The 3rd ISTAP, Faculty of Animal Science, Gadjah Mada University, 2002 ISBN: 979 – 97243 – 1 - 7

UTILISATION OF LOW QUALITY ROUGHAGES FOR RUMINANT FEEDING

Jenny Davis[1]

Introduction

Demand for meat and milk supplies has been predicted to increase dramatically in the next 20 to 50 years (Delgado *et al* 1999). Ruminants in the tropics are in a unique position to help satisfy this demand because of the sheer abundance of low quality roughages and their potential to support ruminant production if specific nutritional strategies are employed. However, these roughages are deficient in critical nutrients that are required to support and maintain the rumen microorganisms. These microbes are essential to convert the feed into organic acids that provide the animal with energy, and in turn, the organisms themselves are the main supply of protein to the animal.

Without a supply of nutrients for the rumen micro-organisms they are not able to reproduce and function sufficiently to digest the feed for the animal. When the rumen nutrients are supplied the efficiency of utilisation of low quality roughages is high. However, when the animal is an early growth phase, late pregnancy or early lactation it requires some additional protein above what can be obtained from microbial protein. This can be supplied in the form of a bypass protein meal (a protein that leaves the rumen intact).

To optimise the use of low quality forage for ruminants' two major requirements must be met:

1. Rumen nutrients must be supplied to meet the nutritional needs of the rumen microorganisms;
2. A source of bypass protein must be supplied to provide additional protein above that supplied by microbial protein.

Rumen nutrients

The rumen microbes require a source of nutrients (nitrogen and minerals) for their growth. These requirements can be met by the use of inorganic minerals mixed with urea and can also be found in foods high in protein and minerals such as legumes, pulses and pasture. However, in order to supply sufficient rumen nutrients, the use of organic foods generally have to be a high proportion of the diet.

Rumen microbes include fungi, bacteria and protozoa. The fungi are responsible for the initial colonisation of the feed particles and the bacteria breakdown the

[1] NRE – Rutherglen Research Institute, RMB 1145 Chiltern Valley Road, Rutherglen Victoria 3685, Australia

particles further to produce organic acids or volatile fatty acids (VFA). Protozoa breakdown feed to produce VFA but also prey on bacteria thereby reducing the numbers entering the intestines. Fermentation of the carbohydrates in the feed produces adenosine triphosphate that is used by the microbes for their own maintenance and reproduction. The VFAs constitute the main energy source for the ruminant. Microbial cells synthesised in the rumen supply the majority of protein digested in ruminants on forage based diets.

Without a supply of rumen nutrients the microbes break down the feed very slowly which in turn decreases the animal's intake as its rumen is full of undigested feed. Without rumen nutrients the animal has a low intake and what it does eat is not fully digested. Molasses/urea blocks are a convenient way to supply rumen nutrients. The urea satisfies the nitrogen demand of the microbes and the molasses supplies many of the limiting minerals and some energy. Another method to increase dry matter intake and utilisation is to treat straw with urea.

Increasing feed quality by treatment of straw with urea

Urea treatment is a method in which straw is treated by ammonia released from urea. Feeding urea treated straw to cattle has been shown to increase milk yield, persistency of lactation, feed intake and live weight gain (Ghebrehiwet *et al.* 1988; Khan and Davis 1981; Perdok *et al.* 1982; Chemjong 1991). Ghebrehiwet *et al.* (1988) found that treating straw with urea can replace rice bran supplementation or results in higher live weight gain for the same level of supplementation. Straw treatment can increase straw digestibility and subsequent intake by the animal. Table 1 shows the effect on cow and calf growth rate after treating rice straw with urea.

Table 1. Effect of treating rice straw with urea on cow and calf performance

	Non Treated	Treated
DM intake, kg/day		
Straw	5.20	8.60
Concentrate	1.5	1.5
Average Daily Gain, g/day		
Cow	-266	93
Calf	181	257

Source: Perdok *et al* 1982

Straw, even when it is supplemented with rumen nutrients to satisfy the rumen's microbe needs still only supplies a maintenance ration for ruminants (Chenost and Kayouli 1997). Even on abundant temperate pastures the full protein needs of a animal in a rapid growth, late pregnancy or early lactation are not met from the synthesis of microbial proteins. For production, additional protein should be given that is in the least degradable form possible (such as oilseed cake, animal protein, protein rich in tannin such as from the leguminous shrubs *Leucaena leucocephala, Gliricidia* etc).

