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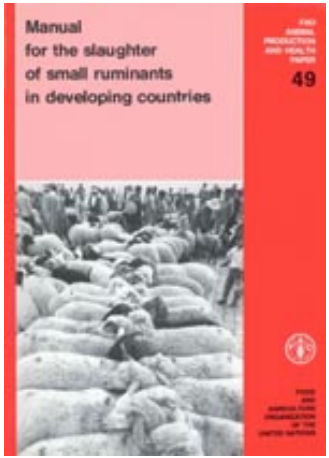

Manual for the slaughter of small ruminants in developing countries

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by

St. John A. Clottey
FAO Consultant

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1. INTRODUCION

1.1 Objectives and Scope of the Manual

The purpose of this Manual is to set out guidelines for the slaughter of small ruminants, namely sheep and goats, in developing countries.

More than any other source of red meat, sheep and goats have the widest distribution in most areas of the developing tropics because of their prolific nature, hardiness in adverse conditions and, most important, their high rate of acceptability with the vast majority of people. Small ruminant stock occur in all types of environment, from rain forests to deserts, and are numerically more common in foreign trade than any other species of livestock (See Table 1B in Appendix I).

In most countries of Africa and Asia sheep and goats serve the dual purpose of supplying dietary needs and as a source of sacrificial offerings, the latter often precluding their use as food. For instance, the Arabian Peninsula, which embodies a number of Islamic states,

though traditionally a livestock-deficient region, imports large numbers of sheep, between 4–5 million annually, for the Haji (Id-el-Fitr) festival.

The popularity of sheep and goats is not always matched by suitable methods and procedures for their conversion into food. The great majority of these animals occurs in rural areas which are also centres of tradition where ritual observances are strongest. Consequently, these are the places where they are mostly slaughtered, consumed and/or used in sacrificial offerings. Unofficial slaughter of small ruminants is much greater than officially recorded slaughter (Table 1A).

1.2 Need to Improve Slaughter Practices

Again in these countries, the methods of sheep and goat handling and slaughter for public consumption invariably follow traditional and ritualistic norms, some of which at times are at variance with acceptable practices resulting in cruelty to animals, quality losses in meat and a challenge to public health and aesthetic values.

The chief objective of this Manual therefore is to outline a few procedures governing modern-day slaughtering, particularly those concerned with humane practices and the attainment of a good quality product which is safe and wholesome for human use. This will be done taking into consideration the key aspects of religious and traditional observances and the possible modifications that can be brought to bear on them for the attainment of the objectives.

Additionally, the important question of livestock and carcass handling, slaughterhouse hygiene and sanitation, waste disposal and byproduct utilization will be covered as will specifications required for the construction, equipping and rehabilitation of slaughter premises. It is hoped that readers or users of this Manual will find it useful and practical.

2. PREMISES FOR SLAUGHTER

2.1 Types of Slaughter Premises

Slaughter premises normally seen in developing countries are of three kinds: modern abattoirs, old slaughterhouses and slaughterslabs and makeshift premises.

Of the three, modern abattoirs represent the most progressive and the ideal in conventional abattoir design, equipping and services. Often built and controlled by central governments with foreign technical assistance and management, these abattoirs are operated on industrial lines with a wide range of services featuring cold storage, processing, by product utilization and waste recycling activities. Some of them have export objectives primarily in chilled and frozen meat although at times some of their manufactured products (and

byproducts) are channelled into local sale in substitution for imports. Few modern abattoirs in developing countries slaughter directly for public consumption, being as they are commercial or profit-motivated establishments with little inclination for low revenue services.

The old slaughterhouses and slaughterslabs handle the bulk of public slaughters. These premises merely make facilities available for use by licensed butchers and traders for the slaughter of livestock at stipulated fees, and in accordance with public health, inspection and marketing regulations. Slaughterhouses and slaughterslabs thus operate as service establishments under the management of municipal and local authorities, their field of activities often being limited to the larger towns and built-up areas.

The third category of slaughter premises, the makeshift, for want of a better term, include all kinds of places such as converted buildings or rooms, shade of trees as well as open baregrounds that a butcher or a community may find convenient for the operation.

Mostly private-owned and under no formal authority or licensing, these premises and their products are neither inspected, quantified nor subjected to trade and health regulations.

Makeshift slaughter premises are characteristic of village and rural locations. Occasionally, however, they may occur in the suburbs or on the fringes of larger towns. In the latter, they are sometimes considered to have links with illegal livestock trading and the slaughter of sick and diseased animals. Because they defy obvious norms in slaughterhouse construction, equipment services and hygiene, their existence and operation is not advised. In unavoidable cases, these premises should be allowed to operate only if the animals and their products are to be inspected.

This part of the Manual will be concerned with slaughterhouses and slaughterslabs of the kind found in larger towns and built-up areas as these constitute the core of official slaughter operations in the developing countries. Indeed, many of the present premises are fairly old structures, having been built several years ago (some more than

half a century old), and at a time municipal engineering and public health requirements were less stringent and different from those prevailing now. The subject of siting, layout and construction are dealt with in this chapter, followed in the next (Chapter 3) with facilities for slaughter, equipment and operating tools. Also taken into consideration are the key requirements for slaughterhouse rehabilitation and modernization.

2.2 Siting

Slaughterhouses are best sited on the outskirts of a town or village, at a distance from built-up areas. This is to prevent possible inconvenience to dwelling-places either by way of pollution from slaughter wastes or by way of nuisance from noise, stench or the presence of scavenging animals such as vultures, stray dogs, etc.

Conversely, remote location secures the premises from contact and likely contamination from residential units close by. Nevertheless, some proximity to the city or town should be maintained to take advantage of

vital services such as power and water supplies.

Another feature of the area selected is that it must be open, treeless and with air currents to provide for natural lighting and ventilation as dark environments can cause lapses in hygiene while stagnant air can induce growth of spoilage organisms on meat and meat handling equipment. Trees also attract birds which are agents of contamination.

The siting of slaughter premises near waterlogged areas must be avoided. Evidently such sites can raise sanitation problems as in the breeding of mosquitoes and stagnation of wastes. Where possible, the location of the plant should be made at a higher elevation relative to the surroundings (Fig. 1).

Location near watercourses or inland bodies of water such as rivers, lakes and lagoons is also unadvisable. This is to avoid the temptation of discharging wastes into the waters with consequent pollution and cross-contamination of the premises. Liquid waste can, however, be discharged into these waters provided it is treated and rendered safe

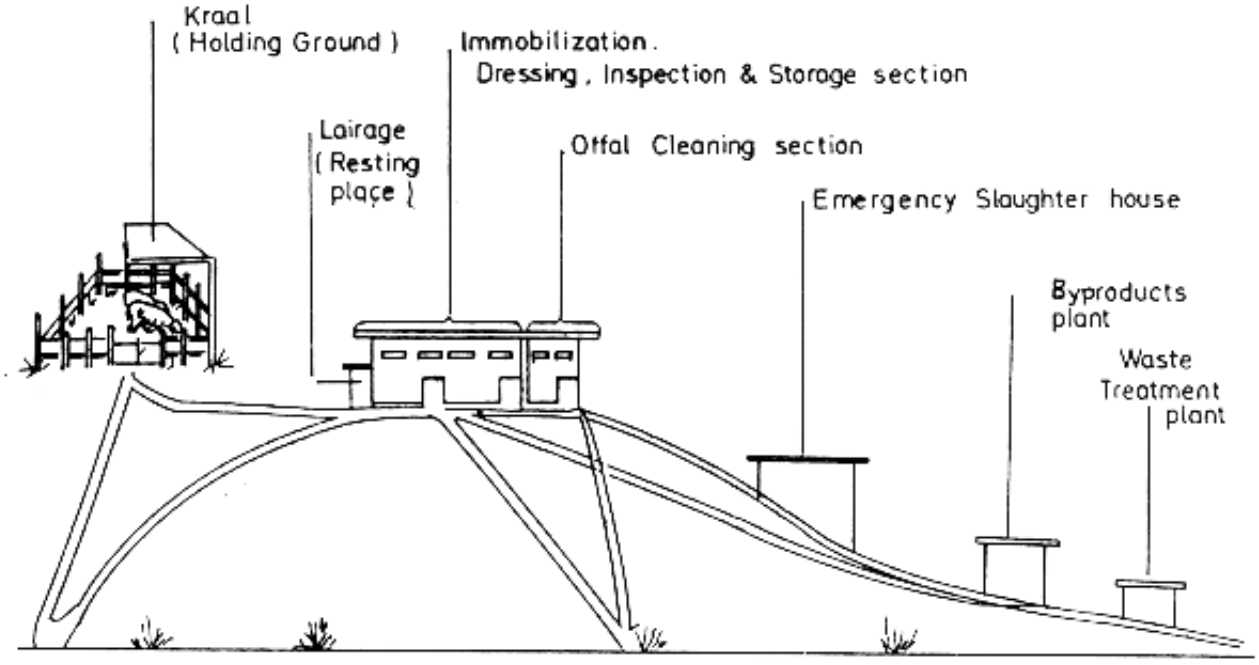
for aquatic life or for humans using the waters.

Discharge of waste into the sea without prior treatment is recommended provided the effluent is delivered through pipes and deposited far out into the sea, at least 5 km from the coast. However, this should be done in line with local municipal and environmental regulations where these exist.

2.3 Lay-out

The choice of a site for construction must be followed by considerations for layout. Here both the premises and the immediate environment need consideration. Premises meant to serve large communities and hence likely to have a heavier workload must be planned as full slaughterhouses and not as simple slaughterslabs. This means that they must have physically identifiable operational zones such as killing, dressing, inspection and off-cleaning areas, each in turn provided with its given set of equipment and operating gear.

FIG. 1 LOCATION OF SLAUGHTER PREMISES AND AUXILIARY UNITS



The premises must be fenced to keep out undesirable individuals and

to prevent animals from entering the yard. Outside the fence, a kraal with roofing must be provided, but within the yard and close to the killing floor, a lairage would be necessary. Lairages are enclosed or roofed spaces for resting animals prior to slaughter, while kraals are essentially holding grounds for animals waiting longer for slaughter. Both must be provided with watering facilities. In addition, the kraals should have feeding troughs for cut herbage, or else the animals should have ready access to grazing in the neighbourhood.

Auxiliary services and functions such as livestock marketing, hide-drying and manure accumulation and collection must be located at some distance from the plant. In other words, no activities should take place in the immediate environs of the premises other than the resting of animals and, if unavoidable, kraaling. Slaughtering in the yard in rural slaughterslabs during peak seasons must similarly be discouraged, as all such activities predispose meat to contamination.

2.4 Materials for Construction and Installation

The general principle regarding the choice of materials for constructing and equipping slaughter premises is that the materials must be durable and be able to resist deterioration or destruction from external influences such as the weather, air, steam, water and insects. This means that materials such as swish, wood, thatch and corrugated iron are undesirable. In their place brick, sandcrete, stone, reinforced concrete, asbestos, tile and slate should be used.

For the operating chambers, the materials used must not be pervious to water and blood or stained by fat; glazed tile or a hard smooth material should be used for the walls to facilitate cleaning and prevent absorption of moisture and fat. A similar principle should apply to the selection of equipment for the chambers: stainless steel, galvanized metal and aluminium are good choices for metal fittings or furnishings while plastics may suit containers and working surfaces. The general items of furnishings are discussed in the next chapter.

3. FACILITIES, EQUIPMENT AND TOOLS

3.1 Water and Drainage

All public slaughter premises must have a dependable source of clean water or what is normally referred to as potable water, preferably pipe-borne, to maintain hygienic and sanitary services in the plant. The water must be well distributed in terms of point-location inside the premises and must be hot, if possible, for hygienic washing of products and facilities.

In the absence of pipe-borne water, surface or underground water from rivers and wells can be used but must be pre-treated. It would be

useful, however, to instal a reservoir or tank on the premises as a security against shortages and breakdown of pumps.

Side by side with water is the question of drainage. All washings or wet cleaning must course over the slaughter floor into a collecting drainage and empty eventually outside the building. The floor should be designed to slope toward the main collecting drain, the latter in turn to slope toward exterior connecting pipes. While the walls must have a hard smooth surface to prevent staining with blood and fat and hence facilitate cleaning, the floor must be rough or grooved to forestall slipping.

3.2 Lighting and Ventilation

Lighting is another important requirement. In the cities and towns, connection with the main municipal electricity supply should be possible, but failing that a diesel generator can be installed. Transparent insets can also be made in the roofing at vantage points to provide natural lighting or sky-lighting. Wide lintel windows or bay

openings, covered with gauze to exclude insects, also serve the same purpose, as well as provide ventilation.

