A STUDY OF THE NUTRITIONAL VALUE OF RUMEN CONTENTS

BY

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INTRODUCTION

The rumen contents from approximately 13,000,000 cattle and 15,000,000 sheep that are slaughtered annually in the United States constitute a serious disposal problem for the packer. Very little research dealing directly with the utilization of this material as a feed stuff has been reported.

Chemical analysis of rumen contents have shown that the crude protein level will range from 7 to 15 per cent on a dry matter basis, depending upon the type of feed eaten by the animal. The yearly loss of protein alone from this rumen material by packing plants amounts to thousands of tons.

It is also a well-known fact that the organisms of the rumen synthesize the water soluble vitamins. Biological assays of rumen contents have shown that this material on a dry matter basis contains amounts of these water soluble vitamins comparable to that contained by whole milk powder, evaporated whey, yeast, or alfalfa leaf meal. Thus it is evident that large quantities of water soluble vitamins are also lost in disposing of this material.

Realizing that the complete utilization of by-products by the packer is an important factor in maintaining the price of livestock, research has been initiated at this station to determine ways and means of processing rumen contents as a possibility of use in animal and poultry feeds.

This thesis is a study of the nutritional value of rumen contents. Four separate experiments were conducted. The first experiment was the determination of the proximate composition of rumen contents collected from cattle and sheep that were fed various feeds. The second experiment

was an assay of the vitamin B_{12} value of rumen contents collected from cattle. The third and fourth experiments were conducted to determine the value of rumen contents in replacing an equal amount of fish meal in an all-vegetable diet for baby chicks.

The results of these studies are reported with each experiment. The discussion of the results and a summary follows the last experiment.

REVIEW OF LITERATURE

Vitamin Synthesis in the Rumen and the Vitamin Content of Rumen Material

Very little information could be found in the literature on the feed value of rumen contents. However, numerous reports were available showing that rumen contents are a source of protein and some of the B-complex vitamins.

Theiler, Green, and Viljoen (1915) observed that ruminants can be maintained for long periods on a diet very low in the water-soluble vitamins. They stated that "We think it at least possible that the vitamin requirements of cattle are so low that they may even be covered indirectly by synthesis carried out by the extensive bacterial flora of the intestine."

Scheunert and Schieblich (1923) were able to show that B vulgate, an organism found in the digestive tract of ruminants, synthesizes vitamin "B".

Eckles, Williams, and Wilbur (1924) fed yeast to dairy calves as a supplement to a standard calf ration. They found no increase in rate of growth from the age of 20 to 180 days. Eckles and Williams (1925) made similar observations with lactating cows. The addition of a dried yeast preparation at the rate of 25 grams per pound of milk produced to a ration commonly fed in good dairy herds did not increase the milk or butterfat yield. No effect could be observed on the condition of the animal or stimulation of appetite.

Bechdel and Honeywell (1927) conducted an investigation to determine the vitamin "B" potency of milk from three cows. The cows were fed for over two years on an experimental ration low in the vitamin "B" growth

factor. The milk was fed to rats as a supplement to a vitamin-B-free basal ration at levels of 8, 10, 12, 16, and 20 c.c. per rat per day. The vitamin B potency was found equal to that of herd milk from cows receiving a good winter ration. It was concluded that vitamin B in milk is not dependent upon the presence of this vitamin in the ration of the cow.

The work of Bechdel et al (1928) proved that the vitamin B complex is synthesized in the rumen contents of a cow. In this investigation a permanent fistula was employed for removing the rumen contents from a cow that was grown to maturity on a ration absent in the vitamin B complex. Alcoholic extracts of the rumen contents, after incubation for 5 days at 37°C, were fed to weanling rats as a supplement to a basal diet. The groups receiving the rumen extracts made an average gain in weight of 5.2 grams per week and maintained a constant rate of growth throughout the 8-week period. In contrast the control rats fed the basal diet did not gain weight. At the end of the 8-week feeding period, there was an average difference in weight of 40 grams between the rumen extract supplemented groups and the control groups.

As the knowledge of the nature of the vitamin B complex increased, investigators confirmed, in a quantitative way, the synthesis of several members of the vitamin B complex in the rumen of sheep and cattle. McElroy and Goss (1939, 1940a, 1940b, 1941a, 1941b) made biological tests on the rumen contents of 4 mature ewes and a cow fed a ration deficient in all the known members of the vitamin B complex. The experimental ration used was composed of washed casein (washed to remove water-soluble vitamins) 5.0, washed sardine meal 6.7, glucose 11.0, corn starch 10.6, mineral mix 3.0, and dried plain beet pulp 63.7 per cent. This B vitamin-

deficient ration was fed from 30 to 45 days previous to the collection of the rumen and reticulum contents. A permanent fistula was employed for removing material from the rumen of the cow. The contents of the rumen and reticulum of the sheep were obtained at slaughter. After collection the rumen and reticulum contents of the sheep and the rumen contents of the cow were immediately preserved with 50 per cent ethyl alcohol. The material was dried at 40 to 50°C. for 48 to 72 hours. It was finely ground in preparation for biological assay. Chicks and rats were used as the assay animals.

The results these workers obtained were that riboflavin was increased 100-fold in the rumen contents of sheep in comparison with the amount present in the basal diet. The rumen contents of the four sheep fed the basal ration which contained less than 0.3 microgram of riboflavin per gram were found to contain 33 micrograms of riboflavin per gram. The dried rumen contents from the fistulated cow fed the same deficient ration contained approximately 25 micrograms per gram. These workers also reported a 6- to 8-fold increase in pyridoxine. The dried rumen contents of the sheep were found to contain 10 micrograms of pyridoxine per gram. The dried rumen contents from the fistulated cow contained 8 micrograms per gram. A 20- to 30-fold increase was also reported for pantothenic acid. The dried rumen contents of the sheep and of the fistulated cow were found to contain approximately 70 micrograms of pantothenic acid per gram. The increase in thiamin was not so marked. These workers reported a figure of 7 micrograms per gram for the rumen contents of sheep and 2 to 2.5 micrograms per gram for the rumen contents of the cow.

The early work of McElroy and Goss was confirmed and extended by Wegner et al. (1940) in a very similar experiment at the Wisconsin

Station. The animal used for the collection of rumen contents was a heifer calf with a rumen fistula. The ration fed consisted of acid-washed casein 4.0, urea 1.0, cod liver oil 1.0, salt mixture 3.0, corn molasses 10.0, corn starch 71.0, and bleached wood-pulp 10.0 per cent. The calf was fed twice daily receiving 2 pounds of ration per feeding. After the calf was fed this ration for several weeks the rumen contents were sampled on alternate days until about 20 kilograms of wet material had been obtained. The size of the sample was approximately 2 kilograms of wet material (12-15 per cent dry matter). Immediately upon sampling, the material was diluted with 95 per cent ethyl alcohol to a final concentration of 45-50 per cent. The material was placed in a cold room (35°F.) in order to stop bacterial action. Two to three days later this material was placed in enamel-lined pans and dried in a drying room for 24 to 40 hours at a temperature of 45 to 50°C. After grinding these samples were again stored in the cold room and removed as needed. The analyses were assayed on a composite sample. The results of this experiment are shown in Table 1.

