HEALTH ASPECTS OF THE CONSUMPTION OF PIGMEAT (PORK)

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INTRODUCTION

Foods of animal origin such as meat, fish, eggs and milk are an important source of easily digested proteins of high biological value and of some other valuable nutrients. However, large communities of people in different parts of the world avoid one or other type of these valuable foods, and vegetarians reject all of them. One of the meats which is widely and vigorously rejected is pork. Its strict avoidance by Muslims and practicing Jews is well known, but other communities in Africa, Central and Southern Asia and Oceania also reject pig meat (see Simoons, 1961, for a discussion of the cultural geography of avoidance of pork and other flesh foods).1

Various theories have been advanced to explain the origin and rationale of avoidance of pork and other foods of animal origin (see Annex). One of the several hypotheses stipulates that the prohibition of pork resulted from a collective experience of disease (or diseases) transmitted or caused by pigmeat in antiquity or ancient times. Various recent findings in food hazards, zoonoses and risk factors related to chronic degenerative diseases have been cited in support of, or against, this theory. Of course, folk medicine and popular food lore of various countries where pork is consumed, are also full of anecdotes ("wisdom") on this subject.

The present paper attempts an examination of the available scientific evidence of the risks to human health associated with the consumption of pork and its products. Where appropriate, a comparison is made with other types of meat, such as beef, mutton. poultry, and fish. The nutritional aspects are referred to only as risk factors where they are hazardous.

Health hazards of pork may be discussed under the following heading:

1. Microbial and parasitic infections transmitted through pork.
2. Non-communicable diseases attributed to the consumption of pork.
3. Risk factors in relation to chronic degenerative diseases.
4. Hazards from residues, and additives in pork and pork products.
5. Hazards in the pig breeding establishments.
6. Other relevant factors.

MICROBIAL AND PARASITIC INFECTIONS

These could be divided into two broad categories: (a) zoonoses, i.e. infections of pigs transmitted to man through meat, and (b) contaminants which may enter meat during handling, cutting, processing, storage, etc. and may cause disease in the consumer. For the purpose of this paper, the second category is unimportant as contamination of pigmeat would not differ from contamination of other meat (beef, mutton, poultry) if they are mishandled in a similar manner. Pathogenic bacteria such as Salmonella, Shigella, Campylobacter, toxigenic Escherichia coli, Staphylococci and others can contaminate meats or plant food products (e.g. bread) under unhygienic conditions.

Of the zoonoses, the more important and widespread bacterial infections like salmonellosis, campylobacteriosis and the protozoan infections (toxoplasmosis and sarcocystosis) are not restricted to pigs and may be transmitted from cattle, sheep (and some from poultry) if the meat is consumed raw or undercooked. The infective agents are readily destroyed by proper cooking and salmonellae would not grow in food stored cold or hot even if they are present in small numbers. Salmonella and Campylobacter ingested in large numbers would produce disease characterised by nausea, vomiting, abdominal cramps and diarrhoea, and sometimes fever. They could cause death in vulnerable groups such as infants, old people and patients suffering from some other diseases.

Of the parasitic zoonoses, the pork tapeworm (Taenia solium) infection may result from consumption of raw or insufficiently cooked meat containing cysticerci of this worm. This is generally a subclinical infection and is detected only by faecal examination. The few clinical cases may show nausea, abdominal pains, flatulence, diarrhoea or constipation. In some cases there is debility and weight loss also.

Taeniasis (T. solium) is common in countries where pigs have access to human excreta. A similar infection caused by the beef tapeworm (Taenia saginata) which is much more widespread than the pork tapeworm,2 has a parallel life-cycle and a similar pathology. The main danger of the pork tapeworm, however, lies in the fact that its larvae (cysticerci) can

infect not only the pig but also man causing a serious disease. If the cysticerci lodge in the subcutaneous tissue or the muscle (even heart muscle) they may not cause any serious symptoms, but often they invade the brain (meninges, cerebral cortex and the ventricles), spinal cord, the eye, and, sometimes several organs simultaneously (disseminated cysticercosis).

Human cysticercosis is a serious problem in countries of Centra13 and South America and represents a heavy burden on the health care services. Most cases of clinical neurocysticercosis treated in hospitals require more than one surgical intervention. Thus, the treatment, which may succeed only in about half of the patients, is cost intensive and difficult.

The larvae of the beef tapeworm (T. saginata) do not cause human cysticercosis.

