

## Goat meat production and its consequences for human nutrition

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### Summary

Worldwide there are few, if any, religious or cultural taboos limiting the consumption of goat meat. In developing countries goats are mainly used in accordance with subsistence needs. In Australia and New Zealand feral goats are perceived to be a cause of much environmental damage. However goats can be managed to reduce infestations of woody weeds and thereby can improve degraded rangelands as well as being the basis of a profitable meat production enterprise. There is a worldwide increase in the use of goats as an alternative source of red meat. Goat carcasses can have dissectable levels of meat as high as 66% to 68%. Goat meat is leaner than other red meats, as goats tend to deposit most of their body fat around the omentum, mesentery and kidneys but the presence of a 'goaty odour' in some meat from older male goats has meant that there has been discrimination against consumption of goat meat. There are two main types of goat meat - capretto from milk feed kids and chevon from older goats and both types of meat tend to be leaner and of blander flavour than sheep meat. Australia is the largest exporter of goat meat which mainly comes from feral goats. The quality and quantity of 'harvested' feral goat meat is unreliable and Australian research is endeavoring to develop appropriate breeding, production and marketing systems to establish a profitable domestic and export goat meat industry.

### Introduction

The goat is the most prolific ruminant of all domesticated ruminants under tropical and sub-tropical conditions and most goat breeds have average litter sizes of 1.5 and higher (1). One of the reasons for the goats ability to survive in some of the most inhospitable regions of the world is its exceptional tolerance to heat stress (2) and its ability to grow on poor quality feed. Therefore goat production is equally suited to marginal farming areas, small farmers or large scale production in the tropics and sub-tropics. Goats when not properly managed can cause extensive damage to vegetation and forests. However carefully managed goats can be used to improve the use of rangelands and control weeds (2) and be a source of meat, milk and fibre.

There are three basic types of goats:

*Fibre* producing goats, for example Angoras that produce mohair and Cashmere goats

*Dairy* goats include Saanens, Anglo-Nubians and Alpine breeds of goats

*Meat* goats of which the (South African) Boer is probably the best known. The potential of Boer goats to make significant contributions to an Australian goat meat industry is currently being researched at the University of Queensland Gatton and Agriculture Western Australia. More about that later in the paper.

There are two main types of goat meat:

*Capretto* which is from milk fed, suckling kids (similar to cattle vealers) to produce a carcass weight of 5-12 kg with pink flesh that is tender and lean (3).

*Chevon* which is from older goats to produce a carcass weight of 16-22 kg. Chevon was the name given to this type of goat meat by the former US Secretary of Agriculture, Henry Wallace in 1924.

The adult male goat is traditionally known as a 'buck', the female a 'doe' and young goats 'kids'. As with other young animals a goat that has been weaned from its mother is known as a weaner.

The purpose of this review is to compile current knowledge on the world goat meat industry. We will examine the distribution of goats worldwide and demand for goat meat; the breeds of goats available and the types of production and processing systems in use; and the effect of nutrition on growth in goats. The later sections will discuss goat carcass and meat quality; and the final section will examine the future needs and strategies in goat meat research.

### **World Situation**

The world goat population was 372 million in 1965, 482 million in 1985 and over 640 million in 1995, with over half of the world goat population found in Asia (4) and more than 90% found in developing countries (2). India has the world's largest goat population which has increased from 66.5 million in 1967-71 to 120 million in 1995 (5).

Goat meat is acceptable to those who, for religious or cultural reasons, do not eat pork (Muslims) or beef (Hindus). For this reason goat, in India, has been designated as the 'national meat animal' (5). Despite its acceptance and its widespread production, the contribution of goat meat to total world meat production and consumption is surprisingly small. Recorded world production of goat meat exceeds 2.8 million tonnes (whereas total meat production is greater than 160 million tonnes) but this probably underestimates the actual level of production because a high proportion is home consumed and not marketed. In 1987, for every kilogram of goat meat consumed in Africa there was 0.5 kg consumed in Asia, and 0.2 kg consumed in North and Central America and 0.2 kg in Europe (2).

### **Demand for goat meat**

#### *Domestic - non Australian*

In 1993 Indians slaughtered 47 million goats (0.47 million tonnes) because of increasing market demand of which chevon was the preferred and most expensive meat (\$3 to \$5/kg, 1996 Australian values) (5). Although the total meat production from goats increased in India from 0.22 million tonnes in 1969-71 to 0.47 million tonnes in 1993, the relative contribution to total meat production more than halved from 36% to 12%. Meat from goats six to 12 months of age is preferred. It is mostly consumed eight hours or more after slaughter and eaten after thorough cooking mainly in the form of curry (5). Less than 1.5% of India's meat is processed and it is thought that goat meat follows this trend (5).

