PN-AAR-973
ISN: 38425

SMALL RUMINANT

COLLABORATIVE RESEARCH SUPPORT PROGRAM

TECHNICAL REPORT SERIES

NUMBER

931-1328

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MEAT PRODUCTION AND CARCASS CHARACTERISTICS OF THE GOAT

Maurice Shelton, Gary Snowder, Elsio Figueiredo

INTRODUCTION

The importance of the goat as a producer of meat, milk and fiber is becoming more widely realized and appreciated. Shelton (1978) and McDowell and Bove (1977) have reported that milk is the most valuable product obtained from the goat. However, only a relatively small percent of the world's goat population is actually milked. Thus, most goats are used only for meat production with skins or hides as a by-product. A very small portion, between 2 and 5 percent, of the world's goat population is used for fiber production.

The USAID Title XII Small Ruminant Collaborative Research Support Program (SR-CRSP) is directed toward increasing the contribution of the goat to meeting man's need for food and fiber. Since meat is the primary product obtained from most of the world's goat population, it seems logical that this end product should itself be the subject of investigation. The present report is concerned largely with research on carcass and dress-off items conducted as a part of the SR-CRSP effort at Texas A&M University (TAMU), Texas Agricultural Experiment Station (TAES) and at collaborating institutions in Brazil. More detailed reports concerning these studies have been made (Snowder, Shelton and Smith 1982, Smith, et al. 1982) or are in press at the present time (Griffin, et al., 1984, Riley, et al., 1984 a, b, Wu, et al. 1984). Additional information obtained from the literature is reported where it contributes missing information or provides useful supporting data. The present report is concerned largely with the goat, but some sheep data are reported for comparison or to fill gaps. Work under this project is also concerned with hair sheep, which are often found intermingled with goats in tropical environments. In terms of meat production and carcass traits, the hair sheep appear to be intermediate between goats and the more traditional types of sheep which have been the subject of numerous investigations.

Annual worldwide meat production from goats is estimated at 1.97 million tons, of which 97 percent is from developing countries (FAO, 1980). This figure was no doubt roughly estimated in most countries since the majority of goat meat is not marketed through organized channels, but is consumed at or near the point of origin. Gall (1982) states that actual production is probably higher than the official estimates. Although goats produce only a small percent of the total world supply of red meat, their contribution is much more important in developing countries (Raun, 1982). Goat meat is not subject to religious taboos as sometimes occurs with other red meat sources such as beef and pork. In some areas, goat meat is preferred and sells at a premium over other red meats. The demand for goat meat exceeds the supply in many parts of the world.

WHERE ARE GOATS PRODUCED?

Most of the world's goat population is located in tropical or subtropical regions with over two-thirds found within 30° of the equator. Such environments, especially the arid tropics, often do not favor large animals due to lack of adaptation or to the type and amount of feed available. Goats may also make a unique contribution on small farms or in small holder agriculture where resources may not permit keeping larger animals such as the cow.

Table 1. World Goat Population and Production by Continents[1]

Region	Goats (millions)	% of Total Numbers	Meat Produced (tons)	% of Total Meat Production
Africa	131	32.0	425	24.7
Nth/Cnt. America	12	3.0	23	1.4
South America	18	4.4	64	5.2
Asia	231	56.4	1075	62.5
Europe	11	2.8	92	5.3
Oceania	0	.0	1	.1
U.S.S.R.	6	1.4	40	2.3
World	410	100.0	1720	100.0

[1]Source: FAO, 1978.

Some information on world distribution of goats and goat meat production is shown in Table 1. From this, it can be seen that a high percentage of the world's goat population and their greatest contribution is in Africa and Asia. Although most of the goats are found in Africa or Asia, some areas of Central or South America (Mexico, Brazil) or the Caribbean have substantial numbers, or substantial numbers in relation to land area available or human population. The top ten countries in total numbers of goats are shown in Table 2. The top 20 countries in which goats make the greatest contribution as indicated by number of goats *per capita* are shown in Table 3, and the top 20 countries in numbers of goats per unit of land area are shown in Table 4. It may be significant to note that none of these are areas where the SR-CRSP is currently working.

Table 2. Top Ten Countries in Total Number of Goats.

Country	Numbers in Thousands
Peoples Republic of China	80,448
India	71,650
Pakistan	30,203
Nigeria	24,000
Turkey	18,775
Ethiopia	17,180
Somalia	16,300
Iran	13,627
Sudan	12,570
Bangladesh	11,500

Source: FAO, 1980.

Table 3. Top 20 Countries in Number of Goats Per Capita.

Country	Number of Goats (Thousands)	Goats Per Capita
Somalia	16,300	3.33
Mongolia	4,715	2.75
Namibia	2,200	2.12
Djibouti	522	1.62
Mauritania	2,600	1.55
Botswana	1,250	1.50
Niger	7,318	1.34
Yemen, AR	7,300	1.23
Mali	5,798	0.81
Yemen DEM	1,350	0.71
Sudan	12,570	0.67
Lesotho	800	0.58
Cyprus	360	0.58
Ethiopia	17,180	0.53
Bolivia	3,000	0.52
Chad	2,320	0.51
Libya	1,500	0.48
Swaziland	270	0.47
Greece	4,465	0.46
Turkey	18,775	0.40
Upper Volta	2,800	0.39
U.A. Emirates	280	0.38
Iran	13,627	0.35

Source: FAO, 1980.

Table 4. Top 20 Countries in Number of Goats Per Unit of Land Area

Country	Goat Population in 1000s	Goats per 1000 ha.
Bangladesh	11,500	858.8
Barbados	28	651.2
St. Kitts	15	416.7
Comoros	87	400.9
Cyprus	360	389.6
Pakistan	30,203	387.9
Mauritius	70	378.3
Yemen AR	7,300	374.4
Lebanon	380	371.5
Haiti	995	361.0
Ruanda	900	360.7
Grenada	12	352.9
Greece	4,465	341.4
Jamaica	380	350.9
Malawi	630	273.9
Nigeria	24,000	263.5
Lesotho	800	263.5
Somali	16,300	259.8
Burundi	657	256.1
Albania	670	244.5

Source: FAO, 1980.

It has been previously pointed out that goats tend to be associated with the arid tropics or subtropics and with developing countries, and Raun (1982) has reported that they are also associated with small holder agriculturalists. The presence of goats in the tropics or subtropics seems to be explained (a) by the fact that their small size and limited fat cover makes them poorly adapted to cold climates (Shelton, 1978) and relatively less affected by high environmental temperatures (Lawson and Shelton, 1983), (b) by their ability to travel long distances in search of food, and (c) their willingness to consume more of the browse species often found in the arid regions (Warren, et al., 1981) or more so than other competing species of domestic ruminants. The association of goats with small holder agriculture should be self-evident since such farmsteads do not provide the resources for significant numbers of the larger species such as cattle or buffalo.

The relationship of goats to less developed or developing countries appears to be explainable by the fact that both tend to be concentrated in arid or tropical regions or more specifically in the arid tropics, and they make a greater contribution under these conditions.

As previously stated, approximately two-thirds of the world's goat population is found within 30° of the equator and almost 80 percent is found within 40°. Asia and Africa hold almost 88 percent of the total numbers. In many such areas, goats have been reported to provide greater capital returns or greater returns per unit of area (Dumont, 1966, and Devendra, 1976). Also, in many areas of subsistence level agriculture, the choice of goats may be based on factors other than annual returns such as the practice of least risk agriculture or the use of livestock as a capital reserve.

