PRACTICAL ACTION
Technology challenging poverty

CURED MEAT PRODUCTS

technical brief

Introduction

Meat is a valuable nutritious food that if untreated will spoil within a few days. However, there are a number of preservation techniques that can be used at a small scale to extend its shelf life by several days, weeks or months. Some of these processing methods also alter the flavour and texture of meat, which can increase its value when these products are sold. This Technical Brief gives an overview of the types of cured meat products that are possible to produce at a small scale of operation. It does not include sausages, burgers, pâtés and other ground meat products. These are more difficult to produce at a small scale because of the higher costs of equipment and the specialist technical knowledge required, or because they pose a greater risk of causing food poisoning.

Spoilage, food poisoning and preservation

Meat can support the growth of both bacteria and contaminating insects and parasites. It is a low-acid food, and if meat is not properly processed or if it is contaminated after processing, bacteria can spoil it and make it unacceptable for sale. Dangerous bacteria can also grow on the meat and cause food poisoning. All types of meat processing therefore need careful control over the processing conditions and good hygiene precautions to make sure that products are both safe to eat and have the required shelf life. Processors must pay strict attention to hygiene and sanitation throughout the processing and distribution of meat products. These precautions are described below and also in Technical Brief: *Hygiene and safety rules in food processing*.

'Curing' is the treatment of meat with preservative chemicals that restrict or prevent the growth of spoilage bacteria and food poisoning bacteria. It is used together with processes that use heat, smoke or low temperatures to give the required shelf life of cured meats. The principles of preservation of cured meats are:

1. The use of preservative chemicals: either salt, chemicals in smoke and/or sodium nitrite/nitrate.
2. Reducing the water content of meat by drying and/or smoking.
3. Reducing the temperature by chilling to around 5°C.
4. Heat from smoking - the effects of heat from the smoke and chemicals in the smoke combine to preserve the meat. Smoke also adds distinctive and attractive flavours to the meat, which can increase its value.

Curing is achieved by either rubbing salt and other preservative chemicals into the meat (salting) or by soaking meat in a solution of these chemicals (brining). Depending on the process, the shelf life of cured meats is increased by several days (e.g. bacon) to several months (e.g. dried meats).

Building and facilities required

It is important that a suitable room is used only for processing meat products. The room should be hygienically designed and easily cleaned to prevent contamination of products by insects, birds, rodents and micro-organisms. This requires attention to the design and construction

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materials to ensure that all surfaces are easily cleaned and have no cracks that could harbour grease, dirt or insects. All internal walls should ideally be clad with plastic laminated boards that can be easily cleaned (and may be a legal requirement if meat products are to be exported). If cladding is not available, walls should be plastered or rendered with concrete and the lower parts tiled to at least 1.5 metres above the floor. Higher parts of walls can be painted with good quality gloss paint if tiling is too expensive.

The floor should be tiled with non-slip terrazzo floor tiles. Because meat processing involves using a lot of water, the floor should slope to a drain to prevent pools of stagnant water forming, which would allow insects and micro-organisms to breed. The drainage channel should be covered with a metal grating that can be removed to clean the drain. A wire mesh cover should be fitted over the drain exit to prevent rodents and crawling insects getting into the building through the drain. This should also be easily removed for cleaning.

Opening windows should be screened with mosquito mesh. Thin metal chains or strips of plastic can be hung from door lintels to deter flying insects, or alternatively, mesh door screens can be fitted. A panelled ceiling should be fitted rather than exposed roof beams, which would allow dust to accumulate that might contaminate products. There should be no holes in the ceiling or roof, and no gaps where the roof joins the walls, which would allow birds and insects to enter. One or more insect 'electrocutors' (Fig. 1) should be hung from the ceiling in the processing room.

Figure 1: Insect electrocutor.
Photo from Actron Inc

An adequate supply of clean water (of drinking quality) should be available from taps in the processing room. Hosepipes with pistol-grip adjustable sprays should ideally be used for washing down floors and equipment. If necessary, water should be treated to remove bacteria. The cheapest and easiest way is to use bleach (also known as 'chlorine solution' or 'hypochlorite'), which is cheap and effective against a wide range of micro-organisms. Water for cleaning should contain about 200ppm (mg/litre) of chlorine, made by mixing 1 litre of bleach into 250 litres of water. Commercial treatment units that use ultra-violet light to destroy micro-organisms in water are suitable for larger-scale processors that use a lot of water.

