Comparison of Digestion in Donkeys and Ponies

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Summary

The study was conducted to compare the ability of donkeys and ponies in utilization of low quality diet. 6 donkeys and 6 ponies (3 donkeys and 3 ponies with a permanent cecal cannula) were fed successively 4 diets based on wheat straw with or without supplementation of energy (ground corn) and nitrogen (soy bean meal or urea). The diets were offered ad libitum twice a day.

The results showed that the dry matter (DMI) and the digestible organic mater intake (DOMI) g/kg$^{0.75}$ and volatile fatty acids (VFA) production were higher in donkeys than in ponies. However, there was no significant differences in apparent digestibilities of OM, CP, NDF and ADF between the two species. Energy and nitrogen supplementations increased the concentration of VFA, in constrast, they decreased ADF and NDF digestibilities in diets. The digestibility of crude proteins (CP) was higher in the diets with nitrogen supplementations.

The donkey utilize better low-quality diet by maintaining a high rate of feed intakes and diet digestibilities and accelerating the mean retention time of diets in digestive tract.

Vergleich der Verdauung bei Ponys und Eseln

In der vorliegenden Untersuchung sollte die Fähigkeit zur Nutzung schwerverdaulicher Futtermittel bei Eseln und Ponys verglichen werden. 6 Esel und 6 Ponies, davon je 3 mit einer Zäkumfistel, erhielten aufeinanderfolgend 4 Rationen auf Weizenstroh als Grundlage mit oder ohne Ergänzung an Energie (Maisschrot) oder Stickstoff (Sojaextraktionsschrot oder Harnstoff). Die Rationen wurden 2mal täglich ad libitum angeboten. Die Ergebnisse zeigen, daß die Aufnahme an Trockensubstanz und an verdaulicher organischer Substanz (in g/kg KM$^{0.75}$) sowie die Produktion von kurzkettigen Fettsäuren bei den Eseln höher waren. Es gab jedoch keinen signifikanten Unterschied bei der scheinbaren Verdaulichkeit der organischen Substanz, des Rohproteins, der Neutral detergent fiber (NDF) und Acid detergent fiber (ADF) zwischen den beiden Tierarten. Energie- und Stickstoffzulagen erhöhten zwar die Konzentration der kurzkettigen Fettsäuren, sie führten jedoch zu einem Rückgang der Verdaulichkeit der NDF und ADF. Nach Stickstoffergänzung nahm die Proteinverdaulichkeit dagegen zu. Esel können schwerverdauliche Futtermittel besser ausnutzen als Ponys, weil sie durch eine entsprechende Verkürzung der mittleren Passagezeit bei gleichbleibender Verdaulichkeit in der Lage sind, mehr Futter aufzunehmen.

Introduction

The hindgut fermenter of non-ruminant herbivores has been considered to be less efficient in utilization of plant cell wall than the foregut fermenter of ruminants (v. Engelhardt et al., 1985). Microbial action is less important in hindgut than in foregut fermenter because the transit time of diet was faster (*Uden* et *al.*, 1982).

Donkeys are frequently fed on low quality roughage. To adapt with this nutritional condition, donkeys increased their feed intake to maintain their energy requirement (*Izraely* et *al.*, 1989).

In the present study, the ability of donkeys to utilize low quality diets with or without energy and nitrogen supplementation was compared with ponies.

Material and Methods

Digestibility in vivo and mean retention time

3 mature donkeys, mean live-weight 241 kg and 3 mature ponies, mean live-weight 200 kg were fed successively 4 diets based on wheat straw (table 1). The animals were weighed at the start and the end of each experimental diet.

The diets (composition s. table 2) were offered ad libitum twice a day in equal quantities at 8 am and 4.30 pm. During a 15-day adaptation in each diet, the ponies and the donkeys were housed in individual stalls with free access to water and mineralized salt, and a 6 day collection was conducted in digestion crates which permitted to collect daily feces and recorded feed intake. Total feces and feed residues were weighed and sampled daily, dried and prepared for analysis.

The rate of passage was measured in parallel to digestion trials for each diet by a single distribution of wheat straw fiber-mordanted in chromium prepared according to *Uden* et *al.* (1980), at a level of 60 g/kg dry matter (*Uden* et *al.*, 1982). Samples of feces were collected at intervals of 3 h at the first and second day, these intervals were less frequent for the next day until the last sampling at 105 h. Accumulated feces for 24 h was sampled for digestion trial. The mean retention time (MRT) of Cr-fibre (CF) to estimate diet rate of passage in the whole gastro-intestinal tract was calculated by the equation according to *Pearson* and *Merrit* (1991).

