The Potential of Rice Straw For Ruminant Production in The Tropics-Effect of Variety, Urea Treatment and Supplementation on Compensatory Growth of Fat-Tail Sheep After a Period of Feed-Qaulity Restriction

S. Chuzaemi[1], J. van Bruchem[2], A. Hidayati[3], Soebarinoto[1], and S. Prawirokusumo[4]

Animal Husbandry Faculty, Brawijaya University, Jalan Mayjen Haryono 161, Malang 65113, Indonesia

ABSTRACT: This research programme was carried out with the obyective to investigate the potential of delayed compensatory growth after a period of feed quality restriction. Sixty fat-tail sheep of 6-8 months of age and ~20 kg live weight at the onset of the experiment, were fed diets based on two varieties of rice straw (L, IR 64; H, Krueng Aceh), with (TS) or without (US) urea-ammoniation. Straw was offered at a level of excess of ~1.2. The experiment covered two periods (I, II) of 120 and 152 days, respectively. In period I, across varieties (L, H) and treatments (US, TS), the sheep were given various levels of commercial concentrates (~20 % crude protein): 0, 5, 10, 20 and 35 $g.kg^{-0.75}.d^{-1}$, respectively. Averaged over level of concentrates (0-35 $g.kg^{-0.75}.d^{-1}$, straw organic matter (OM) intake (OMI_S) and daily gain (DWG) were 37.2, 0.5 (L-US), 44.5, 2.5 (L-TS), 42.2, 1.7 (H-US) and 39.0, 3.2 (H-TS) $g.kg^{-0.75}.d^{-1}$ (SEM 4.5, 0.83). Averaged over varieties and treatments, OMI_S and DWG amounted 43.6, -1.6 (0), 45.3, 0.5 (5), 42.0, 1.6 (10), 37.3, 3.1 (20), 35.4, 6.3 (35) $g.kg^{-0.75}.d^{-1}$ (SEM 5.0, 0,93). With respect to OMI and DWG, urea treated straws showed a positive associative effect to supplementation at levels 5 and 10 $g.kg^{-0.75}.d^{-1}$. In period II, all sheep were given 35 $g.kg^{-0.75}.d^{-1}$ concentrates. Averaged over level of concentrates in period II straw OMI_S and DWG were 32.4, 5.4 (L-US), 37.1, 5.4 (L-TS), 31.9, 5.0 (H-US) and 32.2, 5.1 (H-TS) $g.kg^{-0.75}.d^{-1}$ (SEM 4.5, 0,81). Averaged over varieties and treatments, straw OMI_S and DWG were 36.2, 6.8 (0), 36.7, 5.7 (5), 34.0, 5.0 (10), 29.3, 4.5 (20), 30.8, 4.1 (35) $g.kg^{-0.75}.d^{-1}$ (SEM 5.0, 0.91). During this period, particularly sheep in groups 0, 5 and 10 showed a compensatory effect with respect to straw OMI_S and DWG. Compensatory growth was inversely related to the plane of nutrition in period I, in part brought about by a more effecient conversion of digestible organic matter into gain. This was presumably attributable to a delayed deposition of protein. At the end of the experiment, averaged over level of concentrates live weights were 31.4 (L-US), 34.0 (L-TS), 32.0 (H-US) and 34.3 (H-TS) kg (SEM 1.8). Average over varieties and treatments, live weights amounted to 30.8 (0), 31.6 (5), 31.8 (10), 33.2 (20) and 37.1 (35) kg (SEM 2.0).

Key Words: Feed Quality Restriction, Compensatory Growth, Voluntary Feed Intake, Rice Straw Variety, Urea Treatment, Supplement

Introduction

The low nutritive value of highly fibrous feeds, such as rice straw, is largely due to its low voluntary intake and poor digestibility, both of which result in nutrient mixture, not meeting maintenance requirement and insufficiently balance. The inadequacies of such straw based diets in respect of the rumen microflora and the host animal can be corrected by supplementation (Andries et al., 1987; Chuzaemi et al., 1994a). For moderate levels of production, *e.g.* early growth, particularly small intestinal available protein constitutes a constraint, needed in excess of the quantity synthesized by the rumen microbes (Chuzaemi et al., 1994b). Moreover, through the