One of the more serious parasitic zoonoses transmitted through pork is trichinellosis. The causal agent Trichinella spiralis is a slender worm which lives a few weeks in the small intestine of man and a number of animal species including pigs, dogs, cats, rats, wild carnivores and many others including marine mammals like seals and walruses. The larvae of the worm migrate from the intestine to the muscles of these animals and remain encysted there for years. Human infection results from consumption of insufficiently cooked meat of infected animals or meat products, mostly of porcine origin. The symptoms may start a week or 10 days after ingestion with the start of the muscular invasion phase. They consist of oedema of the upper eyelids, myalgia, headaches, fever, sweating and chills. The disease lasts for 10 to 30 days but muscular pains may persist in some cases for several months. Mortality is generally under 1% but in some outbreaks it may be as high as 30 - 35%.

The pigs get infected through feeding on infected tissues of other pigs, dogs, rats, etc. which may be in the garbage often fed raw to these animals. In recent years, swine trichinellosis (which used to be common in Central and Eastern Europe and in the United States) has been brought under control through boiling of pig feed.

Even so, the infection exists locally in various countries and 50% of pigs in some herds may be infected. In other cases the infection exists in pigs (e.g. in Egypt, where 5 - 10% animals are infected), but human cases do not occur in the local population (Greeks and Copts) as they cook the pork thoroughly. Infections in tourists who consume undercooked pork have been observed. Wild animals are infected in many parts of the world where human cases are absent or rare.

There are a few other, relatively less common zoonoses which can be transmitted through pork but they are usually only locally important and are transmitted also through other meats and foods. But recent outbreaks in the United States have been traced to pigs more often than to other animals. Examples of such infections are yersiniosis (Y. enterocolitica) and listeriosis (L. monocytogenes). They are frequently conveyed in milk, milk products, poultry and other meats.

It will be seen from what has been stated above that the two zoonoses which are particularly associated with the consumption of pork are human cysticercosis and trichinellosis. In all other cases various other meats (beef, mutton, poultry, game) are equally or more importantly implicated. Trichinellosis has been cited as the reason 5 and rationale of the prohibition of pork in ancient times.

NON-COMMUNICABLE DISEASES ASCRIBED TO THE CONSUMPTION OF PORK

Anecdotal claims connecting pork as well as other types of meat with various diseases or infirmities abound in different parts of the world. On the other hand. these foods are credited with being cures for disease or having invigorating effects on consumers. Unfortunately, some of these folk beliefs have been uncritically accepted and propagated in "scientific" language by some physicians or other trained persons even in the so-called developed countries. For example, a practising physician recently ascribed 6 the causation of a number of diseases to the consumption of pork. He stipulated the presence in pork of a specific toxin (Sutoxin) and considered cholestrin, histamine, hormones and an oncogenic factor in swine blood to be the causes of various diseases. He thought also that swine influenza virus (dormant in the lungs) may be transmitted to the consumers.

These claims have been critically examined by various scientific bodies and individual scientists and their views have been summarized in the official report of the German Nutrition Association.7 While admitting that pork may cause food allergy (like other meats, milk, eggs, etc.) they could not substantiate any of the claims and views of Reckeweg and found no evidence of the existence of sutoxin.

Recently, some scientific evidence of the hazards of pork consumption has also emerged. For example, Nanji and French 8 investigated the relationship between average per head consumption of pork, alcohol and mortality from liver cirrhosis in several countries: they found that the correlation between cirrhosis mortality and the product of both alcohol and pork consumption was highly significant. However, in countries and provinces with low alcohol consumption a significant correlation was found between cirrhosis and pork. These observations are important and impressive - but as the authors have remarked themselves this "correlation does not necessarily imply a causal relationship but should be investigated further".

Thus, there is circumstantial evidance of the role of pork in the causation of fatal liver cirrhosis and an accepted role in food allergy. The latter is shared with many other foods of animal origin.

RISK FACTORS IN RELATION TO CHRONIC DEGENERATIVE DISEASES

The two main constituents of meat which are considered to be connected with risk factors of cardiovascular diseases and colon cancer are cholestrol and saturated fats. It will therefore be useful to compare pork with other meats as a source of these constituents.

Cholestrol in human food is derived only from animal products such as meat, milk, eggs and fish. The cholestrol content of some animal products is given 9 in the following table.