3.3 Basic Equipment

The standard installation and equipment required in modern slaughter premises are those necessary to effect a rapid and hygienic conversion of livestock into meat in what might be called the dressing operations, and those required to prepare the offal for further use or disposal into waste, otherwise referred to loosely as cleaning and rendering operations. The facilities required for these services must be carefully selected and kept separate.

a. For dressing (including immobilization) the following are important:

    i. Stunning Pen: A small or narrow enclosure into which the animal is led from the Lairage to be rendered unconscious (in conventional slaughter) after which it is bled; also referred to as the knocking pen;

ii. The Hoise: A device for lifting up the stunned animal for bleeding; it can be operated manually, mechanically or electrically. The hoisting system is often built into an overhead rail-system to facilitate movement of the animal for dressing and the carcass for inspection;

iii. Skinning Cradle: A metal or plastic rest with a trestle arrangement onto which the bled animal is placed for skinning and evisceration, often used where a hoist system is unavailable;

b. The offal gear comprises the following as major equipment:

i. Collecting Troughs: These are containers for receiving blood or collecting gut material and are also utilizable for disposal of non-carcass components such as shanks and hoofs;

ii. Offal Cleaning Tables: Often built into the offal chamber wall, they may be of concrete, galvanized metal or stainless steel

and provided with high pressure water points for cleaning offal.

3.4 Orientation of Slaughter Floor Activities

As far as possible, the carcass dressing and offal cleaning operations should be kept separate. In large slaughterhouses, this is achieved by physical demarcation of the slaughter premises into distinct operational zones or by the disposition of the working gear as a whole.

Where this is not possible, as in a slaughterslab which may operate on a single “all-purpose” floor, the separation of dressing and cleaning operations can be effected by orientation of the activities in such a way that they follow in one direction only. Care must be exercised however, in dressing operations as skinning and evisceration have contaminating influences. Blood collection and the initial handling of condemned meat must also be done carefully and away from the carcass. The practice of slaughtering animals in any available space within the premises is negative to this concept and should be

discouraged.

3.5 Slaughtering Tools

Relatively fewer tools are required for the slaughter of small ruminants, and some can be made by local metal workshops or blacksmiths. They include the following (see also Fig. 2).

a. Sticking Knife: A knife with a six-inch blade (15.2 cm) and a v-shaped end used in severing the blood vessels of the neck to bleed the animal;

b. Skinning Knife: As the name implies, this knife is used for the removal of the animal's skin. Also with a six-inch blade and characteristically curved backwards to allow for ease of operation, it can be used to scrape off burned hair from carcasses being dressed with the skin-on;

c. Meat Saw: A replaceable blade handsaw which is used in sawing

through bone;

d. Meat Chop: Also called the cleaver, the mea chop is a heavy axe used for separating heavy structures, e.g. the head from the neck or the shanks from the leg;

e. Spreader: A metal device for suspending the animal body and spreading out the legs for dressing and inspection;

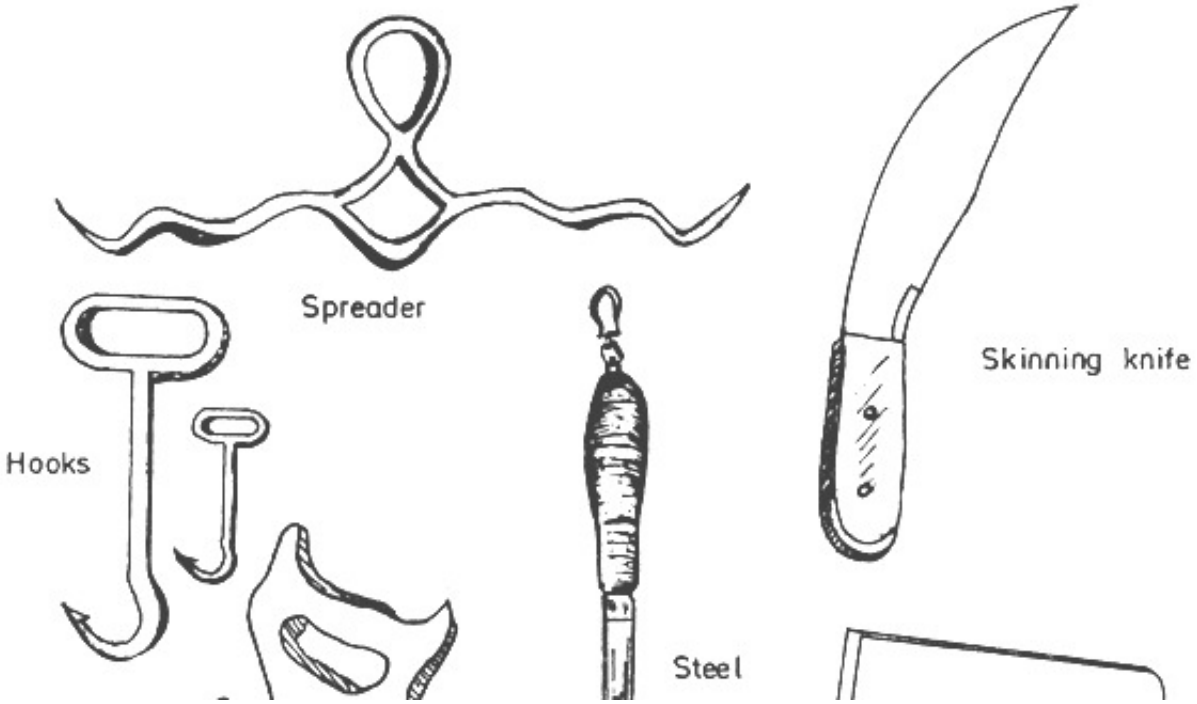
f. Grinding and Honing Stones: Grinding stones are coarse grained and used for the initial sharpening of knives into thin edges, then finished with the honer which is of fine-grain to provide extra thinness. Either oil or water may be used in sharpening knives to prevent the stone from heating the knives;

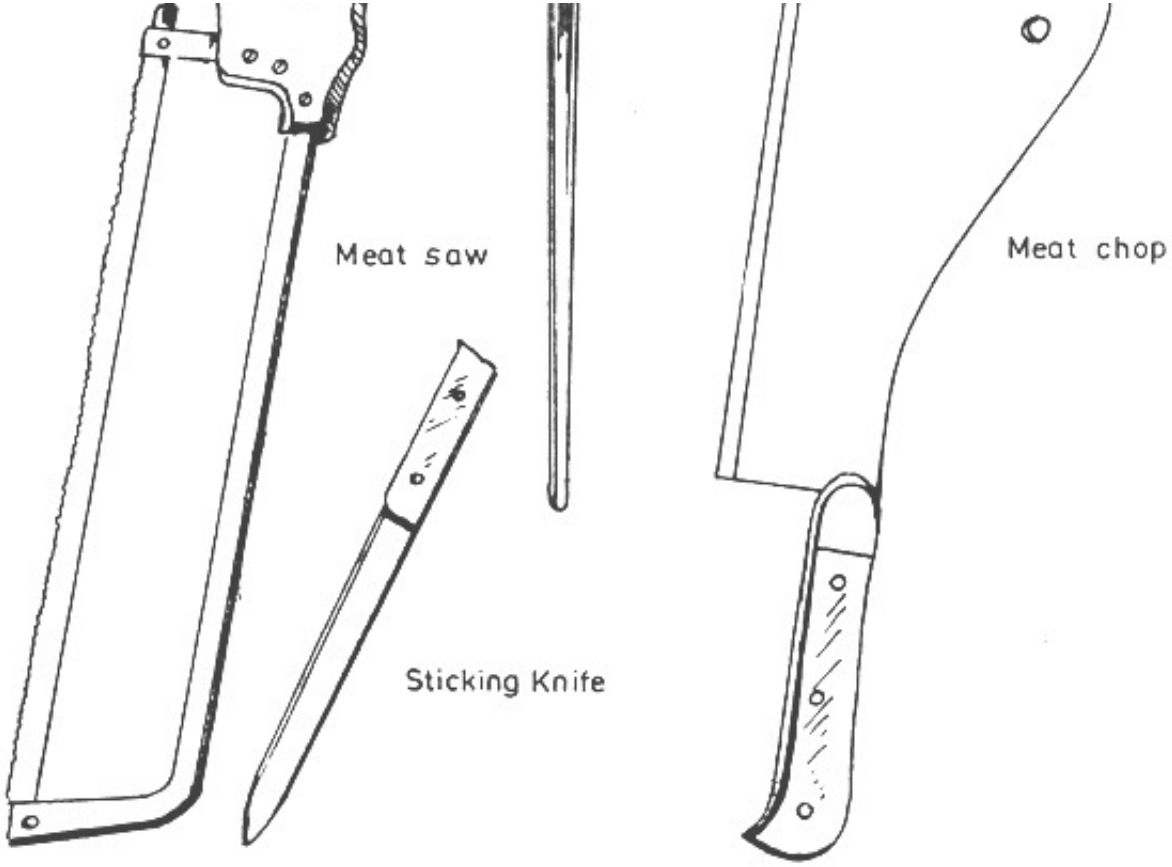
g. Steel: A long, tapering rounded and smooth metal rod on which knives are smoothened from time to time to improve keenness;

h. Meat Tree/Hooks: Metal devices with bent ot curved ends for

holding or displaying parts of the slaughtered meat and offal for washing and inspection.

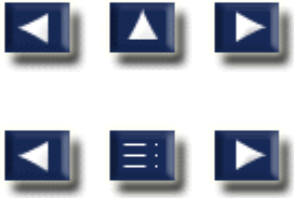
FIG.2 SHEEP AND GOAT SLAUGHTERING TOOLS





The above list constitutes the most important tools required in the

slaughter of small ruminants. At the end of the slaughter operation, they must be washed with detergents or disinfectants before being stored. Blade-edged tools must be sterilized while those liable to corrode should be oiled.



4. SELECTING ANIMALS FOR SLAUGHTER

4.1 Influence of Traditional Preferences

Old animals of all species are normally slaughtered for food in most parts of the developing tropics. This choice is dictated by the fact that animals take a long time to mature. Tradition also plays a role in

selection, as younger animals are often tabooed or barred from diets.

In addition, meat from older animals such as cattle fits in well with food preparation practices and eating habits because of its tough muscle fibres, a property which makes for prolonged cooking and produces chewable rather than tenderized meat, which is greatly desired in these cultures.

4.2 Criteria for Selection

A few guidelines are however worth observing in selecting livestock for slaughter. These deal with the health condition and the physical quality characteristics of the animal, two important factors in the production of wholesome, good quality meat.

a. The Health Aspect

The obvious mark of a healthy animal is a quick, smart appearance underlying which are keen, well-disposed body

reflexes. When such animals move, they do so steadily with ease, not jerkily or with difficulty. Animals that are not fat or bulky, yet unable to move or walk with ease, must be suspect of unsound condition.

When resting, the animals must not be entirely motionless. Some movement or reaction must take place when disturbed. Extremely weak, old and highly emaciated animals often have poor reflexes due to a weak muscle condition which does not produce desirable meat upon slaughter. Also, animals in an advanced state of pregnancy must be spared from slaughtering, the reason being that their blood has large accumulations of harmful waste materials associated with the developing foetus which should not form part of food intended for human consumption.

Ordinary signs of ill-health should not escape the attention of the individuals making selection. Abnormal conditions like a high breathing rate, high temperature and fever, a foamy or frothy mouth, diarrhoea and discharges of various sorts from the body

are all evidence of a state of ill-health. Such animals must be separated from the rest of the stock and treated before being brought for slaughter.

A usual practice in the villages of poorer countries is the slaughter of sick, diseased and dying animals in an attempt to salvage their meat value. This is contrary to accepted conventions and must be prohibited as such meat can be a source of infection or food poisoning.

It must be emphasized, however, that these are mere guidelines for the layman and should not substitute for the services of a professional veterinarian or a trained animal health inspector. Where possible such people should be brought in to assist.

b. The Quality Aspect

Maturity as a criterion for selection of livestock for slaughter in developing countries does not necessarily mean very old animals.

A mature animal simply means a fully developed animal. Thus in sheep the following forms of maturity exist: Lambs (sheep under 1 year); yearlings (sheep about one year old), and mutton (sheep over 1 to 2 years old). According to this scale, the prime choice in developed countries such as the USA or UK might be a lamb, whereas in developing countries, it may be a 2-year old or over, although this is not always the case. Of importance is that some other selection criteria should engage the butcher's attention such as the weight of the animal (if this can be determined at the market) and its build and shape or what is referred to as conformation. These two criteria help in assessing the amount of meat on the animal and the quality of the carcass.

Meatiness:

The heavier an animal is, the more likely it is that it may dress higher, i.e. produce a carcass of heavier weight. This is true of well-fattened animals. Nevertheless other factors sometimes have an effect on carcass yield. For instance, an animal that has a thick skin, pelt or a

heavy cover of hair over the body will most likely yield a lower dressing weight. Similarly, if the amount of “fill” of the gut of ruminants is high, carcass yields tend to be lower. In other words, as the offal or non-carcass components of the animal body increase in weight there is a corresponding drop in the yield of the dressed meat. The butcher should thus acquaint himself with the key criteria of animal selection to make a better choice in the stock he purchases.

Conformation:

Another yardstick of a meaty, good quality animal is the conformation or build of the animal which is seen in its stocky, rounded full-bodied nature. Such animals must also be short-necked, short-legged, and so on. The converse is true of the thin and leggy animals. Often thin animals are also poor-fleshed with bones jutting out. Bulk and wide-framed configurations as occur in some Zebu cattle, though not so much in sheep and goats, often reflect both poor conformation and low meatiness. Well-conformed animals are usually also well-fattened younger stock with fine-textured, palatable meat.