[2]Wageningen Institute of Animal Science (WIAS), Dept. of Anim. Husbandry, Section Anim. Prod. Systems, and Dept. of Human and Anim. Physiology, Agric. Univ. Wageningen, Netherlands

[3]Anim.Husbandry Fac., Muhammadiyah Univ., Malang,

[4]Animal Husbandry Faculty, GMU, Yogyakarta.

more favourable conditions in the rumen, a positive associative effect on fibrous feed intake may be noticed. Alternatively, intake and digestibility can be improved by allowing selection of the more palatable parts through offering excess feed (Chuzaemi et al., 1994c) showed that with this latter approach straw digestible organic matter intake could be about double. However, the response in gain was below expectation, even if the conditions in the rumen could not be considered a constraint for microbial growth.

Related to rainfall not equally spread over the year, the quantity and quality of the feed may fluctuate throughout the seasons. Particularly at the end of the dry season, supplementary feeds become scarce or are preferably used for monogastric animals, *viz.* poultry. Though free access to low-quality feed, through low voluntary intake and limitation of one or more essential nutrients, a feed quality restriction is imposed. Following this strategy, animal output may benefit from compensatory feed intake and growth after re-alimentation during the onset of the wet season. Hogg (1992) describes compensatory growth as a greater than normal growth and recovery of weight for age. However, following nutritional stress, some animals may not show compensatory growth but ultimately achieve their mature size through an extended period of normal growth without expressing an increased growth rate.

The objective of the present experiment was to study the scope of this strategy in local fat-tail sheep under the conditions prevailing in the province of East-Java, Indonesia. Besides, attention was paid to the associative effect of lower level of supplementation on fibrous feed intake and gain performance.

Materials and Methods

Sixty male fat-tail sheep, ranging from six to eight months of age and reared as described by Chuzaemi et al. (1994c), were fed *ad libitum* on two varieties of rice straw, IR 64 (L) and Krueng Aceh (H), either untreated (US), or following treatment with 4 % urea (TS) for 7-14 days. The rice was grown under conditions as reported by Soebarinoto et al. (1994). Details of the chemical composition of the straws were as indicated by Chuzaemi et al. (1994bc).

To determine the response in daily weight gain, these basal diets were supplemented commercial concentrates with a composition as indicated by Chuzaemi et al. (199*c). The concentrates contained about 20 % crude protein and were supplied at levels of 0, 5, 10, 20 and 35 $g.kg^{-0.75}$. The first part of the experiment lasted 120 days. After this period (I), the performance trial was continued for a period of 152 days (period II), with all sheep receiving the concentrate supplement at a level of 35 $g.kg^{-0.75}$.

The sheep were divided into 20 groups of 3 sheep of about similar average live weight. The sheep were spread over the pens and allotted to treatments as outlined in Table 1. Average live weight amounted to ~ 20 kg. Throughout the experiment, the animals were housed individually in pens with free access to water.

The animals were fed at 6.00 and 16.00 h. Straw was offered at a level of excess of 1.2-1.3. Straw residues were collected prior to afternoon feed. The sheep were weighed every period of 8 days, after which straw and concentrates were adjusted. experiment.

Table 1. Lay out of the experiment over sheep and individual pens.

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20[1]
A[2]			<----- US ---->[3]					<------ TS ------>					<------ TS ------>					<------ US ------>		
	L1	L2	L3	L4	L5	H1	H2	H3	H4	H5	L1	L2	L3	L4	L5	H1	H2	H3	H4	H5
B			<----- TS ----->					<------ US ------>					<------ US ------>					<------ TS ------>		
	L1	L2	L3	L4	L5	L1	L2	L3	L4	L5	H1	H2	H3	H4	H5	H1	H2	H3	H4	H5
C			<----- TS ----->					<------ US ------>					<------ US ------>					<------ TS ------>		
	H1	H2	H3	H4	H5	H1	H2	H3	H4	H5	L1	L2	L3	L4	L5	L1	L2	L3	L4	L5

