FOOD PRODUCTION FROM GOATS*

by

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ABSTRACT

The justification for increasing food production from goats rests with the fact that they are neglected in the food production systems. The opportunities for improving this situation are discussed in relation to current contribution, economic importance, biological attributes and potential future production with special reference to the developing countries. 95 per cent of the world population of 473 million goats with an annual growth rate of 1.3 per cent is found in these countries, with large concentrations being found in Asia and the Pacific (57.4 per cent) and Africa (32.0 per cent). The economic value of the species is reflected in the contribution of about 93 per cent of the meat, 73 per cent of the milk and 94 per cent of the fresh skins out of the total world production of these products.

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There was also a total production of approximately $14,550 \times 10^3$ m tons of mohair. Miscellaneous functions include value in income accumulation, employment, security, dung for fertiliser, handicraft and by-product utilisation. Meat is the most important product and three types are produced. The goat genetic resources include 23 valuable improver breeds which have special attributes. The management practices are village, extensive, semi-intensive, very intensive and integration with cropping systems. Very intensive systems using various cultivated forages can support 37-126 goats/ha. The main thesis of this paper is that the present level of productivity can be substantially increased and is associated with more effective use of existing breeds, efficient use of the feed resources, improved health and the formulation of priorities that can focus specifically on the development of goats. This strategy is necessary because although the value of goats is widely recognised, there is inadequate concerted support for its development. It is especially justified for maximising food production which can significantly improve the status and quality of life of the rural people in the developing countries.
I. INTRODUCTION

Food production from the animal genetic resources constitutes a major area of concern in the developing countries. There are two specific reasons for this. Firstly, the rate of food production and distribution from animals has failed to keep pace with the annual growth rate of the human population. Secondly, protein especially of animal origin, rather than energy, is the main limiting factor in the diet of the majority of people in the developing countries. Consequently, the contribution from animals, actual and potential, has been the subject of considerable focus in recent years. The question that can be asked is why is the animal harvest inadequate, and whether this is due to the ineffective and inefficient utilisation of the livestock resources and the application of available technology.

With reference to goats, the fact is that they are probably the most neglected of domestic ruminants in the food production systems of many developing countries. Thus, an enquiry into the value and food production capacity of goats especially in developing countries is timely and appropriate, especially since in recent years, there has been widespread enlightened interest throughout the world about their role in farming systems, biological attributes and potential
contribution. This recognition has been largely stimulated by advances in the science of the species [Gall (1981); Leach (1982); Devendra and Burns (1983)], national consciousness such as the setting of the National Goat Research Institute in India, and international developments: the establishment of the small ruminant collaborative research support programme by the United States Agency for International Development (U.S.A.I.D.), the activities of notably the International Goat Association and also that of such other agencies as the Food and Agriculture Organisation (F.A.O.), the International Livestock Centre for Africa (I.L.C.A.) and International Development Research Centre (I.D.R.C.). More recently, there has been a World Bank assessment of the present and potential role of sheep and goats in development countries [World Bank (1983)].

The main thesis of this paper is that goats can contribute to increased food production. This assumes a good understanding of the characteristics of the species, thorough exploitation of the avenues favouring production and their economic utilisation. Improvements can come from four main areas: better use of existing breeds and improved breeding, increased efficiency of feeding, improved health and the formulation of priorities that can focus specifically on goats. It is also dependent on the removal of the major constraints that
affect production systems. The paper provides a comprehensive discussion of these aspects.

II. POPULATION AND DISTRIBUTION

(Table 1 here) Table 1 sets out the distribution of the world population of goats. It is significant to note that approximately 95 per cent of the total world population of goats is found in the developing countries. Of this, the largest populations are found in Asia and the Pacific (57.4 per cent) and Africa (32.0 per cent). Within Asia and the Pacific, the heaviest concentrations are found in China, India, Pakistan and Bangladesh which together accounted for about 78 per cent of the total population in this region. Within Africa, large populations are found in Nigeria, Ethiopia, Somalia and Sudan; these together account for about 48 per cent of the total population in the continent.

