Effects of Fiber on Digestibility and Transit Time in Dogs[1]

C. F. BURROWS,[2] D. S. KRONFELD, C. A. BANTA[3] AND A. M. MERRITT[2]

University of Pennsylvania, School of Veterinary Medicine, 3800 Spruce Street, Philadelphia, PA 19104

ABSTRACT This study examines effects of variations in fiber content on nutrient assimilation, fecal output, and gastrointestinal transit time in the dog. Four normal Beagles were fed four diets in a randomized block design. The basal diet was a canned, balanced, meat-based dog food (Alpo Trio®) to which was added 3, 6, and 9% by weight of alpha cellulose (Solka Flok®). Food intake and fecal outputs were recorded for 5-day periods. Samples of diets and fecal collections were analyzed for dry matter, nitrogen, fat, carbohydrate and ash; digestibilities were calculated. Transit times were measured by a radiographic marker technique. Fecal weight and water increased linearly; digestibility of dry matter decreased from 90 to 70% and ash from 43 to 32% with added fiber. Responses of protein, carbohydrate and fat were less pronounced but were regular; regressions of their digestibilities on added fiber were significant. Regression estimate of true digestibility for α-cellulose was 6%. Intestinal transit time decreased from a mean of 37.4 to 28.7 hours with added fiber. Decreased intestinal transit time would contribute to depression of dry matter digestibility. Increased fecal water output probably also reflected retention by fiber. J. Nutr. *112:* 1726–1732, 1982.

INDEXING KEY WORDS α-cellulose · digestibility · nutrient assimilation · transit time · dogs

Dietary fiber affects gastrointestinal function and fecal output (1). In humans, the addition of wheat bran to the diet normalizes the speed of intestinal transit (2, 3) as well as increasing fecal wet and dry weight (4, 5). Fiber also decreases nutrient and mineral assimilation but to a degree that varies with the type and physical composition of the fiber (4–6).

Comparatively little is known about the effects of fiber on canine gastrointestinal function. Fat assimilation is lower and fecal weight is higher in dogs fed a commercial dry food containing 5% crude fiber as compared to a canned meat-based diet (7), but there are no data on the effect of specific fiber types on any aspect of gastrointestinal function in this species. Even though such information would be important from a comparative aspect alone, it becomes even more essential inasmuch as the dog is a widely used experimental animal and that fiber is a poorly defined component of a number of commercial dog foods. Fiber supplementation has also been advocated, without any real scientific basis, as treatment for a variety of canine gastrointestinal disturbances (8, 9).

The purpose of this study was, therefore, to examine the effects of one widely used standardized fiber (α-cellulose) on nutrient assimilation, transit time, and fecal output in the dog.

MATERIALS AND METHODS

Four healthy, young adult, female Beagles, about 10 kg in body weight were fed each

 Received for publication 20 May 1982.

[1] This study was supported in part by Allen Products Co., Allentown, PA and by a grant from the Morris Animal Foundation and Seeing Eye, Inc. Published as Florida Agricultural Experimental Station Journal Series no. 3968.

[2] Present address: Department of Medical Sciences, College of Veterinary Medicine, University of Florida, Gainesville, FL 32610.

[3] Allen Products, Inc., Allentown, PA 18001.

TABLE 1

Composition of diets

Constituent[1]	Fiber added % 0 (diet A)	3 (diet B)	6 (diet C)	9 (diet D)
Protein	37.8 ± 1.6	29.5 ± 0.3	30.2 ± 3.2	28.5 ± 2.8
Fat	55.1 ± 1.3	52.3 ± 4.2	44.9 ± 3.1	41.3 ± 3.6
NFE[2]	1.2 ± 0.5	7.3 ± 4.3	8.9 ± 0.7	11.0 ± 1.5
Fiber[3]	0.6 ± 0.2	6.5 ± 0.4	11.2 ± 0.1	14.7 ± 1.2
Ash	5.6 ± 0.4	4.4 ± 0.4	4.8 ± 0.6	4.5 ± 0.5
Moisture[1]	68.2 ± 3.4	68.9 ± 3.9	65.1 ± 1.4	63.2 ± 1.0
Digestible energy, *kcal/g*	7.42	6.95	6.35	5.99

