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Purified Ration Studies with Lambs

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Determination of nutrient requirements for ruminants has been difficult due to their poly-stomached anatomy. After ingestion, feedstuffs are subjected to considerable alteration in the rumen by bacterial fermentation. Such processes by bacteria in the rumen as protein synthesis, vitamin synthesis, cellulose fermentation, fat alteration or synthesis make it difficult to assess the original ration fed in terms of nutrient requirement of the animal. Considering the complex activities of the microorganisms that inhabit the rumen it becomes apparent that the nutrient requirement of the ruminant involves the nutrient needs of the rumen microorganisms as well as those of the animal.

Madsen *et al.* (2) were the first group of workers to develop a purified ration for sheep that promoted near-normal growth. Recently purified rations have been used in studying the utilization of inorganic sulfur by sheep (7) (8) (9). Purified diets for mature ruminants present a special problem in that they normally consume rations high in cellulose. It has been demonstrated that rations low in fiber will cause digestive disturbances in ruminants (4). It is probable that some type of fiber is necessary in the ration of ruminants for normal rumen function. Ruminating lambs are able to make satisfactory growth on rations in which over 90% of the nitrogen of the ration is supplied by urea. This raises the question as to the type of dietary nitrogen to supply the ruminant animal.

The results reported in this paper are attempts to evaluate several dietary factors in the development of a purified ration for lambs that will give growth rates similar to those obtained on natural rations.

Experimental

Two experiments were conducted each consisting of 7 treatments with four ruminating lambs. In experiment I the lambs weighed approximately 57 pounds and in experiment II, 62 pounds. The formulation of the purified rations was similar to that used by Thomas *et al.* (9) and Starks *et al.* (7). The rations for the 7 treatments in experiment I are given in table 1. The overall purpose of experiment I was to determine the value of a natural roughage (wheat straw) in purified rations for lambs, the value of three different sources of nitrogen and the value of a yeast supplement.

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The rations fed in experiment II are given in table 2. The objectives of this trial were to further study the value of a natural roughage, the value of a ruptured yeast, water extracted straw and a low cobalt mineral mixture.

All lambs were maintained in individual pens throughout the duration of the experiments. Feed, water and salt were kept before the animals at all times. The lambs were bedded with shavings All rations were mixed by hand. The wheat straw was locally grown and ground in a hammer mill through a quarter inch screen. This size particle prevented the lambs from separating out the wheat straw from the remainder of the ration. For water extraction the ground straw was placed in a sack in a barrel and water continuously run through the barrel for 10 days. The straw was then dried and mixed with the ration in the usual method. Considerable color was leached from the straw during the extraction period. No analysis was made on the extracted straw. The wood cellulose used is known commercially as "Solka Floc BW 40".[1] The wood meal was prepared from soft wood shavings by grinding in a hammer mill through an eight inch screen. Commercial dry torula yeast was used. The special yeast was torula in which the cell wall had been ruptured before drying. Commercial crude casein was used. The drackett protein was a purified soybean protein. The mineral mixture used is the same as that reported by Ruf *et al.* (5). The special mineral mixture had the cobalt salts deleted from the formula. All rations were formulated to contain about 12% crude protein. The animals in experiment I were fed for 84 days and those in experiment II, 70 days.

Results and Discussions

The results of experiment I are presented in table 3. Approximately twenty-five percent of the lambs started on this experiment refused to eat the ration and were removed early in the experiment. Only data for the lambs finishing the experiment are included in table 1. The response of the lambs finishing the test in experiment I cannot be considered completely satisfactory however the consistancy of response between treatments suggest that the data is useful in planning future studies.

Addition of yeast to the straw ration increased total gain by 12 pounds. Feed consumption was increased by approximately fifty percent. This beneficial effect of yeast in purified rations has been reported previously (5). Replacement of the wheat straw by additional wod cellulose (treatment 3) failed to maintain the weight of the lambs. Addition of yeast to this ration (treatment 4) increased total gain by 10.5 pounds. The replacement of the urea of the ration by the preformed proteins, casein and drackett (treat-

[1]Brown Company, Berlin, New Hampshire.

Table 1

Purified Rations for Lambs. Experiment I.

	Treatment Number and Designation						
	1 Straw	2 Straw + Yeast	3 Wood cellulose	4 Wood celullose + Yeast	5 Casein	6 Casein + Yeast	7 Drackett Protein
Wheat straw[1]	10.0	10.0	—	—	—	—	—
Wood cellulose	20.0	20.0	30.0	30.0	30.0	30.0	30.0
Corn Starch	35.0	31.0	35.0	31.0	25.0	23.0	25.0
Cerelose	24.3	24.1	24.2	24.1	24.2	24.2	24.2
Lard	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Urea	3.9	3.1	4.0	3.1	—	—	—
Yeast	—	5.0	—	5.0	—	5.0	—
Casein	—	—	—	—	14.0	11.0	—
Drackett Protein	—	—	—	—	—	—	14.0
Minerals[2]	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Methionine	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Choline Chloride	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1]The following vitamins were added per pound of all rations in both experiment I and II; vitamin A, 1000 IU; alpha-tocopherol acetate, 6 mg; vitamin D, 200 IU.
[2]See Literature cited number 5.

Table 2

Purified Rations for Lambs. Experiment II.