Consistent with the high populations in Asia and the Pacific and Africa, these two regions also recorded highest annual growth rates of 1.6 - 1.8 per cent over the period 1961-1965 and 1980-1982. The exception was Oceania with the highest growth rate of 6.4 per cent per annum. Table 1 also indicates that the ratio of goats:sheep was narrowest for Asia and the Pacific and Africa. It is also of interest to note that the goat population represents about 16 per cent of the total world population of domestic ruminants.
The distribution of goats varies according to size of holdings. In Asia, about 64 per cent of the population of goats and 46 per cent of the population of sheep are kept in holdings below 5 ha of land. Small farm systems combining animals with crops, including goats, is thus the backbone of traditional agriculture in Asia [Devendra (1983a). By comparison in Africa, where extensive management systems are more common, about 89 per cent of the goats and 91 per cent of the sheep were kept in holdings of between 1 to 100 ha. A parallel situation was true for the distribution of cattle.

III. CURRENT CONTRIBUTION

The economic contribution of goats in developing countries is reflected in the main products from them: meat, milk, skins and mohair. Table 2 indicates that the developing countries together produced as much as 92.5 per cent of the meat, 73.0 per cent of the milk and 94.3 per cent of the fresh skins of the total world production. Mohair is an important fibre from goats and the main producers are South Africa, Turkey, Texas (U.S.A.), Lesotho and Argentina together produced about 14.6 m tons of the product. Another type of fibre of considerable economic significance is pashmina (cashmere) produced in Central Asia.
IV. FOOD FROM GOATS

Goats produce two very important foods, which in order of importance in the developing countries are meat and milk. It is appropriate to briefly discuss these.

1. Meat

Three types of goat meat are produced [Devendra (1981)]:
(a) meat from kids (cabrito, 8-12 weeks of age)
(b) meat from young goats (1-2 years of age)
(c) meat from old goats (2-6 years of age)

The first type of meat is very popular in Latin America and the Caribbean. The second category is possibly the most widely produced meat, while the third group generally produces tougher meat. A large proportion of the meat produced in the tropics comes from this group.

Presently, the demand for goat meat is in excess of supply and this has resulted in very high prices for the meat as well as live animals. In many countries such as in South East Asia, the West Indies and parts of Africa, goat meat is the highest priced relative to all other meats sold in the market. This has resulted in three notable
developments. Firstly, there has been an increased import of feral goat meat from Australia and New Zealand to lucrative markets in the Near East region. Secondly, there has also been considerable substitution of goat meat by poor quality mutton to take advantage of the high price differential between the meats. The third development, and a continuing one, is increased slaughter of especially breeding animals, which has had the effect of reducing the rate of growth of the base population. A case in point is Central America and the Caribbean where increased demand for goat has resulted in this situation (Table 1).

The quantitative and qualitative aspects of meat production from goats has been recently reviewed [Devendra and Owen (1983)]. It is generally believed that goat meat has more lean than mutton [Devendra and Burns (1983)], and this is associated with less subcutaneous and inter-muscular fat than sheep [Ueckermann (1969);(Owen et al.,1977, 1978); Ladipo (1973)]. The total edible and commercially valuable portions of the carcass are important aspects of economic goat production. Table 3 indicates that these values are high in many countries in the tropics. In
temperate countries, a recent development has been the use of goat meat in the sausage industry. Up to 20 per cent goat meat has been used in frankfurters [(Eggen et al., 1973); (Marshall et al., 1977)]. The addition of up to 40 per cent had little effect on processing characteristics or palatability.

2. Milk

Goat milk is widely consumed wherever it is produced. It is usually consumed fresh, but is also used for making other products. In view of the impact in recent years to promote increased milk production from cows and/or buffaloes, especially for the urban areas in many developing countries, the value of goats producing milk for the rural areas has become especially important.

Goats as suppliers of milk serve a most useful function in producing valuable animal proteins to the rural community. This small and consistent contribution of milk and also meat is significant in that both are available to the vulnerable groups, the subsistence peasants, pregnant and nursing mothers and the young, to whom the supply of animal proteins of high biological value often makes the difference between adequate nutrition
and undernutrition. The majority of these people cannot afford to buy meat and/or milk or, alternatively, are unable to get these by rearing cattle or buffaloes. The efficiency of milk production in dairy cows and goats is the same, but in many parts of the developing countries, however, milk can be produced more efficiently and by use of the limited resources [Devendra and Burns (1983)].