#### *Export - non Australian*

A large volume of goat meat is exported live. In 1987, African countries, primarily Sudan and Somalia, exported around 500,000 live goats to the Middle East. At the same time, Asian countries imported some 600,000 live goats. The bulk of goat (meat) exported from India is frozen and chilled and accounts for 65-75% of total meat exports. The contribution of goat meat to total meat export from India accounts for less than 7%, compared to 70-80% for buffalo and 20% for mutton. India exports most of its chevon into Middle East countries (eg. UAE, Saudi Arabia, Kuwait).

The main reasons for a lack of goat export industry in developing countries are: most goat enterprises are small scale; the countries lack an organised meat industry; and the diseases goat are likely to be carrying prohibit their importation into developed markets. The inability of

developing countries to gear their production systems to worldwide market demands for goat meat has been exploited in recent years by Australia and New Zealand.

#### *Export - Australian and New Zealand*

Table 1. Export of live goats, goat meat and goat products (\$'000) (6)

Description	1990-91	1991-92	1992-93
Live goats	1900	3800	950
Fresh, chilled or frozen goat meats	16040	20360	20660
Goat and kid skin (untanned)	1920	1880	2210
Goat or kid leather (tanned)	800	1490	1770

Goat meat exports from Australia and New Zealand are derived from harvesting feral goats descended from escaped domestic stock. Most goats are exported as carcasses (Table 1.). Export of live goats is limited to a few specific markets (Malaysia and a few Middle East countries) that require their own Halal slaughter which greatly influence demand and consequently the number exported each year varies widely (Table 1.). Australia exports bone-in whole carcasses with a carcass weight range of 12-20 kg to Singapore, Malaysia, Japan, Mauritius and the Caribbean, and boneless meat to the United States of America and Canada. There is a rapidly growing export market of Australian capretto carcasses into Europe. Much of New Zealand's goat export, of average carcass weight of 10 kg, is destined for markets in southern Europe, the Caribbean and south-east Asia.

#### **Breeds of goats**

Goats have been bred with varying capacities to produce meat, milk and fibre. There are 102 described breeds and a large number of mixed type goats in the world (7) ranging in mature body weight from small tropical goat breeds (9-13 kg) to large European dairy breeds and Boer goats which can exceed 100 kg (Table 2.). For example in India there are 20 recognised goat breeds, in addition to a vast multitude of mixed genotypes which constitute 75% of the total Indian goat population (5). In India goat breeds have evolved through selection for different requirements in different regions - a number of breeds evolved in the temperate Himalayan region to produce fine quality fibres such as mohair and cashmere; the major dairy breeds are found in the North and North-western region, dual purpose breeds are found in the Southern and Western zones, and the prolific meat breeds are found in the Eastern part.

Table 2. Mature body weight and wither height of various goat breeds (based on (8)).

Breed	Country	Sex	Body weight (kg)	Withers height (cm)
Feral	New Zealand	M	27-36	-
		F	19-26	-
Feral	Australia	M	50	75
		F	30-40	65
Angora	Australia/USA	M	46	70-65
		F	40	60-55
Beetal	India	M	60	92
		F	35	77
Damascus	Cyprus	F	70	75
Saanen	Australia/France	M	80-120	80
		F	50-90	75
Improved Boer	South Africa	M	115	75
		F	50-70	65

There are a range of dairy (eg. Saanens, Anglo-Nubians, Alpines) and fibre producing breeds (Cashmeres and Angoras) of goats in Australia. In Australia the main source of goat meat has been from harvesting feral (wild) goats. These feral goats show characteristics of a range of

dairy and fibre breeds (eg. some have well developed udders while others produce reasonable amounts of good quality cashmere). A major problem for those interested in developing a goat meat industry or simply consuming goat meat is that feral goats vary tremendously in their weight, carcass and meat quality characteristics. Until the 1980's there were no true goat meat breeds in Australia. Other than feral goats the only other source of goat meat were males from dairy goat breeds and cull animals, mostly older goats, from the fibre producing breeds. As these breeds were bred for traits generally unrelated to carcass characteristics the meat quality of these animals would have done nothing to enhance a consumers desire to eat more goat meat.