Dry matter (DM) contents were determined by weighing before and after drying for 24 h (feed) and for 48 h (feces) at 80 °C in ventilated oven. Organic matter (OM) was determined by ashing for 6 h at 550 °C. Crude protein (CP, N x 6.25) was analysed by the method of Kjeldahl. Cell wall fractions: neutral and acid detergent fiber (NDF) and ADF) were determined by the detergent methods discribed by *Goering* and *Van-Soest* (1970). Cr-marker was measured by atomic absorption spectometry using nitrous oxyde acetylene flame after sample preparation described by *Siddon* et *al.* (1985).

Microbial activity in the cecum

Microbial activities were measured in 3 mature donkeys (mean live-weight 229 kg) and 3 mature ponies (mean live-weight 203 kg) fitted with a permanent cecal cannula. They were fed the same diets simultaneously in digestion trials and were housed in individual stalls with free access to water and mineralized salt.

Table 1: Composition of experimental diets (g/kg)

Ingredient	Diet I	Diet II	Diet III	Diet IV
Wheat straw	770	785	785	1000
Ground corn	150	215	215	–
Soy bean meal	80	–	–	–
Urea	–	–	11*)	–

*) isonitrogenous to diet I.

Cecum juice was sampled before and 4, 6 and 8 h after the morning meal, through the cecal cannula. The pH was measured directly by an electrode digital pH-meter (Bioblock pH 07). Volatile fatty acids were determined using a gas chromatography according to the method of *Jouany* (1982).

Statistical analysis

Statistical significances of differences between donkeys and ponies were determined using the t-test and interaction effects between treatments using analysis of variance: factorial design 2 x 4.

Results

Digestibility and mean retention times

In this study, the animals ate the diets in relatively stable quantity: 57.5 to 64.3 g/kg$^{0.75}$ (donkey) and 36.5 to 41.3 g/kg$^{0.75}$ (pony), except during diet II when nitrogen supplementation was cancelled, ponies tended to eat less. The dry matter intake (DMI) was significantly higher ($P < 0.01$) in donkeys than in ponies. We noted that during diet II and IV, DMI decreased slightly in both species (table 3).

Apparent digestibility of OM, CP, NDF and ADF (table 3) was not significantly different between donkeys and ponies, whereas OM digestibility of diet III was greater than that of diet I and IV. Diets I and III with nitrogen supplementation were significantly higher in CP digestibility than diet II without nitrogen supplementation. Cell wall fractions (NDF and ADF) digestibility was significantly lower ($P < 0.01$) in diet I than in others diets.

The donkey was able to eat a greater quantity ($P < 0.01$) of digestible OM (21.2 to 30.8 g/kg$^{0.75}$) than the pony (14.9 to

Table 2: Chemical analysis of experimental diets (% DM)

Items	Diet I	Diet II	Diet III	Diet IV
OM organic matter	93.6	93.4	93.4	92.8
CF crude fiber	35.6	34.2	33.6	42.4
NDF neutral detergent fiber	63.9	63.3	62.2	77.1
ADF acid detergent fiber	40.4	38.5	37.6	46.5
CP crude protein	8.2	5.3	8.2	3.5

Table 3: Digestible organic matter and dry matter intake, digestibility of OM, CP, NDF and ADF and MRT between donkeys (D) and ponies (P)

Items	Diet I		Diet II		Diet III		Diet IV		SEM
	D	P	D	P	D	P	D	P	
DMI (g/kg$^{0.75}$)	64.3**	41.3	58.7*	36.5	60.7*	41.9	57.5**	41.0	5.0
DOMI (g/kg$^{0.75}$)	27.9**	19.2	28.4**	18.1	30.8**	23.0	21.2*	14.9	1.9
d-OM (%)	46.3	49.5	51.8	53.2	54.4	59.0	39.9	39.4	4.4
d-CP (%)	64.8	64.0	50.3	48.9	66.8	67.8	0.0	0.0	5.6
d-NDF (%)	31.0	28.7	38.0	34.2	41.0	41.0	40.7	39.7	4.8
d-ADF (%)	30.2	28.6	38.3	33.3	39.5	40.1	37.8	39.2	5.2
MRT (h)	48.1	49.6	52.8	54.7	49.6	52.0	53.1	55.3	2.5

means between species in the same diet with superscript differ significantly, *P<0.05 **P<0.01.
SEM = standard error of means

Table 4: Concentration (mmol/l) and proportion (mol %) of VFA and pH in cecal juice of donkeys (D) and ponies (P)

