Nutrition and meat production

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Abstract: *Nutritional treatment, especially of dietary protein and energy variables, is the most important environmental factor affecting meat production in goats. The statement is justified by decreasing per caput supplies, a high income elasticity of demand for goat meat, continuing low productivity in goats, and efficiency in the use of the available feed resources. Improved nutrition results in thicker muscle fibres, better developed muscles in the neck, thorax, and fore limb, and greater omental and mesenteric fat depots in goats than in sheep. The plane of nutrition affects the growth of muscles, muscle fibre diameter, chemical composition (protein, fat, and minerals), and total energy deposited in the carcass, amount of fat and its distribution, and time to slaughter weight. The feed-conversion efficiency has a marked influence on the efficiency of meat production. Two important indices of goat meat value are total edible and total commercial proportions, which range from 48 to 72% and 56 to 96%, respectively. These indices must be considered in the context of the economic value of the carcass and noncarcass components of goat meat. The nutritional strategies that merit attention are increased utilization of crop residues, agroindustrial by-products, and nonconventional feeds, increasing the use of dietary nitrogen sources, use of urea–molasses block licks, strategic use of supplementary proteins, and increased cultivation and utilization of proteinaceous forages. These strategies can provide for the more efficient use of feed resources and the application of innovative feeding systems to stimulate increased goat meat production in Asia.*

Résumé: *La nutrition, en particulier les protéines alimentaires et les variables énergétiques, est le principal facteur externe de production de viande chez les chèvres, un énoncé que justifient les approvisionnements décroissants per capita, la forte demande de viande caprine, par ceux dont le revenu est élevé, la constante faible productivité des chèvres et l'efficience de l'utilisation des ressources alimentaires disponibles. Une meilleure nutrition engendre une augmentation du volume de la fibre musculaire, une meilleure musculature du cou, du thorax et des membres antérieurs, et des dépôts de gras omentals et mésentériques plus importants chez la chèvre que chez le mouton. Le niveau de nutrition influe sur la croissance des muscles, le diamètre de la fibre musculaire, la composition chimique (protéines, gras et minéraux), l'énergie totale emmagasinée dans les carcasses, la quantité de gras et sa distribution et le poids à l'abattage. L'efficacité de la conversion alimentaire a aussi une influence marquée sur la production de viande. Il existe deux indices importants de la valeur de la viande caprine : la proportion de viande comestible et la proportion de viande commerciale, lesquelles varient, respectivement, entre 48 et 72 % et entre 56 et 96 %. On doit prendre en considération ces indices suivant la valeur économique de la viande qui provient et de la carcasse et du reste de l'animal. Les stratégies nutritionnelles qui méritent notre attention reposent sur l'utilisation accrue des résidus des cultures, les dérivés agroindustriels, les aliments inhabituels, une plus grande utilisation des sources alimentaires azotées, l'utilisation de blocs d'urée et de mélasse à lécher, l'utilisation stratégique de suppléments protéiques ainsi que la culture et l'utilisation accrues des fourrages protéiniques. Ces stratégies assurent une meilleure utilisation des ressources alimentaires et des systèmes alimentaires innovateurs et, partant, l'augmentation de la production de viande caprine en Asie.*

Resumen: *El tratamiento nutricional, especialmente de proteína dietética y variables energéticas, es el factor ambiental más importante que afecta la producción de carne en las cabras. La afirmación anterior se justifica por la disminución en el suministro per capita, una gran elasticidad en el ingreso en la demanda de carne de cabra, una baja productividad continuada en las cabras, y la eficiencia en el uso de los recursos alimentarios disponibles. Una nutrición mejorada trae como resultado fibras musculares más gruesas, músculos mejor desarrollados en el cuello, tórax, extremidades toráxicas, y un* *omental y depósitos mesentéricos de grasa de mayor tamaño en las cabras que en las ovejas. El plano de nutrición afecta el crecimiento de músculos, el diámetro de fibra muscular, la composición química proteína, grasas y minerales, y la energía total depositada en la canal, la cantidad de grasa y su distribución y el peso en el momento de la matanza. La eficiencia en la conversión del alimento tiene una marcada influencia en la eficiencia de la producción de carne. Dos indices importantes del valor de la carne de cabra son las proporciones comestibles y comerciales totales que van del 48 al 72% y del 56 al 96% respectivamente. Esos índices se deben considerar en el contexto del valor económico de los componentes de la canal y los que no pertenecen a la canal en la carne de cabra. Las estrategias nutricionales que merecen la atención son el incremento en la utilización de residuos de consechas, subproductos agroindustriales y alimentos no convencionales que incrementan el uso de fuentes dietéticas de nitrógeno, el uso de bloques para lamer de urea y molasas, el uso estratégico de proteínas suplementarias y un incremento en el cultivo y utilización de forrajes proteínicos. Estas estrategias pueden llevar a un uso más eficiente de recursos alimenticios y la aplicación de systemas innovativos de alimentación para estimular una mayor producción de carne de cabra en Asia.*