Unless an animal has reached an advanced age or is weak and diseased, an effort should be made to condition it prior to slaughter. This can be achieved by feeding concentrates (grain byproducts) and cut herbage for about 2 months. Again, no rule will be established here as some animals have a limited genetic capability to put on the desired weight or to improve their conformation by feeding. Individual norms must therefore be established for the different breeds of stock.

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5. TRANSPORT, HANDLING AND CARE OF ANIMALS

5.1 Reasons and Guidelines for Trucking Animals

Vehicular transport of animals to slaughter is slowly gaining ground in the poorer countries in place of the on-the-hoof method. This is quite evident with sheep, goats and pigs because of difficulties of herding numerous small stock on-the-trotter to slaughter, a practice which also subjects the animals to stress, exhaustion, weight losses and lower quality carcasses.

Road transport featuring special trucks is probably the cheaper, commoner and more convenient means of conveying animals because it affords more direct links with production and marketing centres than does rail or air. A few precautions are worth nothing in road transporting small ruminants to slaughter:

a. the trucks must be specially designed or conveniently modified to convey the stock;

b. they should allow ample ventilation and lighting;

c. if open trucks are used, the top should be covered with a tarpaulin

or canvas material to protect the animals from rain and sunshine;

d. they should have easy loading and off-loading mechanisms to prevent injuries, and above all

e. they must provide for maximum comfort of the animals.

In loading the trucks, the animals should be kept from a state of excitement. Rushing them in with force or with violent beatings must be avoided: heavy whips often cause bruises which ruin the quality of the meat. A moderate-size flock must be transported at a time. Overloading and overcrowding should not take place: animals get bruised, suffocate or become exhausted when this happens, and over long distances they may lose weight.

Sheep and goats may be trucked together, but should not be mixed with cattle especially the bulky, long-horned type which are apt to squeeze and trample upon them or cause them injuries.

When trucking is routine (i.e. regularly between fixed points) and over long distances clearly defined routes must be followed, these being provided with resting stops for feeding and watering.

On arrival at the slaughter holding ground, they must be discharged, with patience, avoiding all cruelty. Immediately upon off-loading, the animals should be stored out: the sick and fatigued to be placed in special pens and the normal animals in the kraal. Needless to say, the sick animals should regain fitness before being slaughtered.

Should it be necessary to lift and carry the sheep or goat, one hand must be placed under the jaw with the other at the hock. They should not be lifted by grasping the skin or hair as this causes surface bruising. To catch them, a leg must be grabbed first.

The trucks in which the animals are conveyed should be washed and disinfected after the discharge, but if this is not possible, they should be swept thoroughly and sprinkled with sawdust.

5.2 Animal Holding and Care

Physically fit animals that are to be slaughtered within 24 hours must be conveyed direct to the lairage for rest. Those waiting their turn are to be held in a kraal or pen.

During the resting period any excitement must be avoided. Feed must be kept away from the animals at least during the last eight hours before slaughter. However, fresh clean water may be provided throughout the resting time. Ante-mortem inspection should be made during this period or about twelve hours before the animals are delivered to the killing floor.

Rest is important because when animals are overworked or fatigued carcasses of lower quality result from slaughter. The meat is similarly affected if the animals get a heavy “fill” from feeding prior to slaughter. Time must therefore be allowed for the gut to empty itself of bulk at which time fewer nutrients as possible will be present in the blood stream and the cells of the body. With this, spoilage bacteria act less

on the carcass, thus reducing the incidence of off-taste and souring.

It should be noted further that when a great deal of food is present in the gut, it makes evisceration difficult. Conversely an empty gut reduces viscera size and makes its removel easier: it also lessens the possibility of spilling the contents of the gut on to the carcass, thus facilitating its cleaning, while eliminating contamination.

6. SLAUGHTERING PRACTICES AND TECHNIQUES

6.1 Forms of Slaughter

Slaughter methods prevailing throughout the world are governed either

by tradition, ritual or legislation depending upon the people and the country. In essence, the methods relate to the manner in which the animal is killed and bled and to some extent dressing and handling prior to use as food.

Ritualistic or religious slaughter often requires the animal to be in a state of consciousness at the time it is bled. This is characteristic of Jewish (Kosher), Sikh (Jhatka) and orthodox Islamic (or Halal) slaughters. Some cultures in Africa and Asia also slaughter animals in the conscious state although these do not necessarily carry ritualistic connotations.

Where a complete state of unconsciousness is rendered prior to bleeding the process is known as humane slaughtering. Under such practice, the state of unconsciousness and accompanying painlessness is effected either by mechanical, electrical or chemical means in a process called stunning. Stunning also renders the animals motionless thus eliminating excitement and possible cruelty.

6.2 The Humane Method and Conventional Techniques of Slaughter

Unless disallowed by rituals and established traditions, the humane method and associated techniques of slaughter are recommended for use as they allow for safer, more economic and hygienic operations and a desirable quality product. The following steps are crucial in the application of the method;

(a) Stunning

The modern mechanical method of stunning is by shooting, consisting of two forms:

i. use of a captive bolt pistol which delivers a force (concussion) into the head of the animal to make it unconscious;

ii. use of a penetrating free-bullet gun or firearm. Compression stunners with or without penetrating heads, using air (not

cartridges) are also employed in immobilizing livestock.

An older method in which a knocking or striking hammer is wielded on the head of the animal is now disallowed in humane practices in some countries, but in extreme and needy cases the hammer can be used to stun small ruminants by a quick blow at the back of the neck.

Stunning by electricity is used widely on small animals especially pigs. The simplest mechanism consists of electrodes or probes built in the form of tongs with insulated handles and applied between the ear and eye of the animal for 1–4 secs. About 5–7 secs must elapse before the animal is bled. The level of voltage used for sheep and goats is between 60 and 70 volts/AC 50–60 cycles.

Chemical stunning is a term applied to the use of carbon dioxide in making animals immobile before bleeding. Like the electrical form, Co_2 stunning, though a costly method, is nevertheless used quite commonly on small livestock including sheep and goats. The animals are led individually or in pairs into a pit, tunnel or a compartment where CO_2

of 65–75 percent (optimum 70 percent) concentration is released for 60 secs. The animals quickly pass into an unconscious state, but are not suffocated. They are then removed and bled immediately.

It is re-emphasized that stunning only deadens consciousness. So life is still manifest including the pumping action of the heart by which blood is forced out of the body facilitating bleeding.

(b) Bleeding

Stunned animals must be positioned first for bleeding. A vertical or hanging position is achieved by shackling below the hock of one hind leg and hoisting the animal (head down) to a convenient height. Alternatively, the animal can be placed horizontally on a concrete slab or a sturdy plastic pallet for bleeding.

The actual bleeding operation is made by sticking or inserting the sticking knife through the neck behind the jaw bone and below the first neck bone. The object is to sever the blood vessels of the neck and let

out blood. If the sticking is made at a lower position than indicated the oesophagus might be cut and the viscera contaminated.

The bleeding should be as complete as possible, the usual time for sheep and goats being about 2 minutes. Insufficient bleeding and slow death could mean that the severance of the neck vessels is incomplete, or specifically that the arteries leading to the head have been missed, having only cut the veins during sticking. Practice and experience, however, perfect the technique.

Hoist bleeding is more hygienic and is recommended. It also facilitates collection of blood for further use.

(c) Skinning

In removing the skin of sheep and goats initial cutting of the skin is done around the leg to expose and loosen the tendon of the hock for use as a means of hanging the carcass. This process is called legging. A second step called pelting (after the term pelt normally applied to

the skins of lambs and other wool or fur-bearing animals) involves the removal of the entire skin and preparation of the animal body for evisceration. Tropical sheep and goats have hair not wool on their bodies, thus the term skinning is more appropriate for them. Skinning, like stunning, can be done either in the horizontal or hanging position, the former being more suited to small slaughterhouses and the latter for larger premises with bigger orders and with facilities or equipment for railing the individual carcasses one after another.

i. Hoist Skinning

With the animal body in the hoist position, and the skinning knife in hand, legging is commenced at the back of the free (unsuspended) leg by removing the skin around the hock and working toward the toes (Fig. 3). This exposes the tendon on the back leg and the smooth joint just above the toe. The foot is cut off at this joint and the tendon loosened and hung on a hook to suspend the leg. The process is repeated for the other leg while the cuts are continued on the inside of both legs towards the naval

region. The body skin is next removed. First an opening is made in the front legs, cutting toward the jaw and continuing over the brisket to the naval. Using the knife, the brisket is skinned, but from this stage on, the knife is normally not used further. This is to protect the “fell”, a fine membrane occurring between the skin and the carcass which helps to improve the appearance of the carcass and reduce surface shrinkage. In place of the knife, therefore, skinning is accomplished by fisting or by use of the human fist, forced between the skin and the fell to remove the skin. Fisting also protects the skin from cuts and bruises which otherwise lower its value as a byproduct. The process of fisting begins from the brisket to the navel, then over the sides of the carcass, the rear legs and around the shoulders ending at the forelegs. The latter is skinned in the same manner as the hindleg with the foot being cut off at the breakjoint. To drop the skin off, a cut is made around the tail and bung and below the jaw with a knife. After this the tongue is removed, washed and placed on a hook and the head sectioned at the neck joint.

ii. Horizontal Skinning

The animal is placed on its back on a flat raised surface, such as a sturdy plastic pallet or a concrete slab. Cutting and fisting then begin at the forelegs, working toward the belly and sides of the animal, ending at the hindlegs. The tendon between the hock and the toes is exposed and loosened and the feet, bung and head cut at the designated points.

(d) Eviscerating

With the external structures, skin, feet and head, removed the next step is to cut open the animal body to dislodge the contents and produce the carcass. To avoid contamination of the carcass through accidental cuts or punctures of the stomach and intestines, simple but well-directed steps are followed. For this, it is important that the carcass remains or is placed in the hanging position.

The first step in evisceration is to cut around the tied bung or rectum

and free it completely from all attachments and drop it in the pelvic cavity.

Using the saw or cleaver (Fig 2), the breastbone is cut or chopped along the midline up to its tip. Another cut is made from the cod or udder using the skinning knife down the midline into the breast cut. By practice, the pelvis (or lower part of the abdomen) is left uncut.

The body cavity is entered into to sever the ureter connections to the kidneys while the intestines are loosened up further, then the stomach and intestinal mass (also known as the paunch) are pushed slightly out of the midline opening. (In industrialized countries, the kidneys and spleen are often left in the sheep carcass.) At this stage, the liver is held out and severed of its connecting tissues then pulled out together with the freed contents of the abdominal cavity and dropped into a paunch truck. The gall-bladder is cut from the liver, taking care not to spill its bitter contents onto the carcass and spoil the taste of the meat.

The final stage in evisceration is the removal of the contents of the chest cavity. By cutting the thin muscle sheet or diaphragm separating this cavity from the belly, the pluck (i.e. heart, lungs, trachea and oesophagus) can be pulled out as a unit. The foreshanks (i.e. the upper and lower arms) are fastened together using a tendon or a thick rubber band to plump the shoulders. The carcass is then washed and railed to the inspection bay.

(e) Postmortem Inspection

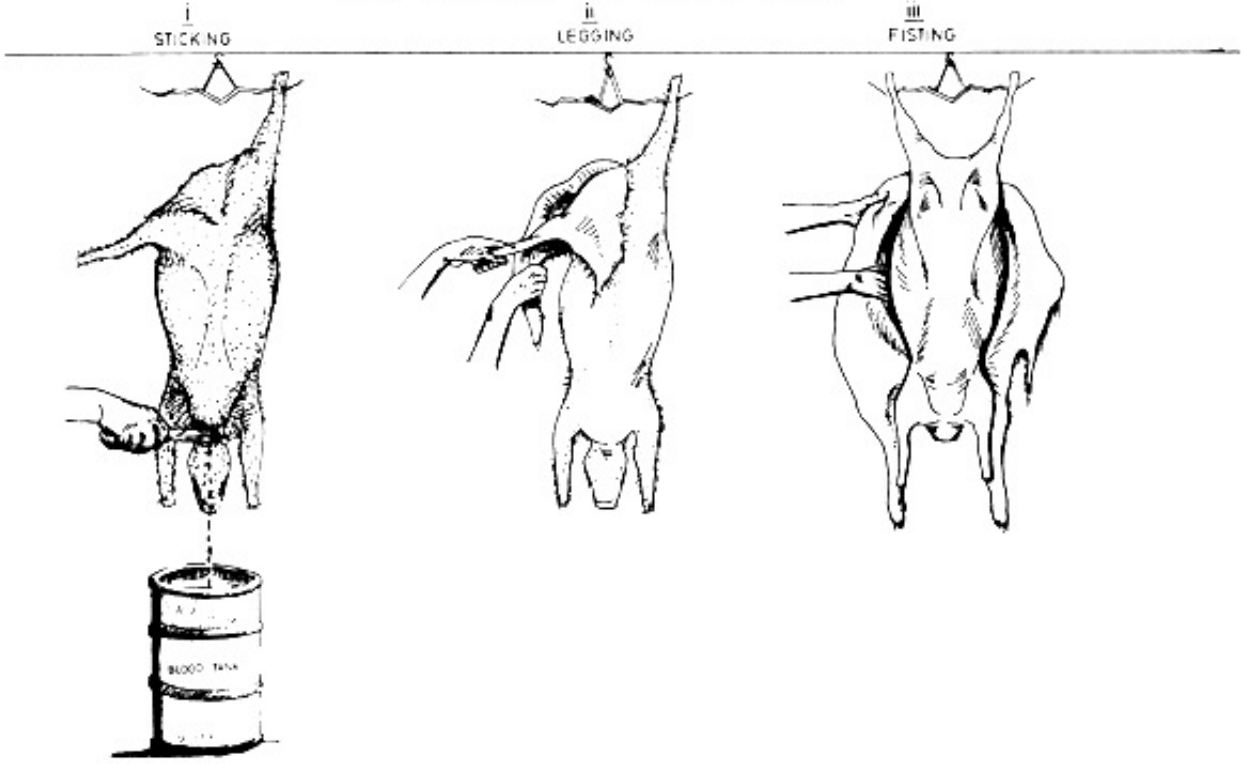
Aside from the carcass, parts of the animal body which are assembled for inspection are the tongue, head, pluck, liver and paunch (Fig 3). The carcass is held still in the suspended position. However, the visceral organs including the head and tongue are placed on hooks in a separate bay while the stomach and intestines remain in the truck. Each carcass is identified with its set of organs for inspection.

