Res. Bull. Obihiro.,27(2006):9～13

Position and rate of intestinal fermentation in adult ostrich evaluated by volatile fatty acid

Akio Hongo, Yukiko Ishii, Hidetaka Suzuta, Devee Enkhee, Yuji Toukura, Masaaki Hanada, Satoshi Hidaka and Shunzo Miyoshi

(Received:April 28,2006)

揮発性脂肪酸により評価したダチョウ成鳥における腸管内醗酵の場所と速度

本江昭夫・石井友紀子・鈴田英隆・デヴィ エンヒェー・藤倉雄司・花田正明・日高智・三好俊三

ABSTRACT

The study was conducted in Obihiro, Japan to examine the position and rate of intestinal fermentation in three adult ostriches (*Struthio camelus*) with mean liveweight of 103±4.7 kg. The ostriches were fed fresh leaves of orchardgrass (*Dactylis glomerata*). At twenty five hours before the slaughter, they ingested 100 g fresh leaves mixed with 20 g oblong strips (2mm wide and 30 mm long) of a filter paper, in which chromium oxide was absorbed at a rate of 40 %. After the slaughter, small intestine, cecum and large intestine were cut into 3, 2 and 7 pieces, respectively, with the same length in each organ.

Crude ash content in digesta samples was the highest in muscular stomach (90.1±1.17 %), compared with 27-51 % in other organs of glandular stomach, small intestine and cecum. The percentages of both dry matter and organic matter were significantly higher in colon. The peak of chromium content was observed at the final position of large intestine, suggesting passage rate of grass leaves through all digestive organs being about 24 hours. A small peak of total content of volatile fatty acids was observed at middle part of small intestine, suggesting the commencement of volatile fatty acid forming in small intestine. The peaks of both total content of volatile fatty acids and acetic acid content were observed in colon, being 24.5±7.25 % and 15.5±5.75 %, respectively. Acetic acid content rapidly decreased at the following sites of large intestine, suggesting active absorption of acetic acid in colon.

Key words: Adult ostrich, Chromium, Colon, Fermentation, Volatile fatty acid,

INTRODUCTION

The ostrich is an important animal in many livestock industries, especially in developing countries, because of meat and skin productions (Cooper *et al*. 2004). The ostrich has a large potential to utilize the more fibrous energy sources such as various kinds of low-quality straws or silage (Cilliers *et al*. 1997: Glatz *et al*. 2003). The ostrich is polygastric herbivores and relies on its hindgut as the primary site of fermentation and water absorption, especially bacteria inhabit (Salih *et al*. 1998: Swart *et al*. 1993). There are many studies on a close coupling between production and absorption of volatile fatty acid (VFA) in the hindgut (Musara *et al*. 2002: 2003). It is estimated that VFA

帯広畜産大学畜産環境科学専攻（080-8555 北海道帯広市稲田町）

Course of Agro-Environmental Science, Obihiro University of Agriculture and Veterinary Medicine, Inada, Obihiro, Hokkaido, 080-8555 Japan.

E-mail: ahongo@obihiro.ac.jp

production in the hindgut provides more than 57 % of maintenance requirements (Fievez *et al*. 2001).

Factors influencing the successful growth of ostriches include the provision of proper housing, adequate ventilation, exemplary hygiene and correct dietary requirements (Cooper 2000). Feed comprises over 60% of the cost of growing ostriches to slaughter weight (Glatz *et al*. 2003). To produce quality products, it is essential to collect information on feed utilization efficiency and nutrient requirements of ostriches at different maturity stages (Miao *et al*. 2003).

This study was conducted to examine the position and rate of intestinal fermentation in adult ostrich in order to improve the utilization of plant resources.

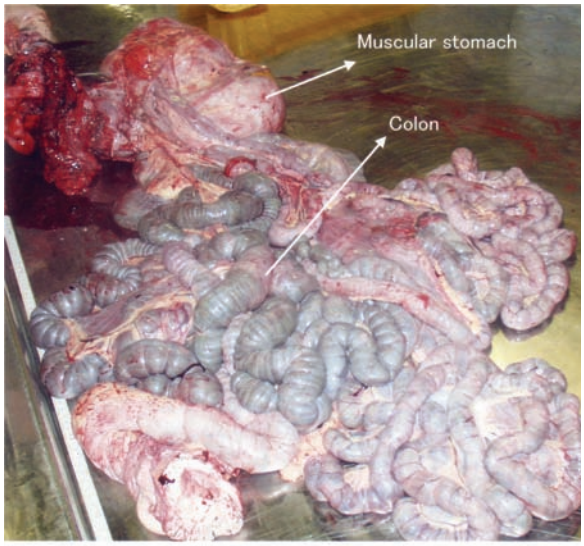

Fig. 1 Photograph of digestive organ of ostrich.