[1] Constituents expressed as percent of dry matter, mean ± SEM of two analyses of each diet except moisture which is expressed as percent as fed. [2] NFE or nitrogen-free extract is the remainder after subtracting protein, fat, ash and fiber from 100. [3] Fiber was measured as crude fiber (8).

of four diets in a randomized block design. The basal diet was a single batch of canned, nutritionally balanced, highly palatable, commercial meat-based dog food (Alpo Trio, diet A), to which was added 3% (diet B), 6% (diet C), and 9% (diet D) by weight of fiber in the form of α-cellulose (Solka Flok,® Brown Company, Berlin, NH.). Proximate analysis of diets is listed in table 1. Solka Flok is described in table 2. Solka Flok was supplied as a finely ground powder, analysis[4] of which showed it to have a mean log particle size[5] of 46 μm (10). Dogs were housed in stainless-steel metabolic cages and were fed

TABLE 2

Analysis of α-cellulose[1]

Constituent	Percent composition as fed, dry matter
	%
Dry matter	93.06
	% dry matter[2]
Total ash	0.13
Cell wall[3]	99.07
Hemicellulose[4]	4.54
Lignin	4.68
Cellulose	89.79

[1] Fiber analysis was performed by Dr. J. B. Robertson, Department of Animal Science, Cornell University, Ithaca, NY. [2] Total ash, cell wall, hemicellulose, lignin and cellulose are expressed as percent dry matter. [3] Cell wall, neutral detergent fiber. [4] Calculated by difference.

at 1300 hours daily at a rate that maintained a constant body weight. The animals were acclimatized to each diet for 14 days, after which the total amount of feces passed during a 5-day period was collected and weighed. Samples were frozen at −16° until analysis. Aliquots of each diet and of each 5-day fecal collection were analyzed for dry matter, fiber, protein, fat, and total ash by using standard techniques (11); soluble carbohydrate was calculated as nitrogen-free extract (NFE). From these balance data were calculated efficiencies of digestion:

$$\text{Apparent digestibility (\%)} = \frac{\text{Intake (g/5 days)} - \text{feces (g/5 days)} \times 100}{\text{Intake (g/5 days)}}$$

Digestible energy was calculated by application of appropriate Atwater factors (table 1). Aliquots of each 5-day period collection were also analyzed for total volatile fatty acid (VFA) concentration[6] by gas-liquid chromatography (12).

Gastrointestinal transit time was measured using a modification of Hinton's method (13).

[4] Fiber analysis was performed by Dr. J. B. Robertson, Department of Animal Sciences, Cornell University, Ithaca, NY 14853.

[5] Using weighted averages, we calculated from the data in tables 1 and 2 that Solka Flok contained 65.1 ± 1.3% (mean ± SEM) crude fiber on a dry matter basis. Presuming that lignin contributes 4.7%, the remaining 60.4% of crude fiber probably derives from cellulose. This would leave about one-third of the cellulose (29.4%), together with hemicellulose (4.5%), in the term found by the difference, nitrogen-free extract (NFE).

[6] Total volatile fatty acids were acetic, proprionic, isobutyric, butyric, isovaleric and valeric acids.

TABLE 3

Fecal responses to α-cellulose

Variable	Diet[1] A	B	C	D	Statistical analysis: Anova F	Anova P <	Contrast[2] t	Contrast P <	Regression[3] r	Regression P <
Weight, *g/day*	47 ± 3	78 ± 2	107 ± 7	147 ± 4	96	0.001	6.531	0.001	0.97	0.001
Water, *ml/day*	32 ± 2	50 ± 2	67 ± 5	95 ± 4	56	0.001	11.99	0.001	0.96	0.001
Water, %	68[4] ± 1	64 ± 1	62 ± 1	65 ± 1	6.35	0.008	−1.367	0.206	0.50	0.496
VFA,[5] *mM/day*	6.9 ± 1.5	10.0 ± 2.1	10.7 ± 1.2	11.0 ± 2.1	1.08	0.392	1.833	0.100	0.42	0.088
VFA, *mM/liter*	227 ± 62	199 ± 40	159 ± 12	115 ± 18	1.60	0.240	−2.611	0.031	−0.53	0.036

[1] Mean ± SEM. [2] Linear orthogonal contrast. [3] Linear regression. [4] Mean water content of diet A was significantly different according to the Tukey test (15). [5] Total VFA was composed of acetic, proprionic, isobutyric, butyric, isovaleric and valeric acids.

