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The utilization of nutrients for growth in goat kids and lambs: Aspects to be considered

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SUMMARY - Both goat kids and lambs show feeding behaviour typical of the pre-ruminant animal. The former exhibit a special ability for maintaining their energy balance, modifying the efficiency of utilization of energy intake and the energy retention partition into protein and fat, according to the existing environmental conditions. The dietary factors which determine voluntary feed intake in these animals, are the same ones which establish the body composition. The limiting effect that abomasal size can have on intake can be counterbalanced by the dry matter content of the milk replacer. For post-weaning period data from many studies have shown greater solid feed intake and better feed to gain ratio from growing lambs than kids of similar age. Similarly, the consumption of silage made of a variety of by-products (poultry litter, olive cake, citrus pulp) was greater in ewe lambs than goat kids. Cereal grain processing (grinding, rolling or grinding followed by pelleting) is of no value in lambs, whereas grinding followed by pelleting improved feed to gain ratio in kids. There has been superiority of goats compared to sheep in dealing with feedstuffs rich in tannin and of poor quality. The efficiency of utilization of ME for maintenance is similar in the pre-and post-weaning period, but the energy requirements for weight gain are higher in the post- than in the pre-weaning period. Kids require greater dietary CP concentration than lambs of the same age. The presence of fish or meat meals together with soybean meal in the concentrate mixture enhances body weight gain and feed to gain ratio in kids but not in lambs.

Key words: Nutrient utilization, growth, goat kids, lambs, review.

RESUME - *"L'utilisation de nutriments pour la croissance chez les chevreaux et agneaux : aspects à considérer". Les chevreaux ainsi que les agneaux montrent un comportement alimentaire typique de l'animal pré-ruminant. Les premiers montrent une aptitude spéciale pour le maintien de leur bilan énergétique, en modifiant l'efficacité de l'utilisation l'ingestion d'énergie et du fractionnement de la rétention d'énergie en protéine et en gras, selon les conditions environnementales existantes. Les facteurs du régime qui déterminent l'ingestion alimentaire volontaire chez ces animaux sont les mêmes que ceux qui donnent lieu à la composition corporelle. L'effet limitant que la taille de l'abomasum peut avoir sur l'ingestion peut être contrebalancé par la teneur en matière sèche du lait de remplacement. Pour la période post-sevrage, des données provenant de plusieurs études ont montré une plus grande ingestion alimentaire solide et un meilleur ratio aliment-gain chez des agneaux en croissance par rapport à des chevreaux du même âge. De la même façon, la consommation d'ensilage provenant de divers sous-produits (fientes de volaille, tourteau d'olive, pulpe d'agrumes) a été plus grande chez les agneaux que chez les chevreaux. La transformation des graines de céréales (mouture, roulage ou mouture suivie de granulation) n'a aucune valeur pour les agneaux, tandis que la mouture suivie de granulation améliore le ratio aliment-gain chez les chevreaux. On a vu la supériorité des caprins par rapport aux ovins lorsqu'il s'agit de valoriser des aliments riches en tannins et de mauvaise qualité. L'efficacité de l'utilisation de l'énergie métabolisable pour l'entretien est semblable pendant la période pré- et post-sevrage, mais les besoins en énergie pour le gain de poids sont plus élevés pendant la période post-sevrage que pendant la période pré-sevrage. Les chevreaux nécessitent une plus grande concentration en protéine brute alimentaire que les agneaux du même âge. La présence de farine de poisson ou de viande avec la farine de soja dans le mélange de concentré permet un plus grand gain de poids corporel et un meilleur ratio aliment-gain chez les chevreaux, mais pas chez les agneaux.*

Mots-clés : *Utilisation de la nutrition, croissance, chevreaux, agneaux, révision.*

Introduction

The young of caprine and ovine species, once they have consumed sufficient colostrum, consume a diet based either on maternal milk or on a milk substitute during the first stages of their life. Artificial milk feeding is used to different extents for goat kids and lambs. Data from studies on the nutritional and productive aspects of this practice have provided the scientific basis necessary for determining the most appropriate feeding system to be used in each case. Differences have been identified in the feeding behaviour of these types of animals. These differences need to be taken into account for optimizing the growth process during the milk-fed period, whether the animal is to be slaughtered early or not.

