# MEAT AND MEAT PRODUCTS IN NUTRITION

R.J.J. Hermus, TNO-CIVO Toxicology and Nutrition Institute, Zeist
H.F.F. Albers, Dutch Meat Board, Rijswijk

## Introduction

Meat is an important food. Most people enjoy eating meat because of its sensory characteristics. Meat is the food around which meals are planned at home and away from home. Meat is also a very nutritious food as it supplies a considerable part of the daily nutrient requirements for large groups in the population.
However, there are indications that limits to meat consumption are being reached. In addition, consumers are becoming increasingly health conscious and suspicious about fat, salt, residues and additives which may be concealed in products. Although at the same time, the convenience and attractiveness of many meat products are highly appreciated (1). Poultry meat appears to be less susceptible to this reaction and is expected to surpass beef as the principal meat of the U.S.A. by the turn of the century. In Europe the Commission of the E.C. expects pig meat to hold first place.

## Meat Consumption : Europe and U.S.A.

The overall availability of meat on the E.C.-market in 1984 amounted to an average of 81 kg/capita (2). It has increased from 70 kg in 1973, and it is projected to increase further to 87 kg in 1991. Among the different countries of the E.C. a wide variation exists, ranging from 72.5 kg/capita in the U.K. till over 100 kg in France. For comparison, the figure for the U.S.A. was 111.2 kg/capita in 1984 and for the German Democratic Republic 92 kg in 1983 (figure 1).
This data is based on gross figures of whole carcasses. This includes a twofold inaccuracy. Firstly, some parts of the carcass are not utilized for human consumption i.e. bones and fat trimmings. For this part a correction of about 25 % has to be made. Secondly, the gross figures do not allow for losses, wastage and the use of human food as pet food. No general correction factors are available for this second error as this is strongly individually determined. Consequently, per day the amount available for consumption varies between 148 and 228 g per capita (raw weight).

The four major meat categories, beef and veal, pig meat, poultry, and sheep and goat have a different share in each country. In the E.C. as a whole pig meat takes the major share with 37.8 kg; beef and veal is second with 24.4; poultry is third with 14.8 kg; sheep and goat fourth with 3.6. Increases until 1991 are expected to respectively 41.6 kg, 25.5 kg, 16.2 kg and 3.7 kg/capita. In the U.S.A. the consumption of poultry has risen to 29.8 in 1984. Its use has doubled over 20 years.
Only part of the meat is bought by the housewife for consumption at home. In the Netherlands, a country with a relatively low meat consumption, about 60 % of the meat is bought as fresh meat for home consumption (3). About 20 % is bought as processed meat, either cured, smoked, boiled or canned. The remaining 20 % is eaten outdoors in restaurants and e.g. as snacks. In some countries in the E.C., the outdoor consumption of meat may be (far) more than 30 % of the total meat consumption.

## Nutritive Value

Meat is considered as a very nutritious food. It contains a large variety of different nutrients and most of these are essential for the human body. A meal which is based on meat, therefore, provides a safe basis for fulfillment of nutrient requirements. Moreover, the contents of nutrients, relative to the caloric value of most meats, are high as well i.e. the product has a high nutrient density. This allows it a place in many modern low-energy diets which are recommended nowadays to large segments of the population.
The macro-composition of the main meat categories is shown in figure 2.

Protein : the protein content of meat is rather constant if considered in the fat-free part of it. Fat will, of course, dilute the protein content. The proteins in meat from all animals are almost completely digested. The resulting amino acid mixture is easily absorbed and provides the body's protein synthesis machinery with a substrate in proportions, which are very close to the body's requirements. As a consequence, at least 97 % of the meat protein is utilized by the human body to enable it to take care of its tissue growth and repair tasks.
Often the milk protein, casein is used as a reference protein to judge the quality of a food protein. Evans et al. (3) demonstrated that fresh tissue and organ meat were superior to and processed meat equalled casein (table 1). They also investigated the consequences of different food preparation methods on the protein value, i.e. frying, boiling and microwave cooking. The results are also shown in table 1. It is clear that protein quality will not necessarily be reduced during the household preparation of meat.
Proteins in meat are not only important from a nutritional point of view, they also provide for its structure (by its collagen), its colour (by (oxy-) myoglobin), and its taste. The brown colour and the appetite-stimulating flavour of cooked meat are the result of a partial, chemical breakdown, in combination with a chemical reaction with carbohydrates.
However, the potentially toxic compound lysino-alanine (LAL), which is frequently present in heat treated milk, infant formula or egg white, is not observed in meat or processed meat (4).

Fats are well-known as source of concentrated energy and as malefactor for ischaemic heart disease and obesity. But fats are also the suppliers of essential fatty acids and the carriers of vitamins A, D, E and K. Fat also adds to the flavour, the tenderness and the juiciness of meat and meat products. The amount of fat in meat differs with the type of meat, the animal source, age at slaughter, sex and the fodder used. Also by genetic breeding it has been possible to reduce the average fat content of pig meat carcasses during recent years, which is illustrated in table 2, showing the figures of British carcasses in 1975 and 1984 (8) and table 3, showing the quality of Dutch pig carcasses since 1966 (9).
At the same time the classification of carcasses into quality classes has resulted in considerable improvements. About 70 % is classified as 1A or EEA which means that no incentives are left for further improvement of carcass leanness.

The consumer nowadays is very keen about the fat content of foods though this knowledge is not always correct. In a recent study from the UK (10) it was reported that when consumers were asked to name sources of fat 71 % mentioned meat, 59 butter, 55 cheese, 34 milk and 20 % margarine. Of the respondents 76 % agreed that "we are educated not to eat animal fats". "Sausages contain a lot of fat" was agreed upon by 95 %, while 50 % agreed that meat contains more fat than is good for you. Margarine was thought to contain less fat than butter by 40 % of the sample.

The fat content of free-living mammals, e.g. the wild game of Africa, is very low compared to that of intensively reared animals. Also the ratio saturated to poly-unsaturated fatty acids is much narrower in wild game from woodland environment, i.e. 3:1 than the same ratio among domesticated bovine species, i.e. 50:1 (5).

It can be generalized that the depot fat from monogastric animals such as chickens, turkeys, and pigs but also humans rather readily reflects the general characteristics of the dietary fatty acids. The "soft pork" problem, caused by increased intakes of linoleic acid from feed such as peanuts or soybeans, refers to the softer or more oily appearance of pig carcasses. Linoleic acid in the soybean case was deposited at the expense of oleic acid. An increase of linoleic acid from about 10 to about 20 % did not result in any processing or product characteristics that could not be dealt with in a satisfactory manner. Also studies undertaken in the Netherlands by TNO-CIVO and the University of Utrecht have demonstrated the feasibility of increasing the linoleic acid content of pig meat and of producing a range of meat products with satisfactory technical and sensory properties (6).

The unsaturation of ruminant fats, be it body fat or milk fat, is much more difficult to change. The microbial flora in the rumen readily hydrogenates the unsaturated fatty acids which are usually abundantly present in fodder, e.g. in grass lipids. Therefore, any attempt to increase the degree of unsaturation, will have to circumvent the ruminal flora. This may be accomplished by protecting the fat by a non-digestible substance like formaldehyde denatured casein.

In the Netherlands pork meat (medium fat) contains circa 5 - 10 % poly-unsaturated fatty acids. About 10 to 15 % of the total intake of pufa in the Dutch diet comes from meat and meat products.
By cooking meat the fat content shows a regression to the mean effect. Meat with originally a high fat content loses some of its fat, while lean meat takes up some fat from the medium (see figure 3). Changes however are small and the water content changes are much more drastic. The fatty acid composition of fat meat does not change appreciably during cooking. However, cooking of lean or medium fat meat in a poly-unsaturated rich oil will alter fatty acid composition slightly due to some exchange of fat.

The cholesterol content of meat is about 60 to 70 mg per 100 g for all kinds of meat, lean or fat, from beef, pork, veal, lamb or chicken. For the cholesterol content, therefore, it does not matter whether fat or lean pork or beef is chosen. Some parts of chicken or turkey may contain slightly more cholesterol as the skin provides about 110 mg per 100 g. Also meat from organs such as heart (150 mg), liver (300 mg), and brains (> 2000 mg per 100 g) are important sources of cholesterol.

The consumer nowadays is very keen about the fat content of foods though this knowledge is not always correct. In a recent study from the UK (10) it was reported that when consumers were asked to name sources of fat 71 % mentioned meat, 59 butter, 55 cheese, 34 milk and 20 % margarine. Of the respondents 76 % agreed that "we are educated not to eat animal fats". "Sausages contain a lot of fat" was agreed upon by 95 %, while 50 % agreed that meat contains more fat than is good for you. Margarine was thought to contain less fat than butter by 40 % of the sample.