Fig. 2 Digested process of ingested grass leaves along digestive organs of ostrich.. 1: Grass leaves, 2: In glandular stomach, 3-4: In muscular stomach and 5: In small intestine.

MATERIALS AND METHODS

The experiment was conducted in Obihiro, Japan.

Ostriches

Every ostrich (*Struthio camelus*) was born on 9 July 2003. They were fed chopped dry diet mostly composed of grass leaves.

Intake of chromium oxide

For previous three days, ostriches had been fed fresh leaves (6 kg/day) of orchardgrass (*Dactylis glomerata*) chopped 5 cm length. At nine of the clock on the day before the slaughter, they were fed 100 g fresh leaves and 20 g oblong strips (2mm wide and 30 mm long) of a filter paper, in which chromium oxide was absorbed at a rate of 40 % solution. Every diet offered was eaten by ostriches for two hours. Then, 3 kg fresh leaves were given, and another 3 kg in the evening.

Body measurement

Before the slaughter, body measurement was carried out by ordinary methods with respect to body weight, body height, body length, chest width and chest girth.

Collecting digesta samples

At 10-11 of the clock on September 28, three ostriches were sacrificed to collect digesta samples within digestive tract (Fig. 1). At first, the weight and length of digestive organs were measured. Small intestine, cecum and large intestine were cut into 3, 2 and 7 pieces, respectively, with the same length in each organ. Each piece was weighed. Then, digesta samples included in each of pieces or digestive organs were collected and weighed (Fig. 2). All digesta samples were kept in plastic bags and stored in a freezer.

Measurement of water and ash contents

Defrost samples of 3-20g were taken into the crucibles and dried at 60℃ for 48 hours. The moisture content was obtained after 2 hours drought at 135℃. Then, crude ash content was obtained after 2 hours heat treatment at 600℃.

Measurement of chromium

Chromium contents in digesta samples were determined by colorimetric method. Samples were added to alkaline reagent including tri-potassium and potassium hydroxide and were baked 800℃ for 30 minutes. Then, the ash was diluted with distilled water and chromium content in the solution was measured its absorbance at 360 nm using spectrophotometer (U-2001, Hitachi, Japan).

Measurement of volatile fatty acid

Aqueous extracts of digesta samples were used for measuring volatile fatty acid concentration. Volatile fatty acids were analyzed by gas chromatograph (GC-2010, Shimadzu, Japan) equipped with a flame-ionization detector and a capillary column (ULBON HR-52, 0.53mm i.d. × 30m × 3.0μm), using 2-ethyl-n-butyric acid as the internal standard.

Statistical analysis

Variables of observed properties were analyzed using a paired t-test and an analysis of variance (Snedecor and Cochran 1967). Three ostriches were included into the replication.

Table 1 Body measurement, and weight and length of digestive organs.

A. Body measurement		B. Fresh weight of digestive organs (kg)	
Body weight (kg)	103±4.7	Glandular stomach	2.9±0.34
Body height (cm)	137±0.8	Muscular stomach	4.3±0.27
Chest width (cm)	52±0.3	Small intestine	2.3±0.27
Body length (cm)	85±1.0	Cecum	1.2±0.14
Chest girth (cm)	121±2.8	Large intestine	10.2±0.77
		Sum	20.9±1.55
C. Total weight of digesta samples within all digestive tracts (kg)		D. Total length of intestine (m)	
Fresh matter	13.0±0.81	Small intestine	5.7±0.14
Dry matter	6.8±0.80	Cecum	1.6±0.06
Organic matter	3.2±0.81	Large intestine	13.5±0.22
		Sum	20.8±0.30

* Figures show mean±se.

RESULTS AND DISCUSSION

For 25 hours before the slaughter, ostriches had ingested 3.1±0.37 kg fresh grass leaves (0.93±0.111 kg dry matter). The body measurements, and weight and length of digestive organs are shown in Table 1.

Crude ash content

Crude ash content in digesta sample was the highest in muscular stomach (90.1±1.17 %), compared with 27-51 % in other organs of glandular stomach, small intestine and cecum, although significantly not different (p<0.076), as shown in Fig. 3. Along large intestine, crude ash content gradually increased and attained the higher value (73.7±2.69 %) at the final position of large intestine. This increasing pattern of crude ash content along large intestine may be due to nutrient absorption.

