The ratio of roughage to concentrate on milk secretion rate in goats fed *Stylosanthes hamata* hay

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Abstract

An experiment was conducted to evaluate the effect of roughage to concentrate ratio (R:C) on milk secretion rate (g/h) in goats using a cross-over design in which each goat passed sequentially through all the treatments in random order. The treatments (R: C) were: A = 70 percent roughage : 30 percent concentrate; B = 50 percent roughage : 50 percent concentrate e and C = 30 percent roughage : 70 percent concentrate. In the experiment, seven goats were milked once a day, from the 2nd to 8th week of lactation, thrice per week for 2 weeks per treatment. The animals were fed at 4 percent body weight (DM basis). The feed consisted of Stylosanthes hamata hay (S. hamata hay) and a 17.2 percent CP concentrate ration. Data were analysed using the treatments as main effect with live weight and week of lactation as covariates. There was no significant treatment effects on milk secretion rate (P>0.05). Overall milk secretion rate was 5.23g/h. Week of lactation also had no significant effect (P>0.05). However, live weight of doe at time of milking had a highly significant effect (P>0.001) with milk secretion rate increasing by 0.41g/h per kilogram live weight. The R2 values for the predictive mathematical relationship for goats fed Stylosanthes hamata hay at 4 percent body weight in the dry season was R2 = 0.888. It can therefore be deduced that for a lactating doe in the 5th week of lactation at 20kg body weight fed at 4 percent with Stylosanthes hamata hay to concentrate ratio at 70 percent roughage : 30 percent concentrate would give a milk secretion rate of 6.717g/h while at 50 percent roughage : 50 percent concentrate it would give 6.662g/h and 30 percent roughage : 70 percent concentrate level would give 7.054g/h.

Keywords: *Stylosanthes hamata hay, concentrate, goats, milk secretion*

Introduction

Goat is one of the earliest domesticated animals due to its convenience for milking. Milk synthesis naturally commences following parturition. To perform this synthesis, mammary cells need all the elements necessary for their metabolism and especially the metabolites such as glucose, acetate and non-esterified fatty acids. The way these metabolites are used depends on the nutritional status of the animal (Broster and Broster, 1984; Gengler, 1996). Gross production of milk precursors depend on the digestible energy content of the dry matter ingested. The relative proportion is connected with the level of diet (Grossman et al., 1999). Diets rich in long fiber (unground forages) tend to increase the percentage of acetate in the volatile fatty acids produced whereas diets rich in cell carbohydrates (starch and soluble sugars) result in higher percentage of propionate and sometimes butyrate (Morand-Fehr et al., 1981). The nature of forage has a greater effect on milk production because of the differences in intake and digestibility related to crude fiber. Thus, an increase in energy intake is often achieved through a larger concentrate feed supply thereby changing the forage concentrate ratio. In view of the above, this work was aimed at investigating optimal ratio of roughage (*Stylosanthes hamata hay*) to concentrate for milk secretion rate and to model a relationship between the milk secretion rate and roughage to concentrate ratio.

Materials and Methods

Experimental site

The study was conducted at the College of Animal Science and Livestock Production Teaching and Research Farm, University of Agriculture, Alabata Road, Abeokuta. The region lies between latitudes 7^0 55'N - 7^0 8'N and longitudes 3^0 11.2' - 3^0 2.5'E and it is within the rainforest vegetation zone of South-Western Nigeria. The mean annual temperature of 23.2^{0}C and relative humidity of 81.5 percent with a seasonal rainfall of 1,112.7mm respectively (ORBDA, 2004).

Experimental animals and management

The study involved seven goats (5 West African Dwarf goats, WAD and 2 Red Sokoto goats) of varying ages (between 3 – 10 years), parities (1^{st} – 7^{th} parity) and live weight (14 – 36kg). The goats were managed intensively with animals kept in cross-ventilated pens with slatted floors. They were fed *S. hamata hay* supplemented with concentrate feed at 4 percent body weight on dry matter basis and they had free access to water. Three roughage to concentrate ratios which constituted the experimental treatments were 70 percent roughage : 30 percent concentrate; 50 percent roughage : 50 percent concentrate and 30 percent roughage : 70 percent concentrate. The gross composition of the concentrate feed and the proximate nutrient composition of *S.* hamata hay are shown in Tables 1 and 2 respectively. The experiment was carried out during the dry season period while daily routine practices such as cleaning of the pens and water troughs were done. Bales of stylo hay of about 220kg were prepared using the hay baler. Also, concentrate ration of about 220kg were also compounded. All does were allowed to be suckled by their kids till the 2^{nd} week of lactation before the commencement of the experiment. Does were fed at 4 percent body weight on dry matter basis twice a day in morning and in the evening at 3 treatment levels. Feeding of test ingredients commenced at the 2^{nd} week of lactation for all the animals. Each of the treatment was allotted to the does at different weeks based on randomized allotment for six weeks making each animal a replicate. On the milking days (Mondays, Wednesdays and Fridays), kids were separated from their dams at 08:00 hr before feeding and the dams were milked dried. Milk collected was weighed and recorded as off-take. The isolated dams were again milked four hour later that is at 12:00 noon to obtain the four hour milk yield from which milk secretion rate (g/h) was calculated. Kids were returned to their dams after milking and this procedure was repeated on other milking days within the week. The live weight of each lactating doe was taken weekly throughout the duration of the experiment.