1) pen within raw; 2) row; 3) untreated (US) and urea treated (TS); 4) IR64 (L) and Krueng Aceh (H); 5) 1, 0; 2, 5; 3, 10; 4, 20; 5, 35 g cocentrates per $kg^{0.75}$

The results were analyzed statistically using the ANOVA procedure of the DBSTAT (Brouwer, 1990) according to the following model:

$$Y_{ijk} = \text{Mean} + \text{Variety}_{i(1,2)} + \text{Treatment}_{j(1,2)} + \text{Level}_{k(1..5)} + \text{error}_{ijk}$$

The total degrees of freedom (df) was 60 and the error term had df = 53. The ANOVA analysis was performed on data corrected for differences between sheep in live wight (LW) at the onset of the experiment, based on MW ($LW^{0.75}$). Significant differences were tested with the two-tailed Student's t test (Snedecor and Cochran, 1967).

Results

For evaluation, the whole experiment was subdivided into 6 periods (I_{1-3} and II_{1-3}) of resp. 40, 40, 40, 48, 48 and 56 days. The level of concentrates varied throughout periods I. From period II onwards all sheep were given concentrates at a level of 35 $g.kg^{-0.75}.d^{-1}$. Across varieties (L, H) and treatments (US, TS), a summary of straw and concentrate organic matter intake is presented in Figure 1. Voluntary intake of rice straw gradually increased from period I_1 to I_3, showing hardly any difference between concentrate levels 0 and 10. With 35 $g.kg^{-0.75}.d^{-1}$, straw intake gradually decreased. However in periods II_1 and II_2, again hardly any difference was observed between levels 0/35-35.

Averaged over periods I_{1-3} resp. II_{1-3}, the results on straw organic matter intake and gain have been summarized in Table 2. Across levels of concentrate, in periods I_{1-3} urea treatment did increase straw intake of L though not of H. As a result, voluntary intake of untreated straw (US) was highest for H, whereas for the TS straws the opposite was observed. These differences were reflected in daily gain and live weight at the ende of periods I_3 and II_3, respectively.

During the re-alimentation part of the experiment (periods II_{1-3}), the contrasts were less pronounced. However, in comparison with L-TS for H-TS again a lower intake was observed, which showed a tendency to be reflected in daily gain. On average, live weight at the end of the experiment did not differ between L-US and H-US, neither between L-TS and H-TS. The effect of urea treatment was superior to the contrast between varieties.

