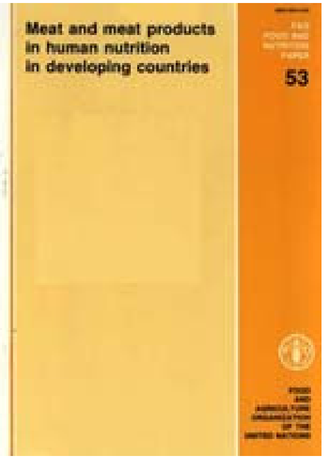

Meat and meat products in human nutrition in developing countries

---

by **Arnold Bender**

Commissioned jointly by the
Animal Production and Health Division
and the
Food Policy and Nutrition Division of FAO

FAO
FOOD AND NUTRITION PAPER 53
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 1992

Copyright

The Chief Editor,
FAO, Viale delle Terme di Caracalla,
00100 Rome, Italy,
e-mail:copyright@fao.org

Contents

Acknowledgments

Preface

Chapter 1 - Meat production and quality

- Meat and meat products
- Production and consumption
- Reduction of losses
- Meat quality
- Future strategies on livestock production

Chapter 2 - Role of meat and meat products in human nutrition

- Nutritional value of meat
- Composition
- Meat by-products
- Cooking
- Methods of processing and preservation of meat

Processed meat products
Methods of meat preservation without refrigeration
Recent developments in meat processing

Chapter 3 - Meat and health

Meat consumption role of meat in the diets
Meat as a source of protein
Meat as a source of vitamins and minerals
Health concerns associated with the consumption of meat
Toxic compounds formed during processing and cooking
Other potential problems
Conclusion

References

Glossary

Tables (part I)

Tables (part II)

Tables (part III)

Tables (part IV)

Acknowledgments

Contents - Next

M-80
ISBN 92-5-103146-0

Preface

The basis of a good diet - one adequate for growth, development and maintenance of health - is variety; a variety of foods can supply enough of the complete range of nutrients. Much of the malnutrition seen in the world is a result of relying too heavily on a single staple food.

Improvements in the diet depend on a knowledgable selection of foods that complement one another in the nutrients that they supply. It is, however, difficult in many regions to obtain such variety. Meat can complement most diets, especially those dependent on a limited selection of plant foods.

Meat and meat products are concentrated sources of high quality protein and their amino acid composition usually compensates for shortcomings in the staple food. They supply easily absorbed iron and assist the absorption of iron from other foods as well as zinc, and are rich sources of some of the vitamins in the B group. By providing such nutrients, meat consumption can alleviate common nutritional deficiencies.

The production of animals for meat can be integrated into the overall food system without competing directly with crops for human food; it enables utilization of land that is difficult to cultivate, and supplies valuable by-products as well as improving the fertility of the soil.

The appropriate utilization or expansion of existing sources of meat calls for coherent development of a complex system of production, processing and marketing, including aspects of finance and expertise for construction and operation of meat plants, and means of storage, meat preservation, transport and marketing.

In many regions in developing countries meat production is carried out with efficiency, and slaughter and processing are based on many of recent scientific developments. However, even in industrialized countries there is often considerable room for improvement. In other regions methods are less advanced, with poor control of sanitation, leading to considerable loss of products as well as to the risk of meat borne diseases. Improvements of techniques of slaughter and processing, especially in hygiene, would result in greater yields and higher profits. These would also provide the incentive for increased production.

While it is highly efficient in industrialized countries to specialise in single purpose animals it is often more efficient in some areas to raise dual-purpose animals. There is also scope for increased yields and efficiency by developing indigenous species for meat production, species that even without genetic selection thrive under local climatic conditions and withstand local diseases. Overall there is a great potential in the developing world to increase the production of meat and meat products to the benefit of the health of the consumer.

FAO acknowledges the contribution by Prof. A E. Bender from the UK for writing and editing the book incorporating a manuscript prepared by Mr. Hamid Ahmad from Pakistan. The book is jointly commissioned by the Food and

Nutrition Division and the Animal Production and Health Division of FAO and published as part of the FAO series Food and Nutrition Papers.

This publication has been jointly commissioned by the Food Policy and Nutrition Division and the Animal Production and Health Division. The book provides information on nutrition strategies with emphasis on developing countries, and it is intended as a source of information for livestock and meat technologists, nutritionists, food scientists and dieticians concerned with the production, processing and consumption of meat for improving of the nutritional quality of the diet and health of the population.

Patrick Cunningham
Director
Animal Production and Health Division

John R. Lupien
Director
Food Policy and Nutrition Division

Chapter 1 - Meat production and quality

Meat and meat products

<u>Livestock Products as Food</u>

Current trends indicate that by the end of the century 80% of the world's population will be living in the under-developed countries and a significant number of these will have large food deficits. An increased production of animal protein would make an important contribution towards filling this deficit (FAO 1984, FAO 1985, FAO 1990A).

On a world-wide basis cereals supply more than 50% of human requirements for energy and nearly 50% of the protein. Animal products, meat, milk, eggs and animal fats, supply 17% of the energy and 32% of the protein but there are vast regional differences between developed and under-developed countries. Table 1-1A shows world production 'of the various types of meat and illustrates these differences. In Oceania and North America, for example, the amounts of protein available per caput per day from meat are 31.5 and 38.3 g respectively, compared with 4.5 g in the developing countries of Africa and 4.8 g in the Far East (FAO Food Balance Sheets, 1990).

The amounts of protein and fat from meat available per caput per day are shown in Table 1-1B. The ranges indicate considerable differences even between countries classed together as developed or developing.

In most communities meat has long occupied a special place in the diet, for a variety of reasons including taste preference, prestige, tradition and availability, with the nutritional aspects being included more recently (Rogowski 1980).

While it is true that meat is not essential in the diet and many people thrive on diets derived largely or even entirely from plant foods (so long as the amounts and variety are sufficient) there are many diets that would be considerably improved by the inclusion of even small amounts of meat and meat products. This is because, compared with plant foods, they are concentrated sources of protein and a range of vitamins and mineral salts. As little as 25 g of meat will supply 45% of a child's daily need for protein and half the vitamin B12; the addition of 100 g of meat to the average Zambian diet would increase the protein by 50%, iron by 12%, niacin by 40% and energy by 25% (Jensen 1981). Apart from supplying additional protein the amino acids in that protein complement the cereal sources of protein by making good their relative deficiency of lysine (See Chapter 3). Moreover, compared with plant foods the iron in meat is well absorbed and meat promotes the absorption of iron from other foods.

Types of Meat

Meat is the flesh and organs of animals and fowls. There are various legal definitions of meat in different countries designed to control the composition of products made with meat.

The flesh of cattle, pigs and sheep is distinguished from that of poultry by the term red meat, while the flesh of poultry (chicken, turkey, duck, pigeon, guinea fowl) is termed white meat.

In addition to the common domestic animals a wide variety of wild animals are eaten - possum, deer, rabbit, moose, caribou, bear, polar bear, seals, walruses depending on availability and local custom, as well as horse, camel, buffalo, goat, dog and rodents. Meat from non-domesticated animals is sometimes termed game meat (de Janvry and Sadoulet 1986). Overall, as indicated in Table 1-1A, by far the greater part of meat supplies is from four sources but this may not be so in certain localities.

The relative importance of these various sources of meat in the diet varies from region to region and in different cultures; many that are rejected for various reasons in one culture are fully accepted in others. In the Indian sub-continent beef is socially and economically perceived as being second class compared with lamb, mutton and poultry, while the reverse is true in most industrialized countries; many western people abhor the thought of eating dog or horse meat which is relished elsewhere; the relative demand for organ meats compared with muscle meat varies in different regions.

Production and consumption

Developing and Developed Countries

Agricultural progress in most developing countries has mainly involved an increase in the production of staple crops and the introduction of industrial crops. New varieties, improved farming techniques, greater use of fertilisers, irrigation and chemical control of pests (a group of procedures collectively termed The Green Revolution) have resulted in considerable increases in production, sufficient, in the absence of climatic disasters, to meet domestic needs in many countries and even, in some instances, to provide a surplus for export.

On the other hand developments in livestock production have lagged far behind. Although there has been an increase over the years in the amount of meat available in developing countries the quantities are small. Between 1980 and 1990 world production of meat increased by 29%; 15.6% in developed countries and 56% in developing countries, but the latter was from a very low base. The daily per caput availability of protein from meat increased by 24% but this was an increase from only 4.9 g to 6.1 g in contrast these figures increased in developed countries by 8%, from 27.4 to 33.9 g per day (FAO Food Balance Sheets).

The mean annual output of milk and meat from cattle in the developing countries of Africa and the Far East is less than one tenth of that obtained in Europe (Blaxter 1975; FAO 1990A). This is a result of traditional subsistence farming practices which provide minimum feeding and management levels to livestock. Animals in developing countries are prized mainly for their draught power (Table 1-2 and Ramaswamy, 1980) and manure world-wide some 250-300 million buffalo make a major contribution to the supply of energy; so far as food is concerned they are prized more for their milk than for their meat. Yet as per capita income rises in Third World countries the demand for meat products is rising faster than that for cereals and outpaces supplies.

The problems of meat production are complex and include multiple biological, economic and social factors. The practices of the small-holder system of livestock production need to be gradually developed so as to fit local conditions and meet increasing demands. Modern scientific practices developed in industrialized countries are rarely directly transferable to developing countries and, if they are to be transferred usually need to be adapted to local conditions.

Promotion of Livestock Production

Three main reasons have been suggested for devoting scarce financial and technical assistance to livestock production in developing countries:

1. The possibility of moving into activities with higher added value per unit of product marketed and into products with higher income elasticity of demand.

2. The possibility of increasing supplies of grain products and of diversification of marginal lands into the production of feed grain, oilseed crops and fodder crops as a result of the Green Revolution.

3. The perception of livestock as a means of increasing rural incomes and increasing rural on-farm and off-farm employment (APO 1976, Bachman and Paulino 1979, De Boer 1982).

Animal versus Plant Production

Meat production from grazing animal calculated as energy or protein yield per hectare is very inefficient when compared with plant products. Yields, of course, vary enormously from one region to another and even from one farm to another in the same region but the figures in Table 1- 3 reveal the comparative inefficiency of animal production in those terms.

Animals are, moreover, poor converters of energy into foods for human consumption; if cereal grain is fed to livestock it requires on average 7 kcal input for every kcal generated - ranging from 16 for beef production to 3 kcal for broiler chickens. One argument that has been put forward against industrial systems of meat production is the competition between animal feed and food for direct consumption by human beings. However, certain animals like ruminants are valuable as converters of inedible agricultural and industrial by-products such as bagasse, molasses, sugar cane rinds, beet pulp, cotton seed hulls, poultry manure and urea, into products of high nutritional value, and they can graze on marginal land that is otherwise of little use (FAO 1976, APO 1990).

This can be illustrated by the considerable production of milk IA India largely using feed materials unsuitable for human food. It is estimated that in the hands of the smallholder some 60% of feed comes from farm by-products and 40% from natural vegetation (Groenwold and Crossing 1975). There have been several publications on this subject - "The Role of Animals in Meeting World Food Needs" (Rockefeller 1975), "The Contribution of Livestock on Small Farms. (FAO 1976), "The Potential for Livestock in Farm Diversification" (APO 1990) - but developments have been slow in most countries of the Third World.

Increasing Demand for Meat Products in Developing Countries

Increasing populations and increased demand per capita together with moderately rapid to rapid income growth lead not only to an increased demand for staple foods but also for preferred foods including, particularly, meat products (see income elasticities of demand Table 1-4). As a result meat consumption grew in the Third World between 1961-65 and 1973-77 at an average rate of 3.4%, and in the fast growth economies at more than 6% (Sarma and Young 1985). The expected average meat consumption by the year 2000 is 20 kg/head/year with a deficit in production of some 20-25 m tonnes. Meat consumption between countries varies from 4 kg per head per annum in low income groups to 35 kg in high income groups. In general there is a relation between income and the consumption of animal products but this does not always hold.

The growing demand for meat products that accompanies rising income has been paralleled by increasing interest in food quality, safety and nutritional aspects, which all give rise to appropriate legislation.

In some countries where economic growth has been rapid and sustained over a considerable period of time the contribution of the livestock subsector to agricultural gross domestic product has increased substantially. In Korea, for example, it increased from 5.4% of agricultural GDP in 1961 to 15.4% in 1973. In Taiwan (Chang 1981) it rose from 18% in the period 1952-57 to 29.5% in 1977. These figures can be viewed against an overall average increase of 1040% in developing countries and of 60% in the United States.

In most developing countries, however, the low level of meat supplies is due to the low return of resources devoted to animal production, which, in turn, depends on the low purchasing power of the vast majority of the population (FAO 1990A).

Constraints on Meat Production

Other constraints on meat production include inadequate feeding and poor management of animals, to which must be added animal health problems, lack of skilled manpower, problems arising from land tenure, lack of financial resources, and poor rural infrastructure - roads, power, health care, marketing organisation.

There is a great deal of illegal or poorly supervised slaughter which means that regulations are not being enforced, and conditions are unhygienic. Disease, parasites and poor management of all aspects of meat production impede progress. It is estimated that world-wide per year up to 50 million head of cattle and buffaloes and 100 million sheep and goats die from disease and parasites - mostly in the Third World. Even greater losses of production are estimated to arise from ailing and unthrifty animals and from poor handling before slaughter. In many regions of developing countries animals trek to market, often with inadequate feed and water and under considerable stress which lead to losses of both of weight and quality of meat. In parts of Africa, for example, it is estimated that there is often a 30% loss of weight and 10% mortality on the way to market.

In most areas animals are slaughtered on a simple slab, usually at night or in the early morning when the temperature is lower, and the meat is sold without refrigeration or further processing within a few hours.

The general disregard for grades and quality of meat both in buying and selling does not encourage investment to improve meat output. A more discerning market tends to develop with economic growth, and both producers and consumers would benefit by sale and purchase on grade and quality bases.

Increased Production and Productivity

Increases in meat production can be encouraged by stable profitable outlets in connection with improved processing and handling facilities and consequently large-scale investment. Loan institutions are usually not geared to make loans to small farmers because the administrative costs of small loans are relatively high and so some 70-80% of small farmers in most developing countries do not have access to institutional credit.

Shortage of trained personnel is another constraint on livestock production; there is a need for skilled producers, processors, distributors, extension advisers and technicians. Lack of qualified control personnel and veterinarians leads to enormous losses in quality and quantity of livestock products.

Lack of refrigeration and other preservation techniques results in considerable losses and can lead to public health problems. If animal production is to compete with crop production intended for direct consumption by human beings, then the efficiency of meat production and meat processing must be greatly increased (FAO 1990B). This is of particular importance for the supply of meat to growing populations.

Increasing Yields

There are many and continuing developments in the western world that increase productivity of animals ranging from artificial insemination of animals with synchronized oestrus and embryo transfer to recombinant DNA technology intended to improve growth and feed conversion. These are far from practicable in most parts of the developing world and, instead, there would seem to be considerable potential in making better use of indigenous animals and more immediate gains from better handling before and during slaughter and from closer control of processing.

The resources necessary for livestock production include water, feed, land, labour, capital and energy. Efficiency of output can be related to any of these and so what is perceived as efficiency will differ with the measure and local availability of these resources.

For example, it is common practice in intensive farming in the west to keep species separate and while this is efficient on managed pasture with a sward consisting of a few species of plants it may not be the most efficient method in developing regions since a mixture of types of animals can make better use of the wide variety of grazing species from grasses and legumes through creeping plants to tree-leaves.

One of the biological constraints on the production of animal products is poor food conversion efficiency by the animals, in particular meat-producing animals. Scientific progress has been made in industrialized countries in selective breeding for strains with high feed conversion efficiency that could be adapted to meet the needs of developing countries (Blaxter 1975, De Boer 1982).

Age of Slaughter

One aspect of yield of meat is the age of slaughter in relation to maximum feed conversion efficiency, which applies to animals reared solely for meat. In the early stages when growth is rapid there is comparatively good return of meat for feed consumed. This declines with increasing maturity and at a later stage the weight gain is largely fat - which may or may not be wanted by the consumer but is, in any case, an inefficient procedure.

Thus efficiency of production of livestock products can be improved by appropriate livestock management to capitalise liveweight gain potential of young animals, adequate assessment of marketing premiums for carcass characteristics, together with genetic selection and the use of multi-purpose animals.

Multi Purpose Animals

While maximum feed conversion efficiency can be achieved by specialising in the production of one product such as milk, eggs or flesh, it may be more efficient overall, despite a small loss of efficiency of production of any one product, to use animals for more than one purpose such as milk and meat or eggs and flesh (multi-purpose animals). It has been shown that dual-purpose beef-milk animals are more energy efficient for the same mix of final products than specialist systems - 44% compared with 34% (Preston 1977).

The choice between specialist and multi-purpose animals will depend on the socioeconomic aspects of the whole process and, to some extent, on the demands of the consumer. Slaughter of culled animals that have completed their life cycle as milk or egg producers results in tough meat typical of old animals, which may or may not suit the consumer. The extreme example comes from the Third World where draught animals are slaughtered when they cease to be economically useful for traction; however, tough meat is often acceptable locally where the meat is cut into small pieces and thoroughly cooked.

Fuller Use of Animal Tissues

The profitability of livestock production can be increased by making fuller use of the available animal tissues (Table 1-5). This requires special attention to separation of the organ meats and to the preparation of by-products. There is often considerable loss of these food materials from spoilage which can be reduced only by greatly improved hygiene and handling. In large-scale processing units with long distribution chains this invariably demands refrigeration. The small-scale sector can manage to market these products through short distribution chains without refrigeration which in any case is not available in most of these premises.

Unusual Species

There is potential in currently unexploited indigenous animals as sources of meat. Wild animals supplement domestic meat supplies in many parts of the world and there would appear to be considerable potential in developing these animals as managed meat producers. They are already adapted to local environments and so have advantages over imported stock and they appear to be resistant to many diseases that affect domestic livestock. Developments of this kind have already taken place in many countries illustrating this potential e.g. the farming of red deer in Scotland, hybrid deer in New Zealand (Ainger 1991), bison and water buffalo in other areas. Giraffe, elephant, hippopotamus, antelope, rhinoceros and possum can be added to the list; game reserves could be exploited as managed sources of meat.

These indigenous species are unselected and so there is considerable potential in selective breeding for improved growth rates, adequate production per unit of land and improved carcass composition where this is necessary to satisfy the consumer. One comparison between buffaloes and cattle showed that the former gained more weight than the cattle - 0.7 kg per day compared with 0.5 kg - but the dressing-out weight of the carcass was 47% compared with 50% (FAO 1976). The considerable improvements that have been achieved by breeding plans (originally by traditional but more recently by scientifically-based methods) and, above all, by improved overall management in the well-known domestic species indicate the potential achievement if such methods were applied to indigenous species.

It is not possible to arrive at "average" performance of animals since there are such large variations and so much depends on management but comparisons can be made through the "normal" levels of performance. Table 1-6 indicates "normal" levels of performance of some of the commoner domesticated and less common species (Spedding and Hoxey 1975). These animals, of course, may have differing potentials for improvement through feeding, management and disease control.

Inter Breeding

Some indigenous species will interbreed with conventional livestock and so provide important genetic reservoirs for maintaining and improving the quality of the stock.

Their use in meat production could also offer protection to some threatened or endangered species which might otherwise become extinct. Examples are species such as benteng in Indonesia, yak of Central Asia's high country and mithan of the border regions of India, Burma and Bangladesh.

Use is already being made of domestic bovine hybrids; the madura in Central Asia is a hybrid between benteng and cattle; domestic forms of at least two Asian pig species (the Indonesian wild boar and the Sulawesiwarty pig) are important husbandry animals. Other advantages of using unusual species are that some can subsist without encroaching on the feed requirements of others since they eat different species of plants or different parts of the same species, and feed at different times of the day and at different heights from the ground.

