The Use of Low Quality Roughage for Ruminants

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SUMMARY

IT is suggested that, in view of more up-to-date knowledge of ruminant nutrition, a new approach to the use of low quality roughage is indicated.

Overall, results both in U.S.A. and Australia show that large quantities of low grade fodders, if properly supplemented, could be used economically.

From time to time more or less authoritative estimates are made which show that the daily increase in the world's population requires ever increasing quantities of foodstuffs - particularly the protective foods, such as meat, milk and eggs - and of wool.

The Malthusian doctrine put forward in the middle of the 18th century, forecast that the population of the world would, in a relatively short period of time, find it increasingly difficult to feed itself. I think it is obvious that, sooner or later, the world's population must reach saturation point when the tragedy envisaged by Malthus will be with us. However, there are many ways of deferring the evil day, and one of these is to make better use of the low quality roughages which abound in such countries as the Americas, and Australia.

Low-quality roughages are varied in type but all are characterised by a low-protein, high-fibre content. These roughages may be conveniently grouped as under:-

(1) Farm-conserved fodders of low protein content such as cereal straw, poor meadow hay, and poor lucerne hay. First-cut lucerne hay with a large weed content, or lucerne that is overgrown before cutting, at its best, can only be considered to be of poor quality.

(2) Native grasses, conserved as hay, and edible shrubs.

(3) Stemmy, mature natural herbage.

(4) Farm and factory by-products such as corn-cobs, corn stalks, cotton-seed hulls, etc., and perhaps strangest of all, old newspapers and sawdust. (A patent has been recently taken out in U.S.A. for the processing of waste paper for animal feed. Waste paper is, of course, practically pure cellulose and, therefore, largely digestible in the rumen.) The huge piles of sawdust at the West Coast lumber mill sites are also being investigated as to their suitability for cattle feed. It is claimed that, by irradiating the sawdust, up to two-thirds of the carbohydrates present can be changed to a form utilisable by cattle. So far these claims seem to be based on the use of the artificial rumen technique.

Cereal hays are produced in fairly large volume in the farming areas and McClymont, in a recent publication of the N.S.W. Department of Agriculture, makes this comment:

"Cereal hay, or chaff, with about 5 per cent. protein is often fed to growing stock or milking ewes on poor pasture. It will hold them against slipping badly in condition, but will not help them to grow or to produce much wool or milk".

Meadow hay can vary widely in chemical composition. If it has a good legume content and is made at just the right stage it will have a good protein content and will provide for growth and production without supplementation. Much meadow hay, however, is made too late, has a low legume content, contains unpalatable weed growth, or for other reasons is low in protein and unpalatable to the stock.

Lucerne hay cut at the right stage and properly cured is the finest of all hays but, unfortunately, weather conditions at harvest time, and poor techniques result in a great quantity of poor hay being produced. Very often, particularly on river flats, the first cut is so weedy that it often has to be burnt.

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There is no market for poor quality hays and they represent a serious loss unless they are profitably utilised through the animal. Native grass, hay and edible shrubs provide a very large volume of low-grade roughage and suitable supplementation is necessary to get the best results. If the native grasses and herbage are sufficiently dense, ensiling is the best method of conserving. the nutrients, because when good quality silage is made there should be no necessity for supplementation.

The third group consists of standing natural herbage that had matured and lost much of its nutrients. This herbage, especially in a year like 1955, represents the greatest volume of low-quality roughage available to graziers.

The fourth group, which includes farm and factory by-products, all have good feeding value if properly treated. To use these by-products effectively, they must be put through a hammer mill and a supplement mixed with the ground material. While these particular roughages are not widely available in Australia, there are areas where considerable quantities at present go to waste.

From this brief description it will be seen that, although they vary one to another in physical make-up and appearance, they are all good sources of energy but are generally unpalatable to stock. Stock will eat them when forced to but their thrift suffers. Even mature stock have difficulty in maintaining condition on such fare and it is totally unsuitable for young growing stock and for females late in pregnancy or lactating.

Fortunately, scientific investigation, coupled with practical feeding trials, mostly in U.S.A., have shown that not only can these low-grade fodders be so supplemented that sheep and cattle will eat them readily, but they can also supply the bulk of the ration.

From the earliest published works on animal nutrition, it has been recognised that the microbial population of the rumen enables the ruminant to digest large quantities of roughage. For example, if the description of the place of bacteria in animal physiology given by Kellner in 1908, is compared with that given by Morrison in "Feeds and Feeding", published in 1948, very little difference will be found. Both these authorities state that the bacteria are essential to the digestion of roughages and leave it at that.

It is true that many investigators, from Kellner's to Morrison's time, have prepared tables of digestibility for many of these low-grade roughages, but in the light of more recent investigations, the tables are unreliable, one worker claiming a variation in digestibility of up to 20 per cent. It is apparent that the earlier investigators did not give sufficient credit to the role of rumen microflora in what takes place while the ingesta is in the rumen.

