

DIGESTIBLE NUTRIENTS OF FEEDING STUFFS FOR THE DOMESTIC RABBIT ¹

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INTRODUCTION

The rational feeding of the domestic rabbit has come to be a matter of consequence since the production of this animal as a source of meat for human consumption has attained a permanent and justifiable place in the general food economy.

This report presents the results of the determination of the composition, digestibility, and digestible nutrients of 47 feeding stuffs available for rabbit feeding in the United States. The results of similar investigations by Weiske (6, 7, 8),³ Von Knieriem (3, 4), and Brüggemann (1), covering an aggregate of 16 roughages and 12 concentrates, are also included for comparative purposes and for the presentation of digestible-nutrient values not given in, but computed from, the papers by Weiske and Von Knieriem.

EXPERIMENTAL SUBJECTS AND EQUIPMENT

The experimental rabbits were young female New Zealand Whites, weighing about 4 pounds each.

The metabolism cages were a standard product having floor dimensions of 18 by 20 inches and a height of 12 inches. The floor of each cage was of $\frac{3}{4}$ -inch mesh No. 12 gage wire, through which the feces dropped onto a $\frac{1}{2}$ -inch mesh stainless-steel screen, and the urine was directed by a galvanized-iron funnel pan into a bottle below the cage. The stainless-steel screen and funnel pan were free from the body of the cage and were readily removable for the collection of the excreta.

Water was provided outside the cage proper in a cup which fitted over an opening in the door of the cage.

The usual earthenware feeding dishes were found unsatisfactory for quantitative work, since the feed could be scratched out easily. To overcome this difficulty a galvanized-iron feeder with inbent edges was devised and suspended from the door of the cage. This device almost completely prevented the scattering of feed.

A piece of block salt was kept in the cages of the rabbits at all times.

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³ Italic numbers in parentheses refer to Literature Cited, p. 683.

EXPERIMENTAL METHODS

FEEDING TECHNIQUE

Roughages were cut with a clover cutter and were shaken through a $\frac{3}{8}$ -inch-mesh screen. The longer pieces thus separated out were returned to the cutter until practically all the material had passed through the screen. The final product was coarse enough to be acceptable to the rabbits, but was relatively free of pieces over 2 inches in length, which they would have wasted.

All of the dry roughages, except bluegrass, were fed alone and the digestibility determined directly. Since the rabbits lost much weight when fed on dried bluegrass alone, this was fed with a commercial rabbit ration and the digestibility determined by difference.

The quantities in which the dry roughages were fed were determined largely by the palatability of the product. The maximum amount of the most satisfactory roughages, such as alfalfa hay, that a rabbit could be trusted to clean up was about 80 gm. per day. In general, the quantity of dry roughage that a rabbit would eat was well below that which would have been required to maintain its body weight.

The green roughages, roots, and tubers were cut up into pea-sized pieces and were fed fresh in quantities estimated to furnish dry matter equivalent to the 40 gm. of alfalfa hay with which they were given.

Aliquot samples were taken at the time of each feeding and were kept in pyrex dishes at 50° C. in a Freas oven. At the end of an experiment the oven-dry samples were allowed to come to moisture equilibrium with the air. They were then weighed, ground in a Wiley mill, and retained for analysis, sealed in glass bottles.

Each of the concentrates was fed with an equivalent weight of alfalfa hay. Cottonseed cake was fed also with soybean hay and with vetch hay. The reasons for this will be given later.

Corn (maize) was fed coarsely cracked; all other grains were fed whole.

The oil cakes were fed in pea size, since rabbits do not like pulverized dry feeds.

Milk was fed in liquid form to the extent of 300 gm. daily with 40 gm. of alfalfa hay. No difficulty was encountered in getting the rabbits to drink 150 gm. of milk at each feeding.

The quantity of concentrate fed was usually 40 gm. daily, in addition to the 40 gm. of alfalfa hay. This combination provided nutrient somewhat in excess of the maintenance requirement.

The feed was given twice daily in equal portions and weighed immediately prior to feeding. Aliquot portions of the concentrates were saved each time the feeding stuffs were weighed, and the composite samples representing the collection period were ground and sealed up in the same way as were the roughage samples.

In general, three rabbits were used for each treatment. That this number was sufficient to establish valid digestion coefficients for the group was determined from experiments in which 10 or more trials were made.

COLLECTION AND TREATMENT OF FECES

The feces were usually collected over a period of 10 days. In certain cases when the supply of feed was insufficient or the animals

showed signs of malaise, the collection periods were curtailed to 7 days. Collection was always preceded by a preliminary feeding period of 5 to 7 days, usually the latter. The preliminary feeding was deemed to be sufficiently long to establish equilibrium between the feeding treatment and any effects of coprophagy that might have existed, since the quantity of feed eaten daily in two equal portions was constant and the daily weights of the feces were consistent after a few days.