Thirty radiopaque pellets cut into 4-mm lengths from 2.5-mm OD radiopaque tubing were mixed thoroughly with a meal. After the meal, the food bowl was checked to ensure that all pellets had been ingested. The cage was checked regularly (at least every 2½ hours), and any feces collected and frozen. The time of collection or the exact time of defecation, if observed, was recorded. At the end of the study, all the individual fecal collections were radiographed, and the pellets counted. The time from feeding to the exact time of defecation, if observed, or the midpoint between cage checks when the feces containing the last pellet was passed was taken as the transit time. Transit times were measured in triplicate for each dog and diet during days 3–13 of the study. Complete collections of pellets rather than 80% as in humans were attempted, because most of the pellets are passed in one bowel movement in the dog. Actual recoveries of the pellets in feces were 94 ± 1% (SD); radiographs showed that no pellets remained in the digestive tract.

The data were examined initially by analysis of variance. The relationships between dietary fiber and dependent variables were tested by regressions (14), differences between individual groups were examined for statistical significance by Tukey's test (15) or by linear orthogonal contrast (16). Regression analysis was used to estimate the true digestibility of cellulose (17).

RESULTS

Analysis of variance showed significant differences between diets for fecal weight and water (table 3), for digestibilities of dry matter and ash (table 4) and for transit time (fig. 1). Linear regressions of dependent vari-

TABLE 4

Effects of α-cellulose on digestibilities

	Digestibility of diet (%) A	B	C	D	Statistical analysis: Anova F	Anova P	Contrast[1] t	Contrast P	Regression[2] r	Regression P
Dry matter	89.6 ± 0.7[3]	81.9 ± 0.5	75.0 ± 1.4	69.6 ± 0.8	81.3	0.001	−14.9	0.001	−0.97	0.001
Protein	90.8 ± 0.9	88.8 ± 0.5	87.7 ± 1.0	87.2 ± 1.4	2.41	0.117	−2.346	0.045	−0.59	0.016
Fat	99.4 ± 0.1	99.2 ± 0.2	99.1 ± 0.2	98.9 ± 0.2	1.52	0.259	−3.143	0.013	−0.52	0.041
NFE[4]	—	30.4 ± 4.8	19.8 ± 6.5	17.3 ± 3.6	1.87	0.209	−2.291	0.065	−0.51	0.089
Fiber	30.2 ± 10.1	9.5 ± 2.6	6.2 ± 3.9	4.8 ± 3.0	0.558	0.590	−0.911	0.371	−0.32	0.307
Ash	42.5 ± 4.5	21.6 ± 4.9	34.6 ± 3.2	31.9 ± 3.0	4.67	0.022	−0.963	0.342	−0.21	0.437

[1] Linear orthogonal contrast. [2] Linear regression. [3] Mean ± SEM. [4] NFE, nitrogen-free extract.

ables on added fiber were significant for fecal weight, water, and VFA concentration (table 3), and for apparent digestibilities of dry matter, protein, fat and NFE (table 4). Variations between periods or dogs had no significant effect on dependent variables except transit times (fig. 1).

Fecal output

Mean fecal weight of dogs fed the basal diet was 47.0 g/day, and it increased linearly by 11.1 g/day for each percent of added cellulose (table 3). These increments consisted of about 4.2 and 6.9 g/day of dry matter and water, respectively, i.e., a moisture content of 61%. Fecal moisture of dogs fed the basal diet was 68%, significantly higher than the moisture content of diets B, C and D (table 3).