Distribution pattern of dry matter and organic matter

Total amounts of dry matter and organic matter within all digestive organs were 6.8±0.80 kg and 3.2±0.81 kg, respectively. Distribution pattern of dry matter and organic matter in digesta sample is shown in Fig. 4. The percentages

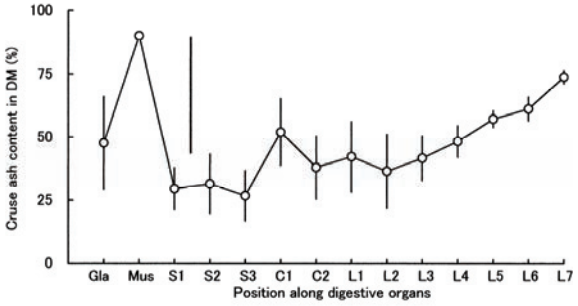

Fig. 3 Crude ash content of digesta samples in dry matter along digestive organs of ostrich. Attached lines with symbols show s.e. of mean and vertical lines show s.e.d. of the mean differences.
Gla: Glandular stomach, Mus: Muscular stomach, S1-S3: Small intestine from the first third to the last third, C1-C2: Cecum from the first half to the latter half, and L1-L7: Large intestine from the first seventh to the last seventh.

of both dry matter and organic matter were significantly higher (p<0.001) in colon (L2 in Fig. 4), being 18.2±0.21 % and 23.9±1.10 %, respectively. These higher values may be caused by the enlargement of colon, providing a suitable nutritional environment for fermentative microflora (Swart *et al*. 1993).

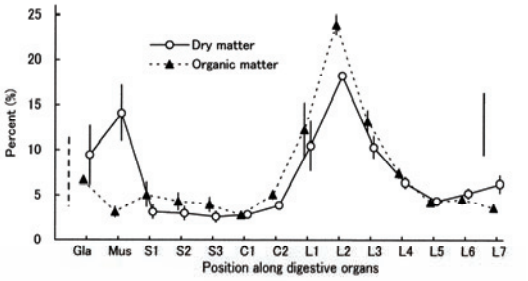

Fig. 4 Distribution patterns of dry matter and organic matter contents in digesta samples along digestive organs of ostrich. The terminology is the same as Fig. 3.

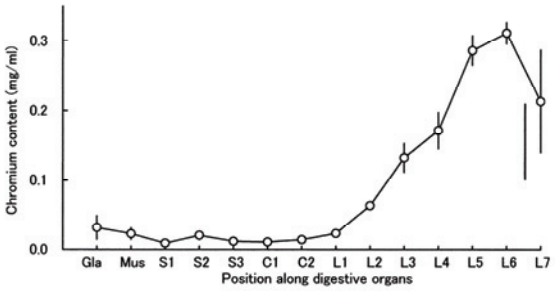

Fig. 5 Chromium content in digesta samples along digestive organs of ostrich. The result was ontained 25 hours after ingestion. The terminology is the same as Fig. 3.

Chromium content

Digesta samples were obtained after 25 hours of chromium oxide ingestion. The peak was observed at the final position of large intestine (Fig. 5), suggesting passage rate of grass leaves through digestive organs being about 24 hours.

Swart *et al*. (1993) reported that passage rate varied considerably (21 - 76 hours) with overall mean of 40.1 hours and was independent of liveweight. This longer term was obtained using young ostriches with liveweight of 5 - 46 kg. In this study, adult ostriches had 103±4.7 kg liveweight. Therefore, it seems that passage rate may be highly influenced by liveweight.

Volatile fatty acid content

Total content of volatile fatty acids and acetic acid content are shown in Fig. 6. With respect to total content of volatile fatty acids, a small peak was observed at middle part of small intestine (S2 in Fig. 6), suggesting the commencement of volatile fatty acid forming in small intestine. The peaks of both total content of volatile fatty acids and acetic acid content were observed in colon (L1 in Fig. 6), being 24.5±7.25 mmol/100 ml and 15.5±5.75 mmol/100 ml, respectively. Rapid decrease of acetic acid content was observed at the following sites of large intestine (3.8±2.83 mmol/100 ml at L2), showing active absorption of acetic acid in colon.

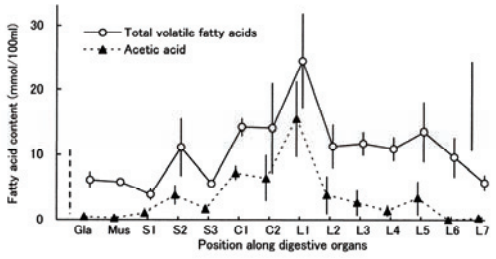

Fig. 6 Acetic acid and total volatile fatty acid contents in digesta samples along digestive organs of ostrich. The terminology is the same as Fig. 3.