Feces were collected daily throughout the experimental periods. The fresh feces were kept overnight at 50° C. in a ventilated Freas oven, from which they were transferred to open jars and left exposed to the air until the end of the collection period. They were then weighed each day during several days, to assure equilibrium with the air, and were then ground in a Wiley mill. The ground samples were kept in sealed bottles for analysis.

METHODS OF ANALYSIS

The feeds and feces were subjected to the conventional analyses for moisture, nitrogen, ether extract, crude fiber, ash, and energy, with nitrogen-free extract computed, as usual, by difference.

Moisture was determined as the loss in weight of a 2-gm. sample when heated overnight at 80° C. in a Freas oven and thereafter kept in a vacuum desiccator containing sulfuric acid until no further loss in weight occurred. Constant weight was obtained after 2 days in the vacuum desiccator. This procedure was found to be quite as accurate as drying to constant weight entirely in the vacuum desiccator, which would have required about 3 weeks.

Nitrogen was determined by the boric acid modification of the Kjeldahl method. Copper sulfate was used as the catalyst in the digestion, and methyl red as the indicator in the titration.

Ether extract was determined by extracting the dried samples employed in the moisture determination for 48 hours in Soxhlet extractors.

Crude fiber was determined on the residue from the ether extraction by the official method of the Association of Official Agricultural Chemists.

Ash was determined as the ignition residue from a 3- to 5-gm. sample which had been brought up slowly, overnight, to a temperature of 550° C. in a muffle furnace under rheostat control.

Energy was determined by means of an adiabatic Emerson bomb calorimeter.

RESULTS

DIGESTIBILITY AND DIGESTIBLE NUTRIENTS OF FEEDING STUFFS

The composition and the digestibility of the feeding stuffs, and the digestible nutrients contained therein, are presented in tables 1, 2, and 3, respectively. Supplementary tables 4, 5, 6, and 7 give the results of the similar work by Weiske (6, 7, 8), Von Knieriem (3, 4), and Brüggemann (1). The feeding stuffs on which results are reported both in the previously published studies referred to and in the investigation now presented are the following: Clover, timothy and vetch hays, barley, linseed cake, milk, oats, rye, and wheat. In general, the digestion coefficients given in the earlier and in the present work are in essential agreement.

A comparison of the results obtained for dry roughages with rabbits with those reported by Morrison (2) for similar feeds with ruminants shows, respectively, the following average digestibility: Protein, 65 and 60 percent; ether extract, 48 and 55; crude fiber, 17 and 53; and nitrogen-free extract, 58 and 65 percent.