Output of VFA in dogs fed the basal diet was 6.9 mM/day, and it was increased by 4 to 5 mM/day in each of the cellulose-supplemented diets (table 3). In contrast, the response of fecal concentrations was a linear decrease that was partly correlated ($r = 0.53$) with the increase in fecal water output.

Digestibility

Mean dry matter digestibility in dogs fed the basal diet was 89.6%, and it decreased linearly by 2.2% for each percent of added cellulose to 69.6% for diet D (table 4). Ash digestibility was significantly lower in diet B than in diets A, C or D according to analysis of variance, but the regression of ash digestibility on added fiber was not significant.

Diminutions of apparent digestibility of protein and fat with additions of fiber were small, and differences between diets were not significant according to analysis of variance. The responses were regular, however, and regressions of digestibilities of protein and fat on added fiber were significant as was linear orthogonal contrast (table 4).

Apparent digestibility of NFE was small and the mean was slightly negative for diet A. Since NFE was calculated by difference and its concentration in diet A was only 1%, the negative estimate of apparent digestibility was probably anomalous, and it was excluded from statistical analysis. NFE digestibility declined with added α-cellulose (table 4).

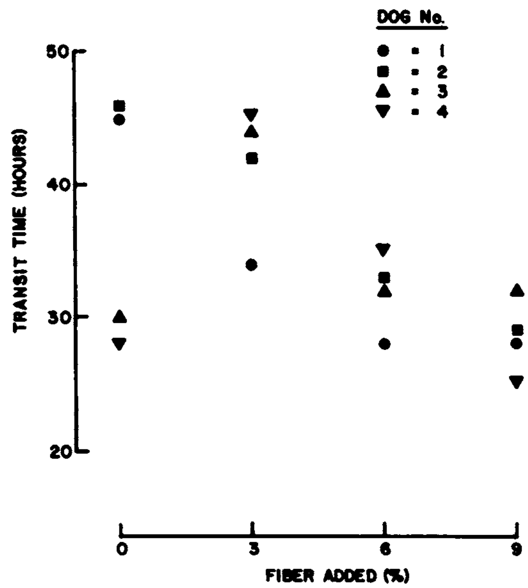

Fig. 1 The relationship between α-cellulose and gastrointestinal transit time in the dog. Addition of α-cellulose had 2 effects; in dogs 1 and 2 there was a steady decrease in transit time, whereas in dogs 3 and 4 an initial increase preceded a decrease.

Apparent digestibility of added fiber was not significantly different between diets (table 4). True digestibility of fiber and endogenous fecal fiber excretion were estimated from the regression of the product of apparent digestibility and diet content on diet content (fig. 2). The regression *constant* is an estimate of endogenous excretion, while the regression *slope* is an estimate of average true digestibility (14). For fiber, 2 of 16 experiments yielded estimates of apparent digestibility that were slightly negative (−0.64 and −2.26). These were assigned a value of zero or were deleted to give 2 regression equations for the product (P) of digestibility and fiber content on content (C):

If N = 16, then

$$P = 25.5 + 3.6C, \quad r = 0.32, \quad P < 0.10$$

If N = 14, then

$$P = 18.3 + 5.9C, \quad r = 0.51, \quad P < 0.05$$

These equations provide estimates of true

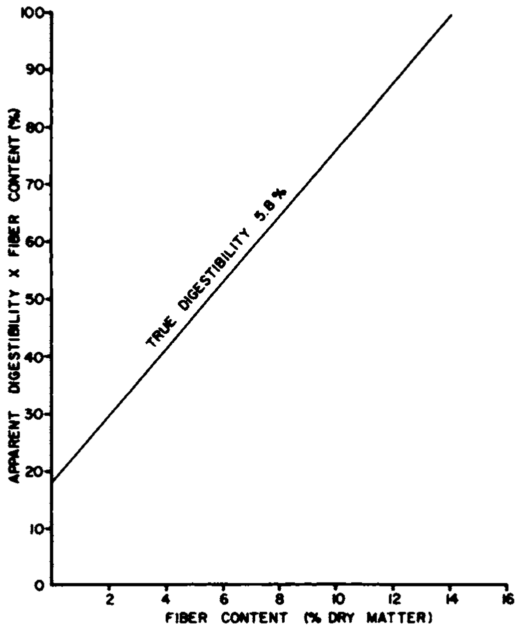

Fig. 2 Estimation of true fiber digestibility and endogenous fiber output in the dog by means of the Lucas plot (17). The regression constant is an estimate of endogenous excretion, while the regression slope is an estimate of average true digestibility.

fiber digestibility of either 3.6 or 5.8% and endogenous fecal fiber of 18 or 25%.