Items	Diet I		Diet II		Diet III		Diet IV		SEM
	D	P	D	P	D	P	D	P	
VFA (mmol/l)	67.1***	40.9	59.6***	38.6	59.5*	41.9	47.0*	33.6	3.5
Acetic	68.2	71.3	69.3	72.6	68.6*	73.5	71.1*	74.1	1.7
Propionic	23.1	24.0	20.6	22.8	21.5	21.6	21.6	20.9	1.5
Butyric	6.9***	3.7	8.7***	3.9	8.8**	4.3	5.8	4.2	0.4
Isobutyric	0.9	0.7	0.8*	0.4	0.5	0.3	0.7	0.3	0.2
Valeric	0.4*	0.2	0.3	0.2	0.2	0.2	0.3	0.3	0.1
Isovaleric	0.5***	0.2	0.4***	0.1	0.3**	0.1	0.5	0.2	0.1
pH	6.8**	7.1	6.8**	7.1	6.7*	7.0	6.9**	7.3	0.1

means between species in the same diet with superscript differ significantly, *P<0.05 **P<0.01 ***P<0.001.
SEM = standard error of means

23.0 g/kg$^{0.75}$). In both species, concentrate supplementations on wheat straw diet increased the digestible organic matter intake (DOMI) significantly.

The mean retention time (MRT) tended to be higher ($P < 0.07$) in pony than in donkey and appeared to be faster in diet I than in diet II, III and IV (table 3).

Microbial activity

Although VFA production did not significantly alter between the different times after distribution of the morning diet, we noted that VFA concentration (figure 1) was highest after 6 hours in donkeys and after 4 hours in ponies (except in diet I).

VFA production (mmol/l) was significantly higher ($P < 0.001$) in donkeys 47.0 to 67.1) than in Ponies (33.6 to 41.9), whereas concentrate supplementation on diets based on wheat straw increased VFA production (table 4).

The proportion of VFA (percent molar) indicated that the concentrations of butyric, isobutyric, valeric, and isovaleric acid were higher ($P < 0.01$) in donkeys than in ponies, in contrast with acetic acid (table 4). We did not find any differences between the proportion of propionic acid in the two species.

In the cecal juice of donkeys, the pH (6.7 to 6.9) was significantly lower ($P < 0.001$) than in ponies (7.0 to 7.3). pH increased slightly in diets without concentrate supplementation.

Discussion

In spite of apparent digestibilities were not significantly different between the two species, there was a tendency for ponies to digest better organic matters than donkeys. This tendency might result from the transit time which was shorter in donkeys than in ponies and limited the digestion of diets in donkeys. However, the feed intake was higher in donkeys than in ponies. *Izraely* et *al.* (1989) reported that the donkey maintained a high rate of feed intake when low quality diet was fed. The donkey ate more but digested lower the diet than the pony when straw diet was fed. In constrast, when a good quality of hay was fed, there was no significant differences on feed intake and the donkey digested better the diet than the pony (*Tisserand* et *al.*, 1991). The mean retention time in the whole gastrointestinal tract was longer in donkeys than in ponies, if the diet was offered in restricted quantities (*Suhartanto* et *al.*, 1992). We suggest that the acceleration of transit times and the lowering of digestion coefficients of diets were less important compar-

