

APPARENT DIGESTIBILITY OF NUTRIENTS AND ENERGY IN A
SEMI-PURIFIED DIET AS PELLET FORM

Masao Kametaka* and Yuriko Monzen

Department of Agricultural Chemistry, Faculty of Agriculture,
University of Tokyo

*Present address: Kyoritsu Women's University, Hitotsubashi
2-2-1, Chiyoda-ku, Tokyo 101 Japan

Introduction

Recent attention has been focussed on the effects of dietary protein content and energy density on food utilization. Quantitative fitness for the relationship between protein content and energy density in the rabbit ration has been mostly estimated by a lot of feeding trials, but knowledges on the nutritional and physiological basis remain to be accumulated.

Our present aim is to make clear a relationship between digestibility of dietary protein and digestible energy in a semi-purified diet as pellet form.

Materials and Method

Three male rabbits of Japanese white strain weighing 2.85 kg (No.18), 2.95 kg (No.19) and 3.0 kg (No.21) were fitted with their circular neck collars of 30 cm in diameter made of synthetic resin commercially called Acrylite weighing about 150 g to prevent coprophagy. They were fed on a semi-purified type of diet made to a pellet form as shown

in Table 1. (Kametaka, 1967)

Table 1 Ingredients and percentage composition of an experimental semi-purified diet^a

Ingredient	kg in one lot mixed	Percentage composition	
Casein ^b	2	Moisture	5.12
Linters fiber(wet) ^c	15	Crude protein	11.34
Wheat starch	9.5	Total N	1.81
Soybean oil	1	Proteinous N	1.73
Lard	1	Ether extract	11.29
Sucrose	1	Crude fiber	6.40
Agar-agar	1	Ash	4.50
Salt mixture ^d	1	Nitrogen-free extract (NFE)	61.38
Alfalfa hay ^e	0.5	Manganese dioxide (MnO ₂)	0.14
Total	32		

Besides the above ingredients, the followings were added: Vitamin mixture^f 100 g, Manganese dioxide^g 40 g, Cu-chlorophyllin^h 6 g.

- a) Partly modified from the report of Diller et al., 1961.
- b) Washed with hot water and then hot 95 % of ethanol, and contained 14.7 % of nitrogen.
- c) No.82 linters pulp for filter paper manufactured by Tōyō Roshi Co., Ltd.
- d) Hawk-Oser's mixture, 1931.
- e) Dehydrated hay with 3.33 % of nitrogen and 25.43 % of crude fiber in dry matter.
- f) Thacker's mixture, 1956.
- g) Indicator, purity 96 % purchased from Baker and Adamson Co. Ltd. (Kametaka, 1957a and 1957b)
- h) Green pigment additive, added in proportion of about 0.03 %.

The semi-purified diet was prepared as follows: To thirty-two kg of feed ingredients, vitamin mixture, manganese dioxide and Cu-chlorophyllin were added, blended with 7 l of distilled water and pellets of 7 mm in diameter formed by the pelleting machine (Grimma manufacturing Co., Germany), followed by drying at 70°C for two hours, resulting in ca. 5 % of moisture.

A digestion trial was undertaken to determine apparent digestion coefficients of nutrients and gross energy for ten days with these rabbits.

Chemical composition of the diet and feces was proximately determined by the official method of A. O. A. C., nitrogen

in urine analysed by the Kjeldahl method and manganese by the colorimetric method after wet-ashing in addition of conc. H_2SO_4 and conc. HNO_3 to samples tested (Kametaka, 1970). Caloric values of diet and feces were determined by the Vaccum-flask adiabatic oxygen calorimeter (Ogawa Seiki Co. Ltd., Japan).

Results and Discussion

Food intakes of three rabbits for ten days resulted in 405, 550 and 699 g and they consumed 740, 1035 and 2510 ml of drinking water, excreting 295, 704 and 1259 ml of urine respectively.

An example of experimental data during the digestion trial on the rabbit No. 21 fed on the pellet diet is shown in Table 2.