MEAT AND CARCASS CHARACTERISTICS

In most studies relating to meat production or value, only the carcass receives emphasis. However, there are a number of non-carcass dress-off items which are at times used for human consumption. The latter are comparatively more important in developing countries than in developed countries where much of the research on meats has been done. Thus, it seems to be important to look at the total off-take to assess the relative importance of these in quantitative as well as qualitative terms. Shown in Table 5 are some of the products which may be obtained at slaughter arranged into edible and non-edible groups. It must be realized that the classification of edible vs. inedible is not an exacting one. In this case, essentially all parts which might be considered digestible by man are listed as edible, and those which consist largely of keratinized protein, and thus indigestible by man, are listed as inedible. Whether or not they are actually consumed by man would be highly influenced by the customs of the society involved and the degree of need for food or food of animal origin.

In attempting to discuss yields of the various products obtained at slaughter, terminology and method of reporting lead to a great deal of confusion. The most common or most meaningful method is to express yields of carcass or dress-off items as a function of live weight. However, this gives rise to considerable variation depending on amount

Table 5. A Partial List of Products Obtained at Slaughter

Edible	Inedible
Carcass	Feet
Head	Hair
Blood	Skin or Hide
Kidneys	Horns
Heart	Hooves
Liver	
Lungs	
Fat Trim	
Tongue	
Stomach	
Intestines	
Testicles	

of shrink, amount of fat, and whether warm or chilled carcass weights are used. A number of workers refer to empty body weights, but it is not always clear how these values are obtained. Smith, et al. (1982), subtracted the weight of viscera and its contents and expressed components as a function of viscera free body weight. This was done primarily to account for differential shrink between various experimental groups. Gall (1982) did an extensive literature review relating to yields of goat carcass. He reported values ranging from 36.2 to 55.0 percent with a mean of 46.4 percent for carcass weight expressed as a function of live weight. For carcass weights expressed as a function of empty body weights, he reported a range of 40.2 to 64.7 percent with a mean of 56.13 percent. Using the viscera free weights, Smith, et al. (1982), reported carcass yields for meat type goats of 65.3 and 66.2 percent for young intact males and aged females respectively. Some of the very high values reported by Gall (1982) are derived from very young preruminant animals or possibly heavily shrunk animals.

Based on the review values taken from Gall (1982) and those in Table 6, it is obvious that one of the characteristic features of goats is their low dressing percent. No attempt is being made to review the dressing percent of other species, but textbook values show swine at approximately 70 percent, slaughter lambs at approximately 50-52 percent, while slaughter cattle may dress as high as 64%. However, it should be pointed out that the quoted values come from animals which have been fed prior to slaughter. The only slaughter animal likely to show yields as low as goats are aged sheep (ewes), especially if they are pregnant or have a heavy clip of wool.

A number of reasons for the low dressing percent of goats can be suggested. The major factors affecting yield are the degree of shrink prior to slaughter (gut fill), the amount of fat on the carcass (Figure 1), type of feed which the animal has been consuming, and genetic differences in the ratio of musculature to anatomical features. Almost universally, goats do not fatten readily, and when they do it tends to be placed internally. Also, most commercial programs do not call for or justify a period of fattening prior to slaughter for goats, as is often practiced with other species. The tendency to fatten, the

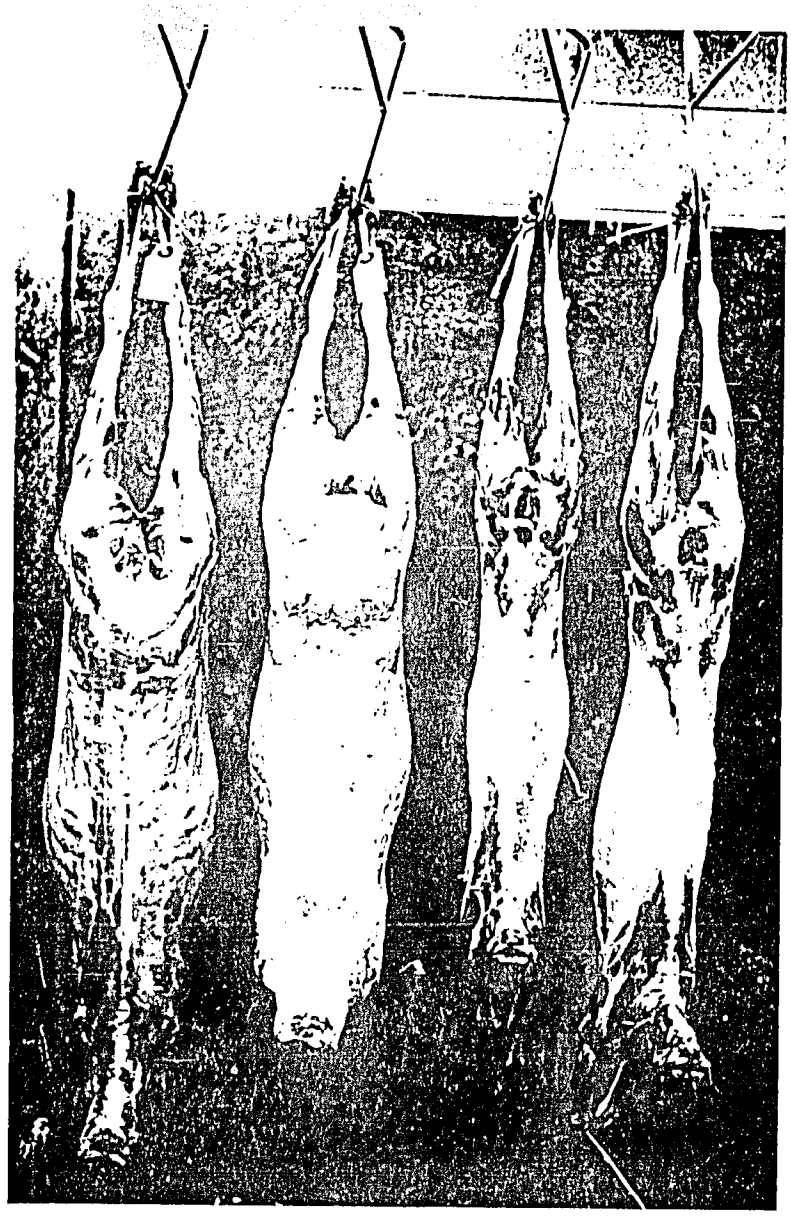
Table 6. Yields of Various Slaughter Components Expressed as a Function of Live Weight

Type of Animal	Meat type		Young Angora Males	Young Meat type Males	Young Meat type Wethers	Aged Angora Females	Aged Meat type Females	Mean for Goats	Hair Sheep		Mean for Sheep
	Male Kids	Castrate Kids							Black Bellied Barbados Young Males	Black Bellied Barbados Aged Females	
Number	12	24	9	7	13	10	17	92(Total)	11	10	21
Source of data*	1	1	2	2	2	2	2		3	3	
Live Wt., kg.	27.6	24.6	28.0	36.1	29.4	38.4	35.4	30.6	35.5	33.6	34.5
Carcass Wt., kg.	12.5	11.2	12.3	16.6	13.5	12.5	16.3	14.0	16.7	15.8	16.2
Dressing Percent	45.3	45.5	44[4]	46[4]	46[4]	44[4]	46[4]		47[4]	47[4]	
Blood, percent			5.3	4.4	4.8	7.8	5.4	4.8	4.6	5.2	4.8
Head, percent	8.9	8.7	9.9	8.4	7.8	10.7	8.4	8.4	9.7	8.4	9.0
Feet, percent			1.7	1.6	1.7	2.2	1.7	1.7	1.3	1.4	1.3
Pelt, percent	12.7	11.5	16.8	10.5	7.9	15.7	9.1	10.3	9.3	8.5	8.9
Lungs, percent			1.9	2.0	1.5	2.3	2.2	1.9	2.0	2.5	2.2
Liver, percent			2.1	1.6	1.6	2.9	2.1	1.8	1.6	2.1	1.8
Heart, percent			0.8	0.8	0.6	1.2	1.1	0.8	0.6	0.8	0.7
Viscera and Content			17.5	24.7	28.1						

*Source of data: 1 - Unpublished data from Texas Agricultural Experiment Station.
2 - Taken from Smith, et al. (1982).
3 - Taken from Riley, et al. (1984).