Meat processing produces both solid and liquid wastes that contain fat and blood, both of which are highly polluting if not treated properly. Processors should consult local health authorities when designing the meat processing room to find out whether special on-site treatment of wastes is required before disposing of them in municipal drains. If mains drainage is not available, it is necessary to construct treatment facilities to prevent wastes becoming a breeding ground for insects or causing pollution of local water supplies. The room should have adequate lighting for safe operation of equipment. There should be adequate power supplies to operate electrical equipment. Because meat processing requires refrigerators and/or freezers, it is important that the power supply is reliable, and in areas where power interruptions are likely, it is necessary to have a backup generator that starts automatically when the power fails.

Equipment

All meat processing equipment should be designed and constructed so that it can be easily cleaned. Mixing bowls, tanks etc. should have a smooth internal surface without corners, and all welds should be ground to a smooth finish. Ideally, all equipment should be made from stainless steel, but alternatives include polished aluminium, or food grade plastic for containers and equipment that are not heated. Mild steel cannot be used because it will rust and contaminate products, and brass, iron or copper cannot be used because they promote rancidity of fats in meat products.

The layout of equipment within the room should allow food to move between different stages in a process without the paths crossing. This reduces the risk of contaminating finished products with raw meat. There should also be sufficient room behind equipment for cleaning. The layout of the processing room should take the following principles into account:

- Incoming meat should be placed in a refrigerator or cold store at below 5°C, or in a freezer. This equipment should not be used to store finished products or any other materials.
- There should be physical separation between areas that are used to prepare meat (e.g. boning, filleting etc.) and subsequent processing.
- Smoking, cooking or drying stages should be carried out in a separate room to prevent steam or smoke from entering the main processing area.
- Separate rooms or cupboards should be used to store dry ingredients, packaging materials and cleaning chemicals.
- Dried or smoked products should be stored in a cool area that is well-ventilated and protected from insects and sunlight. Other products should be stored in a refrigerator or cold store at around 5°C, which is not used to store anything else.
- Changing rooms, toilets and showers should be separated from the processing room by at least two doors.

An example of the layout of a meat processing room is shown in Fig. 2.

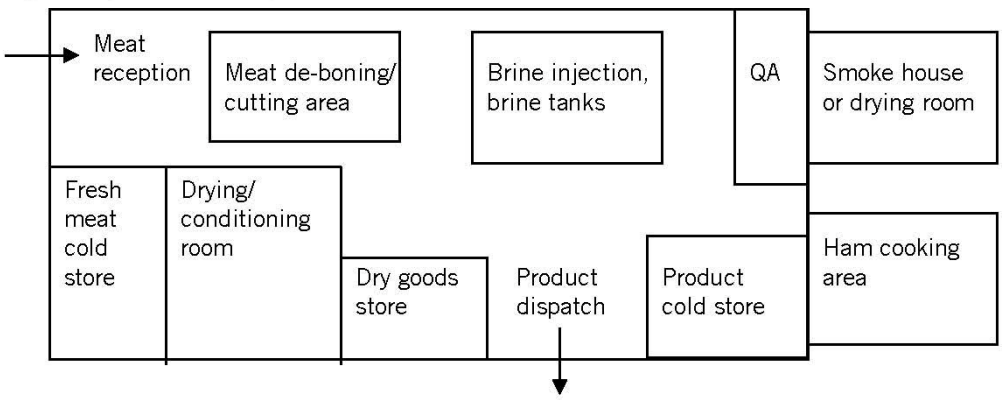

Figure 2: Layout of a meat processing room

Quality assurance

Because meat has a high risk of causing food poisoning, it is essential that processors pay great attention to the quality of the meat that they buy. Two types of danger exist: 1) infections from the living animal that are carried by the meat or infectious organisms such as parasites that grow in the meat; and 2) infections caused by contamination of the meat after slaughter. A qualified person should inspect animal carcasses to ensure that the meat is free of disease. Contamination of meat in the abattoir can come from contact with animal faeces, poor quality water, dirty equipment and poor hygiene by abattoir workers. To ensure that good quality meat is used, processors should only buy it from reputable farmers or suppliers, and not rely on local street markets or middlemen. Further details of hygiene and correct management in abattoirs is given in *Guidelines on Small Slaughterhouses and Meat Hygiene for Developing Countries*.