TABLE 1.—Composition of feeding stuffs supplied rabbits in this investigation

Feeding stuff and source	Water	Crude protein	Ether extract	Carbohydrates		Ash	Energy per gram
				Crude fiber	Nitrogen-free extract		
	Percent	Percent	Percent	Percent	Percent	Percent	Calories
Dry roughages:							
Alfalfa hay (Pennsylvania).....	11.4	17.9	1.5	30.9	32.4	5.9	4.12
Alfalfa hay, western, 1938, (California) ..	6.5	20.4	2.2	20.4	42.1	8.4	4.20
Alfalfa hay, western, 1939, (California) ..	10.1	27.2	2.9	21.6	28.8	9.4	4.03
Bluegrass (California).....	9.6	26.1	4.3	18.9	31.3	9.8	4.13
Clover hay (Pennsylvania).....	12.5	12.9	2.7	24.7	41.2	6.0	3.91
Kale (California).....	10.6	23.1	3.7	11.9	33.3	17.4	3.32
Kudzu hay (Alabama).....	7.2	10.9	1.5	42.2	33.2	5.0	4.22
Lespedeza, common (Alabama).....	10.5	14.8	2.8	27.7	39.0	5.2	4.29
Lespedeza sericea (Alabama).....	7.9	11.4	1.6	29.7	44.4	5.0	4.29
Lespedeza sericea (Mississippi).....	11.4	9.4	2.1	32.4	39.8	4.9	4.16
Melilotus hay (California).....	10.6	21.1	2.9	22.6	33.0	9.8	3.99
Milo hay, green (California).....	10.0	19.3	3.7	21.6	34.2	11.2	3.87
Oat hay, green (Pennsylvania).....	6.8	7.1	3.1	37.4	38.3	7.3	4.10
Peanut hay (Alabama).....	7.9	9.7	2.6	37.7	37.5	4.6	4.14
Soybean hay (Alabama).....	10.4	10.6	1.4	38.0	33.2	6.4	3.95
Soybean hay, green (Pennsylvania).....	7.5	14.5	1.9	28.6	37.5	10.0	3.94
Sudan grass (California).....	11.0	15.8	3.7	20.2	40.5	8.8	3.88
Timothy hay (Pennsylvania).....	10.1	5.9	1.8	30.7	47.1	4.4	4.07
Vetch hay (California).....	10.3	19.2	3.1	24.5	35.3	7.6	3.96
Wheat hay, green (Pennsylvania).....	10.3	19.4	3.6	23.2	33.7	9.8	3.93
Green roughages, roots, tubers:							
Cabbage.....	91.5	1.7	.1	.9	5.1	.7	.34
Carrot.....	87.7	1.4	.1	1.2	8.7	.9	.48
Celery.....	94.4	.9	.1	.8	2.5	1.3	.19
Rutabaga.....	86.9	1.3	.1	1.2	9.8	.7	.52
Sweetpotato.....	58.1	1.8	.3	1.0	37.9	.9	1.73
Turnip.....	91.8	1.0	.1	1.1	5.2	.8	.32
Yam.....	68.6	1.4	.4	.9	27.7	1.0	1.29
Concentrates:							
Barley.....	14.5	10.7	1.2	6.4	65.0	2.2	3.88
Beef pulp.....	11.5	8.3	.3	21.8	55.5	2.6	3.83
Bread, dried.....	4.4	15.8	2.5	.3	73.5	3.5	4.23
Brewers' grains.....	5.7	28.7	5.8	16.2	40.6	3.0	4.93
Buckwheat.....	14.8	10.4	2.3	10.8	60.0	1.7	3.85
Corn.....	14.0	10.0	3.6	2.1	68.9	1.4	3.98
Cottonseed-oil cake.....	6.7	39.7	6.6	13.3	26.8	6.9	4.55
Linseed-oil cake.....	10.8	36.8	4.0	7.8	35.2	5.4	4.29
Milk.....	87.8	3.1	3.7	---	4.6	.8	.72
Milo maize.....	6.5	12.1	2.8	1.9	75.0	1.7	4.03
Oats.....	12.1	10.9	4.2	10.6	58.9	3.3	4.18
Peanut-oil cake.....	6.0	42.8	7.7	4.4	32.6	6.5	4.57
Rye.....	14.1	9.7	1.4	2.1	70.9	1.8	3.91
Sesame-oil cake.....	5.5	39.4	8.7	6.7	26.5	13.2	4.22
Soybean-oil cake.....	9.3	45.5	4.6	5.0	29.9	5.7	4.44
Soybeans, whole, Manchu.....	6.8	40.9	17.1	5.6	24.5	5.1	5.23
Wheat.....	14.9	8.9	1.3	2.2	70.9	1.8	3.79
Wheat bran.....	10.4	16.7	3.9	10.5	51.6	6.9	4.09
Mixed rations:							
Purina omolene.....	12.1	12.4	2.7	7.8	60.6	4.4	3.98
Purina rabbit chow.....	11.0	14.9	3.3	13.7	52.1	5.0	4.02

TABLE 2.—Average digestibility of feeding stuffs supplied rabbits in this investigation