TABLE 1

The Vitamin Content of Rumen Contents (Collected from a Calf Fed a Semi-Purified Diet) as Measured by Different Assays

(Micrograms per gram dry matter)

Factor	Assay Methods	Basal Ration	Rumen Contents
Thiamin	chicks	0.0	10-12
Riboflavin	microbiological	0.4	18.6
Nicotinic Acid	chemical	60.0	220.0
Pantothenic Acid	microbiological	3.4	55.5
Pyridoxine	rat	0.0	7.0
Biotin	microbiological	0.018	0.087

It was observed that the addition of thiamin to the basal calf ration increased the relative production of each other member of the vitamin B complex except nicotinic acid.

Wegner et al. (1941) conducted an experiment to determine the rumen synthesis of the vitamin B complex on natural rations. The animal used for the collection of rumen contents was a Holstein heifer equiped with a rumen fistula. The basal ration fed consisted of 15 pounds of corn silage, 4 pounds of timothy hay, and 4 pounds of grain mixture (½ ground corn, ½ ground oats with salt and bone meal added). The same general procedure for collecting, drying, and grinding the rumen contents were used as in the previous experiment. The results of this investigation are shown in Table 2.

TABLE 2

The Vitamin Content of Rumen Contents (Collected from a heifer fed a natural diet) as Measured by Different Assays

(Micrograms per gram dry matter)

Factor	Assay Methods	Basal Ration (Calculated Content)	Rumen Contents
Thiamin	chick	3.3	4-5
Riboflavin	microbiological	5.68	24.6
Nicotinic Acid	chemical	225.0	530.0
Pantothenic Acid	microbiological	10.2	26.6
Pyridoxine	rat	2.5	4-5
Biotin	microbiological	0.068	0.080

Johnson et al. (1941) found that dried rumen contents from goats and sheep fed on a purified diet devoid of thiamin and riboflavin contained 1 to 3 micrograms of thiamin and approximately 20 micrograms of riboflavin per gram of dried material.

Booth and Hart (1942) produced a vitamin concentrate from rumen contents which contained from 17 to 20 micrograms of riboflavin per gram.

Their process consisted of heating the rumen material to a temperature of 194°F., pressing out the fluid, and then evaporating the fluid to dryness at a rather low temperature. This concentrate was comparable in riboflavin content to such materials as whole milk powder, evaporated whey, yeast, and alfalfa leaf meal.

Hunt and co-workers (1943) offered further evidence of the presence and origin of riboflavin and thiamin in the rumen contents of cattle. Their experiments included studies on the effect of whole versus ground corn, the proportions of hay to corn, and increasing amounts of pure carbohydrates in a partially synthetic ration on the thiamin and riboflavin production in the rumen. Steers with artificial rumen fistulas were used. The rations were fed from ten to fourteen days before samples of ingesta were collected. The entire rumen content was removed, mixed thoroughly and sampled, and the remainder returned to the rumen. Rat assay and microbiologic methods were used in determining riboflavin values.

The results of the experiments indicated that riboflavin is synthesized in the rumen. There was also evidence that the kind and physical state of the feed consumed are important factors. The riboflavin content of the rumen material was higher when the corn was fed ground than when it was fed whole and as the amount of corn was increased the riboflavin level increased. The corn apparently made a favorable medium by supplying available carbohydrates for bacterial growth. On a corn-free ration (high hay plus protein supplement) there was but little, if any, synthesis of riboflavin. The authors suggested that possibly the increased riboflavin value found when ground corn was fed was due to the greater concentration of water soluble material per gram of dry ingesta.

When the carbohydrate level in the partially synthetic ration was varied, it was found that the higher the carbohydrate level of the ration

the greater was the amount of riboflavin found in the dried ingesta. The results of the biological assay (using the rat) and the microbiological method gave close correlation on the riboflavin values of the feed and ingesta.

Hunt et al. obtained no evidence that thiamin was synthesized in the rumen as judged by a comparison of feed and the ingesta, with a possible exception of an experiment in which ground corn was fed.

Lardinois, Mills, Elvehjem, and Hart (1944) conducted an experiment to determine the effect of nitrogen added to a ration as urea and the extent of the vitamin B complex synthesis in the rumen of a fistulated cow and calf. Their aim was to determine if there was any correlation between added nitrogen and carbohydrates on the vitamin synthesis in the rumen.

These workers found that the addition of urea as a source of nitrogen definitely increased the synthesis of riboflavin, nicotinic acid, biotin, and pantothenic acid in the bovine rumen when a readily available carbohydrate was present. Pyridoxine and folic acid could not be too closely correlated with ration composition. Lardinois et al. concluded that the synthesis of the member of the B complex is not at a maximum in the absence of a readily fermentable carbohydrate and probably a low population of microorganisms.

The data indicated that thiamin may not be synthesized in the rumen. However the author stated that it seems more than probable that it is synthesized, but absorbed or destroyed at a rate equal to its synthesis.

Frey and Kratzer (1945) determined the amount of thiamin, riboflavin, pantothenic acid, and niacin in rumen contents from feed lot steers. Seven composite samples from 140 steers were analyzed. Each composite

sample consisted of equal amounts of the rumen contents of approximately 20 steers which had been on similar rations. The results are shown in Table 3.

TABLE 3

Thiamin, Riboflavin, Niacin, and Pantothenic Acid Found in the Rumen Contents of Steers

Vitamin	Micrograms per Gram of Dried Rumen Contents		
	Lowest Value Found	Highest Value Found	Average of 7 Composite Samples
Thiamin	8.3	13.0	10.0
Riboflavin	9.7	13.0	12.0
Niacin	30.0	62.0	43.0
Pantothenic Acid	39.0	66.0	49.0

Feeding Experiments with Rumen Contents

Hammond (1944) conducted an experiment to determine the value of various combinations of conventional feed stuffs, dried cow manure, and dried rumen contents as a substitute for alfalfa leaf meal in an all-vegatable-protein ration for growing chicks. Five hundred and sixty Rhode Island Red chicks were used in this experiment. The chicks were evenly distributed among 16 pens of a steam-heated brooder house. The basal diet used was composed of ground wheat 50.55, soybean meal 35.00, alfalfa leaf 8.00, B-Y feed 2.00, steamed bone meal 2.00, ground limestone 1.25, manganized salt 1.00, and vitamin A and D feed oil 0.20 per cent. The substitute mixtures for the replacement of the alfalfa meal in the basal diet were made up of different levels of conventional feedstuffs. The feedstuffs used were peanut meal, corn gluten meal, soybean meal, corn gluten feed, ground alfalfa hay, dried distiller solubles, wheat bran, ground limestone, and vitamin A and D oil. The substitute mixtures, the dried cow manure, and the dried rumen contents were fed at an 8 per cent level to replace the alfalfa leaf meal.