The fat content of free-living mammals, e.g. the wild game of Africa, is very low compared to that of intensively reared animals. Also the ratio saturated to poly-unsaturated fatty acids is much narrower in wild game from woodland environment, i.e. 3:1 than the same ratio among domesticated bovine species, i.e. 50:1 (5).

It can be generalized that the depot fat from monogastric animals such as chickens, turkeys, and pigs but also humans rather readily reflects the general characteristics of the dietary fatty acids. The "soft pork" problem, caused by increased intakes of linoleic acid from feed such as peanuts or soybeans, refers to the softer or more oily appearance of pig carcasses. Linoleic acid in the soybean case was deposited at the expense of oleic acid. An increase of linoleic acid from about 10 to about 20 % did not result in any processing or product characteristics that could not be dealt with in a satisfactory manner. Also studies undertaken in the Netherlands by TNO-CIVO and the University of Utrecht have demonstrated the feasibility of increasing the linoleic acid content of pig meat and of producing a range of meat products with satisfactory technical and sensory properties (6).

The unsaturation of ruminant fats, be it body fat or milk fat, is much more difficult to change. The microbial flora in the rumen readily hydrogenates the unsaturated fatty acids which are usually abundantly present in fodder, e.g. in grass lipids. Therefore, any attempt to increase the degree of unsaturation, will have to circumvent the ruminal flora. This may be accomplished by protecting the fat by a non-digestible substance like formaldehyde denatured casein.

In the Netherlands pork meat (medium fat) contains circa 5 - 10 % poly-unsaturated fatty acids. About 10 to 15 % of the total intake of pufa in the Dutch diet comes from meat and meat products.
By cooking meat the fat content shows a regression to the mean effect. Meat with originally a high fat content loses some of its fat, while lean meat takes up some fat from the medium (see figure 3). Changes however are small and the water content changes are much more drastic. The fatty acid composition of fat meat does not change appreciably during cooking. However, cooking of lean or medium fat meat in a poly-unsaturated rich oil will alter fatty acid composition slightly due to some exchange of fat.

The cholesterol content of meat is about 60 to 70 mg per 100 g for all kinds of meat, lean or fat, from beef, pork, veal, lamb or chicken. For the cholesterol content, therefore, it does not matter whether fat or lean pork or beef is chosen. Some parts of chicken or turkey may contain slightly more cholesterol as the skin provides about 110 mg per 100 g. Also meat from organs such as heart (150 mg), liver (300 mg), and brains (> 2000 mg per 100 g) are important sources of cholesterol.

Normally, meat is not a very important source of dietary cholesterol. Only in very strict cholesterol-reducing diets it is important to limit cholesterol intake and to consider the cholesterol content of meat. Due to its high cholesterol content, it is recommended to limit consumption of organ meat to not more often than once a week.
Since cholesterol in meat is associated with structures such as the cell membrane, mitochondria, nuclei, reticulum, etc. it seems highly improbable that any significant reduction in cholesterol concentration could be achieved without altering membrane structure and the normal function of muscle.

**Vitamins**, especially of the B-complex, are abundantly present in meat. Meat ranks as one of the principal sources of most of them (figure 4). The most important are thiamin, riboflavin, niacin, pyridoxin and cyanocobalamin. The fatter types of meat and also organ meats contain the fat-soluble vitamins retinol, tocopherol and cholecalciferol.
Thiamin is one of the most important of the B-vitamins. It is essential in carbohydrate metabolism. The deficiency disease beri-beri is a result of extreme shortage of thiamin. In Western countries such cases are rare nowadays.
However, the decreased cereal intake and the advanced degree of refining in industrial processing of vegetable products, causes the intake to be marginal. Mild symptoms of marginal, biochemical thiamin deficiency may therefore be expected, such as poor muscle tone, fatigue, loss of appetite, depression and irritability.
Pork is the best source of thiamin in most Western countries. Pork contains about 0.6 mg thiamin per 100 g meat. The recommended daily allowance is 0.6 mg per 1000 kcal. Thiamin is soluble in water and broken down by heat.
An important part of the thiamin which is lost from the beef or pork meat during cooking, can be recovered from the gravy (see figure 5).

Riboflavin is part of a number of important enzymes in the body. These enzymes are involved in carbohydrate, amino acid and fatty acid metabolism. Dietary requirements are calculated in proportion to protein needs (0.025 mg per g protein). Liver is the richest source of riboflavin (3.0 mg per 100 g) but muscle tissue is also an important source (0.1 mg per 100 g). Riboflavin is stable to heat but labile upon light exposure. Upon cooking it can be found in the gravy for a considerable part (see figure 5).

Niacin is part of several enzymes in the Krebs-cycle: the metabolic pathway into which all the energy sources - carbohydrates, fatty acids and amino acids - ultimately pass in order to liberate their chemical energy to make it available to the body. The organism is also able to synthesize niacin from the amino acid tryptophan. The efficiency of this conversion is 1:60.
Niacin is a very stable vitamin, being resistant to heat, light, air, acids and alkali.
Liver is the most excellent source of niacin, but muscle tissue is also an important source.

Pyridoxin, pyridoxal and pyridoxamine, together form the vitamin B6 complex. This vitamin carries out a large number of essential functions; however, its role in transamination reactions is very prominent. It helps to prevent dermatitis and dementia. The recommended dietary allowance is set by the U.S. Academy of Sciences at about 1.5 - 2.0 mg per day. Meat contains 0.1 - 2.5 mg per 100 g. The vitamin B6 complex is rather labile to heat. Less than half the original amount is left in meat upon cooking (see figure 5).

Cyanocobalamine or vitamin B12 is particularly important to prevent a particular type of anemia. In principle, only products from animal origin contain this vitamin though some plant foods have been shown to be vitamin B12 positive e.g. seeweeds. It is not yet elucidated whether the growth of certain micro-organisms may be held responsible for the positive result in these products. The requirement of the body is very low, a few micrograms per day. Body stores are sufficient to survive a period of half a year to 2 years before any symptoms of a deficiency occur.
Vitamin B12 is rather stable to heat.

Fat soluble vitamins are not very abundantly present in most meat products. Only organ meats, especially the liver, contain considerable amounts of vitamins A, D and E. Pork liver is an excellent source of vitamin K (100 - 200 µg/100 g).

**Minerals.** A number of minerals are known to be essential for the human body and therefore for the diet. Some of these are needed in relatively large amounts: calcium, phosphorus, magnesium, zinc, iron and copper. Also the electrolytes sodium and potassium are considered in this context.
Other elements are only needed in trace amounts: the trace elements i.e. selenium, cobalt, fluorine, manganese, iodine and aluminium. They usually play a role as catalyst or cofactor in enzyme systems (see table 4).

Iron. The human body contains 2 - 4 g iron, of which about 70 % as haemoglobin, which is involved in the transport of oxygen in the blood. A diet deficient in iron will cause anemia, characterized by paleness, listleness, lowered resistance to infection and fatigue.
There has been a long interest in iron absorption and iron availability. It has been suggested that iron absorption is not an inherent characteristic of the substance being assayed but possibly a result indicating the absorption of the iron source under a specific set of test conditions. This is because the control of iron homeostasis resides in the mucosal membrane as well as with many secondary dietary factors. Therefore the experimental technique consists of an internal calibration with a double isotope technique on the study of absorption from a test meal as compared with some standard (solution or meal) in the same person.
Iron from meat is usually well absorbed, up till 50 %. The absorption of this heme-iron is not affected by the dietary factors which enhance (vitamin C, protein) or which inhibit (coffee, tea, phytate) iron absorption. If meat is present in a meal, this will enhance the absorption of the non-heme iron present in the same meal as well by an up till now unknown mechanism.
The poor availability of iron from egg yolk and the inhibiting effect of egg yolk on non-heme iron from other products has been atributed to the presence of a phosphoprotein, phosvitin, which binds tightly most of the inorganic iron in egg yolk.

Zinc is important for many metabolic processes in the body. Over 100 enzymes have been identified as zinc dependent. Symptoms of a deficiency include depression of growth, loss of appetite, delayed sexual maturation, delayed wound healing, parakeratosis and apathy.
Zinc from almost any source is readily available, providing the diet does not contain compounds that interfere with the absorption, reabsorption or its homeostasis. Phytate is the most important dietary factor known to interfere with the absorption of zinc. Currently, it seems that the molar ratio of phytate to zinc, that will allow adequate available zinc in the diet to become absorbed, is 10:1 or less.
The daily requirement for zinc is about 10 to 15 mg. The total body content of zinc of an adult is over 2.0 g.