The efficient nutrition of goats is the most important factor affecting meat production of developing-country species (Devendra 1987a). This is justified by three considerations. Firstly, the availability of dietary nutrients influences to a large extent the genetic potential of the animal in terms of edible tissues produced. Secondly, feed costs are perpetually increasing and efficient nutritional management implies that the dietary nutrients that are fed can support maximum growth, in which the value of the response is greater than the cost of the feeds utilized. Thirdly, efficiency in the use of the available feed resources assumes that these resources will be used by appropriate animal species, consistent with their dietary needs, capacity, and potential value for meat, milk, fibre, or skin production.

The value of these considerations is particularly compelling in two contrasting situations. In countries such as Pakistan, India, and Bangladesh, chronic feed shortages continuously limit per-animal performance such that many of the important breeds seldom demonstrate high production. By comparison, elsewhere in Southeast Asia, there are abundant sources of fibrous, lignocellulosic materials and nonconventional feed resources, some of which may be fed to goats and converted to meat. Under these circumstances, there is clearly a need for innovative feeding strategies that can provide maximum productivity from goats in Asia. This is especially important in the face of decreasing per caput supplies, increasing demand, and a high income elasticity of demand for the goat meat (Devendra, this issue).

In striving for a high efficiency of production, it is especially important in specific feeding systems aimed at maximizing productivity to maintain an appropriate species, to aim for a realistic potential level of production, to take advantage of the available dietary ingredients, and to identify the objectives clearly in terms of production and profitability. In this, it is particularly important to understand the intrinsic abilities of goats, various aspects of their feeding behaviour, their response to individual environments, and their potential productivity in the context of the efficient utilization of production resources. With specific reference to feed resources, it is equally important to keep in perspective the participation of rumen microorganisms to convert the energy of cellulose, hemicellulose, and other structural carbohydrates, especially coarse fibrous materials, and various nitrogenous compounds, including nonprotein substances like urea and poultry litter, into useful animal products.

This paper emphasizes the special significance of nutrition, its influence on meat production with reference to growth and tissue composition, and some strategies that can be pursued to increase goat meat production in Asia.

Growth

Fowler (1968) described growth to include two aspects: increase in mass per unit time and changes in form and composition resulting from differential growth of the component parts of the body. The process of growth and the physiological factors governing it in young animals also apply to kids. This involves centripetal body growth and successive growth and development of the tissues: bones, muscle, and fat, in that order. However, the tissue compositional characteristics are somewhat different in the kid. This refers particularly to water, lipid, and ash contents, which are lower than in lambs (Gaili 1976).

The nutritional factors affecting growth and meat production have been studied in several breeds in several countries. The pattern obviously varies with breed and environmental factors and is reflected, for example, in the adult body weight of selected breeds of meat goats with a live weight range of 11.2–24.6 kg at 12 months age (Devendra and Burns 1983). These differences are a manifestation of adaptation and function because of the plane of nutrition. Particular reference is made to the studies on the East African goat in Uganda (Wilson 1958a,b, 1960); Katjang goats in Malaysia (Devendra 1966); Barbari and Jamunapari goats (Sengar 1975) and Osmanabadi goats (Gaffar and Biabani 1986) in India; Boer goats in South Africa (Skinner 1972); and Sudan Desert goats (Gaili 1976). These studies, with the exception of those in India, have been recently reviewed by Devendra and Burns (1983).