[4]In these data, the dressing percent was standardized to the values shown.

Figure 1. A Comparison of Goat and Sheep Carcasses



Ewe Carcass	Slaughter Lamb Carcass (fed lamb)	Young Goat	Aged Female Goat

placement of the fat, as well as the development of the carcass itself should be subject to change through selection. However, there is an almost total absence of documented success in doing so with goats. Only the Boer goat appears to stand out as having higher yields and superior fattening qualities (Skinner, 1972). Some data taken from Ueckerman (1969) are reported in Table 7.

Table 7. Meat Production and Carcass Yields in Boer Goats

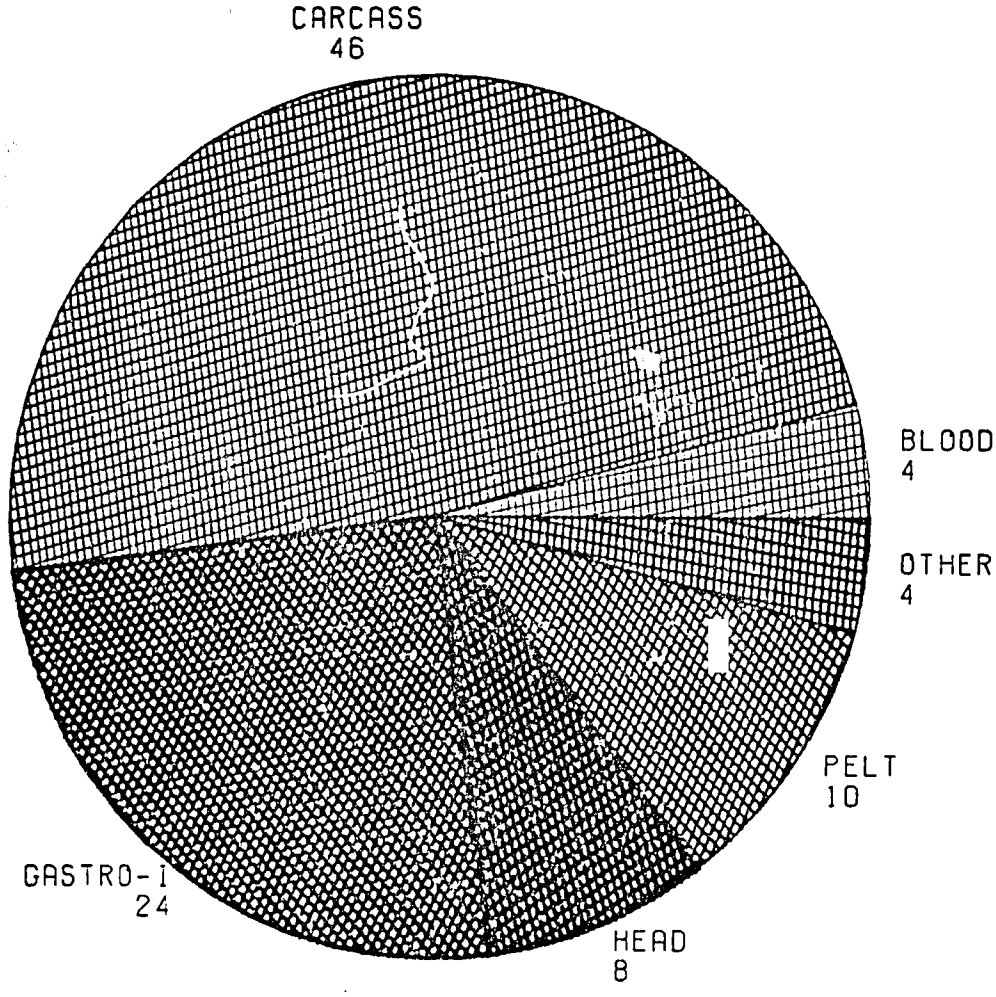
Ration	Roughage 100%		Roughage: Concentrate 60: 40		Roughage: Concentrate 40: 60	
Slaughter wt., kg	31.8	45.5	31.8	45.5	31.8	45.5
Number	231	336	182	308	168	301
Wks to slaughter	33	48	26	44	24	43
Feed to gain ratio	10.3	13.3	8.1	9.5	8.6	9.5
Av. daily gain, gm	122	124	155	136	168	139
Dressing percent	49.4	52.4	51.8	56.3	54.6	56.5

These data confirm the effect of type of ration on yield, and that under fed conditions Boer goats may dress as high as 56 percent. On the other hand, rate of gain and feed efficiency are not necessarily more favorable than what might be expected with other types of goats. The degree to which Boer goats represent a response to artificial selection by man or to which they may have simply evolved under reasonably favorable feed conditions of South Africa is not clear at present.

Dress-off Items

It has been previously stated that in developing countries the dress-off items at slaughter are comparatively more important than is the case in the United States. In any case, there is a need to look at the relative importance of the various products obtained at slaughter. The percentage of live weight represented by the carcass and of some of the dress-off items for goats and hair sheep are shown in Table 6 and Figure 2. The major portion of the live weight is made up of the carcass and the viscera and its contents. In the studies conducted as a part of the TAMU SR-CRSP project, no attempt was made to obtain the weight of the viscera free of its contents. Also, a transportation and a period of holding prior to slaughter resulted in a differential shrink between various groups. Therefore, some of these data have been standardized to a constant carcass yield basis. The dressing percent values used are based largely on unpublished information available to the authors, but the figure of 46 used for meat goats is essentially the same as the 46.4 percent reported as a mean for the studies summarized by Gall (1982). In respect to partitioning the gastro-intestinal trait and its contents, some data reported by Santa Rosa, et al. (1984), provides a basis for calculation. In their data, the gastro-intestinal tract less its contents represented 7.39 percent of the live weight if the latter is adjusted to a carcass yield of 46 percent. This value has been used in the preparation of Figure 2. Aside from the carcass and the viscera, the major dress-off items are the skin or pelt (10.5%), the head (8.4%), and the blood (4.4%). The values used are taken from data reported in Table 6. The skin has been listed as inedible. The head or

Figure 2. Dress-Off Items in Percent From Goat Slaughter



trimmings from the head would be useable, but of low yield. The blood represented 4.4 percent of which approximately 70+ percent would be water. The liver and the heart represent the dress-off items which are most readily or widely used for human consumption, and in these studies they represented only 2.4 percent of the live weight. Uncertainty about the use of such products as the blood, lungs, viscera, and head for human consumption make it difficult to calculate relative value. However, it is clear that the major share of the human food obtained from the goat at slaughter is that of the carcass. This is even more true in respect to market value since the producer may receive little or no cash value for the dress-off items. The dress-off items are of greater significance in the case of home slaughter. The overwhelming conclusion is that even in developing countries attempts to commercialize goat production should include emphasis on improving carcass value and yield.