Buffalo as a Meat Source

In many countries - Italy, Egypt, Bulgaria, Australia, Venezuela - Buffalo has been developed as an animal resource to produce meat and has been shown to equal and surpass local cattle in growth, environmental tolerance, health and production of meat and calves. Popular misconception about the toughness of buffalo meat is largely due to its consumption after a life as a draught animal; however, when raised for meat and slaughtered at a young age the steaks are lean and appear to be as attractive as beef. Several trials have shown a preference for buffalo steaks over beef steaks; for example the demand for buffalo steaks in the northern territory of Australia exceeds supply and much of the meat in the Philippines is from buffalo. Another plus point is that buffalo meat is accepted by Hindus who forbid the slaughter of cows.

The buffalo is comfortable in a hot, humid environment, and is more resistant to ticks and other diseases. Raising buffalo not only as a draught animal but also as a meat producer could make a major contribution to meat supplies in many parts of the world. It is already exported from India and Pakistan to Thailand, South-east Asia and the Middle East.

At the other end of the size scale is the rabbit, which has a high reproductive rate and yields a quick profit and is free from most social and religious taboos.

Integration with Crop Production

A consideration of meat production solely in terms of its conversion ratio from crops is incomplete since the development of livestock calls for closer integration between animal and crop production. Livestock and crop activities complement each other at farm level; the crop sector supplies fodder for the livestock (Hudson 1976,

Jobling and Jobling 1983), and the livestock provide draught and traction power for crop production as well as manure, and make use of crop residues.

Supplies of fodder can be increased by cultivating varieties with higher yields, fodder can be produced in periods between major cash crops and crop production itself benefits from the application of manure.

Animals yield more than just meat - wool and hair, hides and pelts from the skins, traction power needed for cartage, herding of the animals, irrigation, and transport of the crops, and they produce waste materials that can be used for fuel and biogas production as well as fertiliser (Table 1-7).

Reduction of losses

Slaughter

In many developing countries the slaughter of animals is traditionally carried out in unsuitable buildings by untrained staff with little attention to sanitary principles. Preslaughter handling is poor and sometimes leads to spread of infection during transportation and in overcrowded lairages, as well as to loss of weight. The condition of the animal can deteriorate within a few days between selection for slaughter and actual slaughter: fatigue and lack of food will deplete muscles of glycogen which may result in quality deficiencies of the meat after slaughter. While walking animals to market is apparently the cheapest method of transport the loss of weight and the mortality may make this method expensive.

Traditional methods of processing and marketing also militate against quality. Even in larger towns abattoirs that have been specifically designed to supply meat to the expanding centres of urban population too often suffer from unsatisfactory hygiene. Sanitary regulations, where they do exist, may be disregarded and not enforced.

Some of the traditional slaughter operations, developed when they served a small local population, are carried out in the open, on a slab, hanging under a tree or from a fixture in a walled area. There are no cooling facilities and to counter tropical temperatures slaughter is sometimes carried out at night, when it is cooler and the meat transported and sold before mid-day.

In some areas in developing countries the retailer buys live animals from a livestock market or from farms and carries out the slaughter himself and carts the carcass to his retail outlet.

In smaller slaughterhouses this system has to be tolerated but supervision by veterinary authorities is essential. However, in larger operations slaughter should be carried out by a trained staff of abattoir workers in order to maintain the necessary standard of hygiene.

Care must be taken in slaughter and handling since, for example, improper and insufficient bleeding does not allow the necessary degree of acidity to develop in the meat and shortens shelf-life; improper dehiding of the carcass leads to heavy contamination; improper evisceration through accidental opening of stomach and tripes spreads contamination; contact with unclean materials during transport adds to contamination.

Refrigeration

The commonest method of prolonging the shelf life of meat is by cooling. Meat is first chilled after slaughter. It may be kept chilled if there is only a short period of time for distribution. For longer storage periods meat has to be frozen. The shelf life of all typs of unpackaged meat held at chilling temperature, 0�C to + PC or even better - 1�C to +4�C, is only between a few days and one to two weeks - depending on the cut of meat, temperature, bacterial load and relative humidity. The shelf life is much longer at freezing temperatures and depends on circumstances such as whether or not it is packaged, type of packaging temperature, etc. Table 1-8 gives some indication of safe storage times at different freezing temperatures; under optimal conditions shelf life can be even longer than indicated.

Most processed meat products also need to be kept refrigerated from the time of processing until their consumption.

However, the provision of refrigeration presents one of the biggest problems in many areas of developing countries since supplies of electricity are often inadequate. If meat has to be stored then greater use must be made of other methods of preservation.

Traditional Methods of Meat Preservation

Traditionally foods have been preserved by salting, drying and smoking, methods that have been improved by modern technology.

The simplest and most commonly used method is drying in the open air under the influence of wind and sun. Under favourable climatic conditions a product of good quality can be obtained but otherwise losses from spoilage, infestation and contamination can be excessive; and meat is susceptable to natural predators.

Artificial drying plants which are used in advanced meat processing are energycapital- and technology-intensive, and require skilled labour. They are not suitable for the needs of small-scale producers in developing countries who manufacture small quantities for short periods throughout the year.

An alternative is the type of fuelled mechanical dryer used in humid tropical regions to dry export commodities such as cocoa, coffee and copra. They use wood or charcoal as fuel so their use is restricted to areas where there are abundant supplies of wood.

In other areas the most suitable solution may be to improve existing sun-dry methods or to introduce solar drying, a method by which sun drying is enhanced. The process is best carried out in an enclosed structure so the product is protected from rain, dust, insects and predators and reduces the risk of deterioration of quality and spoilage both during the drying process and during subsequent storage (FAO 1990c).

There are many traditional dried meat products in various regions around the world pastrami in Turkey, Egypt and Armenia, charque in South America, kilishi in Nigeria and West Africa, qwanta in Ethiopia and East Africa, biltong in South Africa. Local requirements, tastes and facilities will obviously influence decisions as to whether dried meat is acceptable and also the most useful process.

Contents - Next

Meat quality

Contents - Previous - Next

There are two major aspects of meat quality, nutritional quality which is objective and "eating" quality as perceived by the consumer - flavour, juiciness, tenderness and colour - which is highly subjective.

There are considerable differences between the preferences of individuals including preferences for different cuts of meat, lean or fatty, muscle or organ meats, methods of cooking, etc.

In the industrialised countries the demand for what is perceived as eating quality and also the demand for particular qualities for a range of products from the meat processing industry dictate the breed, feed and management of the animals with intensive rearing and specially formulated dietary supplements and a tendency to slaughter earlier.

On the other hand the demand in most developing regions of the world is for more animal products of almost any kind. The animals live under variable conditions often of rough grazing and grow more slowly, yielding older animals for slaughter; when animals are primarily used for draught they are very old at the time of slaughter. Old animals yield meat that is less juicy and of a quality that differs considerably from that demanded in the industrialised countries.

Post-Mortem Changes

The post-mortem changes that take place when muscle is converted into meat have a marked effect on the quality of the meat.

After slaughter the glycogen in the muscle is converted into lactic acid causing a fall in pH from an initial value of pH 6.8 - 7.3 to about 5.4 - 5.8 at rigor mortis. If animals are stressed immediately prior to slaughter as when they are roughly handled or fight one another the muscle glycogen is released into the blood stream and, after slaughter, is rapidly broken down to lactic acid while the carcass is still warm. This high level of acidity causes a partial breakdown of muscle structure which results in pale, soft and exudative meat (termed PSE) - a condition mostly occurring in pigs. The meat losses some of its water-binding capacity which is so important in certain types of meat processing.

Long-term stress before slaughter or starvation uses up the glycogen so that less lactic acid is formed after slaughter resulting in an abnormal muscle condition in which it remains dark purplish-red on exposure to air instead of a bright red colour. This is termed dark, firm and dry (DFD) in the case of pigs and "dark cutting" in beef. The condition is rarer in lambs. Such meat and products made with it have a pH above 6.0 and spoil quickly since the low acidity favours rapid bacterial growth.

PSE and DFD meat are perfectly safe to eat but limited in their processing capacity. PSE meat has higher drip and cooking losses due to the reduced water-binding capacity (WBC). As well as the pale colour the meat has less flavour than usual.

DFD meat has normal or increased WBC and so is suitable for scalded/boiled sausages and other cooked products but it has poor meat flavour. While there is no remedy for these defects in the meat, DFD and PSE meats can be blended with normal meat for the preparation of products of good quality.

After slaughter as the glycogen in the tissues is exhausted rigor mortis sets in and the whole carcass become stiff. This is due to the contraction of the muscle fibres when the actin filaments of the muscle fibres slide inwards between the myosin filaments so shortening the myofibrils.

If the meat is cooked when the muscles are still in rigor it is extremely tough. This condition is prevented by "aging" or "ripening" after slaughter which is achieved by storing the meat until the muscles gradually recover their extensibility and become more tender through partial enzymatic breakdown of the muscles fibres. At this stage rigor mortis is said to be resolved.

Rigor is completed in cattle after 12-24 hours and is resolved by periods that depend on the temperature:- 10-13 days at 0�C, 4-5 days at 10�C, 30-40 hours at 20�C and 10-11 hours at 30�C The process is twice as fast in pork as beef or lamb: it is faster in young animals and slower in "red muscles. that function slowly and continuously in the living animal. "Aging" also leads to improvement of flavour.

Obviously if meat has to be sold within a few hours of slaughter it is still in pre-rigor or rigor, and the tough meat has to be cooked longer with some loss of nutrients.

If lamb, and to a lesser extent beef, are chilled too rapidly after slaughter the muscles may undergo extreme contraction or "cold shortening" which results in very tough meat when cooked. Pork is almost unaffected in this way. Cold shortening does not take place when the carcass is cooled more slowly - the temperature must not fall below 10�C before the onset of the rigor. To achieve this the carcass is kept at ambient temperature for some hours to accelerate rigor and then rapidly chilled or frozen - a process called "conditioning".

Old animals, especially old draught animals, have a high content of tough connective tissue in the muscle and prolonged cooking at a low temperature is needed to soften the meat by hydrolysis of the connective tissue - a fact not always known to consumers.

So it is clear that in many areas conditions militate against good quality meat long transport of animals and poor lairage facilities prior to slaughter reduce the glycogen in the muscles , poor hygiene, high ambient temperature and lack of refrigeration during and after slaughter lead to heavy contamination and growth of microorganisms and considerable losses from spoilage together with dangers of food poisoning. All this can be aggravated by inadequate care of the meat during transport and in the market.

Obviously there is room for improvement in conditions of meat production even for purely local consumption to reduce losses and improve efficiency but if shipment of meat to distant parts is to be considered then it is essential to adopt the sophisticated techniques and methods of refrigeration that are now expected in national and international trade.

Control of Hygiene and Safety

The safety of meat calls for control throughout the food chain from the farm of origin, and inspection before and after slaughter, to the handling and storage of meat and the products until the time it is consumed. The responsibility for the production of safe and wholesome meat is shared by the industry and the controlling authority. This requires a controlling authority that is adequately resourced and has the legal power to enforce the requirements and which should be independent of the management of the establishment where the meat is produced.

The Codex Alimentarius Commission has elaborated (besides meat inpection Codes) the Recommended International Code of Hygiene Practice for Fresh Meat (CAC/RCP 111976) and the Recommended International Code of Hygienic Practice for Poultry Processing (CAC/RCP 14-1976) which describe the minimum requirements of hygiene for meat and poultry production.

The application of these Codes can be an important step towards the targets:

a) that the food will not cause infection or intoxication when properly prepared;

b) does not contain residues (of pesticides, veterinary drugs and heavy metals) in excess of established limits;

c) is free from disease;

d) free from obvious contamination;

e) free from defects generally recognised as objectionable;

f) has been produced under adequate hygienic control;

g) fulfils the expectation of the consumer in regard to composition.

The Codex Alimenarius Commission Guidelines include advice on the construction of abattoirs and the facilities required; control of pests, quality of water for cleaning and disinfection; rules of meat inspection and hygienic practices (including supervision by a veterinary inspector).

The Code of Hygienic Practice for Fresh Meat is currently under revision to include a more systematic approach to sanitation and process control, namely Hazard Analysis Critical Control Points (see next section).

The growing demand for meat, both per capita and due to growing populations, will increase pressure on slaughter-houses. There is obviously a vast gap between the state of the art in industrialized communities and traditional method in some of the more remote areas of the Third World. Custom-built abattoirs which allow separation of the various stages of the process to prevent cross- contamination and sophisticated techniques of quality control are far removed from slaughter under conditions where energy for refrigeration and adequate supplies of hot (potable-quality) water for cleaning purposes are not available.

Such desirable facilities might be made available in densely populated areas where a regular throughput justifies capital expenditure but it is obvious that these standards must be regarded as long-term objectives in remote areas where slaughter and meat production follow tradition rather than scientific principles.

Indeed, the guidelines concede that traditional practices may permit departure from some of the requirements laid down when fresh meat is produced for local trade.

The Codex Commission recognised that small or relatively isolated abattoirs did not warrant the full-time presence of a veterinary inspector if a veterinary assistant is available for meat inspection. But it was also recommended that meat hygiene in general should be under the control of a veterinary inspector.

As regards the Code of Practice for small manufacturers the Commission suggested that this should be left to the discretion of the authorities in each country.

Hazard Analysis Critical Control Points (HACCP)

As is emphasized elsewhere in this publication an important priority in meat production is to minimise contamination with enteropathogenic organisms during slaughter, dressing and subsequent handling of meat.

A recent development to achieve and ensure safety in food production in general is a systematic approach based on an assessment of the various risks associated with each step of the process. The object is to identify the relative seriousness of risk - Hazard Analysis Critical Control Points.

Critical Control Points are any procedures or locations where control can be exercised over factors that, if controlled, prevent or minimise hazard.

With regard to meat production the HACCP concept systematically identifies potential hazards in the entire chain from animal production to consumption and ranks them according to severity and likely frequency. This covers facilities, equipment and operation and is intended to augment and refine the various codes of manufacturing practice undertaken by industry.

The procedure is intended to enable management to take preventive measures rather than depend on intensive testing of the end-products.

Future strategies on livestock production

It is obvious if livestock production is to be expanded to meet demand and to export that financial arrangements, the use of on-farm resources, production in-puts, veterinary and health services, marketing facilities and resources for research will all need to be improved and expanded. Programmes will need to be suited to local conditions. So far as ruminants are concerned large-scale expansion depends on the availability of land.

In contrast with the developed world much of the meat production in the developing countries is in the hands of small-holders with herds of 2-5 animals, with low productivity and it is improvement in their productivity that will help to fulfil most of the demand rather than the development of large-scale production. It is the opportunistic strategy of resourcepoor farmers to give the animals better feed only when at good milk-yielding age or to increase their strength as draught animals at certain periods of the year. It is then that they tend to compete more directly for food with human beings. Increasing the productivity of each animal is the most efficient way of producing more meat products - doubling the yield (of milk or meat) per animal requires less feed than doubling the number of animals.

A large number of technical policies must be defined in order to establish appropriate livestock development programmes. These involve subjects such as breeding, pasture development, use of non-conventional animals, veterinary programmes, improved farming systems, transport and economic policies including financial production incentives and marketing structure.

Chapter 2 - Role of meat and meat products in human nutrition

Nutritional value of meat

Meat, and other animal foods such as milk, can make a valuable contribution to the diets in developing countries. It has less nutritional importance in industrialised countries where a wide variety of foods of all kinds is available.

Many diets in developing countries are based on cereals or root crops and are relatively bulky, especially where fats are in short supply, and this can limit the total energy intake. This is especially true of infants after weaning and young children.

The importance of meat in the diet is as a concentrated source of protein which is not only of high biological value but its amino acid composition complements that of cereal and other vegetable proteins. It is also a good source of iron and zinc and several B vitamins, and liver is a very rich source of vitamin A.

Composition

The animal carcass consists of muscle, connective tissue, fat and bone and some 75% water in proportions depending on species, breed, size, age, etc. The muscle (lean meat) is relatively constant in composition in a given species (Table 2-1). The greatest variable in the carcass is the amount of fat, which can range from 2% in some free-living animals to 1540% in domesticated animals intensively reared.

Since the major source of variation in meat composition is the proportion of lean to fat it is useful to consider the composition of lean and fat separately and then to calculate the nutrient composition of the product from the proportions of the two. (Table 2-2).

With the variations between individual animals of the same species under the same management, together with different managements and errors arising from differing sampling and analytical techniques, there are many and considerable differences in the composition of meat as reported in the scientific literature; table 2-3 provides reasonable average or typical values (see also Table 2-12).

It will be noted that the lean meat of various species has similar values for macronutrients and inorganic constituents. The same is true of the vitamins with the exception of pork which has very high levels of thiamin.

Although lean meat has a high water content, about 75%, it is a good source of protein - 20% on a wet-weight basis compared with 8-12% in cereals.

Influence of Diet

The limited effect of diet on the nutrient composition of lean meat is illustrated in a trial in which the composition of intensively-reared beef (fed barley and protein supplements with grazing ad lib) was compared with extensively-reared (grazing alone) as two extremes of husbandry practice (Harries et al 1968). Analysis of the same muscles from animals on the two systems showed no significant differences in their content of protein, fat, iron, thiamin, riboflavin and niacin. There were greater differences between animals fed on the same system on different farms than between different feeding systems, showing that management practices had the greater effect.

With the exception of vitamin A stored in the liver, diet has little effect on vitamin content, but it has been shown that the addition of thiamin to the diet of pigs can double or treble the amount of thiamin in various muscles (Pence 1945).

Influence of Age at Slaughter

As animals grow the proportions of total nitrogen and fat, and also the amounts of iron, increase as the animals approach maturity, and more slowly after that.

At the same time the ratio of polyunsaturated to saturated fatty acids (P/S ratio - see Chapter 3) falls. Collagen (connective tissue) becomes less soluble and less digestible so animals that are poorly fed and so take several years to reach a useful size, provide meat of lower eating quality. Animals killed after a lifetime of work provide even tougher meat. Older animals have a high proportion of water-soluble extractives in the muscle and animals reared on poor pasture, and which are therefore relatively old by the time they reach a size suitable for slaughter, have long been used for the preparation of meat extract.

Protein

The protein of typical mammalian muscle after rigor mortis but before post-mortem degradative changes contains about 19% protein: 11.5% is structural protein - actin and myosin (myofibrillar), 5.5% soluble sarcoplasmic protein in the muscle juice, 2% connective tissue (collagen and elastin) encasing the structural protein and about 2.5% fat dispersed among the protein fibres (Table 2-1).

Myoglobin is present in relatively large quantities in heart muscle because of heavy oxygen demand: (the highest amount of myoglobin in mammals is found in the whale to permit prolonged submersion under water).

Collagen differs from most other proteins in containing the amino acids, hydroxylysine and hydroxyproline and no cysteine or tryptophan. Elastin, also present in connective tissue, has less hydroxylysine and hydroxyproline. Hence cuts of meat that are richer in connective tissue have lower protein quality (see Chapter 3). Their content of connective tissue makes them tough and in many regions these cuts of meat bring a lower price. The amino acid composition is given in table 24.

Immediately after rigor mortis there is almost 2.5% carbohydrate present - lactic acid, glucose and derivatives.

As distinct from the average of the whole animal carcass the composition of meat as cut for consumption shows some variation depending on the cut (table 2-5). The types of cut often differ in different regions.

In addition there will be further differences in the amount of water and fat lost in different methods of cooking.

Lipids

Lipids (fats) are found at three sites in the body.

1) The largest amount by far is in the storage deposits under the skin and around the organs. This constitutes the obvious, visible fat in a piece of meat and can be as much as 4050% of the total weight in fatty meat or fatty bacon. This adipose tissue is composed largely of triglycerides contained in proteinaceous cells with relative little water.

Clearly this visible fat can be trimmed off the meat during processing, before cooking or at the table - a growing practice in the western world. (See Chap. 3).

2) Small streaks of fat are visible between the bundles of muscle fibres, intermuscular fat, i.e. in the lean part of the meat; this is known as "marbling" and can amount to 4-8% of the weight of lean meat.