Feeding stuff and source	Trials	Dry matter	Crude protein	Ether extract	Carbohydrates		Ash	Energy
					Crude fiber	Nitrogen-free extract		
Dry roughages:								
Alfalfa hay (Pennsylvania).....	19	48.1	72.3	16.0	18.2	63.3	62.4	45.9
Alfalfa hay, western, 1938 (California).....	3	67.5	80.7	20.0	29.8	81.9	67.4	64.6
Alfalfa hay, western, 1939 (California).....	3	63.4	83.6	39.1	27.3	74.8	60.7	61.6
Bluegrass (California).....	3	45.2	74.4	40.9	12.6	41.0	45.7	45.4
Clover hay (Pennsylvania).....	3	52.8	62.8	61.8	19.7	67.2	64.3	49.3
Kale (California).....	3	76.0	81.1	40.7	59.5	83.4	74.1	69.3
Kudzu hay (Alabama).....	3	38.0	62.5	12.4	16.1	55.8	59.0	34.4
Lespedeza, common (Alabama).....	3	44.7	66.7	45.9	10.6	59.3	53.1	43.0
Lespedeza sericea (Alabama).....	3	31.5	28.7	54.3	7.3	46.5	41.4	28.6
Lespedeza sericea (Mississippi).....	3	32.9	30.8	50.0	8.5	50.2	51.1	30.5
Melilotus hay (California).....	3	56.9	79.0	49.2	6.5	73.4	72.4	53.6
Milo hay, green (California).....	2	44.8	71.1	46.3	15.7	46.6	49.5	42.7
Oat hay, green (Pennsylvania).....	1	29.1	61.0	53.8	10.4	35.5	50.0	26.9
Peanut hay (Alabama).....	3	47.1	55.0	69.7	25.0	65.9	46.1	44.2
Soybean hay (Alabama).....	1	41.3	67.1	31.8	16.6	58.9	54.6	38.1
Soybean hay, green (Pennsylvania).....	3	52.3	69.6	9.0	24.0	71.7	43.6	49.6
Sudan grass (California).....	3	53.8	68.1	49.4	26.6	64.1	44.9	52.3
Timothy hay (Pennsylvania).....	3	36.5	46.6	44.2	10.7	51.0	45.3	34.6
Vetch hay (California).....	3	56.2	78.3	62.8	11.0	72.4	68.5	52.6
Wheat hay, green (Pennsylvania).....	3	50.5	77.6	50.3	22.0	53.2	55.7	49.3
Green roughages, roots, tubers:								
Cabbage.....	3	101.3	98.6	83.3	88.2	102.9	94.1	100.3
Carrot.....	3	92.8	85.7	79.4	56.4	97.8	87.6	90.8
Celery.....	3	92.5	76.8	90.7	93.3	98.8	86.6	89.3
Rutabaga.....	3	99.3	89.4	83.3	103.6	100.0	96.0	97.6
Sweetpotato.....	2	92.6	43.8	75.6	94.3	94.4	103.7	90.4
Turnip.....	3	97.7	90.6	102.9	82.1	101.0	86.2	96.7
Yam.....	3	96.1	51.7	80.2	123.1	96.8	109.0	93.7
Concentrates:								
Barley.....	3	82.5	84.8	106.2	12.5	89.3	41.1	82.4
Beet pulp.....	3	82.1	48.3	-52.4	71.8	91.6	77.7	79.1
Bread, dried.....	3	100.2	95.2	98.5	-----	100.9	105.4	99.0
Brewers' grains.....	3	56.4	84.7	80.8	20.6	48.7	15.6	60.0
Buckwheat.....	3	78.7	72.2	95.2	16.5	89.3	89.2	76.1
Corn.....	10	91.3	84.2	93.1	145.8	91.9	44.8	92.0
Cottonseed-oil cake.....	4	66.0	83.5	98.6	30.7	56.3	33.6	70.4
Linseed-oil cake.....	3	77.3	86.4	98.8	20.5	81.1	34.6	79.4
Milk.....	3	92.3	99.6	95.3	-----	94.1	84.1	91.1
Milo maize.....	3	89.3	72.1	95.6	103.1	90.6	105.8	86.9
Oats.....	3	68.2	78.6	97.6	-2.4	78.7	20.7	69.6
Peanut-oil cake.....	3	91.4	91.2	101.1	48.9	96.2	69.2	92.3
Rye.....	3	90.5	79.1	82.1	53.6	93.0	86.2	89.7
Sesame-oil cake.....	3	81.6	90.9	101.3	73.2	84.4	30.2	90.3
Soybean-oil cake.....	4	89.7	89.7	96.1	51.9	95.5	66.8	90.0
Soybeans, whole, Manchu.....	3	88.8	87.9	95.5	85.3	90.8	62.9	89.4
Wheat.....	3	93.3	84.6	100.0	28.5	96.6	53.6	92.8
Wheat bran.....	3	62.6	83.0	77.2	24.3	65.3	33.0	64.3
Mixed rations:								
Purina omolene.....	6	74.9	76.3	87.2	17.0	82.8	52.7	74.6
Purina rabbit chow.....	5	68.1	76.3	81.0	18.2	78.9	58.6	67.2

TABLE 3.—*Dry-matter content and digestible nutrients of feeding stuffs supplied rabbits in this investigation*

