

Calorific value and cholesterol content of normal and low-fat meat and meat products

R. Chizzolini,* E. Zanardi,
V. Dorigoni and S. Ghidini

Istituto di Scienza e Tecnologia degli Alimenti,
Università di Parma, 43100 Parma, Italy
(fax: +39-0521-902752)

This review deals with the topic of fat and cholesterol intakes derived from the consumption of meat and meat products and the impact that the development of low-fat products might have. The relationships between fat and cholesterol intake and blood cholesterol levels are discussed in the light of the most recent findings.

The calorific value and the cholesterol content and, therefore, the relative dietary contribution of meats are discussed in relation to animal species, type of muscle and main representative products. The relationship between fat and cholesterol content in meat is thoroughly examined. The lowering of fat content in fresh meat and in meat products is analysed in relation to the proposed aim of reducing calorific value and, possibly, the amount of cholesterol. The effect of cooking is also reviewed. Some final comments are devoted to the oxidative hypothesis of chronic cardiovascular diseases. © 1999 Elsevier Science Ltd. All rights reserved.

International medical institutions have been recommending for the past 40 years that dietary fat intake should be controlled as quantity of calories and type of

fats introduced. Nutritional guidelines suggest that dietary fat should provide between 15 and 30% of total calories and that saturated fats should be limited to between 0 and 10% of caloric intake [1]. It is also advised that cholesterol intake should not exceed 300 mg per day.

Limitations in fat and cholesterol intakes are thought to be important measures to prevent obesity and hypercholesterolaemia, conditions that are considered to predispose to various chronic diseases of the circulatory system. Relationships appear to exist, also, between a high-fat intake, especially saturated fat, and an increased risk of some cancers, especially cancers of the colon, breast and prostate [2].

Epidemiological and clinical studies have suggested that high-fat diets, regardless of their fatty acid distribution, increase blood cholesterol concentrations [3–5]. The latter point, though, has been disputed by Nelson *et al.* [6] who suggested that it is the ratio of the various fatty acids in the diet that determines the changes in blood cholesterol levels upon changes in the dietary fat intake, not the percentage of calories from fat, either saturated or unsaturated. Blood levels of cholesterol-low density lipoproteins (LDL) would appear to be unaffected by the percentage of fat calories in the diet. More specifically, it appears that saturated fatty acids of 12–16 carbon atoms increase blood total-, LDL- and HDL-cholesterol concentration and the LDL:HDL ratio [7]. Polyunsaturated ω -6 fatty acids tend to decrease LDL-cholesterol levels, while mono-unsaturated ones are probably essentially neutral with respect to cholesterol. Fatty acids of the ω -3 series have not been shown to have consistent effects on blood cholesterol, although long-chain ω -3 polyunsaturates are effective in reducing blood triacylglycerol levels, a risk factor on their own for cardiovascular disease [8].

Studies dealing with the role of dietary cholesterol on blood cholesterol go as far back as 1956 when Keys *et al.* [9] studied serum cholesterol level and cholesterol intake. The results indicated that in the adult man the serum cholesterol level is essentially independent of the cholesterol intake over the whole range of natural human diets. Similarly, Morris *et al.* [10] and Kahn *et al.* [11] found no correlation between the levels of serum cholesterol and the daily intake of foods considered rich in cholesterol. Nichols *et al.* [12] also concluded that blood cholesterol varied from the lowest to the highest

* Corresponding author. r.chizzo@unipr.it (R.Chizzolini)

concentrations independently of dietary cholesterol. Recent research on the subject appears to confirm that dietary cholesterol has only a minor effect on serum cholesterol and LDL cholesterol levels [6,13]. Such views do not agree entirely with some reports in which a relationship was observed between nutrition styles and serum cholesterol levels, like, for instance, some studies regarding China's rural population, vegetarians or food intervention trials [14–16]. In the latter case, though, greater changes were seen in men with higher baseline serum cholesterol concentrations, in hypertensive than in normotensive men and in older subjects. An increase of serum cholesterol level has been observed in Japan since 1960 in parallel with an increase in the consumption of meat, eggs, milk and dairy products but the mortality rate from stroke decreased by 70% in the same period [17].