It is appropriate to refer to the early classical work of Wilson (1958a,b, 1960), who studied the growth and development of kids from birth to slaughter and evaluated the carcasses. Nutritional status had a considerable effect on live weight gain and external measurements. In kids weighing about 2.2 kg at birth, the greatest linear increase was shown by body length; least, by length of the lower hind leg. Sex differences were apparent for all the external measurements studied when the results were compared on the basis of equal age, male kids having significantly larger measurements than female kids. The effect of nutritional regime produced significant differences in all external measurements studied on the basis of equal age and equal weight, with low-plane kids having larger measurements than high-plane kids. A high plane of nutrition had a significant effect on growth rate: high-plane kids reaching 15 kg at approximately 20 weeks; low-plane kids reaching 15 kg after 48 weeks. The sex difference in live weight increased markedly after 16 weeks. Whereas the weekly growth of females slowed to approximately 0.2 kg/head, the males continued at the rate of approximately 0.5 kg/head. The kids showed a marked recuperative capacity when changed from low- to high-plane feeding, indicating the significance of good feeding for growth, even at a later stage.

Muscle

Muscles enable bodily function and their total content and quality are of economic significance. Muscle is also the tissue of primary importance in a nutritional context. The genetic capacity for growth, in particular, the influence of nutrition, has a strong effect on the rates of growth in different muscles. The pattern of growth can in turn influence bodily function and the type of muscular activity.

In comparative studies between goats and sheep, Owen et al. (1978) and Gaili and Ali (1985a) have reported that goats tend to have more carcass muscle

Table 1. Mean fibre diameter (μm) of three muscles from control and fattened Sudan Desert goats and sheep.

Muscle	Sheep		Goats		SE[a]
	Control	Fattened	Control	Fattened	
Semitendinosus	35.8	44.9	37.8	62.5	0.96[a]
Longissimus (lumbar)	32.5	52.8	34.3	60.9	0.62[b]
Biceps brachii	41.7	45.8	45.2	64.7	0.79[b]

Source: Gaili and Ali (1985b). Standard error of the difference between two means.

[a]Standard error of the difference between two means.

[b]Row means differ significantly (P < 0.05).

and bone than sheep. Both studies also reported that the muscles of the neck, thorax, and forelimb regions of the goat were better developed than in sheep. However, the back and leg muscles were less developed in goat than in sheep. In all the muscles studied by Gaili and Ali (1985a), goats had significantly ($P < 0.05$) thicker fibres than sheep; the differences between species were more marked in fattened animals compared with the control (Table 1). These results suggest clearly that goats respond more to nutritional treatment than do sheep, since the differences of the results between species were greater for goats than for sheep. Thus, for example, the differences for semitendinosus, longissimus thoracis et lumborum (thoracic part), and biceps brachii muscles in goats were 24.7, 26.6, and 19.5 μm, respectively; the corresponding values in sheep were 9.1, 20.3, and 4.1 μm. When the data for goats were expressed as a percentage of the corresponding fibre diameter of the control animals, the results were 65.3, 77.5, and 43.1%, respectively; the corresponding values for sheep were 25.1, 62.4, and 9.6%. In both species, the longissimus thoracis et lumborum (thoracic part) increased most in fibre thickness and biceps brachii exhibited the lowest increase. Semitendinosus was intermediate.

Fat deposition

Of all tissues, the effects of dietary energy and protein variables are particularly conspicuous on adipose tissue. Breed differences are apparent in the deposition of adipose tissue and perhaps even in the mobilization of the lipids depending on function (meat, milk, or dual purpose) (Table 2). Subcutaneous fat deposition is low and, in any case, occurs late in the growth process. Visceral fat deposition such as renal and mesenteric fat follow later.

The content of adipose tissue is dictated principally by the plane of nutrition, especially the availability of dry matter (DM), level of feeding, and energy and protein contents. Generally speaking, the higher the availability of DM, energy, and protein, the greater the process of growth and deposition of fat. This is seen in the total content of the tissue in the carcass (Table 2) and its distribution (Table 3). Wilson (1960) also demonstrated this point, including the fact that females contained more fat than males.

Between goats and sheep, species differences in the deposition of fat in terms of amount and location are evident. The comparative study of Gaili and Ali (1985a) involving control and fattened animals showed that sheep had less

Table 2. The effect of plane of nutrition on percentage tissue composition in Barbari and Jamunapari bucks slaughtered at 14 months in India.