I. Preweaning period

Differences in feeding behaviour

The morphological development of ovine and caprine species is quite different, this difference being apparent at an early age. The main characteristic of the caprine carcass is its leanness, there being very little inter- and intra-muscular fat, and this can be to the detriment of the carcass quality (Morand-Fehr *et al.*, 1985; Sanz Sampelayo *et al.*, 1987). In an attempt to identify the nutritional factors which cause these differences, Sanz Sampelayo *et al.* (1994) carried out a series of trials using goat kids and ewe lambs housed under identical conditions. The Granadina goat kids and Segureña lambs were kept at 24ºC and fed the same milk replacer *ad libitum* during the first two moths of life. The balance and comparative slaughter trials revealed that in both types of animals the energy digestibility was similar, but the dry matter (DM) and metabolizable energy (ME) intakes per kg metabolic body weight were lower for goat kids than ewe lambs. For goat kids and ewe lambs these values were: 0.93 and 0.94; 45.4 and 50.1 g/kg$^{0.75}$ per day and 937 and 1033 kJ/kg$^{0.75}$ per day, respectively. At the same time the mean values for total energy retention (ER), heat loss (HL), energy retained as protein (ERp) and energy retained as fat (ERf) were 263, 674, 131 and 132 kJ/kg$^{0.75}$ per day for goat kids and 343, 690, 132 and 211 kJ/kg$^{0.75}$ per day for lambs, respectively. The principal nutritional causes of the difference in development of the two animal species identified under *ad libitum* feeding conditions were the lower rate of feed intake and the higher rate of heat loss in goats kids and, more specifically, the higher rate of energy retention in the form of protein and the lower rate retained as fat in goat kids than in lambs.

Since the differences in the rate of heat loss and in the partition of the retained energy between protein and fat indicate differences in the utilization of ME for maintenance and/or growth, a further series of trials were designed in which the energy metabolism of Granadina goat kids and Segureña lambs housed at 24ºC was analysed (Sanz Sampelayo *et al.*, 1995a). In this latter series the animals were on different feeding levels and the energy metabolism was estimated by the comparative slaughter method. The requirements of ME for maintenance (MEm), the efficiencies of utilization of ME intake for retention (K), as well as the ME intake values at which ERp and ERf began to take place, were established for the two classes of animal. The estimated values of MEm, as well as those of K were 456 kJ/kg$^{0.75}$ per day and 0.55 for goat kids and 393 kJ/kg$^{0.75}$ per day and 0.54 for lambs, respectively. The intakes of ME at which either protein retention or fat deposition was initiated were: 258 or 575 kJ/kg$^{0.75}$ per day for goat kids and 428 or 362 kJ/kg$^{0.75}$ per day for lambs, respectively. It is well recognized that heat losses at maintenance normally reach higher values in leaner animals. Taking into account the fact that goat kids can be considered to be metabolic types in which fat deposition is more difficult than in lambs, the results obtained for the maintenance requirements agree with the generally accepted rule that animals which show greater difficulty in laying down fat, mobilize and use fatty acids for energy greater than those animals in which fat deposition occurs more readily. At the same time the results indicated that in goat kids protein retention began at ME intakes markedly lower than those estimated as being maintenance requirements, while fat deposition started to occur once the ME intakes had surpassed maintenance requirements considerably. Both of these observations indicate that in these animals fat mobilization for protein retention normally occurs. In contrast, in the lambs, practically as soon as the maintenance requirements had been satisfied, both protein retention and fat deposition began to take place.