REFERENCES

Cilliers, S.C., Hayes, J.P., Chwalibog, A., Preez, J.J. and Sales, J. (1997) A comparative study between mature ostriches (*Struthio camelus*) and adult cockerels with respect to true and apparent metabolisable energy values for maize, barley, oats and triticale. *British Poultry Science* **38**, 96-100.

Cooper, R.G. (2000) Management of ostrich (*Struthio camelus*) chicks. *World's Poultry Science Journal* **56**, 33-44.

Cooper,R.G., Horbanczuk, J.O. and Fujihara, N. (2004) Nutrition and feed management of the ostrich (*Struthio camelus* var. *domesticus*). *Animal Science Journal* **75**, 175-181.

Fievez, V., Mbanzamihigo, L., Piattoni, F. and Demeyer, D. (2001) Evidence for reductive acetogenesis and its nutritional significance in ostrich hindgut as estimated from in vitro incubations. *Journal of Animal Physiology and Animal Nutrition* **85**, 271-280.

Glatz, P.C., Ru, Y.J., Hastings, M.Y., Black, D. and Rayner, B. (2003) On farm assessment of high fibre dietary sources for grower and finisher ostriches. *International Journal of Poultry Science* **2**, 293-299.

Miao, Z.H., Glatz, P.C. and Ru, Y.J. (2003) The nutrition requirements and foraging behaviour of ostriches. *Asian Australasian Journal of Animal Sciences* **16**, 773-788.

Musara, C., Chamunorwa, J., Holtug, K. and Skadhauge, E. (2002) Water absorption in relation to fermentation in the colon of the ostrich (*Struthio camelus*). *Onderstepoort Journal of Veterinary Research, South Africa* **69**, 315-320.

Musara, C., Chamunorwa, J., Holtug, K. and Skadhauge, E. (2003) Insight into the mechanism of short chain fatty acid absorption in the ostrich (*Struthio camelus*) proximal colon. *British Poultry Science* **44**, 316-326.

Salih, M.E., Brand, T.S., Schalkwyk, S.J., Blood, J.R., Pfister, B. and Akbay, R. (1998) Number of cellulolytic bacteria in the gastro-intestinal tracts of ostriches fed diets with different fibre levels. *Proceedings of the Second International Scientific Ratite Congress, Oudtshoorn, South Africa* pp. 43-45

Snedecor, G.W. and Cochran, W.G. (1967) *Statistical Methods.* 6th edn. Ames: Iowa State University Press.

Swart, D, Siebrits, F.K. and Hayes, J.P. (1993): Utilization of metabolizable energy by ostrich (*Struthio camelus*) chicks at two different concentrations of dietary energy and crude fibre originating from lucerne. *South African Journal of Animal Science* **23**, 136-141

要　約

植物資源の利用を改善するために、平均生体重が103±4.7kgの3羽のダチョウ成鳥(*Struthio camelus*)における腸管内醗酵の場所と速度を調査した。ダチョウにオーチャードグラス(*Dactylis glomerata*)の葉身を給与し、屠殺の25時間前に100gの葉身と20gの長方形のロ紙(幅2mm、長さ30mm)を採食させた。ロ紙には40%の酸化クロム水溶液を吸着させておいた。屠殺後、小腸、盲腸、大腸を同じ長さになるようにそれぞれ3、2、7個に分割した。

消化管内容物中の粗灰分の割合は筋胃で最も高く(90.1±1.17 %)、腺胃、小腸、盲腸では 27-51%であった。乾物と有機物の割合は盲腸で最も高かった。クロム濃度のピークは大腸の最後の部分で認められ、ダチョウ成鳥のすべての消化管を通過する時間は約 24 時間と推察された。揮発性脂肪酸の総量の小さなピークが小腸の中間部で認められ、ここですでに醗酵が開始されていることを示唆していた。揮発性脂肪酸の総量と酢酸濃度の両方のピークが結腸で認められ、平均値はそれぞれ 24.5±7.25 mmol/100ml と 15.5±5.75 mmol/100ml であった。酢酸濃度は大腸を下行するにつれて急速に低下しており、酢酸は結腸において活発に吸収されていることが示唆された。

キーワード： ダチョウ成鳥、クロム、結腸、醗酵、揮発性脂肪酸