Selenium occurs in a number of forms in food and there is as yet little information available concerning the biological availability. The best studied metabolic reaction in which selenium is involved is the reaction of glutathion peroxydase. The selenium content of food-stuffs is related to the protein content, geographical origin of the food, the chemical form of selenium.
Selenium is assimilated into methylselenomethionine by non-accumulator plants. This amino acid is incorporated into tissue proteins. The selenium content of foods on the Dutch market is shown in tables 5 a and 5 b. The large variation in selenium content of bread-grains is remarkable and underscores the tremendous difficulties in assessing the nutritional role of trace elements (7).

## Evaluation of Meat in the Diet

There are two ways available to evaluate the nutritional value of meat in the diet: (a) by the calculation of the nutrient density and (b) by calculating the proportional contribution of the product under investigation to the intake of nutrients in a given diet or to recommended intakes for certain categories of the population. In both cases it is unavoidable to limit the evaluation to a specific diet, a specific population or nation and a specific moment.

## Nutrient Density

With the increased tendency for a sedentary life-style by a significant portion of the population, a decrease in energy intake is essential to avoid the development of obesity. Thus, in order to receive adequate intakes of nutrients in proportion to calories, nutrient dense foods must be used. When calorie moderation is required, animal foods, including meat and dairy products have a favorable nutrient density for the protein, many of the vitamins as well as certain minerals such as iron and zinc.
In figures 6 - 9 the nutrient densities of the following food groups have been shown: meats, whole-grain bread, whole milk and vegetables. A density of more than 1 for a nutrient means that the product under analysis is a rich source of that nutrient, relative to the energy content of that product. A density less than 1 indicates a relatively poor source of that nutrient. The diagrams also reflect a balanced or they indicate a very inbalanced composition. The picture for vegetables is of course complicated by the low energy content, the large bulk becoming inhibitory to a larger intake.

## Contribution of Meat to Dietary Intake

The consumption of meat in the Netherlands is one of the lowest in the E.C. Meat constitutes nevertheless an important part of the dietary pattern. As against a contribution of about 13 % to the energy intake, is the contribution to the protein intake (34 %), fat intake (23 %), iron (38 %), and thiamin (34 %) even more important. Also the retinol contribution (18 %) is important. However, calcium and vitamin C are almost absent from meat (see figure 10).
It is remarkable that the two food groups which are famous for their nutrient density and also wanted because their being a rich source of protein, vitamins and minerals, i.e. meats and dairy products also deliver together about 25 % of the energy and 40 % of the daily dietary fat. In the U.S.A. milk and dairy products provide about 15 - 20 % of the fat intake; meat, poultry and fish deliver about 35 - 45 % of the total fat consumption.

## Some highlights

**Sodium.**
In most industrialized countries hypertension is a public health issue. The consumption of sodium is thought to play a role in the etiopathogenesis of hypertension. Therefore, in most countries a reduction of dietary sodium intake is recommended. Moreover, potassium and calcium are considered as sodium antagonists and substitution of these for sodium may become a solution. In the Netherlands meat products contribute about 15% of the daily sodium load of the population (11). The salt content of most meat products is about 2,5 - 3 %. However, a large range of salt concentrations is present in the meat products on the market. A reduction with 25 % appears feasible both from a bacteriological and sensory point of view. Research at CIVO-TNO has also demonstrated that substitution of one third of sodium by potassium is the upper limit becasue of sensoric reasons. More research in this area with specific products and on a larger scale under real life conditions is urgently indicated.

**Elderly**
One of the issues which causes care to public health authorities is the increasing proportion of elderly people in the community. The diet of elderly people tends to be marginal because of low intake, due to lack of physical activity and reduced appetite, losses during food preparation and interference of denture problems and incapacidating pathology. We at CIVO-TNO studied between 1984 and 1985 a large group of about 500 elderly people in the Netherlands. From 108 males and females between 65 and 80 years old detailed data was obtained concerning meat consumption as well (12). The group was divided into high and low (HM and LM) meat consumers. A daily amount of 70 gram of meat served as dividing line. The HM group had a significantly higher intake of energy, protein, mono-unsaturated fat and haeme iron than the LM group. All biochemical parameters of nutritional status were not different, except iron status which was slightly worse among LM elderly. Among the elderly, especially women, who are single and those who have got a prescribed diet consume leass meat.
It should be studied further whether meat consumption is higher because of better health or whether better health is the consequence of more meat consumption.

**Dieters**
As food intake among dieters is deliberately reduced it becomes very important that the remaining diet has a high nutrient density.
From U.S. data it can be concluded that dieting among females increased with age. Males also dieted but in lower proportions. For those aged 19 - 34 years 12 - 16 % of the women and 6 % of the men dieted. For individuals aged 65 - 74 years, 33 % of the women and 23 % of the men dieted. Most of the diets are energy restriction regimens. For young adult males who were dieting 370 kcal less energy intake was noted than among non-dieters. Among women the differences ranged between 180 and 560 kcal. From other studies it has become clear that dieters sometimes fail grossly to fulfill dietary recommendations, providing only 40 - 60 % of the dietary allowances. This data stress the importance of a nutritious diet i.e. including lean milk, dairy and meat products in such rations.

**Nitrate, nitrite, nitrosamines**
Nitrate and nitrite have been used for the production of cured meats because of the development of color, flavor and the protection against botulism and other foodborne diseases. Because of possible nitrosamine formation there is a current trend to eliminate nitrate from most products and to reduce the amount of nitrite as much as possible. Nitrosamines have been found to be carcinogenic in a variety of animal species and they must therefore be suspected as carcinogen for man as well.
Under present conditions the contents of nitrosamines in cured meat products like bacon are very low (13) and much lower than during the seventies (14). Vecchio et al. (13) calculate daily volatile nitrosamine exposure from bacon to be 1.4 nmol/person. They conclude on this basis that "fried bacon represents a minor exposure when compared to other known exposures", such as from the workplace, tobacco or cosmetics.
One important pathway for nitrite and nitrosamine exposure however, is the endogenous one. One or two hours after a meal, containing nitrate such as from vegetables, high concentrations of nitrate and nitrite can be found in the saliva. Recent research at CIVO-TNO has been aimed at finding out under which conditions this conversion of nitrate takes place and whether this leads to nitrosamine formation in the stomach (15). Results indicate that (i) nitrite formation in saliva is very variable from person to person; (ii) some consistency is present in nitrite formation within an individual, i.e. some individuals are hyper-converters; (iii) in the stomach contents variable amounts of nitrosamines are found from endogenous origin; (iv) nitrosamines are only found in the stomach after a meal which contains both nitrate rich vegetables and fish; not with meat; (v) incorporation of vegetables with a reduced nitrate content does not reduce nitrosamine formation; apparently nitrate is not the limiting factor at this nitrate level. Investigations are now under way to study ways to reduce or prevent nitrosamine formation by vitamin C in the diet and to estimate the prevalence in society of nitrate-nitrite hyperconversion.

**Cancer**
In several epidemiological studies, mainly those comparing different populations or cultures, strong indications have been produced that there might be a link between meat consumption and the occurrence of cancer, especially of the breast and the colon (16). It is not clear which component of meat should be held responsible for this carcinogenic potential if at all.

A strong correlation is present between meat consumption and fat intake. Also an inverse correlation between meat and dietary fibre intake is common. These may confound real relationships.
The discovery of Sugimura et al. (17) that there are powerful mutagens on the surface of fried meat lead to the hypothesis that these mutagens were responsible for colon cancer development. Any form of cooking led to the formation of mutagen activity (18). Though not all mutagens have been identified, several such compounds are now known, all belonging to the class of heterocyclic aromatic amines, characterized by amino-imidazoquinoline (IQ). The carcinogenic activity of fried meat mutagens is under study now in a chronic carcinogenesis study with rats in the Netherlands, with support from the Dutch Meat Board. Results will be available within about one year from now.