Transit time

Addition of α-cellulose significantly influenced transit time ($F = 4.375$, $P = 0.008$). The mean transit time was 37.4 hours for diet A, 41.3 hours for diet B, 32.8 hours for diet C and 28.7 hours for diet D (fig. 1). Interaction between dogs and diets was probably significant ($F = 1.56$, $P < 0.10$). Two dogs (#1 and #2 in fig. 1) had transit time of 45.6 ± 3.3 hours on diet A, whereas the others (#3 and #4) had transit times of 29.2 ± 2.1 hours, and this difference was significant ($t = 4.160$, $P < 0.005$). Responses to the first increment of fiber were in opposite directions: transit time decreased in dogs #1 and #2, but increased in dogs #3 and #4 (fig. 1). The regression of transit time on added fiber, excluding diet A, was $r = -0.53$ ($P < 0.001$).

The frequency of fecal collections averaged 2.03, 2.74, 3.10 and 3.57 per day for dogs fed diets A, B, C or D, respectively.

DISCUSSION

Our findings in dogs are consistent with previous observations on other animals and especially humans. Increments of food fiber increased fecal weight, depressed digestibility and decreased transit time.

Fecal output

The increase in fecal bulk and weight with added fiber was accounted for largely by material containing less moisture than in the feces of dogs fed the basal diet, even though there was a significant correlation ($r = 0.95$) between dietary fiber and fecal water. Depression of dry matter digestibility with increasing fiber intake was also probably important ($r = 0.65$). Particle size is an important determinant of the water-holding capacity of dietary fiber. Finely ground bran for example is less effective than coarse bran in holding water and in promoting rapid transit through the gut (18). Finely ground wood cellulose also has a very low hydration capacity (19) and has little effect on fecal volume or transit in humans (20). This study, in contrast, showed α-cellulose to have a significant effect on fecal water output, even though there were no changes in fecal moisture, and the feces became bulkier and more powdery with increasing fiber intake. The observation that increased fecal bulk and weight is not due entirely to water-retaining properties of added fiber supports recent observations in humans. Pectin, which has a greater water-holding capacity than bran has a much lower influence on fecal weight and there is an overall inverse relationship ($r = -0.88$) between water-holding capacity and fecal bulk (21).

The concentration of volatile fatty acids expressed as millimolar per liter of fecal water for diet A is close to that found by Banta et al. in the canine colon (22). These workers also found VFA concentration in the canine colon to be unaffected by diet. In the present study the decreased concentration of VFA with increasing fiber was partly due to dilution by the increased daily fecal water output ($r = 0.53$). The 58% increase in mean daily total VFA output for diet D as compared to diet A is possibly due to increased bacterial degradation of added fiber.

Digestibility

Added fiber progressively decreased the apparent digestibilities of protein and fat. In humans, the effect of fiber on nutrient assimilation depends on the type of fiber studied, and the present study suggests that the type and quantity of fiber ingested is also important in determining nutrient assimilation in the dog.

There is a generally held belief that increased fiber results in a reduction of apparent nutrient digestibility (23). Bran decreases the digestibility of dry matter, energy, protein and minerals (6). Most work has been focused on the effect of fiber on fat digestion, since it is decreased absorption of fat that accounts for lower blood lipids and the decreased incidence of a number of diseases when high fiber diets are ingested (24). Fecal fat output in humans has been increased by feeding bran (4, 23, 25) but not by "pure fiber" such as ispaghula husk (26). α-Cellulose is also a pure fiber in that unlike bran it contains no fat. We have previously shown that fat assimilation in dogs fed a cereal-based diet is 7% lower than that in dogs fed a meat-based diet (7). The results of the present study show that this difference cannot be explained by α-celluloselike components of dry dog food.