In more recent times considerable attention has been given to the physiology or ruminant digestion, and Blaxter, of the Hannah Dairy Research Institute, has reviewed the subject in "Advance in the Physiology of Domestic Animals" (Vol. I, 1955). He states:

"The study of ruminant nutrition in many respects is the study of a remarkable symbiosis between the animal and the vast population of bacteria and infusoria which inhabit its digestive tract . . .

"With ruminants, dietary carbohydrates and proteins are subject to much bacterial action in the rumen, and to a lesser extent in the caecum before assimilation in the body and subsequent dissimilation in the tissues."

After listing various factors operating in and through the rumen, Blaxter comments: "All are contingent upon the fact that the microbiological population of the rumen occupy such an important role in the animal's economy".

It is indicated that a new approach to the feeding of cattle and sheep is necessary if advantage is to be taken of their facility economically to convert into meat, milk and wool poor quality feed that is now largely wasted. While it is common knowledge (and knowledge that has been capitalised on in U.S.A., U.K. and Europe), that high-protein vegetable meals such as linseed, cotton seed, soybean, etc., give improved production from livestock, particularly dairy cattle, it must be realised that the ruminant digestion story is not a simple one. The factors at work are numerous and apparently complex.

In an address given in 1953 at the Washington State College, Beeson made the following comments:—

"Cattle (and sheep) were designed to convert large amounts of roughages (high cellulose feeds) into edible beef (and wool and milk).

"Approximately 85 per cent. of all the feed nutrients consumed by ruminants are derived from roughage feeds in the form of pasture, hay, silage or stalk by-products. Therefore, the improvement in the efficiency of production of beef (or wool) must come primarily through learning how to convert high-cellulose feeds such as corn cobs, straw, corn stalks, cotton-seed hulls, corn and sorghum silage, dry range forage and pasture into highly efficient growing and fattening rations.

"Research findings show that the growth response of cattle is affected greatly by the balance of energy, proteins, vitamins and minerals and other factors available to the animal in its daily feed.

"The billions of bacteria which inhabit the rumen, IF PROPERLY NOURISHED, are capable of breaking down and converting indigestible roughages into usable form.

"Therefore, in order to properly feed ruminants on high roughage diets, a supplement must be fed which contains adequate nutrients to NOURISH THE MICRO-ORGANISMS IN THE RUMEN and also to meet the daily nutritional requirements of the animal".

A good deal of practical work in this field has been done in U.S.A., one of the first reports coming from Purdue University. Here Beeson and Perry developed a supplement for use with poor quality roughage, widely known and used by cattle feeders as PURDUE SUPPLEMENT A. This supplement, which. has a crude protein content of 32 per cent., was made up as follows:

In 1,000 lb., 650.5 lb. Soybean Meal.
140 lb. Molasses.
140 lb. Lucerne Meal.
52 lb. Bone Meal.
17 lb. Salt, with 1 oz. Cobalt Sulphate to 100 lb. sa.t
5 lb. Vitamin A & D Concentrate.

After many feeding trials, Beeson and Perry came to the conclusion that urea could be used to replace some of the soybean meal. They recommended that 250 lb. of Soybean meal be replaced with 210 lb. corn meal (or its equivalent), and 40 lb. urea. This modified supplement also contains crude protein at the 32 per cent. level.

The supplement was fed at the rate of 3.5 lb. per day to steers weighing from 400 lb. to 750 lb. at start of the test and the following table summarizes their results:—

RESULTS OF FEEDING "SUPPLEMENT A" WITH VARIOUS ROUGHAGES.

	Initial Weight lb.	Daily Gain lb.	Feed per Steer Daily	
			Roughage lb.	Supplement A lb.
Clover-Timothy Hay| Meadow Hay/	595	0.88	20.0	—
Corn Cobs	478	1.50	13.4	3.5
Cottonseed Hulls	732	1.19	23.1	3.5
Oat Straw	485	0.78	12.4	3.5
Soybean Straw	480	0.78	13.3	3.5
Corn Silage	481	2.21	37.0	3.5
Corn Stover Silage	475	1.04	31.3	3.5
Grass Silage (Preservative)	475	1.97	36.0	3.5
„ „ „	735	2.01	54.4	3.5

Many variations of the supplement have been tested, both with the animal and with the artificial rumen. The general conclusions reached were that the supplement needed to supply readily-digested carbohydrate and nitrogen. The nitrogen could be either in the form of protein or as a combination of protein and urea. Such supplements favour the development and activity of beneficial types of micro-organisms to the ultimate nutritional benefit to the host.