The riboflavin content of the six samples of cow manure and the sample of dried rumen contents was determined by microbiological methods. Data on the riboflavin content and proximate composition of the dried cow manure and dried rumen contents are tabulated in Table 4.

TABLE 4

The Riboflavin Content and Proximate Composition of the Dried Cow Manures and Dried Rumen Contents

Description of Product	Riboflavin per Pound	Water	Crude Protein	Ash	Fat	Crude Fiber	N.F.E.
	Micrograms	Percent	Percent	Percent	Percent	Percent	Percent
Cow manure (summer) Dried at 47°C.	2585	6.85	12.66	16.07	2.28	34.95	27.43
Cow manure (winter) Dried at 21°C.	1569	6.11	9.63	13.07	0.97	29.03	41.30
Cow manure (winter) Dried at 47°C.	1950	3.05	9.78	20.03	1.38	29.37	36.56
Cow manure (winter) Dried at 80°C.	1828	2.87	9.24	20.09	1.81	28.96	37.19
Cow manure (winter) Dried at 120°C.	1588	1.83	9.58	26.40	1.81	27.26	33.37
Cow manure (winter) Dried at 160°C.	1438	2.17	9.41	30.91	1.24	26.42	30.11
Rumen Contents Dried at 47°C.	6214	4.05	14.37	8.40	1.50	38.50	33.48

The average live weight of the chicks at the ages of 6 and 10 weeks, and the efficiencies of feed utilization to those ages are shown in Table 5.

TABLE 5

The average live weights and efficiencies of feed utilization of chicks on a diet in which cow manure, rumen contents, and various mixtures of conventional feedstuffs were used as substitutes for alfalfa leaf meal.

Pen No.	Substitute for alfalfa leaf meal, comprising 8 per cent of the diet	Average Live Wt. 6 weeks	Average Live Wt. 10 weeks	Efficiency of Feed Utilization* 6 weeks	Efficiency of Feed Utilization* 10 weeks
1	Substitute mixture No. 1	299	845	0.233	0.235
2	Substitute mixture No. 2	264	700	0.189	0.166
3	Substitute mixture No. 3	277	689	0.204	0.184
4	Substitute mixture No. 4	275	701	0.199	0.169
5	Substitute mixture No. 5	306	843	0.236	0.203
6	Substitute mixture No. 6	318	829	0.236	0.204
7	Substitute mixture No. 7	290	791	0.203	0.180
8	Alfalfa leaf meal	324	810	0.231	0.210
9	Alfalfa leaf meal	301	799	0.209	0.190
10	Cow manure (summer) dried at 47°C.	479	1089	0.274	0.232
11	Cow manure (winter) dried at 21°C.	481	1122	0.298	0.255
12	Cow manure (winter) dried at 47°C.	419	948	0.245	0.201
13	Cow manure (winter) dried at 80°C.	428	991	0.259	0.221
14	Cow manure (winter) dried at 120°C.	439	1003	0.282	0.236
15	Cow manure (winter) dried at 160°C.	414	1033	0.237	0.216
16	Rumen contents dried at 47°C.	480	1078	0.287	0.242

* Gain in live weight per unit weight of feed consumed

Chicks fed 8 per cent dried cow manure and dried rumen contents in place of alfalfa meal made greater gain than those fed alfalfa leaf meal and the substituted mixtures. Efficiency of feed utilization tended to be higher in the pen of chicks fed dried cow manure and dried rumen contents than those fed substitute mixtures or alfalfa leaf meal. Evidently, some nutrient common to dried cow manure and dried rumen contents was not supplied in adequate quantity by the basal diet. The comb and wattles of the chicks fed cow manure dried at 47°C., showed

an androgenic effect indicating the presence of a hormone present in cow manure. Cow manure dried at higher temperatures and dried rumen contents did not show this effect.

Ferrin (1946) fed 8 per cent dried rumen contents from cattle to growing pigs as a supplement to tankage and soybean oil meal. Dried whey, alfalfa meal, irradiated yeast, niacin, riboflavin, and iodized salt were included in all rations. Dicalcium phosphate and calcium carbonate were added to the soybean oil meal to equalize the mineral intake. Pigs averaging 49 pounds in initial weight were fed in groups of 10 head on concrete floors.

During the first 49 days of the feeding period, the average daily gain per pig was 1.47 pounds in the lot receiving tankage and 1.46 pounds in the lot receiving tankage and dried rumen contents. The feed consumed per 100 pounds of gain were 370 and 352 pounds, respectively. In two similar rations where soybean oil meal replaced tankage the average daily gain per pig was 1.04 pounds and with rumen contents added, 1.18 pounds. Feed consumed per 100 pounds of gain was 433 pounds on the ration containing soybean oil meal and 397 pounds when the rumen contents were added.

Rumen contents from cobalt deficient sheep and from cobalt supplemented sheep were assayed for vitamin B_{12} activity by Hale, Pope, Phillips, and Bohstedt (1949). Chickens were used as the assay animals. Five separate trials have shown that some growth factor(s) is missing from the rumen contents of the cobalt deficient sheep. The rumen contents from the cobalt supplemented sheep consistently gave 30 to 40 grams more chick growth during the assay period of four weeks than did the rumen contents from the cobalt deficient sheep. In some instances the cobalt deficient rumen contents gave less growth than the basal ration. This slower growth rate could be completely overcome by adding vitamin B_{12} to the ration of rumen contents from the cobalt deficient sheep.

EXPERIMENT I

Introduction

Very few studies have been reported concerning the proximate chemical analysis of rumen contents. The purpose of this experiment was to determine the chemical content of rumen contents collected under varied conditions and subjected to various methods of processing. All samples were collected at the time of slaughter. Samples were collected from grass-fed and grain-fed cattle and sheep. Collections were made at the local meat laboratory and at commercial packing plants in Oklahoma City.

Experimental

All samples were analyzed by the Agriculture Chemistry Research Department using the official A. O. A. C. methods. These analysis are shown in the following tables.