The level of quality assurance in meat processing depends on the risk associated with the particular product, and this is assessed by risk (or hazard) analysis using the HACCP (Hazard Analysis Critical Control Point) system. Meat processors should carry out a hazard analysis for each of their products (details are given in *How to HACCP*). In summary, meat products are low-, medium- or high-risk foods as follows:

Low-risk meat products:	None.
Medium-risk meat products:	Biltong and similar cured, dried meats, smoked meats, bacon.
High-risk meat products:	Sausages and other ground meat products (eg.beefburgers, pâtés), cooked hams.

Cured, dried and smoked meat products are each suitable for small-scale production, provided that careful attention is paid to hygiene, whereas ground meat and uncured meat products require greater expertise and care, and these are not included in this Technical Brief.

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Cleaning and sanitation

Good hygiene and sanitation is essential in all types of meat processing. Bacteria can rapidly spoil meat if processing is not done quickly and properly and it is essential that hygienic food handling is carried out with these products. In general inexperienced people should not process meats and training in hygienic food handling should be given (e.g. by a local Bureau of Standards) to all staff to minimise risks associated with these products.

Equipment should be thoroughly cleaned after each day's production, using a cleaning schedule that indicates which equipment is to be cleaned, who is responsible for cleaning it, how it should be cleaned, and who is responsible for checking that cleaning has been done properly. All equipment should be washed with hot water and a detergent that is recommended for use with meat products, then a disinfectant (or sanitiser) and then rinsed with chlorinated water. Equipment and surfaces should be allowed to dry in the air, because wiping with cloths can re-contaminate them. If they are available, brushes with coloured bristles are preferred because the coloured material can be seen easily if it is lost in machinery or in the product. At the end of a working day, a slight 'chlorine' odour in the processing room indicates that it has been properly cleaned. A summary of guidelines on hygiene and sanitation is given in Technical Brief: *Hygiene and safety rules in food processing*.

Legislation

In most countries, the legislation for processing meats is more stringent than for many other types of food. In addition to general regulations that govern labelling, weights and measures and hygiene when handling foods, special regulations may govern the manufacture and sale of meat products. There may also be legal limits on the amount of sodium nitrate/nitrite in the final products (typically 250 -500 mg/kg (ppm) of sodium nitrate and 150 - 200 mg/kg (ppm) of sodium nitrite). Meat processors should contact the responsible Ministry for copies of national regulations related to their products, and if necessary get advice from a university food science department or Bureau of Standards to clarify what the regulations mean. They should also obtain a Health Permit from the Ministry of Health or Local Authority that licenses the premises for food production, obtain a Manufacturing Licence from the Local Authority or Ministry of Industry, and obtain Medical Certificates from the Health Authority to certify that all workers are fit to handle food.

Methods of processing

The main methods used to process cured meats at a small-scale are as follows:

- Curing followed by chilling or cool storage (e.g. ham/salted pork, bacon).
- Curing and drying (e.g. biltong).
- Curing and smoking (e.g. smoked bacon or smoked pork).

1) Curing: Salted Meats

A traditional method of salting meats such as pork, beef or chicken is to cut the meat into pieces, dip them in a saturated salt solution (to make a saturated solution, add salt until some crystals do not dissolve). Then press the pieces to remove excess water. The pieces are then rubbed with dry salt, wrapped tightly in cloth that is tied tightly with rope and hung in the air to allow water to drip away. The salted meat is partly dried and has a high salt content, both of which act as preservatives. It is cooked before consumption after thoroughly washing out the salt. The product can be kept for about a month before a rancid taste develops. An alternative method is to pack the salted meat into covered drums. Initially the meat may need to be weighed down, but after about 7 days, meat juices are released and form a strong brine in which the meat is submerged. Salt levels are 12 - 18% in the final product and it can be preserved for up to 3 - 4 months under ambient conditions. After this, fat oxidation causes rancid off-flavours.

1) Curing: Bacon and Ham

Bacon is made from the back, belly and loin cuts of pork, whereas ham and gammon are made from the front or hind quarters. The meat is cured either by dry-salting or in brine. It can be unsmoked or smoked and is usually refrigerated for retail sales. Dry-salting is less common, but involves rubbing fine salt onto the surface of the meat repeatedly over several weeks to make ham. Alternatively, pieces of meat can be 'tumbled' with the salt mixture in a tumbling machine that is similar to a butter churn (see Technical Brief: *Butter and Ghee*). Typically this would be for 30 - 60 mins every 24 hours or for 5 -10 mins every 8 hours.