TABLE 1: CHOLESTROL CONTENT OF SELECTED FOOD PRODUCTS OF ANIMAL ORIGIN

Product	Cholestrol
1. Beef, lean trimmed of separable fat	65
2. Pork, lean, trimmed of separable fat	60
3. Chicken, breast meat	79
4. Chicken eggs	504
5. Lamb, lean, trimmed of separable fat	70
6. Veal, lean, trimmed of separable fat	70
7. Halibut (flesh only)	50
8. Liver (beef, calf, pig and lamb)	300
9. Brain	2000
10. Milk	14

It is evident from the above table that pork is not richer in cholestrol in comparison with several other meats and food products. It may be of interest to mention that cholestrol in the muscle (meat) is associated with structures such as cell-membranes, nuclei, mitochondria, sarcoplasmic reticulum etc., but not with visible intramuscular fat (marbling). Therefore the frequent recommendation to avoid fat meat and take only lean meat in order to reduce cholestrol intake has little scientific basis.

Fat is deposited in various parts of the body of animals which consume above maintenance level feeds. In monogastric animals (pigs, poultry) there is a direct relationship of the amount of body fat to energy in the diet which is less apparent in the ruminants. Fat is deposited in two principal sites in the body: Firstly in fat deposits such as the abdomen (peritoneium, around kidneys), around the heart and under the skin (adipose tissue). In some breeds of sheep, there is an additional depot in the tail and in camels in the hump. The second site is the muscle itself which is more limited than the adipose tissue. The chemical composition of intramuscular fat differs in some respects from the fat of adipose tissue which is true fat, i.e. esters of glycerol with fatty acids. Intramuscular fat, like that of other metabolically active tissues has considerable amounts of phospholipids and unsaponifiable constituents.10

Fat content of muscle differs in various muscles but also with age and species of the animal, genetic factors, nutrition, hormones, and other factors. For comparison between different species the fat content of Longissiumusdorsi,11 the longest muscle in the body, is generally used and is shown in Table 2.

TABLE 2: SOME CONSTITUENTS OF THE LONGISSIMUS DORSI MUSCLE FROM MATURE MEAT ANIMALS

Constituent (Per Cent)	Pig	Ox	Sheep
Water	76.7	76.8	77.0
Intramuscular fat	2.9	3.4	7.9
Total nitrogen	3.7	3.6	3.6

The fat content of Psoas major muscle of pigs and oxen is 1.6 and 1.7% respectively.

For further detailed information on characteristics of meat fats reference is made to Lawrie (1966).11

The depot-fat (adipose tissue) can be easily left out of the diet. In fact large quantities of this fat are discarded or used for industrial purposes. It has been said that the depot-fat of pigs (lard) was largely used for making explosives (nitroglycerines) in the two world wars.12

Pigs are traditionally considered to be fat animals. This is true for pigs fed on grain and other energy feeds. Most of the pigs outside the industrialized countries feed for themselves generally on rubbish heaps where they act as scavengers. Such pigs have relatively minor fat depots and often have so-called "razor backs" characteristic of debilitated animals. In the industrialized countries also there is an increasing demand for lean and low-fat pork. The breeders have now managed to produce animals with 25 to 40% less fat than was the case two or three decades ago. This has been possible through selective breeding and better understanding of animal nutrition. Such approaches have had much slower results in ruminants, such as, cattle and sheep.

Having compared the cholestrol and fat content of various meats, one could mention briefly their role as risk factors for arterial hypertension, atherosclerosis, coronary heart disease and cancer of the large intestine (carcinogenic faecal steroids).

Relationship between blood pressure and (human) body weight has been established in various epidemiological studies13,14 on arterial hypertension. However, the causes of obesity are not entirely dietetic as heredity and exercise are also important factors. Nevertheless, animal fat is a rich source of energy and may contribute importantly to increase of weight if other factors are operative. The role of sodium intake in the causation of hypertension is somewhat unclear. Probably relative intake of potassium, calcium or magnesium may be significant. In limited studies, it has been suggested that the adverse effects of high salt intake may be attenuated by a high protein intake.15 If this is confirmed, meat consumption may have a beneficial effect on hypertension.