Carcass Composition

Assuming a stable population, the primary slaughter animals derived from a flock would be young males (intact or castrates) and aged or culled females. This is assuming that most of the males are surplus and are sold for slaughter at the most opportune time, and that the females are kept for replacements. The latter would be available for slaughter when they are culled for age or other reasons. Theoretically, the numbers of each group would be comparable except for death losses in breeding age does over their productive life, which could be substantial in many environments. Assuming a 6 year productive life and an annual death of 5 percent, a total of 27 percent of the females would be lost prior to their availability for slaughter. Although these values are realistic in well managed flocks, they no doubt represent a serious underestimate of losses in most areas where goats are produced.

A series of studies were conducted contrasting these two age groups. Some of these data are shown in Table 8 for various types and classes of sheep and goats. The percentage of lean, fat and bone were predicted from physical separation of the rack.

Table 8. Percent Lean, Fat and Bone and Shear Force Values for Sheep and Goat Carcasses[1]

Class	All Goats	All Sheep	Young Intact Male Goats	Aged Female Goats	Angoras	Meat Type Goats
Number	56	77	16	27	19	24
Lean %	61.4	58.7	63.8	59.8	63.4	61.1
Fat %	15.8	19.8	13.9	16.6	12.9	16.6
Bone %	22.9	21.6	22.3	23.6	23.7	22.4
Shear force(kg)[2]	8.5	6.7	8.2	8.6	8.5	8.7

[1]Taken from Smith, et al. 1982.
[2]Higher values represent tougher meat.

These data show that goats are leaner than sheep, have a higher bone content and produce less tender meat than sheep. The young male

goats produced carcasses with a higher lean content than aged does. The above values compare favorably with the work of Owen, et al. (1978), who reported the following composition: fat - 11.3%, lean - 59.6% and bone - 21.5%. However, Fehr, et al. (1976), working with young (7-20 wks.) male Alpine kids reported lower fat content (6.4%) as compared to muscle (67.7%) and bone (23.0%). The trend in most developed countries, and with other species, is to produce meat with less fat and more lean. However, the actual amount desired would depend on the intended market. Goat carcasses would almost certainly benefit from some increase in subcutaneous or intramuscular fat. Although supporting data are not provided by the present series of studies, it is characteristic of most types of goats that a high proportion of the fat is placed inside the body as kidney or pelvic fat. Gall (1982) states that "50 to 60 percent is in the body cavities." Intramuscular fat might be expected to improve eating qualities. However, the biggest gain would be from some increase in subcutaneous fat cover. Fehr (1976) states that "subcutaneous fat is not developed enough to permit optimum storage and optimum commercial presentation" (of the carcass). Experience with other species of meat animals suggests that it should be relatively easy to improve the tendency to fatten or the site of its deposition. However, the almost universal absence of a tendency to fatten among various goat breeds suggests that it may be necessary to create something which does not presently exist or is not available at a given site. Thus, researchers or producers should not assume that this task can be quickly accomplished.

Castration

It has been previously pointed out that surplus young males should constitute the most important animal to be exploited for meat production In terms of management, the most pertinent question is should these animals be castrated. Historically, castration has been practiced with essentially all species utilized for meat production. In the U.S. there is a limited trend to produce intact male lambs if they are slaughtered at a young age and before sexual maturity. The traditional reasons for castration are to prevent uncontrolled matings, reduce the tendency for males to become "bucky" or develop coarse forequarters, and in order to take advantage of the improved fattening tendency of the castrates. Thus, the pertinent questions are do these same factors apply to the goat and are they important?

Several comparisons have been made between castrated and intact male goats. In the present series of studies, 140 male kids were used to study methods of castration and the effect on certain carcass components. These animals were initially kept as males until some preliminary selections could be made. The treatments were applied at an average weight of 19.8 kg. Some of the results are shown in Tables 9 and 10. These data confirm that with goats, like other species, intact males grow faster and are leaner than castrates. Even so, these data again show all the goats to have very little fat cover. Also, in the U.S. market the castrates sold for a higher price. Market surveys in Brazil (Zometa, 1984) indicate that a higher price is paid for castrate animals compared to intact males or alternatively that castrates are more easily merchandized. One of the more extensive studies contrasting intact males and castrates was that reported by Bayraktaroglu, Akman and

Table 9. Results of Castration of Meat Type Male Kid Goats

Treatment	No.	Initial Wt. kg.	Gain kg.[2]	Condition Score[3]	Sale Price[4] US $ Per Head
Intact Males	46	19.7	7.32	3.5	15.75
Castrated by Knife	48	19.3	6.86	3.9	17.00
Castrated by Burdizzo[1]	46	19.8	6.73	3.9	18.00

[1]One kid died after castration by burdizzo and four showed signs of improper or incomplete castration.
[2]Weight gains following 103 days on pasture.
[3]Condition scores were assigned on a 1-6 basis, with the high values being fatter.
[4]Twelve (12) animals were randomly kept from each group for slaughter and the remainder were sold at a local auction. The prices shown are that received for the remaining animals which were sold.

Table 10. Slaughter Data From Castrate Vs. Intact Males

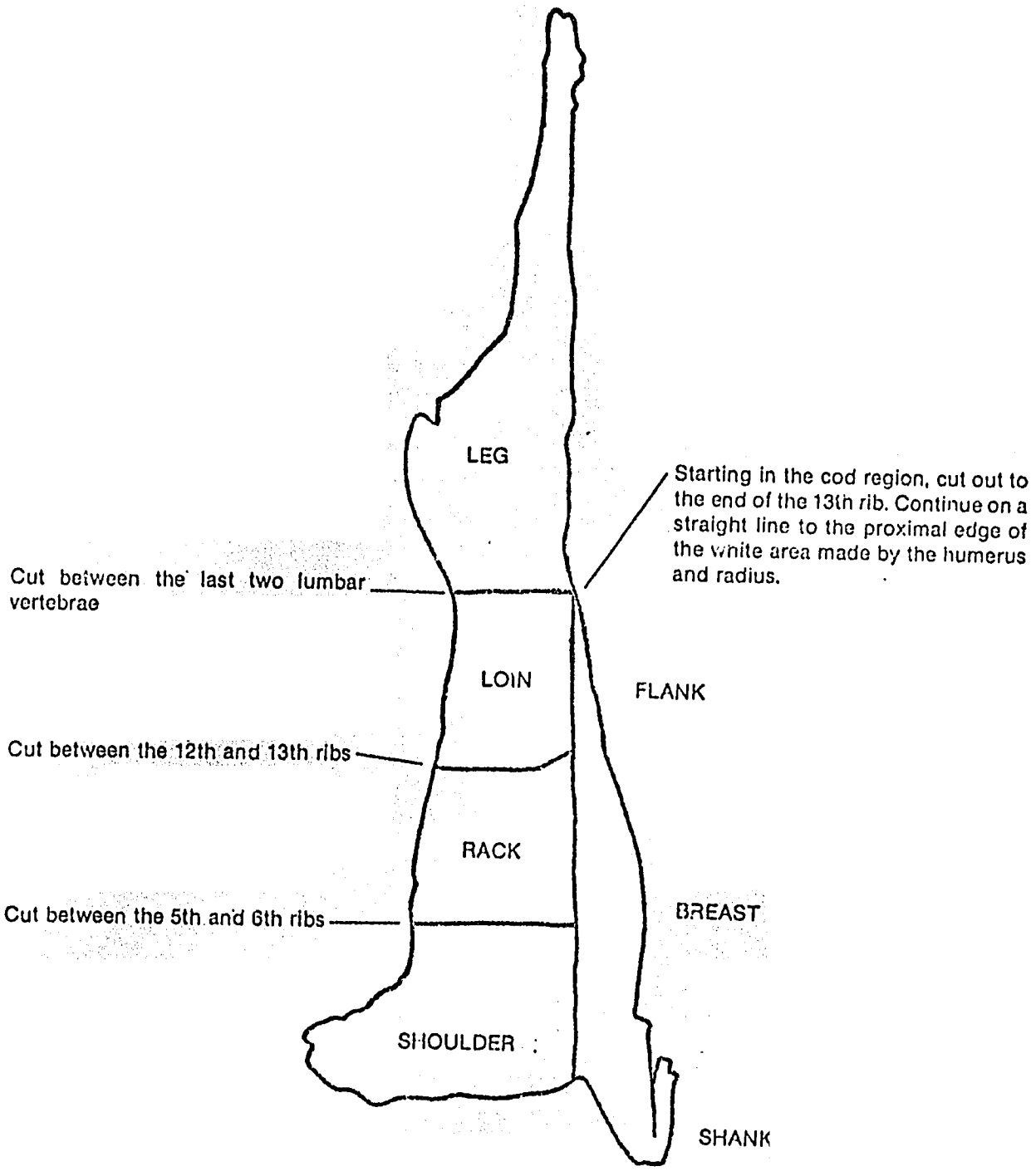
Treatment	No.	Slaughter Wt. kg	Hide Wt. kg	Carcass Wt. kg	Dressing Percent	Backfat Thickness cm.	Ribeye Area sq. cm
Intact Males	12	27.6	3.50	12.5	45.3	.010	11.35
Castrates	24	24.6	2.82	11.2	45.5	.254	10.09