The metabolic behaviour described for goat kids and lambs, as a result of which the former are more inefficient in the metabolic utilization of energy and fatten with greater difficulty, is not always demonstrated in this way. Prieto (1993), after subjecting lambs and goat kids to different environmental temperatures (12, 24 and 30ºC), found that goat kids were less sensitive than lambs at the lowest temperature used. At practically the same ME intake values, kids achieved a higher energy retention, this being linked to fat deposition. In contrast, at the two highest temperatures, the behaviour was similar to that described above. The findings of Prieto (1993) are in Table 1.

Prieto (1993) stated that probably all the differences mentioned above in the behaviour of goat kids as compared with lambs, can be explained by its leanness, their metabolism being particularly directed towards the maintenance of the energy balance. Faced with any circumstance that could lead to an increase or a decrease in this energy balance, the goat kid reacts so that there is a much smaller change than would occur with lamb.

Table 1. Metabolizable energy intake (MEI), energy retention (ER) and energy retention as fat (ERf) in Granadina goat kids and Segureña lambs according to the environmental temperature

Environmental temperature	MEI (kJ/kg$^{0.75}$ per day)	ER (kJ/kg$^{0.75}$ per day)	ERf (kJ/kg$^{0.75}$ per day)
12ºC			
Goat kids	898	177	89
Lambs	886	132	47
24ºC			
Goat kids	859	211	111
Lambs	881	268	163
30ºC			
Goat kids	869	239	152
Lambs	851	311	209

Dietary factors affecting the voluntary feed intake

The first manifestation of the different behaviour of goat kids as compared to lambs from a nutritional point of view is their lower voluntary feed intake. Thus, to achieve an optimum growth in these animals, it is necessary to study the factors that determine its intake. It is well known that in the pre-ruminant animal the relationship between body-weight and body composition appears to be unaffected by the level of intake. This lack of response may be accounted for by the relatively low voluntary feed intake of these animals, so that no excess energy is available to be stored as fat (Walker, 1986). Sanz Sampelayo *et al.* (1990) found that for the first month of life, the composition of the empty body weight of the pre-ruminant Granadina goat kid, was established by the empty body weight, independently of the level of feed intake and the nutritional regime. For all of these reasons and with the aim of optimizing the growth process of these animals, the dietary factors determining feed intake were analysed. This analysis was carried out while assuming that these factors could at the same time determine body composition. To this end a series of milk replacers were designed and used for feeding Granadina goat kids. These milk replacers differed from each other in the proportion of protein (20, 24 and 28%) and fat (20, 24 and 28%) they contained and, as a result, in their digestible protein (DP) and ME contents. This study showed a strong relationship between the DM intake (DMI; g/kg body-weight and day) and the amount of DP (g/kg DM) and ME (MJ/kg DM) in the milk replacer.

$$[(DMI=0.43\ (\pm 0.06)\ DP-0.92\ (\pm 0.34)\ ME-0.00097\ (\pm 0.00012)\ DP^2 \quad (n=54;\ R^2=0.980;\ RSD=4.2)]$$

Animals were consuming less DM as the ME content of the diet increased and more DM as the DP content increased until the latter reached a certain value which would give maximum intake. The relationship between the MEI (MJ/kg body-weight and day) and the DP content of the milk replacer was also very high.

$$[(MEI=4.46\ (\pm 0.24)\ DP-0.0084\ (\pm 0.0011)\ DP^2 \quad (n=54;\ R^2=0.982;\ RSD=75.8)]$$

The DP content of the feed which gave the maximum intake was 265.5 g DP/kg DM, and/or 300 g crude protein/kg DM.

At the same time, as had been assumed, feed composition essentially established the dry matter, fat and energy content of the empty body weight. Thus, during growth the goat kid regulates its intake so as to satisfy its energy requirements, these increasing as the protein content of the feed increases. As the protein content increases, the energy intake also increases, and, as a result, not only is there an increased growth, but also an increase in the fat deposits. This process terminates when the animal reaches the limits of its capacity for protein retention (Sanz Sampelayo *et al.*, 1995b).