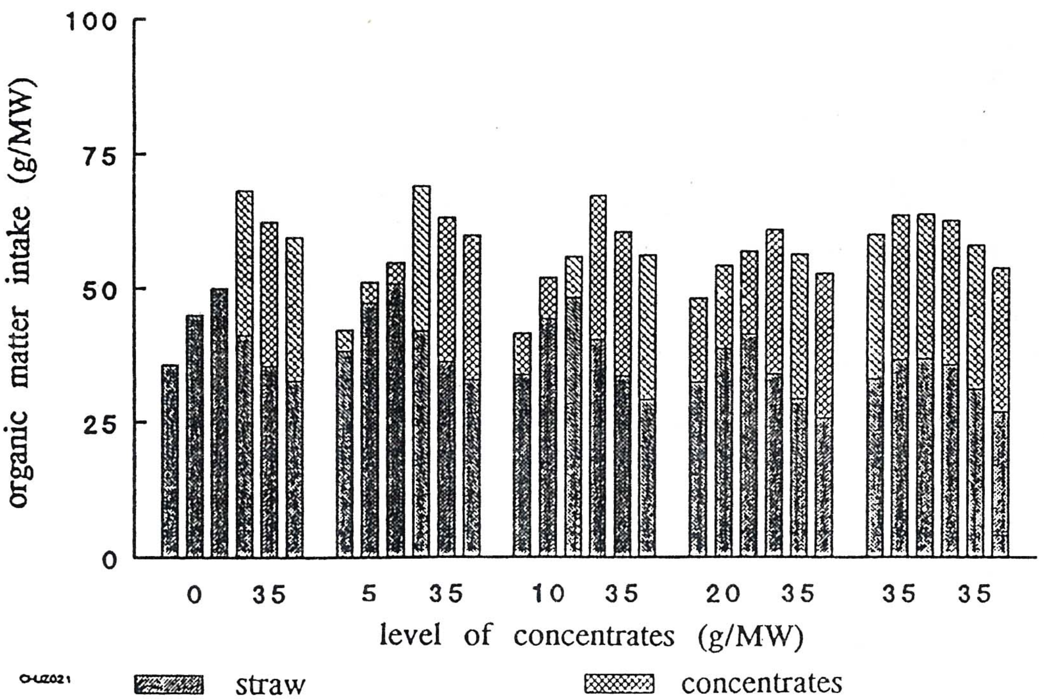

Figure 1. Intake of straw and concentrate organic matter in time course (periods I_{1-3} - II_{1-3} in relation to the level of concentrate supplementation.

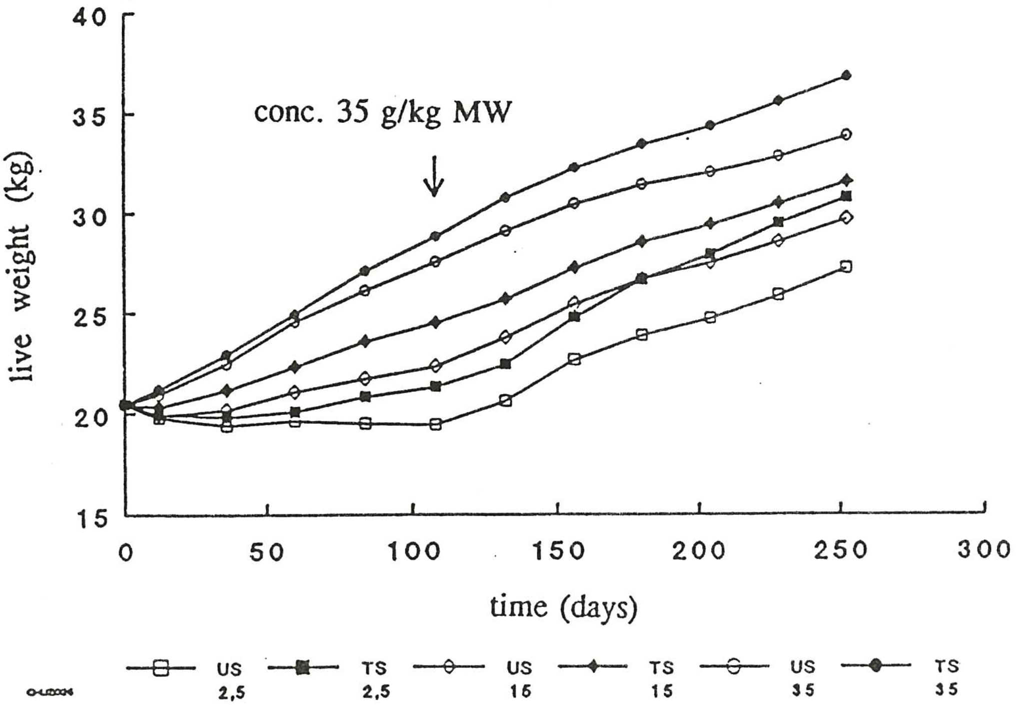

Figure 2. Daily gain on US and TS diets in relation to level of concentrates 0-5 (2.5), 10-20 (15) and 35 $g.kg^{-0.75}.d^{-1}$.

The level of concentrate supplementation showed an interaction with urea treatment, both in respect of straw intake and daily gain. Concentrate at level 5 $g.kg^{0.75}.d^{-1}$ did show a positive associative effect in respect of the intake of TS straws, particularly of H-TS. This interaction was reflected in daily gain. Between levels 0 and 5 $g.kg^{0.75}.d^{-1}$ contrasts were observed of 1.4 and 2.9 $g.kg^{-0.75}.d^{-1}$ for US and TS based diets, respectively. Accordingly, the contrasts in live weight were 1.5 and 3.0 kg, respectively.