Tissue	Place of nutrition[a] HH	MM	LL	Significance[b]
		Barbari		
Bones	18.3	18.5	23.1	$P < 0.05$
Muscle	54.3	54.3	61.5	$P < 0.05$
Fat	27.9	28.5	15.4	$P < 0.05$
Total edible	86.0	86.3	82.0	$P < 0.05$
		Jamunapari		
Bones	18.3	18.5	23.1	NS
Muscle	63.4	57.8	55.2	NS
Fat	13.7	19.4	15.7	NS
Total edible	81.7	81.5	77.0	NS

Source: Adapted from Sengar (1975).
[a]HH, high energy, high protein; MM, medium energy, medium protein; LL, low energy, low protein.
[b]NS, not statistically significant.

Table 3. The effect of plane of nutrition averaged carcass measurements (mm) in Barbari and Jamunapari bucks at 14 months in India.

Measurement	Plane of nutrition[a] HH	MM	LL	Significance[b]
		Barbari		
Length of eye muscle	43.8	43.8	35.0	NS
Depth of eye muscle	19.5	21.0	13.0	NS
Back fat thickness	1.4	2.2	1.0	NS
Thickness of fat over ribs	6.8	7.6	2.0	NS
		Jamunapari		
Length of eye muscle	32.7	43.8	30.0	NS
Depth of eye muscle	17.0	20.5	12.0	NS
Back fat thickness	1.0	0.9	1.0	NS
Thickness of fat over ribs	1.0	3.0	2.0	NS

Source: Adapted from Sengar (1975).
[a]HH, high energy, high protein; MM, medium energy, medium protein; LL, low energy, low protein.
[b]NS, not statistically significant.

developed omental and mesenteric fat depots than goats because of an increased response by the latter to deposit fat in these locations (Table 4).

For the same reason that the extent of fat deposition is controlled principally by the plane of nutrition, a poor covering of fat on the carcass is a reflection of inadequate dietary nutrients. This was evident, for example, in the quality of goats slaughtered for meat to serve Madras city in India. The animals came from rural areas with a background of poor nutrition in which no supplements were provided

Table 4. Adjusted mean weight (±SE) and location of fat deposition in Sudan Desert goats and sheep.

Item[a]	Goats		Sheep	
	Control	Fattened	Control	Fattened
Omentum	60±17	190±40	80±25	110±23
Mesenteric fat	72±30	210±20	90±20	130±30
Tail	9±2	11±2	84±60	149±70

Source: Gaili and Ali (1985a).
[a]Weights of omentum and mesenteric fat are adjusted to common empty body weight (18.03 kg) and tail weight is adjusted to left side weight (4.1 kg) along the slopes of the common regression lines.

Table 5. Growth responses of goats to a rice straw diet supplemented with *Leucaena*, rice bran, and molasses in the Philippines.

Diet[a]	Dry matter intake ($g/kg^{0.75}$)	Daily live weight gain (g)	Feed-conversion efficiency
30% RS + 70% L	64.83a	35.7b	12.56b
30% RS + 50% L + 20% RB	71.82a	68.6a	7.65a
30% RS + 50% L + 20% M	70.40a	50.0ab	10.54b

Note: Means followed by a different letter are significantly different ($P < 0.05$). Each diet mean is the average of five replications.
Source: Rasjid and Perez (1980).
[a]RS, rice straw; L, *Leucaena*; RB, rice bran; M, molasses.

(Thulasi and Ayyaluswami 1983). Live goats and sheep from India were preferred in Saudi Arabia for their lean and tender meat as compared with sheep from Australia, presumably on account of the lesser fat content in the carcasses of the former (IIFT 1978). Likewise, Gaili and Ali (1985a) reported a poor deposition of subcutaneous fat in Sudan Desert goats and sheep, which they attributed to the arid environment. It is pertinent to note that there is one practical implication of carcasses with a low content of subcutaneous fat. The evaporative losses could be higher and this must be minimized by better packing and storage of the meat.