Factors other than cholesterol intake and serum cholesterol level, therefore, must be linked with chronic cardiovascular diseases. Among such factors, genetics and antioxidant dietary intakes appear to be very important.

Mortality from coronary heart disease is exceptionally low in the north of Finland in the Sami (or Lapp) area. It has been reported that the subjects living in the Sami area have higher serum cholesterol concentration, higher LDL-cholesterol and lower HDL-cholesterol/cholesterol ratio but higher serum contents of α -tocopherol and selenium. Serum concentrations of α -tocopherol and selenium were linked with, respectively, reindeer meat and fish consumption [18].

Genetic influences, too, are important to understand susceptibility to coronary heart disease [8] and the effect of genetics on plasma cholesterol levels and lipoprotein distribution is increasingly recognized. It has been reported recently [19] that a genetic variant of the gene coding for the cholesteryl ester transfer protein (CETP) is associated with the progression of atherosclerosis. The CETP mediates the exchange of cholesteryl esters between lipoproteins with a net transfer of such compounds from HDL to LDL and VLDL, promoting in this way the atherogenicity of the latter.

It is now believed that only people with a genetic predisposition toward high cholesterol values would benefit from a reduction in dietary cholesterol [20].

The epidemiological studies linking dietary fat and cholesterol intakes with chronic cardiovascular diseases, in spite of the unsettled opinions briefly mentioned above, have conferred a negative image to meat and meat products which have been accused of being unhealthy for their high content of fat (mainly saturated) and cholesterol. The meat production system has, therefore, been put under pressure to re-examine the nutritional attributes of meat with the result that much effort has been placed in reducing the fat content and in assessing the real impact of meat consumption on serum cholesterol levels [21,22].

Calorific value and cholesterol content of meat and meat products

Lean meat is made up by three main components: water (75%), protein (19%) and fat (2.5%). Minor components make up the remaining 3.5%, and include carbohydrates (about 1%), soluble nitrogenous substances, minerals and vitamins [23]. Such composition values can vary depending on various endogenous (e.g. muscles, breeds, sex, species) and exogenous (e.g. feeding regimes) factors. The main components can vary even more in meat products, especially the comminuted ones.

Carbohydrates are present in very small amounts (normally about 1% or less) in meat and in most meat products. Their contribution to the calorific value of meats is therefore negligible. Proteins, with a calorific value of 4 kcal/g, contribute around 80 kcal/100 g of fresh meat. The value will be lower in many meat products in which protein content decreases to 15% or even less. Fat content can vary from about 1 to 2% of fresh meat (Table 1) to 25% (Table 2) or over 30% of some meat products [31]. Consequently, fat contribution (estimated as 8 kcal/g of adipose tissue, considering the latter as about 90% fat and 10% water) to total calorific value of 100 g serving of meat may range from about 10–15% to above 80%; total calories ranging from about 100 to over 300 kcal.

Calorific value of meats has to be evaluated in the light of meat consumption figures inside the average diet of affluent societies. Average per capita consumption of meat is usually derived from meat production data where meat, though, includes bones, fatty tissues, organs, trimmings and waste of various types. If such figures are freed from non-edible parts, only about 60% of meat production is actually used for human consumption [32,33]. On that basis, for a country like Germany, for instance, real meat consumption would amount to 178 g/day, including meat products. Average composition would be around 17% protein and 20% fat, the latter one deriving from a figure of 8.6% in fresh meat and one of 24.3% in meat products. Meats, therefore, would contribute around 240 kcal/100 g or just over 400 kcal/day [32]. Similar figures have been reported for the United States [33]. Total meat consumption is obviously different in individual countries but average meat composition would not change very much from one country to another. Meat contribution to caloric intake, therefore, can be estimated to range from 10 to 20% of total calories in most developed countries. Similar figures on meat consumption and meat caloric contribution were obtained by other researchers [34–36].