## Conclusions

The consumption of meat in Europe and the U.S.A. is approaching steady state levels. In Europe pork will be the most important source for the years to come. Meat represents a very important place in the diet both from a quantitative and a qualitative point of view. Besides its high nutrient density it is also outstanding as a source of fat in the diet. Though breeding has already resulted in much leaner pig carcasses, consumers still consider meat as one of the most important fat sources which should be reduced. Especially because of the saturated nature of most meat fats, approaches to increase the unsaturation of the fats should be stimulated very strongly at the same time. Because of its high nutrient density the diet of small-eaters like elderly and dieters may take advantage from incorporation of lean meats.
Because of its contribution to the total sodium intake, which is linked to the development of hypertension, attempts to reduce salt contents and to replace part of the sodium by other salts, such as potassium or calcium should be supported and investigated further on larger scales. The endogenous formation of nitrosamines from dietary nitrate and from exogenous and endogenously formed nitrite should be studied further to be able to evaluate better the risks associated with the application of nitrite in meat product processing.
Finally, the factors in meat which may explain the regularly observed statistical correlation between meat consumption and cancer at different sites, should be studied in more detail. The mutagens formed during cooking on the surface of meat deserve primary attention. The anti-carcinogenic role of selenium in meat should be evaluated. This may lead to the need to increase or standardize selenium contents in meats.

## Literature

1. Joseph, R.L. and T.W. Griffiths.
Animal meat products, processing and the consumer.
Proc. Nutr. Soc. 45 (1986), 63 - 69.

2. Commission of the European Communities.
Agricultural Information Services, Brussels (1984).

3. Evans, E., S.C. Carruthers and R. Witty.
Effects of cooking methods on the protein quality of meats as determined using a Tetrahymena pyriformis W. growth assay.
J. Food Sci. 44 (1979), 1678 - 80.

4. Sternberg, M.L., C.Y. Kim and F.J. Schwende.
Lysinoalamine, presence in foods and food ingredients.
Science 190 (1975), 992 - 4.

5. Crawford, M.A.
Food selection under natural conditions and the possible relationship to heart-disease in man.
Proc. Nutr. Soc. 27 (1968) (2), 163 - 172.

6. Houben, J.H. and B. Krol.
Acceptability and storage stability of pork products with increased levels of polyunsaturated fatty acids.
Meat Science 5 (1980) (1), 57 - 71.

7. Bos, D.M.J., R.J. Egger, P. van 't Veer, A. van Faassen, M. Wedel and R.J.J. Hermus.
Possible sources of variation in selenium content of whole-meal bread, white bread and cow's milk in the Netherlands.
In: W. Baltes (ed.) Strategies in food quality assurance.
Proceed. 3rd Eur. Confer. Fd. Chem., Antwerp (1985).

8. Kempster, A.J., G.L. Cook and M. Grantley-Smith.
National estimates of the body composition of British cattle, sheep and pigs with special reference to trends in fatness. A review.
Meat Science 17 (1986), 107 - 138.

9. Merks, J.W.M. and G. Eikelenboom.
Fokkerijmaatregelen ter verbetering van de kwaliteit van varkensvlees.
Bedrijfsontwikkeling 16 (1985) (12), 479 - 482.

10. Fallows, St. J.
Consumer attitudes to foods and nutrition.
Nutrition and Food Science March/April (1986), 8 - 9.

11. Voedingsraad (Nutrition Council).
Report on "Reduction of the use of table salt".
The Hague, June 1986.

12. Rover, C.M. de, K.F.A.M. Hulshof, C. Kistemaker and M. Wedel.
De betekenis van vlees in de voeding van mensen van 65 tot 80 jaar.
CIVO-TNO report number V 86.173 (April 1986).

13. Vecchio, A.J., J.H. Hotchkiss and C.A. Bisogni.
N-Nitrosamine ingestion from consumer-cooked bacon.
J. Food Science 51 (1986) (3), 754 - 6.

14. Ellen, G., E. Egmond and E.T. Sahertian.
N-Nitrosamines and residual nitrite in cured meats from the Dutch market.
Z. Lebensm. Unters. Forsch. 182 (1986) 14 - 18.

15. Groenen, P.J.
Vorming van nitriet en nitrosaminen in het menselijk lichaam.
Ned. Tijdschr. v. Diëtisten 41 (1986) (5), 124 - 7.

16. Willett, W.C.
Diet and Cancer: a whirlwind Odyssey through a sea of inconsistency.
Bibl. Nutritio et Dieta 37 (1986), 121 - 9.

17. Sugimura, T. et al.
Mutagen-carcinogens in food, with special reference to highly mutagenic pyrolytic products in broiled foods.
In: Origins of Human Cancer. Book C. Edited by H.H. Hart, J.D. Watson and J.A. Winsten, p. 1561.
Cold Spring Harbor, New York.

18. Knize, M.G. et al.
Effects of temperature, patty thickness and fat content on the production of mutagens in fried ground beef.
Fd. Chem. Toxicol. 23 (1985) (12), 1035 - 40.

Fig. 1. Meat consumption in the EC and the USA in 1984 in kg / per capita.

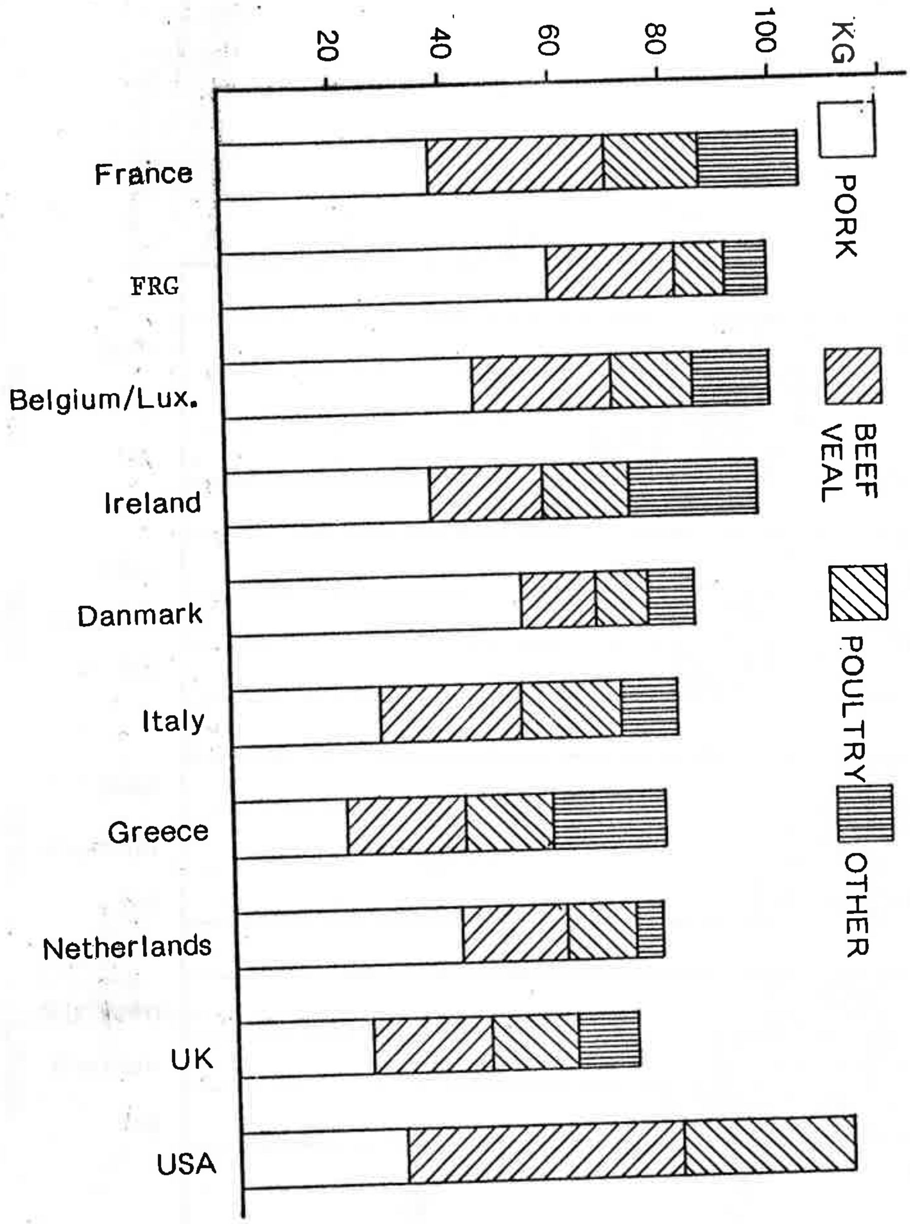

Fig. 2. The composition of meat.