Tuncel (1983) and Tuncel and Akman (1983). These studies confirm that intact males are heavier, make more efficient gains but have a higher percent of their weight in the lower value forequarters.

Goats may be somewhat unique in respect to the use of intact males for meat production. Intact males, much more so than males of other species, develop objectionable odors and show a highly developed libido, features which almost certainly interfere with management and market acceptability. Also, modest improvement in fat cover with castrates, as suggested earlier in this report, should be beneficial in commercialization of the goat for meat production. This would be especially true if the carcasses are exported to enter commercial trade channels as contrasted to household or domestic use.

The end result is that castration should generally be recommended in terms of the effect on market acceptability. Balanced against this might be the concern over infection or death losses resulting from castration. Good data on this point collected under small holder conditions is not available. In the data reported in Table 9, one animal of 95 was lost due to the operation. This would represent a tolerable level of approximately one percent. In this study, the average price differential between castrates and intact males was $1.75 per head. On this basis, one could absorb approximately a 9 percent death loss, which would not likely occur in practice.

Figure 3. Method of Cutting Goat Carcasses in Experimental Studies



One might be concerned about the method of castration. The alternatives are surgery, burdizzo, elastrator, chemical and manual manipulation. There are also at least two methods of partial castration such as the "short scrotum" and the Russian method, both of which theoretically result in sterilization, but do not prevent masculinization or rutting. Neither of these would have the desired effect on the carcass and thus should probably not be recommended. There is no clear cut evidence to dictate which method of castration is preferable, but among producers with significant numbers, the surgical method is much more widely used. It seems a safe statement that the hazards are less if done when the animal is young.

Retail Cuts From Goat Carcasses

Data have been previously presented on the lean, fat and bone ratio of goat carcasses (Table 8). However, carcasses are not merchandised as lean or fat, but are sold at retail either as entire, halves, quarters or smaller cuts. Where carcasses are fabricated into cuts, the cutting procedure will no doubt vary widely between countries.

In one study, a total of 95 young intact male meat type goats were used to investigate the relationship of various live animal measures to the yield of retail cuts (Snowder, Shelton and Smith, 1982). The animals were from known sire groups, and thus sire differences could also be determined. The animals involved were approximately 12 months old at the time of slaughter. The cutting procedure was the same as that traditionally used for lamb in the U.S. market (see Figure 3). The live animal measures taken and the retail cuts into which the carcasses were fabricated are shown in Table 11 along with the mean values. The percent which each cut represents of the total is shown in Figure 4. These data show the shoulder and leg to make up over 65 percent of the total weight of the carcass. In general, the rear quarter cuts of leg and loin are considered the more valuable cuts compared to the more bony forequarter cuts. In these animals the rear quarter cuts (leg and loin) constitute 40 percent of the carcass weight with 59.2 percent in the forequarters. The remaining portion was in kidney and pelvic fat trim. In this study, the proportion of the weight found in the forequarters may be somewhat elevated since the data were derived from males. Also, the yields of the various cuts might be expected to vary with different breeds, age or sex groups. However, these differences are expected to be minor.

Based on this study, goats had less kidney and pelvic fat than sheep (Kemp, et al. 1970), but in other respects the data for sheep and goats are essentially comparable. Based on these values, both sheep and goats have a lot of room for improvement in respect to the proportion of the carcass which is found in the more valuable cuts. However, there is a notable absence of success stories, either in research or in practice, in breeding for altered body proportions resulting in a more valuable carcass.

Selection for altered carcass components is difficult because they cannot be measured in the live animal and the obvious difficulty this presents. One approach which has been explored with other species is to attempt to use live animal measures as predictors of carcass traits. The measurements taken in the present study are outlined in Table 11. These actual measures are significantly related to each other due to

Figure 4. Retail Cuts of Goat Carcasses in Percent

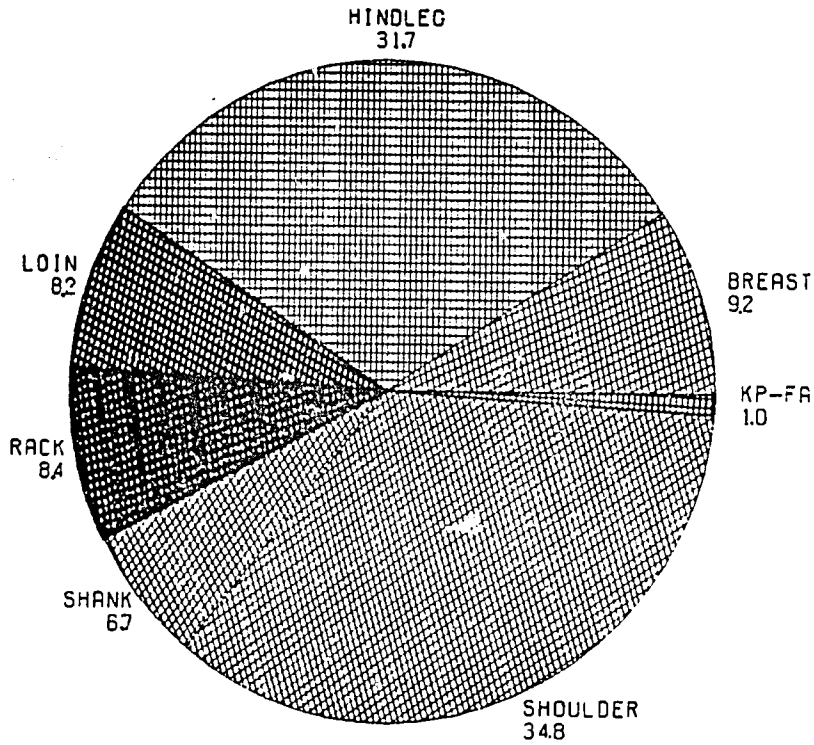


Table 11. Overall Means of Live and Carcass Measurements in Intact Male Meat Type Goats