Table 2 Food intake, drinking water, urine and feces excreted in rabbit No. 21

Day	Food intake g	Drinking water ml	Urine ml	Feces in wet matter	
				Hard g	Soft g
1st	80	250	38	24.3	1.7
2nd	76	170	86	20.6	12.2
3rd	75	200	119	30.3	6.5
4th	50	270	180	33.4	8.1
5th	61	300	216	30.5	11.8
6th	80	300	196	6.1	28.8
7th	59	300	152	14.8	11.8
8th	75	270	84	27.4	8.3
9th	78	250	188	21.1	6.1
10th	65	200	0	13.7	3.9
Total	699	2510	1259	222.2	99.2

Table 3 shows an example of digestion coefficient of nutrients (B) based on proximate chemical composition of hard feces and soft feces (A) in the rabbit No. 18.

Table 3 An example of digestion coefficient of nutrients in rabbit No. 18

A) Percentage composition of hard feces and soft feces in dry matter^a

Nutrient	Hard feces	Soft feces
Crude protein	11.81	28.81
Total N	1.89 ^b	4.61 ^b
Proteinous N	1.40	3.57
Ether extract	1.45	1.77
Crude fiber	35.52	19.51
Ash	13.70	11.30
NFE	37.60	38.61
MnO ₂	0.79	0.55

a) Moisture content on an air-dried sample was 9.11 % in hard feces and 9.79 % in soft feces.

b) $4.61/1.89=2.4$ (Kametaka, 1973)

B) Basic data on digestion coefficient of nutrients for ten days

Nutrient	Food intake (405) ^a g	Hard feces (68.9) ^a g	Soft feces (12.6) ^a g
Dry matter	384.3	62.7	11.4
Organic matter	366.0	54.1	10.1
Crude protein	45.8	7.4	3.3
True protein	43.8	5.5	2.6
Ether extract	45.7	0.91	0.21
Crude fiber	25.9	22.0	2.1
NFE	247.8	23.5	0.44
MnO ₂	0.566	0.497	0.062

a) Figures in parentheses mean total amounts of food intake and feces in air-dried matter at 60°C.

A positive nitrogen balance averaged 0.2 g a day was found during the digestion trial for ten days as shown in Table 4.

Table 4 Nitrogen balance in three rabbits

Nitrogen	Rabbit No.		
	18	19	21
Intake g	7.33	9.96	12.65
Excretion			
in hard feces g	1.19	1.33	2.25
in soft feces g	0.53	0.62	1.06
in urine g	4.03	7.66	5.31
total g	5.75	9.61	8.62
Balance g	+1.58	+0.35	+4.03

Apparent digestion coefficients of dietary nutrients and gross energy during the digestion trial for ten days in three rabbits fed on the pellet diet are shown in Table 5.

Table 5 Apparent digestion coefficients of nutrients and gross energy

Nutrient (%)	Rabbit No.		
	18	19	21
Dry matter	80.7	77.1	79.8
Organic matter	82.5	84.5	81.9
Crude protein	76.6	80.4	74.1
True protein	81.6	84.5	76.8
Ether extract	97.6	98.5	92.4
Crude fiber	6.9	11.7	6.0
NFE	90.3	87.7	92.5
Energy			
Food intake ^a kcal	1753	2381	3027
Feces excreted kcal	307	378	574
in hard feces	257	313	428
in soft feces	50	65	146
Digestion coefficient %	82.5	84.1	81.0
MnO ₂ ^b	98.8	99.8	99.9

- a) Gross energy value of the semi-purified pellet diet averaged 4.33 kcal per g in natural matter. This value was calculated with correction of acids (HNO₃ and H₂SO₄) formed in the oxygen bomb after combustion. Energy values of hard feces and soft feces in air-dried matter from three rabbits were as follows (kcal per g) ; 3.73 and 4.01 in No.18, 3.56 and 3.84 in No.19, 3.84 and 4.02 in No.21 respectively.
- b) Recovery rate %

The semi-purified diet fed in this experiment is somewhat characterized, as shown in Table 1, by several constituents to help acceptability for rabbits, i.e. wet linters fiber instead of purified cellulose (NRC, 1977), casein instead of isolated soy protein, lard to give a good taste, sucrose as sweetening, agar-agar to prevent pellets from excessive hardness, and some alfalfa hay.