Moreover, an interaction was observed between concentrate level and straw variety. During periods I_{1-3}, the contrasts between L and H were more pronounced at lower levels of concentrate. At level 35 $g.kg^{0.75}.d^{-1}$, hardly any difference was noticed. This phenomenon was confirmed during periods II_{1-3}, showing no difference in intake between L-US and H-US. For the TS straws, the highest intake was found for the L variety. As a result, the contrast between L and H decreased from 1 kg after period I_3 till 0.5 kg after period II_2. Contrary to that, the contrast between US and TS increased from 1.8 kg after period I_3 till 2.5 kg at the end of the experiment. This slightly better response with the TS diets has been visualized in Figure 2.

Discussion

In Figure 3, averaged over untreated and urea treated straws the relationship between whole diet DOMI and DWG is presented for in relation to the level of concentrates during periods I_{1-3}, and for periods II_{1-3} with all sheep supplemented at a level of 35 $g.kg^{-0.75}.d^{-1}$. In this figure, the open symbols refer to the first part of the experiment (periods I_{1-3}), whereas the closed symbols were obtained with a supplement of 35 $g.kg^{-0.75}.d^{-1}$. In the sheep given a 35 $g.kg^{-0.75}.d^{-1}$ supplement from the onset of the experiment, DWG over DOMI decreased in the second part of the experiment. This may be related to a gradual change in the ratio between protein and fat deposition of these animals. Daily gain can be regarded as a funtion of energy (DOMI) intake and the efficiency of conversion of metabolizable energy into net energy (NE). As pointed out below, thisis related to the composition of gain.

Table 2. Rice straw organic matter intake (OMSI, $g.kg^{-0.75}.d^{-1}$), daily gain ($g.kg^{-0.75}.d^{-1}$) and live weight (LW) of sheep in relation to straw variety (L, H), urea treatment (US, TS) and level of concentrate (C, $g.kg^{-0.75}.d^{-1}$).

	Period I_{1-3}				Period II_{1-3}			
	C	OMSI	gain	LW	C	OMSI	gain	LW
L-US	0[1]	39.9	-3.5	17.3	35	34.3	7.3	29.2
	5	40.4	-1.3	19.5	35	30.7	5.0	27.7
	10	38.3	-0.3	20.9	35	34.3	5.4	30.3
	20	33.3	2.0	23.5	35	29.9	5.0	32.9
	35	33.8	5.5	27.7	35	32.8	4.4	36.7
L-TS	0	46.0	-1.6	19.2	35	39.5	6.9	30.8
	5	47.5	1.2	22.3	35	40.5	5.8	32.8
	10	47.6	2.8	23.9	35	42.7	5.0	33.1
	20	43.7	3.3	24.7	35	30.3	4.4	33.0
	35	37.5	6.7	29.2	35	32.3	5.1	40.1
H-US	0	49.2	-0.8	19.9	35	34.8	5.8	29.4
	5	47.2	-0.2	20.8	35	38.4	6.2	31.6
	10	41.5	0.7	21.6	35	28.7	5.5	31.2
	20	36.5	2.8	24.4	35	28.5	4.6	33.1
	35	36.7	6.1	28.1	35	29.1	3.1	34.4
H-TS	0	39.0	-0.5	20.4	35	36.3	7.3	33.6
	5	46.2	2.5	23.4	35	37.1	5.9	34.2
	10	40.5	3.1	24.7	35	30.2	4.1	32.4
	20	35.8	4.1	25.9	35	28.7	4.2	34.0
	35	33.5	6.7	29.2	35	28.9	3.9	37.2
LSD[1]		10.07	1.86	2.04		9.16	1.82	4.07
L-US[2]		37.2	0.5	21.8		32.4	5.4	31.4
L-TS		44.5	2.5	23.9		37.1	5.4	34.0
H-US		42.2	1.7	23.0		31.9	5.0	32.0
H-TS		39.0	3.2	24.7		32.2	5.1	34.3
LSD[2]		4.50	0.83	0.91		4.46	0.81	.82
	0[3]	43.6	-1.6	19.2	35	36.2	6.8	30.8
	5	45.3	0.5	21.5	35	36.7	5.7	31.6
	10	42.0	1.6	22.8	35	34.0	5.0	31.8
	20	37.3	3.1	24.6	35	29.3	4.5	33.2
	35	35.4	6.3	28.6	35	30.8	4.1	37.1
LSD[3]		5.03	0.93	1.02		4.99	0.91	.04
Mean[4]		40.7	2.0	23.3		33.4	5.2	32.9
SEM[4]		0.79	0.15	0.16		0.79	0.14	.32