3) There are small amounts of fat within the muscle structure - intra muscular or structural fats - in amounts varying with the tissue. This can be 1-3% of the wet weight of muscle nd 5-7% of the weight of the liver.

Structural fats are largely phospholipids and include long chain fatty acids. Fatty acids are of three types. (1) Saturated fatty acids in which all the carbon atoms in the chain carry their full quota of two hydrogen atoms and the carbons are linked by a single bond; (2) mono-unsaturated fatty acids (MUFA) in which one hydrogen is missing from each of two adjacent carbon atoms which are therefore linked by a double bond; and (3) polyunsaturated (PUFA) in which two or more pairs of hydrogen atoms are missing and there are several double bonds in the carbon chain (Table 2-6).

The physiological significance of these fatty acids in the human diet is discussed in Chapter 3. Species, breed, sex, age, and environment influence the amount as well as the degree of unsaturation of the fat (mainly the ratio between unsaturated oleic acid and the saturated palmitic and stearic acids).

Animals living in woodlands in Uganda and Tanzania (eland, hartebeest, giraffe, buffalo, warthog) and also free-range cattle have only about 2% of lipid in the muscle, of which about 30% is PUFA. Those grazing on grassland have about 3% lipids in the muscle of which about 15% is PUFA.

In contrast lean domesticated cattle (fed on supplemented diets) have about 5% lipids of which only 8% is PUFA, and intensively-reared fatstock have 15-30% lipids Table 2-8 (Crawford 1975).

The cholesterol content of meat is compared with that of some other foods in Table 2-7.

<u>Vitamins</u>

The body content of most vitamins is largely independent of diet. Apart from the thiamin effect on pig meat mentioned above, the exception is vitamin A which is stored in the liver in amounts depending on intake, with small amounts present in the kidney - these are the only tissues to contain significant amounts of this vitamin (there are traces, 10- 60 ug/100 g, in muscle). Under free range conditions of grazing there is a very high intake of carotene (pro-vitamin A) which is mostly converted into retinol (vitamin A). Tables 2-2 and 2-9 list the typical vitamin content of raw meat and offals.

Pig meat is very rich in thiamin compared with all other animals, nine times as much, but has the same content of riboflavin as others.

Liver is by far the richest of animal tissues in all the vitamins, and includes unchanged carotene as well as being the only tissue to contain more than a trace of vitamin D.

<u>Minerals</u> (Tables 2-2,2-3 and 2-9)

Meat and offals contain a wide variety of mineral salts. The contents of iron, zinc and copper vary considerably in different species, liver being by far the richest source of these minerals compared with muscle tissue.

High levels of minerals in the feed do not necessarily increase the level of that mineral in the flesh and there is a complex inter-relation between minerals. For example, the molybdenum content of sheep meat increases with dietary molybdenum only when dietary sulphate levels are low. Dietary molybdenum inhibits the accumulation of copper which is partly off-set by increased manganese. Liver copper decreases and molybdenum increases with increasing amounts of molybdenum. Other inter-relations between minerals include calcium and zinc (Byerly 1975).

Copper is used in some feeding systems for pigs as a growth stimulant and can result in levels of several hundred parts per million of copper in the liver.

When pasture is deficient in minerals, especially phosphorus and cobalt, the amounts in the muscle are reduced.

Meat by-products

The amount of carcass meat obtained from animals varies with the type of animal only about one third of the total weight of cattle and lambs and half of the pig (Table 2-10A).

The other parts of the animal - liver, heart, brains pancreas (gut sweetbread) thymus (chest sweetbread), tripe, feet (trotters), tail, testes (fries), intestines (chitterlings), cheek meat and head meat and fat (tallow, lard, suet) - are collectively called offal, variety meats, side meats or organ meats in various countries (Table 2-10B). With regard to poultry, the term giblets means liver (with gall bladder removed), heart and gizzard and any other material considered as edible by the consuming country. Not all parts are eaten depending on consumer acceptance, religion and tradition as well as regulations imposed for reasons of hygiene.

Intestines are used as containers for sausages of the different types, blood may be used in sausages, pork skins may be eaten or used as a source of gelatin. In addition, some inedible by-products such as bonemeal can be used as a mineral supplement in animal feed and there are other inedible by-products of economic value such as hides and horns.

Nutritional Value

The nutrient content of offals is given in Table 2-9. In general they are richer than lean meat in iron, copper and certain B vitamins, with liver being a particularly rich source of vitamins A, B1, B2, B6, B12, niacin and pantothenate and even some vitamin C.

Kidney is a rich source of B1, B2 and B12: pancreas is a good source of B1, B2, C and pantothenate.

The vitamin C in lungs, spleen and thymus is usually present in sufficient quantity to allow some to survive cooking.

Other organ meats compare well with lean meat as sources of the vitamins, and all meat products are good sources of zinc and of iron, liver, lungs and spleen being especially rich in iron (Anderson 1988).

Ears and feet have a high protein content but much of this is collagen and so of poor nutritional value, although when consumed this has no significant effect on the quality of the protein of the diet as a whole.

Cooking

Meat as purchased may include bone, outer layers of fat, gristle and tendons which are removed to differing extents before cooking, so that the composition of meat "on the plate" can vary enormously.

Meat and meat products are considered cooked when the centre of the product is maintained at a temperature of 65-70�C for 10 minutes since the proteins will then be coagulated and the meat tenderised by partial hydrolysis of the collagen. The vegetative form of bacteria, but not spores, will have been destroyed (thermoresistant spores can survive heating above 100�C). The completion of the cooking process is generally indicated by a change of colour from red to brown (red to pink in cured products) and flavours are developed.

Denaturation of red myoglobin and conversion to brown myohaemochromogen starts at 40�C and is almost complete at 80-85�C (Lawrie 1991). Cooked flavour results from a number of reactions including changes in lipids, carbohydrate and protein, with heat breakdown of peptides and amino acids and reactions between proteins and carbohydrates.

Meat from older animals richer in connective tissue requires longer cooking at 5060�C - a temperature at which collagen can be hydrolysed. If heated for long periods at temperatures above 80�C amino acids begin to decompose with the production of unpleasant flavours. (Hydrolysis of collagen is rapid during the canning process when high temperatures are employed for only a short time).

In comminuted meat products, such as sausages, the particles of meat become bound together during cooking through coagulation of extracted proteins. In products that contain pastry this has to be cooked at the same time as the meat.

Water is lost during cooking, the amount depending on time, temperature, method of cooking, size of sample, heat penetration and composition leading to an increase in concentration of the fat and protein. Table 2-11 shows the changes in composition and indicates changes in fat content which depend on the method of cooking.

There is a loss of water-soluble vitamins, minerals and protein in the juices but this is a small proportion of the total present and, moreover, in most cooking procedures the juices are usually consumed with the meat.

With so many factors that can influence changes on cooking literature data are rarely comparable - unless the work has been carried out in the same laboratory - and cannot be expected to do more than indicate the general effects.

The Massachusetts Data Bank has tabulated the average amounts of nutrients in meats of various types and the large coefficients of variation illustrate the impossibility of attempting to provide precise figures (table 2-12).

Effect on Fat

Even in deep frying there is a loss of fat since lean muscle does not absorb the cooking fat. As an example from one set of food composition tables, raw rump steak containing 18.9% protein and 13.5% fat has a total of 32.4% dry matter (ignoring minerals). Expressed as a proportion of dry matter this is 58.3% protein and 41.6% fat.

When grilled, i.e. cooked by radiant heat with added fat the loss of water and fat reduces the total fat to 30.7% of the dry matter while the protein increases proportionately 693%.

When fried the loss of water is greater than in grilling but the loss of fat is less so that the proportion of protein becomes 66.2% and the fat 33.7% of the dry matter.

Table 2-13 illustrates data for chicken and also shows the differences between dark and light meat and the effect of including the skin in the analysis.

Boiling of chicken causes a greater loss of water than roasting but no loss of fat so that as a proportion of dry matter, fat is highest in the boiled product.

Effect on Protein

Proteins can be damaged from the nutritional point of view when part of an essential amino acid is rendered unavailable. This involves first lysine at temperatures around 100�C; then cystine and methionine at temperatures around 120�C, and other amino acids after prolonged heating (Bender 1978).

At the rather low temperature needed to cook meat there is little loss of available lysine and no loss of methionine and cystine. For example no change in protein quality was found after roasting in an open pan at 163�C when the internal temperature did not rise above 80�C; or when the meat was browned in an oven for 30 min. then sterilised in a can (Mayfield and Hedrick 1949, Rice 1978).

When meat is roasted the outer part reaches a high temperature and turns brown because of a reaction between the lysine and reducing substances present (Maillard or browning reaction) which produces the desired roast flavour. However, since the roasted part is only a small fraction of the total piece of meat and the internal temperature does not exceed about 80�C there is no measurable change in the quality of the protein as a whole.

Effect on Vitamins

Thiamin

One of the most sensitive vitamins is thiamin; it is both water-soluble and heat-labile. It is also damaged by oxygen and at neutral and alkaline pH. It is very susceptible to destruction by sulphur dioxide and sulphites which are used in some countries to preserve comminuted meat products. There is also some destruction during treatment with ionising irradiation but this can be reduced by irradiating in the frozen state. Table 2-14 shows some figures for losses of thiamin.

The juices exuded from meat during cooking include part of all the water-soluble constituents, including mineral salts, proteins and vitamins but except for the heat-labile thiamin these are recovered in the juices consumed with the meat, unless they have been damaged by excessive heat.

In a general review of the subject (Karmas and Harris 1988) losses of thiamin are given as 1540% on boiling, 40-50% on frying, 30-60% on roasting and 50-70% on canning. All figures listed for cooking losses of vitamins must be regarded as rough average values since they will depend on time and temperature and conditions of cooking, the particular product, the size of the pieces of meat and thus heat penetration, to which must be added errors due to sampling and the considerable errors that are unavoidable in vitamin determination. Literature figures can be used only for guidance and if more accurate figures are required they must be determined on the product in question subjected to the specific process - and even then are subject to the problems of analysis.

Riboflavin and Niacin

Cooking losses of riboflavin (Table 2-14) average around 10%. Riboflavin is relatively stable to most cooking practices (excluding the high temperature of roasting) and to canning and dehydration. It is damaged by sun-drying and under any alkaline conditions; dry-curing and smoking lead to about 40% loss, wet curing to about 10% loss.

Niacin is stable to heat, light, oxygen, acids and alkalies and also to irradiation but can, of course, be leached from the food; losses average about 10%.

Other B Vitamins

There is less reliable information about other B vitamins but some reported figures are presented in Table 2-15. On average about one third of the vitamin B6 and pantothenate are lost in cooking.

Contents - **Previous** - **Next**

Methods of processing and preservation of meat

Contents - **Previous** - **Next**

Meat was originally processed to preserve it, but since the various procedures cause so many changes in texture and flavour it is also a means of adding variety to the diet. Processing also provides scope to mix the less desirable parts of the carcass with lean meat and in addition is a means of extending meat supplies by including other foodstuffs such as cereal in the product.

Meat is a highly perishable products and soon becomes unfit to eat and possibly dangerous to health through microbial growth, chemical change and breakdown by endogenous enzymes.

These processes can be curtailed by reducing the temperature sufficiently to slow down or inhibit the growth of micro-organisms, by heating to destroy organisms and enzymes (cooking, canning), or by removal of water by drying or osmotic control (binding the water with salt or other substances so that it becomes unavailable to the organisms). It is also possible to use chemicals to inhibit growth and, very recently, ionising radiation (however, the last is not allowed in some countries).

Traditional methods that have been used for thousands of years involve drying in wind and sun, salting and smoking. Canning dates from early in the 19th century and allows food to be stored for many years since it is sterilised and protected from recontamination.

Chilling and Freezing

While mechanical refrigeration is a modern process it is known that the ancient Romans kept food cool with ice. "Chilled" meat is usually stored at temperatures around 1�C to +4�C when it keeps well for several days. Provided that the meat is kept very cool(1�C to 0�C) and that slaughter and meat cutting are carried out under strict hygienic conditions, modern packaging techniques including storage under carbon dioxide or nitrogen or in vacuum can extend this period to about 10 weeks.

Chilling at temperatures very close to the freezing point of meat, -15�C, diminishes the dangers of most pathogens and slows the growth of spoilage organisms; growth of some organisms, moulds, virtually ceases at -10�C.

Most pathogens (Salmonella, Staphylococcus species and Clostridium perfringens) are inhibited by cooling but Listeria monocytogenes can grow at + 2�C, some Salmonella species at +5�C and Campylobaner at +7�C.

Non-pathogens include Pseudomonas species which predominate on the exposed surface of chilled meat and Laaobacilli on vacuum-packed meat.

Freezing - commercially at -29�C and domestically at -18�C - is now a standard method of preserving for periods of 1-2 years but there is some deterioration of eating quality compared with fresh or chilled meat.

However, there are problems in chilling and freezing meat. If it is cooled too rapidly below 10�C before the pH of the muscle has fallen below a value of about 6, the muscle fibres contract (cold shortening) and the meat is tough when cooked. This problem applies more to small animals, such as lamb, which cool down rapidly. The modern procedure is to cool the carcass to 10-15�C ("conditioning") and to hold that temperature for a few hours until the pH has fallen to 6. Beef carcasses can be suspended in such a way as to exert a pull on certain muscles to prevent contraction. Another method is to apply electrical stimulation to the carcass after slaughter (low volt) or after evisceration (high volt) for 2-4 minutes to bring down the pH rapidly.

Another problem can arise during thawing of pre-rigor frozen meat when the muscle contracts and exudes a substantial part of its weight as tissue fluids (thaw rigor) (Lawrie 1991). Clearly, freezing of meat is not a straightforward procedure and calls for certain expertise. Only post-rigor meat should be frozen.

Nutritional Changes by Freezing

Meat is frozen without any prior treatment, unlike vegetables which have to undergo a preliminary blanching process to destroy enzymes involving considerable loss of water-soluble nutrients. So there is little or no loss of nutrients during the freezing procedure, nor, so far as there is reliable evidence, during frozen storage - apart from vitamin E.

Proteins are unchanged during frozen storage but fats are susceptible to rancidity. Pork and poultry meat are more susceptible since they are richer in unsaturated fatty acids than other meats, and comminuted meat is also very susceptible to rancidity because of the large surface area which is accessible to oxygen.

The vitamin E is damaged because the first products of fat rancidity, hydroperoxides, are stable at the low temperature and oxidise the vitamin. At room temperature they break down to harmless peroxides, aldehydes and ketones, so that vitamin E is more stable at room temperature than during frozen storage.

The losses incurred in frozen meat mostly take place when the meat is thawed, and juices are exuded containing soluble proteins, vitamins and minerals. This is termed "dripthaw" and the amount depends on the length of time of ageing (time between slaughter and freezing), whether frozen as carcass or meat cuts, conditions of freezing and speed of thawing; it varies between 1% and 10% of the weight of the meat and is usually about 5%.

There is some loss of nutrients when the meat is cooked after thawing; results published in the scientific literature tend to measure the combined losses from the original fresh meat to the final cooked product. Unfortunately the results vary so much that it is not possible to draw conclusions.

It must be emphasised that the variations are largely due to difficulties in analysis of the B vitamins, and to differences in conditions and methodology - even results from the same laboratories are inconsistent. This is illustrated very clearly by results published from one group of investigators who examined pork loin after freezing and storage at -12�C and 24�C and subsequent cooking at regular intervals over one year for changes in thiamin, riboflavin and pyridoxine (Mikkelsen, Rasmussen and Zinck 1984). Despite constant experimental conditions analyses at two monthly intervals showed wide fluctuations, especially for thiamin, which were attributed by the authors to difficulties in analytical methods.

It was tentatively concluded after storage at -12�C and cooking that about 90% of the thiamin was retained but no firm conclusions could be drawn about other vitamins. No conclusions could be drawn about storage at the lower temperature!

For riboflavin about 90% was retained at -12�C and 100% after storage at -24�C and cooking, although these results were also variable.

For pyridoxine 80% was retained when stored at -12�C and cooked but the results were erratic.

In the same report ground beef was examined only after 1 year storage and showed 80% retention of thiamine, 85% of riboflavin and 100% of pyridoxine at both temperatures.

A summary of earlier work (Fennema 1975) suggested that losses during freezing and storage of meat and poultry for 6 - 12 months at -18�C but excluding subsequent cooking, ranged between zero and 30% for thiamin, riboflavin, niacin and pyridoxine. A survey of frozen meals analysed after freezing, storage and cooking reported losses of up to 85% of thiamin, 55% of vitamin A, 33% vitamin E, 25% niacin and pyridoxine (De Ritter et al 1974).

Little research in this area has been reported in recent years and this limited number of reports illustrates the difficulty of making even generalisations about the stability of vitamins in frozen meat products.

Processing - General Aspects

Processed meats are products in which the properties of fresh meat have been modified by the use of procedures such as mincing, grinding or chopping, salting and curing, addition of seasonings and other food materials, and, in many instances heat treatment. Most of these processes extend the shelf life of meat. Their manufacture, in most instances, depends on the ability of the mixture to retain water since they are emulsions of protein, fat and water.

Meat Content of Processed Meats

Where there is a demand for consumer protection it is often necessary to legislate to control the meat content of products that include other food ingredients.

Even if no additives are included meat products can contain variable amounts of lean muscle tissue, fat and connective tissue. A method of assessing the apparent meat content of a raw product is by determination of the total nitrogen content on a fat-free basis and multiplying by an average conversion factor, corrections being applied for the contributions from cereals or other nitrogen-containing ingredients e.g. 3.45 for pork products, 3.55 for beef, 3.7 for chicken (3.9 for breast of chicken and 3.6 for dark meat), 3.45 for ox liver, 3.65 for pig liver (3.55 for liver of unknown origin), 2.7 for kidney, 3.2 for blood and 3.0 for tongue. There are no agreed factors for conversion of nitrogen for cooked, cured or processed meat and the apparent meat content of such products is expressed approximately in terms of "raw meat equivalents" (Egan, Kirk and Sawyer 1981).

Other methods used for legal control purposes refer the composition of meat products directly to the nitrogen or protein content of the dry, fat-free product or to the water: nitrogen ratio. Lean meat can be determined directly by measurement of 3-methyl histidine which is characteristic of meat protein but if large amounts of fillers and binders are present the method is unreliable.

The proximate composition of some processed meat products is given in Tables 216, United Kingdom products, and 2-18, United States products; in both instances the composition is regulated so these data are not universally applicable and serve only as examples.

Curing

Curing was originally a term applied to preservation in general but is now restricted to preservation with salt (sodium chloride) and sodium or potassium nitrite or nitrate or a mixture of these two salts. The nitrate serves as a reservoir for nitrite - the active compound - since bacteria in the curing solution form it from the nitrate.

The use of salt is one of the oldest methods of preserving meat since at concentrations greater than 4% in the aqueous phase it inhibits the growth of most spoilage organisms. To function as a complete preservative the salt concentration would need to be around 17%, at which levels the product would be unpalatable. In most cured meat products the salt concentration is between 2.5 and 5% and the nitrite inhibits the growth of other organisms. Nitrite also reacts with proteins when heated to form compounds (called Perigotype factors) that inhibit the development of spores of Clostridium botulinum, the cause of botulism, the most serious type of food poisoning.

Additionally, nitrite is broken down to nitric oxide, which reacts with the red colouring matter in muscle, myoglobin to form deep-red nitrosomyoglobin. As the protein is denatured, this is converted, rapidly when heated and more slowly otherwise, into a pink compound which is responsible for the typical colour of cooked ham, canned luncheon meat, franfurters and raw ham, dry sausage, etc.

The early curing procedures were lengthy and recent developments have led to a reduction in the time required. For example instead of simply immersing the meat in brine it is first injected with the curing solution and the process can be completed in 1 - 2 weeks. Thin slices of meat such as bacon can be cured in a few hours, and the processing time can be reduced to a few minutes if heated and if the cure is completed in the final package.

