as a basal diet the best performance was obtained when supplementing with Stylo 184 or *Spilanthes acmella Murr*. Supplementing with Guinea grass resulted in the lowest performance due to lower CP content and low intake

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