The use of urea as a source of non-protein nitrogen, in sparing the use of nitrogen from expensive protein sources, considerably reduces the cost of supplementation. Urea is now being widely used in the U.S.A. for stock feeding purposes. It has been estimated that the consumption of urea by livestock in 1954 was over 50,000 tons, and in a Feed Trade Journal (12th November, 1955), it was estimated that the consumption for 1955 would be double that figure.

In most of the U.S.A. feeding trials on the utilisation of low quality roughage, the supplemental protein has been of vegetable origin. However. a German report claims a threefold increase in the bacterial population when fish meal was used in the ration, and work at Aberdeen, Scotland (J. Agric. Sci. 44 (3)) tends to confirm this.

Apart from some experimental work at Glenfield Research Station and some practical feeding trials at Belabula Farms, very- few feeding trials with urea have been conducted in Australia.

At Belabula, the principal source of the protein has been animal protein meals, which are rich sources of complete proteins as well as certain vitamins and trace minerals.

Our most eminent animal physiologists and animal nutritionists are the first to acknowledge what little is known of protein make-up, and what happens in the rumen where the activities of the micro-organisms appear to be able to synthesize amino acids and vitamins, different in nature or in greater quantities than were supplied in the feed.

William Albrecht, of the University of Missouri, one of the most brilliant research scientists in animal nutrition, has this to say in one of his many papers:—

"Only plants and bacteria can synthesize simple ingredients to create proteins; animals and men must assemble theirs from plants, other animals or bacteria (some of them within the digestive tract)".

Beeson and Perry found that the protein of soybean meal, cotton-seed meal or linseed meal gave equally satisfactory results in their feeding trials, so that it would seem that the micro-organisms can use them, together with non-protein nitrogen, for their own purposes.

The other portions of the Purdue supplement are:—

(1) Carbohydrates.

Energy feed, in readily available form, is contributed by the oil and starch of the soybean meal and the sugar of molasses, while, of course, lucerne meal also has some energy value. Where urea and corn meal is used to supplant portion of the soybean meal, the corn meal is a rich source of energy.

While some readily available carbohydrate in the feed is necessary, investigators agree that an excess depresses the digestibility of the coarse material used, through the microflora working on it to the neglect of cellulose digestion.

(2) Minerals.

The mineral content is supplied by bone meal, salt, and cobalt sulphate. Where meat meal is used to supply portion of the protein supplement, it will usually supply sufficient calcium and phosphorus.

The use of cobalt in animal feeding is a comparatively recent innovation, but results following its use have been impressive because of its role in the synthesis of Vitamin B12.

Lucerne meal and molasses are both rich in minerals and, experimenters in this field of ruminant supplementation have found that the ash of these materials have given results as satisfactory as the normal feed material. This would indicate, apparently, that the minerals contained in lucerne and molasses are among the essentials for developing a population of healthy rumen micro-organisms. Furthermore, both lucerne meal and molasses have been shown to supply other factors which contribute to rumen bacteria requirements. Although these factors have not been identified, the techniques employed have shown that after all the other factors are accounted for, there is still some additional benefit when these materials are present in the supplement which is absent when they are left out.

(3) Vitamins.

The Purdue supplement contains a proportion of Vitamins A and D. Low grade roughages are apt to be low in carotene. Experimental work, both in the U.S.A. and in Australia, has shown that the supply of Vitamin A is an essential to the well-being of stock and that liver reserves of this vitamin can be depleted if the animal is kept on a prolonged diet of low grade roughage. Vitamin D is used in U.S.A., but although Franklin has obtained a good response from the use of this vitamin with sheep in Tasmania, its general use has not been proved to be essential in Australia.

The results from supplementation with "Purdue A" given above are not the results of single feeding trials, but are compounded from a large number of trials. Similar results have also been obtained from carefully executed trials at a number of other centres in the U.S.A.

In addition to various feeding trials, a great deal of work in this field has been done by examining ingesta obtained from the rumen of a live animal by the rumen fistula technique. Furthermore, the artificial rumen technique has also contributed much to our understanding of ruminant digestion.

In Southern Australia, as we all know, there are usually two periods of the year, one in the winter months of June, July, August, and the other January to the autumn break in the weather (which means a longer or shorter period, depending on when the weather "breaks"), when our livestock are forced to eat roughage of various kinds and qualities. This situation prevails at Belabula Farms, so that in 1953 it was decided that we should institute feeding trials based on the U.S.A. work as reported up to that time.

In developing a concentrate supplement, we had in mind the experience gained over 30 years, when a supplement very similar in make-up to the Purdue A supplement, but with a protein content of 18 to 20 per cent., had given very satisfactory results to large numbers of graziers.

This knowledge, together with the acute shortage of protein meals, led to the decision to first try out the concentrate with the lesser protein content.