The simplest method of brine curing involves placing deboned cuts of pork so that they are fully submerged in a tank of refrigerated brine (below 5°C) for five days, turning them occasionally. The brining tank should be constructed from stainless steel, food-grade plastic or concrete lined with ceramic tiles and waterproof grouting. The brine typically contains 25 kg salt, 3 kg sodium nitrate and 50g sodium nitrite per 100 litres of water. Ham and 'sweet-cure' bacon brines may also contain sugar, and other specialist brines may contain a variety of herbs and spices, including juniper berries, nutmeg, cloves, peppercorns, rosemary or bay leaves. Further details are given in *Opportunities in food processing*.

The brine causes water to pass out of the meat and as a result the strength of the brine falls as it becomes more diluted. The strength is checked daily using a 'salometer' (see QA below), and curing salts are added to maintain the brine strength. Once curing is completed, the brine should be discarded and a new batch prepared for the next meat.

Figure 3: Brine injection needles. Photo from Cyborg Equipment Corporation

More rapid curing can be achieved by injecting the meat with brine before tank curing. This brine is slightly stronger and contains 30 kg salt per 100 litres of water and the same amount of sodium nitrite/nitrate as tank brine. The meat should be injected in about 20 places, deep into the meat, which causes the meat to increase in weight by 8 -10%. At larger scales of operation an electric injection pump (Fig. 3) that has 5 - 10 needles can be used. After injecting the brine, the meat is cured in a tank as above.

After curing, the meat is allowed to dry and mature under refrigeration at below 5°C for approximately 5 - 7 days. The humidity in the room should be kept at approximately 85% by keeping the floor wet with saturated brine (not water) at all times (saturated brine gives an air humidity of 75%). Bacon is then sliced to the required thickness using a manual or electric meat slicer (Fig. 4.). It can be wrapped in greaseproof paper if it is sold quickly, or sealed in either plastic bags or plastic trays with heat-sealed plastic covers. It is stored under refrigeration for retail display for about 2 -3 weeks. Vacuum packing extends the shelf life further, but vacuum packing machines are expensive to buy and to maintain, and they are only suitable for processors that can justify the expense with high levels of profitability.

Figure 4: Bacon Slicer. Photo from ProCook

Cured hams are cooked by either roasting, or by boiling in sealed plastic pouches. The internal temperature should reach at least 70°C, with the cooking time approximately one hour for each kg in weight of ham. They are then sliced and packaged in a similar way to bacon. NB: because cooked ham is eaten without further cooking, it is essential that strict hygiene is enforced to prevent contamination of the meat after cooking. This is therefore a product that should only be produced by experienced meat processors.

Quality assurance

The main QA checks are to accurately weigh meat and curing salts to ensure that the correct concentrations are used in the brine. A 'salinometer' is a type of hydrometer that is calibrated to measure the concentration of salt in brine (Fig. 5). A sample of brine is placed in the testing cylinder, usually at 20°C, and the glass salinometer is allowed to float in the brine. The reading is taken from the stem of the salinometer and converted to % salt using conversion tables supplied with the equipment. If no salinometer is available, the correct brine strength is one that will just float a fresh egg or a freshly peeled potato.

Figure 5: Salometer used to test brine strength

Careful attention must be paid to proper cleaning of slicing machines to prevent them recontaminating the cured meat. The temperature of curing and subsequent storage should also be monitored to ensure that it is 5°C +/- 1°C. Processors should check to ensure that distribution vehicles and retailers' display cabinets are capable of maintaining this temperature to ensure the quality and shelf life of their products.

2) Curing and drying

Dried, salted meats are important traditional foods, with the best-known example being **Biltong,** a snack food in Southern Africa. It has a dark brown colour with a salty taste and a flexible, rubbery texture. The process involves the following stages:

1. Good quality fresh beef from the hind quarters is selected and as much fat and connective tissue as possible is removed.
2. The meat is cut into strands, first along the muscle fibres and then across the muscle fibres to produce uniform sized strips 2 cm wide, less than 1 cm thick and 20 - 40 cm long.
3. A salt/spice mixture is rubbed into the meat slices (500g mixture per 10 kg sliced meat). A typical spice mixture is as follows for 100 kg meat:

	kg
Salt	3.74
Sugar	1.87
Potassium nitrate	0.02
Potassium sorbate	0.2
Mixed spice	0.21
Black pepper	0.10
Onion powder	0.03
Garlic powder	0.03
Ground ginger	0.03
Mustard powder	0.03

4. Hang each slice of meat on a hook and hang the hooks on wires in a well-ventilated room. The slices of meat should be contained in netting/gauze to protect them from insects while the meat dries.
5. Dry the meat (e.g. for 7-10 days at 25-30°C, <80% humidity, with a gentle breeze).
6. (Optional) cut the slices to approximately 10 cm long.
7. Pack the dried meat in polythene bags and heat seal.
8. Store in cool dry conditions away from sunlight to minimise rancidity and moisture pickup, to give a storage life of several months.