When a basal ration of rice straw was fed to young cattle together with rumen nutrients, treatment of the rice straw with ammonia resulted in a significant increase in growth rate. When ammonia treatment was combined with a supplement of 800 g/d of cottonseed meal (a source of bypass protein) growth rate was increased from 40 g/d on the basal diet (untreated rice straw) to 600 g/d (Figure 1).

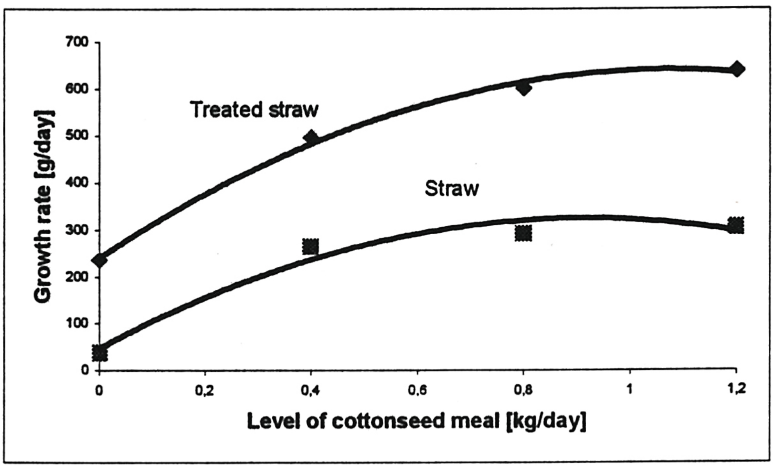

Figure 1. The growth rates of young cattle supplemented with cottonseed meal and fed a basal diet of straw or ammoniated treated straw (Source: Perdok 1987)

Bypass protein

Due to the cost of treatment the growth rates of cattle achieved by feeding treated straw as compared with untreated straw are not economically attractive unless production levels are boosted with bypass protein supplements which reduce the time to market and the total feed requirements (Leng 2002). Bypass protein supplies additional protein directly to the animal through its ability to escape breakdown in the rumen. The level of protein in a bypass protein meal may vary from 15 to 60 percent, but what is important is that a significant proportion of the protein is relatively resistant to microbial digestion in the rumen. The two main factors that determine the amount of bypass protein are the solubility of the protein material and the complexity of its structure. Low solubility due to heat treatment, binding with tannins or treatment with chemicals such as formaldehyde increases the amount of the protein that is washed out of the rumen intact to be digested in the small intestine. Complexity of the protein as a result of a protein having a high proportion of sulphur amino acids makes it less readily degraded by microbes in the rumen.

An example of a typical production response to bypass protein is given in Figure 2. Here Zhang Weixian *et al* (1994) report on studies undertaken on the use of urea ensiled or ammoniated wheat straw as the basal diet for fattening cattle in the Hebei and Henan provinces in China. They demonstrated that feeding of ammoniated straw alone was inadequate in terms of exploiting the nutrients potentially made available for animal production. The dry matter digestibility of the control diet was 58.6% in the Henan trial and the total dry matter intake was 2.6% of animal liveweight. Adding 1 kg of hulled cottonseed cake improved total ration digestibly to 67.3% and improved intake to 2.9% (Zhang Weixian et al 1994). Daily liveweight gain improved from 250 to 600g.

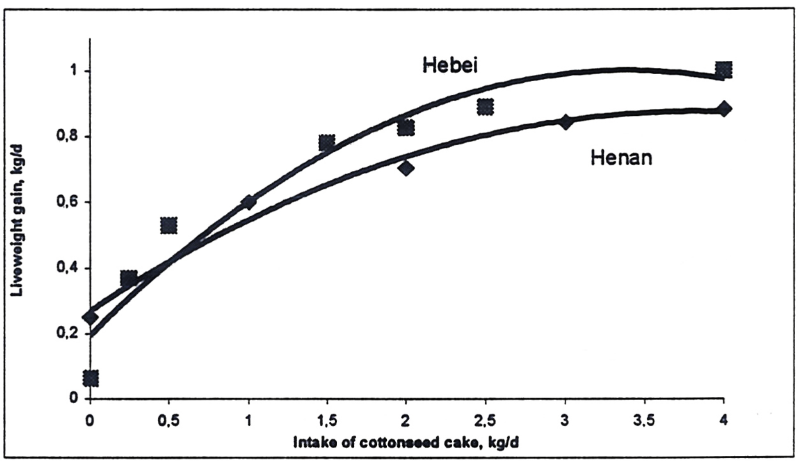

Figure 2. The response of Yellow cattle fed wheat straw treated with ammonia to supplements of cotton cake (pressure extracted) (Source: Zhang Weixian *et al* 1994)