The nutritive value of goat milk is of special interest, Jenness (1980) has recently reviewed this aspect in detail. Although goat, cow and human milks are approximately isocaloric and supply about 3.10 MJ/l of energy, there are differences in the proportions of the energy derived from lactose and protein. In goat and cow milk, fat, protein and lactose account for about 50, 25 and 25 per cent of the energy, but in human milk they furnish 55, 7 and 38 per cent. Calculations of the nutritional adequacy of goat milk for human infants [Jenness (1980)] demonstrated that the supply of protein, calcium, phosphorus, vitamin A, thiamin, riboflavin, and pantothenate were in excess (Figure 1). On the other hand, it was deficient in iron and vitamin A, B12 and C. Goat milk like cow milk, had a satisfactory balance of essential amino acids equalling or exceeding the WHO (1973) requirements for each amino acid.
Three special attributes of goat milk are worthy of mention:-

a) The fat globules are small in size. While the range of size of the fat globules is the same as the cow (1 - 10 \( \mu \)m in diameter), the content of smaller globules is greater [Fahmy, Sirry and Safwat (1956)]. Up to 4.5 \( \mu \)m in diameter, the percentage distribution of fat globules was 85.7 per cent in sheep, 82.7 per cent in goats, 62.4 per cent in cow and 40.9 per cent in buffalo milks.

b) The fat and protein contents are more easily digestible. Tubercle bacillus is rare and there are also anti-allergy properties. Thus goat milk can replace cow milk for those allergic to the latter.

c) The vitamin A is carried intact.

In addition to the use of goat milk for consumption, other products include cheese, butter and yoghurt. Cheeses are particularly popular and over 400 and 800 names of cheeses have been described [Goerner, Palo and Bertan (1968)]. Either pure goat milk or goat milk combined with cow, buffalo or sheep milks may be used [Delforno (1977)]. Fresh cheese ("Queso Blanco" in Latin America), soft cheeses (Greek "Feta") or hard cheeses ("Chevrotin" in France) can be produced.
In Cyprus "Halloumi", a semi-hard cheese is produced and is widely consumed. Other goat milk products include low fat, fortified, flavoured or condensed milks, buttermilk, butter and ice cream; the data on these however, is very limited (Lowenstein et al., 1979)

3. Miscellaneous Functions

Goats are also valued for a variety of other non-food miscellaneous functions. These are worthy of mention especially in the context of their integral role in complex agricultural systems. These include inter alia:

a) Income - important means of earning supplementary income and also income accumulation

b) Employment - creation of employment for shepherds and landless peasants

c) Security - source of investment, security and stability

d) Fertiliser - the return of dung and urine contributes to farm fertility

e) Handicraft - fibre and skins are used extensively in handicraft

f) By-product utilisation - they enable economic utilisation of non-marketable crop residues and value added to these.
V. THE GOAT GENETIC RESOURCES

It is estimated that there are approximately 300 breeds and types of goats in the world, the majority of which are found in the tropics and sub-tropics [Devendra and Burns (1983)]. Of these, 70 breeds are found in Africa and 22 in South East Asia.

Table 4 lists the important improver indigenous breeds in the tropics and sub-tropics according to speciality, excluding the improved dairy breeds from the temperate regions. At least 23 breeds are identified in terms of above-average productivity with respect to meat, milk, prolificacy, mohair, pashmina and skin production. There is no doubt that more concerted and wider use can be made of these breeds and their inherent attributes, including the Anglo-Nubian, Alpine, Saanen and Toggenburg from the temperate areas.

VI. MANAGEMENT SYSTEMS

The management systems appropriate to goats in the developing countries are as follows:
1. Village systems
2. Extensive systems
3. Semi-intensive systems
4. Very intensive systems, and
5. Integration with cropping systems
Of these, the semi-intensive to extensive systems are not particularly common. By comparison, the village, extensive and integration with cropping systems are the traditional methods.

1. Village Systems

Village systems of feeding are of two categories. One is tethering, where 1-5 heads are involved in situations where there is intensive crop cultivation. The second alternative is to feed in situ the various crop residues available. In addition, in both systems, kitchen remnants are commonly given.