Item	No.	Mean	Standard Deviation	Range
Liveweight, kg.	95	26.24	3.52	19.1 - 37.3
Chest width, cm.	95	15.54	1.40	12.3 - 20.5
Chest depth, cm.	95	26.13	1.70	20.9 - 30.0
Loin width, cm.	95	8.47	0.72	7.2 - 11.0
Loin length, cm.	95	17.90	1.96	14.6 - 24.0
Body length, cm.	95	55.59	3.00	49.5 - 66.0
Hip height, cm.	28	61.60	3.44	55.2 - 67.1
Hot carcass weight, kg.	95	13.02	2.15	9.18 - 22.4
Percent (of live wt.)		49.62		
Total leg, kg.	95	4.13	0.63	3.09 - 6.73
Percent (of carcass wt.)		31.74		
Loin, kg.	92	1.07	0.24	0.68 - 2.05
Percent (of carcass wt.)		8.24		
Rack, kg.	92	1.10	0.22	0.68 - 2.00
Percent (of carcass wt.)		8.45		
Total shoulder, kg.	95	4.54	0.80	3.27 - 8.36
Percent (of carcass wt.)		34.85		
Total shank, kg.	95	0.87	0.15	0.64 - 1.32
Percent (of carcass wt.)		6.67		
Breast, kg.	95	1.20	0.25	0.55 - 1.95
Percent (of carcass wt.)		9.22		
Kidney and pelvic fat, kg.	94	0.13	0.03	0.10 - 0.23
Percent (of carcass wt.)		0.98		

variability in size. However, when adjusted or corrected for size, these relationships largely disappear. The relationship of the live animal measures to carcass components are shown in Table 12. Again, most of the measures of scale were highly significantly related to weight of retail cuts. This appears to be explained by variability in size. If the retail cuts are expressed as a function of carcass weight (percent), these relationships largely disappear. One exception to this is a negative relationship of the measures of scale and the percent of leg. The inverse of this or a positive relationship is observed between the measures of scale and the forequarter cuts of shoulder and breast. These relationships can apparently be explained by the fact that these were immature males and as they mature the forequarters develop to a greater extent.

Table 12. Correlation Coefficients[a] Among Live and Carcass Measures in Intact Male Spanish Goats

Carcass Measures	Live Measures						
	Live Weight	Chest Width	Chest Depth	Loin Width	Loin Length	Body Length	Hip Height
Hot carcass	.7629	.6897	.4350	.5075	.3350	.4396	.4473
Total leg wt.	.7417	.6681	.4043	.5168.	.3435	.4128	.4819
Percent	-.342	-.321	-.269	-.113	-.100	-.233	
Loin wt.	.6309	.6086	.2813	.3875	.2181	.3540	.3696
Percent	.131	.201	-.080	.029	-.005	.047	
Rack wt.	.6561	.5823	.3332	.4172	.1036	.3450	.2687
Percent	.048	.046	-.022	.013	-.311	-.006	
Total shoulder wt.	.7216	.6673	.4480	.4977	.3370	.4510	.5434
Percent	.012	.057	.141	.035	.076	.139	
Shank wt.	.7383	.4788	.4376	.4305	.3418	.4924	.3425
Percent	-.046	-.252	-.013	-.084	-.011	.164	
Breast wt.	.6873	.5968	.4523	.3944	.3604	.3470	.1498
Percent	.183	.111	.205	.049	.180	.015	
Kidney & pelvic fat	.5405	.5687	.1728	.2953	.2417	.3303	.1836
Percent	-.005	.095	-.175	-.078	.022	.001	

[a]Correlation coefficient equal to or greater than .195 are statistically significant ($P<.05$).

In summary, these data do not lead to encouragement in terms of using live animal measures as a means of predicting carcass merit in goats. This generally conforms to similar studies with other species.

Since the animals involved in this study were from known sires, half-sib analyses were made to evaluate the potential to change carcass

components through genetic means. For the most part, no significant sire differences were found. This may have been due to small numbers, low heritabilities or to limited genetic variability relative to carcass components in the population. In any case, these results indicate caution in expecting early results in selecting for improved carcass merit based on selections within a given genotype.

Nutritional Value of Carcass Components and Dress-off Items

No studies were conducted in this series of experiments relating to nutritional value of goat meat. Thus, any comments on this aspect are drawn largely from the literature.

This series of studies, as well as others, have shown that goat carcasses have more lean and less fat than other species. This would obviously effect the protein and energy content of the meat. This is evidenced by a lower energy value for goat meat (2.3 m cal/kg.) compared to beef and sheep (3.6 and 3.1 m cal/kg., respectively) as reported by McDowell and Bove (1977). Composition of carcass protein would be expected to be similar for the various species. However, Srinivasan and Moorjani, 1974 (Quoted by Naude and Hofmeyer, 1981) suggest that goat meat may be marginally higher in the essential amino acids arginine, leucine and isoleucine. This may be explained by a higher overall protein content.

No data were located on the nutrient values of the offal or dress-off items of goat meat specifically. However, assuming that the values are similar to that from other species, the dietary value of these products could be very significant to undernourished populations. For instance, the liver is not only a good source of protein, but also precursors of Vitamin A and D, folic acid and poly-unsaturated fatty acids.

Composition of Fat of Goat Meat

The palatability of sheep and goat meat seems to be associated with fatty acid composition as it is in beef (Melton, et al. 1982; Dryden and Marchello, 1970); however, Kemp, et al. (1981), found no definite relationship between fatty acid content of lamb and its organoleptic properties. According to Campion, et al. (1976) the lower melting points of unsaturated fatty acids are associated with soft fat which has less desirable flavor.

Fatty acid composition varies according to age, breed (Wise, 1977; Congiu and Argrolas, 1977) and to a smaller extent with sex and weight (Kemp, et al. 1981). Wu, et al. (1982) studied the fat composition of 120 young intact males and aged females of three breeds of sheep (Karakul, Rambouillet and Black Bellied Barbado) and two breeds of goats (Angora and Spanish). Some of these data are shown in Table 13. The major fatty acids, comprising up to 85% of the total in the subcutaneous fat were oleic (C18:1), stearic (C18:0) and palmitic (C16:0). The percentage of unsaturated fatty acids in ovine/caprine fat (38-49%) from this study were smaller than that reported for ovine fat (54.5-63.6%) by Field, et al. (1978).

Among the five breed/species groups, fat from Karakul sheep had the highest percentages of pentadecanoic (C14:0), margaric (C17:0), heptadecanoic (C17:1) and total unsaturated fatty acids, while fat from Angora goats had the highest percentages of C16:0 but the lowest percentages of C18:1 and total unsaturated fatty acids.

Table 13. Mean Values for Fatty Acid Composition Stratified According to Breed/Specie and Age/Sex Groups.[1]

Specie/Breed/Age Category		Fatty Acid									Total	
		C14:0	C15:0	C16:0	C16:1	C17:0	C17:1	C18:0	C18:1	C18:2	Sat.	Unsat.
Goat (n=42)		3.36**	0.58	26.03**	3.63**	1.81	0.58**	25.91	33.91**	2.75*	57.69**	40.87**
Breed:	Angora (n=18)	3.21^{a}	0.60^{ab}	26.84^{a}	3.58^{ab}	1.91^{b}	0.47^{b}	27.52^{a}	31.58^{c}	2.69^{b}	60.07^{a}	38.33^{c}
	Spanish (n=24)	3.09^{ab}	0.56^{b}	25.15^{b}	3.71^{a}	1.81^{b}	0.69^{b}	25.50^{a}	35.47^{b}	2.48^{b}	56.12^{ab}	42.36^{bc}
Age:	Young intact male (n=15)	4.13**	0.56	26.56	3.51	1.68	0.52	24.33	34.30	3.37**	57.27	41.70
	Aged female (n=27)	2.58	0.59	25.49	3.74	1.94	0.64	27.50	33.53	2.13	58.11	40.04
Sheep (n=78)		2.43	0.59	21.89	2.87	1.96	0.90	23.69	40.05	3.13	50.57	46.95
Breed:	Rambouillet (n=25)	2.64^{abc}	0.51^{b}	22.94^{c}	2.83^{c}	1.85^{b}	0.75^{b}	24.29^{a}	39.05^{a}	3.60^{a}	52.23^{bc}	46.23^{ab}
	Barbado (n=22)	2.10^{c}	0.51^{b}	20.11^{d}	2.69^{c}	1.72^{b}	0.81^{b}	26.45^{a}	40.27^{a}	3.02^{ab}	50.89^{ce}	46.80^{a}
	Karakul (n=31)	2.58^{bc}	0.74^{a}	22.18^{c}	3.02^{bc}	2.25^{a}	1.17^{a}	19.53^{b}	41.88^{a}	3.11^{ab}	47.28^{d}	49.18^{a}
Age:	Young intact male (n=44)	2.70**	0.69**	21.47	2.85	2.05	1.19**	18.35**	43.69**	3.99**	45.26**	51.72**
	Aged female (n=34)	2.17	0.49	22.32	2.89	1.87	0.61	29.04	36.42	2.27	55.88	42.19