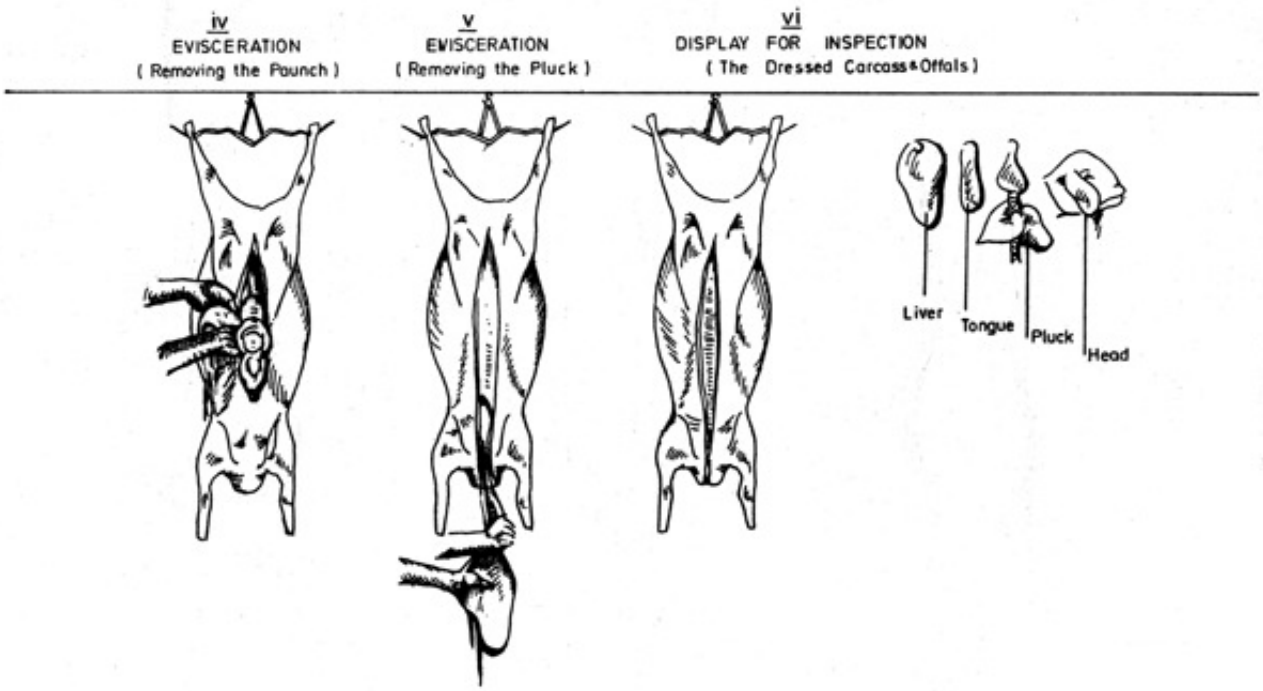
Inspection is normally carried out by professional veterinarians but in some parts of the world trained public health inspectors are employed.

Their duty is to examine the slaughter products for evidence of disease and abnormality and eliminate them from the public meat supply.

FIG.3 DRESSING THE ANIMAL BODY

FIG.3 DRESSING THE ANIMAL BODY





There is no substitute for a trained individual, but if it becomes necessary a plant manager with public health training should be acquainted with critical cases of abnormality and deal with them

expeditiously. Conditions of abnormality that should be viewed seriously to quote one U.S. Department of Agriculture Bulletin on the subject (Farmers Bulletin No. 2264 of 1977) are: "…congestion or inflammation of the lungs, intestines, kidneys, inner surface of the chest or abdominal cavity and numerous yellow or pearl-like growths scattered throughout the organs." Congestion is indicated by accumulation of blood in a part of the organ while inflammation may be signified by heavily swollen areas.

The bulletin however notes that "…bruises, minor injuries, parasites in the organs and enclosed abscesses and single tumors are frequently local conditions that can be easily removed", in which case the remaining material can be used as food. Nevertheless, expert advice must always be sought in doubtful cases.

(f) Special Measures

Carcasses and edible offal that are considered fit for human use are stamped as "INSPECTED" and/or "PASSED" prior to consignment to

markets. Unfit materials or those found unwholesome are marked as “CONDEMNED” and destroyed.

In some countries, partially unfit materials are held as “RETAINED” for further examination when they are condemned if the condition is generalized, but when localized they are trimmed off and passed.

Similarly during ante-mortem inspection animals whose health condition is doubtful are removed from the regular lot as “SUSPECT”, re-examined and either passed for slaughter or condemned as the case may be. Less serious cases are however slaughtered separately to enable useful parts of the animal to be salvaged.

It is a recommended practice to have separate facilities for holding condemned and retained meat as well as suspect animals. “EMERGENCY” slaughter facilities should be made available for handling suspect stock.

In large industrial plants, condemned meat is destroyed by

incineration, although in the smaller slaughterhouses of some developing countries, the burial method serves as a cheaper alternative. Burial pits must be deep, and all material placed in them must be defaced or rendered inedible by use of charcoal dust or lime to prevent possible human (and incidentally dog or hyena) salvaging.

6.3 Traditional and Ritualistic Slaughter

These methods of slaughter differ from the humane practice and its associated techniques in the sense that by interpretation of the basic tenets governing them, the animals must be in a state of consciousness at the time they are bled. The bleeding must also be complete. This is mandatory in the best-known of ritualistic slaughters, the Halal (Islamic), the Kosher (Jewish) and the Jhakta (Sikh) methods.

In most traditional slaughters, however, there are no fast rules, at least in Africa, hence some of the practices can be modified in the light of accepted conventions. It is quite probable that traditional slaughters

represent the fundamental or orthodox practices which have prevailed in human societies throughout the ages and from which all others including the ritualistic and the humane of the present day have been derived.

(a) African Traditional Slaughter

The salient feature of African traditional slaughter is that the sheep or goat is first securely held on its back on the ground by two or three men while the mouth is grabbed tight and drawn backwards to stretch the neck. The slaughterer then cuts the throat transversely with a series of strokes half-way deep into the neck. Blood is allowed to drain off until the animal (still tightly held) is motionless or dies. The head is then severed off completely.

The next processes are skinning and evisceration which are not dissimilar to conventional methods, except that they are conducted on the ground with some randomness, especially where the workmen have no experience.

Skinning begins with severance of the feet, and together with the head, they are saved for further cleaning and use as food. In evisceration, the organs of the belly, intestines, stomach etc. are removed first, followed by the contents of the chest cavity.

Some societies do not skin their animals. Instead the animal body (together with the head and feet) is singed and scraped of the hair, then scrubbed with a sponge and water to remove residual char and hair. After this they are close-shaved, rewashed and eviscerated.

Singeing and scraping the skin in tropical sheep, for instance, is made easier by the fact that these animals have hair not wool. The process naturally increases carcass yield, and evokes flavours highly acceptable to the cultures that use this practice.

Traditional slaughtering is fairly common in the rural areas and villages of the developing world. Considering that large numbers of sheep and goats are slaughtered in these places, and that the practice is basically non-ritualistic, one would expect that traditional slaughters

would, in time, provide a convenient basis for the modernization of slaughtering procedures in these countries.

(b) Islamic Slaughter (Halal)

Of all the ritualistic slaughters the Islamic or Halal method is the most widespread. Derived from the Koran, the law governing Halal slaughter stipulates that the name of Allah (or God) should be mentioned at the initiation of the operation, and that in the exercise of it, blood must flow out completely from the animal.

Islamic practices thus permit animals that are alive only and fully conscious to be slaughtered, as through this complete bleeding can be assured. Among some sects, orientation of the operation toward Mecca, the Holy City of Islam, is demanded in symbolic reinforcement of the reference to Allah.

In strict Halal practice, stunning is ruled out since technically it puts the animal in a state of unconsciousness before bleeding. nevertheless

some Islamic communities accept electrical stunning as cattle, for instance, are known to recover from this application and lead normal lives - an indication that they still remain alive after stunning. Other Islamic groups in parts of Africa and Asia employ the hammer method of stunning.

Slaughters are quickly done - the animal being cast down by a shackling maneouvre, laid on its back while the neck vessels and passages (oesphagus and trachea) are severed by a single slash of a sharp knife. Bleeding proceeds to completion, as blood is abhorred in diets. (Among domestic stock only cattle, sheep and goats are utilized by Islam as food. Pigs are completely banned and operations involving them are not permitted near those of the accepted species.)

These then constitute the main requirements of Halal slaughter. Generally, Islamic slaughters are acceptable to the adherents of other faiths including Christians and some Hindus. However, the reverse is not true for Islamic adherents: that is to say, they do not accept slaughters from members of other religions. Therefore, in some

countries in Asia and Africa, a convenient arrangement is to delegate public slaughters to Islamic butchers. For this reason, the range of commercial ruminant operations from procurement of stock (at farm gate) to butchering and marketing is by convention done by members of the Islamic faith.

(c) Jewish Slaughter (Kosher)

"Kosher" is the term applied to the procedures and techniques of slaughter as well as the products derived therefrom under the Jewish faith, if done according to the laws of the religion. In the Hebrew language, Kosher means fit to be used as food.

The laws of Kosher date back to Moses and affect the species of animals used as food. Like the Islamic religion, these include cattle, sheep and goats among domestic livestock with the exclusion of pigs. The basis of the selection of these species is enunciated in the Talmud, as well as relevant passages of the Bible (Deuteronomy 14: 4–5 and Leviticus 11: 1–8).

Other regulations governing Kosher slaughter are derived from Hebrew traditions referred to as Shehitah. Under these the animals are to be fully conscious, killed and bled thoroughly by one clean stroke of the knife. Animals are however hoisted and shackled first. A 16-inch (40.6 cm) razor-sharp steel knife called the chalaf is stuck into the throat by a trained slaughterer, the shohet, in an operation in which the animal is killed and bled at the same time. Skinning is made from the chest down to the level of the belly, and the chest is cut open first for inspection and later evisceration.

Specified organs of the viscera, lungs, stomach and blood vessels, are examined by an inspector called the bodeck for abnormalities, ruptures and foreign matter. Carcasses that are fit (ritualistically speaking) are passed by the bodeck with a mark on the chest. Condemned ones receive the symbol (+). In some industrialized countries Kosher carcasses meant for public use are re-inspected in the conventional manner by the government authority and passed or rejected depending upon their condition.

By Jewish tradition, only the forequarters or foresaddles of ruminants are utilized as food as these have relatively larger blood vessels which can be seen with ease and removed. The meat is ready for food thereafter. If however storage is desired, the period allowed is 72 hours. Beyond this the carcass becomes trefah or unfit for use as food. The ritual of begissing or washing after the stipulated 72 hours eliminates trefah, and extension of washing after further 72 hour periods is allowed. For carcasses being held under prolonged storage such as export consignments from say South America to Israel, the trefah rule is modified to allow washing before storage and re-washing thereafter regardless of the holding or consignment time.

Kosher slaughters are predominant in Israel and in cities with large Jewish populations such as New York, London and Paris. Although there may be pockets of Kosher practices elsewhere, these slaughters do not occur to a significant extent in developing countries because of the relative absence of Judaism in these places.

(d) Sikh Slaughter (Jhakta)

Although it is the least applied globally of the major religious slaughters, Jhakta is of interest as it represents an extreme departure from known practices.

The method is practised mainly under Sikhism, a religious creed which is an offshoot of Hinduism centred in the Punjab, India. Some other Hindu communities also practise it. In all, Jhakta adherents throughout the world do not exceed 10 million.

The main feature of the method is that it is an instant decapitation process limited only to sheep and goats. (Cattle are regarded as sacred by Sikhs and Hindus and are therefore not eaten.)