2. Extensive Systems

Extensive grazing is common where there is access to grazing and marginal land, using family labour involving mainly women and children. The flock sizes are large (1 to 15 heads) and goats often mixed with sheep belonging to several owners are run together and brought back in the evening. Stocking rates are usually in the range of 1-4 heads/ha. Very extensive systems are rare, as with other parts of the humid tropics, presumably because of the availability of more forages and also crop residues.
3. **Semi-intensive Systems**

Semi-intensive systems are a compromise between the more primitive extensive and intensive systems, depending on the availability of time, labour and also feeds. It is essentially a part-time operation like the village systems. The duration of grazing is about 4-6 hours per day, usually in the late morning or evening. The goats are then housed and given cut forage, mainly tree leaves or crop residues. Very seldom are concentrates offered.

4. **Very Intensive Systems**

Very intensive systems are of two categories: intensive use of cultivated forages or stall feeding. Although goats prefer to browse in comparison to grazing, they can efficiently use cultivated pastures for meat or milk production. Stocking rates of the order of 37-126 goats/ha have been reported depending on the type of grass used, level of fertiliser application and the presence or absence of legumes.

The most intensive form of production is zero grazing but requires high labour and capital investment. It is a system which favours those situations where land is limiting and there exist abundant supplies of crop residues and agro-
industrial by-products. Probably because of the high capital investment, the system has not been adequately used. In Fiji, stall-fed meat goats given sugarcane tops, stovers and straw, coconut cake, rice bran and molasses reached 23-25 kg live weight in about 22 weeks with a gain of 154 g/day compared to 83 g/day in the extensive system (Hussein et al., 1983).

5. Integration with Cropping Systems

This system is especially common in the humid and sub-humid regions of the tropics where there is intensive crop production, notably tree crops such as coconuts, rubber and oil palm. It is the tropical equivalent of the temperate zone intensive arable system.

The advantages of the system are:
(a) increased fertility of the land via the return of dung and urine,
(b) control of waste herbage growth,
(c) reduced use of weedicides,
(d) reduced fertiliser wastage,
(e) easier management of the crop and
(f) distinct possibilities of increases in crop yields, consistent with greater profits, including sale of animals and their products.
The natural cover of coconut and rubber plantations with or without legumes can support 2-12 animals/ha [Devendra (1985a)], but with cultivated grasses under coconuts, the carrying capacity can be increased to between 34-73 animals/ha [Reynolds (1979)]. At present the herbage area under tree crops is underutilised, suggesting that there is considerable potential for using these areas.

VII. INCREASING PRESENT LEVEL OF PRODUCTIVITY

The present level of production of goats can be significantly increased in a number of ways. The more important of these inter alia are:-

1. Effective Use of Breeds

At present, many potentially valuable breeds and strains (Table 4) are underutilised and inadequately exploited. This is coupled to the fact that many have not been accurately or adequately described, and not enough is known about their production potential. The longer this persists, the greater are the chances that uncontrolled and indiscriminate breeding can loose valuable inherent characteristics.
There appear to be only two examples of breeds which have been selected and improved through well planned breeding programmes. One concerns the Boer goat in South Africa and the other is the Damascus in Cyprus. These however represent only two out of a total of 23 potentially valuable improver breeds (Table 4), and clearly emphasises the need for much more research in this direction, with reference to meat, milk, prolificacy, fibre and skin production.

Considerable opportunities exist therefore to select within existing breeds for particular traits and to assess their potential thoroughly in the environment to which they are adapted. Further improvements can be achieved through genetic upgrading using improved breeds from the temperate environment. It is important however that these improved breeds and their crosses are tested in the same environment in which they are expected to perform. The use of individual breeds must be coupled to definite production objectives.
2. **Efficient Use of the Feed Resources**

   The feed resources are also underutilised presently. Efficient utilisation of the feed resources (forages, agro-industrial by-products and non-conventional feeds) is a definite means of increasing performance per animal, and therefore, output per unit area of land.