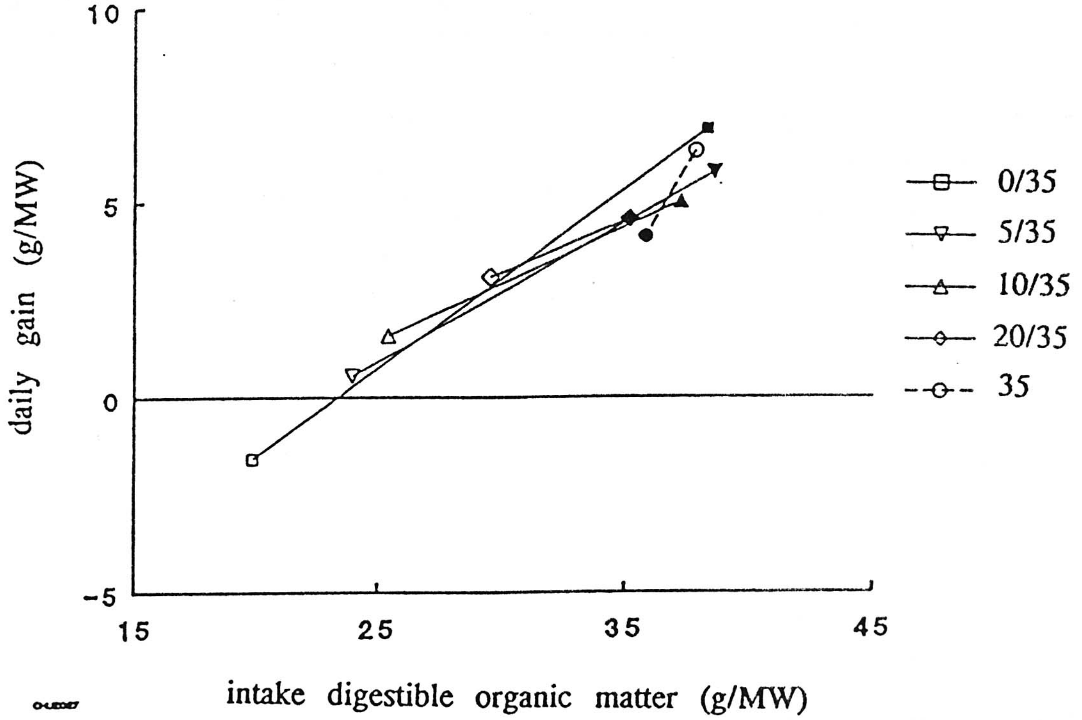

Figure 3. Conversion of whole diet digestible OM into daily gain at levels 0, 5, 10, 20 and 35 $g.kg^{-0.75}.d^{-1}$ of supplementation (periods I_{1-3}; open symbols) and with a supplement of 35 $g.kg^{-0.75}.d^{-1}$ supplement (periods II_{1-3}; closed symbols).

For the other experimental groups, *i.e.* 0, 5, 10 and 20 $g.kg^{-0.75}.d^{-1}$ groups, after re-alimentation the efficiency of conversion of DOMI into gain was inversely related to the level of supplementation during the first part of the experiment. More detailed studies are needed to explain this phenomenon. However, one could imagine that maintenance energy requirements of the animals decrease during restriction. As shown in Figure 4, plotting DWG *vs*. DOMI resulted in the following regression equation (SE in parentheses):

$$DWG\ (g.kg^{-0.75}.d^{-1}) = -9.9\ (0.66) + 0.43\ (0.023)\ DOMI$$
$$(R^2 = 0.95)$$

This regression equation intersects with the X axis at DOMI = 22.8 $g.kg^{-0.75}.d^{-1}$, about equivalent to 360 kJ $ME.kg^{-0.75}.d^{-1}$, a value which can be regarded as quite low indeed. NRC (1981), gives an estimate for maintenance of 424 kJ $kg^{-0.75}.d^{-1}$, an average of 10 original estimates varying from 365 to 482 kJ ME $kg^{-0.75}.d^{-1}$. The slope DWG *vs* DOMI as found in the present experiment was considerably higher than the value found by of Chuzaemi et al. (1994c) in an experiment, in which DOMI was manipulated through offering higher levels of excess straw. Zemmelink et al. (1991) found a similar value in dwarf goats fed hay based diets with varying amounts of concentrates.