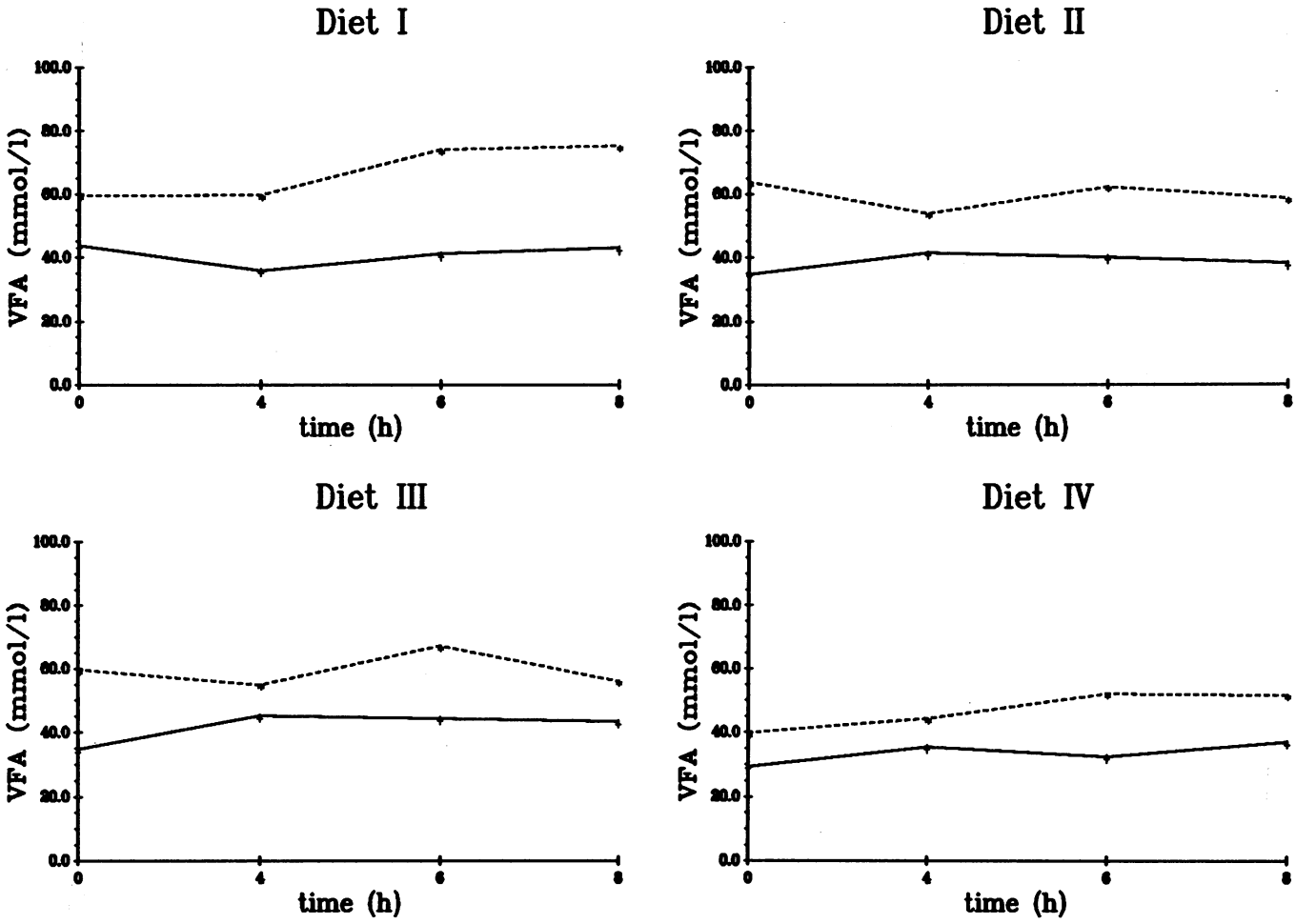

Figure 1: Postpandial concentration of volatile fatty acids in the cecum of donkeys and ponies.

ed to the increase of feed intakes. Consequently the DOMI was higher in donkeys than in ponies.
The donkey was able to eat more (33.9 – 56.9 per cent) than the pony. During the experimental diets, the animals lost live-weights from 2 to 10 kg. Ponies suffered more than donkeys, especially in diet IV. The animals could not rise their feed intake to provide their energy requirement because the diets were too bulky. The feed intake (ingestion capacity) was limited by the volume of digestive tracts, the speed of transit and the palatability of diets. We suggest that energy densities of the diets were too low for the ponies.
In the cecum of equines, the final product of anaerobic microbial fermentation of plant cell wall carbohydrates are the VFA (acetic, propionic, butyric, isobutyric, valeric and isovaleric acids). These VFA are absorbed and constitute important energy sources (*Hintz* et *al.*, 1971 a).
In this study, the production of VFA was higher in donkeys which was in relation to feed intake or digestible organic matter intake. Consequently, the higher VFA concentration decreased the pH. However, the proportion of acetic acid was higher in ponies than that in donkeys, in contrast for the butyric, isobutyric, valeric, and isovaleric acids. Concentrate supplementations on experimental diets increased VFA concentrations, however, the proportion of VFA was slightly altered. *Kern* et *al.* (1973) showed that a concentrate supplementation with a ratio 1 : 3 to hay (timothy hay) influences slightly VFA proportions. The concentrate supplementation effects were more obvious in donkeys where VFA concentrations increased from 26.6 to 42.8 percent than in ponies from 14.9 to 24.7 percent. In difference to the foregut fermenter (ruminants), a concentrate supplementation on diets altered slightly VFA proportions, in particularly acetic/propionic ratios in hindgut fermenters (equines), because an important part of concentrate was absorbed in the small intestine before the compartment with anaerobic microbial fermentations (*Hintz* et *al.*, 1971 b). The amount of concentrates that escaped prececal enzymatic digestion was plant cell wall bound-substances (*Glade*, 1983). It therefore was subjected to anaerobic microbial fermentation which produced the VFA.

Conclusion

The donkey maintained a high rate of feed intake when poor diets were fed by increasing the mean retention time of diet in the digestive tract.
Concentrate supplementations on poor diets based on wheat straw increased significantly VFA production, however altered slightly the proportion of VFA.
The proportion of 23 percent of concentrate in poor diets with a low energy density appeared to be insufficient to meet energy requirements for maintenance of ponies.

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