Regarding dietary factors related to atherosclerosis and coronary heart disease (CHD), a WHO Expert Committee16 reached the following conclusions after having examined the available evidence: "Diets in populations having high average total cholestrol levels and mass CHD are characterized by relatively high saturated fat and cholestrol consumption, a relatively high energy intake in relation to energy expenditure (with resultant high relative weight and prevalence of obesity) and relatively low complex carbohydrate consumption." In

its dietary guidelines the Committee de-emphasized the consumption of "high-fat meats from domestic breeds as principal protein source" and advised "fish, poultry and lean meats used in small portions". The high fat meats would be the so-called red meats which include beef, mutton and pork.

Epidemiological studies in different parts of the world and experimental studies in animal models have shown that diets particularly high in total fat and low in fibre are generally associated with an increased incidence of large intestine (colon) cancer in man.17 Furthermore, it has been shown that the diet variables chiefly associated with colon cancer rates are meat and animal protein; total fat, meat and animal proteins are highly correlated.18 Howell (1975) has pointed out that beef consumption was more related to colon cancer rates than was consumption of pork, poultry or fish.19

HAZARDS FROM RESIDUES AND ADDITIVES IN PORK AND ITS PRODUCTS

In countries with intensive animal production various antibacterial agents and growth promoting substances are used to prevent disease and to increase weight and feed efficiency of the meat animal. These substances have important health implications as many of them may persist in meat and viscera of the slaughter animal .20 The antibacterial agents, such as antibiotics, may cause multi-strain resistance in bacteria pathogenic for man, e.g. Salmonella. This may cause serious problems in therapy when resistant organisms cause human infections.

Among the growth promoting susbstances currently used are natural steroids and xenobiotic anabolic agents like trenbolone acetate, zeranol and synthetic stilbenes.21 The latter include hexestrol, dienestrol and diethylstilbestrol (DES). The correct use of steroid anabolic hormones poses no known health problems to the consumer. On the other hand stilbene oestrogens are orally active, persist in food and DES is a known carcinogen.22 Most countries prohibit the use of synthetic stilbenes but illegal use is known to occur.

Antibacterial agents are used in pigs and other meat producing animals but anabolic agents are used much more frequently in calves and poultry than in pigs. In the latter the weight gain is less marked but the proportion of muscle to adipose tissue may be increased.

Of the various additives used in pork products nitrates and nitrites are the most frequent and most important because they are used in the curing process. Also, in industrialized countries the major part of pork is consumed after curing in the form of ham, bacon and sausages of many kinds. Nitrate is readily reduced to nitrite which is used directly also in curing meats. It inhibits the growth of microorganisms (including the highly dangerous Clostridium botulinum), imparts a reddish pink colour and a characteristic cured flavour to the meat. In the human body, nitrites are converted into nitrosamines which have been shown to cause hepatic cell tumours in rats. Nitrates are present in virtually all foods, especially in vegetables and in drinking water in some localities. Nitrites are used in curing not only pork but other meats such as beef, turkey meat, etc. It is present in small quantity in the human saliva. Because of the concern about the presence of nitrite residues in meats, efforts are being made to reduce their use in curing and to increase the use of other chemicals, such as, ascorbate and erythorbate which have been found suitable for this purpose. In the meantime the nitrite in cured pork products remains a suspected hazard.

HAZARDS OF PIG BREEDING

People who work in piggeries or handle these animals alive or after slaughter are occupationally exposed to certain infections transmitted through contact or proximity. These are mostly bacterial infections like leptospirosis (Leptospira pomona causes swineherds disease), brucellosis (Brucella suis), erysipeloid (Erysipelothrix rhusiopathiae) and anthrax. Pigs may get involved in the transmission of balantidial dysentery (Balantidium coli) which is also transmitted from person to person.

In some areas pigs act as amplifying hosts for Japanese encephalitis virus which is transmitted by mosquitoes. Thus pigs act also as sentinel indicators for the disease before human cases begin to occur.

In comparison to pigs, cattle and sheep can also be reckoned as important sources of human disease. For example, the brucellosis contracted from sheep and goats (Malta fever, Br. melitensis infection) is much more serious and more widespread than swine brucellosis. Leptospirosis can also be transmitted from these animals and from cattle.

As stated above, it has been suggested that swine influenza virus dormant in the lungs or lungworms of swine may cause various types of illness in man. This virus is transmissible to man but in recent decades only a few isolated instances of such transmission on a limited scale have been reported. The virus produced acute respiratory illness and the outbreaks were self-limiting. Some bird species, horses and other animals are suspected as sources of epidemic influenza strains, perhaps by recombination among themselves and with human strains. It has also been suggested that strains of human influenza virus may get localized in swine and may be transmitted back to man but this has not so far been observed to happen in nature.

