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Full Length Research Paper

Roughage to concentrate ratio on milk secretion rate in goats

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An experiment to evaluate the effect of concentration ratio (R:C) on milk secretion rate (g/h) in goats was carried out using a cross-over design in which each goat passed sequentially through all the treatments in random order. The treatments (R:C) were: A = 70:30; B = 50:50 and C = 30:70. In this experiment, 13 goats were fed at 5% body weight (DM basis) using fresh-cut elephant grass (*Pennisetum purpureum*) and a 16.44% crude protein concentrate ratio. The goats were milked from the 6th to 9th week of lactation once a day for one week per each treatment. Data was analyzed by using the treatments as main effect with live weight and week of lactation as covariates. The overall milk secretion rate was 6.86 g/h. It was found that the treatment had a high significant effect ($P < 0.001$) on milk secretion rate. Treatment C gave the highest mean value followed by Treatment B. Treatment A gave the least mean value. The week of lactation and live weight of doe at time of milking had a high significant effect ($P < 0.001$). Milk secretion data was adjusted to 5th week of lactation and 20 kg live weight of doe, and a predictive model based on quadratic function was developed. $Y = 2.27836 + 0.16588X - 0.00135X^2$; $R^2 = 0.94$ where Y = milk secretion rate (g/h) and X = percent concentrate in feed ration. From the curve, the optimum roughage to concentrate ratio (R/C) was 40:60, which should yield a milk secretion rate of 7.37 g/h.

Key words: *Pennisetum pupureum,* concentrate, goats.

INTRODUCTION

Goats are kept in most countries of the world and estimates of numbers have been made by organizations such as the FAO (1986). They are kept for meat, hides, fiber and milk production. Milk production is largely dependent on the shape of the lactation curve. Relevant elements of the lactation pattern are the peak yield, which represent the maximum milk yield during the lactation and the lactation persistency which expresses the ability of animals to maintain a reasonable constant milk yield after the lactation peak (Cannas et al., 2002). In the classification of herbivores according to their diet (Hofmann, 1989) the goat species is included in an intermediate class between grass and roughage eaters (cattle, sheep) and concentrate selectors which do not tolerate high fiber levels and are forced to select less fibrous parts of plants. 'Intermediate feeders' (or opportunistic feeders) change their feeding behaviour according to seasonal changes in diet availability (Fedele et al., 1993; Papachristou, 1996) and are much more versatile than the other two categories of animal. 'Intermediate feeders' are characterized by: (i) high saliva secretion and large absorption surface of the rumen epithelium, which protects the animal from the risk of acidosis; and (ii) considerable enlargement of the digestive apparatus when highly fibrous feed is used (Silanicove, 2000). Due to these characteristics, goats can adapt to a broad range of feeding conditions. It has been demonstrated that even in diets with concentrate levels above 60 – 70%, goats do not greatly alter their productive capacity or their metabolic well-being (Bailoni and Andrighetto, 1995; Economides, 1998; Goetsch et al., 2001; Fedele et al., 2002). However, for correct feed management in milking goats, it is desirable to estimate roughage to concentrate intake in order to optimize the utilization of feed supplements. In fact, the supplements

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

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

Calculated proximate chemical composition of concentrate ration (% dry matter): Crude protein – 16.44; Crude fiber – 11.54; Ether extract – 4.68.

Table 2. Proximate chemical composition of the elephant grass (*P. purpureum*) percent dry matter.

Chemical components	*P. purpureum*
Dry matter	29.68
Crude protein	11.90
Crude fiber	15.12
Nitrogen free extract	1.04
Ash	2.12
Nutrient detergent fiber	61.57
Acid detergent fiber	39.58
Acid detergent lignin	11.60