Analysing the empty-body weight composition obtained in function of the fat content of the milk replacer, it was also possible to estimate the maximum amount of fat which, when included in the diet, would be utilized. This value, equal to 300 g/kg DM, was found to be especially related to the digestive capacity of the animal (Ruiz Mariscal, 1991).

The above mentioned results indicating how the protein content of the feed can determine both the level of feed intake and the body composition of the goat kid agree basically with those found for lambs. In lambs, when the protein content of a milk replacer is increased from 24 to 30%, the feed intake and growth rate increase and the energy content of the empty-body weight is higher (Aurousseau, 1984).

In addition, Sanz Sampelayo *et al.* (1996) carried out a series of trials using different milk replacers with the aim to identify the substances involved in the control at the blood level, of the voluntary intake by the goat kids. In accordance with the results obtained these authors concluded that glucose, triglycerides and insulin, were the substances investigated which seem to be involved in the control of feed intake and/or in the maintenance of the energy balance. Irrespective of the diet, the high correlation between these parameters together with their independence with respect to the feed intake, corroborates this conclusion.

Another interesting aspect deduced from the use of different milk replacers to feed goat kids, is that reported by Ruiz Mariscal (1991) who found that the efficiency of protein utilization for protein retention decreased as the protein content of the diet increased, and increased significantly with increasing dietary fat content. This protein-sparing effect of the fat has also been observed in lambs, especially when the fat was made up of medium-chain triglycerides (Aurousseau, 1988; Aurousseau *et al.*, 1989a,b). The latter authors have suggested that this effect was due to the nature of the fat which enabled it to be readily used as an energy source but not easily deposited. However, in the goat kid it is known that as a result of its metabolic peculiarities, any type of fat, even fat made up of long chain triglycerides, can be easily used to provide energy and, therefore, can take part in protein synthesis (Sanz Sampelayo *et al.*, 1995a).

Abomasal size as the primary factor regulating feed intake

One of the first internal changes that follows feed intake, is gastric distention. In the pre-ruminant animal, abomasal size has been suggested to be the primary factor which limits intake, while once the animal has passed a certain age, it is the amount of energy ingested which becomes the primary limiting factor. Changes in the DM content of a liquid diet are accompanied by an alteration in the intake of the diet as the animal tries to maintain the DM or energy intake constant. Such observations have led to attempts to design better systems of artificial milk feeding for goat kids. To this end it has been necessary to establish the effect of the DM concentration of milk replacers on the feed intake and the utilization of the feed. Allegretti (1995) carried out a series of trials on Granadina goat kids to test the hypothesis that the size of the abomasum is the primary factor limiting feed intake in these animals and to determine whether this effect can be overcome by manipulating the DM concentration of the replacer. Two milk replacers were used. One of them contained 12% DM which was considered to be so low that the animal would have difficulty in compensating for the shortfall by increasing its intake. The other contained 20% DM, which is one of the highest used for feeding such animals. As can be seen in Fig. 1, in addition to there being a higher intake of the low DM liquid feed there was a higher intake of DM by the animals on the high DM feed. The first effect intensified with age, while the second decreased considerably. Both of these findings indicate that the goat kid has a high capacity for adjusting its intake of DM, independently of the concentration in the milk replacer (Allegretti, 1995).