A similar product is 'Quanta', a dried and spiced beef used as snackfood in North Africa. Spices are mixed with fermented honey and about 120 grams of spice mixture (composed of 2.5% salt, 1.5% black pepper, 10% chilli powder (in 86% flour)) are mixed with each kg of meat. The spiced strips are dried in a similar way to biltong.

Quality assurance

Because biltong is not cooked before consumption, it presents a potentially serious food poisoning hazard if strict personal hygiene and hygienic food handling practices are not in place. In

particular, spices should be bought from a reputable supplier because these are often a source of food poisoning bacteria. The main process control points are 1) the size of the strips, which should be uniform to give similar drying times, 2) the drying rate which affects the product quality and moisture content. This depends mostly on the temperature and air speed of the drying air and size of the strips, and 3) the amount of salt/spices that are rubbed into the meat which prevents surface bacterial growth during the initial stages of drying.

3) Curing and smoking

A traditional West African smoked pork product is made from shoulders, feet, head or offal. It is hot-smoked to produce a well-developed smoky flavour. It is only partially cooked and then added to soups or stews. It may be slightly salted (e.g. salt at 3-5% of the weight of meat is rubbed into surface) or unsalted, and usually has a spice mix applied. Smoking is done on a grill mounted above a smoky fire, made from good quality fuelwood, and sugarcane bagasse may also be used to generate smoke. This material imparts a finer smoked flavour and an attractive golden colour to the meat. The meat is turned regularly for 6 - 10 hours to ensure uniform heating and smoking. Hot smoking must be carefully done to avoid over-cooking and charring the product. The cooled product is packaged in sealed polythene bags. Under normal ambient temperatures, smoked pork can be stored for about 4 days when packaged in polythene. If it is refrigerated it has a shelf-life of about 2 weeks at 5 - 10 °C

Equipment for smoking bacon, hams and other meat products can be made locally, or smoking kilns can be purchased. There are two basic types of smoker: those that produce smoke directly in the base of a smoking chamber; and those that have an external smoke generator that supplies smoke to a smoking chamber. Each type can operate as cold smokers (20 - 32°C) or hot smokers (70 - 80°C). Hardwoods are normally used to generate smoke because they produce the required flavours and colour in the smoked food. Resinous woods, such as fir or spruce, should not be used because they impart an acrid unpleasant flavour.

Direct smokers can be constructed from bricks (similar to a baking oven - see Technical Brief: *Bread baking ovens*) or from steel boxes (Fig. 6). A simple indirect smoker can be constructed from an old refrigerator by removing the compressor, cutting a vent in the top of the cabinet and fitting an adjustable air vent in the bottom of one side. The smoke generator is a brick or metal cabinet that contains the fire, which has a vent to control the amount of air entering the cabinet and thus restrict the fire to produce smoke. A pipe is connected from the smoke generator to the hole in the side of the refrigerator.

More sophisticated smokers have fans to control the amount of smoke from the generator and to evenly distribute smoke in the smoking chamber.

Figure 6: Meat Smoker.
Photo from Brougham Hall Foods

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Equipment and material suppliers

Note: This is a selective list of suppliers and does not imply endorsement by Practical Action.

Bacon slicers

These are likely to be available from suppliers in large towns/cities or can be imported from:

- ProCook, Cotswold House, 449 High St, Cheltenham, GLOS, GL50 3HX, UK, Tel: +44 (0) 8700 707172, Email: info@procook.co.uk, Website: www.procook.co.uk/contact_us.html
- SMS Food Equipment, PO Box 152, Macclesfield, Cheshire, SK10 4LX, UK., Tel: +44 (0) 1625 827827, Fax: +44 (0) 1625 820011, Email: enquiries@smsfoodequip.com, Website: http://www.smsfoodequip.com
- BuyCatering.com, 244 Dukesway, Team Valley Trading Estate, Gateshead, Tyne and Wear, NE11 0PZ, UK., Tel: +44 (0) 800 6522779 Fax: +44 (0) 191 482 1122, E-mail: sales@buycatering.com, Website: www.buycatering.com