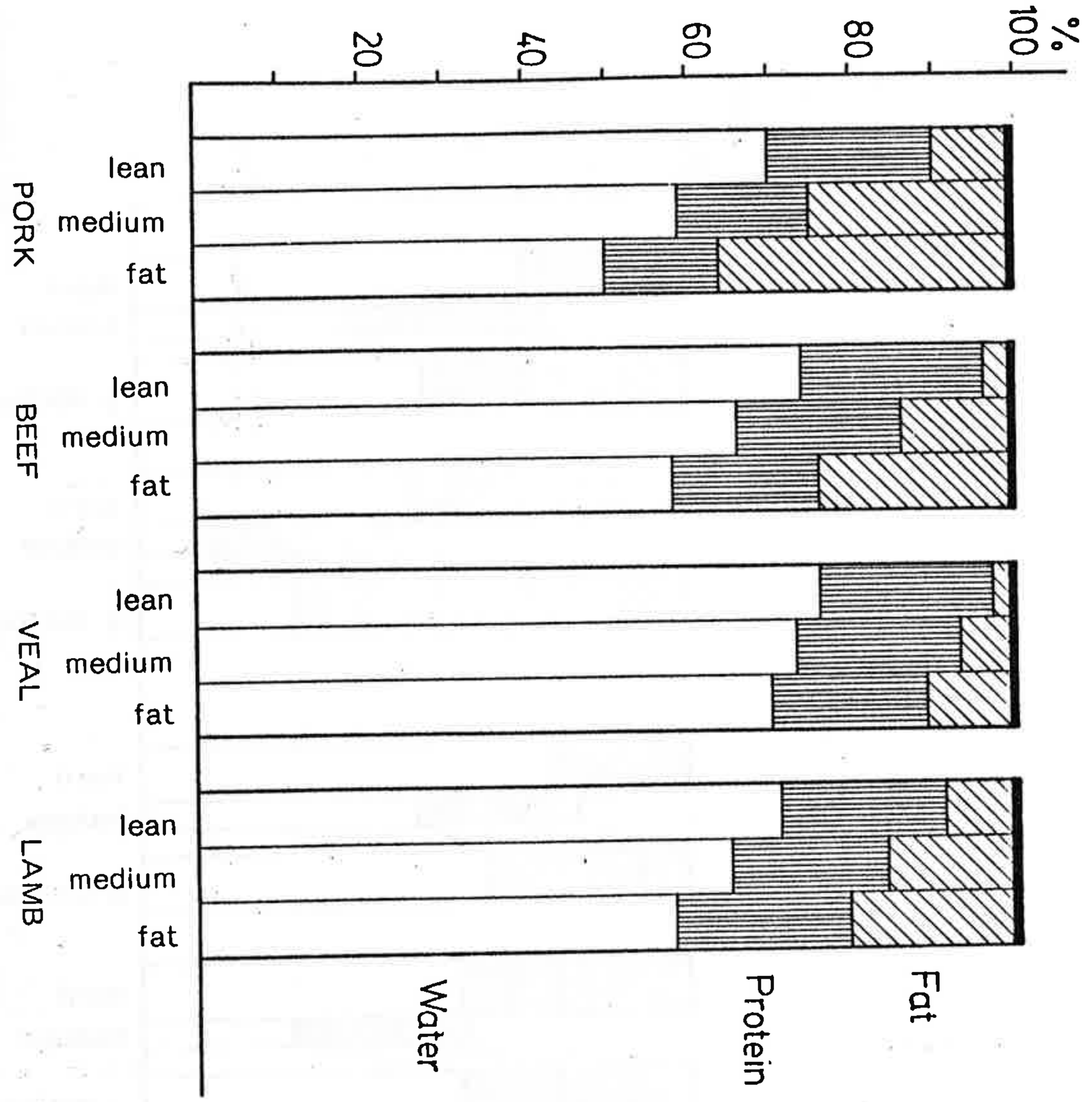

Fig. 3. Changes in the composition of meat after cooking

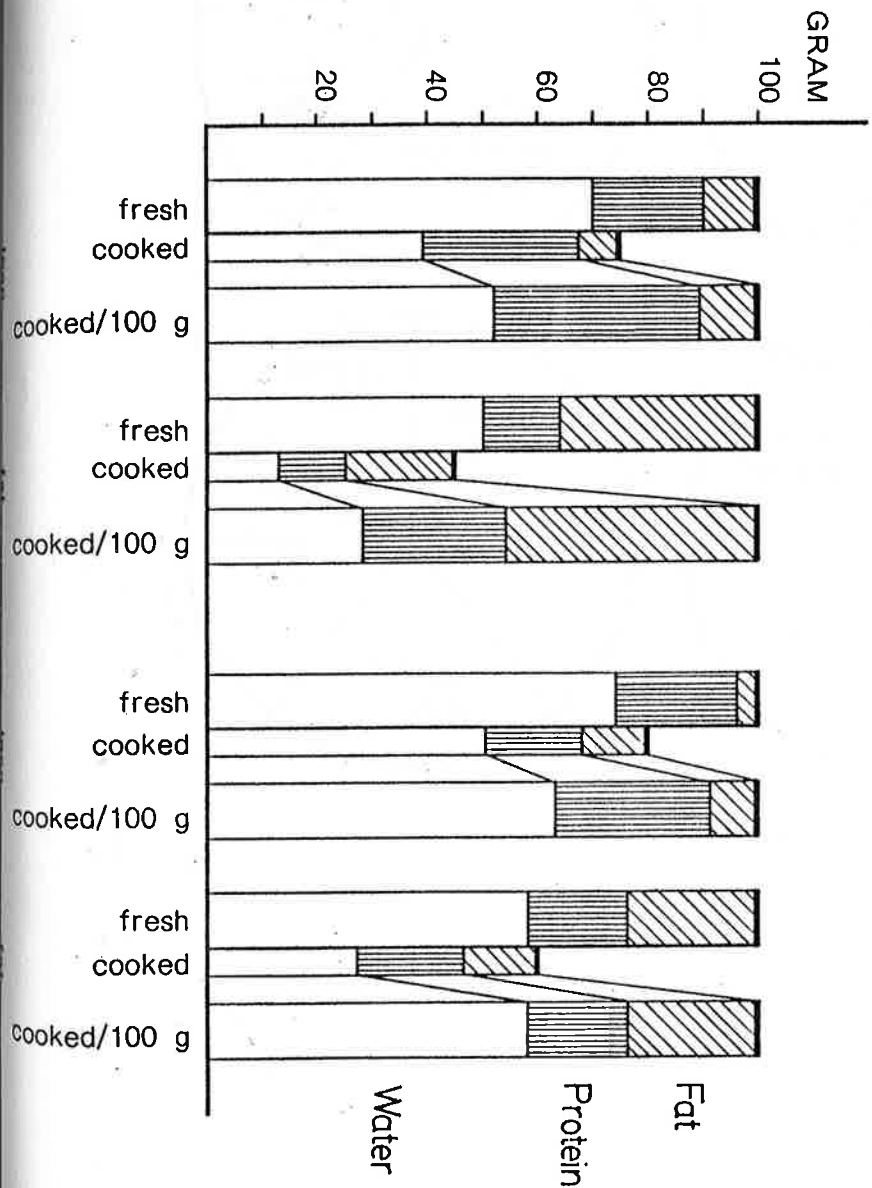

Fig. 4. The contribution of different food groups to the intake of some B vitamins in the Netherlands