can cause a substitution effect on herbage intake, sometimes making this practice too costly. Most of the works carried out on goat milking in Nigeria have been on weekly collection (Ehoche and Buvanendra, 1983; Ibeawuchi et al., 2003; Bemji, 2003; James and Osinowo, 2004). However, the present work focused on daily milking. In view of this, the study was aimed at investigating the optimal ratio of roughage (*Pennisetum purpureum*) to concentrate feed 5% body weight on milk secretion rate in goats during the late wet and early dry seasons. The study also tried 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, Nigeria. The region lies between latitudes 7°55'N - 7°8'N and longitudes 3° 11.2' - 3° 2.5'E and it is within the rainforest vegetation zone of South-Western Nigeria. The mean annual temperature is 23.2°C and relative humidity is 81.5%. Seasonal rainfall is approximately 110.90 mm (9.97%) in the late dry season (January – March); 462.1 mm (41.53%) in the early wet season (April – June); 376.6 mm (33.85%) in the late wet season (July – September) and 163.1 mm (14.66%) in the early dry season (October – December) (ORBDA, 2004).

Experimental animals and management

The study involved 13 goats, 6 of them were West African Dwarf (WAD), 4 were Red Sokoto (RS) and 3 were Crossbred goats of varying ages (between 3 – 10 years), parities (1st – 7th parity) and live weight (14 – 36 kg). The animals were kept in a cross ventilated pens with slatted floors and were managed intensively. Pens and water troughs were cleaned daily. The experiment was carried out from late rainy season to early dry season. Fresh cut *P. purpureum* grass was obtained each day with a compounded concentrate ration. The proximate composition of the *P. purpureum* and the concentrate ratio were determined (Tables 1 and 2). Does were fed 5% of body weight dry matter basis twice a day, in the morning and in the evening at 3 treatment levels of: A (70:30%), B (50:50%) and treatment C (30:70%) roughage to concentrate ratio. Kids were weaned at two weeks of age and artificially reared throughout the period of the experiment. They were bottle-fed with the milk collected from the dams. Does were milked at 8:00a.m in the morning each day throughout the experiment which took place for 3 weeks. Milk collected on each day was weighed and recorded to obtain the milk secretion rate (g/h) from the 24 h yield. Weekly live weight gains of the does were also recorded.

Data analysis

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

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

Data adjustment

Data for milk secretion rate was adjusted using constant estimates from the least squares analysis. The milk secretion rate was adjusted to 5th week of lactation and 20 kg live weight of doe. The adjustment equation is:

$$W = Y + (5 - X_i) * b$$

$$Z = W + (20 - L_j) * c$$

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

Modeling of milk secretion rate and lactation curves

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:

Quadratic function (Model) = $Y = A + BX + CX^2$

Table 3. Summary of analysis of variance of effects of *P. purpureum* 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 (*P. purpureum* to concentrate ratio)	2	22.518***
Week of lactation	1	106.202***
Live weight	1	905.750***
Error	222	1.119

***P < 0.001.

Table 4. Least square means showing the effects of treatment (*P. purpureum* to concentrate ratio) on milk secretion rate in goats.

Source of variation	Subclass (roughage to concentrate ratio, %)	No. of observation	LSM±SEM (g/h)
	1 (70 : 30)	77	6.318 ± 0.12[c]
Treatment	2 (50 : 50)	73	6.842 ± 0.13[b]
	3 (30 : 70)	77	7.400 ± 0.12[a]

[a – c] Means in the same row having different superscript differ significantly (P < 0.001).

Table 5. Constant estimate values (b) for the effect of treatment (*Pennisetum purpureum*), week lactation and live weight on milk secretion rate in goats.

Source of variation	Subclass (roughage to concentrate ratio, %)	Least squares constant (b)
	1 (70:30)	-0.535
Treatment	2 (50:50)	-0.011
	3 (30:70)	0.546
Week of lactation (b_W)		-0.777
Liveweight (b_l)		0.519

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

The outliers numbering twenty five (25) were deleted as they fell outside the approximate normal curve.