Data analysis

The data generated for milk secretion and live weight were analyzed by method of least squares (Systat, 1993) using the model:

$$Y_{ij} = \mu + T_i + bw + cL + E_{ij}$$

Where:

Y_{ij} = the value of parameters of interest

μ = overall mean

T_i = effect of the i^{th} treatment i.e. roughage to concentrate ratio

bW = week of lactation included as covariate

cL = liveweight included as covariate

E_{ij} = random residual error associated with each record

Data adjustment

Data for milk secretion rate were adjusted using constant estimates from the least squares analysis. Milk secretion rate was adjusted to 5^{th} week of lactation and 20kg

Table 1: Gross composition of the concentrate feed used in the experiment

Nutients	% Composition
Brewers' dried grains	30
Wheat offal	40
Palm kernel cake	18
Maize	10
Common salt	1
Bone meal	1
Total	100

Caculated chemical composition of concentrate ration (% dry matter)

Crude protein - 17.20
Crude fiber - 11.54
Ether extract - 4.68

live weight of doe. The adjustment equation is:

$$W = Y + (5 - Xi) * b$$
$$Z = W + (20 - Lj) * c$$

W = Adjusted milk secretion rate
Y = Unadjusted milk secretion rate
Xi = Initial week of lactation estimate
b = Regression coefficient for week of lactation on secretion rate
Z = Final adjusted milk secretion
Lj = Initial live weight estimates of does
c = Regression coefficient for live weight on secretion rate

Modeling of milk secretion rate

The milk secretion rate was regressed on treatment levels i.e. roughage to concentrate combination. Regression was carried out by imputation of the equation into non-linear regression package (Systat, 1993) for the generation of parameters needed. The Quadratic function used was:

Function Model
Model definition
Quadratic $Y = A + BX + CX^2$

Table 2: Proximate chemical composition of the elephant grass (*S. hamata* hay) (%dry matter)

Chemical composition	*Stylosanthes hamata* hay
Dry matter	42.14
Crude protein	15.75
Crude fiber	21.28
Nitrogen free extract	1.52
Ash	2.97
Nutrient detergent fiber	59.75
Acid detergent fiber	49.78
Acid detergent lignin	8.67

Table 3: Summary of the analysis of variance of effect of *S. hamata hay* to concentrate ratio, week of lactation and live weight on milk secretion rate for unadjusted data in goats

Source of variation	DF	Mean squares
Treatment (*S. hamata* to concentrate ratio)	2	2.006
Week of lactation	1	15.878
Live weight	1	184.59***
Error	116	5.933

***P<0.001

Y = Milk secretion rate
A = Constant
B = Linear component regression coefficient
C = Quadratic component regression coefficient
X = Concentrate level

For this experiment, outliers numbering twenty five (25) were deleted as they fell outside the approximate normal curve.

Results

Effect of the ratio of *S. hamata hay* to concentrate fed at 4 percent body weight on milk secretion rate in goats in the dry season

The result of the analysis of variance for the effect of treatment (*S. hamata hay* to concentrate ratio), week of lactation and live weight included as covariate are shown in Table 3 for unadjusted data. From the result, *S. hamata hay* to concentrate ratio (fed at three levels) treatment A (70% R : 30% C); treatment B (50% R : 50% C) and treatment C (30% R : 70% C) had no significant effect (P>0.05) on milk secretion rate. Week of lactation included as covariate also had no significant effect on milk secretion. Live weight variable as a covariate variable on the other hand had a high significant effect (P<0.001) on milk secretion rate. The coefficient of regression (b) for the effect of live weight and week of lactation as covariates on milk secretion rate were 0.413 and -0.217 respectively (Table 4). The result of the analysis of variance for the effect of treatment (*S. hamata hay* to concentrate) was not significant for the adjusted data that is, milk secretion rate to 5th week of lactation and 20kg live weight of doe. The least square means are shown in Table 5.

Predictive mathematical relationships between milk secretion rate and concentrate level during lactation

The predictive mathematical equation showing the relationship between milk secretion rate and concentrate level during lactation with their R^2 is presented in Table 6. The R^2 values for the predictive mathematical relationship for goats fed *S. hamata hay* at 4 percent body weight in the dry season was $R^2 = 0.888$. It can therefore be deduced that for a lactating doe in the 5th week of lactation at 20kg body weight fed at 4 percent body weight (dry matter basis) with *S. hamata hay* to concentrate ratio at 70 percent roughage : 30 percent concentrate gives a milk secretion rate of 6.717g/h while at 50 percent roughage : 50 percent concentrate it would give 6.662g/h and 30 percent roughage : 70 percent concentrate level would give 7.054g/h.