Animal experiments have shown potential risk from nitrosamines formed from nitrite but, as discussed in Chapter 3, the amounts present do not appear to be harmful to human beings.

The addition of sodium ascorbate to the pickling brine accelerates the curing process because of its reducing capacity and allows smaller amounts of nitrite to be used, so there is less residual nitrite in the meat which reduces the possibilities of the formation of nitrosamines. Residual ascorbic acid has an antioxidant effect in stabilising the colour and preventing rancidity.

Tumbling and Massaging

A new technique was developed in the 1960's to accelerate the penetration of salt. Pieces of meat are injected with the curing salt solution or chopped meat immersed in it and then mechanically shaken - "tumbled". Solutions of 2-8% salt are used, sometimes with the addition of polyphosphate, when there is some extraction of water-soluble protein, mainly myosin. The effect is to improve the water-holding capacity of the meat by reaction between the salt and the structural proteins, aided by the polyphosphate. The extracted proteins set to a strong gel on heating and so bind together the pieces of meat, which can then be shaped or sliced.

The term "massaging" is applied to a relatively gentle mechanical treatment while "tumbling" is a more vigorous action.

Smoking

Meat has been treated with smoke from the earliest days - traditionally over a wood fire and more recently by producing smoke from wood sawdust in a generator and conducting the smoke over the meat.

The substances deposited on the meat contribute to the flavour and appearance but with ordinary, light smoking the preservative effect is limited and the product has to be stored refrigerated.

Intensive smoking does prolong shelf life both by heavier deposition of preservatives and by the drying effect of the hot air but it has a detrimental effect on flavour. Consequently preservation by smoking is regarded as an emergency measure when other methods cannot be used.

A modern development making use of the flavouring effect is to use an aqueous solution of the constituents of smoke which reduces the amount of strongly flavoured and other unwanted substances.

Processed meat products

Common Cured Meat Products

The commonest cured products are sausages, bacon, pork shoulder, ham, luncheon meat; any type of meat can be cured either as whole cuts or after comminution.

Bacon is cured pork, in various countries traditionally made from specified parts of the pig but it can be made from any part. There are modifications of the process including so called sweet cure with added sugar (0.25%) and mild cure with less salt.

Bacon can vary greatly in the amount of fat and there are considerable differences between the various published figures; those shown in Table 2-16 are from the same source and so are comparable with one another.

Ham is the cured product of the upper leg and buttock of the pig and differs from gammon only in that the latter is cut from the side of bacon after it has been cured. It is stable when raw after a certain period of maturation but is often cooked to pasteurisation temperature, 70�C, or it may be canned at pasteurising temperature. It may be smoked as an additional means of preservation and flavouring.

Typical analysis of canned ham per 100 g: 65-72 g water, 18 g protein, 5-12 g fat, 0.5-0.8 MJ, 1100-1250 mg sodium, 1.2-2.7 mg iron, 0.2 mg copper, 2 mg zinc, 0.5 mg thiamin, 0.2-0.25 mg riboflavin, 4 mg niacin, 0.2 mg vitamin B6, and may have residual ascorbic acid 10-60 ma.

Sausages

There are some 800 types of sausage made of comminuted or chopped meat of various kinds, seasoned with salt and spices, often mixed with cereal and packed into natural casings (consisting of the connective and muscle tissue of animal intestines) or made of cellulose, collagen or synthetic materials. There are six main types of sausage - fresh, smoked, cooked, smoked and cooked, semi-dry and dry.

Frankfurters, Bologna, Polish and Berliner sausages are generally made from beef, pork and pork fat comminuted with the addition of curing salts and are smoked and cooked. Thuringer, soft salami, mortadella, and soft cervelat are cooked and semi-dry; pepperoni, chorizos, dry salami and dry cervelat are slowly dried to a hard texture without cooking. The nutrient content of a number of products is given in Table 2-18. There are several variants of each type of sausage; for example, a US table of food composition (Watt and Merrill 1975) includes six types of Frankfurters, namely all meat, with non-fat dried milk with cereal and with both these additions, also raw and canned.

Table 2-18 includes two figures from Great Britain which differ considerably from the US figures. These differences can be attributed to variations in composition and method of analysis, and serve to illustrate the approximate nature of any tables of nutrient contents of processed meat products. A major reason for the difference in thiamin content in some comminuted meat products between US and UK tables, is the use of a preservative in UK, namely sulphur dioxide, which destroys most of the thiamin.

Liver sausage contains 10-20% liver and in many cases other edible offals. Blood sausage contains 10-20% whole blood with nitrite salt (not precooked). Other components are precooked meat, edible offals, fatty tissue (cooked sufficiently to separate fat with a low melting point) and pigskin. This type of sausage has a firm consistency due to swollen connective tissue and gelatinized collagen.

Fermented sausages are dry sausages including salami, dry pork and beef sausages and summer sausages, that have been subjected to bacterial fermentation. Meat from a variety of animals may be used, including camel, donkey and horse but rarely mutton, goat or venison. Only well-chilled or frozen meat is used and a temperature of -2 to +5�C maintained during chopping to facilitate comminuting of lean and fatty tissues to the particle size desired and to avoid deposition of fat drops in the batter. Added salt prevents the growth of unwanted micro-organisms and extracts salt-soluble proteins to form a protein gel which binds the pieces of meat together. The bacteria originate from the natural flora of the meat and the environment although starter cultures of Micrococcus, Pediococcus cerevisiae, etc., are sometimes used.

During the slow, prolonged fermentation the pH falls to between 4.8 and 5.4 then the product is dried and may be smoked. Fermented sausage is not cooked and preservation depends on the high acidity and high salt content toegther with the low water content.

Additives

Comminuted products such as sausages and luncheon meats are based on lean meat, which, technologically, provides water-holding and meat-binding capacity, with the addition of fatty meats and, sometimes, organ meats. The amount of these is limited otherwise the products have an unattractive soft texture and high shrinkage on cooking.

The ingredients include cereals and potato starch, termed fillers, which also serve to bulk out the supply of meat products ("meat extenders"). Other ingredients include a number of substances which have considerable water-holding and binding capacity ("binders"). These include egg or egg yolk blood plasma, skim milk powder, caseinates, soya isolates, wheat gluten, whey protein and dehydrated products derived from various vegetable proteins (soybean, safflower, corn, peanut and pea protein) and their binding properties depend on their ability to form irreversible gels on mild heating which serve to hold together the small pieces of meat.

It is not posssible to generalise about the nutritional value of products of such variable composition.

Other Comminuted Products

These are made from chopped (minced, ground) meat and fat and usually include meat from various parts of the animal including trimmings. In specific products organ meats are also used (Table 2 - 17). Some tissues can be included only in restricted amounts because their texture can adversely affect the product.

Other ingredients are included for the purposes of ekeing out meat supplies or for their capacity to bind the minced pieces (See Additives later) and seasoning.

Seasoning is a comprehensive term for ingredients intended to improve flavour such as salt, pepper, spices, herbs and vegetables. Spices commonly used include cinnamon, cassia, clove, ginger, mace, nutmeg, paprika, cardamom, coriander and mustard; herbs include sage, savory, bay leaves, thyme and rosemary; onions and garlic are also used.

Liver and blood have a pronounced colour and flavour and can be included in comminuted meat products only in limited amounts (15-50% of the total) depending on the local acceptability or may be used in specific liver or blood sausages.

Pates can be included with comminuted products since they are made from coarsely or finely chopped meats, precooked and seasoned, and some are cured with salt, nitrite and phosphate.

Luncheon Meat

This is the name given to several products made from finely chopped meat and fat with the addition of cereal and water, preserved by the addition of salt and nitrite and by heating.

Although the nutrient content is very variable a typical analysis of a canned product of this type, per 100 g is:- 5 g water, 13 g protein, 27 g fat (10 g saturated, 12g monounsturated, 3 g polyunsaturated, 70 g cholesterol), 1.3 MJ, 1000 mg sodium, 1 mg iron, 0.3 mg copper, 2 mg zinc, 0.07 mg B1, 1.8 mg nicotinic acid, 1 mg B12.

Corned Beef

This was originally a by-product from the manufacture of meat extract when it was the only meat product that could be shipped from South America before the introduction of refrigerated transport. The latter is made by hot water extraction of the low quality meat from animals that have taken several years on relatively poor pasture to reach suitable size so is relatively rich in connective tissue (as well as in muscle extractives). The meat is coarsely chopped and immersed in hot water to extract the solubles; the exhausted meat is cured by the addition of coarse grains of salt ("corns") and nitrite and canned, often with the addition of fat. It has an extremely long shelf- life and used to play a major role in military rations and in expeditions.

Other meats such as mutton can be treated similarly and some modern processes use unextracted beef.

In the United States the term "corned beef" is applied to what is elsewhere termed "salt beef" i.e. cured whole beef.

Since corned beef is made from extracted meat it is low in water-soluble vitamins, containing per 100 g only a trace of thiamin, 2.5 mg nicotinic acid, 0.2 mg riboflavin, 2 mg B12, 3 mg iron, 0.25 mg copper, 6 mg zinc, together with 950 mg sodium and 60 g water, 26 g protein, 12 g fat and supplying 0.9 Ml (220 kcal).

<u>Burgers</u>

Patties made from minced meat have become popular world-wide through the agency of international fast-food outlets. These were originally hamburgers made from beef with the name derived from the Hamburger sausage but may be made from any meat and "muttonburgers" are marketed in regions where beef is not eaten.

The meat content varies from 100% including about 20% fat, to 80% or less with various additions of cereals, onion and water. Since the pattie is raw it is stored frozen.

Typical composition per 100 g raw hamburgers made from 90% meat is;- 56 g water, 15 g protein, 20 g fat (10 g saturated, 9 g monounsaturated, 1 g polyunsaturated, 100 mg cholesterol), 1.1 Ml, 600 mg sodium, 2.5 mg iron, 0.25 mg copper, 3 mg zinc, 0.04 mg B1, 0.2 mg B2, 4 mg nicotinic acid, 0.2 mg B6, 1 ug B12, 1 mg folate, 0.4 mg pantothenate.

Frying causes a small loss of water, about 5%, and a greater loss of fat depending on the method used - whether under a grill, on a heated surface or over a direct flame. Other nutrients, including protein, are proportionately increased.

Contents - Previous - Next

Methods of meat preservation without refrigeration

Contents - Previous - Next

Drying

Micro-organisms cannot grow unless there is sufficient moisture available to them and drying meat under conditions of natural temperatures and humidity with circulation of air and the assistance of sunshine is the oldest method of preservation (FAO 1990 c).

The free water in a food product, i.e. excluding the water bound to proteins, is termed the water activity (aw). Free water is that part that can be removed as water vapour (and is not the same as the total moisture content). "Water activity" is defined as the ratio of water vapour pressure measured in the product to the pressure of a saturated water vapour atmosphere at the same temperature.

The minimum moisture content necessary for bacterial growth varies with the type of organism. The lowest value for normal bacteria is water activity 0.91; for normal yeasts it is 0.88; for normal moulds 0.80; and for salt-tolerant (halophilic) bacteria it is 0.77.So water activity must be reduced below these levels to preserve the food.

Muscle meat of almost any kind can be dried but it is necessary to use lean meat since fat becomes rancid during the drying process. Drying involves the removal of moisture from the outer layers and the migration of moisture from the inside to the outside, so the pieces of food must be thin. The meat is cut into long thin strips or flat thin pieces and preferably salted, either dry or by dipping into salt solution, to inhibit bacterial growth and to protect from insects.

The pieces are suspended in racks in freely circulating air under hygienic conditions and protected from dirt and dust for the several days required. If the air is warm and of low humidity with relatively small temperature fluctuations between day and night the time needed will be shorter. Slow drying allows deterioration since micro-organisms can multiply in the early stages while the moisture content is still high enough. Another problem arises from the practice in developing countries of using meat from unchilled carcasses and while the temperature is still high the meat ripens rapidly so changing the flavour. At the same time there is some oxidation of the fat so further lowering the quality of the finished product.

There are a number of traditional dried products in various regions. For example biltong in South Africa, which is made from beef or antelope meat cut into strips 1 - 2 cm thick, salted, with the addition of nitrate or nitrite , spiced and dried in air for 1 - 2 weeks.

The outer layer of biltong is hard and brown with a soft, inner, red inside, and is eaten raw. It will keep for a year if stored in airtight packaging.

Typical analysis per 100 g: 11.5 g water, 1.9 g fat, 12.5 g ash, 65 g protein, 1.3 MJ (300 kcal).

Jerked beef or charque is the product used in South America which may be made from beef, llama, sheep, alpaca. The fresh meat is cut into large pieces no more than 5 cm thick, salted, pressed for several days and dried - but it still contains moisture which is allowed to drain freely from the product. It keeps for months at ambient temperatures and is resistant to insect infestation and mould growth.

Pemmican is dried meat that has been powdered or shredded and mixed with fat to form a solid product. Typical analysis per 100 g:- 3 g water, 40 g protein, 45 g fat, 2.4 MJ. Pemmican was almost a routine food taken on earlier expeditions until replaced by modern types of dried meat products.

Other traditional dried products include pastirma (Turkey, Egypt and Armenia), odka (Somalia and other countries of East Africa), qwanta (Ethiopia and East Africa) and kilishi (Nigeria and West Africa). There is a variable loss of vitamins from such products due to the long drying times which can be shortened by the use of modern drying techniques.

Such a procedure is freeze-drying which causes little or no loss of vitamins and results in products which are readily rehydrated and much closer in texture and flavour to fresh meat than the traditional dried product but calls for specialised equipment.

Partial Drying/Intermediate-Moisture Foods

In dried meats the water activity is below levels needed for microbial growth so the product is shelf-stable but there will still be chemical and physical changes due to rancidity and discolouration which call for adequate packaging. Some products such as "dry" sausages and hams cannot be dried adequately without spoiling the product - they are termed "semi-dry" - so it is necessary to combine an incomplete reduction in water activity with other methods such as lowering of pH or the addition of nitrate.

In an attempt to avoid the relatively poor texture and flavour of most dried meat products a modern development is partial drying to a moisture content of 15 to 50% and then reduction of free water to the required low levels by adding humectants such as glycerol, sorbitol or other polyhydric alcohols which combine with the free water so that it cannot be used by the micro-organisms.

The meat is cut into small pieces and treated with a mild salt solution, and the humectant and an antimycotic (anti-mould agent) are added and the meat cooked to 70�C before packaging. It will keep for several months even at 38�C but there are changes in texture, colour and flavour (Lawrie 1991).

Products preserved in this way are called intermediate-moisture foods and they are more succulent than dried foods but the humectants spoil the palatability and the process has been limited to animal foods in industrialised communities and for military purposes.

Canning

Micro-organisms can be completely destroyed by heat (sterilisation) but a sterile product can be readily recontaminated unless it is protected. This is achieved by heating in an air-tight can or bottle, or, more recently, in a heat-resistant or aluminium foil-laminated plastic pouch. Sausages can be filled into retortable synthetic casings sealed with aluminium clips.

The procedure is to seal the food into the container and then heat it under pressure in an autoclave (retort) to the required temperature for the required length of time and to cool rapidly to avoid overheating. Overheating results in too soft a consistency and a burnt taste. It is not always possible to destroy all the organisms without excessive heat which would spoil the product so the objective is to destroy the greater proportion of the organisms when the remaining few pose no hazard so long as the container is cooled rapidly and stored below 20-25�C. This condition is termed "commercially sterile". The established standard is equivalent to a reduction in the number of micro-organisms by a factor of 10 to the power of 12 so it is clear that the higher the initial load of organisms the more will survive a standard heat treatment.

The intensity of heat treatment necessary depends on the nature of the product, its pH, and the amount of salt and other curing agents present as well as on the bacterial load. The time required at a given temperature will vary with the rate of heat penetration to the centre and so with the size of the container.

The intensity of heat treatment is defined in physical terms called F-value, which means that the product received heat treatment with the same effect on micro-organisms as exposure to a temperature of 121�C for 1 minute. The standard is based on the time required at a temperature of 121�C to destroy all spores of Clostridium botulinum, the most dangerous of all toxin-producing organisms. This is termed "the botulinum cook" and such treatment destroys practically all spoilage and other organisms. It takes 2.45 minutes at 121�C to destroy all C. botulinum spores; this is an F-value of 2.45. Spores of other organisms are less or more heat-resistant. F-value 1 is the lethal effect on micro-organisms after 1 minute at 121�C; F-value 2 (3,4) is the lethal effect after 2 (3,4) minutes.

At temperatures greater than 121�C a shorter time is needed to achieve the F-value of 1, thus at 130�C the time is 0.13 min. Correspondingly the time is longer at lower temperatures, thus at 115�C the time is 4 min at 105�C it is 40 min.

These conditions apply to foods of low acidity (pH above a value of 5) and medium acidity (pH 4.5 - 5); with more acid foods the spores of micro-organisms are less heatresistant. Meat products are mostly low-acid, while meat and vegetable mixtures are medium -acid. In practice once the F-value has been determined for a batch of food according to the size of the container the heat treatment required to treat subsequent batches is the same. Generally it has been shown that F-value 4 will usually ensure commercial sterility. Larger canned products may require F-values up to 20-25 owing to the longer periods required for heat penetration.

A fully-treated product of this type will keep for up to 4 years at ambient temperatures but even fully-preserved meat can contain a very heat-stable spore former, Clostridium sporogenes, which poses a hazard only when stored under extreme climatic conditions, namely at temperatures above about 40�C If canned meat is to be stored under such conditions then it must be treated more intensively, F-value 12 or more ("tropical preservation") and then has a shelf life up to 4 years.

Virtually every type of meat product made from chopped, cured meat can be canned, as well as stewed meat, dishes in jelly, soups with meat ingredients, and pastas and sausages in brine.

Products such as luncheon meats, liver sausage, blood sausage and jellied products are adversely affected by high temperatures and are "three-quarters preserved" at F-values 0.6 to 0.8. The temperature reached at the centre of the pack is between 108 and 112�C and the product is stable for up to 1 year if stored at temperatures no higher than 15�C.

Cooked preserved products are simply boiled until the central temperature reaches near to 100�C and they can be stored (protected from contamination) for 1 year at temperatures no higher than 10�C.

Smaller size containers are most suitable for meat products because heat penetration is mostly by conduction so larger containers would require severe heat treatment involving overcooking. Large pieces of meat products such as hams, shoulders, etc., are pasteurised. Pasteurisation is a more gentle process intended to destroy only pathogenic organisms and the treatment limits the central temperature to about 80�C (Fvalue almost zero). This destroys only vegetative cells and refrigeration is necessary to prevent germination of spores. Pasteurised products must be stored between 2 and 4�C when they have a shelf life up to 6 months.

The temperatures quoted must be reached in the centre of the pack to ensure that the entire contents are adequately heated but protein and fat are poor heat conductors. If there is enough liquid in the can, such as meat cooked in gravy, Frankfurters in brine, or through release of liquid from the meat and liquefaction of the fat, heat can penetrate by convection as well as conduction if the can is rotated during the process. This allows a shorter heating time with less damage to flavour, texture and nutrients, and the outer layer of the food is not overheated.

Canning operations must be performed only by fully-trained personnel (FAO 1990c; Hershom and Hulland 1980).

High-temperature Short-time Processing (HTST)

Since the effect of heat in speeding up biological reactions (in this instance destruction of micro-organisms) is greater than the acceleration of chemical reactions (in this instance damage to protein and other nutrients) heating to a higher temperature for a shorter time is an effective means of preservation. Sterilisationis achieved in a shorter time with less damage to the product. The process is termed high-temperature short-time heating (HTST) and has been particularly applied to milk but can be applied to meat if there is sufficient liquid present to allow mixing of the contents by rotating the cans in the autoclave. The cans must be cooled immediately after the temperature of sterilisation has been reached to avoid overheating.

Nutritional Damage

Most of the investigations of nutritional changes in canning have involved fullypreserved foods. There are large differences reported in the literature due to differences in raw materials and conditions of processing.

