Volatile fatty acid production in the grey duiker, *Sylvicapra grimmia*

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Volatile fatty acid production was studied in the rumen and caecum of culled grey duiker (*Sylvicapra grimmia)* and in the rumen of tame fistulated duikers. The caecum had a higher total VFA concentration and production rate per unit volume than the rumen but when considering total volume the caecum was only 14 – 17% of the rumen values. The energy obtained from ruminal VFA was calculated to satisfy 36,1% and 74,9% of the basal metabolic energy requirements of field animals in summer and winter respectively. The total hindgut contribution (caecum + colon) would amount to 19% in summer and 30% in winter emphasizing the importance of fibre fermentation in the hindgut.

Vlugtige vetsuur produksie is ondersoek in die grootpens en sakderm van die uitskot grys duikers *(Sylvicapra grimmia)* en in die grootpens van gefistuleerde mak duikers. Die sakderm het 'n hoër totale vlugtige vetsuur konsentrasie en produksie tempo per eenheid volume gehad as die grootpens, maar wanneer totale volume in ag geneem is, was die sakderm slegs 14 – 17% van die grootpens waardes. Dit is bereken dat die energie wat verkry is van die vlugtige vetsure geproduseer in die grootpens 36,1% en 74,9% van die basale metaboliese energievereistes van velddiere bevredig, in die somer en winter onderskeidelik. Die totale bydrae van die agterderm (sakderm + dikderm) sal 19% in die somer en 30% in die winter wees, wat die belangrikheid van veselfermentasie in die agterderm beklemtoon.

Keywords: Rumen, volatile fatty acids, energy, grey duiker

Introduction

The grey duiker, *Sylvicapra grimmia,* is a small browsing antelope occurring in Africa south of the Sahara. Plants utilized by the grey duiker include *Dichrostachys, Solanum, Diospyros* and *Combretum* species (Wilson & Clarke, 1962). These are mainly deciduous trees and shrubs of which the more fibrous parts are utilized in winter. Volatile fatty acids (VFA) are the most important source of energy to the ruminant and their proportions reflect the type of diet utilized by the animal. Thus VFA production as an energy source, was studied in the rumen and caecum as part of a study on digestion in the grey duiker.

Methods

Eighteen animals were culled in the field and three tame fistulated duikers were used in the laboratory studies. The tame animals were fed a pelleted concentrate diet, which had an energy value of 20,3 kJ per gram DM and 12,6% CF. No roughage was fed to the animals.

Ruminal contents were squeezed through two layers of cheesecloth to obtain the fluid portion. The first 5 ml was pipetted into a test tube containing 0,6 ml 5N – NaOH and used to determine the total VFA concentration. The remainder of the strained rumen fluid (90 ml) was placed in a fermentation flask with mineral medium containing pivalic acid. This was used to determine the VFA production rate by the zero-time incubation method (Carroll & Hungate, 1954). The method was modified by taking samples every 15 minutes for one hour and thereafter every hour to calculate VFA increments and thus production rate. Fermentation in each 5 ml sample was stopped with 0,6 ml 5N – NaOH.

Total VFA concentrations in the samples were determined by steam distillation and titration using 0,1N – NaOH (Fenner & Elliot, 1963). Molar ratio's were determined by gas chromatography, pivalic acid being used as an internal standard (Czerkawski, 1976). The 5 ml samples were acidified to pH 1 with 85% H_3PO_4 and centrifuged at 2 000 rpm for 20 minutes. The supernatant (0,6 μl injection) was analysed using a Pye Unicam GCD Chromatograph with a flame ionization detector and a glass column (4 mm diameter, 1 m length) packed with 60/80 Carbopack C/0,3% Carbowax 20 M/0,1% H_3PO_4. The flow rate of the carrier gas (N_2) was 50 ml per minute. Column temperature was 130° C and detector 210° C.

Whole digesta were used for the VFA production rate incubations with caecal contents of field animals. The processes of sampling and analysis were similar to those of the rumen VFA fermentations.

Results and Discussion

VFA concentration and production rate

Six volatile fatty acids were separated, and identified as acetic, propionic, iso-butyric, butyric, iso-valeric and valeric acids when compared to a standard mixture (Tables 1 and 2).

The total VFA concentrations in the rumen and caecum of field duiker culled in summer were similar (11,7 and 11,9 mmol/100 ml respectively) whereas the winter values were the result of the higher VFA production rate (Table 1). The more fibrous nature of the winter browse would also lead to longer digesta retention times in the tract and a concommitant rise in total VFA concentration in the hindgut.