Feeding stuff and source	Total dry matter	Digestible nutrients in—					Fat	Total
		Crude protein	Carbohydrates			Total		
			Crude fiber	Nitro- gen-free extract	Total			
<i>Dry roughages:</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	
Alfalfa hay (Pennsylvania).....	88.6	12.9	5.6	20.5	26.1	0.5	39.5	
Alfalfa hay, western, 1938 (California).....	93.5	16.5	6.1	34.5	40.6	1.0	58.1	
Alfalfa hay, western, 1939 (California).....	89.9	22.7	5.9	21.5	27.4	2.5	52.6	
Bluegrass (California).....	90.4	19.4	2.4	12.8	15.2	4.0	38.5	
Clover hay (Pennsylvania).....	87.5	8.1	4.9	27.7	32.6	3.8	44.6	
Kale (California).....	89.4	18.7	7.1	27.8	34.9	3.4	57.0	
Kudzu hay (Alabama).....	92.8	6.8	6.8	18.5	25.3	.4	32.5	
Lespedeza, common (Alabama).....	89.5	9.9	2.9	23.1	26.0	2.9	38.8	
Lespedeza sericea (Alabama).....	92.1	3.3	2.2	20.6	22.8	2.0	28.1	
Lespedeza sericea (Mississippi).....	88.6	2.9	2.8	20.0	22.8	2.4	28.1	
Melilotus hay (California).....	89.4	16.7	1.5	24.2	25.7	3.2	45.6	
Milo hay, green (California).....	90.0	13.7	3.4	15.9	19.3	3.8	36.8	
Oat hay, green (Pennsylvania).....	93.2	4.3	3.9	13.6	17.5	3.8	25.6	
Peanut hay (Alabama).....	92.1	5.3	9.4	24.7	34.1	4.1	43.5	
Soybean hay (Alabama).....	89.6	7.1	6.3	19.6	25.9	1.0	34.0	
Soybean hay, green (Pennsylvania).....	92.5	10.1	6.9	26.9	33.8	.4	44.3	
Sudan grass (California).....	89.0	10.8	5.4	26.0	31.4	4.1	46.3	
Timothy hay (Pennsylvania).....	89.9	2.7	3.3	24.0	27.3	1.8	31.8	
Vetch hay (California).....	89.7	15.0	2.7	25.6	28.3	4.4	47.7	
Wheat hay, green (Pennsylvania).....	89.7	15.1	5.1	17.9	23.0	4.1	42.2	
<i>Green roughages, roots, and tubers:</i>								
Cabbage.....	8.5	1.7	.8	5.1	5.9	.2	7.8	
Carrot.....	12.3	1.2	.7	8.5	9.2	.2	10.6	
Celery.....	5.6	.7	.7	2.5	3.2	.2	4.1	
Rutabaga.....	13.1	1.2	1.2	9.8	11.0	.2	12.4	
Sweetpotato.....	41.9	.8	.9	35.8	36.7	.5	38.0	
Turnip.....	8.2	.9	.9	5.2	6.1	.2	7.2	
Yam.....	31.4	.7	.9	26.8	27.7	.7	29.1	
<i>Concentrates:</i>								
Barley.....	85.5	9.1	.8	58.0	58.8	2.7	70.6	
Beet pulp.....	88.5	4.0	15.7	50.8	66.5	.0	70.5	
Bread, dried.....	95.6	15.0	.0	73.5	73.5	5.5	94.0	
Brewers' grains.....	94.3	24.3	3.3	19.8	23.1	10.5	57.9	
Buckwheat.....	85.2	7.5	1.8	53.6	55.4	4.9	67.8	
Corn.....	86.0	8.4	2.1	63.3	65.4	7.5	81.3	
Cottonseed-oil cake.....	93.3	33.1	4.1	15.1	19.2	14.6	66.9	
Linsed-oil cake.....	89.2	31.8	1.6	28.5	30.1	8.9	70.8	
Milk.....	12.2	3.1	4.3	4.3	7.9	15.3	
Milo maize.....	93.5	8.7	1.9	68.0	69.9	6.0	84.6	
Oats.....	87.9	8.6	.0	46.4	46.4	9.2	64.2	
Peanut-oil cake.....	94.0	39.0	2.2	31.4	33.6	17.3	89.9	
Rye.....	85.9	7.7	1.1	65.9	67.0	2.6	77.3	
Sesame-oil cake.....	94.5	35.8	4.9	22.4	27.3	19.6	82.7	
Soybean-oil cake.....	90.7	40.8	2.6	28.6	31.2	9.9	81.9	
Soybeans, whole, Manchu.....	93.2	36.0	4.8	22.2	27.0	36.7	99.7	
Wheat.....	85.1	7.5	.6	68.5	69.1	2.9	79.5	
Wheat bran.....	89.6	13.9	2.6	33.7	36.3	6.8	57.0	
<i>Mixed rations:</i>								
Purina omolene.....	87.9	9.5	1.3	50.2	51.5	5.3	66.3	
Purina rabbit chow.....	89.0	11.4	2.5	41.1	43.6	6.0	61.0	

TABLE 4.—Composition of feeding stuffs supplied rabbits in investigations of Von Knieriem and Weiske