Further, the energetic efficiency of conversion of metabolizable energy relates to the composition of gain. According to McDonald et al. (1988) sheep at half of their mature weight deposit about 325 g fat and 163 g protein per kg gain. For fat an efficiency of conversion is generally accepted in the range of 0.70-0.75. Related to the continuous tunrover, *i.e.* synthetis and degradation, of organ and tissue proteins, NE/ME for net protein deposition ranges 0.50-0.55. The efficiency of conversion of amino acid N truly absorbed from the small intestine (AAN_{TA}) into lean meat protein was found to be of a similar magnitude (ARC, 1984; Oosting, 1993). As discussed by Van Bruchem et al. (1994), under these conditions about 30 g AAN_{TA} is required per kg DOMI. This finding was supported by Oosting (1993) with the following regression equation (SE in brackets):

$$AAN_{TA}\ (mg.kg^{-0.75}.d^{-1}) = -459\ (163.9) + 33.0\ (5.27) * DOMI\ (g.kg^{-0.75}.d^{-1})$$

With 20 $g.kg^{-0.75}.d^{-1}$ concentrate, across varieties and treatments Chuzaemi et al. (1994b) determined an efficiency of microbial protein synthesis of ~20 mg AAN per g rumen degraded organic matter. With a partial organic matter digestibility in the rumen ranging 0.55-0.60 and a true AAN digestibility in the small intestine ranging 0.80-0.85, rumen microbes provided ~10 mg AAN_{TA} per g DOMI. In sheep, Ørskov (1982) estimated maintenance AAN needs of ~350 mg $AAN_{TA}.kg^{-0.75}.d^{-1}$. Relative to energy, Oosting (1993) arrived at an estimate of ~17.5 g AAN_{TA} per kg DOMI. According to the equation AAN_{TA} *vs* DOMI as established by Chuzaemi et al. (1994b) with 20 $g.kg^{-0.75}.d^{-1}$ concentrates, and the other conditions comparable to those prevailing in this experiment to an equation about similar to that of Oosting (1993):

$$AAN_{TA}\ (mg.kg^{-0.75}.d^{-1}) = -392\ (36.9) + 32.1\ (3.36) * DOMI\ (g.kg^{-0.75}.d^{-1})$$

The quantity of AAN needed in excess of rumen microbial AAN was derived from dietary AAN, averaged over varieties and treatments for about 45 % escaping rumen degradation. Therefore, it is suggested that at the level of 35 $g.kg^{-0.75}.d^{-1}$, AAN_{TA} cannot be regarded as a constraint. Hence, the lower efficiency of conversion of DOMI into gain, inversely related to the nutritional history of the animal, is related to a gradual shift in the composition of gain towards fat, however, not because of AAN_{TA} constitutes a constraint, but because of physiological ageing. It seems that the sheep with a history of feed quality restriction, *i.e.* at levels 0-5 $g.kg^{-0.75}.d^{-1}$, were able to extend the period of *early growth*, in other words can prevent animals becoming physiologically older in terms of composition of gain, thus delaying the point of inflection of their growth curve. Besides, in the first period after re-alimentation, the increased efficiency of conversion of DOMI into DWG could be related to lowered maintenance requirements. However, to unequivocally confirm these various suggestions, more in-depth research is needed, amongst others including the assessment of N, C and energy retention, maintenance requirements and protein turnover.

The magnitude of compensatory growth during re-alimentation after a period of feed quality deprivation was related to the sheep's nutritional history, and was more pronounced at lower previous levels of supplementation and with untreated *vs* urea-treated straw as the basal diet.