Analysis showed diet A, to which no fiber was added, contained 0.6% fiber. This fiber was probably animal fiber and most likely comprised protein-polysaccharides of the connective tissue ground substance found in abundance in meat by-products (22). This ground substance is made up of chondroitin sulfates and hyaluronic acid. The polysaccharide portion of these substances is composed of long chains of disaccharide units consisting of glucosamine (or alactosamine) and glucuronic acid. The linkages of these polysaccharides are not such that they can be cleaved by endogenous digestive enzymes, but they could be split by microbial enzymes (22), and it is this bacterial degradation of animal fiber that probably explains the high (30%) fiber digestibility in diet A. This contrasts with the low digestibility of α-cellulose, an observation in keeping with results in other monogastric species (19), The small amount of fiber digestion that occurs in the dog is probably due to microbial activity, and the calculated endogenous fecal fiber output of between 18% and 25% probably represents insoluble bacterial residues.

Transit time

There have been no previous in vivo measurements of gastrointestinal transit time in the dog, and the influence of any type of fiber on transit time has not been examined in this species. Banta et al. (22) measured transit time using a variety of markers but killed their dogs at various times, divided the gut into sections with clamps and assessed transit by measuring the marker in each section. Using 2-mm radiopaque markers in dogs fed an all-meat diet, these workers found that 35% of the markers had been excreted between 8 and 16 hours after ingestion. The present study measured the time for 94% excretion so no direct comparison is possible.

This study has shown that dietary fiber significantly decreases gastrointestinal transit time in the dog, but as in humans, there are wide individual differences both among and within individual animals. Finely ground fiber is generally considered to have little effect on transit time in humans (18, 26), and the effect of α-cellulose on transit time in the dog was unexpected in the light of these observations. The dog has a much simpler colon as compared to humans, and it is possible that the effect of α-cellulose on fecal bulk has a different effect on gastrointestinal motility in this species.

It has been suggested that in humans fiber "normalizes" transit time, speeding up transit when it is slow and decreasing it when it is fast (2). The results of the present experiment suggest a similar effect in the dog; the abnormally fast speed of transit in dogs 3 and 4 was first slowed by addition of fiber before increasing with additional fiber intake.

Based on the results of the present study it would appear that the gastrointestinal response to dietary fiber in the dog is similar to that observed in other species, including humans. The only exception would be that in the dog, α-cellulose has a greater influence on fecal weight and transit time, which is possibly attributable to the comparatively simple nature of the canine colon.

ACKNOWLEDGMENTS

The authors would like to thank Dr. J. B. Robertson, Department of Animal Science, Cornell University, Ithaca, NY for analysis of the Solka Flok.