Feeding stuff	Water	Crude protein	Ether extract	Carbohydrates		Ash	Reference
				Crude fiber	Nitrogen-free extract		
Dry roughages:	Percent	Percent	Percent	Percent	Percent	Percent	
<i>Barbarea vulgaris</i> hay.....	13.7	14.3	3.1	28.2	34.1	6.6	Von Knieriem (3, 4).
Clover hay, white.....	13.4	16.0	3.8	17.2	40.5	9.1	Do.
Clover hay, red.....	13.3	13.5	4.0	24.3	39.3	5.6	Do.
Darnel grass hay.....	8.3	6.3	2.7	36.0	42.4	4.3	Do.
<i>Geum rivale</i> hay.....	12.5	8.9	3.4	23.4	43.3	8.5	Do.
Kidney-vetch hay.....	11.8	10.3	3.2	28.9	39.5	6.3	Do.
Orchard grass, rank.....	11.8	10.2	2.8	28.1	41.0	6.1	Do.
Orchard grass, spare.....	11.4	6.8	2.2	29.2	43.5	6.9	Do.
Timothy hay.....	10.3	6.5	1.6	36.9	39.6	5.1	Do.
Vetch hay.....	15.3	15.5	2.8	23.4	32.3	10.7	Do.
Concentrates:							
Barley.....	6.9	11.3	2.0	4.2	71.9	3.7	Weiske (8).
Coconut cake.....	12.0	21.8	13.5	14.4	33.0	5.3	Von Knieriem (3, 4).
Hempseed cake.....	13.7	26.1	9.2	29.9	12.6	8.5	Do.
Linseed cake.....	11.9	30.1	9.0	9.2	33.2	6.6	Do.
Milk.....	90.7	3.5	5	-----	4.5	8	Do.
Oats.....	6.5	11.1	5.5	9.3	64.7	2.9	Weiske (6, 7).
Palm-kernel cake.....	10.5	16.9	12.0	17.4	39.0	4.2	Von Knieriem (3, 4).
Rapeseed cake.....	10.6	29.9	8.5	11.9	32.1	7.0	Do.
Rye.....	6.0	12.0	1.7	2.1	76.3	1.9	Weiske (8).
Sunflower cake.....	9.5	30.7	9.5	19.4	25.8	5.1	Von Knieriem (3, 4).

TABLE 5.—Digestibility of feeding stuffs supplied rabbits in investigations of Von Knieriem and Weiske

Feeding stuffs	Dry matter	Crude protein	Ether extract	Carbohydrates		Ash	Reference
				Crude fiber	Nitrogen-free extract		
Dry roughages:	Percent	Percent	Percent	Percent	Percent	Percent	
<i>Barbarea vulgaris</i> hay.....	55.3	77.9	62.4	25.9	66.3	72.3	Von Knieriem (3, 4).
Clover hay, white.....	72.7	68.2	50.9	57.4	83.1	72.4	Do.
Clover hay, red.....	55.1	64.4	75.3	26.5	68.2	53.6	Do.
Darnel grass hay.....	35.4	54.2	57.2	12.5	51.8	22.7	Do.
<i>Geum rivale</i> hay.....	55.2	32.9	62.0	25.6	73.1	66.5	Do.
Kidney-vetch hay.....	55.9	65.8	60.1	27.1	73.5	59.6	Do.
Orchard grass, rank.....	47.6	76.0	64.5	15.2	58.5	68.5	Do.
Orchard grass, spare.....	44.2	71.8	63.1	12.4	59.4	55.9	Do.
Timothy hay.....	35.6	56.7	55.0	18.5	48.2	27.4	Do.
Vetch hay.....	56.7	71.3	58.0	29.9	69.2	56.3	Do.
Concentrates:							
Barley.....	84.0	67.7	86.3	25.1	91.2	51.2	Weiske (8).
Coconut cake.....	94.4	95.7	99.1	89.1	95.2	86.6	Von Knieriem (3, 4).
Hempseed cake.....	-----	65.2	90.1	29.3	8.2	11.3	Do.
Linseed cake.....	-----	86.0	93.4	28.1	76.0	38.7	Do.
Milk.....	-----	97.7	91.7	-----	97.8	80.0	Do.
Oats.....	73.7	80.2	93.8	21.6	79.5	46.4	Weiske (8).
Palm-kernel cake.....	-----	92.8	97.7	64.0	77.9	-----	Von Knieriem (3, 4).
Rapeseed cake.....	-----	78.9	85.4	39.8	73.2	-----	Do.
Rye.....	84.4	63.0	76.3	18.5	91.2	34.4	Weiske (8).
Sunflower cake.....	-----	85.7	79.1	13.7	45.0	-----	Von Knieriem (3, 4).

TABLE 6.—*Dry-matter content and digestible nutrients of feeding stuffs supplied rabbits as computed from data of Von Knieriem and Weiske*