In the exercise of Jhakta, the head of the animal is held securely or fastened to a rigid pole or object, and with the hindlegs stretched by hand on the other side, the head is chopped off with a heavy sharp cutlass in a single stroke. After this, the animal body is dressed for use.

7. STORAGE AND CONSIGNMENT OF MEAT

Slaughter operations are not considered as complete until the carcass or meat leaves the premises for consignment to markets. Traditionally in many developing areas, meat is preferred warm, in the freshly slaughtered state; hence it is delivered to markets soon after inspection. By choice, therefore, slaughter premises have no need for cold storage and are thus not provided for in the design. Butchers hence tailor their supplies to the daily needs of the community and surpluses hardly occur.

7.1 Cooling (Short-Term)

Despite the fact that meat is sold fresh in these countries, cooling of carcasses is necessary before conveyance to markets. Freshly slaughtered carcasses, it must be remembered, are warm systems with temperatures close to ordinary body temperatures of 37°C (or 98.6°F) and subject to bacterial attack. They should be cooled rapidly under natural ventilation on the hoist in a well-spaced position until the surface is dry. Where refrigeration is available the cooling should reach a temperature of about 10°C (or 50°F). If it goes below this point, the carcass might “sweat” on the surface when conveyed outside, and this could cause bacterial growth. In the absence of refrigeration on the premises, commercial facilities can be used.

7.2 Prolonged Cooling and Freezing

Refrigerated storage is absolutely necessary if shipment is to be delayed for a day or so. Sheep and goat carcasses are cooled to a temperature between -2° and +2°C (or approx. 28 to 35°F) for a period of 18 to 24 hours. Moving cold air causes rapid action, not only against surface spoilage but also deterioration in deep tissues. After

cooling the carcasses must be consigned promptly in refrigerated vans.

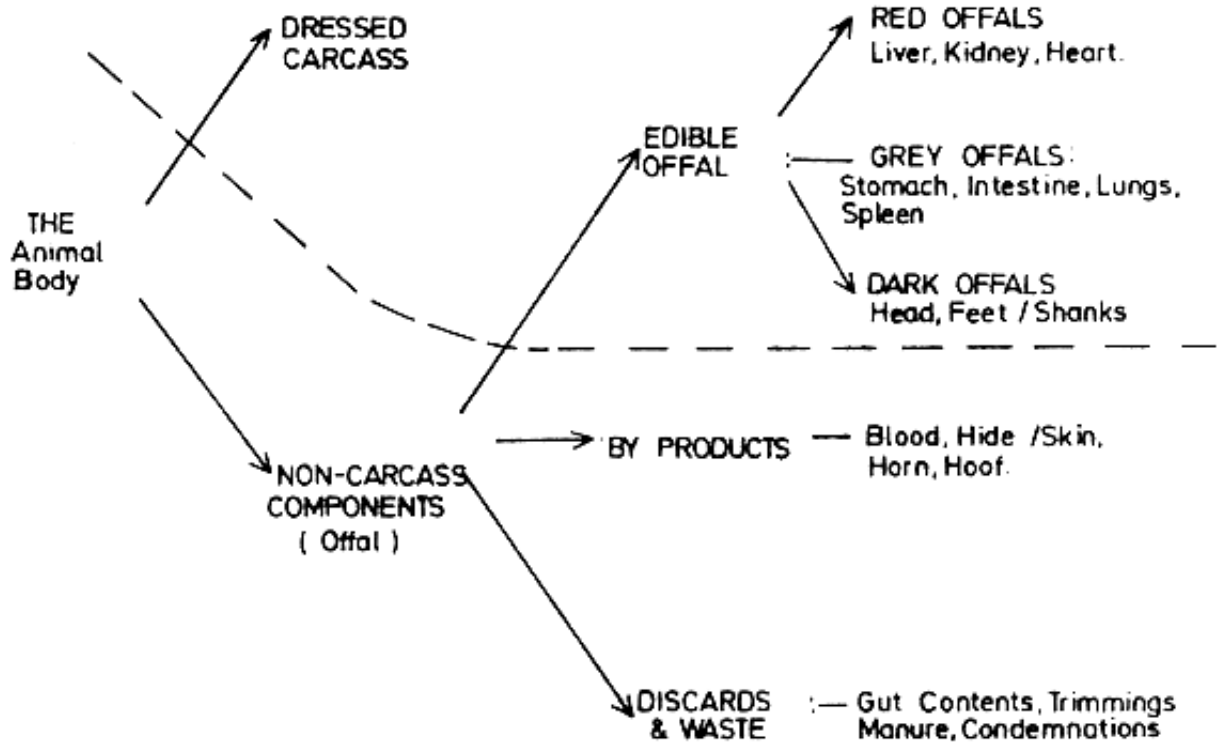
Holding of meat for rationing purposes or against a lean season which is fast becoming a practice in some large urban centres in meat deficient countries calls for extended storage or freezing. Again rapid action is needed. The carcasses can be frozen whole or cut transversely along the last rib into two and packed in a way to allow free air movement around them. It should be noted that slow freezing in contrast to the rapid form causes formation of large ice crystals within spaces in the fibres. Upon thawing, the fibres sometimes rupture resulting in low quality meat.

7.3 Edible Offal

Figure 4 presents a schematic breakdown of slaughter products. Apart from the carcass, other edible meat includes red offals (liver, kidney and heart), grey offals (stomach, intestine, lungs and spleen) and dark offals (head and feet). The red offals can be given the same cooling

treatment as the carcass, but the others should be sold quickly. If storage is desired the grey and dark offals should be held in a separate chamber and spread out to allow for more effective cold action.

FIG.4 SCHEMATIC BREAKDOWN OF RUMINANT SLAUGHTER PRODUCTS


DRESSED CARCASS
RED OFFALS
Liver, Kidney, Heart.
EDIBLE OFFAL
GREY OFFALS:
Stomach, Intestine, Lungs, Spleen
THE Animal Body
DARK OFFALS
Head, Feet / Shanks
BY PRODUCTS
Blood, Hide /Skin, Horn, Hoof.
NON-CARCASS COMPONENTS (Offal)
DISCARDS & WASTE
Gut Contents, Trimmings Manure, Condemnations

NOTE:

Items above the broken line constitute saleable meat. The scheme as a whole is highly generalized and may not represent the state of affairs in all areas. Some communities utilize red offals only for food apart from the carcass.

In others, as much meat as possible is salvaged from the animal including scrapings from hides and skins. The latter are sometimes shaved, cut up and brought to prolonged boiling to soften for use. Blood in most places is flushed into effluents and under normal conditions of slaughter does not constitute a by product, but waste.

7.4 Other Considerations

The development of cold-storage in large municipalities should be made a matter of deliberate policy. This becomes necessary as the population increases and the demand for meat goes up. Refrigeration also improves meat marketing especially at the cold store level where consumer selection for quality offers additional cash advantages to the butcher.

Traditions do change; thus the concept that meat storage can always be provided for indirectly by the animal in the live form may not always be valid. Disease and drought for instance are known to cause reductions in populations of livestock where fit and healthy animals could be slaughtered and stored for future use.

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8. PRINCIPLES OF SLAUGHTER HYGIENE

8.1 Basis and Criteria

The subject of hygiene has been covered, though diffusely, in almost every chapter of this Manual. Because of possible gaps and

omissions, this chapter is presented to consolidate the subject and broaden its scope.

There are three basic criteria upon which hygienic measures in slaughterhouse organization and operations rest. These are the need to:

a. eliminate the risk of bacterial infection and food poisoning with meat as the vehicle of transmission;

b. prevent spoilage or putrefaction and thereby enhance the keeping quality and safety of meat;

c. secure meat of good eating quality, appearance and aesthetic value through proper handling. These latter criteria are discussed at length in Chapter 5.

8.2 Sources of Bacterial Contamination of Meat and Ways to Avoid Them

Unless otherwise infected, the meat of freshly slaughtered animals is basically sterile. The presence of microorganisms on postslaughter carcasses is thus blamed on contamination occurring immediately before, during and after slaughter. The major sources of contamination are the animal itself, tools and equipment used in slaughter, the workmen and the condition of the slaughterhouse environment.

Dirt, soil, body discharges and excreta from animals in holding pens or lairages are the primary sources of contamination of carcasses in the later stages of the operation. This happens irrespective of whether or not the animals are fit and have passed antemortem inspection. In some establishments, the animals are washed just before stunning and bleeding. This step has the added effect of cooling or calming down the animals which factor is of importance in securing good quality carcasses.

For similar reasons, it is advisable to avoid operations on the floor. Hoisting during sticking, skinning, evisceration, washing and inspection is recommended in even modest premises, including makeshift ones.

This, in effect, necessitates the provision of adequate floor space with suitable assembly of equipment to handle the animal bodies. In this respect it is advisable to have only a few workmen on the floor specialized or experienced in the various steps to handle the operations separately with quick and rapid dispatch. Where this is not possible or where floor space does not allow, the principle of separating dressing operations from offal cleaning ones must be strongly adhered to (Chapter 3).

The precautions that must be taken in slaughtering involve the following:

a. Sticking: the knife should be cleaned after each animal is disposed of and rinsed in hot water. It is said that a contaminated knife can transmit bacteria into the animal tissues during the early stages of bleeding when the pumping action of the heart is strongest. If this should happen, deterioration in deep tissues can also result.

b. Skinning: uncontrolled knife skinning or even fisting can similarly

introduce spoilage organisms on the surface of the carcass. By the same token, singeing and scraping of the animal body as is practised under traditional African slaughters must be done to avoid splits in the skin by fire action; and after sponging and washing the carcass, clean hot water should be used in rinsing before evisceration.

c. Evisceration: care should be exercised not to puncture the intenstines. The workmen should follow the procedure of tying the bung (rectal end of the intestine) and the cut end of the oesphagus, then removing the paunch (intestine and stomach) first, followed by the pluck, (trachea, heart, lungs, etc.), both en masse and disposing of them separately. The pluck should be hung on a hook while the paunch should be dropped in a paunch container. Obviously the stomachs and intestines should not be opened while carcass dressing is in operation as such a move can easily cause contamination of the meat.

d. Washing: carcasses should be washed with clean potable water

under pressure if possible. If water is a problem as happens in some rural areas, dry slaughter by trained men should be resorted to as it is safer for carcasses to be dry clean than to contaminate them with water from polluted sources.

e. Storage: this is dealt with fully in Chapter 7.

f. Offal handling: the various classes of edible offal, red, grey and dark (see Fig. 4 for definition), should be cleaned separately. The red offals can be washed on a separate line in the slaughter room after inspection, but grey offals (stomach and intestines) must be moved to a chamber provided for them. Initially they should be emptied of their contents dry, then flushed with water. The dark variety (head, feet) should be singed, scraped and washed outside the premises. Some dark and grey offals are utilized as byproducts by some communities, and should be disposed of as such rapidly.

g. Byproducts: delicate items such as glands and organs, if required,

must be collected and conveyed from the plant by special methods as well as blood to be used for food or pharmaceutical purposes. Blood coagulates soon after it leaves the animal. Handling of this item as well as glands thus poses a problem hence unless the plant is a large one and previous arrangements have been made for their removal, collection should be avoided, more so in small rural premises.

h. Discards and waste: these are variable. Usually in developing countries they include the contents of the gut, blood and trimmings that cannot be used for food and therefore flushed into effluents. However, coagulated blood and other solids must be strained out before disposal. The subject is further dealt with in the next two chapters.

i. Personnel: next to the animal, equipment and methods of operation, the personal hygiene of the workmen is the most singularly important factor in slaughter operations, the reason being that contamination of food and disease transmission thereby

depend equally on the human element as well as on the tools and methods of operation. Individuals assigned to slaughter services must be of sound health and of good personal habits. People who are sick or with boils and sores must be barred from the premises. All must be routinely examined for their health condition. Furthermore persons who habitually exhibit unhygienic habits like spitting, nose-blowing and coughing must not be employed. It is important to allow only approved and scheduled workmen into the premises at the time of operation and these individuals must be identified by a proper attire, e.g. a clean white T-shirt and trousers with long waterproof aprons over them. Boots must be worn with the trousers neatly tucked inside. Above all, the workers must be exposed to a formal code of hygiene.

9. SANITATION AND WASTE DISPOSAL

9.1 Objectives and Scope of Sanitation

Whereas hygienic measures deal with the operational aspects of slaughter or the creation of conditions under which animals, activities and personnel can be secured from contaminating the product, sanitation is focussed on the establishment and maintenance of healthy environmental and appropriate physical conditions congenial to the attainment of a wholesome product. In essence, the two concepts are identical, culminating in the same end-result, but differing in targets.

In this connection, the scope of sanitation may be identified broadly with structures and facilities, i.e. the premises, installation and equipment, that is their disposition and maintenance. Additionally, sanitation covers specific slaughter operations that are likely to cause contamination, e.g. offal cleaning, waste disposal and infestation by

pests, etc. This chapter, like the previous one, will collate aspects of the subject already touched upon as well as add new information.

9.2 Location and Lay Out

The influence of siting, design and construction of slaughter premises on sanitation has been dealt with at length in Chapter 2. In summary, the following guidelines are offered.