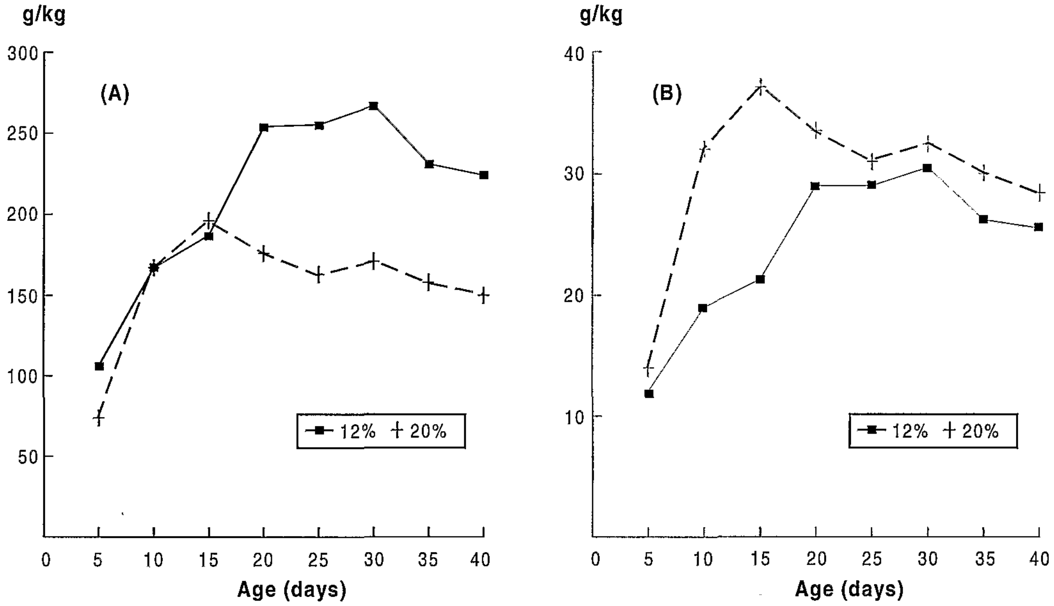

Fig. 1. Daily liquid feed (A) and dry matter (B) intake (g/kg body-weight) in Granadina goat kids according to the DM concentration on the milk replacer and animal age (Allegretti, 1995).

Taking into account the growth rate achieved and the energy intakes reached and establishing the rates of ER for two different periods (between 2-20 days and 21-40 days of age) according to the comparative slaughter method (Table 2), it was found that both the rate of energy intake and the growth rate were higher for the more concentrated milk replacer. At the same time, when the dilute milk replacer was used, the differences found between the results for the two time periods, clearly reflect the fact that during the first period the animals suffered a feeding restriction. The information currently available on the effect of passing from a stage of feeding restriction to one of sufficiency, indicates that the higher growth rate which results arises more from better utilization of the feed than from the higher feed intake. When one passes from the first period to the second, it can be seen that in addition to a higher growth rate and a higher energy intake, there was also a better overall utilization of the energy ingested, this improving from 24% to 37%. The animals fed the higher concentration, however, showed similar growth rates, energy intakes and overall energy utilization efficiencies in the two periods. This indicates that the animals fed the 20% DM milk replacer did not suffer the effects of feed restriction. In the opinion of the author of these trials (Allegretti, 1995), the use of higher concentration milk replacers to feed goat kids appears to annul the restricting effect that abomasal size has on feed intake during the first stages of life.

Table 2. Metabolizable energy intake (MEI), growth rate (GR), energy retention (ER) and efficiency of energy utilization for energy retention (ER/MEI) in Granadina goat kids, according to the DM concentration of the milk replacer and life period

	DM concentration (%)			
	12		20	
Period of life (days)	2-20	21-40	2-20	21-40
MEI (kJ/kg$^{0.75}$ day)	932 ± 53	1068 ± 84	1118 ± 91	1129 ± 32
GR (g/day)	76 ± 9	135 ± 4	139 ± 9	139 ± 15
ER (kJ/kg$^{0.75}$ day	227 ± 35	403 ± 52	353 ± 61	347 ± 24
ER/MEI (%)	24 ± 3	37 ± 2	31 ± 4	31 ± 1

