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INTRODUCTION

In preparing mixed rations for animal use, and also in manufacturing certain preparations for human use, there is an increasing tendency toward fine grinding, in many cases to the consistency of a fine flour. The power, labor, and machine costs involved in reducing a feed to this extreme fineness must be justified by definite advantages before the procedure can be recommended. From the economic viewpoint, finely ground feeds, frequently in the form of pellets or cakes, facilitate handling, storing and feeding of a ration, prevent waste of roughage, and permits the disguising of the composition of a feed, either to protect a trade secret, or less desirably, to cover the introduction of cheap substituents.

Discussions of the relative nutritional merits of whole grain cereals vs. cracked or ground have frequently appeared. Lane ('98) reports that the use of cracked corn increased milk production as compared to the use of whole kernels, in which case, much passed unbroken in the feces. Wilbur ('33) states that while fine grinding increased milk production somewhat, when all factors are considered, the procedure is not to be recommended. Brown and Blakeslee ('33) arrived at a comparable conclusion in lamb feeding experiments. Garragus and Mitchell ('35) conclude that fine grinding of corn increases slightly the energy source for pigs but does not alter its protein value. Kick and Gerlaugh ('37) made an extensive study of the effect of processing cereal grains upon mastication by cattle, but their results, although giving some information, are not well adapted to the problem under consideration because they discuss primarily whole kernels as compared to coarse ground grain, and also because the ground cereal generally was fed with roughage in the form of chopped hay or fodder.

Most investigations have thus considered the nutritional value of the first stage of grinding; i. e., from whole to cracked or coarse cereal grains, with the accompanying roughage in an essentially coarse condition, and have found that there is a definite advantage, justifying the relatively small cost of the processing. This study proposes to determine if the next stage

of milling, i. e., from coarse to a fineness approaching that of flour, confers any further nutritional advantage, and, if so, whether it is to a degree justifying the relatively high cost of the process.

EXPERIMENTAL

Albino rats, New Zealand rabbits, and sheep were fed balanced rations composed of cereal grains and protein supplemented with minerals and vitamins, plus dried green wheat, alfalfa, spinach, cabbage or lettuce.

The wheat and alfalfa were cut when about one foot in height when the green leaves formed the maximum amount of the whole. The spinach, lettuce, and cabbage were cut when the leaves were fully developed and were highly colored as found in late spring.

The coarse mixture was ground through a ¼ inch hammer mill screen and the fine mixture through a specially built hammer mill screen, leaving no particle larger than 0.4 mm. and with the greater portion in the form of a fine powder.

Sheep were fed throughout the study with a low protein ration consisting of one part cottonseed cake, ten parts yellow corn, and ten parts alfalfa, previously described, and a high protein ration consisting of one part cottonseed cake, and one part yellow corn, and two parts alfalfa.

The basic rat ration consisted of:

Polished rice	65 parts
Casein	10 parts
Yeast	4 parts
Butter fat	10 parts
NaCl	1 part

To this ration was added 10 percent of one of the green plants, depending upon the lot considered.

The rabbit ration consisted of:

Oats	60 parts
Ground green wheat or alfalfa	30 parts
Bran	9 parts
NaCl	1 part

Rats and rabbits were raised from weaning age to maturity upon their respective rations; in each case the same feed was used during the periods in the metabolism cages; thrifty feeder lambs were placed on the experimental feed when about six

months of age and weighing seventy pounds. After one to three months' feeding to insure an equilibrium condition, animals were placed in metabolism cages for four to eight day metabolism periods, during which the quantity of feed consumed was measured and the urine and feces collected separately by use of a false screen floor. Feces were preserved by rapid air drying and the urine samples were preserved with acid until the end of the experimental period, at which time the feces were ground and the urine made to a definite volume. Feces and feed were analyzed for moisture, ash, total nitrogen, fat, calcium, phosphorus, and magnesium, and the urine for total nitrogen, calcium, phosphorus, and magnesium according to the methods of the A. O. A. C. From the analytical data, food digestibility values were calculated, and in conjunction with growth and reproduction records and blood analyses, were used as criteria of the nutritional value of the various feeds.