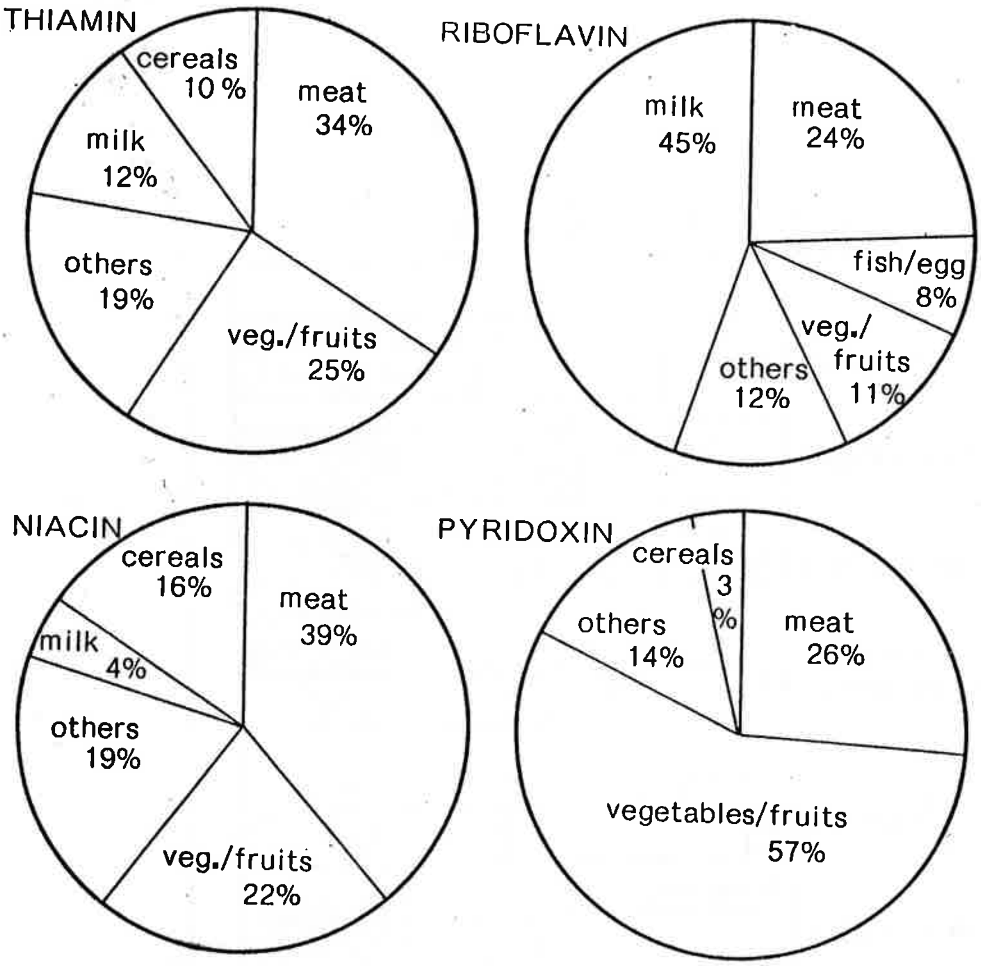

Fig. 5. Retention of some B vitamins after cooking.

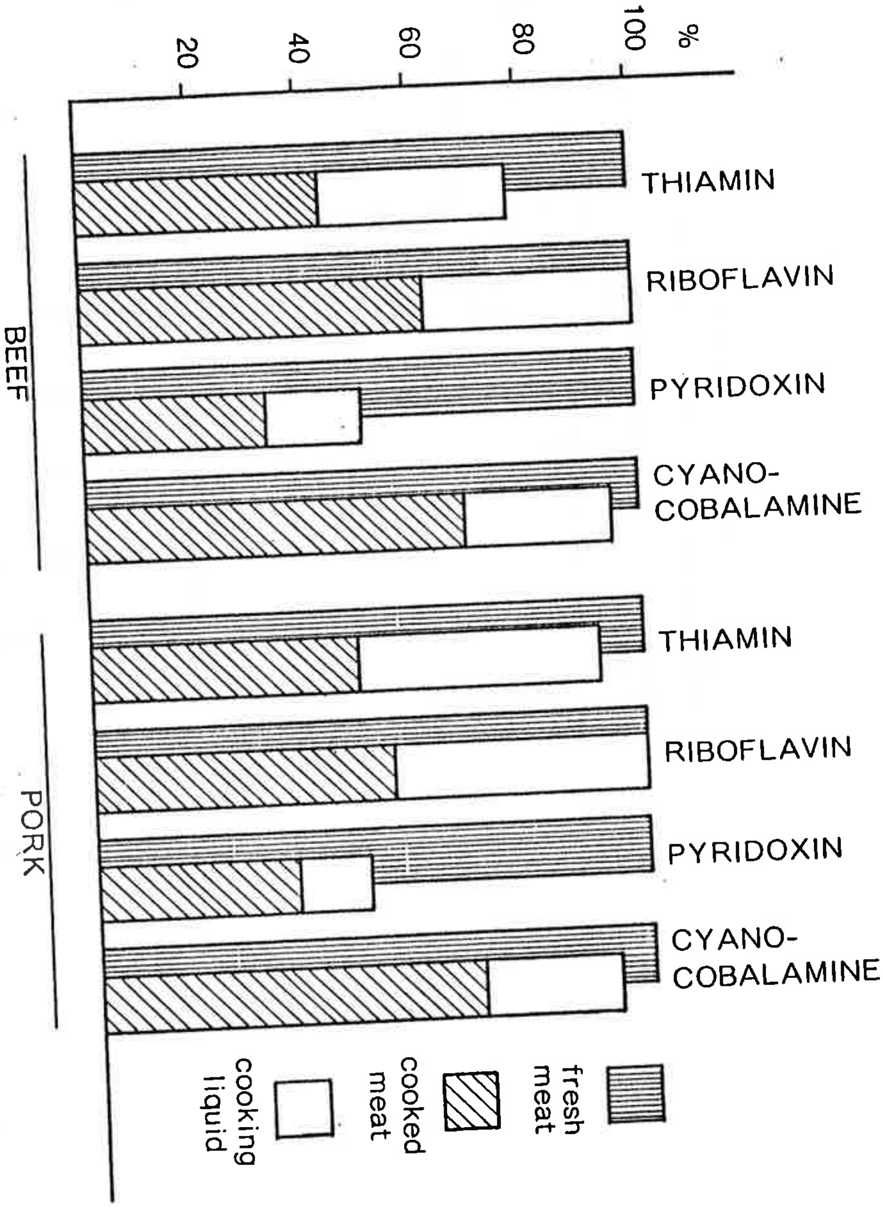

Fig. 6. Nutrient density of meat
(Average of different types and animals)