Brine needles

- Cyborg Equipment Corporation, 8 Graham Street, Wareham, MA 02571, USA. Tel: 1 508 2910925, Fax: 508.291.1899, E-mail/Website: www.cyborgeq.com/contact.html

Insect electrocutors

These are likely to be available from suppliers in large towns/cities or can be imported from:

- Actron Inc. P. O. Box 572244, Tarzana CA. 91357-2244, USA., Tel: 1 818 654-9744, Fax: 1 818 654-9788, Website: www.actroninc.com/ag661.htm
- Shatrshield, 116 Ryan Patrick Drive, Salisbury, NC 28147, USA., Tel: 1 800 2230853, Fax: 1 704 6333420, E-mail/Website: www.shatrshield.com

Salinometers

These are available from most scientific equipment suppliers, for example:

- Nurnberg Scientific, 6310 SW Virginia Avenue, Portland, OR 97239, USA., Tel: 1 503 2468297, Fax: 1 503 246-0360, E-mail/Website: www.nurnberg.com/index.php?main_page=contact_us
- Thimson Instruments (India), Plot No.440-F, Ring Road, In between IOC Bunk & TATA Motors, Hebbal Industrial Area, Mysore 570 016, India, Tel: +91 821 2512050, Fax : +91 821 2411139, Email: thimson@rediffmail.com, Website: www.thimson.com/product.html

Smoking kilns

- Brougham Hall Foods, Brougham, Penrith, Cumbria, CA10 2DE, UK., Tel and Fax: +44 (0) 1768 890270, Email: sales@the-old-smokehouse.co.uk, Website: http://www.the-old-smokehouse.co.uk/acatalog/Brinkmann_Smokers.html

Ultra-violet water sterilizers

- Freshwater Systems, 10360 Sorrento Valley Rd., San Diego, Ca 92121, Website: http://www.freshwatersystems.com/c157-uv-systems.aspx
- SunRay Technologies Inc. 80 Weathervane Dr., Killington, VT 05751, Tel: +1 802 4228680, Fax: +1 802 4228682, Website: www.sunraytech.com/

General suppliers in Southern Africa:

- Shelving & Catering Equipment CC, Silicon St Ladine Polokwane Phone: 015 297 3850 fax: 015 297 3850
- Nylstroom Catering Equipment, Modimolle 0510 phone: 014 717 2002 fax: 014 717 2742 Cell: 082 329 8691 info@kitchenindustrial.co.za
- Casty Trading CC, 24 Delta St NkowaKowa Tzaneen Phone: 015 3033223
- *Mahuru Corporation*, Limpopo 082 296 8501 catering@makuru.co.za

Preservative chemicals can be obtained from pharmacies in major cities or by mail order. The following websites contain lists of international suppliers:

- Sodium nitrite: http://www.powersourcing.com/sf/sodiumnitrite.htm
- Sodium nitrate: http://www.buyersguidechem.de/AliefAus.php

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Further reading

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- Small-scale Processing of Pork, Technical Memorandum #9, ILO, Geneva, 1985.
- The Food Hygiene Handbook, Sprenger, R.A., Highfield Publications. Doncaster DN5 7LY,UK. 2002.
- Tools for Agriculture*: A Guide to Appropriate Equipment for Smallholder Farmers*, ITDG Publishing, CTA & GRET, 1992.
- http://www.biltongbox.com/biltong.html (for varying South African biltong recipes)

Support organisations

- Agromisa Foundation, P.O. Box 41, 6700 AA Wageningen, The Netherlands. www.agromisa.org
- Botswana Technology Centre, PO Box 0082, Gabarone, Botswana. Tel: +267 314161, Fax: +267 374677, Email: scitech@botec.bw, Web: http://www.botec.bw
- Dairy & Meat Officer *(Institutional Support & Training)*, Animal Production & Health Division, Food and Agricultural Organization (FAO), Rome, Italy, Website: http://www.fao.org/
- International Livestock Research Institute (ILRI) Ethiopia, P.O. Box 5689, Addis Ababa, Ethiopia. Tel: (251-1) 613215. Fax: (251-1) 611-892. E-mail: ilriEthiopia@cgiar.org. Website: www.cgiar.org/ilri/
- ILRI-Kenya, P.O. Box 30709, Nairobi, Kenya, Tel: 254-2 630743. Fax:254-2 631499.E-mail: ILRI-Kenya@cgiar.org. Website: www.cgiar.org/ilri/
- Strengthening African Food Processing, www.safpp.net

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