Thiamin is the most labile of the vitamins and reported losses range between 20 and 40%. This is heat destruction since any water-soluble nutrient that is leached out of the meat will be retained in the can and is usually consumed together with the meat. Losses of niacin and riboflavin are about 10%, 20% of biotin, 20-30% of pantothenate.

If more accurate figures are required they would need to be determined on the specific procedure in the factory in question on the particular product.

In principle losses in canning are somewhat higher than in wet cooking since the temperature is higher, and for the parallel reason less than losses in dry cooking methods such as roasting, grilling and frying where the temperature at the surface can be between 180 and 350�C So far as proteins are concerned there is some small reduction in biological value due to reduced availability of methionine and cystine. Semi-preserved meat products heated to temperatures not exceeding 100�C do not suffer this damage.

The heat applied causes partial hydrolysis of the collagen so that tough meat, rich in collagen, is rendered more palatable by being canned.

During storage after canning there can be a loss of thiamin of as much as 30% depending on the length of time, and at higher storage temperatures there can be a reduction in protein quality.

Fat Embedding

A traditional process that is parallel to canning is that of cooking the meat in a vessel that can be sealed under a layer of melted fat and so protected from recontamination.

An example of such a product is mixiria of the Amazon region where the meat is roasted, sliced and sealed in jars.

The layer of fat not only protects the meat from contamination but excludes oxygen, however, organisms can survive so the method is not dependable.

The process of fat embedding was tested by the Australian meat trade in the 19th century - beef was packed into barrels and covered with fat heated to 150�C - but superseded by refrigeration.

It is used to a very limited extent in some industrialised countries, in particular for a product called "potted shrimps", which have been cooked in butter and sealed into jars.

Ionising Irradiation

Micro-organisms can be destroyed by subjecting a food to ionising radiation produced from radioactive or electromagnetic sources. High doses (50 kiloGrays - kGy) are required for sterilisation of meat while recommendations of WHO and legislation in most, if not all, countries limit the dose at present to 10 kGy, simply because safety has been established up to this level.

The 10 kGy dose does not sterilise the product but substantially reduces the bacterial load and is effective in destroying many pathogens including Salmonellae. A dose of 2 - 5 kGy will extend the shelf life of poultry stored at 1-3�C by 8-14 days. Irradiation is of no value as a means of "cleaning up". heavily contaminated food since it would still carry a considerable microbial load, nor does it destroy toxins once they have been produced. Indeed, in some countries where irradiation is permitted microbiological standards are specified for foods to be treated. Irradiation of spices to be used for meat products has proved to be an effective way of lowering their microbial content and so increasing the shelf life of the products.

Although the preservation of food by irradiation has been intensively studied for many years its commercial application is still in its infancy. There are many problems involved since the process calls for heavy investment in factory plant and is regarded with some suspicion by consumers. Moreover irradiation does not destroy enzymes so the meat softens during storage.

Since the radiation penetrates into the product it also penetrates packaging so the food can be protected from recontamination by adequate wrapping before irradiation.

In general irradiation has some deleterious effect on vitamins but the amount of damage is not considered nutritionally significant (Codex 1984A).

Recent developments in meat processing

Mechanically Recovered Meat (MRM)

Also termed mechanically deboned and mechanically separated meat.

When bones are trimmed of adhering meat by hand some of the meat is left attached to the bones. It is said that some 2 million tonnes of meat world -wide are discarded with the bone. This can be recovered by a mechanical scraping process in which bones with adhering meat are generally broken into small pieces and the soft components, meat, fat etc., forced through perforated screens and recovered as a finely comminuted product consisting of a gel of meat, fat and sometimes marrow from the inside of the bones together with fine particles of bone. The bone content should be reduced to a minimum; it has been recommended that the calcium content of MRM expressed on a dry matter basis should not exceed 1.5% (Codex 1983).

MRM can increase the overall profitability of meat production not only by increasing meat yield but also by providing a product with emulsifying properties useful in preparing comminuted meat products. Generally MRM is less acceptable than ordinary muscle meat because it is darker in colour due to its high content of haeme protein, and more readily oxidised because of the high fat content.

Because of its physical state and the longer process MRM is subject to heavy microbial contamination; if not used immediately it needs freezing to prevent decomposition.

Reformed Meat Products

Apart from the high regard for certain cuts of meat in some areas there is a growing demand for lean rather than fatty cuts. The high cost of such products has led to the use of other, less expensive cuts of meat which are higher in content of connective tissue but can have some of this tissue, together with skin and gristle, removed in a process of comminution and reformation.

The pieces of meat are treated in a tumbling device with brine which penetrates the tissues and extracts some of the myofibrillar protein to form a gel (as descibed earlier).

At a low temperature the product can be compressed into thin flakes which bind together when the meat is heated, sometimes with the addition of binding agents such as wheat gluten, egg albumin and soya; the final product can be shaped or sliced.

The nutritive value of reformed meat products depends on the tissue used and the added ingredients, and approximates to that of comminuted products.

Protein Extraction

A recently discovered but highly technical process for recovering edible foodstuffs from by-products of low acceptability (such as lungs and stomachs) is extraction of the proteins.

The procedure is similar to that of preparing textured vegetable proteins usually made to simulate meat. The proteins are extracted in alkali and reprecipitated from solution by acidifying. If the alkaline solution is forced through fine tubes (spinnerets) into the acid solution it is precipitated in the form of long fibres which can be pressed and texturised to a solid form. High temperature extrusion is also used. Other materials such as soya can be incorporated.

There is an added advantage in that the number of micro-organisms is greatly reduced during the process.

A recent method of using low quality meats is the application of the Japanese fish surimi process to meat and poultry by-products. This consists of mechanically deboning and washing to remove water-soluble proteins, enzymes, minerals and fat to leave a product that is stable and with a high concentration of salt-soluble myofibrillar proteins that have the capacity to form strong elastic gels when gently heated. Fish surimi is used to make a range of products by extrusion and shaping and it seems possible to apply the procedure to meat. Low-quality meat is rich in fat and the process is intended to remove the greater part of the fat and to make novel meat products or to add to traditional meat products such as sausages, sliced cooked meat and burgers or other foods.

Contents - Previous - Next

Chapter 3 - Meat and health

Contents - Previous - Next

Meat consumption role of meat in the diets

Meat consumption

Meat consumption is based largely on availability, price and tradition. Meat production is a very complex operation depending not only on demand (which is usually based on price and income) but on many social and economic influences such as official policy, price support mechanisms, and interrelations such as the interaction between beef and milk production, the availability of animal feedstuffs and competition for food between man and animals.

It is difficult to make accurate comparisons of meat consumption between countries because different methods are used to estimate consumption. Figures may be derived from total supplies available at wholesale level, or from records of household purchases, with or without estimates of what is consumed away from home; the estimate of waste, both in preparation of the food and by the individual adds to the uncertainty. Some national estimates fail to include imports, and some surveys include the weight of non-meat components of the products (for example the amount of meat in a product can range between 100% in some burgers to 10% in some pizzas). FAO Food Balance Sheets are prepared from figures for production, imports, stock changes and exports with allowances for feed, processing and "other uses" and the same methods are applied to all regions so that the figures, as in Table 1-1A, are comparable.

Up to a certain level of income the amount of meat eaten varies with income, in the relatively affluent western world where the proportion of available income spent on food has been steadily falling over the past generation, there is now little if any difference between the amounts of meat eaten by the different income groups. This contrasts with the Third World countries (FAO 1990a).

The amount of meat consumed in different countries varies enormously with social, economic and political influences, religious beliefs and geographical differences. It is very large in meat-producing areas such as Uruguay, Argentina, Australia and New Zealand, at 300 g per head per day compared with an average of 10 g in India Indonesia and Sri Lanka Table 1-1A shows the contrast between total meat supplies in developed and developing countries, allowing for exports, imports and stock changes, and Table 3-1 shows that the production per capita in the former is five times as much as in the developing countries. These tables also show the relative size of production of the different types of animals involved.

Role of meat in the diet of developed and developing countries

Meat is held in high esteem in most communities. It has prestige value, it is often regarded as the central food round which meals are planned, various types of meat are sometimes made the basis of festive and celebratory occasions, and from the popular as well as the scientific point of view, it is regarded as a food of high nutritive value.

While it is clear that meat is not essential in the diet, as witness the large number of vegetarians who have a nutritionally adequate diet, the inclusion of animal products makes it easier to ensure a good diet.

There is a marked difference at the present time in attitudes towards meat between the people of the developing and industrialised communities In the former where meat is in short supply it can be taken as a measure of the nutritional quality of the diet as a whole. Where a typical diet is heavily dependent on one type of cereal or root crop, meat, even in small amounts, complements the staple food. It provides a relatively rich source of wellabsorbed iron and also improves the absorption of iron from other foods, its amino acid composition complements that of many plant foods, and it is a concentrated source of B vitamins, including vitamin B12 which is absent from plant foods. Consequently there is pressure to increase the availability of meat products.

In the industrialised countries where food of all kinds is plentiful and cheap there is concern, whether or not misplaced, about the potentially harmful effects of a high intake of saturated fat from animal foods (discussed later), emphasis on continuous development of regulations dealing with hygiene in slaughter houses and during subsequent handling, concern about hormones administered to cattle, what is perceived as excessive addition of water to some processed products - concerns that can scarcely be afforded in developing countries when balanced against food supplies.

With increasing mechanisation in industrialised communities the steady fall in human energy expenditure and consequently in per capita food consumption poses a potential problem in achieving an adequate intake of nutrients even where there is an abundance of food available. With the variety of food available a diet of 8 Ml (2000 kcal) or more per day is likely to supply enough of all the nutrients, but when the intake is 6.5 to 7 MJ (1600-1800 kcal) per day the consumer needs to make an informed choice of foods to ensure an adequate intake of nutrients.

In western Europe the daily average energy intake of women is about 6.5 Ml and that of men 8 MJ (excluding alcohol) and there are reports of biochemical signs of deficiencies of several B vitamins and iron. It is not clear whether this is accompanied by functional defects.

In industrialised countries there have been slow but continuous changes over the years in the relative amounts of different types of meat consumed (beef, pork, lamb, poultry) depending partly on price and influenced by fashion, advertising, etc. In more recent years health aspects, more correctly, perceived health aspects, have become a factor.

The concerns about public health in industrialised countries where coronary heart disease and other "diseases of affluence. are common have led to recommendations to the public to modify their diet, popularised as Dietary Guidelines. These particularly recommend a reduction in fat consumption, especially saturated fatty acids and consequently, even if incorrectly, in red meat (discussed later). This has led in some sections of their populations to a relative increase in the consumption of poultry and fish at the expense of red meat.

In addition there is concern, whether or not misplaced, about the presence in meat of pesticides, residues of hormones and growth promoters used to increase yields, and concern about human diseases thought to be transmitted by beef, together with an increase, for many reasons, in vegetarianism.

Meat as a source of protein

Human Protein Requirements

Human requirements for protein have been thoroughly investigated over the years (FAD/WHO 1985) and are currently estimated to be 55 g per day for adult man and 45 g for woman. (There is a higher requirement in various disease states and conditions of stress).

These amounts refer to protein of what is termed "good quality" and highly digestible, otherwise the amount ingested must be increased proportionately to compensate for lower quality and lower digestibility.

Protein Quality

The quality of a protein is a measure of its ability to satisfy human requirements for the amino acids. All proteins, both dietary and tissue proteins, consist of two groups of amino acids - those that must be ingested ready-made, i.e. are essential in the diet, and those that can be synthesised in the body in adequate amounts from the essential amino acids. Eight of the 20 food amino acids are essential for adults and ten for children.

The quality of dietary protein can be measured in various ways (FAD/WHO 1991) but basically it is the ratio of the available amino acids in the food or diet compared with needs. In the earlier literature this was expressed on a percentage scale but with the adoption of the S.I. system of nomenclature it is expressed as a ratio. Thus a ratio of 1.0 (100 per cent) means that the amino acids available from the dietary proteins are in the exact proportions needed to satisfy human needs; a ratio of 05 means that the amount of one (or more) of the essential amino acids present is only half of that required. If one essential amino acid is completely absent (a circumstance that can occur only experimentally with isolated proteins since any food, let alone a whole diet, consists of a mixture of many proteins) the protein quality would be zero.

There is a popular impression, originating at one time from nutrition textbooks, that the qualities of proteins from animal sources are greatly superior to those from plant sources. This is true only to the extent that many animal sources have Net Protein Utilisation, NPU, (a measure of the usefulness of the protein to the body) around 0.75 while that of many, but not all plant foods is 0.5-0.6. However, after infancy people consume a wide variety of proteins from different foods and a shortfall in any essential amino acids in one food is usually made good, at least in part, by a relative surplus from another food - this is termed complementation. As a result the protein quality of whole diets even in developing countries rarely falls below NPU of 0.7, a value that can be compared with the average of 0.8 in industrialised countries (FAD/WHO 1985).

The value of meat in this respect is that it is a relatively concentrated source of protein, of high quality (NPU 0.75-0.8), highly digestible, about 0.95 compared with 0.8-0.9 for many plant foods, and it supplies a relative surplus of one essential amino acid, lysine which is in relatively short supply in most cereals.

Effect of Cooking on Protein Quality

Apart from the inherent quality of the various proteins a reduction in quality takes place if there is damage to amino acids when the food is cooked. At a temperature below 100�C when proteins are coagulated, there is no change in nutritional quality.

The first changes take place when food is heated to temperatures around 100�C in the presence of moisture and reducing sugars, present naturally or added to the food. There is a chemical reaction between part of one essential amino acid, lysine and a sugar to form a bond that cannot be broken during digestion, and so part of the lysine is rendered unavailable.

When proteins are analysed in order to determine their amino acid composition the procedure involves a preliminary hydrolysis with strong acid which does break the lysinesugar bond, so chemical analysis does not reveal this type of damage and special methods are needed. At a higher temperature or with more prolonged heating, the lysine in the food protein can react with other chemical groupings within the protein itself and more becomes unavailable. In addition the sulphur amino acids (cystine which is not essential and methionine which is) are rendered partly unavailable.

The lysine-sugar reaction results in a brown-coloured compound (the so-called browning or Maillard reaction) which produces an attractive flavour in food and is the main cause of the colour of bread crust and roast meat. While such severe heating reduces the amount of lysine available in these foods the loss is nutritionally insignificant since it affects only a very small fraction of the total amount present.

At the temperature needed to cook meat there is little loss of available lysine or the sulphur amino acids but there can be some loss if the meat is heated together with reducing substances, as may be present when meat is canned with the addition of starch-containing gravy or other ingredients.

Overall the damage to protein caused by cooking is of little practical significance and it can be argued that if there is meat in the diet it is likely that the quantity of protein would compensate for any shortfall in quality.

The nutritional quality of the proteins of meat rich in connective tissue is low since collagen and elastin are poor in the sulphur amino acids - there is only 0.8 g of each per 100 g of total protein compared with values of 2.6 and 1.3 of each respectively in "good meat. Meat is tough to eat when it is rich in connective tissue and such meat is often used for canning since the relatively high temperature involved in the sterilisation process partly hydrolyses the collagen so making the product more palatable. However, it still results in a product with NPU as low as 0.5 compared with a value of 0.75 - 0.8 for good quality meat (Bender and Zia 1976).

Adequacy of Dietary Protein

The protein requirement of an individual is defined as the lowest level of protein intake that will balance the loss of nitrogen from the body in persons maintaining energy balance at modest levels of physical activity (FAD/WHO 1985). The "requirement" must allow for desirable rates of deposition of protein during growth and pregnancy. When energy intake is inadequate some of the dietary protein is diverted from tissue synthesis to supply energy for general physical activity - this occurs at times of food shortage and also in disease states where food is incompletely absorbed and utilised.

A diet adequate in energy is almost always adequate in protein - both in quantity and quality. For example, an adult needs an amount of protein that is equivalent to 7 - 8% of the total energy intake, and since most cereals contain 8 - 12% protein even a diet composed entirely of cereal would, if enough were available and could be consumed to satisfy energy needs, satisfy protein needs at the same time. Growing children and pregnant and nursing mothers have higher protein requirements as do people suffering from infections, intestinal parasites and conditions in which protein catabolism is enhanced. During the stress that accompanies fevers, broken bones, burns and other traumas there is considerable loss of protein from the tissues which has to be restored during convalescence and so high intakes of protein are needed at this time together with an adequate intake of energy.

The digestibility of the proteins of various diets varies considerably. For example, the digestibility of typical Western diets and Chinese diets is 0.95 (i.e. 95% digested). That of the Indian rice diet and Brazilian mixed diet is 0.8 (FAD/WHO 1985). Digestibility is high in diets that include milk and meat and low when maize and beans predominate.

An increase in the amount of protein eaten beyond "requirement" figures compensates for any shortfall in digestibility and protein quality.

Meat as a source of vitamins and minerals

Meat and meat products are important sources of all the B-complex vitamins including thiamin, riboflavin, niacin, biotin, vitamins B6 and B12, pantothenic acid and folacin. The last two are especially abundant in liver which, together with certain other organs is rich in vitamin A and supplies appreciable amounts of vitamins D, E and K.

Meats are excellent sources of some of the minerals, such as iron, copper, zinc and manganese, and play an important role in the prevention of zinc deficiency, and particularly of iron deficiency which is widespread.

Meat Iron

The amount of iron absorbed from the diet depends on a variety of factors including its chemical form, the simultaneous presence of other food ingredients that can enhance or inhibit absorption, and various physiological factors of the individual including his/her iron status. Overall, in setting Recommended Daily Intakes of nutrients the proportion of iron absorbed from a mixed diet is usually taken as 10%.

Half of the iron in meat is present as haeme iron (in haemoglobin). This is well absorbed, about 15-35%, a figure that can be contrasted with other forms of iron, such as that from plant foods, at 1-10%.

Not only is the iron of meat well absorbed but it enhances the absorption of iron from other sources - e.g. the addition of meat to a legume/cereal diet can double the amount of iron absorbed and so contribute significantly to the prevention of anaemia, which is so widespread in developing countries.

Zinc is present in all tissues of the body and is a component of more than fifty enzymes.

Meat is the richest source of zinc in the diet and supplies one third to one half of the total zinc intake of meat-eaters. A dietary deficiency is uncommon but has been found in adolescent boys in the Middle East eating a poor diet based largely on unleavened bread.

Health concerns associated with the consumption of meat

Coronary or Ischaemic Heart Disease

A major cause of death in some parts of the industrialised world is coronary heart disease (CHD) and saturated fatty acids have been implicated as an important dietary risk factor. Since about a quarter of the saturated fatty acids in the diet is supplied by meat fat, the consumption of meat itself has come under fire.

The first stage of development of the disease is a narrowing of the coronary arteries by deposition of a complex fatty mixture on the walls - a process termed atherosclerosis. The fatal stage is the formation of a blood clot that blocks the narrowed artery thrombosis. Even if the thrombosis is not fatal the reduced blood flow to the heart muscle deprives it of oxygen and can lead to extensive damage - myocardial infarction.

Despite many years of intensive investigation the real cause of CHD is not known but a large number of what are termed risk factors have been identified, including a family history of CHD, smoking, lack of exercise, various types of stress and certain disease states together with a number of dietary factors. The saturated fatty acids, myristic and palmitic, have been established as the most important of the dietary risk factors in coronary heart disease.

There are three types of lipoproteins (protein-lipid complexes) in the blood; low density lipoproteins (LDL) in which 46% of the molecule is cholesterol; high density lipoproteins (HDL) which include 20% as cholesterol; and very low density lipoproteins (VLDL) which have 8% cholesterol. High levels of total blood cholesterol are associated with the incidence of CHD and high intakes of saturated fatty acids elevate blood cholesterol levels: hence the association between dietary saturated fatty acids and CHD. It is the LDL that appear to be the main problem and HDL appear to be protective.