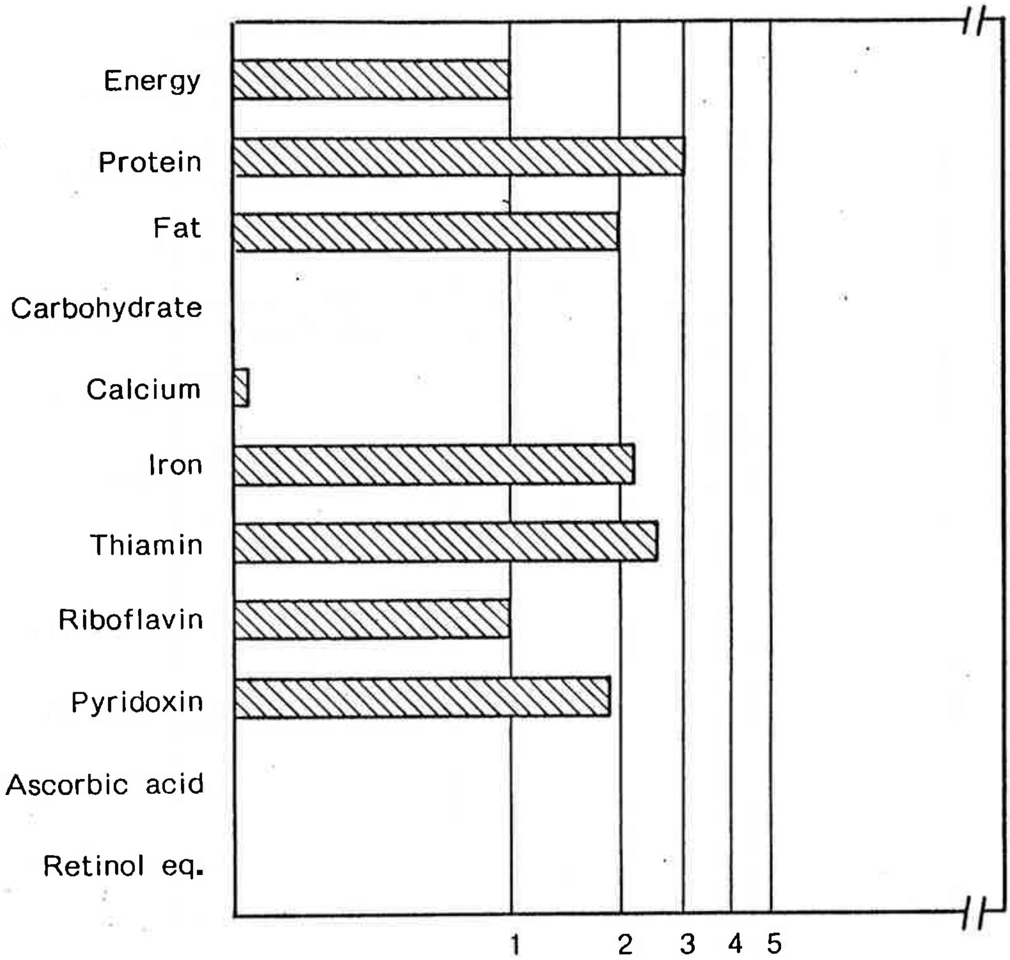

Fig. 7. Nutrient density of whole grain bread

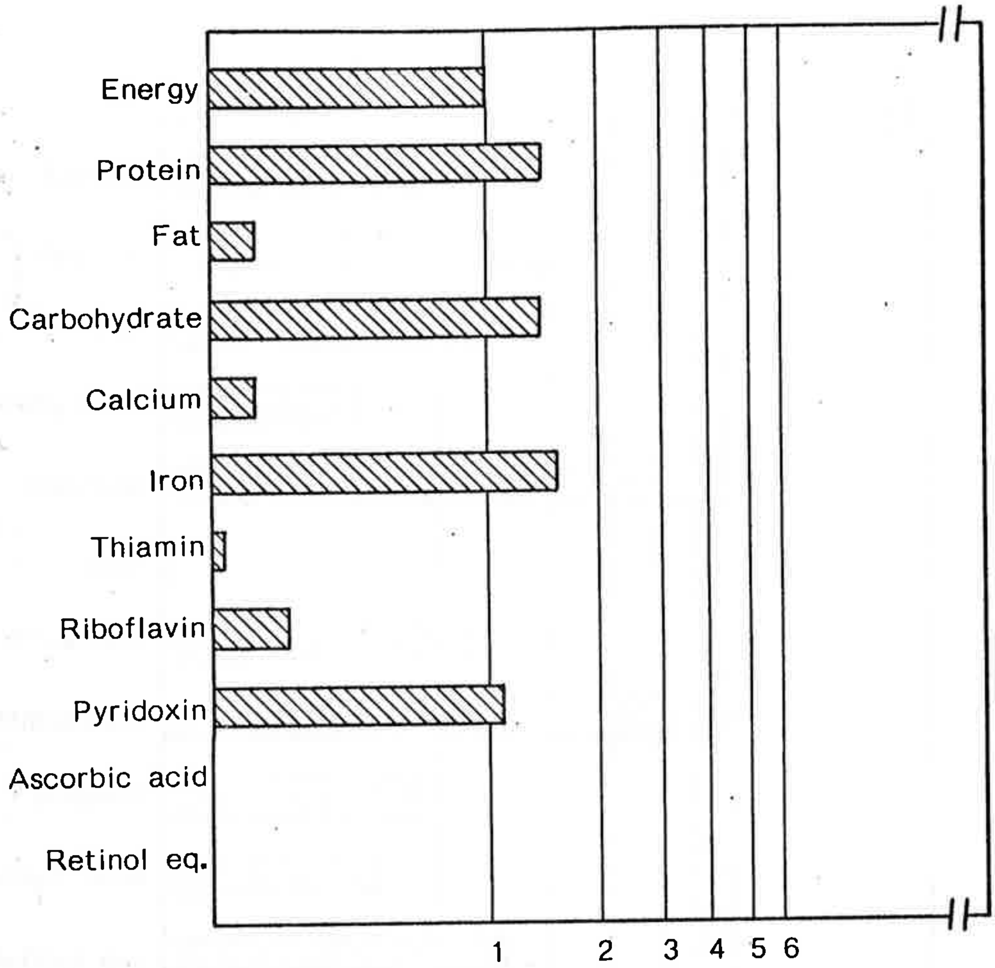

Fig. 8. Nutrient density of whole milk

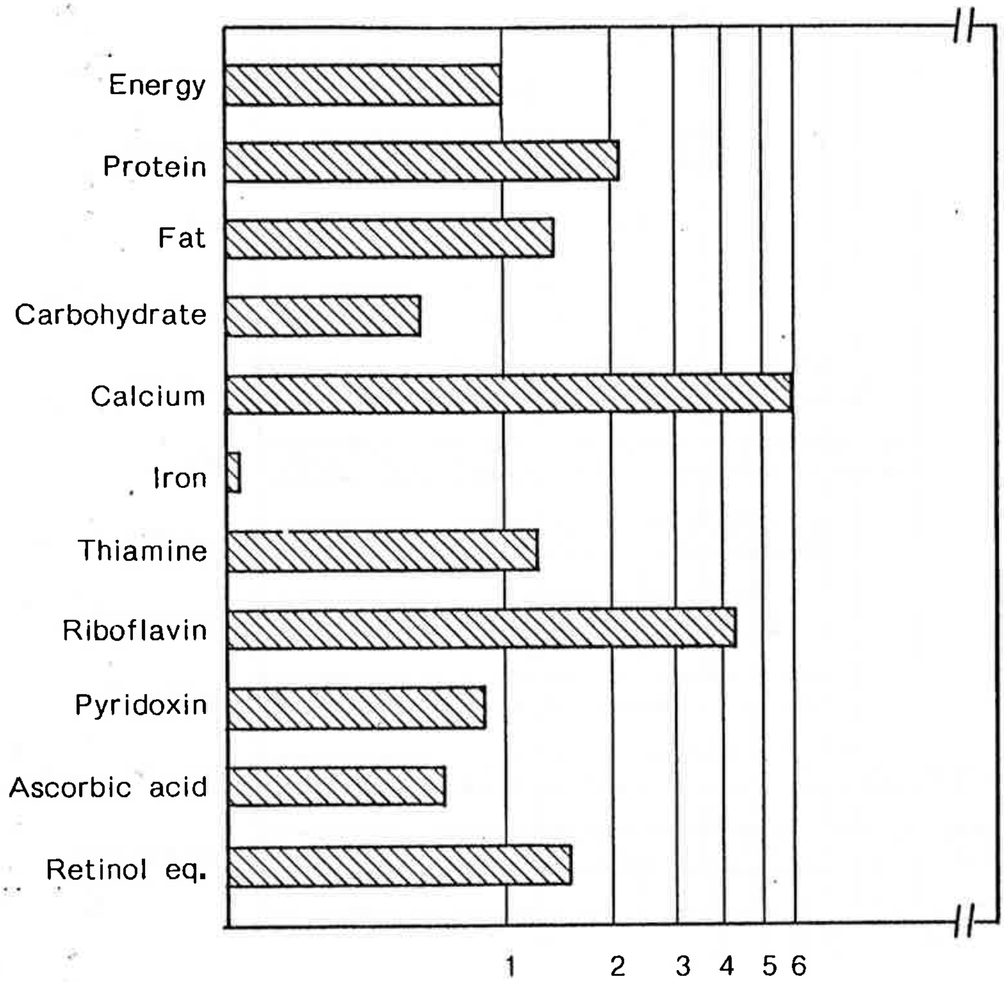

Fig. 9. Nutrient density of vegetables
(Average of summer and winter)

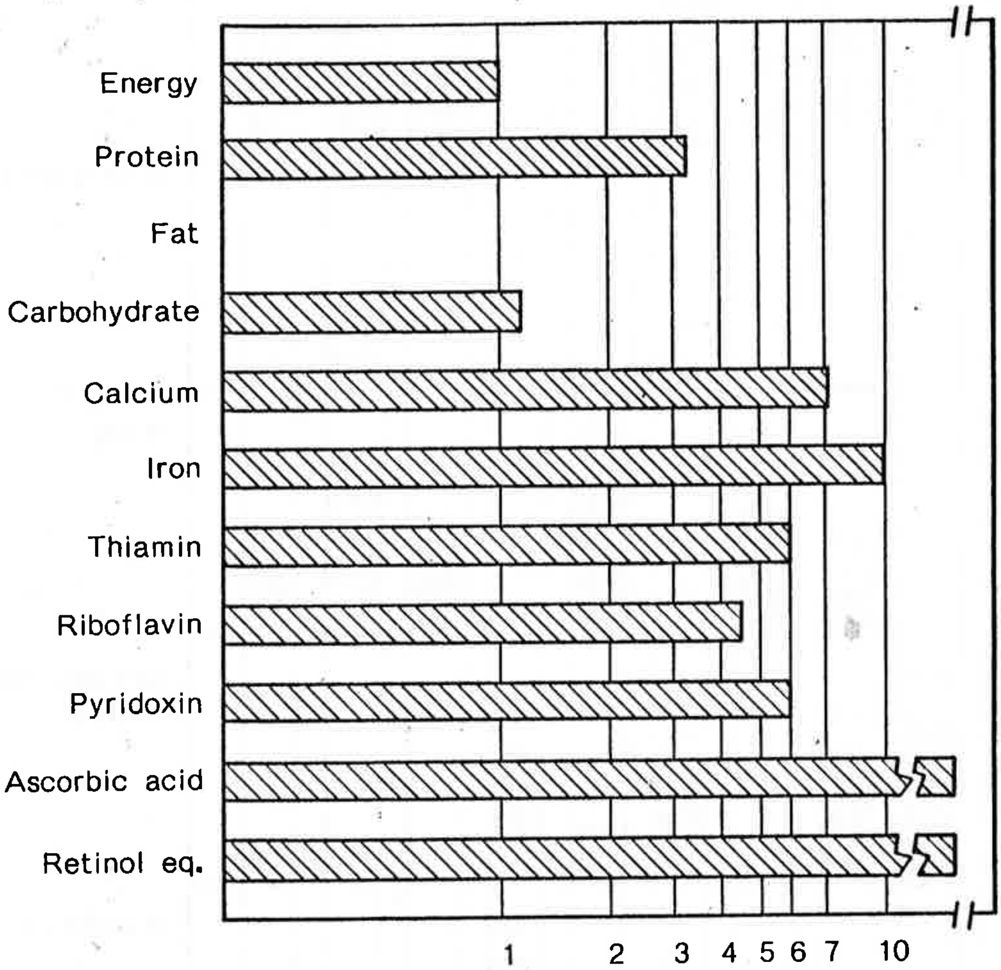

Fig. 10. Contribution of different food groups to the intake of nutrients in the Netherlands. (%)