TABLE 6

Chemical analyses of rumen contents and fraction thereof collected from one grass-fed cow slaughtered at the meat laboratory (Dry-matter basis)

	Sample	Ash	Protein	Fat	Fiber	N.F.E.	Ca.
1.	Rumen Contents Unfermented*	9.79	8.48	1.30	46.12	34.31	.57
2.	Rumen Contents Fermented-2 days**	11.34	8.84	1.50	42.35	35.97	.60
3.	Rumen Residue Unfermented***	5.25	8.84	1.60	46.34	37.97	.61
4.	Rumen Residue Fermented-2 days	6.93	9.12	1.74	48.94	33.27	.61

		Per cent Water	Per cent total solids	Per cent Ash	Per cent Protein
5.	Rumen Liquor Unfermented	98.29	1.71	.86	.22
6.	Rumen Liquor Fermented-2 days	97.12	2.88	1.37	.44

* This sample was dried in large drying pans at 40-50°C. in an electric oven.

** A one-gallon sample was placed in a two-gallon crock and fermented for 2 days in an electric oven. This material was stirred at frequent intervals. After the fermentation process was completed, a portion of this sample was taken for analyses. The remaining portion was separated into two fractions, rumen residue and rumen liquor. The analysis of these two fractions are shown as sample 4 and 6.

*** This fraction was prepared by expressing the juice from an unfermented sample. The analysis of the liquor is shown as sample 5.

TABLE 7

Chemical analyses of a composite sample of rumen contents and fraction thereof collected from four grain-fed* steers slaughtered at the meat laboratory (Dry-matter basis)

	Sample**	Ash	Protein	Fat	Fiber	N.F.E.	Ca.
1.	Rumen Contents Unfermented	8.76	15.50	4.30	32.31	39.13	.37
2.	Rumen Residue Unfermented	6.70	15.00	4.60	33.46	40.24	.37
3.	Rumen Contents Fermented-2 days	8.77	15.47	3.71	31.78	40.27	.38
4.	Rumen Residue Fermented-2 days	6.74	13.48	4.06	34.32	41.40	.29
5.	Rumen Contents Fermented-3 days	8.82	14.08	4.18	29.71	43.21	.36
6.	Rumen Residue Fermented-3 days	7.38	14.53	4.34	32.29	41.46	.36

		Per cent Water	Per cent total solids	Per cent Ash	Per cent Protein
7.	Rumen Liquor Unfermented	96.81	3.19	1.06	.81
8.	Rumen Liquor Fermented-2 days	95.62	4.38	1.34	1.66
9.	Rumen Liquor Fermented-3 days	95.30	4.70	1.33	1.88

* The steers had been full-fed a ration consisting of 5 parts rolled oats, 1½ parts rolled barley, 1 part ground corn, 1½ parts wheat bran, 1 part silage, and a limited amount of alfalfa hay.

** All rumen samples and fractions thereof were handled in the same manner as those presented in Table 6.

TABLE 8

Chemical analyses of a composite sample of rumen contents collected from 30 grass-fed steers slaughtered at a commercial packing plant in Oklahoma City (Dry-matter basis)

Sample*	Ash	Protein	Fat	Fiber	N.F.E.	Ca	P
Rumen Contents Unfermented	14.76	11.73	3.17	37.84	32.50	.84	.84
Rumen Contents Fermented-1 day	13.35	11.83	2.78	35.45	36.59	.94	.85
Rumen Contents Frozen, fermented 1 day	13.47	10.31	2.51	34.89	38.82	.97	.84
Rumen Contents Fermented-3 days	16.64	11.20	3.87	34.18	34.11	.97	.64
Rumen Contents Fermented-5 days	16.35	10.03	2.50	35.63	35.49	.99	.55
Rumen Contents Frozen, fermented 5 days	15.69	9.73	2.45	35.13	36.05	.91	.84
Rumen Contents Fermented-7 days	17.14	11.06	2.53	37.53	31.74	.91	.87

* All rumen samples and fraction thereof were handled in the same manner as those presented in Table 6.

TABLE 9

Chemical analyses of a composite sample of rumen samples collected from 29 grass-fed cows slaughtered at a commercial packing plant in Oklahoma City (Dry-matter basis)

Sample	Ash	Protein	Fat	Fiber	N.F.E.	Ca	P
Rumen Contents Unfermented	15.36	10.47	2.21	33.34	38.57	.89	.82

TABLE 10

Chemical analyses of individual samples of rumen contents collected from 8 grass-fed steers slaughtered at a commercial packing plant in Oklahoma City (Dry-matter basis)

Steer Number	Ash	Protein	Fat	Fiber	N.F.E.	P
1	12.66	9.41	3.21	31.76	42.96	.38
2	12.06	9.53	2.63	31.09	44.69	.36
3	13.32	10.17	3.20	29.25	44.06	.39
4	11.12	9.28	2.52	31.91	45.17	.32
5	11.52	9.52	1.10	32.29	45.57	.36
6	11.41	8.98	1.37	32.49	45.75	.37
7	11.04	8.88	1.72	33.54	44.82	.29
8	13.90	9.45	3.09	29.37	44.19	.36

TABLE 11

Chemical Analyses of Two Composite Samples of Rumen Contents

Sample	Ash	Protein	Fat	Fiber	N.F.E.	Ca	P
Rumen Contents Unfermented (lambs)*	6.63	12.20	4.67	24.75	34.30	.40	.43
Rumen Contents Unfermented (steers)**	6.76	7.25	2.94	23.75	47.13	.24	.36

* A composite sample collected from 2 grain-fed lambs slaughtered at the meat laboratory. The lambs were slaughtered approximately 6 hours after the last feed.

** A composite sample collected from 40 full-fed steers slaughtered at a commercial packing plant in Oklahoma City. The steers were slaughtered approximately 40 hours after their last feed on their full-fed ration. The steers were allowed access to prairie hay at the stockyards.

TABLE 12

Chemical analyses of fermented samples of rumen contents. These samples were processed from one composite sample collected from 4 grain-fed* lambs slaughtered at the meat laboratory.

Sample	Ash	Protein	Fat	Fiber	N.F.E.	NH_3 & Urea Nitrogen
Rumen Contents Fermented**	8.7	13.8	3.9	27.3	46.3	.065
Rumen Contents Fermented with Urea***	9.1	14.8	3.5	26.8	45.8	.075
Rumen Contents Fermented with Cobalt****	8.7	13.3	3.2	26.9	47.0	.105
Rumen Contents Fermented with Urea and Cobalt*****	9.1	13.9	2.8	27.3	46.9	.100

* The lambs had been fed a ration consisting of oats, bran, and alfalfa hay.

** All samples were fermented for 48 hours in fermentation flasks in a water bath maintained at 40°C. One thousand-gram samples of rumen contents were used in these flasks.