Concerning the utilization of available nutrients, the feed-conversion efficiency has a marked influence on the efficiency of meat production. Feed-conversion efficiency is a function of feed composition and the level of feeding relative to maintenance requirements, which, in turn, are dependent on physiological state and maturity. This is evident in the growth response of Philippine goats over 84 days to three types of supplements (*Leucaena leucocephala*, rice bran, and molasses) in a rice straw diet (Table 5).

Effects on carcass composition

Age has a marked effect on carcass composition. In the study of Wilson (1958b), female East African goats were killed at birth and at weights of 4.1, 7.3, 11.3, and 13.6 kg; the carcasses were then evaluated. Since the economic value of the African goat keeper is its meat, edible offal, edible fat, and skin, the dissection data were grouped to show how these components varied with changed in live weight. The proportion of meat in the live animal increased from 24.5 to 37.5% between birth and 4.1 kg; thereafter, the proportion of meat decreased irregularly to 34.9 at 13.6 kg live weight. The proportion of edible offal fell from 6.4% of the total live weight at birth to 4.8% at 13.6 kg. Edible fat increased from 2.6% at birth to a maximum of 11.3 kg and fell to 8.6% at 15 kg live weight. The proportion of skin fell from 12.4% at birth to 7.2% at 13.6 kg.

In India, a long-term study was undertaken on the effects of the plane of nutrition on Barbari and Jamunapari goats. Three levels of energy and protein (75, 100, and 125%) were used employing the Morrison (1956) recommendations in a total of nine treatments. The main findings of this study relevant to this paper

Table 6. The effect of plane of nutrition on daily growth (g/head) of Barbari and Jamunapari kids in India.

	Plane of nutrition			Significance[b]	
Breed	HH	MM	LL	Energy	Protein
Barbari					
0-6 months	36	33	27	P < 0.05	NS
0-14 months	42	38	22	P < 0.05	NS
Jamunapari					
0-6 months	44	46	44	-	-
0-14 months	39	41	30	P < 0.05	P < 0.05

Source: Adapted from Sengar (1975).
[a]HH, high energy, high protein; MM, medium energy, medium protein; LL, low energy, low protein.
[b]NS, not statistically significant.

Table 7. The effect of plane of nutrition on carcass characteristics of Barbari and Jamunapari bucks slaughtered at 24 months in India.

	Plane of nutrition			
Characteristics	HH	MM	LL	Significance[b]
	Barbari			
Live weight at slaughter (kg)	18.7	19.4	11.4	P < 0.05
Dressed carcass (%) weight (kg)	9.2	9.7	4.5	P < 0.05
Dressing(%)[c]	57.3	58.3	53.7	P < 0.05
Edible offals (%)[c]	21.4	20.0	20.6	P < 0.05
	Jamunapari			
Live weight at slaughter (kg)	20.3	21.0	15.8	P < 0.05
Dressed carcass (%) weight (kg)	9.7	9.8	6.1	P < 0.05
Dressing(%)[c]	53.2	53.2	55.5	NS
Edible offals(%)[c]	18.9	20.1	22.9	-

Source: Adapted from Sengar (1975).
[a]HH, high energy, high protein; MM, medium energy, medium protein; LL, low energy, low protein.
[b]NS, not statistically significant.
[c]Expressed as percent of empty live weight.

can be found in Sengar (1975). Growth was retarded and significantly low ($P < 0.05$) with low levels of energy and protein (Table 6). This was manifested in reduced live weight at slaughter, dressed carcass weight, dressing percentage, edible offals as percentage of empty live weight (Table 7), and bone, muscle, and fat composition, especially in Barbari goats (Table 2). The effect of the protein and energy variables on length and depth of the eye muscle, back-fat thickness, and thickness of fat cover on the ribs, however, was not significant (Table 5). Similar results on the carcass characteristics of Osmanabadi bucks have been reported by Gaffar and Biabani (1986). In Mauritius, diets based on sugarcane, sugarcane tops, and *Leucaena* significantly influenced carcass tissues (bone, $P < 0.01$; meat, $P < 0.01$; fat, $P < 0.05$; tendon, $P < 0.001$) in local and Anglo-Nubian goats (Jotee 1984).