The make-up of this supplement was as follows: Grain meals as the principal source of energy, a small percentage of coconut oil meal, whale meat meal and dried whale solubles, as the principal source of protein and calcium and phosphorus, lucerne meal and molasses. The lucerne meal supplied Vitamin A, as well as other essential factors. Added salt, with cobalt and magnesium sulphate, supplied other essential minerals. In 1954-55 urea was included to supply 25 per cent. of the protein equivalent.

In July, 1953, 30 Aberdeen-Angus steers, bred on the property, from the 1952 calf drop, were set aside for the trial.

Average weight of all steers, 1.7.53	658 lb.
Average total live weight gain per animal for 108 days	243.7 lb.
Average daily gain per head	2.26 lb.
Average live weight gain of 7 marked steers for 108 days	288 lb.
Average daily gain per head of marked steers	2.69 lb.

The feed, for the first half of the period, was of poor quality, overgrown, rain-bleached lucerne hay, and for the second half, meadow hay of apparently poor quality. Both lots of hay had no saleable value, but on analysis the meadow hay proved to have a protein content of 13.1 per cent. The concentrate, in cube form, was a proprietary line based on supplements that have proved successful in U.S.A. trials, utilising whale meat meal as the principal source of protein.

In 1954, a second trial with a group of 28 steers (mostly Aberdeen-Angus) was made to check the growth rate. The roughage used was oaten hay with a protein content of 5.2 per cent., supplemented by 3 lb. concentrate per head per day. The concentrate was again a proprietary cubed feed, in which 25 per cent. of the nitrogen content was supplied by urea.

At 19 to 20 months the group had reached an average live weight of 935 lb., with an average daily gain of 1.64 lb., and were sold in February, 1955. A careful check of meat quality (with wholesale and retail butchers) was made, while a few private people also made "taste tests", and all pronounced the beef first class in every respect and quite equal to that from the group raised on choice pasture.

In 1953 a trial was made using sheep. Four hundred and twenty-five weak, but otherwise healthy, Merino wethers were bought in July and were confined to an area of 2 acres. They were fed 2 lb. of poor-quality meadow hay and 4 ozs. cubed concentrate. There were no losses and, after 3 months, 325 were sold at a price which, after allowing for cost of concentrate, showed a good profit.

Of the remainder 3 lots, each of 25, were penned in small yards for special feeding tests in which they received 18-20 per cent. protein concentrate. All lots throve well, wool growth was normal, the fleece being 10 to 11 lb. Subsequently the lots were sold out of the wool at a substantially higher price than the original purchase price.

It is interesting to note that in the two groups fed a concentrate (in the one case supplying the equivalent of 25 per cent. and, in the other 33.3 per cent. of the protein in the form of urea), the live weight increase, wool growth and general health were equally as good as the group receiving concentrate containing no urea. A change to oaten hay as roughage made no difference.

In 1955, several groups of cattle were on feeding trials under the supervision of the Department of Agriculture, but time does not permit detailed results to be given. In due course, the daily gains of the groups will be co-ordinated with results from other weighing centres.

High-roughage, low-protein tests were made with 3 groups of Hereford steers maintained in small yards on supplied roughages (mostly poor-quality, weedy lucerne hay), supplemented by 3 lb. concentrate daily.

Results of these three groups are shown in the table overleaf.

It will be noted that no marked advantage followed the use of 10 mg. stilbesterol in the third group. However, further trials are to be made to ascertain whether the use of stilbesterol is justified under our conditions.

From these trials there emerge two main points of particular interest to graziers:

(1) With suitable supplementation, enormous quantities of low-quality roughage can be converted economically to meat and/or wool.

(2) As the trials recorded were mostly carried out during winter, they show that stock can be kept gaining in condition irrespective of the weather.

It is to be emphasized that at 4d. per pound for concentrate, the cost of supplementing a cattle beast for 90 days is £4/10/-. For sheep at 4 ozs. per day, the cost would be 7/6 per head. In practice, a lesser amount of concentrate would prevent a loss in live weight and would keep the stock in good fettle, which would enable them to make better gains in the following good grazing period.

It is for the grazier to determine whether this expenditure is warranted.

BELABULA CATTLE FEEDING TRIALS, 1955

1955	Roughage Used	Protein Content	Initial Weight	Daily Gain	FEED PER STEER DAILY		Weight at end of trial	Period of feeding
					Roughage (including waste)	Supplement		
0 Hereford Steers	Weedy 1st cut Lucerne Hay Long	(%) 13	(lb.) 607	(lb.) 1.2	(lb.) 25	3	(lb.) 721	(Days) 91
0 Hereford Steers	Weedy 1st cut Lucerne Hay in meal form	13	604	2.1	23	3	802	91
10 Hereford Steers	Weedy 1st cut Lucerne Hay in meal form	13	602	2.0	23	3 + 10 meg. Stilbestrol	787	91