COMPARISONS OF THREE TYPICAL PARTICLE DIAMETERS OF FEED AND DIGESTA IN RUMINANT MEASURED BY IMAGE ANALYZER

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Introduction

Recently, image data analyzing system have been used in measuring particle size of feed and digesta in ruminants to obtain various physical informations on diameters and shapes. The major problem in image analyzing was that the weight of particle was unable to measure directly. If we could grasp the meanings of various physical informations, this new technique of measuring particle size would derive additional informations to the results of sieving method.

This study purposed to clarify the physical relationships between particle weight and three typical diameters of particles and to describe mass base distributions of feed and digesta in ruminants using presieving and measurement by image data analyzing system.

Materials and Method

A castrated Sannen goat fitted with rumen cannula was fed 1100 g of second cut Italian ryegrass chopped hay once a day. A sample of the rumen content was collected via rumen cannula at 4 hours after feeding and feces were totally collected daily. Each sample was divided into 3 groups by wet sieving (1.18, 0.3 and 0.045 mm of mesh opening). Aliquot sample of residue on each sieve was taken out and dispersed on filter paper or grass plate for measurement of particle size. Chopped hay was glued directly on filter paper without sieving. The numbers of particle, maximum Feret's diameters (MAXD), Heywood's diameters (HD; diameter of the circle of equal projected area) and minimum diameters (MIND: projected area/MAXD) were measured using the image data analyzing system. Mean particle weight was derived from residual dry-matter weight and total number of particles in each sieve for each sample.

Relationships between mean particle weights (W) and weight mean diameters (D) were estimated for MAXD, HD and MIND respectively. The procedures were as follows.

In the first, the value of D_1 were derived for each residue using the following equation;

$$D_1 = \Sigma (nd^4) / \Sigma (nd^3) \quad \ldots\ldots [1]$$

where n was number base frequency of each class and d was average length of each class. This equation was usually used assuming that particle weight and volume were proportionate to the cube of the diameter. Coefficients of a_i and b_i were estimated from logarithmic regression analysis of W on D_i.

$$W = a_i \times D_i^{b_i} \quad \ldots\ldots [2]$$

If the value of b_1 was not equal to three, logarithmical regression analysis was done again after re-estimation of D_2 by the following equation modified from the equation [1].

$$D_{i+1} = \Sigma (nd^{b_i+1}) / \Sigma (nd^{b_i}) \quad \ldots\ldots [3]$$

In the same procedure, the calculations were repeated until $b_{n+1} - b_n$ was less than 0.001.

Mass base 50% mean diameter (μ) and standard deviation (σ) were calculated using the method described by Waldo et al. (1971).

Results and Discussion

Table 1 shows the results of the analyses of mean particle diameters and mean particle weights. The HD and MIND were suitable for particle dia-

TABLE 1. RESULTS OF REPEATING REGRESSION ANALYSES OF MEAN PARTICLE WEIGHTS AND MEAN PARTICLE DIAMETERS

Diameter	a	b	r^2	SE
MAXD	4.20×10^{-4}	2.31	0.864	0.263
HD	3.58×10^{-3}	2.88	0.949	0.193
MIND	5.75×10^{-2}	3.21	0.967	0.170

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meter to represent physical size of particle instead of weight or volume, for the values of b were close to three and r^2 were high compared with MAXD. The low value of b for MAXD was probably caused that reduction rate of MAXD was not proportionate to that of particle weight.

Table 2 shows the result of mass base distribution of each sample based on three typical diameter. The ratios of mean MAXD to MIND that were used as a shape index were 16.4, 4.7 and 4.3 for chopped hay, the rumen content and feces, respectively. The high values of this ratio and μ of chopped hay comparing to the rumen content indicated the rapid change of particle shape and size after ingested by animals.

TABLE 2. RESULTS OF MASS BASE DISTRIBUTION OF EACH SAMPLE

Sample	Diameter	μ(mm)	σ	r^2	SE
Chopped hay	MAXD	66.9	2.06	0.975	0.090
	HD	15.6	1.74	0.979	0.150
	MIND	4.07	1.72	0.972	0.221
The rumen content	MAXD	2.18	3.31	0.994	0.019
	HD	1.08	3.04	0.997	0.014
	MIND	0.466	3.02	0.995	0.019
Feces	MAXD	0.874	2.42	0.976	0.069
	HD	0.433	2.19	0.987	0.050
	MIND	0.204	2.14	0.984	0.059

The HD and MIND were suitable for described mass base distribution, that was the same result in table 1, for the value σ for HD and MIND were very close to each other and r^2 were high.

The low value of r^2 for feces compared to the rumen content was caused not for dispersion of data but for the bending of distribution line (Oura and Sekine, 1988). We must take into consideration the relationship between this bending at about 40% of cumulative weight undersize and the mechanism of passage rate of particle in various sizes from the rumen.

(Key Words: Particle Diameter, Image Analyzer)

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