Mean values of apparent digestion coefficients of dietary nutrients and gross energy in three rabbits shown in Table 5

were as follows; dry matter 79, organic matter 82, crude protein 77, true protein 80, ether extract 96, crude fiber 8, nitrogen-free extract 90 and gross energy 82 %. Digestion coefficient of nitrogen in this pellet diet was lower than that of casein estimated under the condition of coprophagy prevented (Ensminger and Olentine, 1978)

From these experimental data, total digestible nutrients, digestible crude protein and digestible energy (DE) of this pellet diet were calculated to be 75 %, 8.7 % and 3.55 kcal/g (gross energy $4.33 \text{ kcal} \times 0.82$) respectively.

The rabbit No. 18 lost 0.15 kg of his body weight during the digestion trial. This body weight loss would be explained by a little lower daily DE intake of this rabbit as calculated to be 144 kcal ($3.55 \text{ kcal} \times 40.5$) than a minimum of 154 kcal (70.5×2.19) energy intake per day required for the basic energetic reactions and also considerably lower energy intake than the maintenance requirement of ME value estimated as 173 kcal (79×2.19). (Cheeke, 1987)

The other two rabbits nearly maintained their initial body weights throughout the digestion trial.

The ratio of soft feces in g to total feces in g excreted during the digestion trial indicated from 16 to 30 percent on a wet matter basis and from 16 to 24 percent on a dry matter basis after the treatment of drying in air-circuit oven at 60°C and nitrogen content in soft feces covered about 31 percent of that in total feces.

Percentage composition of hard feces and soft feces shown in Table 3 seems to be almost similar to that in case of a PVA·Cr₂O₃-containing diet and normal rabbits when coprophagy was prevented (Furuichi and Takahashi, 1984 and 1987).

Total recovery of manganese dioxide ranged from 98.8 to 99.9 percent as shown in Table 5, of which about 11 percent was found in soft feces. This resultant figure was more less in comparison to 28 percent recovery of chromic oxide in soft feces of rabbits fed on the commercial pellet diet containing 1 % chromic oxide as a marker (Furuichi and Ishikawa, 1979). This result may be caused by 6.40 percent of crude fiber

content in the semi-purified experimental diet which was less than half of 14.85 percent in the commercial pellet diet.

In conclusion, the finding obtained in this experiment of three rabbits fed on the semi-purified pellet diet is likely to suggest that the digestion progress in hind-gut of these rabbits differed from that of rabbits fed on the commercial diet consisting of natural ingredients.

References

- Cheeke P.R., 1987. Rabbit feeding and nutrition, Academic Press, New York, 376 pp.
- Diller E.R., Korzenovsky M., Harvey O.A., 1961. Endogenous hypercholesterosis in rabbits fed a fat-free purified diet and the effect of unsaturated lipid. *J.Nutr.* 73 14-16.
- Ensminger M.E., Olentine Jr.C.G., 1978. Feeds and nutrition-complete, Ensminger Publ. Co., Calif., 978.
- Furuichi Y., Ishikawa S., 1979. Fecal excretion pattern of water-soluble and -insoluble markers in rabbits. *Jap.J. Zootech.Sci.*, 50 296-304.
- Furuichi Y., Takahashi T., 1984. Movements of water-soluble and -insoluble markers in the digestive tracts of rabbits. *Jpn.J.Zootech.Sci.*, 55 552-561.
- Furuichi Y., Takahashi T., 1987. Cecum-separation in rabbits and digestibility. *Jpn.J.Zootech.Sci.*, 58 563-567.
- Hawk P.B., Oser B.L., 1931. A modification of the Osborne-Mendel salt mixture. *Science* 74 369.
- Kametaka M., 1957a. On the determination of digestibility with manganese dioxide as indicator. *Jap.J.Zootech.Sci.*, 28 214-218.
- Kametaka M., 1957b. On the distribution of feed constituents in the contents of the alimentary tract. *Jap.J.Zootech. Sci.* 28 219-223.
- Kametaka M., 1967. Some physicochemical properties of digesta in the small intestinal tract of the rabbit fed on a pellet diet. *Agr.Biol.Chem.*, 31 616-624.