With the importation of Boer goats from South Africa in the 1990's there has been a growing interest by investors, hobby farmers and farmers involved in traditional animal industries, in the development of an Australian goat meat industry. This goat meat industry is developing on a crossbred goat—primarily based on Boer bucks mated with 'domesticated' feral does or does from the fibre or milking breeds. In 1996 there were less than 2000 pure Boer goats in Australia (P. Firth personal comment).

### Goat Production and Processing Systems

In most developing countries the average flock size is between three and 10 goats with little provision of special forage or housing. Goats serve the material, cultural and recreational needs of the farmer providing income, employment, security, power, food as well as by-products. Recommendations aimed at increasing the complexity and cost of the production system are considered unlikely to be adopted as they take away one of the major reasons for maintaining the goats in the first place—goats require no capital inputs and their sale represents large profit with virtually no investment risk (2).

In India the most common system for managing goats is extensive grazing of flocks on natural rangelands with or without nutritional supplements. There is a small but growing number of organised farms which follow intensive or semi-intensive management systems (5). In these developing countries the small body size of goats enables them to be slaughtered and dressed easily and hygienically. The size is good for family celebrations and the meat is distributed easily before it spoils.

In Australia goats are managed under a number of systems. For dairy breeds the management has traditionally been intensive with animals normally supplemented through most of their lactation even though they are commonly found in the higher rainfall areas of Australia, as with other dairy species. The management of fibre producing breeds of goats is similar to that of sheep in that they are either found in traditionally mixed farming systems (with cropping and sheep) or in the pastoral zones of Australia and grazed with sheep. The main source of goats for slaughter are from the opportunistic harvesting of feral populations. Estimates of the number of feral goats in Australia vary between one and three million (9)(see Table 3 for details of farmed goats). Because of the similarity of liveweights of sheep and goats it is possible, with minor modifications to the abattoir, to process goats through an abattoir designed for sheep and because of the growing interest in goat meat for both export and domestic consumption there are now seven feral goat processors in Australia (T. Elliott personal comment).

Table 3. Goat numbers ('000s) by type for 1991 to 1993, and Australian state as at 31 March 1991 (6)

Type of goat	Year			Australian state							
	1991	1992	1993	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Fibre	375.5	280.8	188.4	78.1	30.7	28.8	14.8	27.9	8.1	-	0.1
Dairy and other	73.7	67.1	52.8	43.3	2.2	3.1	1.5	1.3	0.3	1.1	-

In the USA goats are usually managed as part of multi-species grazing systems, with the addition of one to three goats per cow to increase forage production by reducing shrub

competition (10). Interestingly enough, the major constraints identified as limiting expansion of goat production in vast areas of the USA rangelands (> 0.3 billion acres) invaded by undesirable browse species are a lack of predator control, inadequate fencing, minimal market structure, and lack of knowledge of goat management (10). These constraints are equally applicable to Australia. The demand for goat meat in the USA is unknown and, with young meat goats currently selling at 20 to 30% higher than beef and lamb prices, the opportunity exists to expand goat meat production (10). In 1987 there were an estimated 826,000 Boer goats and 2,163,000 Angora goats in South Africa (11). Processing of goat meat is similar to that of lamb and in South Africa meat from young Boer goats competes with lamb.

### **Growth and nutrition**

Numerous nutritional influences affect the growth of goats including seasonal conditions and their effect on pasture type, pasture availability, grazing competition; as well as the amount and type of supplements provided; and the age of dam, and the kids birth type. The majority of published reports indicate that there are two major factors that limit meat production from goats - the first appears to be their inherently low growth rates based primarily from research on fibre and dairy goats (1) and secondly the poor nutritional conditions under which they are managed. Improved nutrition of lactating does can increase milk yield (12), which is translated into improved kid growth, an important aspect of capretto production. Further to this, increased milk intake in nursing kids leads to decreased saturation of adipose tissue fats, and increased proportion of fatty acids with odd carbon numbers and branched chains (13). Comparing subcutaneous and perinephric fat of kid carcasses with those of suckled lamb, slaughtered at a similar age, fat in kid tissue is harder because of its higher content in saturated fatty acids, mainly stearic acid. Low fat and cholesterol levels in goat meat from weaned kids are potential positive marketing assets (14).

Increased fibre content of diets fed to goats, at the same dry matter intake, may result in lower dressing-out percentage, due to longer retention times in the digestive tract (8). Nutritional regimes may influence fat distribution in the goat with goats fed or supplemented with grain or concentrates tending to increase carcass fat deposition relative to browsing or grazing animals and make the carcass of goats more 'sheep like' (15). Entire male goats grow faster than castrates which grow faster than females.