II. Postweaning period

Feed intake

There has been difference in solid feed intake between lambs and kids throughout the growing period and particularly in the early post-weaning period. Daily solid feed intake of Damascus kids weaned at 45 days of age (weaning weight 10-12.5±1.9 kg) was below 0.15 kg/head in the first 5 days after weaning and only slightly above 0.15 at 10 days after weaning. Solid feed intake at 60 and 70 d was around 0.27 and 0.4 kg/head, respectively. The corresponding values for Chios lambs weaned at 42 days of age were 0.45, 0.64, 0.77 and 0.95, respectively. Similarly, there were species differences in the voluntary intake of silage made of different by-products (Hadjipanayiotou, 1994). Voluntary intake of olive cake silage was lower in goat kids than ewe lambs (Trial 1: kids 26.1, lambs 49.2 g DM/kg$^{0.75}$; Trial 2: kids 25, Lambs 34 g/kg$^{0.75}$). Estimated ME value of the olive cake silage was higher when fed to lambs than kids (Trial 1: 8.18 *vs* 8.11 MJ ME/kg DM; Trial 2: 5.43 *vs* 4.45 MJ ME/kg DM). Furthermore, higher silage intake favouring lambs was more evident in the first 1 to 3 weeks of introducing the silage, the latter giving support to the fact that goat kids require longer adaptation period to a new by-product/silage feed. Finally, the consumption of silage with strong ammonia smell was low throughout in kids but not in lambs.

Although there are comparative studies showing the superiority of mature goats over sheep in dealing with high tannin diets (Narjisse *et al.*, 1995), higher voluntary intake (Domingue *et al.*, 1991) and digestion of poor quality roughage (Antoniou and Hadjipanayiotou, 1985; Domingue *et al.*, 1991) there are not such studies with growing animals.

Feed to gain ratio

Efficiency of feed conversion, a function of feed composition and level of feed intake relative to maintenance and production needs, has a marked influence on efficiency of a production system. Data of a number of trials carried out at the Cyprus Agricultural Research Institute with growing lambs and kids of a similar biological age and offered the same diet show that Chios lambs grow faster and require less feed per kg weight gain (Table 3).

Table 3. Comparative feed to gain ratios in Chios lambs and Damascus goats at approximately the same physiological age and on similar diets within each trial

	Lambs		Kids	
	Male	Female	Male	Female
Economides, 1986	4.11	4.78	4.93	5.73
Koumas and Economides, 1987	3.87	-	4.30	-
Hadjipanayiotou, 1990	3.62	-	4.94	-
Hadjipanayiotou, 1992	3.85	4.66	4.45	4.87
Hadjipanayiotou, 1992	3.34	-	3.63	-
Hadjipanayiotou and Koumas, 1993	3.68	-	3.99	-
Hadjipanayiotou *et al.*, 1996	2.99	3.28	3.91	3.92

Energy utilization

It has been reported by Sanz Sampelayo *et al.* (1991) that the energy requirements for maintenance by Granadina kids are similar in the pre- (444 KJ/kg$^{0.75}$) and post-weaning (427 KJ/kg$^{0.75}$) period and that in the two periods dietary ME is utilized with the same efficiency for maintenance (0.73 *vs* 0.75). Values ranging between 21.5 and 45.2 KJ ME/g weight gain were reported by Morand-Fehr *et al.* (1982). On the other hand, Lu *et al.* (1987) reported that the growth requirements of Alpine and Nubian young goats within 4-8 months of age are equal to 37.7, 59.0 and 57.4 KJ ME/g gain, respectively, for animals fed diets with 12.8, 11.6 and 10.3 MJ ME/kg DM. Although the values reported by Lu *et al.* (1987) were greater than those recommended by NRC (30.3 KJ ME/g gain) for goats (NRC, 1981), they were comparable to values recommended for finishing lambs 4-7 months old (9.7 Kcal ME/g of gain) (NRC, 1985), growing heifers (ARC, 1980) of 200 to 300 kg body weight (10.7) and growing bulls of 200 to 300 kg body weight (9.0 Kcal ME/g gain). Lower than (13.1 and 14.8 KJ ME/g gain) the above values were reported for milk fed Granadina kids (Sanz Sampelayo *et al.*, 1988).