Effect on chemical composition

Nutritional treatment has a definite effect on the chemical composition of tissues, notably the protein, fat, and ash contents on Barbari and Jamunapari goats. Gaffar and Biabani (1986) showed that a high dietary energy significantly increased ($P < 0.01$) the fat content, daily energy gain, and total energy deposited in the carcasses of Osmanabadi bucks (Table 8). These results are similar to the situation in Barbari goats (Sengar 1975) and sheep (Andrews and Orskov 1970; Ali 1975). Gaili and Ali (1985b) showed that nutritional treatment and species had a significant ($P < 0.01$) effect on the protein, fat, and ash contents of the muscles of goat and sheep (Table 9). The effect of the nutritional treatment × species interaction was significant ($P < 0.01$) in all muscles for protein and fat but not for ash (Table 10).

Osmanabadi bucks (see Table 8) yielded more protein in the suprapinatus muscle than did sheep. In both the semimembranosus and the longissimus thoracis et lumborum (lumbar part) muscles, control or fattened goats had more protein than both groups of sheep.

Total edible and saleable percentages

The total edible (meat and some offal) and commercially valuable (meat and offals) portions of the carcass are important aspects of the economic value of goats for meat production (Devendra and Owen 1983). They are important indices of value throughout the tropics (Table 11). The total edible portions include the offals, which are valuable for two reasons. First, they are extensively consumed in varying ways. Second, the value of the offals offsets the cost of slaughter.

In most developing countries, the value of meat animal is reflected in the commercial value of the carcass and the cuts that comprise it. The latter refers primarily to he edible components. With reference to goats, the traditional reference to only the carcass and its components is not entirely realistic because, as Table 11 suggests, there are other noncarcass components that are important for edible and commercial reasons. Total fat, for example, is a function of nutritional treatment in terms of the extent of fat deposition, especially in the viscera, and is important in estimations of total edible and total saleable percentages. It is suggested that, so far as goats are concerned, nutritional treatment and growth responses in economic and commercial terms must consider the carcass as well as the total saleable value, including noncarcass components as units of trade.

Table 8. Effect of dietary protein and energy variables on the body composition and nutrient deposition in Osmanabadi bucks in India.

Treatment[a]	Body composition: Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Gross energy (Mcal/kg)	Total protein deposited (kg)	Total energy deposited (Mcal)	Daily protein gain (g)	Daily energy gain (kcal)
Control	74.1	16.3	4.0	3.4	3.92	1.0	6.35	-	-
LP:LE	67.1	18.8	7.8	4.5	4.78	4.1	34.45	9.7	88.91
LP:ME	66.3	18.7	9.0	4.9	5.09	3.8	34.48	9.7	89.80
LP:HE	62.8	12.7	10.0	2.5	5.38	4.2	41.69	10.0	112.71
HP:LE	65.9	19.6	7.6	4.8	4.68	4.1	33.17	13.3	116.76
HP:ME	65.2	19.9	8.5	5.0	5.49	4.4	41.99	12.3	130.85
HP:HE	61.1	19.6	12.4	5.1	5.93	4.1	48.49	14.5	195.98
SE[b]	1.49	3.85	0.95	0.93	0.33	0.06**	1.39*	0.35	6.34*

Note: 1 cal = 4.19 J.
Source: Adapted from Gafar and Biabani (1986).
[a]LP:LE, low protein, low energy; LP:ME, low protein, medium energy; LP:HE, low protein, high energy; HP:LE, high protein, low energy; HP:ME, high protein, medium energy; HP:HE, high protein, high energy.
[b]Standard error: *, $P < 0.05$; **, $P < 0.01$.

Table 9. Protein and fat contents (%, dry matter basis) of three muscles in Sudan Desert sheep and goats.

Muscle	Sheep		Goats		
	Control	Fattened	Control	Fattened	SE[a]
Semitendinosus					
Protein	88.1a	75.8c	78.6b	64.4d	0.33
Fat	8.2d	21.0c	17.9b	33.4a	0.43
Semimembranosus					
Protein	87.3a	81.2b	75.3c	66.0d	0.39
Fat	9.5d	16.8c	21.8b	31.9a	0.46
Longissimus (lumbar)					
Protein	86.5a	79.1b	75.8c	65.7d	0.28
Fat	10.0d	17.6c	21.4b	32.3a	0.45

Note: Means in a row followed by a different letter differ significantly ($P > 0.05$).
Source: Gaili and Ali (1985b).
[a]Standard error of the mean.