Fermentation in the caecum was related to the fibrous nature of the feed since the caecum showed a high fibre fermentation (acetate, 85,5 molar %) and less soluble carbohydrate fermentation (propionate, 9,6 molar %; butyrate, 2,9 molar %). Protein and soluble carbohydrates in general ferment more rapidly than fibre and thus less of the former substance leaves the rumen, particularly if the rumen has a fairly high fermentation rate as in the duiker (370 μmol gas/g DM/h). This agrees with the postulate of Kay, Engelhardt & White (1980), that the fibrous components not fermented in the rumen could be utilized in the hindgut.

The caecum has a considerably higher total VFA concentration and production rate per unit volume than the rumen, but when applied to the total volume (Table 1) the caecum was only 14 – 17% of the rumen values.

The laboratory animals differed from the field animals in the molar percentages of acetic and propionic acids present in the ruminal digesta. This is a result of the highly digestible, finely ground diet fed to the laboratory animals.

Table 1 Mean total volatile fatty acid concentrations, production rates and digesta volumes of the rumen and caecum of grey duikers (mean ± SD.)

Measurement		Field rumen (n = 18)	Field caecum	Fistulated rumen (n = 3)
Total VFA conc (mmol/100 ml digesta)	Summer	11,7 ± 1,9	11,9 ± 2,6	11,8 ± 1,3
	Winter	12,4 ± 0,9	18,2 ± 2,8	–
Production rate (mmol/100 ml/hour)	Summer	3,4 ± 1,9	4,4 ± 1,9	6,6 ± 1,3
	Winter	5,9 ± 1,5	9,6 ± 2,8	–
Digesta volume (ml)	Summer	966,8 ± 161,0	149,0 ± 62,0	322,4 ± 29,0
	Winter	1133,9 ± 258,0	119,5 ± 53,0	–

Table 2 Mean volatile fatty acid molar percentages found in the rumen and caecum of grey duikers

Volatile fatty acid	Field rumen	Field caecum (n = 18)	Fistulated rumen (n = 3)
% acetic	70,0	85,5	63,9
% propionic	18,8	9,6	20,7
% iso-butyric	1,2	0,8	1,3
% butyric	7,1	2,9	9,3
% iso-valeric	0,9	0,7	1,4
% valeric	1,8	0,9	3,4

Relative contribution of VFA to energy requirements

The mean gross energy intake of the laboratory animals was 7 066 kJ/day. After subtracting the energy lost in the faeces, the mean intake of digestible energy was 5 916 kJ/day. Taking into account the energy lost in the urine and through methane production, the metabolizable energy intake was 5 342 kJ/day. In general the laboratory animals did not consume enough feed to produce adequate energy for maintenance and this was confirmed by the animals' loss in mass during the experiment.

The VFA energy yield was calculated using the method of Allo, Oh, Longhurst & Connolly (1973). The energy ob-

Table 3 Volatile fatty acid energy yield in kJ/day from the ruminal and caecal digesta

Estimate	Field rumen Summer (n = 18)	Field rumen Winter (n = 18)	Field caecum Summer (n = 18)	Field caecum Winter (n = 18)	Fistulated rumen (n = 3)
VFA production[a] (mol/d)	0,789	1,606	0,157	0,264	0,511
VFA energy[b] (kJ/mol)	1157,1	1157,1	1020,4	1020,4	1242,6
Total VFA energy yield[c] (kJ/day)	912,9	1858,2	160,2	269,4	634,9

[a]VFA production rate × volume
[b]Sum of molar % of each energy value (kJ/mol) where acetate 874,4; propionate 1527,3; butyrate and isobutyrate 2183,5; valerate and isovalerate 2827,8 (Weast, 1978)
[c]a × b

tained from ruminal VFA was calculated as a percentage of the basal metabolic energy requirement and was 36,1% in the summer and 74,9% in the winter for the field duikers (Table 3). The caecum contributes 6,3% in the summer and 10,9% in the winter. In the laboratory animals the rumen VFA provided 26,3% of the basal metabolic energy requirement, 9,0% of the gross energy intake and 10,7% of the digestible energy.

The digesta mass of the colon is approximately twice that present in the caecum. If the colon has the same total VFA concentration and production rate, then the VFA energy contribution would be 12% of the basal metabolic energy requirement in summer and 20% in winter. The total hindgut contribution would then be 18,9% in the summer and 30% in the winter. The percentage of the basal metabolic energy requirement obtained from the total VFA production (rumen included), is 55% in summer and 107% in winter. The importance of fibre fermentation in the hindgut is thus emphasized.

In summer, the difference between the basal metabolic energy requirement and the energy obtained from VFA production in the gastro-intestinal tract is large, but could be made good by direct absorption from the small intestine of soluble carbohydrates and proteins which are readily available in the green browse.

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