   In many situations, dietary protein rather than energy is the main limiting factor. Thus, supplementary protein ensures that requirements are met and there is high animal performance. Good quality protein sources such as groundnut cake and soybean meal are generally expensive and in short supply, which means that these are best retained for non-ruminant feeding. With regard to goats, a realistic alternative approach is to use good quality leguminous forages as sources of supplementary protein.

   There exist several good examples of forages mainly green leaves, and include leucane (*Leucaena leucocephala*), gliricidia (*Gliricidia maculata*), sesbania (*Sesbania grandiflora*), pigeon pea (*Cajanus cajan*) and cassava (*Manihot esculenta* Crantz). Leucaena for example, provides a source of supplementary energy, protein and sulphur and is an economical way of improving feeding systems.
which use crop residues and agro-industrial by-products. When included in diets with Napier grass (*Pennisetum purpureum*), up to 75 per cent leucaena enabled a higher uptake of metabolisable energy (ME) and stimulated live weight gain (Table 5). ME was correlated to live weight gain \( r = 0.970, P < 0.01 \) and gave the relationship \( Y = 4.492 + 10.470X \) where \( Y \) is the live weight gain (g) and \( X \) is ME intake (MJ/day) [Devendra (1982)]. Similarly, Abilay and Arinto (1981) also fed up to 75 per cent leucaena and reported that this level did not affect reproductive performance in goats.

Aside from forages, there also exist an abundant variety of crop residues, agro-industrial by-products and non-conventional feeds [Devendra (1985b)]. The latter for example, account for about \( 194 \times 10^6 \) mt from field and tree crops and constitute approximately 45 per cent of the total availability of by-products from both types of crops in Asia and the Pacific. Many of these are valuable for feeding goats.

Two types of feeding strategy are possible in the utilisation of crop residues, agro-industrial by-products and non-conventional feedstuffs in the tropics. One option is to utilise the feeds intact, in suitable combinations and dietary mixtures which are palatable and provide the necessary nutritional requirements. Figure 2
which illustrates one example of the first strategy, shows the relationship in terms of ME intake in untreated rice straw diets substituted with increasing levels of leucaena forage and the effect on N retention [Devendra (1983b)]. Table 6 summarizes the results.

The second alternative is to use some form of processing techniques (physical, biological or chemical) on the crop residues or agro-industrial by-products. For example, one of several alkalis, such as ammonium hydroxide or calcium hydroxide or even urea can be used. However, the case for processing and/or chemical treatment will need to consider the availability of reliable and proven techniques, practicability, applicability to real farm situations, and more particularly whether it can be economically justified. The latter can only be justified if these are significantly lower than the added benefits in terms of animal response.

The opportunities for more efficient use of the available crop residues and agro-industrial by-products are enormous and every effort must thus be made to make wider use of these, either in combination with grass or in complete diets, commensurate with the recommended nutrient levels according to N.R.C. (1981).
The significance of poor as opposed to good nutrition is demonstrated in a study on the reproductive performance of Barbari and Jamnapari goats where it was shown that the effect in both breeds was to improve the total number of kids born between 66.6 - 73.9 per cent and twins between 34.3 - 38.6 per cent (Sachdeva et al., 1973). Likewise in Katjang goats, live weight at slaughter, hot carcass weight, dressing percentage and weight of meat were improved by as much as 53.8, 79.3, 7.1 and 47.1 per cent respectively [Devendra (1979)].

3. **Improved Health**

The wastage due to disease represents a source of major economic loss in goats especially up to weaning. It is particularly high in densely populated areas where veterinary and diagnostic services are weak. Losses due to goats are of three categories:

(a) Lowered resistance, caused by undernutrition and malnutrition resulting in deaths due to various diseases.

(b) Parasitism due mainly to roundworm infestation is a major cause of loss throughout the tropics and is associated with poor nutrition and reduced resistance.
(c) Transmissible diseases such as coccidiosis and caseous lymphadenitis and pneumonia are serious, cause high mortality and necessitate disease monitoring, appropriate prophylactic measure and/or vaccination.