### **Carcass quality**

The economic value of a carcass depends upon its yield of saleable meat as well as the cutting and processing quality of the meat. Total edible and saleable proportions of the carcass decrease steadily in goats with increasing age from the milk tooth stage - in contrast, in the sheep they reach a maximum at the two tooth stage (16, 17). The maximum saleable portion is therefore reached at a very early stage in the growth and development of the goat. By comparison, dressing out percentage, when expressed in terms of empty body weight, usually increases as the animal increases in age and live weight, by around 2-5% (18). Mature goats can contain 30% carcass fat or more, but this is unusual, and goat carcasses normally contain lower levels of total fat and less subcutaneous fat than sheep.

The effect of liveweight on dressing out percentage in goats of different breeds was studied and no major differences found between breeds, but animals kept on high nutritional planes produced higher dressing percentages (19, 20). Does contain less bone in their carcass than bucks, and yield more edible tissue at the same carcass weight. However due to a greater tendency to deposit fat, females contain less muscle than males at the most weights. Furthermore female goats exhibit lower carcass yields than male goats when compared at similar liveweights. In contrast the effect of castration depends on the time it is carried out. Animals subjected to early castration (7 days of age) tend to have carcass yields 1-2% higher

than entire males, whereas animals castrated after six months of age have not been shown to differ from entire males (2).

Meat from female goats is more tender than meat from males at the same age (21). It is possible that these differences are fat related (females are fatter at similar age and weight, (21)) or merely the consequences of post-slaughter treatment effects (poorly finished carcasses suffer more from cold shortening and greater toughness of the muscle). Although meat from adult male goats is generally believed by the public to have a strong unattractive flavour and odour, the scientific evidence to support its presence is inconclusive (19, 20, 21). Castration of prepubertal male goats may be a solution.

Studies of carcass tissue growth rates have demonstrated the late maturing nature of the goat. Fat tissue development in the carcass is very late not reaching appreciable levels until live weights of 40 kg or more have been achieved (22, 23). It is therefore possible to have carcasses with dissectable levels of meat as high as 66% to 68% (24, 25). Carcass fat levels by comparison are low, in the region 5-14%, depending upon liveweight, age, sex and growth rate (22; Table 4). Body and carcass fat deposition in the goat are quite different from that found in the sheep. Subcutaneous fat cover is characteristically thin in the goat, particularly in grazing animals. Naude and Hofmeyr (1) reported fat cover on the loin of Boer goats of 2.3 mm as compared to 5.4 to 5.9 mm in sheep of similar age and sex. At comparable empty live weights sheep were reported to deposit about 3.5 as much subcutaneous and intramuscular fat as goats (26). Preliminary results of goat research at the University of Queensland indicate that kids of larger sized breeds (Boer, Saanen) have higher birth weights and grow faster and therefore reach capretto slaughter weights quicker than smaller goat genotypes (Angora, feral)(27). There were no significant differences in dressing percentage (range 49-51%) or percentage of muscle (range 60-63%) between the genotypes. There were only minor differences in carcass fat content.

### **Meat quality**

Goat meat is leaner than other red meats, as goats tend to deposit most of their body fat around the omentum, mesentery and kidneys. Viscera and channel fat account for between 50-60% of the total body fat in the goat with the balance situated between (intermuscular), within (intramuscular), and around (subcutaneous) the skeletal muscles (22). In general, goat carcasses have more muscle and thicker muscle fibre bundles than sheep of similar age and weight. Goat meat on average contains around 74.2% moisture, 21.4% protein, 3.6% fat, 1.1% ash; and 12 mg calcium, 193 mg phosphorus, 4.5 mm total folic acid, 2.8 mg vitamin B12, and 118 Kcal/100 g of meat (5).

Although organoleptic quality is affected by a host of pre-and post-slaughter factors, the single most important criterion influencing customer choice is age of the animal at slaughter (2). With increasing maturity the meat from Criollo goats becomes progressively darker, tougher and drier (28). A comparison of Sudanese desert goats and lambs of similar age and liveweight reported that the goat meat had superior water-holding capacity, darker colour and lower fat content than the sheep. After cooking the goat meat was still darker, whereas flavour and juiciness were both significantly lower in the goat meat than the lamb and overall tenderness and overall acceptability were rated similarly between the two species (29). This relationship between maturity and tenderness has been shown by others (19, 21, 30). This is reflected in the fact that the bulk of goats that are slaughtered for markets in most Mediterranean, Caribbean and Latin American countries are caprettos between 8-12 weeks of age (2). Organoleptic evaluation of capretto samples of different goat genotypes (27), indicate that there were only subtle differences between genotypes. Only Boer-Saanen kids achieved the very pale muscle color desired in capretto carcasses.