OTHER RELEVANT FACTORS

In the foregoing pages the health effects of biological, chemical and patho-physiological factors related to pork have been considered. In some individuals strong psychological reactions to pigs may be observed. These are enhanced by observation of the scavenging habits of the pigs on village refuse heaps where they eat filth or will wallow in mud mixed with their own excreta. In Australia and Africa south of the Sahara (except Sudan), there were no domesticated pigs before the Europeans introduced them in the eighteenth century. (In Africa wild pigs were present.) Some local communities in these continents took to pig breeding and pork consumption, but many others refused to do so and still avoid this type of meat, mainly because of revulsion (and not religion).

SUMMARY OF THE HEALTH HAZARDS OF PORK CONSUMPTION

The more important and definitely proven hazards connected with the consumption of pork are the two parasitic zoonoses, trichinellosis and systemic cysticercosis. Both these infections can be life threatening and their prevention requires difficult measures including change of food habits.

Of the non-communicable diseases attributable to pork consumption (food) allergy and liver cirrhosis have been shown to occur, though more work is needed to prove its aetiological role in cirrhosis.

Consumption of pork and lard can give rise to hyperlipidaemia, constituting a risk factor in cardiovascular diseases. Furthermore, high pork and lard consumption in a low fiber diet would have a correlation with high incidence of cancer of the colon. However, these risk factors are shared by pork with other meats and foods of animal origin.

Of the additives used in curing pork for preparation of ham, bacon, sausages, etc. nitrites could be a hazard as they are converted to nitrosamines which have been shown to be carcinogenic in animals. The exact risk for man is not known and nitrites are present in many other foods including vegetables and sometimes in drinking water.

Pig breeding establishments can be sources of transmission of zoonoses to people exposed to living animals; these include leptospirosis (swineherds disease), brucellosis, erysipeloid and anthrax. Pigs may also increase chances of spread of balantidial dysentery and Japanese encephalitis. However, other meat animals can also act as sources of some of these zoonoses and of others which may be equally (or more) dangerous.

Pigs can cause strong psychological reactions (e.g. disgust) especially when scavenging on rubbish heaps or wallowing in mud mixed with their own excreta.

ANNEX
Reasons for avoiding pork as food

The Muslims, Jews and some Christian sects reject pork because of prohibitions as revealed in their Holy Books, the Quran and the Bible. God Almighty is all-knowing and our limited knowledge and science cannot as yet understand all the reasons for prohibitions and recommendations contained in the divine guidance and revelations, although we should keep on striving to understand them.

For Muslims, the prohibition of pimgeat was, at first, theoretical as there were no domestic pigs in Hejaz at the time of the revelation of the relevant verses of the Quran, but Islam is a universal religion (din) and was not meant to be limited to any single geographical area. There have been several communities other than Muslims and people of the book (Kitabis) who avoid pork. Among the pre-jewish people, the Egyptians of the dynastic period avoided pork some 2000 years before the codification of the Mosaic food traditions. Subsequently, pork consumption re-appeared among certain classes of Egyptians but avoidance appeared once again before the first Persian conquest (525B.C.)23. In several parts of Ancient Mesopotamia there was an ambiguity with regard to pigs which were considered sacred and unclean at the same time.

Although the Greeks, in general, freely ate pork, there were religious cults in Asia Minor and Crete which avoided this type of meat.24

In more recent times, large non-muslim communities in Africa (south of the Sahara), Central

Asia (Mongolia), South-East Asia and Oceania also avoid pork;1 these are mostly pastoral peoples.

Some of the hypotheses which have been advanced to explain the avoidance of pork are as follows:

- Reasons of hygiene and hazards to health.
- The pig is a scavenger and visibly dirty in its habits.
- Pork decays rapidly, especially in warm climates.
- Through eating pork one gains the pig's physical or "personality" characters (This belief is widespread and applies also to many other meats and foods.)
- Human souls transmigrate to various animals including pigs.
- Certain groups have totemic relationship with pigs which may have helped the group in some way in the past, thus becoming sacred.
- Hatred of other human groups which eat pork or at least the desire to remain distinct from them.
- Other reasons including low prestige value, strangeness and psychological feelings of disgust.
- Religious prohibition as illustrated by monotheistic religions has already been mentioned in the first two paragraphs of this section and is a powerful factor in pork avoidance.

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