4. Development Priorities

In addition to emphasis being given to better use of existing goat breeds, increased efficiency of feeding and nutrition and improved health control, there exists a fourth factor that needs an overriding attention. This concerns priorities for development that can specifically focus on the potential future contribution of goats. These are conspicuously inadequate presently and is confirmed by the recent World Bank (1983) report which found, based on an analysis of 80 research and/or development projects on a regional basis, that there was a lack of support within developing countries and also within international donor and lending agencies. The report also found that little emphasis was given to research and training especially in developing countries.
There is therefore an urgent need to review policies which directly or indirectly influence the development of the species. This must necessarily take cognisance of the impact of such policies on present production, the demand for products and marketing potential. Considered together, these aspects will have the effect of ensuring maximum use of the available resources and extending the potential contribution of goats especially in food production. Meat production is of primary importance, but milk is also of value. Since livestock development strategies generally tend to favour large scale milk production based on cattle, there is good justification for developing goats for small scale village dairy production to alleviate the supply of animal proteins for the rural poor.

VIII. CONCLUSIONS

Over the last two decades, the potential value of goats has been widely recognised throughout the world. However, many governments have not yet given sufficient attention to this species despite all its attributes, present contribution and steady population growth rate.
At the present level of consumption and pattern of growth, the goat population will reach 900 millions in the year 2000. In cognisance of this, realistic development strategies are necessary that can couple wider official support, both nationally and internationally, with increased utilisation of goats. This has the supreme effect of substantially increasing food production from these animals which is of much significance to the status and quality of especially rural people in the developing countries.

ACKNOWLEDGEMENT
The author appreciates the support of I.D.R.C. for participation in the Congress.

REFERENCES


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<tbody>
<tr>
<td>Africa</td>
<td>152.2</td>
<td>32.2</td>
<td>1.9</td>
<td>1 : 1.2</td>
</tr>
<tr>
<td>N.C. America &amp; Caribbean</td>
<td>10.9</td>
<td>2.3</td>
<td>-1.6</td>
<td>1 : 2.1</td>
</tr>
<tr>
<td>S. America</td>
<td>19.6</td>
<td>4.1</td>
<td>-1.5</td>
<td>1 : 5.5</td>
</tr>
<tr>
<td>Asia and the Pacific</td>
<td>271.3</td>
<td>57.4</td>
<td>1.8</td>
<td>1 : 1.3</td>
</tr>
<tr>
<td>Europe</td>
<td>12.3</td>
<td>2.6</td>
<td>-1.0</td>
<td>1 : 11.6</td>
</tr>
<tr>
<td>Oceania</td>
<td>0.4</td>
<td>0.1</td>
<td>6.4</td>
<td>1 : 530</td>
</tr>
<tr>
<td>USSR</td>
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<td>1.3</td>
<td>-0.4</td>
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<td>World</td>
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<td>100.0</td>
<td>1.3</td>
<td>1 : 2.5</td>
</tr>
<tr>
<td>Developed</td>
<td>25.7</td>
<td>5.4</td>
<td>-1.0</td>
<td>1 : 21.1</td>
</tr>
<tr>
<td>Developing</td>
<td>447.1</td>
<td>94.6</td>
<td>1.3</td>
<td>1 : 1.4</td>
</tr>
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TABLE 2

THE ECONOMIC CONTRIBUTION OF GOATS IN THE DEVELOPING COUNTRIES

[F.A.O. (1982)]

<table>
<thead>
<tr>
<th>Product</th>
<th>Production (10^3 m tons)</th>
<th>Av. Growth Rate/Year (1961-1965 to 1980-1982) (Per Cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat</td>
<td>1,950 (92.5 per cent)^+</td>
<td>1.1</td>
</tr>
<tr>
<td>Milk</td>
<td>5,619 (73.0 per cent)^+</td>
<td>2.7</td>
</tr>
<tr>
<td>Fresh skins</td>
<td>368.7 (94.3 per cent)^+</td>
<td>2.0</td>
</tr>
<tr>
<td>Mohair++</td>
<td>14,550</td>
<td>-</td>
</tr>
</tbody>
</table>

^ As per cent of total world population
++ From the main mohair producing countries: South Africa, Turkey, Texas (U.S.A.), Lesotho and Argentina
TABLE 3

ESTIMATES OF TOTAL EDIBLE AND TOTAL COMMERCIALY VALUABLE MEATS - PERCENTAGES FOR VARIOUS BREEDS OF ADULT GOATS IN THE TROPICS