LITERATURE CITED

1. Cummings, J. H. (1973) Dietary fiber: (progress report). Gut *14*, 69–81.
2. Harvey, R. F., Pomare, E. W. & Heaton, K. W. (1973) Effects of increased dietary fiber on intestinal transit. Lancet *1*, 1278–1280.
3. Paylor, D. K., Pomare, E. W., Heaton, K. W. & Harvey, R. F. (1975) The effect of wheat bran on intestinal transit. Gut *16*, 209–213.
4. Cummings, J. H., Hill, M. J., Jenkins, D. J. A., Pearson, J. R. & Wiggins, H. S. (1976) Changes in fecal composition and colonic function due to cereal fiber. J. Clin. Nutr. *29*, 1468–1473.
5. Kay, R. M. & Truswell, S. (1977) Effect of citrus pectin on blood lipids and fecal steroid excretion in man. Am. J. Clin. Nutr. *30*, 171–175.
6. Farrell, D. J., Girle, L. & Arthur, J. (1978) Effects of dietary fiber on the apparent digestibility of major food components and on blood lipids in man. Aust. J. Exp. Biol. *56*, 469–479.
7. Merritt, A. M., Burrows, C. F., Cowgill, L. D. & Streett, W. (1979) Quantitation of canine fecal fat and trypsin output from normal dogs on a meat-base or cereal-base diet. J. Am. Vet. Med. Assoc. *174*, 59–61.
8. Fennell, C. (1976) The use of Sterculia Gum for controlling intestinal tone in the dog and cat. J. Small Anim. Pract. *17*, 543–547.
9. Strombeck, D. S. (1975) Dietary management of gastrointestinal problems. In: Diet and Disease in Dogs. (Kronfeld, D. S. & Low, D. G., eds.), pp. 32–44, University of California, Irvine, CA.
10. Ensor, W. L., Olsen, H. H. & Colenbrander, V. F. (1970) A report—Committee on classification of particle size in feedstuffs. J. Dairy Sci. *53*, 689–690.
11. Horwitz, W. (1975) Official Methods of Analysis of the Association of Official Analytical Chemists, USA, 12th ed., Association of Official Analytical Chemists, Washington, DC.
12. Merritt, A. M. & Smith, D. A. (1980) Osmolarity and volatile fatty acid content of feces from horses with chronic diarrhea. Am. J. Vet. Res. *41*, 928–931.
13. Hinton, J. M., Lennard-Jones, J. E. & Young, A. L. (1969) A new method for studying gut transit times using radio-opaque markers. Gut *10*, 842–847.
14. Winer, B. J. (1971) Statistical Principles in Experimental Design, 2nd ed., McGraw-Hill, New York.
15. Snedecor, G. W. & Cochran, W. G. (1967) Statistical Methods, pp. 331–334, Iowa State University Press, Ames, IA.
16. Neter, J. & Wasserman, W. (1974) Applied Linear Statistical Models, pp. 590–597, Richard D. Irwin, Inc., Homewood, IL.
17. Van Soest, P. J. (1967) Development of a comprehensive system of feed analysis and its application to forages. J. Agric. Sci. *26*, 119–128.
18. Heller, S. N., Hackler, L. R., Rivers, J. M., Van Soest, P. J., Roe, D. A., Lewis, B. A. & Robertson, J. (1980) Dietary fiber: the effect of particle size of wheat bran on colonic function in young adult men. Am. J. Clin. Nutr. *33*, 1734–1744.
19. Van Soest, P. J. (1978) Dietary fibers: their definition and nutritional properties. Am. J. Clin. Nutr. *31*, 512–518.
20. Van Soest, P. J. (1981) Some factors influencing the ecology of gut fermentation in man. Banbury report 7. Gastrointestinal cancer–endogenous factors. Cold Spring Harbor Laboratory, 61–68.
21. Stephen, A. M. & Cummings, J. H. (1979) Waterholding by dietary fiber in vitro and its relationship to faecal output in man. Gut *20*, 722–729.
22. Banta, C. A., Clemens, E. T., Krinsky, M. M. & Sheffy, B. E. (1979) Sites of organic acid production and patterns of digesta movement in the gastrointestinal tract of dogs. J. Nutr. *109*, 1592–1600.
23. Southgate, D. A. T. & Durnin, J. V. G. A. (1970) Caloric conversion factors. An experimental reassessment of the factors used in the calculation of the energy value of human diets. Brit. J. Nutr. *24*, 517–535.
24. Burkitt, D. P., Walker, A. R. P. & Painter, N. S. (1972) Effect of dietary fibre on stools and transit times and its role in the causation of disease. Lancet *2*, 1408–1411.
25. Walters, R. L., Baird, I. M., Davies, P. S., Hill, M. J., Drasar, B. S., Southgate, D. A. T., Green, J. & Morgan, B. (1975) Effects of two types of dietary fibre on faecal steroid and lipid excretion. Brit. Med. J. *2*, 536–538.
26. Eastwood, M. A., Kirkpatrick, J. R., Mitchell, W. D. et al. (1973) Effects of dietary supplements of wheat bran and cellulose on faeces and bowel functions. Brit. Med. J. *4*, 392–394.