Protein utilization

Sengar (1980) indicated that N-requirements is a function of energy intake. The precision of the recommended values, will be greatly improved when more information on body composition of young kids and in the protein efficiency for growth are available. The NRC (1981) recommended a mean value of 0.28 g CP was required per g of gain. This value is comparable to the recommendation of NRC (1985) of 0.30 to 0.36 g CP/g of gain and that of ARC (1980) of 0.20 to 0.38 g CP/g of gain for sheep. Greater requirements compared to those of NRC (1981) have been reported by Lu *et al.* (1987); in the latter studies, average protein requirements for growth were 0.82, 0.62 and 0.50 g CP/g of gain in growing dairy goat kids fed 15, 13 and 11% CP diet *ad libitum*, respectively.

In most instances, maintenance and low growth rates can be satisfied by microbial protein synthesis. High growth rate requires additional dietary protein which escapes ruminal degradation. The presence of fish meal in the concentrate mixture resulted in a significant improvement of liveweight gain and feed to gain ratio in kids, but not in lambs (Hadjipanayiotou, 1992; Hadjipanayiotou *et al.*, 1996). Similarly, Hadjipanayiotou *et al.* (1996) demonstrated that inclusion of protein sources of animal origin, may improve kid performance and combination of soybean meal with either fish meal or meat meal will result in satisfactory growth rates even at lower levels of dietary crude protein. Rainfed Mediterranean leguminous grain (broad beans, vetch) have been used successfully as partial or complete replacement for soybean meal (Koumas and Economides, 1987). Furthermore, data from our laboratory support the fact that kids require greater dietary crude protein concentration than lambs of the same age in the postweaning growing period.

The extent and rate of degradation of dietary protein in the rumen is affected by the outflow rate of small particles from the rumen. Studies with growing Chios lambs and Damascus kids showed no significant effect of animal species (Hadjipanayiotou, 1990; Hadjipanyiotou, 1995) and age on fractional outflow rate of small particles from the rumen.

Cereal grain processing

Processing of cereal grains has been practiced with the purpose of ensuring better mixing and digestibility of the ingredients. However, Orskov (1979) reported that any processing of cereal grains for mature and growing sheep is likely to be valueless, and suggested that cereal grains should be given whole. Similar findings were also reported for adult goats (Orskov, 1979; Economides *et al.*, 1989); these findings encouraged the idea of feeding whole grains to young kids. Recent studies however, conducted at the Cyprus Agricultural Research Institute (Hadjipanayiotou, 1990; Economides *et al.*, 1990) showed that cereal grain processing (grinding, rolling or grinding followed by pelleting) is of no value in fattening lambs, whereas grinding of cereal grains and then pelleting with other ingredients of the concentrate mixture results in better feed to gain ratios in kids, and therefore justifies the additional processing expenses and improves net income (Table 4).

Feed additives

Lasalocid sodium (37 g/t) improved daily body weight gain (259 *vs* 277 g), feed to gain ratio (3.8 *vs* 3.45) and suppressed coccidiosis (7 *vs* 1 incidence) in growing Damascus kids on a high concentrate diet offered *ad libitum* (Hadjipanayiotou *et al.*, 1988). Unlike kids, lasalocid sodium did not improve the performance of growing Chios lambs and Friesian calves (Economides *et al.*, 1988).

Table 4. The effect of cereal grain processing on the performance of growing lambs and kids

	P[†]		RGP[††]		WGP[†††]	
	Kids	Lambs	Kids	Lambs	Kids	Lambs
Weight gain (g/day)	278	344	244	341	241	323
Feed/gain	4.54	3.56	5.30	3.70	4.99	3.71

[†]All ingredients in pelleted form
[††]Barley grain rolled other ingredients pelleted
[†††]Barley grain whole other ingredients in pelleted form

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