This lipid hypothesis of causation of CHD has led to the adoption in many countries of dietary guidelines which, among other objectives, are intended to reduce the intake of saturated fatty acids as compared with unsaturated fatty acids and so reduce blood levels of LDL.

Types of Fatty Acids

Saturated Fatty Acids (SFA)

Two of the saturated fatty acids, myristic and palmitic acids, appear to be the principal dietary factors that increase the blood cholesterol and do so by increasing LDL The other main SFA in the diet, stearic acid, does not have the same effect (apparently because it is converted to oleic acid which is monounsaturated - see below); fatty acids of shorter chain length appear to have no effect.

In order to explain the terms saturated and unsaturated fatty acids to the consumer, SFA have been equated with animal fats so meat fat is perceived as being saturated, but, in fact, this is only relative. For example pork lard is 40% SFA, beef tallow is 43-50% SFA, depending on the part of the body from which it is derived. These figures can be compared with 20 - 25% SFA in vegetable oils which are perceived as unsaturated. Table 3-2 shows that except for lamb fat the proportion of SFA is about 40% or less. In four of the six samples of meat listed there is a higher proportion of monounsaturates than SFA.

This perception of meat fat as being saturated has led to the belief that meat, particularly red meat, should be avoided. In fact it has been shown that a reduction of total fat intake while still including in the diet 180 g of lean meat containing 8.5% fat can result in a reduction in blood cholesterol levels (Watts et al 1988). The relation between diet and coronary heart disease is not only a subject of considerable misunderstanding in the minds of consumers but also a subject of some controversy among medical scientists.

Monounsaturated Fatty Acids (MUFA)

The fatty acid of main interest is oleic acid (plentiful in olive, rape seed and higholeic safflower oils). The relatively high intake of olive oil and consequently the proportionately low intake of SFA are believed to be important dietary factors in the low incidence of CHD in Mediterranean countries compared with northern Europe. It is not clear whether oleic acid confers direct protection or simply replaces SFA in the diet. Table 3-2 shows the contribution of meat fat to the intake of MUFA.

Polyunsaturated Fatty Acids (PUFA)

These are fatty acids with between 2 and 6 double bonds and long carbon chains of 18 to 22 carbon atoms (Table 3-3). Linoleic acid (18 carbon atoms and 2 double bonds) and linolenic acid (18 carbon atoms and 3 double bonds) are plentiful in many vegetable oils. The very long chain fatty acids, eicosatetraenoic (20C, 4 double bonds) and docosapentaenoic (22 C, 5 double bonds) are plentiful in fish oils and smaller amounts are present in some meat fats.

These very long chain PUFA appear to offer direct protection against "heart disease", particularly against thrombosis, but it is not clear whether the other PUFA in the diet (from vegetable oils) offer protection or simply displace SFA. Consequently it is often recommended that vegetable oils (rich in PUFA) should not simply be added to a diet but should be used to replace other fats when there is a need for fat in formulating food products.

Linoleic and linolenic acids are essential in the diet (they were at one time termed vitamin F) and the very long chain FA are formed from them in the body. It is possible that the rate of their formation may not be adequate under all circumstances and so there may be benefit from consuming some of these very long chain PUFA ready-made in the diet.

Trans Fatty Acids

PUFA exist in nature in two structural forms, termed cis and bans forms. It is the cis forms that are used in the production of fatty products such as special margarines. The other forms, bans, are formed when oils are hydrogenated to make hard fats for some margarines, and small amounts are found in the fats of ruminants where they are formed by bacterial hydrogenation in the rumen.

Experimentally bans fatty acids have been shown to have an adverse effect on both LDL and HDL and so are considered potentially harmful. When calculating the ratio of PUFA and SFA in diets, the bans fatty acids are often included with SFA.

Cholesterol

Cholesterol is a fatty compound involved in the transport of fat in the blood stream and is also part of the structure of cell membranes of tissues of the body. It is not a dietary essential since adequate amounts are synthesised in the body from other dietary ingredients.

Confusion has arisen between the terms blood cholesterol and dietary cholesterol. For most individuals dietary cholesterol has little or no effect on blood cholesterol levels because reduced synthesis in the body compensates for increased dietary intake. However, there are individuals who are sensitive to dietary cholesterol (Reiser and Shorland 1990) and most authorities advise a general reduction in cholesterol intake for everyone.

Meat supplies about one third of the dietary cholesterol in many western diets with the remainder from eggs and dairy products. Since all these foods are valuable sources of nutrients there could be some nutritional risk in restricting their intake. The cholesterol content of meat and other foods is listed in Chapter 2, Table 2-7.

In addition to playing an important role in CHD dietary saturated fats have been implicated in hypertension, stroke, diabetes and certain forms of cancer, so all dietary guidelines include recommendations to reduce total fat intake and especially that of saturated fats.

Some 20 national authorities have issued dietary guidelines which differ mainly in the amounts of the various foods advised (James 1988). Generally it is recommended that total fat should be reduced to 20-30% of the total energy intake, with not more than 10% from saturates, 10-15% from MUFA and with PUFA at 3% or more; this results in a P/S ratio of 1.0.

Most authorities, but not all, recommend a reduction in dietary cholesterol to around 300 mg or less per day.

Poultry Meat versus Read Meat

Dietary guidelines sometimes include advice to substitute, at least in part, chicken for red meat. Chicken meat including its skin contains about the same amount of fat as does medium-fat red meat, 20%; it is necessary to remove the skin with the adhering subcutaneous fat, to reduce the fat content to around 5% - which is no lower than the figure for lean meat.

However, chicken flesh has less saturated fatty acids (33% of the total) and more PUFA (14%) than lean meat with 45% and 4% respectively.

Duck flesh is very fat, containing about 10% fat - 45% when the skin and subcutaneous fat are included; only 27% of duck fat is saturated.

Meat from game birds, grouse, partridge, pheasant and pigeon, contains about 5, 7, 9, and 13% fat respectively, of which about one quarter is saturated.

Apart from differences in the amounts and types of fatty acids in the various kinds of meat, poultry and game their nutrient compositions are similar.

Toxic compounds formed during processing and cooking

While cooking is necessary to develop the desirable flavours in meat (as well as to destroy harmful organisms) the oxidation of fats, especially at frying temperatures, can give rise to compounds that decompose to aldehydes, esters, alcohols and short chain carboxylic acids with undesirable flavours.

Meats are particularly susceptible because of the unsaturated lipids present which are more readily oxidised and because of catalysis by haeme and non-haeme iron.

The more PUFA present the greater the likelihood of oxidation, and pork (3.6 g PUFA/100 g when grilled), duck (meat and skin, cooked, 3.5 g) and chicken (roast meat and skin, 2.5 g) are the most susceptible. Other types of meat are less susceptible, e.g. lamb (grilled cutlets, 1.5 g PUFA), turkey (meat with skin, 1.3), and beef (fried steak, 0.6 g per 100 g).

The adverse effect of these oxidation products on eating quality is well recognised but more recently it has been suggested that some of them may be carcinogenic, and also may be involved in the ageing process and CHD. However, it is possible or even likely that the unpleasant flavours would cause rejection of the food at levels below harmful ranges.

Cholesterol can also be oxidised and the oxidation product has been suggested as a possible factor in CHD (Addis 1986).

Carcinogens

A number of epidemiological studies have suggested a link between the intake of animal protein and predisposition to cancers at various sites -pancreas, breast, colon, prostate and endometrium - but there are many contradictory reports. A summary of eleven case-controlled studies of colon cancer, three of stomach cancer and one of breast cancer concluded that the available data do not provide convincing evidence that removal of meat from the diet would substantially reduce the cancer risk (Phillips et al 1983; Kritchevsky 1990).

The products of pyrolysis of organic material (by overheating and charring), polycyclic hydrocarbons, are believed to be carcinogenic. The most thoroughly investigated of these is 3,4-benzpyrene which is formed on the surface of barbecued and broiled (grilled) and smoked meat products (including broiled fish and roasted coffee).

The main source of these compounds is the flame itself, especially from charcoal, and indirect cooking where the flame is not in contact with the food greatly reduced the amount present.

Nitrosamines

Nitrites, used in curing salts can react with amines commonly present in food, to form nitrosamines.

These have been shown to be carcinogenic in all species of animals examined but it is not clear, despite years of intensive research, whether the amounts present in cured meats affect human beings. The problem is particularly difficult because nitrosamines have been found in human gastric juice, possibly formed from nitrites and amines naturally present in the diet. As a precaution, legally enforced in some countries, there is a tendency to reduce the amount of nitrite used in the curing mixture and to add vitamin C which inhibits the formation of nitrosamines.

Erythorbic acid and tocopherol are also effective in reducing nitrosamine formation. The problem is complex since the process of curing is designed to prevent the growth of Clostridium botulinum which is responsible for botulism, and the risk of botulism is increased if the concentration of nitrate-nitrite is reduced too far. (Moreover, cigarettes contribute far greater amounts of nitrosamines, up to one hundred times as much as cured meats).

Other potential problems

Bovine Spongiform Encephalopathies (BSE)

There is a group of diseases called prion disease, also known as spongiform encephalopathies or transmissable dementias, which include some very rare human diseases, scrapie in animals and BSE. It is not clear whether these all represent the same disease but they have in common the presence of an aberrant form of a normal cell protein called prion protein.

In some countries there have been recent outbreaks of BSE in cattle with the suspicion that it might be transmitted to human beings through affected meat.

This is difficult to prove or disprove and the risk may be remote but it has added to other popular suspicions about meat and may be partly responsible for the reduction in beef consumption in some countries.

Excessive Amounts of Vitamin A in Liver

There are reports in the scientific literature of harmful effects of acute and chronic excessive intakes of vitamin A, mostly from pharmaceutical preparations. Recently, however, concern has been expressed at unusually high levels of vitamin A found in some, few, samples of animal liver, which, if eaten during the early stages of pregnancy, might possibly affect the human foetus.

Residues of Drugs. Pesticides. etc.

Residues of drugs, pesticides and agricultural chemicals can be found in small amounts in meat and meat products. Pesticides, for example, may be applied specifically to the animals to control insects or intestinal parasites but may also be present in meat as a result of exposure of the animals to chemicals used on buildings, grazing areas and crops. While there is no clear evidence that these small amounts cause harm to the consumer they are perceived as a risk. For this reason there is widespread legislation to test for and control a range of chemical substances that may be present in meat (Codex 1991A).

The problem is complicated because several hundred substances are used to treat animals, to preserve animal health and to improve animal production. These include antimicrobial agents, beta-adrenoreceptor blocking agents (used to prevent sudden death in pigs due to stress during transport) anti-helminthics, tranquillizers, anti-coccidial agents, vasodilators and anaesthetics.

Potential safety problems arise from the possibility of residues of these drugs and their metabolites remaining in the tissues (and milk) consumed by human beings. Some tranquillizers, for example, are used in pigs in the immediate pre-slaughter period when there is no time for their removal through the normal metabolic processes . They can persist in the human body so that repeated intakes could possibly result in accumulation of the drugs.

In order to protect the consumers from such risks the Codex Alimentarius Commission publishes Draft Codes of Practice for control of the use of veterinary drugs (Codex 1991A). These provide guidelines for the prescription, application, distribution and control of drugs.

Where there is sufficient scientific information available about the drug in question the Codex Commission defines the following:- Acceptable Daily Intake (ADI) as a measure of the amount of a veterinary drug, expressed on a body weight basis, that can be ingested over a life-time without appreciable health risk (the same term and definition as used for food additives). This is set at one hundredth of the maximum no-observed-effect level (NOEL) determined in experimental animals, on the assumption that human beings may be ten times as sensitive as the test animals used to determine NOEL and that there may be a tenfold range of sensitivity within the human population. When data are incomplete the safety factor may be set at a much higher multiple.

The maximum amount of residue of a drug - maximum residue limit (MRL) - is the maximum concentration per kg fresh weight of food that is recommended by the Codex Commission as being legally acceptable. This is based on the amount considered to be without any toxicological hazard to human health and takes account of other relevant public health risks as well as food technological aspects.

A point is made in the 1991 report that the principal problem is not only the safety of the substances and their residues but the public perception of their safety.

There is no doubt that administration of drugs to animals (and birds) is always a potential risk to human health and so there is a need to control the use of these drugs and to measure the extent of any residues left in the food intended for human beings.

Conclusion

Meat is not an essential part of the diet but without animal products it is necessary to have some reasonable knowledge of nutrition in order to select an adequate diet. Even small quantities of animal products supplement and complement a diet based on plant foods so that it is nutritionally adequate, whether or not there is informed selection of foods.

Side by side with these known benefits of including meat and meat products in the diet are problems associated with excessive intakes of saturated fats, risks of food poisoning from improperly processed products, residues of chemicals used in agriculture and animal production and other potentially adverse aspects discussed.

Within these concepts is the major problem of meat production under conditions that avoid food poisoning and satisfy the economic demands of profitability with the traditional, cultural and religious concerns of the community in question.

There is a steadily increasing demand for meat in the developing countries which can be satisfied by increased domestic consumption and/or increased imports. It is thought that the major increase in domestic production will come from small producers rather than from creating large production units but these lack the essential facilities for producing safe and wholesome products.

If there is to be a significant increase in meat production it will require clear policy decisions with the necessary financial, legislative and technical support. There is considerable potential for increased supplies through better management, selection of animals, avoidance of waste and making use of indigenous species.

If exports are to be considered then attention has to be paid to the strict hygienic and safety requirements involved, whatever the domestic market might tolerate.

Contents - Previous - **Next**

References

Contents - Previous - **Next**

Addis,P.B. (1986) Occurrence of lipid oxidation oxidation in food. Food Chem. Toxic 24. 1021.

Ainger, S. (1991) Hybrid deer - basis for "New Animal.. The Gazette, University of Sydney, Vol. 19, No. 1 .

Anderson, B.A (1988) Composition and Nutritional Value of Edible Meat By-products. pp 1545 in Edible Meat By-products, Advances in Meat Research Vol. 5. Ed. AM. Pearson and T.R. Dutson. Elsevier Applied Science.

APO (1976) Report of Asian Productivity Organisation. Livestock Production in Asian Context of Agricultural Diversification. p 361, Tokyo, Japan.

APO (1990) Report of Asian Productivity Organisation Symposium on Animal Feed Resources, 24-29 Aug. (1987), (SYP/IV/87)

Bachman, K.L. and Paulino, LA (1979) Rapid Food Production Growth in selected developing countries. A comparative analysis of underlying trends (1961-76) Research Rpt. No. 11, International Food Policy Research Institute, Washington.

Bender, AK. (1978) The effect of heat on protein-rich foods. pp 411-426 in Food Quality and Nutrition. Ed. W.K Downey. Applied Science Publishers.

Bender, AK. and Zia, M. (1976) Meat quality and protein quality. 1. Fd. Technol. 11. 495498.

Blaxter, K.L. (1975) Increasing Output of Animal Products - Technical Measures for increasing productivity. In Man Food and Nutrition. Ed. Rechcigl CRC Press, Cleveland, Ohio, USA

Byerly, T.C. (1975) Effects of agricultural practices on foods of animal origin. In Nutritional Evaluation of Food Processing. Ed. R.S. Harris and E. Karmas. Avi Publishing Co. Westport. pp 58-97.

Chang, H.S. (1981) Problems and Challenge of Agriculture in a rapidly Developing Economy: The Taiwan Experience, Taipei, Taiwan. Food and Fertilizer Technology Centre, Extension Bulletin No. 160.

Codex (1983) Recommended International Code of Practice for Production, Storage and Composition of Mechanically Separated Meat and Poultry meat intended for further processing. CAC/RCP 32-1983. 1st Ed. Rome.

Codex (1984A) "General Standards for Irradiated Floods" and "Recommended International Code of Practice for the operation of radiation facilities used for treatment of food" CAC Vol. XV Edition 1. Rome.

Codex (1991A) Report of the Sixth Session of the Codex Committee on Residues of Veterinary Drugs in Foods. ALINORM 93/31 Joint FAD/WHO Food Standards Programme. Rome

Codex (1991B) Committee on Meat Hygiene ALINORM 93/16

Crawford, M.A (1975) Meat as a source of lipids, in "Meat", Eds D.J.A. De Boer (1982) Livestock in Asia. Ed J.C. Fine and R.G. Lattimore. IDRC Report 202

de Janvry, A and Sadoulet, E. (1986) The Condition for Harmony between Third World Agricultural Development and US Farm Exports. Am. J. Agric. Econ. 68(5), 1340-1346

De Ritter, E., Osadca, M., Scheiner, M. and Keating, J. (1974) Vitamins in frozen convenience dinners and pot pies. J. Amer. Dietet. Assoc. 64. 391-397

Egan, H., Kirk, R.S. and Sawyer, R. (1981) Pearson's Chemical Analysis of Foods. Churchill Livingstone

FAO (1976) Integration of Livestock with Crop Production at Small Farm Level. Vols.I and II, Bangkok, Thailand, FAO RAPA Publication No. RAFE 27

FAO (1984) Food Balance Sheets 1979-81 FAO Rome

FAO (1985) The Fifth World Food Survey. FAO Rome

FAO (1990A) World Meat Situation and Outlook. Commodities and Trades Division. ME 90/1. FAO Rome

FAO (1990B) Workshop. Traditional and low cost methods of meat preparation in Asia and Pacific. FAO Rome

FAO (1990c) Manual on Simple Methods of Meat Preservation. Health Paper No. 79. FAO, Rome.

FAD/WHO (1991) Protein Quality Evaluation. Report of Joint FAD/WHO Expert Consultation. FAO Food and Nutrition Paper 51. Rome

FAD/WHO (1985) Energy and Protein Requirements. Tech. Rpt. Series 724 WHO, Geneva

FAO (1991) Guidelines for Slaughtering, Meat Cutting and further processing. Animal Production and Health Paper No 91. FAO, Rome.

Fennema, O. (1975) Effect of freeze-preservation of food processing. pp 244-288. Ed. R.S. Harris and Karmas, E. Avi Publishing Co. Westport, Conn.

Groenewold, H.H. and Crossing, P.R. (1975) The Place of Livestock in Small Farm Development. World Animal Review, 15. 2-6

Harries, J.M., Hubbard, A W., Alder, F.E., Kay, M. and Williams, D.R.(1968) Studies on the composition of food. 3. The nutritive value of beef from intensively reared animals. Br. J. Nutr. 22. 21-31

Hershom, A.C. and Hulland,E.D. (1980) Canned Foods, Themal Processing and Microbiology. Churchill-Livingstone

Hudson, R.J. (1976) Potential for Meat Production from Marginal Land Resources. Misc. Publ. Dept. of Animal Science. University of Alberta, Edmonton, Alberta, Canada

James,W.P.D.(1988) Healthy Nutrition. WHO Regional Publications, European Series No.24, Copenhagen, Denmark.

Jensen, J.H. (1981) Meat in International Dietary Pattern pp 35-56. In Meat in Nutrition and Health. Eds. R.R. Franklin and P.N. Davis, National Livestock and Meat Board. Chicago, USA.

Jobling, A. and Jobling, CA (1983) In Upgrading waste for Feeds and Food. Eds. D A, Ledward, A.J. Taylor and R.A. Lawrie, Butterworths, London

Karmas, E. and Harris,R.S. (1988) Nutritional Evaluation of Food Processing. VNR 1988

Kritchevsky, D. (1990) Meat and Cancer pp 89-104. In Pearson and Dutson.