*** 2.5 grams of urea were added.

**** 0.5 gram of cobalt sulfate was added.

***** 2.5 grams of urea and 0.5 gram of cobalt were added.

Results

The chemical contents of the rumen contents analyzed in this experiment were influenced by the ration fed the animals (sheep and cattle) and interval between the last feeding and time of slaughter. The protein content of the rumen material collected from grass-fed cattle varied from 8.5 to 12.0 per cent. The rumen contents collected from full-fed sheep and cattle varied in protein content from 7.25 to 15.50 per cent. The fiber content was high in most instances. The ash content of the rumen material was high. This is in agreement with the studies of Burroughs et al. (1946). Fermentation in various ways did not increase the value of rumen contents to any appreciable extent.

EXPERIMENT II

Introduction

This experiment was conducted with a threefold purpose in mind: The first objective was to assay rumen contents for vitamin B_{12} activity. The second objective was to determine if fermentation increased the "overall" nutritive value of the rumen contents. The third objective was to determine if freezing previous to fermentation had any adverse effects upon the fermentation process.

It has been demonstrated that the vitamin B_{12} requirement of an animal may be related to the amount of protein in the ration. The results obtained by Hartman and his associates (1949) in studies of the reproductive performance of rats fed increasingly high levels of protein indicated that as the level of protein is increased, the need for a factor, which was later identified as vitamin B_{12}, increased. The young rats fed the high levels of protein (65 per cent) showed much more severe symptoms of the deficiency than those rats fed lower levels of protein (19 and 25 per cent). Similar observations were made by Ruben and Bird (1947) with chicks fed rations composed primarily of corn and soybean meal. These workers observed that the vitamin B_{12} needs increased as the level of protein increased. Thus, in this experiment a 70 per cent soybean meal diet was used to more critically evaluate rumen contents for vitamin B_{12} activity.

Experimental

A. Assay Procedure:

Two hundred and forty New Hampshire cockerals purchased from a commercial hatchery were used in this experiment. Male-chicks were used

to minimize variability within groups. The day-old chicks were weighed, wing banded, and evenly distributed as to weight among 10 pens of two electrically heated battery brooders. The average initial weight of the 24 birds of each lot was between 41 and 42 grams. Feed and water was allowed ad libitum. The feed was mixed in an electric Hobart mixer in sufficient quantities to last approximately one week. All chicks were fed a 70 per cent soybean meal depletion diet during the first three weeks of the trial. This diet was similar to that used by Ruben and Bird (1947). The chicks were individually weighed at the end of the three-week depletion period. The average weight of each lot at this time was so uniform that it was not necessary to relot for the assay period. Rations were assigned to lots at random. A three-week assay period was used for lots 4, 6, 8, 9, and 10. Lots 1, 2, 3, 5, and 7 were carried for only a two-week assay period. The chicks were individually weighed during the assay period at seven-day intervals. Mortality was noted as it occurred.

The depletion ration, which was also used as the basal during the assay period, and the supplemented rations assayed are shown in Table 13. The positive control ration consisted of the basal supplemented with 2 per cent Wilson's 1:20 liver powder. The dried rumen contents were supplemented to the basal ration at the 3 per cent level. Supplements were added at the expense of the entire ration. The soybean meal (Staley's) used during this study was a high quality expeller product.

B. Collection and Processing of the Rumen Contents to be Assayed

The rumen material used in this study was collected from 30 grass-fed steers slaughtered at a commercial packing plant in Oklahoma City. The steers were handled in the routine manner by the stockyards and packing company. The entire contents of the rumen was thoroughly mixed before

sampling. A one-gallon sample was collected from each steer. The 30 individual samples were used to form one composite sample.

At the laboratory the composite sample was thoroughly stirred and 5 one-gallon samples were withdrawn. Sample 1 was spread thin in a large aluminum drying pan and dried in an electric oven at 101°F. for 48 hours. Samples 2, 3, 4, and 5 were placed in individual 2-gallon crocks and allowed to ferment in an electric oven at 101°F. for 1, 3, 5, and 7 days, respectively. The rumen material was stirred at frequent intervals during the fermentation process. The remainder of the rumen material was packaged in one-gallon ice cartons, sealed, and placed in a deep-freeze for future use. After a seven-day interval, three samples (6, 7, and 8) were removed from the freezer, thawed, and fermented for 1, 3, and 5 days, respectively. All fermented samples were dried in a manner similar to sample 1. The samples were individually ground in a Wiley mill to allow uniform mixing with the other ingredients of the ration.

Results

The growth results of the chick during both the depletion period and supplemented period are summarized in Table 14. It will be noted that the chicks of lots 6, 7, and 8 fed the basal ration supplemented with 3 per cent rumen contents fermented 1, 5, and 7 days, respectively, made greater gains during the three-week assay period than the chicks of lot 4 fed the basal ration. The chicks of lot 9 fed the basal supplemented with 2 per cent Wilson's 1:20 liver powder also made greater gains than the chicks of lot 4. These differences were not statistically significant when subjected to the analysis of variance test of Snedecor (1946). It should also be noted that the rumen contents

TABLE 13

Composition of Rations Used in Vitamin B_{12} Assay Studies with New Hampshire Chicks

Ration Component	Rations and Lot Numbers (in per cent except for vit. mix)									
	1	2	3	4	5	6	7	8	9	10
Yellow Corn (ground)	28	28	28	28	28	28	28	28	28	28
Soybean Meal	70	70	70	70	70	70	70	70	70	70
Mineral Mix*	2	2	2	2	2	2	2	2	2	2
Vitamin Mix** (ml./kg. of feed)	20	20	20	20	20	20	20	20	20	20
Liver Powder	—	—	—	—	—	—	—	—	2	—
Rumen Contents (unfermented)	—	—	3	—	—	—	—	—	—	—
Rumen Contents (fermented 1 day)	—	—	—	—	—	3	—	—	—	—
Rumen Contents (frozen, fermented 1 day)	—	3	—	—	—	—	—	—	—	—
Rumen Contents (fermented 3 days)	3	—	—	—	—	—	—	—	—	—
Rumen Contents (frozen, fermented 3 days)	—	—	—	—	3	—	—	—	—	—
Rumen Contents (fermented 5 days)	—	—	—	—	—	—	—	—	—	3
Rumen Contents (frozen, fermented 5 days)	—	—	—	—	—	—	3	—	—	—
Rumen Contents (fermented 7 days)	—	—	—	—	—	—	—	3	—	—

* Mineral mixture was that of Hegsted *et al.* (1941)

** The water soluble vitamin mixture supplied per kilogram of ration the following amounts of the various vitamins: Thiamin HCl 4 mg., riboflavin 6 mg., pyridoxine HCl 3 mg., calcium pantothenate 20 mg., niacin 20 mg., choline chloride 1 gm., folic acid 1 mg., inositol 20 mg., and p-aminobenzoic acid 20 mg.
A and D oil containing 3000 U. S. P. units of vitamin A and 400 A. O. A. C. chick units of vitamin D per gram was fed at the rate of 5 grams per kilogram of feed.

fermented before freezing for 1, 3, and 5 days gave slightly better results in each case during the 2-week assay period than the rumen contents frozen and then fermented for the same corresponding period of time. All rumen contents fermented fresh gave slightly better results than the rumen contents unfermented for the 2-week assay period, however, in two instances the rumen contents frozen and then fermented produced less gain than the rumen contents unfermented.