RESULTS

The ratio of *P. purpureum* to concentrate feed at 5% body weight on milk secretion rate in goats

The analysis of variance for the effect of roughage (*P. purpureum*) to concentrate ratio, week of lactation and live weight included as covariate (for the unadjusted data) are shown in Table 3. The results showed that treatment (roughage to concentrate ratio) had a high significant effect (P < 0.001) on milk secretion rate. Treatment C had the highest effect on milk secretion rate with a mean value of 7.400±0.12 g/h followed by treatment B with a mean value of 6.842±0.13 g/h while treatment A had the lowest effect with a mean value of 6.318±0.12 g/h (Table 4). Week of lactation and live weight used as a covariate variable had a high significant effect (P < 0.001) on milk secretion rate. The coefficient of regression (b) for the effect of the live weight as covariate on milk secretion rate was 0.519 and -0.777 for the week of lactation (Table 5). The result of the analysis of variance for the effect of treatment (*P. purpureum* to concentrate) on milk secretion rate for the adjusted data that is, milk secretion rate to 5th week of lactation and 20 kg live weight of doe had a significant effect (P < 0.001) as shown in Table 6.

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

Table 6. Summary of the analysis of variance for the effect of treatment (*P. purpureum*) on milk secretion rate in for adjusted data in goats.

Source	DF	Mean squares
Treatment (*P. purpureum* to concentrate ratio)	2	30.162**
Error	224	5.712

**P < 0.01.

Table 7. Predictive mathematical relationship showing the effect of concentrate level on milk secretion rate fed at 5% body weight.

Experiment	Function	Predictive equation	R^2
P. purpureum + Concentrate	$Y = A+BX+CX^2$	$Y = 2.27836+0.16588X+ 0.00135X^2$	0.940

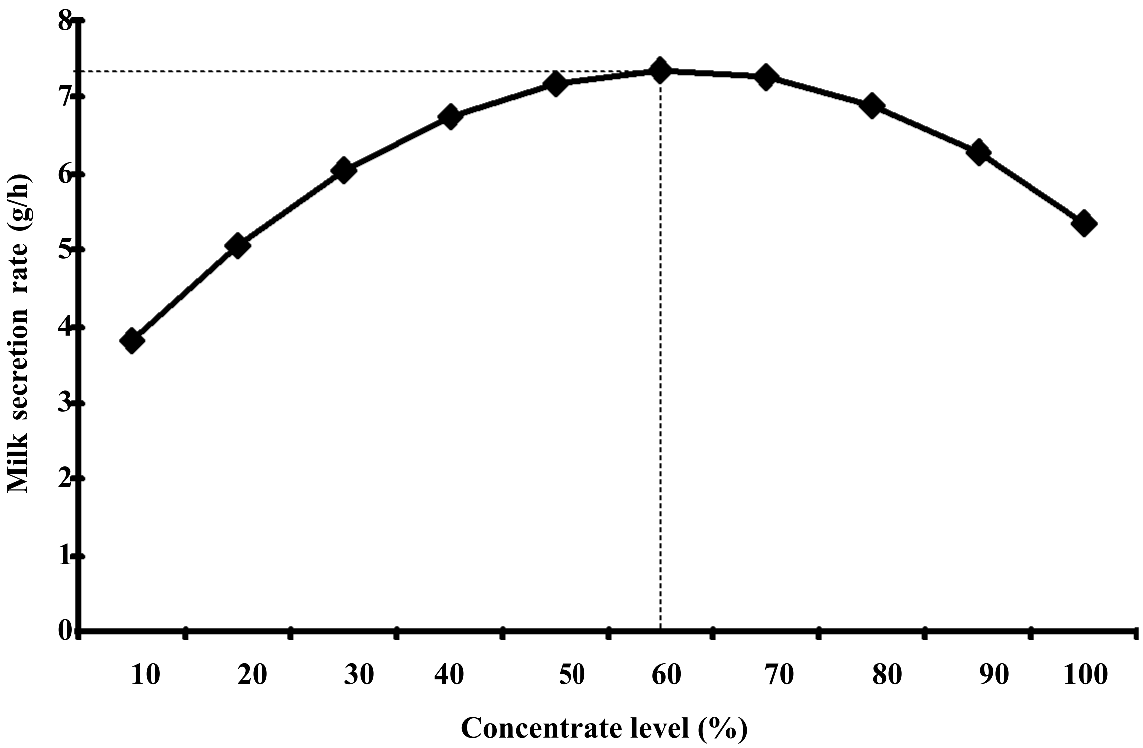

Figure 1. Effect of roughage to concentrate ratio on milk secretion rate in goats at 5% feeding level.

level during lactation with their R^2 values is presented in Table 7. The R^2 value for predicting mathematical relationship for lactating doe fed 5% body weight dry matter basis with *P. purpureum* was 0.940. It can therefore be deduced that for lactating doe in the 5th week of lactation at 20 kg body weight fed 5% body weight dry matter basis with *P. purpureum* to concentrate at 70:30% roughage to concentrate would give a milk secretion rate of 6.039 g/h, 50% roughage to 50% concentrate would give 7.197 g/h and 30% roughage to 70% concentrate gives a milk secretion rate of 7.275 g/h (Figure 1).