In all, sixty-four rats were observed in these studies. Table I gives the average data for the coefficients of digestibility of the food constituents as well as the nitrogen and mineral retentions. Each figure in the table represents the average of five separate metabolism trials and in each trial four rats were used over a four-day period. These rats averaging about 190 grams consumed each ration uniformly.

The data for the lettuce study demonstrate a very close agreement between the utilization of the fine and coarse ground ration, with the coarse ground ration showing a slightly favorable retention of minerals. The alfalfa metabolism study illustrates the same general trend. In the case of the animals consuming cabbage and spinach, any difference falls within the probable experimental error, lending no mathematical significance to the apparent slight advantage indicated in cases. Table II gives the beginning weight, final weight, reproduction, and mortality records for the four groups. The spinach and cabbage rats were not mated. Again, there is no significant advantage to recommend either the coarse or the fine ground type of ration.

The young of all rats were continued on their mother's rations with growth and development apparently remaining equal.

Fourteen rabbits, from two litters produced in the colony, were divided into similar groups and fed their respective experimental rations, as described. These were moistened at the time of feeding to increase palatability and to minimize waste. Table III represents the averages of five separate metabolism determinations of five days' duration upon each experimental

group. It should be noted that the same diet was used through the complete study. A preferential utilization of the coarser ration between the two groups using dried green wheat as a roughage is indicated but not proved by a mathematical study. The rabbits consuming the coarse ration made slightly better gains in weight, beginning with an average weight of 1150 grams and increasing 700 grams in eighty-four days.

The difference in the fine and coarse alfalfa studies is no greater than the variations within the groups with the exception that the greater retention of the minerals of the fine feeds seem to be slightly significant. The gain in weight, over 1870 grams for the females and 1790 for the males in 168 days, is almost identical. Three of the mated females of the fine group produced fifteen young, and two of the coarse consuming group gave birth to, and weaned eight young.

The data for the sheep metabolism studies, presented in Table IV, indicate in general a very similar utilization of both the coarse and fine ground modifications of either the high or low protein ration. However, the fine ground ration was decidedly less palatable or preferred by the sheep. In several instances, metabolism experiments ha dto be repeated because sheep were "off feed" for no apparent reason other than dislike of the fine ground ration. Without moistening, it was often refused entirely.

The slightly better general appearance and gain in weight of those animals consuming the coarse ground rations was probably due to the greater palatability of the coarser type of ration. This and other idiosyncrasies of sheep that make them a difficult animal to use in metabolism studies are the only explanations of discrepancies appearing in the data.

The serum calcium and the phosphorus distribution in the blood of those rats fed the coarse and fine rations which included alfalfa or lettuce as roughage material were determined with the view of detecting any possible variance in the utilization of calcium or phosphorus that was not indicated in the metabolism studies, it having been postulated by many that fine grinding should make the cell contents more available. However, as is illustrated in Table V, these analyses completely confirmed the conclusion of no significant preferential utilization for either the coarse or fine ground type of ration.

CONCLUSION

Metabolism studies, growth and reproduction records, and blood analyses indicate comparable utilization of the coarse or the fine ground rations. The exceptions are the greater gain in weight of the rabbits consuming the coarse over those consuming the fine wheat ration, and the slightly better condition and gain in weight of sheep fed the coarse rations over those fed the fine, attributable to the greater palatability of the coarse rations to the sheep.

Grinding a feed to a powdery state confers no additional nutritional value, may decrease the palatability of a feed sufficiently to affect adversely the development of an animal, and is of itself a relatively costly process. Fine grinding of feed is, therefore, not advisable.