[1]The comparisons are to be made between species, breed within and across species, and age within species.

(a,b,c,d)The means in the same column bearing a common superscript letter are not different (P<0.05).

**Young intact males differ (P<0.01) from aged females within that specie group.

*Young intact males differ (P<0.05) from aged females within that specie group.

Source: Adapted from Wu, et al. (1982).

The fatty acid composition averages by breed are shown in Table 13. There were significant differences in percentages of most of the fatty acids in subcutaneous fat from goats vs. sheep. Percentages of C14:0, C16:0, CI6:1 and total saturated fatty acids were higher ($P<0.01$) in subcutaneous fat from goats. However, sheep had higher ($P<0.05$) percentages of C17:1, C18:1, C18:2 and total unsaturated fatty acids.

Analysis of subcutaneous fat from aged females revealed that goats had higher ($P<.05$) percentages of C14:0, C16:0 and C16:1, but lower ($P<.05$) percentages of C18:1 than did sheep. Both young intact male and aged female goats had lower ($P<.05$) percentages of C18:1 than did young male and aged female sheep.

Palatability or Acceptability of Goat Meat

The amount of emphasis to be placed on quality or palatability of meat in developing countries may be subject to considerable question. Questions might be asked concerning the relative preference for the meat of the goat as compared to that of other species or the importance of quality traits such as tenderness within species such as the goat. One study was conducted (Griffin, et al. 1983) in which these factors were investigated. The traits investigated were flavor, juiciness, tenderness and overall palatability. Earlier studies at this institution (Smith, et al. 1974) have suggested that goat meat was significantly less tender than that of sheep. However, subsequent developments suggest that this may have been an artifact due to an interaction between quick chilling and cold shortening of the carcasses. Since goat carcasses were smaller and had less fat cover, it is felt that they chilled much more quickly, thus affecting tenderness.

The importance to be attached to palatability traits would be a function of the eating habits of the society involved and/or how the meats are utilized. For instance, people who have historically consumed goat meat would react positively to any distinctive flavor; whereas people who had not previously consumed goat meat might react negatively. Likewise, for meats served in a highly processed form, tenderness would be of little concern, whereas for meats served as chops, steaks or roasts it might be particularly important. There is also considerable variability in the degree to which people look with disfavor on tough meat. It seems a reasonably safe assumption that in the case of domestic or home consumption in developing countries, quality traits are likely to be of limited importance; but that in attempts to commercially exploit goat meat production to such outlets as hotel and restaurant trade, or more affluent households, the quality traits should be of concern.

In the present study, loin chops and leg steaks from sheep and goats were evaluated by domestic (U.S.) and foreign (non U.S.) panelists. The reason for the two panels results from thesis that U.S. panelists may be less predisposed to consuming meat of these species and might also be more critical of quality traits in meat. However, it should be pointed out that both panels were drawn from students attending Texas A&M University; and thus may not be truly representative of the population from which they were derived. This may be particularly true of the foreign panel in that they likely represent the more affluent portion of society. Some of the results are shown in Table 11. These data show that the foreign panel consistently gave

higher ratings in all comparisons. However, the differences tended to be small and were statistically significant only in the case of flavor, tenderness and overall palatability of the leg steaks. The meat of the sheep rather consistently received more favorable ratings than goat meat, and for the most part these differences were significant. The only trait in which goats rated as high as sheep was that of flavor. These results suggest a problem or cause for concern in attempts to commercially exploit meat production from goats. Exceptions to this may be with populations which have traditionally consumed goat meat, and would thus likely be less critical, or for methods of preparation in which quality traits, such as tenderness, would be of little concern. There was little difference in the ratings given young males and aged females. In this connection, it should be recalled that neither of the types of animals used in this study would necessarily represent the most desirable slaughter animal. It has already been suggested that of those markets which have been tested, castrate animals received a higher price. Except for localized situations, it appears that most consumers choose goat because it is cheaper, or they expect it to be cheaper, and not because they prefer it. It has been suggested (Primov, 1984) that this is the case in Northeast Brazil.

Table 14. Mean Sensory Panel Ratings for Loin Chops and Leg Steaks for Foreign vs. U.S. panels, Sheep vs. Goats and Age Groups[1]

Cut	Trait	Domestic Panel (n=60)	Foreign Panel (n=60)	All Sheep (n=72)	All Goats (n=48)	Young Males (n=60)	Aged Females (n=60)
Loin chops	Flavor	5.2	5.3	5.2	5.4	5.1	5.4
Loin chops	Juiciness	5.0	5.1	5.3	4.7	5.0	5.1
Loin chops	Tenderness	4.9	5.2	5.5	4.3	5.1	5.0
Loin chops	Overall Palatability	4.9	5.2	5.2	4.8	5.1	5.1
Leg steaks	Flavor	5.1	5.3	5.2	5.2	5.2	5.3
Leg steaks	Juiciness	4.3	4.6	4.6	4.1	4.3	4.6
Leg steaks	Tenderness	4.2	4.8	5.0	3.9	4.7	4.4
Leg steaks	Overall Palatability	4.6	5.0	5.0	4.4	4.8	4.8

[1]Ratings were assigned on an eight-point hedonic scale with the higher values being more desirable.

CONCLUSIONS AND RECOMMENDATIONS

1. Increased contribution of goats to meet man's needs for food (and other products) is more likely to be obtained from (a) increasing numbers in areas where goats are uniquely adapted to utilizing the vegetation available, but are not presently available in adequate numbers, and (b) improving the productivity in areas where goats are presently found in large numbers than is the case through improved meat or carcass qualities. The United States is a good example of the potential for increased numbers. It has been estimated that the country

has 800 million acres on which brush or shrub is present or in which encroachment is a problem (Plummer, 1971). Much of this is in the south or southwestern parts of the country. These areas have the potential of producing untold millions of goats, and if used wisely would be ecologically sound and reduce the need for mechanical or chemical control of invading brush. In spite of this potential, the U.S. has only 2-3 million head of goats.

A large percent of the estimated world population of 450 million head of goats are found in developing countries where the productivity is often low. For instance, it has been estimated (Shelton, 1981) that the off-take from goat flocks in many LDC areas is on the order of 10-20%, whereas the potential is theoretically over 100%. If one accepts the previously stated numbers of 450 million goats and 1.97 million tons of meat, the daily accretion of meat would be 11.7 grams per day per head. This would be substantially above the off-take figure stated above, however the 11.7 gram figure is substantially below the potential. For instance, if a majority of the total number was made up of breeding females and each produced one 25 kg. kid per year, the daily accretion in weight would be 31.5 grams, not including body weight gains of the breeding female.