These authors found that while total dry matter intake across the treatments remained within a very narrow range of from 2.5% and 2.7% of animal liveweight, straw was progressively being replaced by cottonseed within the diet (Zhang Weixian *et al* 1994). Leng (2002) stresses the point that the amount of feed needed to turn off an animal is related to its growth rate and that the higher the growth rate the lower the feed requirements per unit of liveweight produced (Table 2). From Table 2 it can be seen that a supplement of 0.25 kg/day of cottonseed cake causes a more than fivefold increase in daily gain and a corresponding improvement in feed conversion rate.

Table 2. The amount of ammoniated wheat straw and cottonseed cake required to produce 100kg live weight gain from Chinese Yellow breed steers fed ad libitum ammoniated wheat straw plus a mineral supplement.

Cottonseed supplement fed (kg/day)	0	0.25	0.5	1.5	2.0	2.5
Live weight gain (kg/day)	0.063	0.370	0.529	0.781	0.829	0.892
Straw consumed to produce 100kg live weight (tonnes)	6	1.1	0.92	0.56	0.48	0.46
Cottonseed cake consumed (tonnes) to produce 100kg live weight	0	0.1	0.1	0.14	0.22	0.24
Number of animals that can achieve an extra 100kg of live weight on 6 tonnes of straw	1	5+	6+	10+	12+	13+
Conversion of protein meal to live weight (g Lwt gain/g feed concentrate)	-	1.2:1	0.93:1	0.48:1	0.26:1	0.31:1

Calculations by Leng 2002 based on data from Zhang Weixian *et al* 1994

Increasing protein to the animal by defaunation with oil

Another technique for ensuring sufficient protein is available to the animal is to manipulate the microbial ecosystem to minimise the number of protozoa in the rumen. Bird *et al* 1979 showed that rumen microflora manipulation by removal of protozoa, increased average daily gain in sheep fed low-protein diets. Protozoa engulf bacteria and preferentially stay in the rumen, which leads to a decreased bacterial protein flow to the small intestine (Veira *et al* 1984). Decreasing the protozoal numbers would therefore improve the protein nutrition to the animal.

Nguyen Thi Hong Nhan *et al* (2001) demonstrated that a single drench of groundnut oil was able to significantly increase liveweight gain of cattle in Vietnam. This was further demonstrated in Cambodia where Mom Seng *et al* (2001) gave a single drench of cooking oil at 5mL/kg live weight to local "yellow" cattle (mean live weight 114 kg ± 4.35kg). These animals were isolated from non-drenched cattle. The basal diet used was *ad libitum* rice straw and a 300g/d rumen supplement (13% urea; 3% diammonium phosphate, 27% sugar palm syrup, 13% water, 33.5%

rice bran, 5% salt, 5% lime and 0.5% sulphur). In addition, the basal diet was fed with or without a supplement of fresh cassava foliage at 3% lives weight. Using the oil drench alone increased live weight gain from 53 g/d to 124 g/d while the use of the oil plus cassava supplement increased live weight gain to 302 g/d (Figure3).

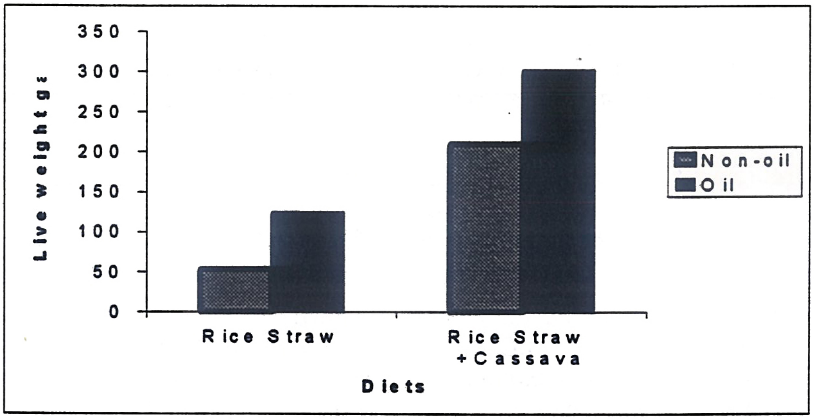

Figure 3. Effect of oil drench on liveweight gain of local "Yellow" cattle in Cambodia (Source: Mom Seng *et al* 2001)

Conclusion

When a basal diet of low quality roughage is fed the primary limiting factor is rumen nutrients. Once these are provided by supplying a source of nitrogen and minerals the animal is able to basically maintain its weight. Depending on the level of animal production required supplements such as oilseed cake, animal protein or leguminous shrubs that provide a source of bypass protein increase the protein available to the animal and increase liveweight gain. Further production can be obtained by the use of treated straw as this increases the digestibility and subsequent intake of the basal diet.