TABLE I
Rat metabolism studies
Average of eighty rat-days

	DIGESTION COEFFICIENTS				GRAMS RETENTION PER PERIOD			
Ration	Protein	Fat	Fiber	N. F. E.	N.	Ca.	P.	Mg.
Alfalfa								
Coarse	82.6	93.3	26.8	96.1	3.690	0.401	0.320	0.100
Fine	84.2	92.4	23.7	95.4	3.108	0.398	0.273	0.088
Cabbage								
Coarse	86.7	95.2	31.2	97.6	2.749	0.249	0.244	0.075
Fine	87.3	96.6	24.7	97.1	2.479	0.302	0.325	0.133
Spinach								
Coarse	85.8	93.2	53.4	96.5	3.090	0.062	0.283	0.153
Fine	86.4	93.1	48.8	97.2	4.210	0.070	0.368	0.161
Lettuce								
Coarse	85.2	94.1	42.0	96.2	2.950	0.437	0.345	0.095
Fine	87.0	93.3	40.3	96.9	2.786	0.429	0.289	0.116

TABLE II
Growth of rats

Ration	Days Observed	BEGINNING WEIGHT		GAIN IN WEIGHT		No. of Young	No. Young Weaned
		Male	Female	Male	Female		
		gm.	gm.	gm.	gm.		
Alfalfa							
Coarse	175	66	61	254	160	31 (5 litters)	20
Fine	175	65	62	271	158	25 (4 litters)	19
Lettuce							
Coarse	168	61	62	260	165	29 (4 litters)	20
Fine	168	63	63	240	157	26 (4 litters)	15
Cabbage							
Coarse	154	63	56	223	167		
Fine	154	63	62	257	160		
Spinach							
Coarse	126	53	53	223	158		
Fine	126	61	50	234	156		

TABLE III
Rabbit metabolism studies
Average of twenty-five rabbit-days

Ration	DIGESTION COEFFICIENTS				GRAMS RETENTION PER PERIOD			
	Protein	Fat	Fiber	N. F. E.	N.	Ca.	P.	Mg.
Wheat								
Coarse	83.5	88.2	35.9	78.9	6.937	0.714	2.173	0.633
Fine	81.6	87.6	24.1	76.9	6.757	0.586	1.294	0.423
Alfalfa								
Coarse	71.1	85.6	18.5	72.7	2.666	0.397	0.327	0.231
Fine	78.2	85.0	22.5	76.6	3.750	0.655	0.633	0.256

TABLE IV
Sheep metabolism studies
Average of twenty-five sheep-days

Ration	DIGESTION COEFFICIENTS				GRAMS RETENTION PER PERIOD			
	Protein	Fat	Fiber	N. F. E.	N.	Ca.	P.	Mg.
Low Protein								
Coarse	74.8	74.2	47.7	86.3	58.736	10.70	5.22	2.48
Fine	73.6	78.9	45.1	85.6	62.323	11.80	5.59	3.03
High Protein								
Coarse	77.8	80.2	47.0	81.2	61.719	9.57	10.55	3.83
Fine	75.8	78.1	42.2	78.7	79.000	8.69	10.36	5.16

TABLE V
Serum calcium and phosphorus distribution in the blood of rats fed coarse and fine ground rations

Ration	Serum Calcium Mg. per 100 Ml.	PHOSPHORUS IN BLOOD, Mg. Per 100 Ml.						
		Total Phosphorus		Lipoid Phosphorus		Inorganic Phosphorus		
		Whole Blood	Cells	Plasma	Cells	Plasma	Cells	Plasma
Alfalfa								
Coarse	14.5	63.0	120.0	18.3	21.8	6.4	4.2	7.8
Fine	14.2	60.7	117.0	18.2	22.5	7.5	3.5	7.6
Lettuce								
Coarse	12.6	62.0	124.4	20.3	27.3	7.0	2.5	7.8
Fine	13.0	64.9	112.9	20.9	23.8	7.0	2.5	7.5

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