In summary, the above statements indicate a very great potential for an increased production from goats. This potential is several multiples of that currently existing. A number of problems or limitations must be overcome to realize this potential, and research directed at exploiting this potential should be a high priority and a multi-national goal. How this should be accomplished is the goal of the overall SR-CRSP effort.

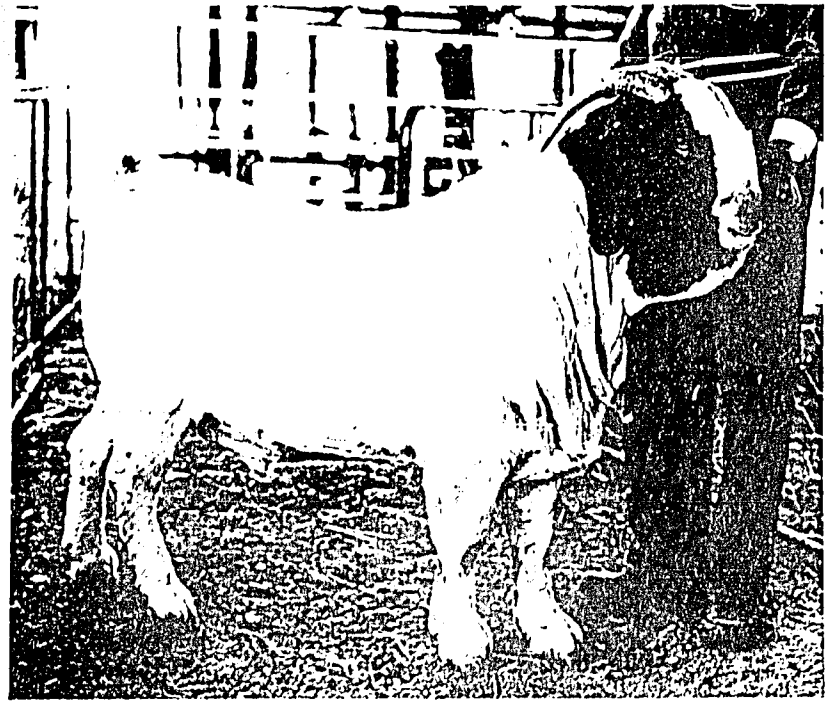
2. Although very secondary to that to be obtained through improved production, improved carcass and by-product value should not be ignored. In this discussion it is assumed that the carcass is the primary product and thus by definition other "dress-off" items are called by-products. The most valuable by-product is likely that of the pelt or skin, which is not being addressed in this report, but was discussed by Figueiredo, Shelton and Fant (1982). The other by-products or dress-off items at slaughter are of less value as a whole or per unit of weight, and thus on a quantitative basis they should not be maximized. However, it would be desirable to merchandize them to the best advantage with a view of increasing overall income. Thus, improved carcass weight and value is the primary means of effecting a positive change. As suggested earlier, this might be accomplished through increased yield, some increase in fattening tendency and placement of fat and possibly altered body proportions to present a larger portion of the weight in the more valuable cuts. Some of these, such as increased dressing percent and improved fat cover may be obtained through management. Some suggested management practices would be castration, improved level of nutrition, and age at slaughter. However, improved dressing percent, improved fat cover and more desirable placement of fat, and altered body proportions might be approached though breeding.

3. Improvement in carcass merit or slaughter value, as well as for total productivity, through genetic means might be approached by crossbreeding or through selection within breeds or lines. To the

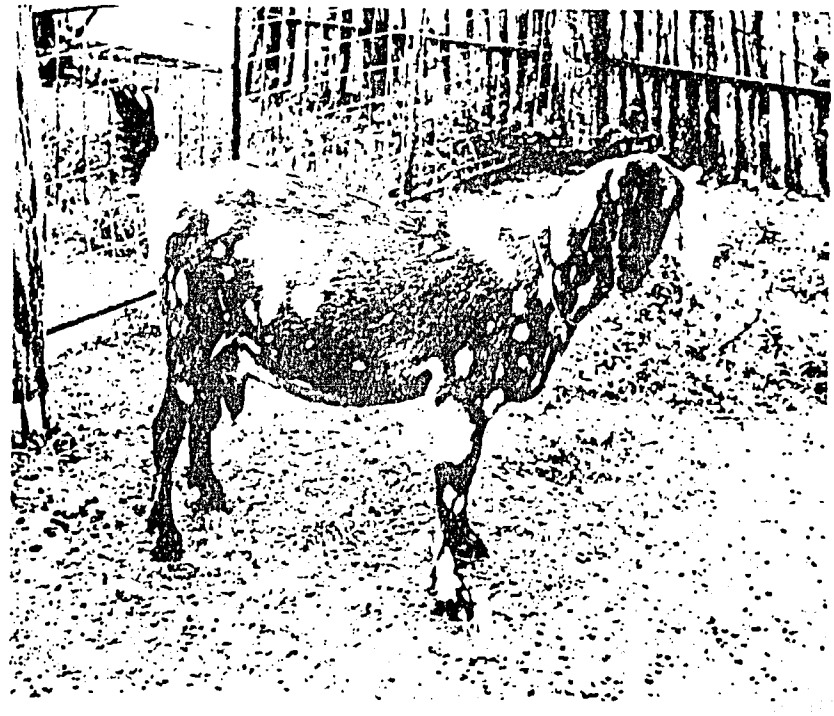
extent that superior types are available, crossbreeding offers a much more rapid means of bringing about change. However, a decision to practice crossbreeding either in a commercial scheme or as an initial stage in the transition to another breed should be approached based on other production attributes as contrasted to carcass value alone. The options in respect to breeds available for crossbreeding in goats are very limited. Two breeds appear to warrant attention at the present time. These are the Boer goat and the Anglo Nubian. The Boer goat (Figure 5) is generally recognized as having superior growth and carcass qualities (see Table 7), and thus should be considered for crossing. It should be pointed out that comparative studies involving data from the Boer and other goats are very limited. This applies to both production and carcass traits. In most areas, it will be difficult to gain access to the Boer goat, because they are generally unavailable outside South Africa. The other breed suggested for consideration for crossing was the Anglo Nubian. This breed is available at most places in the world. It also has the potential of serving a dual purpose role. In areas where the Anglo Nubian might not be available, other similiar types are relatively widespread, particularly in Africa and Asia. It can be shown that the Anglo Nubian has acceptable levels of reproduction and growth (EMBRAPA - 1983), but comparative slaughter data is limited.

4. Selection within breeds or lines was suggested as a means of improving carcass value. Again, it should be pointed out that appropriate selection practices should be based on overall merit as contrasted to carcass value alone. However, the almost universally poor yield and fat cover of goat carcasses suggests that either they have not been selected for improved carcass value or that they have not responded to selection. The data obtained in the present series of studies does not lead one to be greatly encouraged. For instance, selections based on phenotypic measures did not show a high correlation with carcass value, and sire differences were of a low magnitude and not statistically significant. Selection for improved fleshing might involve selection for improved growth rate or rate of fat deposition, an alteration in manner of fat deposition from internal to subcutaneous, altered carcass proportions and altered eating qualities. Other livestock species have responded well to selection for increased growth rate and rate of fattening and alteration in manner of fat deposition. Certainly, selection experiments should be initiated with goats to test their response. However, despite considerable effort with other species, there are few success stories in selection for altered body proportions, and it would seem a questionable goal to undertake this with goats at the present time.

Figure 5. Examples of Suggested Meat Type Breeds



Boer Goat Male



Anglo Nubian Female

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