	Treatment Number and Designation						
	1	2	3	4	5	6	7
	Straw	Straw + Wood meal	Wood meal + Yeast	Extracted straw	Wood cellulose + Yeast	Wood cellulose + Ruptured yeast	Straw + Special minerals
Wheat straw	10.0	10.0	10.0	10.0	—	—	20.0
Wood meal	—	15.0	15.0	—	—	—	—
Wood cellulose	20.0	20.0	20.0	20.0	30.0	30.0	20.0
Corn starch	35.0	25.0	20.8	35.0	31.0	31.0	35.0
Cerelose	24.0	19.0	19.0	24.0	23.8	23.8	24.0
Lard	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Urea	3.9	3.9	3.1	3.9	3.1	3.1	3.9
Yeast	—	—	5.0	—	5.0	—	—
Ruptured yeast	—	—	—	—	—	5.0	—
Minerals	3.5	3.5	3.5	3.5	3.5	3.5	—
Special minerals[1]	—	—	—	—	—	—	3.5
Methionine	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Choline Chloride	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1]Cobalt deleted from mineral mixture.

ments 5 & 7) failed to produce growth greater than the urea alone. This would suggest that the type of nitrogren ingested in the ruminants does not have the importance it does in the monogastric animal. In fact, under the conditions of this experiment it appeared to have little significance. Addition of yeast to the casein ration (treatment 6) resulted in an 11 pound increase in gain. It is interesting to note that in every instance the yeast addition resulted in an increased gain of 10.5 to 12 pounds. This test suggests yeast fed in connection with a purified ration contains some factor in addition to its total nitrogen content which is essential for the

Table 3

Weight Gains and Feed Consumption of Lambs Fed Purifed Rations. Experiment I. 84 days.

Treatment	No. Lambs	Total Grain, lbs	Daily Feed Intake, lbs.
1. Straw	3	5.7	1.47
2. Straw + Yeast	3	17.7	2.18
3. Wood cellulose	2	–4.5	1.10
4. Wood cellulose + Yeast	3	6.0	1.63
5. Casein	3	–5.0	1.03
6. Casein + Yeast	3	6.0	1.44
7. Drackett protein	3	–5.0	1.05

Table 4

Weight Gains and Feed Consumption of Lambs Fed Purified Rations. Experiment II. 70 days.

Treatment	No. Lambs	Total Grain, lbs	Daily Feed Intake, lbs.
1. Straw	3	12.3	2.22
2. Straw + Wood meal	4	14.8	2.63
3. Straw + Wood meal + Yeast	4	11.2	2.62
4. Extracted straw	4	13.2	2.20
5. Wood cellulose + Yeast	4	2.2	1.62
6. Wood cellulose + Ruptured yeast	4	6.5	2.04
7. Straw + Special minerals	4	3.8	1.55

rumen microorganisms or the animal. This test further indicates that some fibrous material such as wheat straw is necessary in a purified ration for lambs in order to obtain satisfactory gain. The failure of a preformed protein such as casein or soybean protein to promote greater growth than urea further supports the contention that one of the major roles of dietary nitrogen in the ruminant is to supply the nitrogen requirements of the rumen bacteria.

The results of the second experiment are presented in table 4. The growth of these lambs was considered satisfactory and only one animal was removed from the experiment. Weight gains for

the better gaining groups approach normal but are not as good as reported for some purified ration studies (8).

Addition of 15% wood meal (treatment 2) apeared not to increase weight gains over the straw only. However feed intake was increased by 18%. This increased feed intake accounts for the wood meal added to the ration. Schneider (6) reports a negligible energy value of wood meal with sheep. Feed intake with the wood-meal rations was considered good. Addition of yeast in connection with the wood meal had no effect upon weight gains or feed consumption (treatment 3). This is in contrast with the results in experiment I. However in experiment I no treatment without yeast made gains as large as corresponding treatments in experiment II.

The water extraction of the straw appeared to have no effect upon gain or feed consumption. This would suggest that the beneficial effect of straw in a purified ration is its fibrous character rather than some specific water soluble nutrient. The two wood cellulose rations with the added yeast (treatments 5 & 6) gave weight gains similar to the corresponding treatments in experiment I. There was some suggestion that the ruptured yeast produced slightly higher gains than did the regular yeast. Feed consumption was 25% higher with the ruptured yeast group as compared with the regular yeast.

Of special interest in experiment II is treatment 7 which received a mineral mixture containing no added cobalt. Weight gains and feed consumption were poor with this group. The effect of a cobalt deficient ration on the ruminant is well known (1) (3). This low cobalt treatment and treatment 1 were formulated the same except for the cobalt in the mineral mixture. This would indicate that the poor results on treatment 7 was due to the deletion of the cobalt from the mineral mixture. If these results can be verified then this type of ration would lend itself very well in studying the nutrition and metabolism of trace minerals in ruminants. To date trace mineral deficiencies in ruminants have been shown only with natural rations in which the mineral in question is extremely low.

The purified ration offers an excellent opportunity to study the nutrient requirements of ruminants. However, from the above it is apparent that many factors are involved in the development of a purified ration that will give growth similar to that expected on a natural ration.

Summary

A purified ration was fed ruminating lambs in order to evaluate several dietary factors in an attempt to develop a suitable purified ration for lambs that will give growth rates similar to those obtained with natural rations. The basal ration was formulated as follows:

ground wheat straw 10.0, purified wood cellulose 20.0, corn starch 35.0, corn sugar 24.3, lard 3.0, urea 3.9, minerals 3.5, methionine 0.2, choline chloride 0.1, plus vitamins A, D and E. Factors studied were deletion of the wheat straw, addition of wood meal, water extraction of the straw, addition of yeast, substitution of the urea with two proteins and deletion of cobalt from the mineral mixture. The results in terms of rate of gain and feed consumption indicate that some fibrous material is needed in the ration of ruminants. Yeast apparently contains nutrients required by lambs consuming purified rations. In these experiments urea was as satisfactory as the proteins tested in supplying the nitrogen requirements of the animals.

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