- Kametaka M., 1970. Effects of intestinal fistulae fixation on digestibility and passage of radioactive manganese dioxide through the intestinal tract. *Agr.Biol.Chem.*, 34 1210-1219.
- Kametaka M., 1973. Mikrobiologie der Verdauung beim Kaninchen. 290 *Biologie und Biochemie der mikrobiellen Verdauung*, Giesecke D. und Henderickx H.K. BLV Verlagsgesellschaft mbH, München.
- NRC-Nutrient Requirements of Rabbit, 1977. National Research Council, National Academy of Sciences, Washington D.C., 15.
- Thacker E.J., 1956. The dietary fat level in the nutrition of the rabbit. *J.Nutr.* 58 243-249.

APPARENT DIGESTIBILITIES OF PROTEIN AND ENERGY IN A SEMI-PURIFIED DIET AS PELLET FORM

Masao KAMETAKA * and Yuriko MONZEN

Department of Agricultural Chemistry, Faculty of Agriculture, University of Tokyo * Present address; Kyoritsu Women's University, Hitotsubashi 2-2-1, Chiyoda-ku, Tokyo 101 Japan

Three rabbits fitted with neck collars were fed on a semi-purified diet as pellet form, which consisted of wheat starch, casein, soybean oil, lard, linter fiber, sucrose, agar-agar, some alfalfa hay, Cu-chlorophyllin (green pigment additive), mineral and vitamin mixtures, including manganese dioxide as an indicator. Gross energy value of this pellet was 4.33 kcal per g. Digestion trials were undertaken to determine apparent digestibilities for 10 days with these rabbits. Their food intakes resulted in 405, 550 and 699 g, indicating 1.58, 0.35 and 4.03 g of positive nitrogen balance respectively. Digestibilities of crude protein, true protein, ether extract, crude fiber, nitrogen-free extract and gross energy averaged 77, 80, 96, 35, 90 and 83 % respectively. Nitrogen contents of soft feces amounted to about 31 % of total fecal nitrogens and recovery rates of manganese dioxide in total feces ranged from 98 to 99 %, 11% of which was recovered in soft feces.

ペレット状半精製飼料に含まれる蛋白質とエネルギーのみかけの消化率
 魯高正夫*, 門前百合子

東京大学農学部農芸化学科*現 共立女子大学, 東京都千代田区一橋2-2-1, 101 日本

首輪を装着した3頭のウサギにペレット状半精製飼料が給与された。この飼料の配合原料は小麦デンプン, カゼイン, 大豆油, 豚脂, 濾過綿, ショ糖, 寒天, 少量のアルファルファ乾草, 銅クロフィルリン(緑色色素添加物), 無機塩類とビタミン混合物であり, それに指示物質として二酸化マンガンが加えられた。このペレットの総エネルギー価は 4.33 kcal/g であった。10日間の消化試験の成績は次の通りであった。飼料摂取量は 405, 550, 699g となり, また 1.58, 0.35, 4.03g の「 N 」の窒素出納を示した。粗蛋白質, 純蛋白質, 粗脂肪, 粗繊維, 可溶無窒素物と総エネルギーの消化率は平均値としてそれぞれ 77, 80, 96, 35, 90 と 83% を示した。ソフト糞中の窒素含量は全糞中の窒素量の約 31% となり, また全糞中への二酸化マンガンの回収率は 98~99% で、このうちの 11% はソフト糞中に回収された。