The ideal site for a slaughterhouse should be fairly airy, outside built up areas and possibly close to the coast, if such a location is available. Established townships if close to the premises could easily be the source of air-borne contaminants from households or industries. The area must be open, preferably on high ground, to keep drainage from stagnating in the surroundings. Alternatively, the area must be dry and not waterlogged or puddled as these could cause mosquito breeding. River, lake and lagoon sites must be avoided partly for the above reason, but chiefly to prevent livestock from drinking from them if polluted as well as to eliminate the temptation of discharging slaughter

wastes into the waters, which could be drinking sources for humans.

Finally, the site must be large enough to accommodate auxiliary slaughter functions or structures such as holding pens (kraals), an emergency slaughterslab and a byproducts plant. The immediate vicinity should be cleared of all bush, and roadways leading to and from the premises must be well laid out and paved.

9.3 Construction and Facilities

Materials used in constructing and equipping the plant (Chapter 3) must be durable. Specifically they must be impervious to water, easy to clean and to sanitize, non-corroding and not attractive to insects or termites.

Demarcation must be made of the slaughter/dressing zone from the offal/waste handling areas, and these areas from personnel places of convenience such as bathrooms and toilets. The interior of all rooms and chambers should have ample lighting and ventilation: lighting to

facilitate the work and ventilation to flush out stagnant air and enhance the keeping of the product.

Of operational facilities needed, water is most important. Standards in industrialized countries stipulate the use of ample potable water from the public or municipal supply system. The water must be colourless, odourless and free from organic matter. It must also be well conditioned to eliminate, for instance, 'hardness' and be properly distributed in the plant such as at strategic points with hosing where necessary. Hot as well as cold water is necessary.

In the developing countries, these conditions may be difficult to attain especially in rural areas. Some municipalities can only clarify water, but not treat, sterilize or condition it; consequently in some towns pipe-borne water is boiled prior to drinking.

Many rural slaughter outlets draw their water supplies from the same source, river or lake, which may serve also for washing, bathing and even drinking, not to mention occasional waste disposal. Even where

dug-outs and wells are available, the quality of water can still not be guaranteed unless a treatment plant is available to assure safety for use in slaughter operations.

9.4 Cleaning Operations

Large quantities of clean water are required in the cleaning of floors, walls, equipment and tools. The operation should begin with removal of solid waste such as meat and fat trimmings, bone chips, blood clots and so on by brushing them off the floor. High pressure hosing is then applied, starting from the walls and other rigid facilities and ending with the floors. Hot hosing under pressure is more ideal as it melts down fat and removes sticky waste from corners and drains.

For scrubbing of tables, working surfaces and tools, hard fibre brushes and detergents are recommended. Liquid detergents are more useful than ordinary soaps, because they dissolve more easily in water by reducing the hardness while absorbing dirt or attaching themselves to it for removal by flushing with water. If liquid detergents are not

available, powdered soap may be dissolved in water and used. After rinsing the washed items should be disinfected. Knives must be sharpened and sterilized or boiled in water.

9.5 Waste Disposal

(a) Large Slaughterhouse

The wastes from a large slaughterhouse are a heavy polluter of any recipient. The waste water from a meat plant should be allowed into a municipal drainage system without previous thorough treatment in a waste water treatment plant. The details of such treatment are outside the scope of this manual. An outline is however given in order to show the size of the problem.

In the slaughter premises, the general principle regarding waste disposal is that initially, the solids and sweepings from operational waste (of the dressing chamber and offal floors) must be removed from the liquid. Secondly, the operational Liquid must be separated

from the conventional drainage, namely that of toilets and bathrooms. The two lines should be kept apart within the premises well to the outside before being joined together.

The purpose of this is to prevent contamination of the premises in the event of a back-up of conventional sewage in the early stages of discharge. A catch-basin must be provided to collect residual solids, especially fat to prevent clogging of the system. Clogging can also result from discharge and coagulation of blood in the drainage and create further back-up problems. Thus by collecting blood in special containers, much inconvenience is avoided and valuable raw material provided for byproduct processing (Chapter 10).

The principle of handling liquid waste from the common outside drainage system is first to screen out, collect and cart off solid matter. The rest is then let into a basin in which the finer and lighter particles settle while fat is skimmed off, including suspended organic matter which is sedimented from the water phase. (A sludge is formed which can be collected and added to manure and processed together

(Chapter 10).)

In the second phase of the treatment, bacterial breakdown of dissolved substances in the water phase takes place. This process requires oxygen to convert organic matter into simple inorganic substances. The latter are removed by physical treatment or by chemical means. At this stage the water is considered treated, though not recommended for human use. It can be used for agricultural purposes or discharged into water bodies.

(b) Rural Slaughter Premises

These premises pose a problem as investment in waste treatment plants is too high in comparison with the low work load. Far easier and safer is to bury all solid and semi-solid waste along with manure in pits to make compost. Blood should, however, be collected separately and dried into blood meal. Both processes are described in Chapter 10.

The liquid effluents can be spread out on the ground at some distance

from the plant for quick drying as they empty on a slope from deep concrete drains away from the plant. Straw bedding should be placed on the ground initially to absorb the liquid and re-layered at each time of disposal. The site should be constantly maintained to ward off vermin (see below).

9.6 Vermin and their Control

The term “vermin” is applied to creatures which by nature like living close to man, scavenging on food and filth. In slaughter premises, the commonest vermin are rats, mice, flies and cockroaches. All multiply in great numbers within a short time.

The dangers posed by these creatures is that they live in hidden places such as splits, holes and crevices in floors and walls gathering dirt on their skin, appendages, mouth or mouthparts with which they contaminate food, sometimes destroying the food outright. Furthermore, by their contamination of food, they are capable of transmitting disease mechanically to man. In the case of rats, they can

cause food poisoning, rabies, typhus fever and bubonic plague among other diseases.

Cleanliness and general environmental sanitation basically keeps them away, as accumulation of waste, refuse, manure etc. soon attracts them to slaughter premises. Doors and windows should be secured against all possible openings to ward off vermin. The insect group are usually kept off by flyproof and fly trap devices as well as gauze screenings, while rodents are at best exterminated by chemical poisons. However, caution should be exercised in the use of chemical exterminators as some of them often have harmful effects on man.

10. BYPRODUCT UTILIZATION

10.1 Definition of a Byproduct

Items of value produced during slaughter other than the carcass and edible offal are referred to as byproducts. Byproducts are thus inedible material less rejects and waste. Figure 4 amplifies the definition.

Byproduct industries are many and specialized in industrialized countries particularly the USA and Europe. The range of products is also wide and diversified. This is made possible by volume and variety in raw material and, most important, in technology. A list of the major possible uses of byproducts is presented in Appendix I (Table 3).

Less-developed countries conversely have limited yields of slaughterhouse byproducts due to the greater premium placed on non-carcass components as a source of food. Table 2 shows for instance that the average East and West African cattle yield a high proportion

of their body weight as saleable meat relative to inedibles, the ratio being about 70 percent : 30 percent. On the other hand, in North America the saleable yield profile of slaughtered steers compared to inedible material is in the region of 60 percent : 40 percent. This ratio is however reversed at the retail level as the carcass is deboned and trimmed of excess fat in response to consumer preferences.

Potentially available byproducts from cattle are thus higher in yield in North America (45 percent) than say West Africa (9 percent), the latter comprising only the hide. Similarly, sheep and goat skins constitute the only body components of value outside edible meat. The yield here accounts for about 15 percent of liveweight in the East African goat. In the West African dwarf goat no byproducts are harnessed when the animal is dressed with the skin on, i.e. by singeing and scraping off the body hair. Consequently, maximal use is made of the animal body, about 75 percent as food, leaving the rest as rejects.

It is possible, nevertheless, to modify slaughter practices in the poorer countries and salvage usual rejects, blood, horns, hoofs, gut contents,

and any condemned meat and manure for byproduct processing. Also in cultures where stomachs, intestines, lungs and reproductive organs are banned from diets, much raw material can be retrieved for further use.

It appears, however, that such utilization can be possible only where volume is available (as in large municipal abattoirs) and provided cattle products are included. In this way the opportunity is offered not only for more economic production but also as a means of removing nuisance from the slaughter premises, and assuring a hygienic and sanitary environment.

Apart from hides and skins (which are already being utilized) the following groups or items of byproducts can be considered for processing, taking into consideration their agro-industrial significance:

a. Soft organs - stomachs, intestines, lungs, carcass trimmings, reproductive structures etc. (where not utilized for food); floor sweepings, drainage trappings and condemned meat - together

for rendering into meat/bone meal;

b. Hard organs - horn and hoof can similarly though separately be processed into horn/hoof meal and used as fertilizer;

c. Blood - can be dried into blood meal and used in animal feed.

d. Gut contents and manure (from lairages and kraals) for compost or fertilizer production; another possibility here is biogas production.

The general principles involved in the production of these items (including hides and skins) are outlined below.

10.2 Hides and Skin Curing

Hides and skins have the highest yield and value of all products of livestock other than the carcass, and in some livestock-rich developing countries such as Somalia and the Sudan, they account for substantial

portions of export revenue. The approximate yield of green (or fresh) hides and skins in pastoral tropical livestock is as follows:

	Percentage of Liveweight…	**Aver. wt. kg**
Cattle	6–8	18
Large Sheep & Goats	14–16	6
Dwarf Sheep & Goats	10–12	4

Hides and skins are processed into leather by tanneries, hence it is necessary to preseve them for storage and shipment after removal from the animal. The method of preservation is curing, either in free air or by use of salt or both. In each of these methods the preservative principle is the same, namely, removal of moisture from the product to enhance keeping quality. Thus air acts by facilitating evaporation of moisture from the skin, and

salt by osmotic withdrawal of water, thus making the moisture unavailable for growth of microorganisms. Salt has an additional protective effect as it penetrates the tissues and with its presence inhibits the growth of deteriorating organisms.

a. Air-Curing

Hides and skins must be cured immediately after removal from the animal body. Initially, they are prepared for this process by cleaning off residual meat, fat and manure from the surface in a process called fleshing. They are then washed, drained and trimmed to remove the ears and lips. To air-cure the hide or skin, the ideal method is to stretch it with strings from all sides and angles over a wooden frame or wire loop, and suspend it in the open to allow air to circulate freely around it and dry uniformly (Fig. 5).

This method is preferred to ground drying which yields a

poor quality product with cracks, wrinkles and folds, as well as subjecting the hide or skin to moulding and putrefaction. Hot, dry environments such as prevail in some tropical savannahs are best suited to air drying, but not the humid or the wet-forest type. The main disadvantage about air drying is that shrinkage is high, about 40–50 percent of green weight; hence the finished weights are low, although they incur correspondingly lower shipping costs.

b. Salting

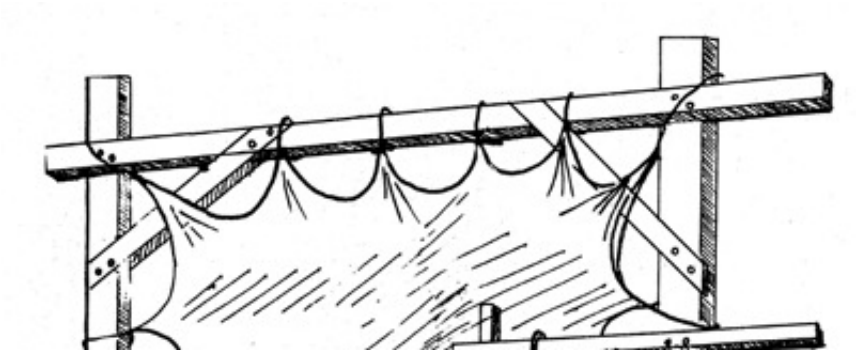
Salt-curing processes are of two kinds: dry and wet. In the former process, the simplest method, called green salting, is to rub the flesh surface with dry salt and stack the salted pieces in a pile in a cool place under some weight for 30 days. At the end of the process the hides and skins are removed, shaken of the salt and folded for consignment. (They can, however, be air-dried over a wire or wooden

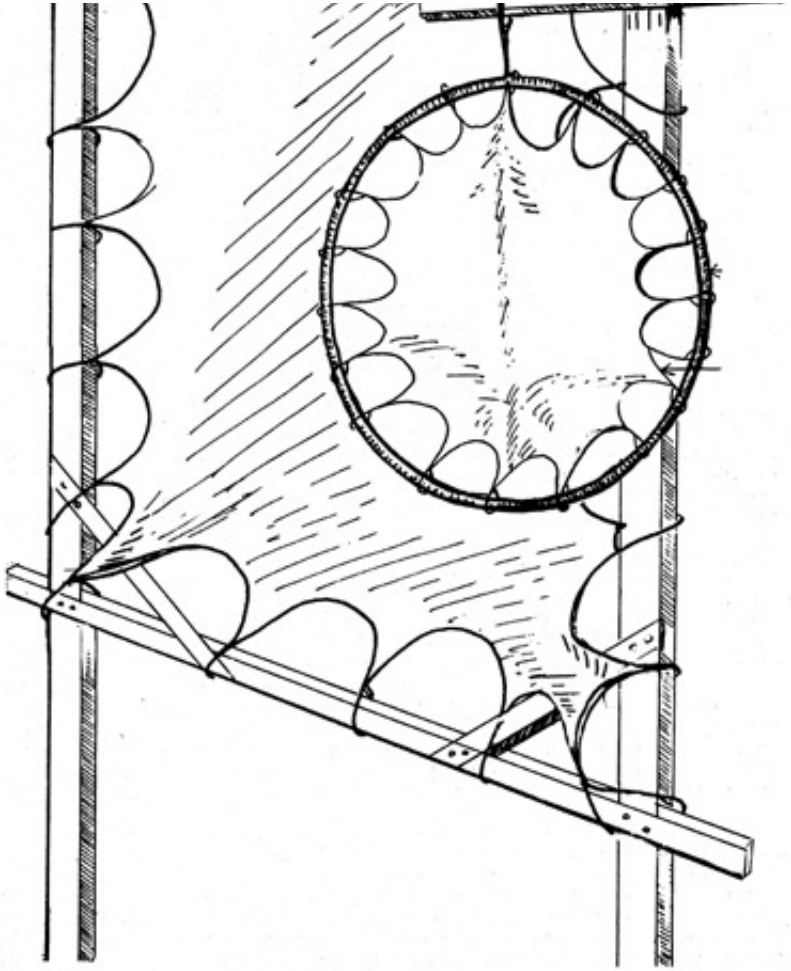
frame after salting). The rate of application of salt is 25 percent of green weight, but fine salt is used for skins and coarse salt for hides. Shrinkage is less when hides and skins are green salted, but increases with additional air-drying.