TABLE 14

The Value of Rumen Contents when Supplemented to a 70 Per Cent Corn-Soybean Meal Ration

Supplements to basal	Depletion Period		Test Period (supplements added)				
	Average initial weight	Average weight 3 weeks	Average gain first week	Average gain second week	Average total gain 2 weeks	Average gain third week	Average total gain 3 weeks
None (Lot 4)	41.58	210.92	101.66	110.96	212.62	112.96	325.58
3% Rumen Contents unfermented (Lot 3)	41.63	210.13	101.58	114.33	215.90	------	------
3% Rumen Contents fermented 1 day (Lot 6)	41.54	209.42	106.50	120.00	226.50	140.54	367.04
3% Rumen Contents frozen, fermented 1 day (Lot 2)	41.29	211.00	104.46	119.04	223.50	------	------
3% Rumen Contents fermented 3 days (Lot 1)	41.63	211.17	99.04	121.00	220.04	------	------
3% Rumen Contents frozen, fermented 3 days (Lot 5)	41.67	210.67	98.71	111.25	209.96	------	------
3% Rumen Contents fermented 5 days (Lot 10)	41.00	207.92	102.90	116.88	219.75	119.91	339.67
3% Rumen Contents frozen, fermented 5 days (Lot 7)	41.25	209.12	101.17	109.71	210.88	------	------
3% Rumen Contents fermented 7 days (Lot 8)	42.00	210.63	109.50	105.25	214.75	132.12	326.87
2% Liver Powder (Lot 9)	41.63	213.25	105.83	117.46	223.29	127.96	351.25

EXPERIMENT III

Introduction

The chicks fed rumen contents for 3 weeks in Experiment II demonstrated that some growth promoting factor(s) was present. Therefore, this experiment was designed to determine if rumen contents could replace an animal protein supplement (fish meal) to a corn-soybean meal ration adequate in minerals and all known vitamins except B_{12}.

It has been established by numerous investigators that rations composed primarily of corn and soybean meal supplemented with minerals and all known vitamins except vitamin B_{12} would not support maximum growth of chicks. When rations of this type were supplemented with materials of animal origin, considerably better growth could be obtained. Almquist (1943) indicated that protein from animal origin should constitute 5 to 10 per cent of the protein in all-mash starting rations for chicks in which soybean meal is the principal protein supplement. Most of the evidence cited was concerned with the use of proteins derived largely from fish and milk products. Heuser and Norris (1944) showed that to obtain optimum growth of chicks up to 8 weeks of age, rations containing large quantities of soybean meal should contain a minimum of 2 to 3 per cent of animal protein concentrates, such as fish meal, meat scraps, or dried skim milk. Wilgus and Zander (1945) reported that soybean meal was not satisfactory as a sole protein supplement for rapid growth and that as little as 1.25 per cent of meat and bone scraps sufficed to promote growth but that 2.5 per cent produced optimum results. Because of the variability in soybean meal and in other feed ingredients, Clark and Cunningham (1945) expressed the opinion that some animal protein is necessary in broiler rations, but for optimum results, the animal protein

should be supplied in part by fish meal. Studies by Berry et al. (1945a, 1945b, 1945c) indicated that soybean oil meal is adequate in protein quality, but deficient in some of the vitamins supplied by animal products.

Experimental

A. Assay Techniques:

One hundred and fifty New Hampshire cockerals obtained from a commercial hatchery were used in this experiment. Male chicks were used to minimize variability within groups. The same general procedures as to wing-banding, lotting, feeding, and housing were used as in Experiment II. The average initial weight of each of the 7 lots was approximately 41 grams. The chicks were individually weighed at seven-day intervals. A six-week growth trial was used for the chicks of lots 1, 2, 3, and 4. Lots 5, 6, and 7 were carried for only 4 weeks. The rations used in this study are shown in Table 15. All supplements were added at the 5 per cent level at the expense of corn.

B. Collection and Processing of Rumen Contents:

The rumen contents used in this study were collected from 4 lambs slaughtered at the Animal Husbandry Meat Laboratory. The lambs had been fed a ration consisting of oats, bran, and alfalfa hay. The lambs were slaughtered approximately 6 hours after the last feeding. The entire content of the rumen of each lamb was collected. The four individual samples were used to form one composite sample.

The rumen contents were processed as follows: unfermented, fermented, fermented with urea, fermented with cobalt, and fermented with urea plus cobalt. The unfermented rumen contents were processed in the same manner as that used in Experiment II. The fermented samples were prepared by

TABLE 15

Rations Used in Comparing Rumen Contents and Fish Meal Each Supplemented to a Corn-Soybean Meal Ration

Ration Component	Rations (in per cent except vit. mix, cod liver oil) 1	2	3	4	5	6	7
Ground yellow corn	58	63	58	58	58	58	58
Soybean meal	35	35	35	35	35	35	35
Fish meal	5	—	—	—	—	—	—
Rumen contents (unfermented)	—	—	5	—	—	—	—
Rumen contents (fermented with cobalt)	—	—	—	5	—	—	—
Rumen contents (fermented)	—	—	—	—	5	—	—
Rumen contents (fermented with urea)	—	—	—	—	—	5	—
Rumen contents (fermented with urea and cobalt)	—	—	—	—	—	—	5
Minerals*	2	2	2	2	2	2	2
Vitamin mix** (ml/kg of feed)	20	20	20	20	20	20	20
Cod liver oil*** (gms/kg of feed)	15	15	15	15	15	15	15

* Mineral mixture was that of Hegsted *et al.* (1941).

** The water soluble vitamin mixture supplied per kilogram of ration the following amounts of the various vitamins: Thiamin HCl 4 mg., riboflavin 6 mg., pyridoxine HCl 3 mg., calcium pantothenate 20 mg., niacin 20 mg., choline chloride 1 gm., folic acid 1 mg., inositol 20 mg., and p-aminobenzoic acid 20 mg.