Table 10. Ash content (%, dry matter basis) in three muscles of Sudan Desert sheep and goats.

Muscle	Species			Treatment		
	Goats	Sheep	SE[a]	Control	Fattened	SE[a]
Suprapinatus	3.3	2.8	0.45	3.6	2.5	0.45
Semimembranosus	3.1	2.5	0.27	3.0	2.6	0.27
Longissimus (lumbar)	3.4	2.4	0.32[b]	3.1	2.6	0.32

Source: Gaili and Ali (1985b).
[a]Standard error of the difference between the two means.
[b]The difference between the two means is significant at $P < 0.05$.

Table 11. Total edible and total commercially valuable meats of various breeds of adult goats in the tropics.

Breed (sex)[a]	Location	Total edible (%)	Total commercially valuable (%)	Source
Small East African (F)	Uganda	48.3	55.5	Wilson (1958b)
Katjang(F)	Malaysia	61.2	81.5	Devendra (1966)
Indigenous(M)	Malawi	74.5	80.5	Owen (1975)
Barbari(M)	India	87.6	-	Sengar (1975)
Indigenous(M)	Botswana	72.3	79.6	Owen et al.(1978)
Indigenous(M)[b]	Botswana	71.8	79.2	Owen et al.(1978)
Indigenous(F)	Botswana	74.3	80.9	Owen et al.(1978)
Boer(F)	Botswana	70.0	78.0	Owen et al.(1978)
Katjang(F)	Malaysia	71.5	96.2	Devendra (1980)

[a]F, female; M, male.
[b]Male castrates.

Nutritional strategies

The justification for appropriate nutrition and more attention to efficient nutritional management are associated with the continuing low productivity in goats. It is also justified by the considerable opportunities for applying the recent advances in goat nutrition. The nutritional strategies that can be pursued for accelerating meat production have been recently discussed (Devendra 1987b,c):

- Increased utilization of crop residues, agroindustrial by-products, and nonconventional feeds;
- Increased use of dietary nitrogen sources;
- Use of urea–molasses block licks;
- Strategic use of supplementary protein sources; and
- Increased forage cultivation and utilization, especially of *L. leucocephala*, cassava (*Manihot esculenta*) leaves, sesbania (*Sesbania grandiflora*), and pigeon pea (*Cajanus cajan*) (Fig. 1).

The basic strategy is to ensure that a sufficient amount of feed from the available resources is available on a year-round basis and can match the requirements of the animals for meat production. Innovative measures and efficient feeding systems in which dietary nutrient supply can be constantly ensured, taking advantage of seasonal surpluses, conservation, and storage practices, are important. Concerning the potential value of cereal straws and other fibrous agricultural residues, options for increasing their utilization by goats have recently been discussed (Trung and Devendra 1987). Urea or ammonia treatment and the use of leguminous forages are particularly promising.

Fig. 1. Woman and children carrying cut fodder for feeding goats in Nepal.

Table 12. Performance of weaner kids in a semi-arid environment in India.

Parameter	B[a]	B+F	B+C	B+F+C
Initial weight (kg)	12.0	12.0	12.7	12.5
Final weight (kg)	13.8	14.7	22.8	22.3
Total weight gain (kg)	1.8	3.7	10.0	9.7
Average daily weight gain (g)	19.4a	41.7b	111.0c	108.2c
Dressing (%)	45.7a	44.5a	48.2b	49.1b
Net return per kid (INR/90 days)[b]	–	9.0	3.6	0.2

Note: Means in the same row followed by a different letter differ significantly ($P < 0.05$).

Source: Parthasarathy et al. (1983).

[a]B, browsing (7 h/day); F, forage; C, concentrates.

[b]In February 1988, 12.2 Indian rupees (INR) = 1 United States dollar (USD).