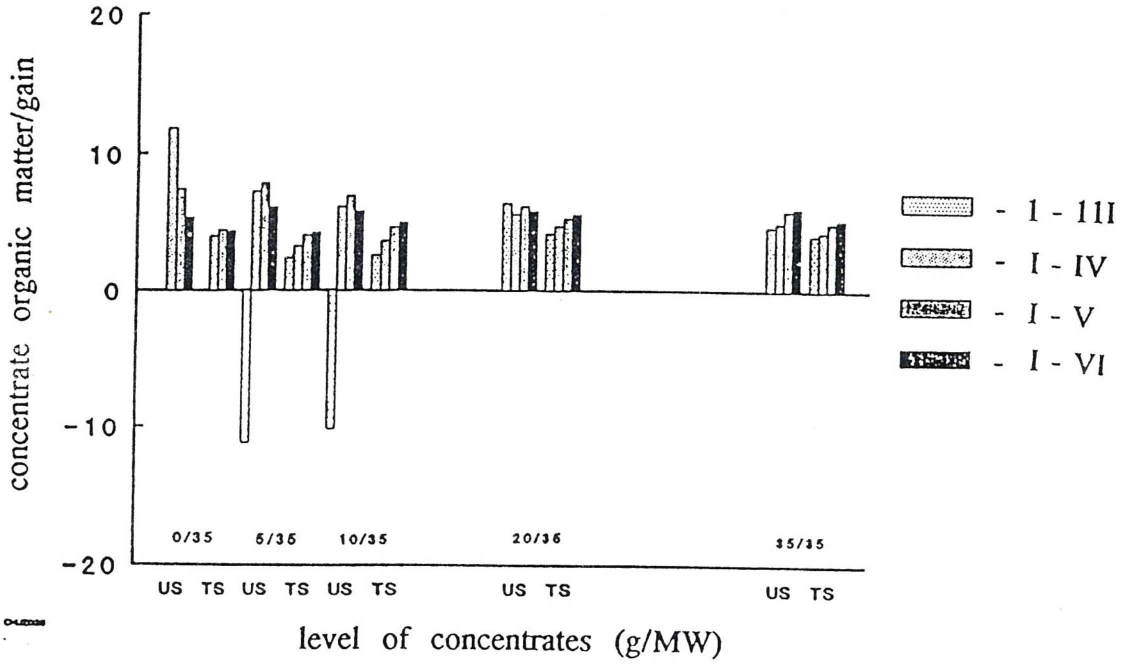

Figure 4. Ratio between the cumulatif quantity of suplement to gain in relation to feed quality deprivation, compensatory growth and urea treatment.

Related to regional conditions, distribution of temperature and rain fall over the seasons, costs of supplementary feeds and market prices, there seems scope for feeding strategies taking full advantage of this phenomenon of compensatory growth. This has been illustrated in Figure 4, showing in a cumulative way the ratio between supplement organic matter and gain. For US diets, this ratio was slightly lower at level 0/35 $g.kg^{-0.75}.d^{-1}$ compared to levels 5/35 to 35/35 $g.kg^{-0.75}.d^{-1}$. For the TS diets, a lower ratio was found for levels 0/35 and 5/35 $g.kg^{-0.75}.d^{-1}$. Besides, on average the TS diets showed a slightly lower ratio compared to the US diets.

Which option should be chosen under specific conditions would depend on various considerations. For the L straw, the contrast between the 0/35 and 35 $g.kg^{-0.75}.d^{-1}$ groups remained large compared with the H straw, on average 8.4 *vs* 4.3 $g.kg^{-0.75}.d^{-1}$. This decision would further depend on the costs of urea and supplementary feeds, the desired weight at slaughter and the market prices throughout the seasons. However, in case of shortage of supplementary feeds, the present experiment shows that farmers may be advised that there may be no harm in imposing feed quality restriction to a level slightly below maintenance. At a later stage, when supplementary feeds are more abundantly available and thus cheaper, the efficiency of conversion of nutrients has certainly not become less. Seemingly carcass composition won't be adversely affected, with a resultanc benefit for the farmer's household.

Acknowledgements

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