*** The cod liver oil used contained 2000 units of vitamin A and 125 units of vitamin D per gram.

means of an artificial rumen. A series of four 2-liter glass fermentation flasks were placed in a water bath maintained at a constant temperature of 40°C. The four flasks were connected so that one source of carbon dioxide served all flasks to maintain anaerobic conditions. The procedure was essentially the same as Burroughs et al. (1946). To each of the flasks was added 1000 grams of rumen contents. In addition to the rumen contents, the following material was added to three flasks: flask 1, 2.5 grams of urea; flask 3, 0.5 gram of cobalt sulfate; and flask 4, 2.5 grams of urea and 0.5 gram of cobalt sulfate. The contents of all flasks were stirred simultaneously. A small electric motor provided power for the agitators which were operated for a 15 minute period at 6-hour intervals. A continuous fermentation period of 48 hours was used. At the end of the fermentation period, the contents of the fermentation flasks were individually dried in an electric oven at 40 to 50°C. All samples were ground in a Wiley mill. This process was repeated until sufficient amounts of the rumen contents were provided for the chick assay.

Results

The results of this study are summarized in Table 16. The chicks fed rations 1, 3, and 4 (basal ration plus 5 per cent fish meal, 5 per cent rumen contents unfermented, and 5 per cent rumen contents fermented with cobalt, respectively) made greater gains to 4 and 6 weeks than those fed ration 2 (basal ration). These differences were statistically significant at the 1 per cent level of probability. The chicks fed rations 5, 6, and 7 (basal plus 5 per cent rumen contents fermented, 5 per cent rumen contents fermented with urea and cobalt) also made significantly greater gains to 4 weeks than those fed the basal ration. Statistical analysis showed no significant differences between the 4-week gains of lots 1, 3, 4, and 6; and the 6-weeks gains of lots 1, 3, and 4.

TABLE 16

Summary of the Results Comparing Fish Meal and Rumen Contents Each Supplemented to a Corn-Soybean Meal Ration and Fed to Chicks

Supplements to Basal	Average Gain (weeks) 1	2	3	4	Average Total Gain 4 weeks	Average Gain (weeks) 5	6	Average Total Gain 6 weeks
None (Lot 2)	43.61	69.65	60.08	70.65	224.0	82.57	103.04	439.61
5% Fish Meal (Lot 1)	54.09	90.22	91.65	123.52	359.5**	138.17	165.91	663.56**
5% Rumen Contents fermented with cobalt (Lot 4)	46.09	92.83	94.39	114.09	347.8**	153.82	152.17	653.39**
5% Rumen Contents (Unfermented) Lot 3	49.91	85.87	88.87	123.26	349.9**	126.17	150.26	624.35**
5% Rumen Contents fermented (Lot 5)	46.95	77.95	80.45	94.68	300.0**	------	------	--------
5% Rumen Contents fermented with urea (Lot 6)	48.18	84.36	90.63	125.05	349.9**	------	------	--------
5% Rumen Contents fermented with Urea and Cobalt (Lot 7)	43.73	89.35	82.57	109.52	325.2**	------	------	--------

** Indicates that the gains were statistically highly significant when compared to those of the chicks fed the basal ration.

EXPERIMENT IV

Introduction

This study was a repetition and continuation of Experiment III. The unfermented rumen contents (sheep) used in the preceeding experiment produced almost as much increased gain over the corn-soybean meal basal ration as the supplements, rumen contents fermented with cobalt (sheep), and fish meal. Therefore, one purpose of this study was to determine if this increased growth over the basal ration by the addition of unfermented rumen contents (collected from lambs fed the same ration as those in Experiment III) could be repeated under similar experimental conditions. The second purpose was to compare the value of rumen contents from full-fed lambs and steers slaughtered at different periods after the last feeding.

Experimental

A. Assay Procedure:

One hundred and twenty New Hampshire cockerals obtained from a commercial hatchery were used in this experiment. The day-old chicks were weighed and wing-banded. Twelve chicks with an average initial weight of approximately 41 grams were placed in each of the five pens of two electrically heated battery brooders. Feed and water was allowed ad libitum. Duplicate lots were used for each ration fed. Rations were assigned to the 5 lots of each battery brooder at random. A six-weeks growth study was used for all lots.

The rations used in this study are shown in Table 17. Supplements were added at the expense of corn. The APF supplement 5 (Lederle) was the residue from the manufacture of aureomycin. The soybean meal was an expeller product manufactured by Staley and Company, Decatur, Illinois.

B. Collecting and Processing of Rumen Contents

Rumen Contents from Lambs

The rumen contents of 2 lambs slaughtered at the meat laboratory were collected. The lambs had been fed the same ration as those used in Experiment III. The lambs were slaughtered approximately 6 hours after the last feeding. The entire content of the rumen of each lamb was collected. The two samples were mixed thoroughly to form one composite sample. The composite sample was dried in an electric oven at 50°C. The rumen contents were ground through a Wiley mill. The proximate chemical analysis of this sample is shown in Table 11, Experiment I.

Rumen Contents Collected from Steers

The entire contents from 40 steers slaughtered at a commercial packing plant in Oklahoma City were collected. These were college-owned steers that had been full-fed a ration composed primarily of corn and cottonseed meal with a limited amount of alfalfa hay and silage. The steers received their last feed of this ration on a Sunday night and were slaughtered the following Tuesday morning. While in the stockyards the steers had access to prairie hay. The rumen contents were dried through a sweet potato dehydrator. The temperature of the dehydrator varied from 200 to 400°F. This operation was not too successful due to high moisture content of the rumen material. However, approximately 30 pounds of the dried rumen contents were collected. The rumen contents were ground in a hammer mill. The proximate chemical analysis of this sample is shown in Table 11, Experiment I.

Results

The results of this study are summarized in Table 18. All supplemented rations produced a greater gain to six weeks than the basal

TABLE 17

Rations Used in Comparing Rumen Contents, Fish Meal, and APF Each Supplemented to a Corn-Soybean Meal Ration

Ration Component	Ration Numbers				
	1	2	3	4	5
	per cent	per cent	per cent	per cent	per cent
Ground Yellow Corn	58	63	63	58	58
Soybean Meal	35	35	35	35	35
Fish Meal	—	—	—	—	5
Rumen Contents Unfermented--Sheep	—	—	—	5	—
Rumen Contents Unfermented--Steers	5	—	—	—	—
APF #5	—	—	.25	—	—
Minerals*	2	2	2	2	2
Vitamin Mix**	20 ml.	20 ml.	20 ml.	20 ml.	20 ml.
Cod Liver Oil***	15 gms.	15 gms.	15 gms.	15 gms.	15 gms.

* Mineral mixture was that of Hegsted et al. (1941).

** The water soluble vitamin mixture supplied per kilogram of ration the following amounts of the various vitamins: Thismin HCl 4 mg., choline chloride 1 gm., riboflavin 6 mg., pyridoxine HCl 3 mg., calcium pantothenate 20 mg., niacin 20 mg., folic acid 1 mg., inositol 20 mg., and p-aminobenzoic acid 20 mg.