Table 4: Constant estimate values (b) for the effect of treatment (*S. hamata hay*), week of lactation and live weight on milk secretion rate in goats

Source of variation	Subclass (roughage to concentrate ratio %)	Least squares constant (b)
Treatment	1 (70:30)	-0.127
	2 (50:50)	-0.136
	3 (30:70)	0.236
Week of lactation (b_w)		-0.217
Liveweight (b_l)		0.413

Discussion

Results from the current study indicates that various treatment that is (roughage to concentrate ratio) had no significant effect ($P>0.05$) on milk secretion rate. It could be due to the fact that the roughage to concentrate ratio feeding level of 4 percent body weight dry matter basis was not sufficient for the does, hence a reduced milk secretion rate. This agreed with the findings of Morand-Fehr et al. (1982), who stated that substantial decrease in milk production occurs when nutrient uptake is restricted. It could be also be due to the season in which the experiment was carried out. It was carried out in the dry season where the temperature is high hence, a reduced milk secretion rate. This could also be attributed to the dried nature of the legume used that is, *S. hamata hay* which could have resulted into inadequate supply of dry matter, hence a reduced milk secretion. On the other hand, live weight when included as covariate had a higher significant effect on milk secretion rate that is, there was a positive regression coefficient of milk secretion rate on body weight. This is in line with Gall (1980), Ehoche and Buvanendran (1983), James (2000) and Bemji (2003). This increase could be attributed to the increase in udder size as well as foetal growth and development. Week of lactation included as a covariate had no significant effect on milk secretion rate. This could be due to both loss of secretory tissue and fall in the rate of

Table 5: Least square means showing the effects of treatment (*S. hamata hay* to concentrate ratio) on milk secretion rate in goats

Source of Variation	Subclass (roughage to concentrate ratio %)	No of Observation	LSM±SEM (g/h)
Treatment	1 (70 : 30)	42	5.217 ± 0.43
	2 (50 : 50)	41	5.183 ± 0.44
	3 (30 : 70)	38	5.276 ± 0.45

Table 6: Predictive mathematical relationship showing the effect of concentrate level on milk secretion rate fed at 4% body weight

Experiment	Function	Predictive Equation	R^2
	Quadratic $Y= A+BX+CX^2$	$Y= 7.64169-0.04759X+0.00056X^2$	0.888

secretion per cell. In concluding, future experiments could consider increasing the roughage to concentrate ratio feeding level from 4 percent body weight dry matter basis to about 5 percent. If *S. hamata hay* is to be used, the experiment could be done during the wet/dry season. This is to avoid the dryness of the roughage and also other types of roughages could be tried alongside with concentrate.

References

Bemji, M. N. 2003. Milk production and pre-weaning growth of West African Dwarf and Red Sokoto goats. Ph.D. Thesis, Department of Animal Breeding and Genetics, University of Agriculture, Abeokuta, Nigeria. pp137

Broster, W. H. and Broster, V. J. 1984. Reviews of the progress in Dairy Science: long term effects of plane of nutrition on the performance of the dairy cow. *J. Dairy Res.* 51:149- 196

Ehoche, O. W. and Buvanendran, V. 1983. Milk yield and composition of milk and pre-weaning growth rate of Red Sokoto goats in Nigeria. *Wld. Rev. Anim. Prod.* Vol. xix (2): 19-24

Gall, C. 1980. Relationship between body conformation and production in dairy goats. *Journal of Dairy Science* 63(10):1768-1781

Gengler, N. 1996. Persistency of lactation yields: A review Interbull Bulletin 12:87-96

Grossman, M., Hartz, S. M. and Koops, W. J. 1999. Persistency of lactation yield: a novel approach. *J. Dairy Science* 82:2192-2197

James, I. J. 2000. Changes in udder traits of West African Dwarf, Red Sokoto and Sahel goats during pregnancy and lactation and their effects on partial daily milk yield. MSc. Dissertation, Department of Animal Production and Health, University of Agriculture, Abeokuta, Nigeria

Morand-Fehr, P., Bas, P. and Sauvant, D. 1981. Effect of protected lipids on the milk performance and the metabolism in goats in early lactation. Symposium on goat feeding, *Tours*, 12-15 May 1981. Vol. 2:594-611

Morand-Fehr, P., Chilliard, Y. and Sauvant, D. 1982. Goat milk and its components; secretory mechanism and influence of nutrition factors. Proc. of Third International Conference on Goat Production and Disease. College of Agriculture, The University of Arizona, Tucson, Arizona. Jan. 10-15, 1982. Dairy Goat Journal Publishing Company

Ogun-Osun River Basin Development

Authority (ORBDA). 2004. Reports on meteorological data for the experimental station geographical zone

Systat 1993: Computer package version 1993. Systat Inc., Chicago, Illinios, USA

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