Hides and skins are said to have been wet-salted when cured in brine which is a strong solution of salt prepared at 15–20 percent concentration. The term brine curing is also used for the process. For skins fine salt without impurities is used, while rock salt suffices for hides. The immersed products are held in cellars often in the slaughter premises at a temperature of 10° to 16°C (or 50 – 60°F) for 3 to 4 weeks. Shrinkage is fairly low, between 15 and 25 percent. Thus yields are higher, up to 70 percent which in effect makes wet salting the most desirable process in sales returns. The wet-salted hides and skins are also of best quality barring deterioration which can be more pronounced in wet hides compared to the dried varieties.

Cured hides and skins are graded and purchased according to weight, quality and condition. The weight criterion as explained previously is based on curing yield. Quality basically refers to the class of hide or the breed or type of animal from which it is extracted, while condition relates to physical characteristics such as the extent of damage to the animal, due for instance to disease, branding and flaying methods.

FIG.5 AIR-DRYING OF HIDES & SKINS BY THE FRAME & LOOP METHODS RESPECTIVELY





10.3 Meat/Bone Meal Production

The raw materials for quality production of meat/bone meal are all parts of the animal, less the skin or hide, hair, horn, hoof, blood and gut contents. This means that they may include skinned heads and feet, bones, viscera and carcass trimmings which are not utilized for food. Condemned material and relevant parts of freshly dead animals can be included, but not putrefactive material or that in a high state of decomposition. This material should be incinerated or buried in deep pits.

A steam-rendering tank is used for meat/bone meal production. This is an oblong-shaped or vertical cylinder with a cone-shaped base built of heavy steel and fitted with a steam-charging mechanism to provide high temperatures for cooking.

Water is first introduced into the tank, up to about one-third

capacity; hence the term wet-rendering which is commonly applied to the operation. (Dry-rendering excludes the addition of water and in fact expels moisture from the system. It is used mainly to extract fat from tissues. Tanks used in dry-rendering are of the horizontal type, the heat being applied at lower temperatures)

When water has been placed in the wet-rendering tank the relatively heavier materials like bones, feet and heads are put in next in reduced sizes at the bottom of the tank. Softer organs such as those of the viscera and carcass trimmings are layered next. Finally, fat is placed on top, allowing a headspace for the boiling action. In practice, the fill does not exceed three-quarters of the cylinder's volume.

With the tank closed, steam is charged through the bottom directly into the tank. This is done under pressure which should keep rising to about 18 kg (or 40 lb) and held there for about 5

hours. It should be noted that the boiling point of water is elevated as pressure increases. Thus at ordinary atmospheric pressure water boils at 100°C (212°F), but with an extra pressure of say 4.5 kg (10 lb) the boiling point is raised to 115°C (240°F) and at 6.8 kg (or 15 lb) to 121°C (or 250°F) and so on. Heat is necessary to break up, soften the tissues and release fat, and importantly destroy harmful microorganisms.

At the end of the heating time, the pressure is lowered gradually and the tank is allowed to cool for 40 – 45 min. During this time, the heavier material gravitates to the bottom. Water collects above this while fat settles on top. The fat is removed first (as a byproduct, tallow) followed by the water. Finally the cooked meat and bone material is discharged. After removing residual moisture, the meat/bone material is dried, milled and bagged. (The cooking water contains some dissolved protein and fat: both are removed separately, the protein being added to the meat/bone meal before drying, and the fat to tallow stock).

Meat/bone meals, sometimes called feeding tankage, are used in animal rations. Each batch should, however, be analysed to determine the nutrient composition as the phosphorus and protein content are important criteria for grading and marketing.

Horn and hoof are prepared similarly to meat/bone meal, but this is done separately. Often the horn/hoof meals are used as fertilizers.

10.4 Production of Blood Meal

Blood is fairly rich in nutrients, especially protein, but being liquid it readily collects dirt once it leaves the animal body. Dirt starts putrefaction which lowers the blood's usefulness, and if drained outside on the slaughterhouse grounds sanitation problems arise by virtue of its clotting property. Other nuisances created by clotted blood are stench, filth, attraction of rodents and the breeding of flies. It is of utmost importance that blood

when collected should be handled in a hygienic manner and processed with minimum delay.

(a) Collection and Yield

Blood can be collected directly in metal or plastic drums if the animals are hoisted for bleeding, but if killed on the floor small enamel or plastic bowls can be placed immediately beneath the let-out to receive the blood and empty it into the drum. The estimated yield of blood and blood meal in average tropical livestock is as follows:

	Fresh Blood		Dried Blood or Blood Meal, kg
	As % of livewt.	Weight, kg	
Cattle	2.5	6.30	1.26
Sheep and Goats	0.6	0.25	0.05

(b) Small Scale Processing

Where only a few animals are slaughtered in a day, small-scale low-technology processing can be undertaken rather than to spill the blood to waste and create problems of sanitation. Thus from say 10 cows and 3 sheep, approximately 64 kg of fresh blood can be obtained which can yield at least 12 kg of dried blood. To process this the blood is cooked in a tank to coagulate it, and is drained of liquids which collect on top after cooling. The coagulum is then broken up and spread on a tarpaulin or plastic sheeting for drying. Alternatively, the coagulated mass can be placed in a simple solar dryer for drying (Fig. 6).

(c) Wet Rendering

In plants that have steam-rendering tanks, the fresh blood can be mixed with selected non-carcass components of the description given in Chapter 10, paragraph 2, and wet-rendered. In this

instance, the blood should substitute for water in the tank. An advantage here is that the protein content of the offal meal will be raised quantitatively with the addition of blood, although some amino acids may be damaged by the strong action of the heat while others may leach into the cooking water.

(d) Commercial Drying

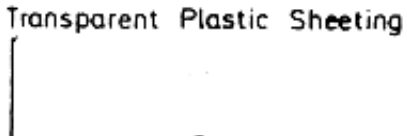
A more productive approach is to process the blood under relatively reduced temperature conditions using a commercial blood drier. In principle, the blood-drier is a dry-rendering tank disposed horizontally and invested with a steam-jacket. Special devices are provided within the tank to prevent blood from coating on the interior walls and reducing drying efficiency.

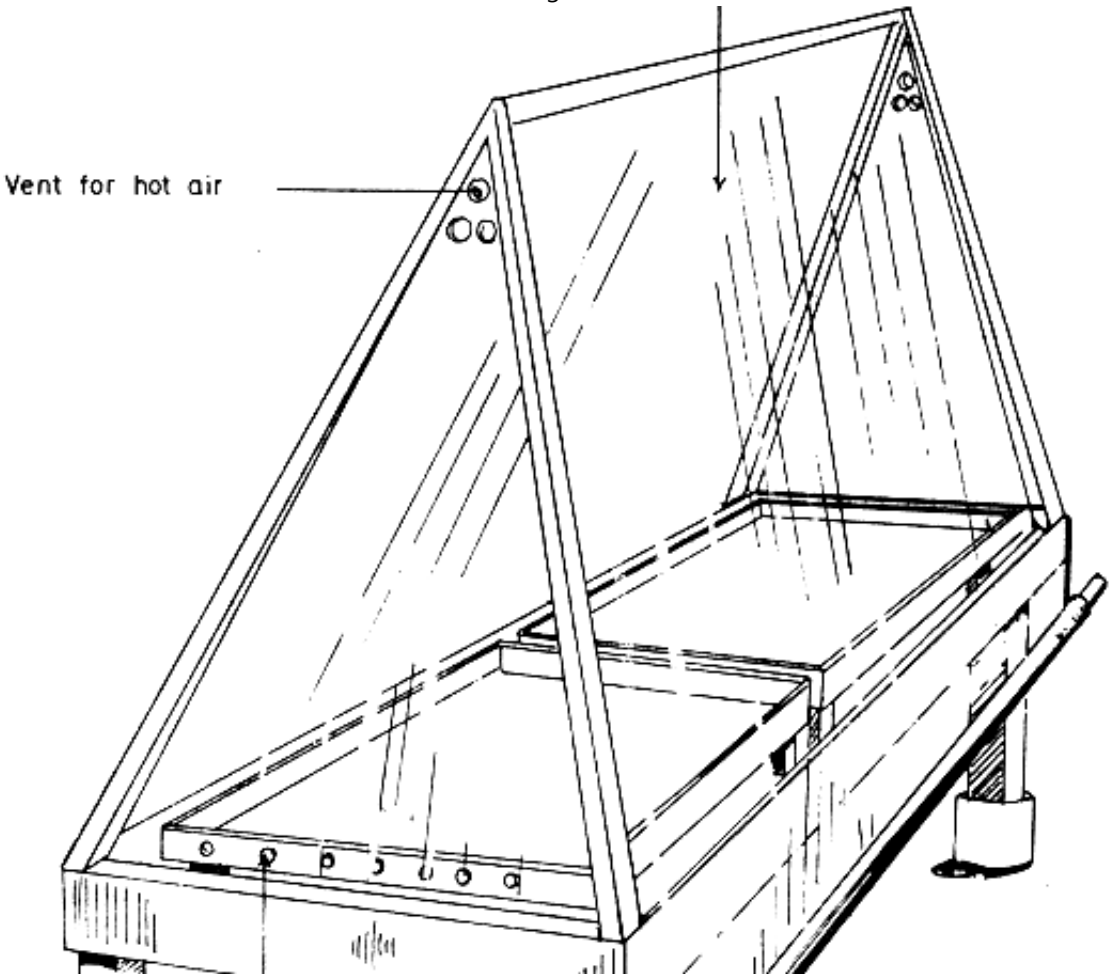
Blood is introduced into the tank as a coagulated mass, previously obtained by steam action. As much liquid as possible should be squeezed from the coagulum. Heating is initiated at

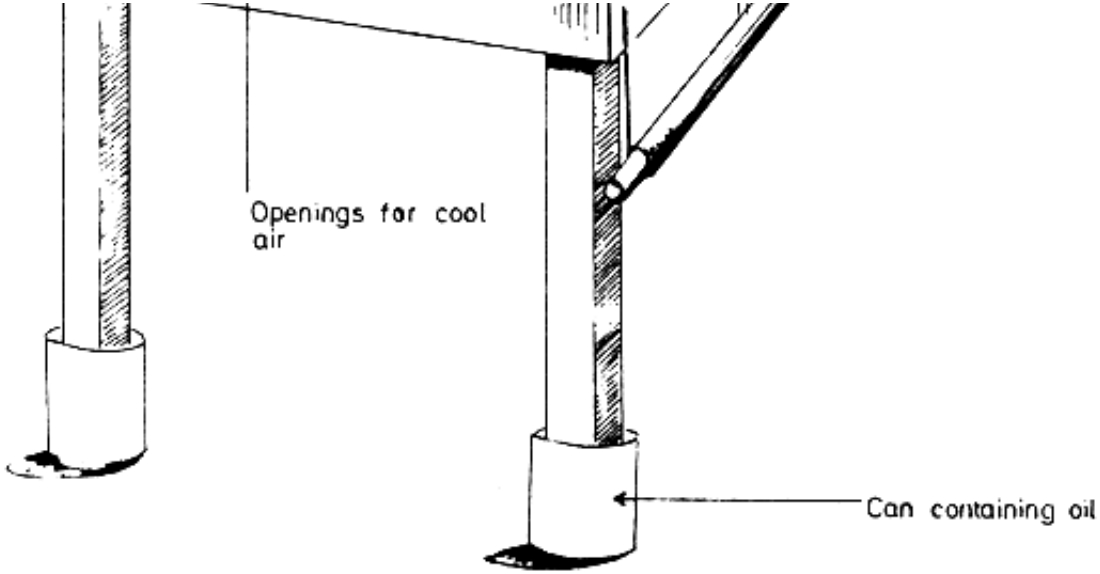
82°C (180°F) and progressively raised to 94°C (200°F) for about three hours, then elevated to 100°C (212°F) for 7 hours. Drying is complete when the final moisture level in the dried product is about 12 percent. During drying, moisture is constantly and rapidly removed from the tank by means of condensers to which the tank is connected.