Lawrie, R.A. (1981) In Meat in Nutrition and Health. Ed.KR. Franklin and P.N. Davis. National Livestock and Meat Board, Chicago, USA

Lawrie, R.A. (1991) Meat Science 5th Ed. Pergamon, Oxford

Mayfield, H.L and Hedrick, M.T. (1949) The effect of canning, roasting and coming on the biological value of the proteins of western beef, finished on either grass or grain. J. Nutr. 37. 487-494

McCance and Widdowson (1991) The Composition of Foods. 5th Ed. Holland, B. Welch, AA., Unwin, I.D., Buss, D.H., Paul, AA. and Southgate, D.A.T. Royal Society of Chemistry, Cambridge, U.K

Mikkelsen, K., Rasmussen, E.L and Zinck, O. (1984). Retention of vitamins B1, B2 and B6 in frozen meats. pp 777-781. In Thermal Processing and Quality of Foods. Ed. P. Zeuthen, et al. Elsevier Applied Science

Noble, I. (1965) Thiamin and riboflavin retention in braised meat. J. Amer. Dietet. Assoc. 47. 205

Pearson, L.J. and Dutson, T.R. Eds. (1990) Meat and Health. Advances in Meat Research. Vol 6 Elsevier Applied Science

Pellet, P.L and Young, V.R. (1990) Role of meat as a source of protein and essential amino acids in human nutrition. pp 329-370 in Pearson and Dutson.

Pence, J.W., Miller, R.C, Dutcher, R.A. and Ziegler, P.T. (1945) Storage of thiamine in pork muscle. J. Amer. Sci. 4. 141-145

Phillips, R.L, Snowdon, D.A. and Brin, B.H. (1983) Cancer in vegetarians. In "Environmental Aspects of Cancer. The role of the macro and micro components of foods". Ed E.L Wynder, GA Leveille, J.H. Weisburger and G.E. Livingston. Food and Nutrition Press, Westport, CT.

Preston, T.R. (1977) A Strategy for Cattle Production in the Tropics. World Animal Review, 21. 11-17.

Ramaswamy, N. (1980) Report of Draft Animal Power as a Source of Renewable Energy. FAO, Rome.

Reiser, R. and Shorland, F.B. (1990) Meat Fats and Fatty Acids. pp 21-62 in Pearson and Dutson

Reiter, LA and Driskell, J.A. (1985) Vitamin B6 content of selected foods served in dining halls. J. Amer. Dietet.Assoc. 85. 1625

Rice, E.E. (1978) The nutritional content of meat and meat products. In "The Science of Meat Products". 2nd Ed. J.F. Price and B.S. Schweigert, p 287. Food and Nutrition Press, Westport, CT

Rockefeller (1975) The Role of Animals in meeting the World Food Needs. New York, USA, Rockefeller Foundation

Rogowski, B. (1980) Meat in Human Nutrition. World Rev. Nutr. Dietet. 34. 46. Ed. G.H. Bourne. Karger

Sarma, J.S. and Young, P. (1985) Livestock Products in the Third World: Past Trends and Projections to 1990-2000. Research Report No. 49. Washington International Food Policy,Lnstitute

Sawyer, R. (1975) "The Composition of Meat; Analytical Aspects" in "Meat". pp. 287-301 Ed. D.J.A Cole and R.A Lawrie, Butterworths.

Spedding, C.R.W. and Hoxey, A M. (1975) The potential for conventional meat animals". pp 483-506 in "Meat". Ed.Cole and Lawrie.

Watt, B.K. and Merrill A.L. (1975) The Composition of Foods. Agricultural Handbook No 8. US Dept. of Agriculture

Watts, G.F., Ahmed, W., Quiney, J., Houlston, R. et al (1988) Effective lipid-lowering diets including lean meat. Brit. Med. J. 296. 235-237.

Contents - **Previous** - **Next**

Glossary

Contents - **Previous** - **Next**

actin	protein muscle
aerobes	bacteria that require oxygen
amino acids	components of proteins (essential amino acids those that cannot be made in the body and so are essential in the diet)
anaerobes	bacteria that can grow in the absence of oxygen
anti-mycotic	anti-mould agent
ascorbic acid	vitamin C
	sterilising device involving heat destruction of

autoclave	microorganisms
botulism	severe form of food poisoning from toxins produced by Clostridium botulinum
carotene	precursor to retinol
collagen	protein in connective tissue of muscle
complementation	filling a gap; with reference to proteins a shortage of an amino acid in one protein is made good by a relative surplus of another
curing salts	mixture of sodium or potassium nitrite and nitrate
elastin	protein in connective tissue of muscle
folate	unnumbered member of B group of vitamins
glycogen	body (liver and muscle) reserve carbohydrate
HTST	high-temperature short-time heating to destroy microorganisms
indigenous	native born
lipids	group name for all types of fat
Maillard reaction	reaction between the lysine in a protein with a reducing sugar to form a brown compound
mesophilic organism	those that grow best at temperatures of 10-40�C
metmyoglobin	brown, oxidised form of myoglobin
microorganisms	bacteria, moulds and yeasts
MUFA	monounsaturated fatty acids

myoglobin	purple-red colouring matter of muscle (2% of total muscle protein)
myosin	major protein of contractile mechanism of muscle
niacin	unnumbered member of B group of vitamins
nitrogen	effectively (but not precisely) alternative term for proteins
oxymyoglobin	bright red oxygenated form of myoglobin
pantothenate	unnumbered member of B group of vitamins
pasteurisation	heat treatment sufficient to destroy pathogenic organisms
pathogens	bacteria that cause disease
phospholipids	structural lipids containing phosphate
P/S ratio	ratio of polyunsaturates to saturates
psychotrophic organisms	those that grow best at temperatures of -2 to + 7�C
PUFA	polyunsaturated fatty acids
pyridoxine	vitamin B6
retinol	vitamin A
riboflavin	vitamin B2
rigor mortis	stiffening of muscles after slaughter

Contents - Previous - Next

Tables (part I)

Contents - Previous - Next

TABLE 1-1A - World Meat Supplies (million tons)

	1970	1980	1990
World Total	100	136	176
Bovine Meat	39.5	46	53
Sheep & goat meat	6.9	7.5	9.6
Pig meat	35	53	69
Poultry meat	15	26	40
Other meat	3.1	3.5	3.7
Developing countries Total	29.5	46	72
Bovine meat	11	14	19
Sheep & goat meat	3	4	5.7
Pig meat	10	17.7	31
Poultry meat	3.9	8.5	14.5
Other meat	1.3	1.5	2
Developed countries Total	70	90	103.5
Bovine meat	28	31.5	34

Sheep & goat meat	3.7	3.4	3.9
Pig meat	25	35	38.5
Poultry meat	11	17.6	25
Other meat	1.8	1.9	1.7

Source: FAO (1991)

TABLE 1-1B - Protein and Fat Available from Meat Products - grams/caput/day (ranges in brackets) 1990

	Developing countries		Developed countries	
	Protein	**Fat**	**Protein**	**Fat**
Total	6.1	10.4	27.4	33.9
	(4.5 - 14.7)	(3.8 - 16.9)	(13.1 - 38.3)	(13.9 - 54.4)
Bovine meat	1.8	1.9	10.1	12.5
Sheep & goat meat	0.5	0.6	1.0	1.4
Pig meat	2.3	6.8	8.1	15.3
Poultry meat	1.2	1.0	7.6	4.6

Table 1-2 - Estimated numbers (in millions of units) of draught animals and tractors. 1980-2000

Region	1980		1990		2000	
	Draught animals	Tractors	Draught animals	Tractors	Draught animals	Tractors
90 Developing countries	165	2.6	175	5.8	185	14.2
Africa	14	0.2	16	0.5	17	1.3
Far East	126	0.6	135	1.6	145	4.9
Latin America	17	1.3	17	2.9	16	6.2
Near East	7	0.5	7	0.9	6	1.8
Low-income countries	130	0.5	140	1.3	150	4.4

Source: Ramaswamy (1981)

Table 1-3

Yield of vegetable and animal foods (million kcal per hectare)			
Grain	5	Beef	0.4
Rice	7	Eggs	0.5
Potatoes	12	Milk	1.8

Cassava	12		
Banana	13		
Sugar	25		
Land (in ha) needed to produce 20 kg protein per year (sufficient for one adult)			
Beans	0.25	Dairy cows	1 - 3
Grass	0.3 - 0.6	Chickens	3
Cereals	0.6	Sheep	2 - 5
Potatoes	0.7	Pigs	5
		Beef	3 - 6

Table 1-4 - Income elasticities of demand for livestock products and cereals, 1975

Country Group/Region	**Meat**	**Milk**	**Eggs**	**Cereals**
Developed economies	0.25	0.05	0.27	0.22
Developing economies	0.63	0.57	1.00	0.16
Africa	0.79	0.68	1.05	0.21
Asia and the Far East	0.97	0.52	1.07	0.22
Near East	0.72	0.53	0.83	0.13
Latin America	0.37	0.49	0.60	0.16

Source: Food and Agriculture Organization of the United Nations, Rome, 1978.

Table 1-5 - Approximate yield of various items obtained from meat animals

Item	Steer	Lamb	Pig
Live weight, kg	455	45	100
Dressed carcass, kg	273	23	70
Retail cuts, kg	190	16	56
By-products, kg			
Hide or pelt	36	7	-
Edible fats	50	4	16
Variety meats	17	1	4
Blood	18	2	4
Inedible fats, bone and meat scrap	80	10	8
Unaccounted items (stomach contents, shrink, etc.)	64	5	12

Source: Principle of Meat Science; Eds. Forrest et al. (1975).

Table 1-6 - 'Normal' performance levels and attributes

Species	**Mature size (kg liveweight)**			**Reproductive rate (No. of young/year)**	**Ratio of males to females for breeding**	**Yield/progeny (kg carcass weight)**
	Male		**Female**			
Cattle	700-800		450-700	0.9	1:30-50	200-300
Buffalo	665-718		509-548	144-279		
Musk oxen		365		0.5-1.0		
Yak	230-360		180-320			
Sheep	30-150		20-100	1-2+	1:30-40	18-24
Goats	48-58		45-54	1-3	1:40	4.3-8.4
Deer (rod)	124		75-82	1	1:1.6-6.6	20-64
Horses	1000		700-900	1	1:70-100	360
Camels	450-840		595	0.5	1:10-70	210-250
Alpaca		80				
Llama		80-110				
Rabbits	4.0-7.2		4.5-7.6	30-50	1:15-20	1-2
Guinea pigs			0.6-1.0	20-30		0.7
Capybara	60		45	8.7		15.3
Pigs	350		220	20	1:20	45-67
Dogs		12-15				
Hens	4		3	108	1:10	1.45

Ducks	4.5		4.0	110-175	1:5-8	2
Geese	5-10		4.5-9	25-50	1:2-6	4-5
Turkeys	13-23		8-12	40-100	1:10-15	3-9

Source: Spedding and Hoxey (1975)

Table 1-7 - Products other than meat

Species	Products				
	Milk	Skin	Fibre	Feathers/down	Faeces
Cattle	+	+	+		+
Buffalo	+	+			+
Musk oxen			+		
Yak	+	+	+		
Sheep	+	+	+		+
Goats	+	+	+		+
Deer (red)		+			
Horses	+	+	+		+
Camels	+	+	+		+
Alpaca			+		

Llama			+		
Rabbits		+	+		+
Guinea pigs			+		
Capybars		+			
Pigs		+	+		+
Dogs					
Chickens / Hens				+	+
Ducks				+	+
Geese				+	+
Turkeys				+	+
Game animals and birds				+	

Source: Spedding and Hoxey (1975)

Table 1-8

Storage conditions for chilled animal products			
Commodity	**Temperature (�C)**	**Relative humidity (%)**	**Practical storage life**
Beef	-1.5 to 0	90	3-5 weeks
Beef (10% CO_2)	-1.5 to -1	90-95	max. 9 weeks

Lamb	-1 to 0	90-95	10-15 days
Pork	-1.5 to 0	90-95	1-2 weeks
Veal	-1 to 0	90	1-3 weeks
Chicken	-1 to 0	>95	7-10 days
Rabbit	-1 to 0	90-95	max. 5 days
From: Recommended conditions for cold storage of perishable products, International Institute of Refrigeration, Paris, 1967 & 1971			

Practical storage life of meat and meat products			
Products	Practical storage life in months		
	-18�C	-25�C	-30�C
Beef carcass	12	18	24
Roasts, steaks, packaged	12	18	24
Ground meat, packaged (unsalted)	10	>12	>12
Veal carcass	9	12	24
Roasts, chops	9	10-12	12
Lamb carcass	9	12	24
Roasts, chops	10	12	24
Pork carcass	6	12	15
Roasts, chops	6	12	15
Ground sausage	6	10	

Bacon (green, unsmoked)	2-4	6	12
Lard	9	12	12
Poultry, chicken and turkeys,			
eviscerated, well packaged	12	24	24
Fried chicken	6	9	12
Offal, edible	4		
From: Recommendations for the processing and handling of frozen foods, International Institute of Retrigeration, Paris, 1972.			

Contents - Previous - Next

Tables (part II)

Contents - Previous - Next

Table 2-1 - Approximate composition of mammalian skeletal muscle (percent fresh weight basis)

	Percent		Percent
WATER (range 65 to 80)	75.0	NON-PROTEIN NITROGENOUS SUBSTANCES	1.5
		Creatine and Creatine phosphate	0.5

PROTEIN (range 16 to 22)	18.5	Nucleotides (Adenosine triphosphate (ATP), adenosine tiphosphate (ADP), etc.)	0.3
Myofibrillar	9.5	Free amino acids	0.3
Myosin	5.0	Peptides (anserine, carnosine etc.)	0.3
Actin	2.0		
Tropomyosin	0.8		
Troponin	0.8	Other nonprotein substances (creatinine, urea, inosine monophosphate (IMP), nicotinamide adenine dinucleotide (NAD), nicotinamide adenine dinucleotide phosphate (NADP))	0.1
M protein	0.4	CARBOHYDRATES AND NON-NITROGENOUS SUBSTANCES (range 0.5 to 1.5)	1.0
C protein	0.2	Glycogen (variable range 0.5 to 1.3)	0.8
a-actinin	0.2	Glucose	0.1
b-actinin	0.1	Intermediates and products of cell metabolism (hexose and triose phosphates, lactic acid, citric acid, fumaric acid, succinic acid, acetoacetic acid, etc.)	0.1
Sarcoplasmic	6.0	INORGANIC CONSTITUENTS	1.0

Soluble sacroplasmic and mitochondrial enzymes	5.5	Potassium Total phosphorus	0.3
Myoglobin	0.3	(phosphates and inorganic phosphorus)	0.2
Hemoglobin	0.1	Sulfur (including sulfate)	0.2
Cytochromes and flavoprotein	0.1	Chlorine	0.1
		Sodium	0.1
Stroma	3.0	Others (including magnesium, calcium, iron, cobalt, copper, zinc, nickel, manganese etc.)	0.1
Collagen and recticulin	1.5		
Elastin	0.1		
Other insoluble proteins	1.4		
LIPIDS (variable range: 1.5 to 13.0)	3.0		
Neutral lipids (range: 0.5 to 1.5)	1.0		
Phospholipids	1.0		
Cerebrosides	0.5		
Cholesterol	0.5		

Source: Principles of Meat Science by Forrest et al. (1975) W.H. Freeman & Co

Source: Principles of Meat Science by Forrest et al. (1975) W.H. Freeman & Co.

Table 2-2 - Composition of fat and lean (per 100 g wet weight)

					Fat*			
	Water	**Protein**	**Pat**	**Energy**	**Sat.**	**Mono**	**Poly**	**Chol**
	(g)	**(g)**	**(g)**	**(MJ)**	**(g)**	**(g)**	**(g)**	**(mg)**
Beef fat, raw	24	9	67	2.6	29	32	3	90
lean	74	20	5	0.5	2	2	0.2	60
Lamb, fat	21	6	72	2.8	36	28	3	75
lean	70	21	9	0.7	4	3	0.4	80
Pork, fat	21	7	71	2.8	26	29	11	75
lean	72	21	7	0.6	2.5	3	1	70

Fat*: - saturated, monosaturated, polyunsaturated, cholesterol.

Table 2-2 (continued) - VITAMINS AND MINERALS

	Fe	**Cu**	**Zn**	**A**	**D**	**E**	**B1**	**B2**	**Niacin**	**B6**	**B12**	**Folate**	**Pantothenate**	**Biotin**
	mg	**mg**	**mg**			**mg**	**mg**	**mg**	**mg**	**mg**	**µg**	**µg**	**µg**	**µg**
Beef,														

fat, raw	1.0	0.1	1.0	-	-	0.3	-	-	-	-	tr	-	-	tr
lean, saw	2.1	0.14	4	tr	tr	0.15	0.07	0.25	5	0.3	2	10	0.7	tr
Lamb, fat	0.7	0.15	0.8	-	-	0.3	-	-	-	-	tr	-	-	tr
lean	1.6	0.17	4	tr	tr	0.1	0.14	0.3	6	0.25	2	5	0.7	2
Pork, fat	0.7	0.1	0.4	tr	tr	0.03	-	-	-	-	tr	-	-	tr
lean	0.9	0. 15	2.4	tr	tr	0	0.9	0.25	6	0.45	3	5	1	3

(McCance and Widdowson 1991)

Table 2-3 - TYPICAL ANALYSES OF VARIOUS TYPES OF MEAT

Source	**Protein**	**Fat**	**Na**	**K**	**Ca**	**Mg**	**P**	**Fe**	**Cu**	**Zn**	**Cl**
	(X wet wt.)	**(% wet wt.)**	**(mg/100g wet wt.)**								
Ox lean, av	20.3	4.6	61	350	7	20	180	2.1	0.14	4.3	59
Sheep											

lean, av	20.8	8.8	88	350	7	24	190	1.6	0.17	4.0	76
Pig lean, av	20.7	7.1	76	370	8	22	200	0.9	0.15	2.4	71
Calf, filet	21.1	2.7	110	360	8	25	260	1.2	-	-	68
Rabbit lean, av	21.9	4.0	67	360	22	25	220	1.0	0.54	1.4	74
Chicken, light meat, av	21.8	3.2	72	330	10	22	180	0.9	0.25	1.6	86
dark meat, av	19.1	5.5	89	300	11	25	190	1.2	0.20	2.0	90

Source	**Thiamin**	**Riboflavin**	**Nicotinic Acid**	**B6**	**B12**	**Folic Acid**	**Biotin**	**E**
	(mg)	(mg)	(mg)	(mg)	(µg)	(µg)	(µg)	(mg)
Ox lean, av	0.07	0.24	5.2	0.32	2	10	Tr	0.19
Sheep lean, av	0.14	0.78	6.0	0.25	2	5	2	0.10
Pig lean, av	0.89	0.25	6.2	0.45	3	5	3	-
Beef, fillet	0.10	0.25	7.0	0.30	1	5	Tr	-
Rabbit lean, av	0.10	0.19	8.4	0.50	10	5	1	0.13

Chicken, light meat, av	0.10	0.10	9.9	0.53	Tr	12	2	0.08
dark meat, av	0.11	0.22	5.4	0.30	1	12	3	0.14

(Lawrie 1981)

TABLE 24 - AMINO ACID COMPOSITION (ma AMINO ACID PER g PROTEIN) OF MUSCLE PROTEINS, CONNECTIVE TISSUE COMPONENTS AND SELECTED MEAT PRODUCTS

	Beef	Pork	Lamb	Cured Processed Meats	MDM*	Actin	Myosin	Tropomyosin	Bovine Collagen	Bovine elastin
Aspartic acid	88	89	85	91	88	107	115	117	43	9
Threonine	40	51	49	49	32	77	54	31	18	9
Serine	38	40	39	42	38	58	41	40	35	7
Glumatic acid	144	145	144	129	142	140	229	320	99	19
Proline	54	46	48	52	61	50	25	6	114	106
Glycine	71	61	67	80	82	43	26	9	187	189
Alanine	64	63	63	64	67	58	59	89	74	158
Valine	57	50	50	52	61	49	47	29	23	140
Methionine	23	25	23	22	28	42	33	25	8	Tr

Cystine	14	13	13	15	15	12	11	9	-	-
Total SAA	37	38	36	37	43	43	54	44	34	8
Isoleucino	51	49	48	49	39	84	55	39	15	31
Leucine	84	75	74	74	80	82	108	121	28	72
Tyrosine	32	30	32	29	25	67	33	29	67	13
Phenylalanino	40	41	39	40	43	48	47	9	21	52
Total aromatic	72	71	71	69	68	115	80	38	88	65
amino acidsHistidine	29	32	27	28	30	27	24	10	8	1
Lysine	84	78	76	74	78	70	146	184	30	4
Arginine	66	64	69	66	77	74	79	75	75	11
Tryptophan	11	13	13	10	5	20	9	-	-	-