Feeding stuff	Total dry matter	Digestible nutrients in—						Reference
		Crude protein	Carbohydrates			Fat	Total	
			Crude fiber	Nitrogen-free extract	Total			
	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	
Dry roughages:								
<i>Barbarea vulgaris</i> hay	86.3	11.1	7.5	22.6	29.9	4.4	45.4	Von Knieriem (3, 4).
Clover hay, white	86.6	10.9	9.9	33.7	43.6	4.4	58.9	Do.
Clover hay, red	86.7	8.7	6.4	26.8	33.2	6.8	48.7	Do.
Darnel grass hay	91.7	4.0	4.5	22.0	26.5	3.5	34.0	Do.
<i>Geum rivale</i> hay	87.5	2.9	6.0	31.7	37.7	4.7	45.3	Do.
Kidney-vetch hay	88.2	6.8	7.8	29.0	36.8	4.3	47.9	Do.
Orchard grass rank	88.2	7.8	4.3	24.0	28.3	4.1	40.2	Do.
Orchard grass, spare	88.6	4.9	3.6	25.8	29.4	3.1	37.4	Do.
Timothy hay	89.7	3.7	6.8	19.1	25.9	2.0	31.6	Do.
Vetch hay	84.7	11.1	7.0	22.4	29.4	3.7	44.2	Do.
Concentrates:								
Barley	93.1	7.7	1.1	65.6	66.7	3.9	78.3	Weiske (8).
Coconut cake	88.0	20.9	12.8	31.4	44.2	30.1	95.2	Von Knieriem (3, 4).
Hempseed cake	86.3	17.0	8.8	1.0	9.8	18.7	45.5	Do.
Linseed cake	88.1	25.9	2.6	25.2	27.8	18.9	72.6	Do.
Milk	9.3	3.4		4.5	4.5	1.0	8.9	Do.
Oats	93.5	8.9	2.0	51.4	53.4	11.6	73.9	Weiske (8).
Palm-kernel cake	89.5	15.7	11.1	30.4	41.5	26.4	83.6	Von Knieriem (3, 4).
Rapeseed cake	89.4	23.6	4.7	23.5	28.2	16.3	68.1	Do.
Rye	94.0	7.6	1.4	69.6	71.0	2.9	81.5	Weiske (8).
Sunflower cake	90.5	26.3	2.7	11.6	14.3	16.9	57.5	Von Knieriem (3, 4).

TABLE 7.—*Digestibility and digestible nutrients of feeding stuffs supplied rabbits as computed from data of Brüggemann (1)*

Feeding stuff	Digestibility of—					Digestible nutrients	
	Organic matter	Crude protein	Crude fat	Crude fiber	Nitrogen-free extract	Protein	Total
	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
Meadow hay	47.2	60.1	43.1	18.5	64.5	5.2	39.1
Lucerne hay	61.3	75.7	15.9	38.6	72.6	16.6	48.5
Stinging nettle hay	63.0	95.6	31.6	42.4	78.9	20.8	51.9
Green lucerne	81.5	89.1	70.8	66.0	88.0	5.6	15.8
Green sweet lupine	78.9	91.1	73.2	56.5	84.1	3.3	8.9
Ensilaged maize	55.0	79.4	96.1	24.2	68.8	1.3	12.7
Oats	63.8	79.0	90.3	18.0	72.2	10.3	57.1
Barley	89.6	78.0	90.2	72.2	93.3	9.7	77.2
Wheat	94.0	81.0	91.8	90.5	97.0	10.9	82.2
Beet roots	96.6	66.4		100.0	95.7	.3	10.9
Steamed potatoes	98.3	58.3	100.0	100.0	99.1	1.3	22.0

It is noticeable from this comparison that the digestibility of the crude fiber of dry roughages by rabbits is remarkably low. This observation is not new, having been made by Von Knieriem as early as 1898 and recently confirmed by Brüggemann (1) and Watson and Godden (5). The latter workers found the total digestibility, as well as that of crude fiber, of pasture herbage, consisting of mixed grasses with some clover, to be less with rabbits than with sheep. They suggested that the lower digestibility of crude protein, ether extract, and nitrogen-free extract might well be due to sweeping-out or occlusion effects of the indigestible fiber. Such effects are not evident from the present data, since the digestibility of the constituents other than crude fiber compares fairly well with that for ruminants.

From the data reported by Morrison (2) for horses and swine it appears that the capacity of rabbits to digest crude fiber is less than that of horses and nearly equivalent to that of swine.

Since the digestibility of true fat by rabbits is almost complete, as evidenced by the digestibility of the ether extracts from the whole grains, seeds, and oil cakes, it seems quite justifiable to suggest that the percentage digestibility of the ether extracts from the dry roughages furnishes a rough measure of the proportion of the fatty acid esters to the nonlipide constituents of the ether extracts.

Among the better roughages for rabbits, judging by the digestible nutrients they furnish, are dried kale, alfalfa, vetch, and clover hay, green soybean and green wheat hay, and Sudan grass. Peanut hay might be included in this list, but the lot of hay employed in the present work contained some nuts, which may have accounted for a considerable portion of the digestible nutrients.

The poorest of the dry roughages was definitely oat hay. Not only was it unpalatable but the weight of the feces from the hay almost equaled that of the hay itself. One rabbit died, apparently of undernutrition, after subsisting on 60 gm. of oat hay daily for 9 days. Another rabbit, subsisting on 80 gm. of oat hay daily, lost 560 gm., or 30 percent of its original weight, in 2 weeks.