<table>
<thead>
<tr>
<th>Breed</th>
<th>Location</th>
<th>Total Edible (Per Cent)</th>
<th>Total Commercially Valuable (Per Cent)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small East African</td>
<td>Uganda</td>
<td>48.3</td>
<td>55.5</td>
<td>Wilson (1958)</td>
</tr>
<tr>
<td>Katjang</td>
<td>Malaysia</td>
<td>61.2</td>
<td>81.5</td>
<td>Devendra (1966)</td>
</tr>
<tr>
<td>Indigenous</td>
<td>Malawi</td>
<td>74.5</td>
<td>80.5</td>
<td>Owen (1975)</td>
</tr>
<tr>
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<td>Botswana</td>
<td>72.3</td>
<td>79.6</td>
<td>Owen et al. (1977)</td>
</tr>
<tr>
<td>Indigenous</td>
<td>Botswana</td>
<td>71.8</td>
<td>79.2</td>
<td>Owen et al. (1977)</td>
</tr>
<tr>
<td>Indigenous</td>
<td>Botswana</td>
<td>74.3</td>
<td>80.9</td>
<td>Owen et al. (1977)</td>
</tr>
<tr>
<td>Boer</td>
<td>Botswana</td>
<td>70.0</td>
<td>78.0</td>
<td>Owen et al. (1977)</td>
</tr>
<tr>
<td>Katjang</td>
<td>Malaysia</td>
<td>71.5</td>
<td>96.2</td>
<td>Devendra (1980)</td>
</tr>
</tbody>
</table>

1 Females  
2 Males  
3 Male castrates
TABLE 4

IMPROVER INDIGENOUS BREEDS IN THE TROPICS
AND SUB-TROPICS

<table>
<thead>
<tr>
<th>Breed</th>
<th>Speciality</th>
<th>Country of Origin</th>
</tr>
</thead>
<tbody>
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<td>Angora</td>
<td>Mohair</td>
<td>Turkey; sub-tropical, dry</td>
</tr>
<tr>
<td>Barbari</td>
<td>Meat, prolificacy</td>
<td>India; tropical, dry</td>
</tr>
<tr>
<td>Beetal</td>
<td>Milk</td>
<td>India; tropical, dry</td>
</tr>
<tr>
<td>Black Bedouin</td>
<td>Milk, meat (desert)</td>
<td>Israel; Egypt; tropical, dry</td>
</tr>
<tr>
<td>Black Bengal</td>
<td>Prolificacy, skin</td>
<td>India; tropical, dry</td>
</tr>
<tr>
<td>Boer</td>
<td>Meat, prolificacy</td>
<td>S. Africa; tropical, dry</td>
</tr>
<tr>
<td>Criollo</td>
<td>Prolificacy</td>
<td>S. America; tropical, subtropical</td>
</tr>
<tr>
<td>Damani</td>
<td>Milk</td>
<td>Pakistan; tropical, dry</td>
</tr>
<tr>
<td>Damascus*</td>
<td>Milk, prolificacy</td>
<td>Syria, Lebanon; subtropical, dry</td>
</tr>
<tr>
<td>Dera Din Panah</td>
<td>Milk</td>
<td>Pakistan; tropical, dry</td>
</tr>
<tr>
<td>Jamnapari</td>
<td>Milk, meat</td>
<td>India; tropical, subtropical, dry</td>
</tr>
<tr>
<td>Kamori</td>
<td>Milk</td>
<td>Pakistan; subtropical, dry</td>
</tr>
<tr>
<td>Kilis</td>
<td>Milk</td>
<td>Turkey; subtropical, dry</td>
</tr>
<tr>
<td>Katjang</td>
<td>Meat, prolificacy</td>
<td>Indonesia; Malaysia; tropical, humid</td>
</tr>
<tr>
<td>Malabar</td>
<td>Milk, prolificacy</td>
<td>India; tropical, humid</td>
</tr>
<tr>
<td>Maradi</td>
<td>Skin</td>
<td>Niger; Nigeria; tropical, dry</td>
</tr>
<tr>
<td>Marwari</td>
<td>Milk</td>
<td>India; tropical, dry</td>
</tr>
<tr>
<td>Ma T'ou*</td>
<td>Meat, prolificacy</td>
<td>China; subtropical, humid</td>
</tr>
<tr>
<td>Mubende</td>
<td>Skin</td>
<td>Uganda; tropical, dry</td>
</tr>
<tr>
<td>Sudanese Nubian</td>
<td>Milk</td>
<td>Egypt; Sudan; tropical, dry</td>
</tr>
<tr>
<td>Sudanese Desert</td>
<td>Meat, prolificacy</td>
<td>Sudan; tropical, dry</td>
</tr>
<tr>
<td>West African Dwarf</td>
<td>Prolificacy</td>
<td>West Africa; tropical, dry</td>
</tr>
<tr>
<td>Zaraiby*</td>
<td>Milk</td>
<td>Egypt; tropical, dry</td>
</tr>
</tbody>
</table>