DISCUSSION

The results of the study showed that 30:70% (roughage: concentrate) ratio favoured milk secretion rate the most. This could be as a result of the high level of concentrate which led to an increased feed and energy intake thereby increasing milk secretion. Morand-Fehr et al. (1982) affirmed that the synthesis of goat milk largely depends on nutritional milk precursors present in the blood plasma and taken up by the udder. It could also be attributed to the fact that the increased feeding level of 5% body weights of dry matter of fresh-cut *P. purpureum* was sufficient in meeting the nutrient requirements of the does hence, an increased milk secretion rate. In this study, the week of lactation when used as covariate, had significant effect on milk secretion rate. There seems to be a high milk secretion rate around the 3rd – 5th week of lactation which corroborates with the findings of Akinsoyinu et al. (1977). They reported that peak milk yield occurred 3rd – 5th weeks of lactation in Red Sokoto and West African Dwarf breeds respectively. Also, when live weight is used as a covariate, it has significant effect on milk secretion rate. This also is in line with the work of Akinsoyinu et al. (1977). The significant effect could be due to the increased feeding level of 5% body weight which favoured increased weight gain and udder development resulting in an increased milk secretion rate.

Milk production throughout lactation, in goats as in other domestic ruminants, is the result of the processes of synthesis and secretion of organic and inorganic compounds and of active and passive blood filtration by specialized epithelial cells of the mammary gland (Mepham, 1987). Starting from the end of gestation, there is a phase of rapid cellular activation, followed by cellular regression (cellular remodeling) at varying rates, that ends with the cessation of lactation or dry-off (Hurley, 1989). All of these physiological mechanisms result in a typical pattern of milk yield over time, characterized by an initial phase of increasing production which reaches a maximum (lactation peak) and then declines more or less rapidly until dry-off. Knowledge of the main characteristics of the lactation curve is of great help to dairy producers and professionals in making management and breeding decisions. The prediction of total milk yield from a few tests in early lactation enables one to: (i) calculate the gross income that can be obtained from a goat; (ii) choose which animals that have to be culled; (iii) identify sick animals on the basis of a decrease in yield before the appearance of clinical signs (subclinical mastitis); and (iv) identify high producing animals that have higher dietary requirements than average- producing animals (Gipson and Grossman, 1989).

The applications of mathematical modeling in animal science is one of the most important applications in the description of the temporal evolution of milk production in domestic animals. Lactation curve models are implemented in feeding management software for livestock species (Boe et al., 2005) which represent an essential component of random regression test day models. It is an upgraded version of genetic models used to predict breeding values and to estimate variance components for milk production traits in dairy animals (Schaeffer, 2004). The most common approach in lactation curve modeling is to fit suitable functions of time, y = f(t), to test day records. Such an empirical approach is essentially aimed at describing the regular continuous component of the lactation pattern. Most studies on goat lactation curve modeling deal with average curves of homogenous groups of animals (parity order, kidding season, number of kids at parturition). When average curves are modeled, almost all functions give good fitting performances, R^2 values are often higher than 0.80 (Montaldo et al., 1997; Todaro et al., 2000; Macedo et al., 2001; Fernandez et al., 2002). In the present study, an R^2 value of 0.940 was obtained. Finally, it can be concluded from the present study that 40:60% (roughage to concentrate) is the optimum ratio that favours milk secretion rate though the investigative treatment result favoured 30:70% (roughage to concentrate). Also, the predictive mathematical model showing the relationship between milk secretion rate and roughage to concentrate ratio achieved a good fit with *P. purpureum* to concentrate ratio. With 60% concentrate level having the peak secretion rate of 7.37g/h.

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