A noticeable difference in palatability was evident between the *Lespedeza sericea* from Mississippi and that from Alabama. The former had a pronounced odor of tea and was much less palatable than the sample from Alabama. The digestibility of the two samples, however, was not considerably different.

All the constituents of the green roughages, roots, and tubers were found highly digestible by rabbits. Even the crude fiber of these feeding stuffs was highly digestible. It is obvious, however, that the method of determination of crude fiber is not sufficiently definitive to allow interpretation of the high digestibility of crude fiber in these feeding stuffs as compared with its low digestibility in the dry roughages. It appears that the chief virtue of the green roughages and roots as feeding stuffs for rabbits is in their accessory food factors rather than in the quantities of digestible nutrients which they supply.

In regard to the concentrates—those which furnished digestible nutrients in excess of 80 percent of their weight are listed in order as follows: Soybeans, dried bread, peanut-oil cake, milo maize, sesame-oil cake, and corn. Wheat, rye, linseed-oil cake, barley, and dried beet pulp furnish digestible nutrients ranging from 70 to 80 percent of their weight. The constituents of milk are highly digestible by rabbits, but this feeding stuff is doubtless more valuable in furnishing accessory food factors than quantities of digestible nutrients. Soybean-oil cake, peanut-oil cake, soybeans, sesame-oil cake, linseed-oil cake, and brewer's grains may be listed as notable sources of protein for rabbits.

TOXICITY OF COTTONSEED-OIL CAKE FOR RABBITS

There seem to be no published observations on the toxicity of cottonseed-oil cake for rabbits. In the early part of this work cottonseed-oil cake was offered in pellet form, with an equal weight of alfalfa hay, to three rabbits. Two of these rabbits refused to eat the cottonseed pellets after the second day. The third rabbit continued to eat the cottonseed for 9 days before refusing. This rabbit

ceased producing feces and lost all appetite for any kind of feed offered. By the eleventh day its abdomen was hard and bloated, and it died on the thirteenth day after cottonseed-oil cake had first been eaten. Post-mortem examination indicated practically complete intestinal stasis. The contents of the caecum and lower gut were hard-packed and dry.

Attempts to feed other rabbits on cottonseed pellets and alfalfa hay ended with their rejection of the cottonseed after 2 or 3 days. No obvious ill effects appeared in these rabbits.

At a later date three rabbits were offered pellets of cottonseed-oil cake with vetch hay. They refused to eat the cottonseed after 6 days, showing signs of constipation. Two of these rabbits recovered after being fed cabbage and a commercial rabbit ration for several days. The third rabbit continued to fail; and, because of the advancing symptoms of anorexia, constipation, abdominal rigidity, etc., it was killed for autopsy. Among the overt symptoms, intestinal stasis was again marked. The lungs, kidney, heart, and liver appeared normal.

The feeding of cottonseed-cake pellets with soybean hay (green, dried, from Pennsylvania) was unique in that the rabbits continued to eat the cottonseed over a much longer period than with the other roughages. One rabbit exhibited no ill effects after receiving 40 gm. of cottonseed cake with 40 gm. of soybean hay daily for 16 days. None of the unfavorable symptoms observed previously in other rabbits appeared in this one; but 4 days after being taken off the cottonseed diet and put onto a commercial rabbit ration the rabbit died. The second of these rabbits ate the cottonseed with soybean hay for 15 days before exhibiting signs of constipation and failure of appetite. This rabbit continued to fail and was killed on the eighteenth day after initiation of the cottonseed feeding. The third rabbit in this group rejected the cottonseed-soybean hay diet after 14 days, lingered for 7 days by nibbling at offerings of cabbage and commercial rabbit ration, but died on the twenty-second day after the initiation of the cottonseed feeding.

The cottonseed cake fed was made from seed grown in the San Joaquin Valley, Calif., in 1937.

No study was made of the cause of the observed toxicity of the cottonseed-oil cake.

SUMMARY

The composition, digestibility, and digestible nutrients of 47 feeding stuffs, including dry roughages, green roughages, roots, tubers, concentrates, and commercial mixed feeds, for rabbits, are reported. The greater part of the determinations were made in triplicate.

Concentrates were found to be well digested, and, with the exception of crude fiber, roughages were nearly as well digested by rabbits as by domestic animals.

Kale, alfalfa, vetch, clover, soybean, wheat, and Sudan grass were found to be among the better roughages for rabbits.

The poorest roughages studied were bluegrass and oat hay.

When fed as the sole concentrate, with the same quantity of roughage, cottonseed meal was found to be toxic to rabbits, the most prominent effects being intestinal stasis and loss of appetite.

Results of previously published work are tabulated and all available data concerning the utilization of feeding stuffs by rabbits are thus brought together.

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