Table 4. Dissectible lean, fat and bone contents of goat carcasses, and lean:bone ratios (based (8)).

	Sex	Carcase weight (kg)	Percentages			L:B ratio	Source
			Lean	Fat	Bone		
Australian feral	M	5	63.3	5.8	28.6	2.21	(31)
	F	5	64.0	10.0	22.7	2.82	
	M	11	64.1	13.2	19.3	3.32	
	F	11	58.5	22.6	15.8	3.70	
Boer	M	4	70.0	9.2	20.8	3.37	Casey & Naude (cited in (32))
		12	68.1	17.8	13.8	4.93	
		17	64.5	21.8	12.6	5.12	
		22	63.3	24.1	12.0	5.28	
Saanen	M	5	60.9	9.9	25.6	2.38	(8)
		20	60.1	14.0	21.5	2.80	
		50	59.7	17.6	19.2	3.11	
	F	10	61.8	10.6	24.7	2.50	
		20	55.1	22.0	17.4	3.17	
		30	51.5	33.7	14.1	3.65	

Tenderness of meat depends on, among other factors, the amount and states of three types of protein: the connective tissue, myofibrils and sarcoplasm. Although young animals have more connective tissue per unit weight in their muscles, it is largely a different type than that found in older animals and hence is more tender. In bovine muscle and possibly goat muscle, the proportions of salt and acid-soluble collagens decrease with age as does collagen solubility on heating, while the degree of collagen molecule cross-linking increases (33).

Although there is some evidence that goat meat is tougher than sheep meat from animals of similar age (1, 21) it is thought that intrinsic differences in muscle tenderness between sheep and goats are unlikely and that pre-slaughter animal treatment and post slaughter carcass treatment are probably more important determinants of tenderness (1). In particular, the relatively low subcutaneous fat cover of goats can permit rapid cooling and consequent cold-shortening of muscles. Appropriate processing techniques should be used to minimise this problem (34). However, in a recent study comparing sheep, Angoras and Boer goats, where carcasses of similar weight and fat score were compared, the sheep meat was found to be more tender, contained less fibrous tissue residue and had a more pronounced species flavour than that of Angora or Boer goat meat (35). With increasing fatness of carcass, the tenderness and species flavour of the cooked meat increased significantly. The authors concluded that the meat from goats was acceptable from an eating quality point of view, but was clearly distinguishable from lamb or mutton. Other studies on meat from Angora and Spanish goats have reported that goat meat has equivalent juiciness to beef and pork but is less juicy than lamb (36, 37). Juiciness of meat is directly related to the intramuscular lipid and moisture content of the meat (38).

Fatty acid composition of animal fats can affect taste and odour of meat. Research with sheep indicated that the C8-C10 branched chain fatty acids in the meat (principally chircinoic acid) were the components primarily responsible for the distinctive species flavour and aroma of goat and sheep meat (39). It is likely that in goats, like sheep and cattle, more saturated fatty acids are deposited as the rumen develops because of rumen hydrogenation of dietary fats (33). There is evidence that unacceptable goat flavours are enhanced with age and higher levels of feeding (40, 41).

Chevon contains more arginine, leucine and isoleucine than mutton and has more oleic acid and less linoleic acid in body fat deposits. Chevon possesses better emulsifying properties than lamb and has a naturally bland flavour and lends itself to spice variation according to one's own tastes better than any other meat (5).

### Future needs and strategies in goat meat research

There is a need to establish suitable production systems for goat breeds including their nutritional requirements in Australia and other goat meat producing countries. There is an urgent need for an international live goat and goat carcass grading system for international trade. In Australia there is a need to develop an organised meat goat industry rather than harvesting a feral resource. It is necessary for India and other developing countries to implement an organised meat goat industry. To ensure that all goats being produced are suitable for human consumption there needs to be authentic goat meat quality data generated that is then promoted to consumers.

### Acknowledgement

A jointly funded Meat Research Corporation and Rural Industries Research and Development Corporation project being undertaken by staff at The University of Queensland Gatton and in Agriculture Western Australia are endeavoring to resolve some of these issues in the goat meat industry.

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