Complete moisture removal is not desirable otherwise the final product would darken or char, while above the 12 percent level the residual moisture can cause deterioration and loss of nutrients. The protein content of the finished product is about 80 percent.

FIG. 6 A SIMPLE TENT SOLAR DRYER




Vent for hot air



10.5 Manure, Compost and Biogas

Digestive and excretory wastes of ruminants, collectively referred to as manure are a mixture of dung and urine and occur in two forms: as sweepings from lairages which are built into

heaps outside the slaughter building and collected from time to time in small quantities by small-scale farmers to enrich soil fertility, and as kraal manure which may remain permanent on the holding ground. Kraal manure is less-preferred because it is often sogged with water (from rains) or mixed with earth from treading by the animals as well as straw from bedding, thus creating problems in collection and spreading on farms.

(a) Use of Manure

In either form, the quality and usefulness of manure becomes reduced as exposure to the open without protection or sheds or roofing causes loss of valuable nutrients, e.g. nitrogen by evaporation, and soluble substances (potassium and phosphorus) by leaching during rains. Otherwise cattle dung is a good source of phosphorus while the urine yields liberal amounts of nitrogen and potassium. Furthermore, the organic matter component of the manure remains longer in the earth when

applied to soils to provide crops with a steady source of nutrients.

Fresh, straw-free manure with its urine mixture can be collected and held in special sheds or enclosures to decay a little before being put on the soil. If placed on the soil surface without prior decay or improper mixing with the soil, the manure loses considerable nitrogen, apart from physically smothering plant growth. Ruminants are known to avoid grazing close to pastures with dung on them.

(b) Composting

The process of breaking down organic matter in dead plant material, crop residue and leaves by decay before returning them to the soil can also be applied to old manure. The process is called composting. Farm composts are normally heaped above the ground, alternate layers of plant residue being sprinkled with

ammonium sulphate, lime and water to facilitate decay. The pile is protected from rain and strong winds by being covered with heavy logs or a mud wall, then left to rot.

For environmental and sanitation reasons, the composting of manure should be done in pits or bunkers instead of stacks and heapings. A pit is an ordinary hollowing of the earth, while a bunker is a chambered structure constructed with cement blocks or bricks above the ground (Fig. 7). Both structures must be roofed or provided with sheds for security against rain. By the same token, water-logged areas must be avoided when locating the structures. The pits and bunkers are filled with alternate layers of kraal and lairage manure which should be wetted slightly with some liquid waste water from the slaughterhouse. They are then topped with leaves and covered with heavy boards or roofing sheets. Breakdown of the material proceeds slowly. After 2–3 weeks the contents should be turned and mixed, repeating the process after 4–5 weeks. In about 8 weeks or less

the compost should be ready. Well-rotted manure must be fine textured without much straw in it.

(c) Biogas Production

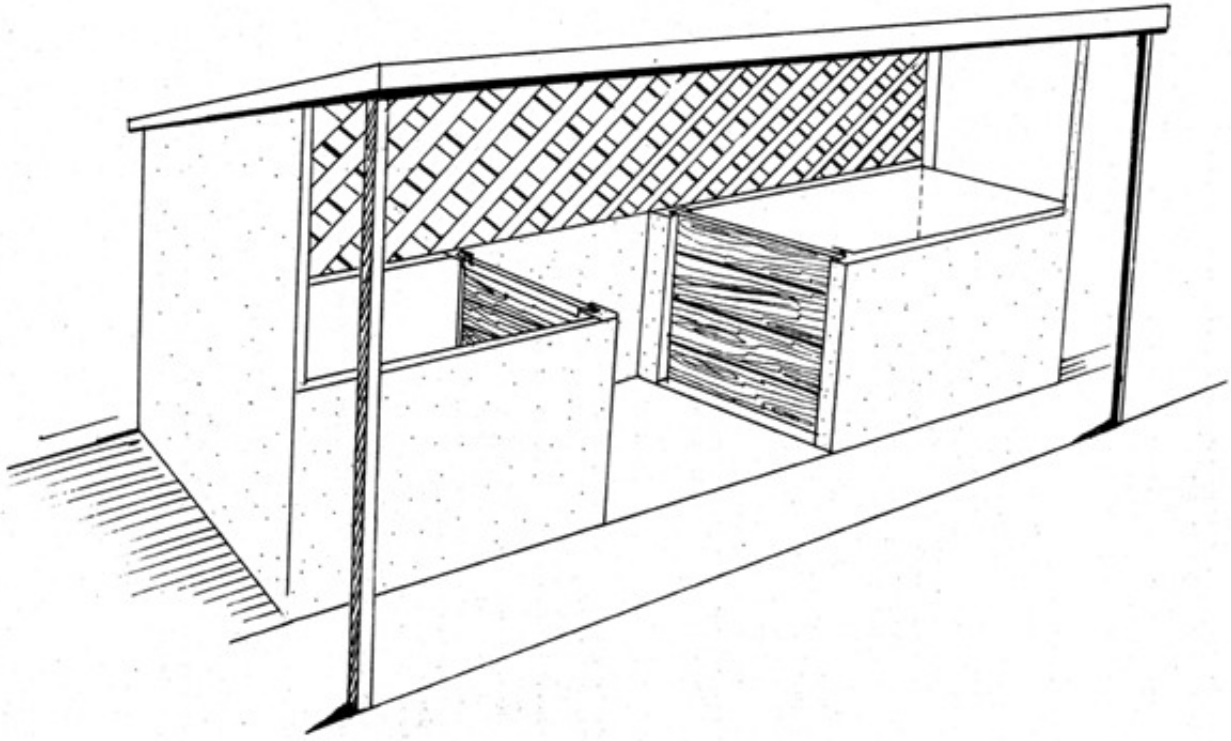
Compost of even higher fertilizing characteristics is obtained as a byproduct in the breakdown of manure in special devices called digesters for the production of biogas. (Biogas is so called because it is a mixture of gases produced as a result of anaerobic breakdown of organic matter by bacteria. The gases in the mixture are methane, 60 percent which is the main component and a source of fuel; carbon dioxide, 36 percent, and hydrogen, oxygen, nitrogen and hydrogen sulphide making up the rest.)

As a rule, biogas production is not economic, the yield being very low. In animal wastes, for instance, the yield of biogas is lowest for cattle; pigs are intermediary with poultry being highest on the

scale. In addition, operational problems exist affecting the charging of the system and continuous flow of gas, not to mention the explosion hazard. Proven commercial plants must be procured if biogas production from animal wastes is contemplated. In this case the digester gas utilization must be based on a practical necessity such as requirement for heating water (by direct burning) to maintain sanitary services in the slaughterhouse.

Because of its low yield, another consideration can be the advantages offered by biogas production in the treatment of organic wastes including the removal of offensive and insanitary influences from the environment. Whichever the application, compost is always produced from the operation, which with treated liquid waste, can be used in vegetable cultivation to yield revenue to offset costs.

FIG. 7 SKETCH OF A BUNKER FOR COMPOSTING MANURE



APPENDIX I

TABLE 1: SMALL RUMINANT CONSUMPTION IN SELECTED DEVELOPING COUNTRIES

A: BY SLAUGHTER (IN EASTERN AFRICA, LIVESTOCK-RICH AREA) ESTIMATED VALUES ROUNDED TO NEAREST THOUSAND

	SHEEP		GOAT	
UGANDA (1982)				
Official Slaughters	1 000	**(1.9%)**	7 000	**(1.8%)**
Unofficial Slaughters	54 000	**(98.1%)**	390 000	**(98.2%)**
Total	55 000	**(100%)**	397 000	**(100%)**
Stock Population	900 000		1 000 000	

ETHIOPIA (1983)				
Official Slaughters	40 000	**(0.5%)**	10 000	**(0.2%)**
Unofficial Slaughters	7 880 000	**(99.5%)**	6 650 000	**(99.8%)**
Total	7 920 000	**(100%)**	6 660 000	**(100%)**
Stock Population	24 000 000		18 000 000	
SUDAN (1983)				
Official Slaughters	420 000	**(12.8%)**	100 000	**(5.3%)**
Unofficial Slaughters	2 860 000	**(87.2%)**	1 790 000	**(94.7%)**
Total	3 280 000	**(100%)**	1 890 000	**(100%)**
Stock Population	19 600 000		14 900 000	

The low official slaughters (i.e. slaughters in recognized premises, the products of which are inspected) compared with unofficial ones are an illustration of the fact that a high proportion of small ruminants is consumed in rural areas where most unofficial slaughters take place.

Source of Original Data

Department of Veterinary Services & Animal Industry, Kampala, Uganda (July 1984); Animal Resources Development Department, Addis Ababa, Ethiopia (Aug. 1984). Animal Resources Department, Khartoum, Sudan (August 1984).

Table 1 - contd.

B. BY IMPORT (TO THE ARABIAN PENINSULA, A MEAT-DEFICIENT REGION). (VALUES IN METRIC TONS ROUNDED TO NEAREST THOUSAND - INCLUDING CARCASS EQUIVALENT OF LIVE ANIMALS)

		BEEF	MUTTON & GOAT	RATIO OF MUTTON/GOAT TO BEEF
SAUDI ARABIA				

	1980	71 000 mt	95 000 mt	1.3:1.0
	1981	80 000 mt	130 000 mt	**1.6 : 1.0**
UNITED ARAB EMIRATES				
	1980	2 000 mt	28 000 mt	**12.7 : 1.0**
	1981	5 100 mt	14 000 mt	**4.7:1.0**
KUWAIT				
	1980	11 000 mt	36 000 mt	**3.3:1.0**
	1981	10 000 mt	45 000 mt	**4.5:1.0**
QATAR				
	1980	400 mt	9 700 mt	**24.3 : 1.0**
	1981	1 500 mt	10 000 mt	**6.7:1.0**
SOUTH YEMEN				
	1980	200 mt	3 400 mt	**17.0 : 1.0**
	1981	400 mt	3 500 mt	**8.8:1.0**

The high level of mutton/goat imports over beef by the Arabian

Peninsula shows the high preference for and consumption of small ruminants in meat-deficient areas and the importance that these species command in the diet and culture of developing countries.

Collated from data furnished by the Commodities and Trade Division, FAO, Rome (July 1984).

TABLE 2: COMPARATIVE YIELD OF SLAUGHTER PRODUCTS IN INDUSTRIALIZED COUNTRIES AND THE DEVELOPING TROPICS

		CATTLE			SMALL RUMINANTS	
	North America	East Africa	West Africa	The Lamb in N. America	E. African Long Legged Goat	West African Dwarf Goat
Aver. Livewt. kg	500	300	250	40	40	30

Carcass %	56	52	50	48	52	54
Edible Offal %	3	18	20	3	11	21
Byproducts %	25	10	9	18	14	0
Rejects & Losses %	16	20	21	31	23	25

Percentage yield of byproducts is higher for cattle in developed than in developing areas, and presents greater variety. Among sheep and goats, the yield in some cases is similar in volume, although again, the developed countries show more diversity. Much of the rejects in the less-developed areas can, however, be utilized in byproduct industries. (Chapter 10, para. 3)

Sources:

Ministries of Agriculture, Uganda, Ethiopia and the Sudan (July -

Aug. 1984) Swift & Co., Chicago USA (1960) and Food Research Institute, Accra, Ghana.

TABLE 3: MAJOR SLAUGHTERHOUSE BYPRODUCTS AND THEIR USES

BLOOD

Liquid Blood: as a source of serum for pharmaceuticals, and as albumin for the glue, textile and dye industries. Dried Blood: as blood flour; also as blood meal for animal feed and fertilizer.

BONES/FEET/SHANKS

Bone meal as animal feed or fertilizer; also bone is used in the manufacture of combs, buttons, cutlery handles, etc; other uses include glue, gelatin and tallow.

HOOFS AND HORNS

As hoof/horn meal for use as fertilizer, gelatin and glue; also for combs, buttons and hairpins; objets d'art (including souvenirs and articles of tourist attraction).

HIDES & SKINS

Cured hides/skins for leather - footwear, gloves, belts, bags, upholstery and saddlery.

HAIR & WOOL

Brushes, yarn, fabrics and fibres.

GLANDS & ORGANS

Examples: Thymus, thyroid, pituitary, gonads, pancreas and gall bladder - for pharmaceuticals.

INTESTINES

Sausage casings, musical instruments/strings and surgical ligatures.

STOMACHS, OTHER OFFALS, CONDEMNED MEAT

Meat/bone meal for animal feed or fertilizer; Tallow: for soap and glycerine; and for lubricants, grease and waxes.

GUT CONTENTS, MANURE, SOLID WASTE

Compost, Biogas - as fuel for heating and lighting.

APPENDIX II
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2. Eradication of hog cholera and African swine fever, 1976 (E* F* S*)
3. Insecticides and application equipment for tsetse control, 1977 (E* F*)
4. New feed resources, 1977 (E/F/S*)
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