The strategic use of protein supplements merits special attention because of the high cost of dietary protein. The use of a protein supplement for goat meat production must be carefully considered especially in relation to genotype and potential for growth. The importance of strategic supplementation is seen in the results of a recent study in India. The treatment involved feeding either green forage, concentrates, or green forages and concentrates to browsing weaner kids (Table 12). As would be expected, treatments significantly stimulated daily live weight gains and affected dressing percentages ($P < 0.05$). The net returns indicated that the supplementary feeding with forages gave the highest margin of profits followed by concentrates and the combined treatment. The results emphasize the value of green forages and question the necessity for feeding concentrates for meat production.

The strategy of efficiently using scarce concentrates implies that protein concentrates must be conserved and preferentially utilized, e.g., coconut cake, cottonseed cake, fish meal, groundnut cake, palm kernel cake, soybean meal, and rice bran, all of which are commonly found. Many of these examples are more efficiently used by nonruminants animals; some may even need to be protected for local use rather than be exported.

Conclusions

Meat-production efficiency in goats necessitates that the available feed resources and feeding systems compatible with high production be used. The process of growth and the physiological factors governing it as well as the effects of dietary protein and energy variables on tissue growth in goats are similar to those in other animals. However, as might be expected, species differences exist. Goats appear to have thicker muscle fibres, better developed muscles in the neck, thorax, and forelimb, and greater omental and mesenteric fat depots than sheep. Although traditionally, the carcass and its components are considered in economic and commercial terms as the unit of trade; in goats, in addition to the carcass, noncarcass components and the total saleable components assume economic significance. The opportunity to increase goat meat production is enormous in the context of the more efficient use of production resources and innovative nutritional strategies.

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Abstract/Résumé/Resumen

Abstract: This publication presents the results of a workshop held in Tando Jam, Pakistan, 13–18 March 1988, that focused specifically on all aspects of goat meat production in Asia. The workshop addressed the factors affecting meat production (breeding, nutrition, reproduction, sex, management, animal health, and diseases), the nutritional value of goat meat, methods of slaughter, processing techniques, consumer preferences, and the national and international marketing of goats. The detailed discussions on these aspects were further highlighted by country case studies, prevailing situations, issues and policies, and potential for improving the prevailing patterns of production. An important session covered broader issues concerned with research and development, strategies for increasing production, and export potential, especially in Near East markets. These discussions enabled a definition of research and development priorities and the scope for increasing goat meat production.

Résumé: Cette publication fait le compte rendu d'un atelier tenu à Tando Jam, au Pakistan, du 13 au 18 mars 1988 et qui a porté sur tous les aspects de la production de la viande de chèvre en Asie. Il y a été question notamment des facteurs influant sur la production de la viande (sélection des espèces, nutrition, reproduction, sexe, gestion, santé animale et maladies), de la valeur nutritive de la viande de chèvre, des méthodes d'abattage, des techniques de transformation, des préférences des consommateurs et du marketing national et international des chèvres. En plus de discuter de ces questions en profondeur, les participants ont aussi abordé les points suivants : études de cas de certains pays, situations actuelles, enjeux et politiques, et possibilités d'améliorer les tendances actuelles de la production. Lors d'une séance importante, les participants se sont penchés sur des questions plus vastes concernant la recherche et le développement, les stratégies qui permettraient d'augmenter la production et les possibilités d'exportation, particulièrement vers les marchés du Proche-Orient. Ces discussions ont permis de définir des priorités en matière de recherche et de développement et de déterminer le potentiel de croissance de la production de la viande de chèvre.

Resumen: Esta publicación contiene los resultados de un taller celebrado en Tando Jam, Paquistán, del 13 al 18 de marzo de 1988, dedicado específicamente a todos los aspectos de la producción de carne de cabra en Asia. El taller estudió los factores que afectan la producción de carne de cabra (cruce, nutrición, reproducción, sexo, manejo, salud y enfermedades), el valor nutricional de la carne caprina, los métodos de sacrificio, las técnicas de procesamiento, las preferencias del consumidor y el mercado caprino nacional e internacional. Las discusiones detalladas sobre estos aspectos se vieron además enriquecidas con el potencial para mejorar los patrones prevalecientes de producción. Una de las sesiones importantes cubrió los aspectos más amplios de investigación y desarrollo, estrategias para el aumento de la producción, potencial de exportación, especialmente en los mercados del cercano oriente. Las discusiones permitieron determinar las prioridades de investigación y desarrollo así como las posibilidades para aumentar la producción de carne caprina.

Contents