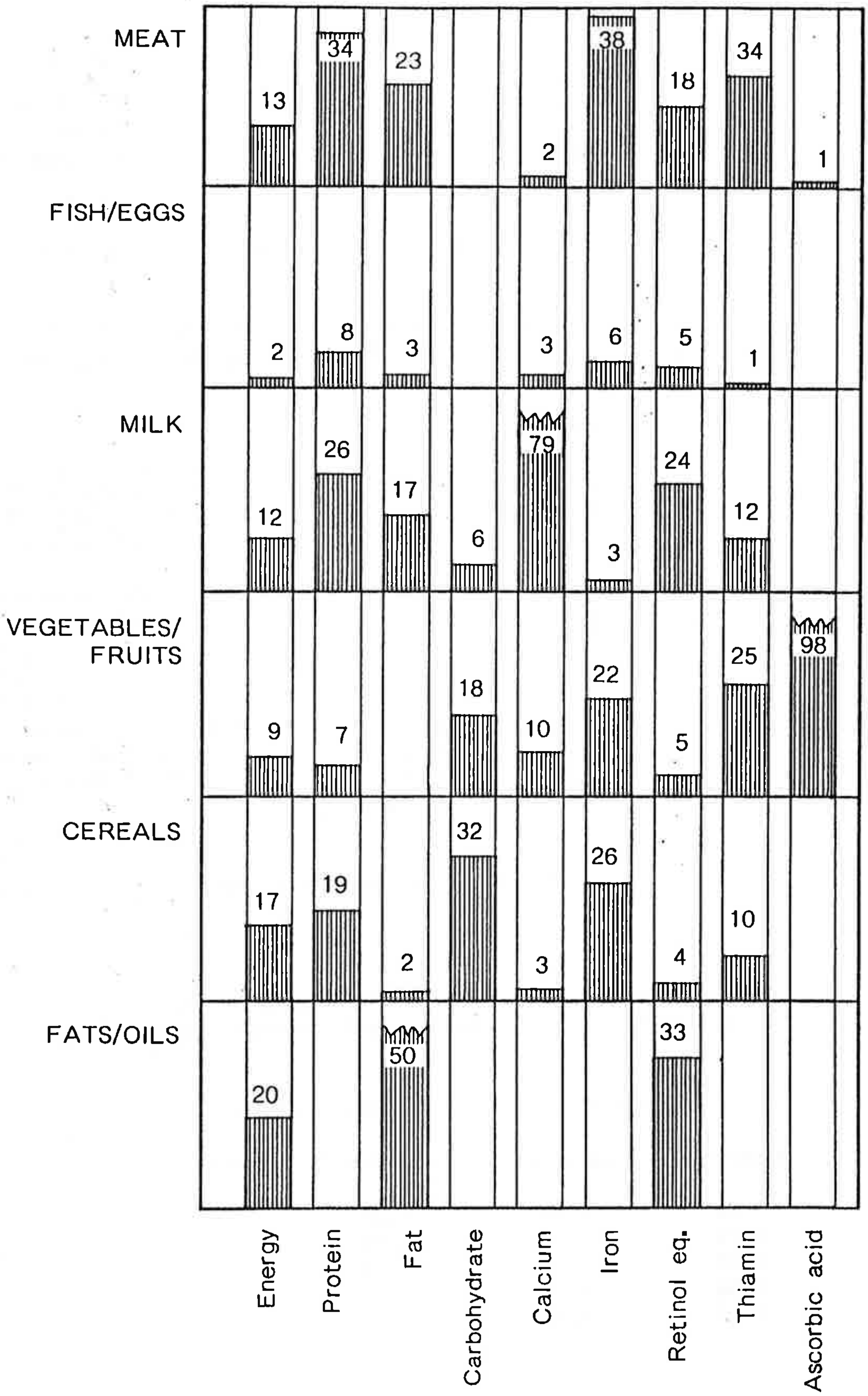

Table 1 : Relative Nutritive Value of Meats (RNV) (3)

| | RNV (relative to casein) | | | |
|---|---|---|---|---|
| | fresh | fried | boiled | microwave |
| tissue meat (n:6) | 112 | 103 | 116 | 106 |
| organ meat (n:4) | 104 | 95 | 106 | 106 |
| processed meat (n:8) | 98 | 93 | 101 | 93 |

Table 2 : Mean fat content of pig carcasses

British National Estimates of Pig Carcass Composition
Produced for the Periods of 1975 and 1984 (8)

| | 1975 | 1984 |
|---|---|---|
| Mean carcass weight (kg) | 61.3 | 62.6 |
| Mean $P_2$ fat thickness (mm) | 17.0 | 13.5 |
| Tissues in carcass (%) | | |
| Lean | 47.6 | 52.1 |
| Intermuscular fat | 5.6 | 5.0 |
| Subcutaneous fat | 19.5 | 16.1 |
| Flare fat | 1.9 | 1.6 |
| Separable fat * | 27.4 | 22.8 |
| Lipid in lean (%) | 5.5 | 5.0 |
| Lipid in separable fat (%) | 76.8 | 73.4 |
| Lipid in carcass (%) | 22.3 | 19.4 |
| Fat trim in carcass (%) | 8.8 | 7.5 |

* sum of intermuscular, subcutaneous and flare fat

Table 3 : Average results of backfat thickness and proportion ham and chops between 1966 and 1983 in Dutch pigs (9)

| | Backfat (mm) | | % ham | |
|---|---|---|---|---|
| | Landrace | Yorkshire | Landrace | Yorkshire |
| 1966 | 29.1 | 31.3 | 44.2 | 42.6 |
| 1971 | 27.2 | 28.2 | 45.5 | 44.1 |
| 1976 | 22.8 | 22.2 | 47.5 | 46.8 |
| 1981 | 22.7 | 22.2 | 46.6 | 46.8 |
| 1983 | 22.4 | 21.6 | 46.6 | 46.9 |

Table 4 :Some enzymes containing or requiring metal ions as cofactors

| | | |
|---|---|---|
| Zinc | $Zn^{2+}$ | Alcohol dehydrogenase<br>Carbonic anhydrase<br>Carboxypeptidase |
| Magnesium | $Mg^{2+}$ | Phosphohydrolases<br>Phosphotransferases |
| Manganese | $Mn^{2+}$ | Arginase<br>Phosphotransferases |
| Iron | $Fe^{2+}/Fe^{3+}$ | Cytochromes<br>Peroxidase<br>Catalase<br>Ferredoxin |
| Copper | $Cu^{2+}/Cu^{+}$ | Tyrosinase<br>Cytochrome oxidase |
| Potassium | $K^{+}$ | Pyruvate phosphokinase<br>(also requires magnesium) |
| Sodium | $Na^{+}$ | Plasma membrane ATPase<br>(also requires potassium and magnesium) |

Table 5 a : Selenium content of wheat of various origins in the Netherlands (ng/g wet weight) (7)

| | Selenium | Range |
|---|---|---|
| Canada (n=4) | 599 | 500 - 687 |
| U.S.A. (n=6) | 455 | 417 - 575 |
| The Netherlands (n=6) | 93 | 41 - 142 |
| Germany (n=5) | 52 | 30 - 80 |
| France (n=8) | 38 | 15 - 113 |

Table 5 b : Selenium content of food on the Dutch market (unpubl. results from CIVO-TNO) (μg/kg wet weight)

| | number samples | mean | range |
|---|---|---|---|
| hen's eggs | 45 | 190 | 140 - 260 |
| cow's milk | 57 | 11 | 6 - 19 |
| whole meal bread | 40 | 134 | 45 - 220 |
| white bread | 40 | 78 | 25 - 145 |
| pork-liver | 39 | 556 | 330 - 910 |
| pork-chops | 39 | 133 | 110 - 160 |
| beef-cubed | 39 | 59 | 25 - 110 |