***MDM - mechanically deboned meat**
(Pellet and Young 1990)

Table 2-5 - Composition of different cuts of meat

	Cut of meat	**Protein**	**Moisture**	**Pat**	**Ash**	**Cal/100 g**
		(%)	**(%)**	**(%)**	**(%)**	
BEEF	Chuck	18.6	65	16	0.9	220

	Flank	19.9	61	18	0.9	250
	Loin	16.7	57	25	0.8	290
	Rib	17.4	59	23	0.8	280
	Topside	19.5	69	11	1.0	180
	Rump	16.2	55	28	0.8	320
PORK	Ham	15.2	53	31	0.8	340
	Loin	16.4	58	25	0.9	300
	Shoulder	13.5	49	37	0.7	390
	Spare rib	14.6	53	32	0.8	350
LAMB	Breast	12.8	48	37	0.7	380
	Leg	18.0	64	18	0.9	240
	Loin	18.6	65	16	0.7	220
	Rib	14.9	52	32	0.8	360
	Shoulder	15.6	58	25	0.8	300

(Sawyer 1975)

Table 2-6 - Composition of Fats

	Total fat (%)	Per cent of total fat		
		SFA	**MUFA**	**PUFA**

Beef fat	67	43%	48%	4%
Lamb fat	72	50%	39%	5%
Pork fat	71	37%	41%	15%
Chicken, meat and skin	18	33%	42%	19%
Duck, meat and skin	43	27%	54%	12%
Calf liver	7	30%	18%	26%

SFA - Saturated Fatty Acids
MUFA - Monounsaturated Fatty Acids
PUFA - Polyunsaturated Fatty Acids

Table 2-7 - Cholesterol content of various foods (mg/100 g)

Milk	14
Butter	230
Hard cheese	70-100
Eggs	450
Egg yolk	1 260
Meat and poultry	60-120
Heart	140-260

Brain	2 000 - 3 000
Liver	300 - 350
Fish	50 - 60
Crustacea	100 - 200

Contents - Previous - Next

Tables (part III)

Contents - Previous - Next

Table 2-8

Constituents of meat from some free living animals				
Species	**Composition of meat**			
	Ash	**Fat**	**Solid nutrient**	**Calories /100g**
	(g/100 g fresh weight)			
Eland	1.1	1.9	23	125
Hartebeest	1.2	2.1	24	130
Topi	1.3	2.3	23	126
Giraffe	1.4	2.2	22	123
Buffalo	1.1	1.8	22	120

Warthog	1.2	2.3	25	132
Free range cattle	1.1	2.0	22	120
Intensive fat stock	0.9	15.0	18	230

A comparison of the fatty acids in muscle total lipids, triglycerides and ethanolamine phosphoglycerides1

Fatty acid designation	Bos taurus2 (Beef)			Taurotragus oryx (Eland)		Syncerus caffer (Buffalo)		Bos Indicus3 (African beef)		
	Total	Trigly ceride	EPG	Total	EPG	Total	EPG	Total	Triglyceride	EPG
16:0	29.0	33.0	12.0	19.0	9.0	16.0	11.0	17.0	29.0	15.0
18:0	18.0	16.0	36.0	20.0	33.0	22.0	32.0	18.0	16.0	33.0
18:1	47.0	45.0	16.0	17.0	9.0	23.0	14.0	28.0	48.0	18.0
18:2,n-6	1.2	1.0	1.6	22.0	8.5	16.0	4.5	14.0	3.6	3.7
18:3,n-3	0.9	0.5	0.8	4.1	3.8	5.0	3.0	3.5	2.1	2.0
20:3,n-6	0.3	0.1	3.0	0.8	0.4	0.3	0.9	1.1	0.1	1.1
20:4,n-6	1.2	0.2	12.0	6.4	15.0	7.1	12.0	7.0	-	13.0
20:5,n-3	0.2	-	2.9	1.0	1.9	1.1	2.5	1.8	-	1.9
22:5,n-3	0.5	-	8.0	3.8	9.3	3.0	9.0	4.0	-	11.0
22:6,n-3	0.2	-	1.4	0.8	3.4	0.2	0.9	0.8	-	1.2

1The results are expressed as the percentage (by weight) of the total fatty acids. These results illustrate that whole tissue fatty-acid analyses need not reflect the fatty-acid

composition of cell structural lipids.
2Intensive reared for the London market
3Non-intensive obtained from the Siroti market, Uganda

(Crawford. 1975)

Table 2-9 - Composition of offals (per 100 g raw)

Table 2-10A - PROPORTIONAL VALUE DERIVED FROM CARCASS MEAT AND DIFFERENT BY-PRODUCTS FROM CATTLE, HOGS AND LAMBS

	Cattle	**Pig**	**Lamb**
	(%)	**(%)**	**(%)**
Carcass meat	34	52	32
Bones	16	17	18
Organs	16	7	10
Skin and attached fat	6	6	15
Blood	3	3	4
Fatty tissues	4	3	3

Horns, hoofs, feet and skull	5	6	7
Abdominal and intestinal contents	16	6	11

(Goldstrand 1988)

Table 2-10B - NOMENCLATURE OF OFFAL (VARIETY MEATS, SIDE MEATS, ORGAN MEATS)

Tissue	
Stomach	Pork- maw
	Sheep - paunch
	Cow - tripe
Rumen	Blanket tripe
Reticulum	Honeycomb tripe
Omasum	Bible
Abomasum	Reed
Weasand	Gullet meat surrounding oesophagus; throat meat in lamb and veal
Giblets	Neck, gizzard, heart and liver of poultry
Small intestines of	Chitterlings

pigs	
Fat	(1) Lard - surrounding stomach and kidneys mainly of pigs (2) Tallow (hard fat or dripping) beef and mutton fat from parts other than kidney
Suet	From kidneys of oxen and sheep

Table 2-11 - Change in composition from cooking meat and meat products (per 100 g)

	Water	Protein	Fat	Energy		Thiamin	Niacin
	(%)	(%)	(%)	kcal	MJ	(mg)	(mg)
Bacon, collar joint lean & fat, raw	51	15	29	320	1.3	0.4	2.7
boiled	49	20	27	325	1.3	0.3	2.6
Beef brisket, raw	62	17	21	250	1.4	0.05	3.7
boiled	48	28	24	290	1.2	0.04	4.3
Rump steak, raw	67	19	14	200	0.8	0.08	4.2
fried	56	29	15	250	1.0	0.08	5.5
grilled	59	27	12	220	0.9	0.08	5.7
Lamb cutlets, raw	49	15	36	390	1.6	0.09	4
grilled	45	23	31	370	1.5	0.10	5
Veal fillet, raw	75	21	3	110	0.5	0.1	7

roast	55	32	12	230	1.0	0.06	7
Chicken meat, raw	74	21	4	120	0.5	0.1	8
boiled	63	29	7	180	0.8	0.06	7
roast	68	25	5	150	0.6	0.08	8
Rabbit meat, raw	75	22	4	120	0.5	0.1	8.4
stewed	64	27	8	180	0.7	0.07	8.5
Ox liver, raw	69	21	8	160	0.7	0.25	13
stewed	63	25	10	200	0.8	0.2	10
Beefburgers, raw, frozen	56	15	21	265	1.1	0.04	3.7
fried	53	20	17	265	1.1	0.02	4.2
Beef sausage, raw	50	10	24	300	1.2	0.03	5
fried	48	13	18	270	1.1	0	7
grilled	48	13	17	270	1.1	0	5

(McCance and Widdowson, 1991)

Table 2-12 - Per Cent Composition Raw and Cooked Meats (Coefficient of Variation) (From Massachusetts Nutrient Data Bank)

Product		**Protein**	**Fat**

Beef steak (with bone)	Raw	18.7 (15)	19.4 (65)
	Cooked	26.4 (16)	21.4 (63)
without bone	Raw	19.2 (14)	16.9 (74)
	Cooked	27.4 (15)	17.6 (75)
Pork chops	Raw	19.3 (11)	15.1(61)
	Cooked	27.0 (14)	20.9 (36)
Bacon	Raw	6.3 (58)	69.7 (30)
	Cooked	18.0 (59)	52.9 (59)
Lamb	Raw	17.1 (13)	18.5 (60)
	Cooked	24.7 (14)	19.2 (62)

(Pellett and Young, 1990)

Table 2-13 - Macronutrients in Chicken (in %)

Product	**Water**	**Protein**	**as % DM***	**Fat**	**as % DM***
Light	74.4	21.8		3.2	
Dark	74.5	19.1		5.5	
Total with skin	64.4	17.6		17.7	
Total meat raw	74.4	20.5	82.7%	4.3	17.3%
Boiled	63.4	29.2	80%	7.3	20%

Roast	68.4	24.8	82.1%	5.4	17.9%

***DM = Protein + Fat**
(McCance and Widdowson, 1991)

Table 2-14 - Retention of vitamins B_1 and B_2 in different cuts of braised meat

	Weight	**Time of cooking**	**Vitamin B_1**	**Vitamin B_2**
	(lb)	**(min/lb)**	**(% retention)**	**(% retention)**
BEEF				
Short ribs	4.5	30	25	58
Chuck	6	35	23	74
Flank steak	1.75	28	30	72
Round (roast)		27	40	73
Round (steak)		18	40	65
VEAL				
Chops	1.75	28	38	73
Round steak	1.75	27	48	76
PORK		Total time of cooking		

Chops		50 min	44	64
Spare ribs		2 h	26	72
Tenderloin		40 min	57	83

(Noble, 1965)

[Contents](#) - [Previous](#) - [Next](#)

Tables (part IV)

[Contents](#) - [Previous](#)

Table 2-15 - Vitamins B_6, B_{12} and Folate

Vitamin B_6, Vitamin B_{12}, and Folate content of cooked lean beef			
Item	**Vitamin B6**	**Vitamin B12**	**Folate**
	(μg/100 g)	**(μg/100 g)**	**(μg/100 g)**
Round			
Top, broiled	0 56	2 48	12
Eye, roasted	0 38	2 17	7
Loin, broiled			
Top loin	0 42	2 00	8
Tenderloin	0 44	2.57	7

Rib			
Small end, broiled	0 40	3 32	8
Large end, roasted	0 26	2 61	9
Chuck, braised			
Blade	0 29	2 47	6
Brisket, braised			
Flat portion	0 28	2.58	8
Ground (85% lean)			
Broiled (medium)	0 27	2 71	9
Pan-fried (medium)	0 28	2.45	9

Percent retention of Vitamin B_6, Vitamin B_{12} and Folate in cooked lean fresh beet or pork			
% retention			
Item	Vitamin B_6	Vitamin B_{12}	Folate
Beet, fresh, lean			
Braised	46	67	72
Broiled	74	75	87
Roasted	66	72	88
Pork, fresh, lean			
Braised	52	60	65
Broiled	0	91	86

Roasted	64	82	95
(Watt and Merrill, 1975)			

Retention of Vitamin B_6 in Roast fleer		
Roast beef	Vitamin B_6	Vitamin B_6 retained
	(mg/100 g)	(%)
Initial	0.47�0.12	-
Reheated	0.26�0.11	55.3
Held 1 h (66�C)	0.22�0.10	46.8
Held 2 h (66�C)	0.20�0.10	42.6
Held 3 h (66�C)	0.15�0.07	31.9
(Reiter and Driskell, 1985)		

Table 2-16 - Composition of Cured Meats per 100 g (in %)

	Water	**Protein**	**Total Fat**	**SFA**	**MUFA**	**PUFA**	**Chol**	**Energy**
							(mg)	**(MJ)**
Bacon, fat only, raw	13	5	80	31	36	9	200	3.0
Lean only	67	20	7	3	3	1	20	0.6

Collar, joint lean & fat boiled	50	20	27	11	12	3	100	1.3
Gammon, joint, lean& fat, boiled	54	25	19	7	9	2	70	1.1
Gammon rashers, grilled	52	30	12	5	6	1	45	0.9
Rashers, lean & fat, fried	30	25	40	16	18	4	140	1.9
"streaky" fried	28	23	45	18	20	5	160	2.0
"streaky" grilled	35	25	36	14	16	4	130	1.7
Beef, salted, silverside, boiled	55	29	14	6	7	0.6	80	1.0
Ham, canned	73	18	5	2	2	0.6	70	0.5
US data	65	18	12					0.8

SFA Saturated Fatty Acids
MUFA Monounsaturated Fatty Acids
PUFA Polyunsaturated fatty acids - as per cent total fat
Chol Cholesterol (ma per 100 g meat)
(McCance and Widdowson, 1991 - figures rounded off)

Table 2-16 (continued) - Composition of cured meats per 100 g

					VITAMINS						
	Na	**Fe**	**Cu**	**Zn**	**E**	**B1**	**B2**	**Niacin**	**B6**	**B12**	**Pantothenate**
	(mg)	**(mg)**	**(mg)**	**(mg)**	**(mg)**	**(mg)**	**(mg)**	**(mg)**	**(mg)**	**(μg)**	**(mg)**
Bacon, fat only	560	0.7	0.06	0.6	0.1	-	-	-	-	tr	-
lean only, raw	900	1.2	0.1	2.5	0.06	0.7	0.3	4.7	0.5	tr	0.6
collar joint lean and fat, boiled	1100	1.6	0.2	4	0.1	0.3	0.2	2.6	0.2	tr	0.4
Gammon joint lean and fat boiled	1000	1.3	0.2	3	0.1	0.3	0.2	2.6	0.2	tr	0.4
gammon rashers grilled	2100	1.4	0.2	3	0.1	0.9	0.2	6	0.3	tr	0.6
Rashers, lean and fat, fried	1900	1.3	0.1	3	0.2	0.4	0.2	5	0.3	tr	0.3
"streaky" fried	1800	1.2	0.1	2	0.2	0.4	0.2	5	0.3	tr	0.3
"streaky" grilled	2000	1.5	0.15	3	0.1	0.4	0.2	4	0.3	tr	0.5

Beef salted silverside boiled	900	3	0.25	6	0.3	0.03	0.3	3	0.3	2	0.8
Ham, canned	1250	1	0.2	2	0.1	0.5	0.25	4	0.2	tr	0.6
US data	1100	3				0.5	0.2	4			

Table 2-17 - Typical composition of cooked sausages made of precooked raw materials

Component	**Type**							
	Liver paste		**Liver sausage**		**Cooked sausage with high collagen content**		**Blood sausage**	
	1	2	1	2	1	2	1	2
(%)								
Liver	10	10	15	10	10	5	5	-
Fatty tissue	30	30	20	20	10	25	30	20
Head meat	20	30	20	30	40	33	15	5
Lean meat trimmings	5	-	5	-	5	-	-	5
Other organs	5	10	10	15	5	10	10	13

Pigskin/beef tendons	-	10	5	13	15	20	30	-
Broth	14	15	15	15	15	10	-	15
Caseinate	3	3	2	3	-	-	-	-
Seasonings	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Nitrite salt	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Fried onions	1	-	1	-	-	-	-	-
Cured blood	-	-	-	-	-	-	20	10

Table 2-18 - Composition of sausages of various types (US values except for two UK figures) Per 100 g

	Water	Energy	Protein	Fat	Iron	Vitamins (mg)		
	(%)	MJ	(%)	(%)	(mg)	B1	B2	Niacin
Blood sausage	46	1.6	14	37				
Bock worst	62	1.0	11	24				
Bologna	56	1.2	12	30	1.8	0.16	0.22	2.6
Capicola	26	2.0	20	45				
Dry Cervelat	29	1.8	25	38	2.7	0.3	0.2	5.5
Frankfurter, raw	56	1.2	13	28	1.9	0.16	0.2	2.7
Knock worst	58	1.1	14	23	2.1	0.17	0.2	2.6

Liver worst fresh	54	1.2	16	26	5.4	0.2	1.3	6
Mortadella	50	1.3	20	25	3			
Pork sausage	35	1.9	18	44	2.4	0.8	0.3	4
cooked								
UK figures, fried	45	1.3	14	25	1.5	0.01*	0.25	4
Salami, cooked	51	1.2	18	26	2.6	0.25	0.25	4
UK figures	28	2.0	19	45	1.0	0.2	0.2	5
Thuringer	49	1.2	19	25	2.8	0.1	0.25	4

*** Preserved with SO_2 which destroys thiamin**

(Watt and Merrill, 1975)

Table 3-1 - World population and meat production in various regions

Countries	Population 1985 (millions)	Meat production					
		Total Million (metric tons)	Per capita (kg)	Approximate percentages			
				Cattle	Sheep	Pigs	Poultry

Developed							
North America	264.2 (1.0)	28.2 (1.4)	106.8	43	1	25	30
Western Europe	377.4 (0.4)	31.0 (2.4)	82.0	32	4	46	20
Oceania	19.0 (1.4)	3.7 (1.2)	196.0	50	31	9	10
Eastern Europe and USSR	392.4 (0.8)	27.1 (2.5)	69.0	36	5	44	15
Developing							
Africa	449.0 (3.0)	5.0 (2.4)	11.2	48	15*	9	28
Far East	1 379.4 (2.3)	6.3 (3.9)	4.6	15**	13*	57	16
Latin America	406.2 (2.4)	15.3 (2.8)	37.6	56	3	19	22
Near East	240.2 (2.8)	4.4 (4.2)	18.2	37	28	<1	35
Developing countries	3 632.8 (2.2)	52.1 (4.0)	14.3	44	12	22	23
Developed countries	1 210.5 (0.8)	94.8 (2.2)	78.3	37	4	37	21

Source: FAO (1986), USDA (1988)
***Includes goat**
****Includes buffalo**
Note: Values in parentheses for population and production data are the annual rates of change

Table 3-2 - Polyunsaturated Fatty Acids and Cholesterol Fatty Acid (% total fatty acids)

Source	C18:2	C18:3	C20:3	C20:4	C20:5	C22:5	C22:1	C22:4	C22:6	Cholesterol (mg/100 g)
Ox, lean	2.0	1.3	Tr	1.0	Tr	Tr	-	-	-	59
Sheep, lean	2.5	2.5	-	-	Tr	Tr	-	-	-	79
Pig, lean	7.4	0.9	-	Tr	Tr	Tr	-	-	1.0	69
Rabbit, lean	13.5	0.7	Tr	0.7	0.7	Tr	-	-	-	71
Chicken, lean	20.9	9.9	Tr	1.9	1.9	1.3	-	-	-	90
Brain, sheep	0.4	-	1.5	4.2	0.7	3.4	0.6	0.8	9.5	2200
Heart, ox	2.5	0.5	Tr	0.7	0.7	Tr	-	-	-	140
sheep	7.3	2.7	Tr	2.1	2.1	Tr	-	-	-	140
Kidney, ox	4.8	0.5	Tr	2.6	Tr	Tr	-	-	-	400
sheep	8.1	4.0	0.5	7.1	Tr	Tr	-	-	-	400
pig	11.7	0.5	0.6	6.7	Tr	Tr	-	-	-	410
Liver, ox	7.4	2.5	4.6	6.4	0.7	5.6	-	-	1.2	270
sheep	5.0	3.8	0.6	5.1	-	3.0	-	-	2.4	430
pig	14.7	0.5	1.3	14.3	-	2.3	-	-	3.8	260
calf	15.0	1.4	2.1	9.0	0.3	4.0	-	-	2.5	370

Sweetbread, sheep	2.1	2.2	-	1.3	Tr	-	-	-	-	260
Tongue, sheep	4.0	3.4	-	Tr	Tr	-	-	-	-	180
Tripe, ox, dressed	1.5	0.6	-	Tr	Tr	-	-	-	-	95

(McCance and Widdowson's "The Composition of Foods" 4th Ed. 1978 A.A. Paul and D.A.T. Southgate HMSO)

Contents - **Previous**