* Indicates breed is polled
### TABLE 5

**EFFECT OF VARYING LEVELS OF DIETARY LEUCAENA ON THE PERFORMANCE OF GOATS IN MALAYSIA** [Devendra (1982)]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100 G</td>
</tr>
<tr>
<td>Daily live weight gain (g/day)</td>
<td>11.7 a+++</td>
</tr>
<tr>
<td>DMI as per cent of LW</td>
<td>3.43</td>
</tr>
<tr>
<td>Feed efficiency (g DMI/g gain)</td>
<td>30.3 a</td>
</tr>
<tr>
<td>Height at withers (cm)</td>
<td>5.89 a</td>
</tr>
<tr>
<td>Body length (cm)</td>
<td>7.98 a</td>
</tr>
<tr>
<td>Heart girth (cm)</td>
<td>5.84 a</td>
</tr>
</tbody>
</table>

+ Results refer to the mean value for males and females
++ G - Napier grass (*Pennisetum purpurem*), L - *Leucaena leucocephala*
+++ Mean with the different italicized letters differ significantly ($P<0.05$)
TABLE 6

THE EFFECT OF SUPPLEMENTATION WITH LEUCAENA FORAGE

ON THE INTAKE AND UTILISATION OF RICE STRAW [Devendra (1983b)]

<table>
<thead>
<tr>
<th>Treatment</th>
<th>DMI as Percentage of Body Weight</th>
<th>OM Digestibility</th>
<th>ME Intake (MJ/kg)</th>
<th>N Retention as Percentage of Intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 per cent Rice Straw (RS, chopped)</td>
<td>2.9 a*</td>
<td>50.9 a</td>
<td>3.63 a</td>
<td>0.1 a</td>
</tr>
<tr>
<td>90 : 10, RS : Leucaena+1</td>
<td>2.6 a</td>
<td>51.3 a</td>
<td>4.22 b</td>
<td>20.2 b</td>
</tr>
<tr>
<td>80 : 20, RS : Leucaena+</td>
<td>2.6 a</td>
<td>49.5 a</td>
<td>4.39 b</td>
<td>16.4 b</td>
</tr>
<tr>
<td>70 : 30, RS : Leucaena+</td>
<td>2.7 a</td>
<td>52.5 b</td>
<td>5.17 c</td>
<td>23.6 b</td>
</tr>
<tr>
<td>60 : 40, RS : Leucaena+</td>
<td>3.1 a</td>
<td>53.3 b</td>
<td>6.04 d</td>
<td>31.5 c</td>
</tr>
<tr>
<td>50 : 50, RS : Leucaena+</td>
<td>2.7 a</td>
<td>55.5 b</td>
<td>6.76 e</td>
<td>27.5 c</td>
</tr>
<tr>
<td>40 : 60, RS : Leucaena+</td>
<td>2.6 a</td>
<td>52.4 b</td>
<td>4.74 b</td>
<td>30.8 c</td>
</tr>
</tbody>
</table>

* In the total dry matter intake

1 Leucaena forage: 22 per cent crude protein and 22.18 MJ/kg gross energy content

* Means on the same line with different superscripts differ significantly (P<0.05)
FIGURE 1. Nutrients in goat milk in relation to requirements of human infants (Jenness, 1980).
Figure 2. Trends in the intake of ME and N retention in sheep with increasing level of dietary leucaena forage inclusion in (100-X) rice straw.