References

Bird S H, Hill M K, and Leng R A. 1979. The effects of defaunation of the rumen on the growth of lambs on low-protein-high energy diets. British Journal Nutrition 41:81-87.

Chemjong P B. 1991. Economic value of urea-treated straw fed to lactating buffaloes during the dry season in Nepal. Tropical Animal Health and Production, 23: 147-154.

Chenost M and Kayouli C. 1997. Roughage utilisation in warm climates. FAO Animal Production and Health Paper 135, FAO, Rome.

Delgado C, Rosegrant M, Steinfeld H, Ehui S and Courbois C. 1999. Livestock to 2020; The Next Food Revolution. Food, Agriculture, and the Environment Discussion Paper 28. International Food Policy Research Institute. Washington DC.

Ghebrehiwet T, Ibrahim M N M, and Schiere J B. 1988. Response of growing bulls to diets containing untreated or urea-treated rice straw with rice bran supplementation. Biological Wastes, 25(4): 269-280.

Khan, A K M N, and Davis C H. 1981. Effect of treating paddy straw with ammonia (generated from urea) on the performance of local and crossbred lactating cows. In: M.G. Jackson, F. Dolberg, C.H. Davis, M. Haque and M. Saaadullah (eds.), Maximum Livestock Production from Minimum Land. Proc. Seminar, 2-5 February 1981, Bangladesh, Mymensingh Agricultural University, Bangladesh, pp. 168-180.

Leng R A. 2002. Requirements for Protein Meals for Ruminant Meat Production in Developing Countries. FAO Expert Consultation and Workshop on Protein Sources for the Animal Feed Industry. FAO Expert Consultation and Workshop on Protein Sources for the Animal Feed Industry. April 29 – May 3.

Mom Seng, Preston T R, Leng R A and U ter Meulen. 2001. Effect of a single drench of cooking oil on the rumen ecosystem and performance of young local "yellow" cattle fed rice straw and cassava foliage. Livestock Research for Rural Development. 13(4).

Nguyen Thi Hong Nhan, Nguyen Van Hon, Ngu N T, Von N T, Preston T R, and Leng R A. 2001 Practical Application of defaunation of cattle on farms in Vietnam: Response of young cattle fed rice straw and grass to a single drench of groundnut oil. Asian-Australian Journal of Animal Science, 14 (4): 485-490.

Perdok H B. 1987. Ammoniated Rice Straw as A Feed for Growing Cattle. PhD Thesis, University of New England, Armidale, Australia.

Perdok H B, Thamotharam M, Blom J J, Van Den Born H. and Van Veluw C. 1982. Practical Experiences with Urea-Ensiled Straw in Sri Lanka. In: T.R. Preston, C.H. Davis, M. Haque and M. Saadullah (eds.), Maximum Livestock Production from Minimum Land. Proc. 3rd Seminar, 13-18 February 1982, Bangladesh Agricultural Research Institute, Joydebpur, Bangladesh, pp. 123-134.

Perdok HB, Muttettuwegama G S, Kaasslhieter GA, Boon H M, Van Wageningen M M, Arumugam V, Linders M G F A, and Jayasuriya M C N. 1984.

Production Responses of Lactating or Growing Ruminants Fed Urea-Ammonia Treated Paddy Straw With or Without Supplements. In: The Utilisation of Fibrous Agricultural Residues as Animal Feeds. Ed. P T Doyle. School of Agriculture and Forestry, University of Melbourne, Parkville, Victoria.

Veira D M, Ivan M and Yui P Y. 1984. The effect of ciliate protozoa on the flow of amino acids from the stomach of sheep. Canadian Journal of Animal Science 64, 22-23.

Zhang Weixian, Gu Chuan Xue, Dolberg F, and Finlayson P M. 1994. Supplementation of ammoniated wheat straw with hulled cottonseed cake. Livestock Research for Rural Development, 6(1).