*** The cod liver oil used contained 2000 units of vitamin A and 125 units of vitamin D per gram. (15 grams per kilogram of feed)

ration. This difference was not significant when subjected to the analysis of variance test described by Snedecor (1946). The average six-week gains of chicks in Lots 6, 7, 8, 9, and 10 (battery brooder 1) was less than the average gain of the chicks fed the same corresponding ration in Lots 1, 2, 3, 4, and 5 (battery brooder 2). This variation was especially great in chicks fed rations 3, 4, and 5 (basal plus .25 per cent APF, 5 per cent rumen contents unfermented-sheep, and 5 per cent fish meal, respectively). The average gain of chicks fed ration 4 (basal plus 5 per cent rumen contents unfermented-sheep) was slightly greater than the chicks fed ration 1 (rumen contents unfermented-steers). However, the average gain of chicks fed ration 4 was not as great as that produced in Experiment II. The ration supplemented with fish meal gave response very similar to that produced in the preceeding experiment.

TABLE 18

Summary of the Growth Results of Chicks Fed a Corn-Soybean Meal Ration

Supplements to Basal	Lots	Average Gain (weeks) 1	2	3	4	Average Total Gain 4 weeks	Average Gain (weeks) 5	6	Average Total Gain 6 weeks
5% Rumen Contents	1	39.58	68.67	85.92	110.50	298.67	98.50	155.42	548.59
Unfermented (Steers)	10	38.60	57.10	85.80	97.60	279.10	104.20	151.80	535.10
Ration 1	Aver.	39.09	62.89	85.86	99.05	288.86	101.35	153.61	541.85
	2	36.58	65.33	80.08	85.58	237.57	90.92	151.33	509.83
None	8	40.18	63.45	81.91	83.64	269.08	81.55	153.27	504.00
(Ration 2)	Aver.	38.38	64.39	81.00	84.61	268.33	86.24	152.30	506.92
	3	47.50	84.17	105.58	119.33	356.58	123.33	168.08	648.00
.25% APF	9	39.33	71.42	95.25	107.67	313.67	123.00	161.83	598.50
(Ration 3)	Aver.	43.42	77.80	100.42	113.50	335.13	123.17	164.96	623.25
5% Rumen Contents	4	40.82	75.64	99.36	108.55	324.37	120.55	158.45	603.36
Unfermented (Sheep)	6	40.75	68.08	88.75	98.50	296.08	83.92	152.50	532.50
(Ration 4)	Aver.	40.79	71.36	94.06	103.53	315.23	102.24	155.48	567.93
	5	46.50	90.83	117.00	119.00	373.33	133.83	175.83	683.00
5% Fish Meal	7	40.91	75.82	89.82	102.45	309.00	116.00	181.18	606.18
(Ration 5)	Aver.	43.71	83.33	103.41	110.73	341.17	124.92	178.51	644.59

DISCUSSION

The proximate analyses of rumen contents demonstrated that the nutrient value was influenced by the ration fed the animals (sheep and cattle) and the interval between the last feeding and the subsequent collection of rumen material. These results are in agreement with the studies of Burroughs et al. (1946). These workers reported that the nutrients of rumen ingesta varied with plane of nutrition and interval between the last feeding and collection of rumen material.

The average 3-week gains of the 3 lots of chicks in Experiment II fed the basal ration supplemented with 3 per cent fermented rumen contents were equal to the gains of the chicks fed liver powder. In this experiment all of the supplements produced greater gains than the basal ration. Thus it seems apparent that the growth factor(s) present in the fermented rumen contents used in this study (Experiment II) may be identical to the growth factor present in Wilson's liver concentrate. The results of the test to determine the value of fermentation and the effects of freezing previous to fermentation on the value of rumen contents were not too conclusive since a comparison could be made only for the two-week assay period.

In the 6-weeks growth trial of Experiment III rumen contents unfermented, rumen contents fermented with cobalt, and fish meal when supplemented at the 5 per cent level to a corn-soybean meal ration produced 40-50 per cent greater gains than the basal ration. The average total gains produced by all supplemented rations at both 4 and 6 weeks were highly significant over the gains produced on the basal ration. There were no significant differences among the 6-week gains of all supplemented

rations. Thus it is evident that some nutrient was present in rumen contents and fish meal that was not supplied by the basal ration. Studies by Berry et al. (1943) and Marvel et al. (1945a, 1945b, 1945c) indicated that soybean meal is adequate in protein quality for the chick. The basal ration used in the experiment was supplemented with all minerals and vitamins required by the chick except vitamin B_{12}. Thus it appears that at least one growth factor present in the rumen contents assayed in this experiment was vitamin B_{12}.

The growth response (Experiment IV) produced by the addition of 5 per cent unfermented rumen contents (sheep) and 5 per cent unfermented rumen contents (cattle) were not as marked as that reported for the unfermented rumen contents used in Experiment III. However, the average six-weeks gains of the chicks fed the rations supplemented with rumen contents were about 10 per cent greater than the gains of the chicks fed the basal ration. These gains were not as great as that produced by the addition of 0.25 per cent APF or 5 per cent fish meal to the basal ration. It should be noted that the average six-week gains of all lots of chicks housed in battery brooder 2 were less than the gain of their replica lots in battery brooder 1. The gains of the replica lots fed rumen contents unfermented (sheep), APF, and fish meal showed wide variation. Thus it seems evident that some environmental factor influenced the results of this trial.

SUMMARY

The nutritional value of rumen contents was studied in four separate experiments. Proximate analyses were used to determine the nutrient value of the rumen material. Growth assays with chicks were used to determine the value of rumen contents as a supplement to corn-soybean meal rations.

Proximate analyses of the rumen contents demonstrated that the nutrient value was influenced by the ration fed the animals (sheep and cattle) and the time between the last feeding and the subsequent collection of the rumen material.

Rumen contents, when added to a 70 per cent soybean meal ration, produced a growth response which was equal to that of Wilson's liver concentrate. The growth response was not significant when compared to the basal ration.

Fish meal, rumen contents fermented with cobalt, and rumen contents unfermented when supplemented at the 5 per cent level to a corn soybean meal ration produced a growth response which was highly significant over that produced by the basal ration. There were no significant differences found among the growth responses produced by the three supplemented rations.

Rumen contents unfermented (sheep) and rumen contents unfermented (cattle) assayed in Experiment IV, when supplemented at the 5 per cent level to the same basal ration as used in Experiment III, produced a growth response. However, this growth response was not as great as that produced by the addition of 5 per cent fish meal or 0.25 per cent APF to the basal ration.

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