Dietary cholesterol is strictly linked with foods of animal origin as all of them contain cholesterol since cholesterol is an essential constituent of animal cells.

Since the appearance of the first reports linking serum cholesterol with chronic heart diseases, a great deal of

Table 1. Average composition, cholesterol content and calorific value of some representative types of meat and fat [24]

Type of meat	Water (%)	Protein (%)	Fat (%)	Cholesterol (mg/100 g)	Energy value (kcal/100 g)
Beef (muscles)	75.10	22.00	1.90	60.00	115
Veal (muscles)	76.40	21.30	0.81	70.00	101
Pork (muscles)	74.70	22.00	1.86	65.00	114
Mutton (fillet)	75.00	20.40	3.41	70.00	122
Chicken (average)	72.70	20.60	5.60	81.00	144
Turkey (average)	63.50	20.20	15.00	74.00	231
Lamb (intermuscular fat)	25.80	5.49	68.30	75.00	673
Beef (intermuscular fat)	20.20	8.20	70.90	99.00	710
Pork (intermuscular fat)	18.00	4.70	76.70	93.00	749

Table 2. Fat, cholesterol and calories content of some meat products (average values from more than one sample, adapted from various authors)

Type of product	Fat (%)	Cholesterol (mg/100 g)	kcal/100 g	Reference
Hamburger	13.01	43.57	313	[25]
Beef sandwiches	15.39	55.63	316	[25]
Frankfurters pork	24.4	65.0	286	[24]
Frankfurters beef–pork	26.7	46.7		[26]
Frankfurters all-beef	25.5	40		[26]
Frankfurters chicken	23.4	94		[26]
Salame Milano	31	71		[27]
Mortadella	27	81		[27]
Würstel	32	110	340	[28]
Parma ham	16	80	240	[28]
Bresaola	8	37	225	[28]
Beef patties	19.2	86.3	272	[29]
Beef patties	1.4–35.3	78–90	110–360	[30]

work has been done to estimate cholesterol content in animal tissues used as human food. Earlier methods for the determination of cholesterol were not sufficiently precise nor standardized and the data published in different studies were not always comparable at the time, neither are comparable with the latest ones. For that reason, only data published in recent years have been presented in Tables 1–3 where average cholesterol contents of the main types of meat, muscles and meat products are presented. The data are intended only for illustrative purposes and are not meant to be an exhaustive anthology of the subject. A recent investigation on fat and cholesterol content of some commercial pork cuts in Spain has produced higher values than those presented in Table 2 but, as the authors pointed out, different methods for cholesterol quantification or sampling or trimming of adipose tissue could be responsible [41].

Average cholesterol contents of the main meat species are summarized in Table 1 and more detailed data on cholesterol contents of the most important muscles are presented in Table 3. Although variations can be seen among different species and muscles, their magnitude appears to be generally low. Indeed a number of studies have demonstrated that the differences, sometimes detected in cholesterol content among some breeds, or between sexes or in relation with some feeding regimes,

are small and of no real use for dietary reductions of cholesterol intake [41–47].

Significant and interesting differences, instead, have been reported in cholesterol content between muscle types. A typical and indicative example is the study conducted by Smith *et al.* [48] on pectoralis muscles of duckling (16% white fibres) and chicken (100% white fibres). Duckling pectoralis muscle has been found to have more cholesterol (99.11 mg/100 g muscle) than broiler pectoralis (47.41 mg/100 g muscle).

Similar observations have been reported by Fernandez *et al.* [49] in pigs, where muscle *Longissimus lumborum* (predominantly white) was found to have significantly lower content of cholesterol than *Semispinalis capitis* (predominantly red). In beef, although to a lower extent compared with pork, Browning *et al.* [50] found that *Supraspinatus* and *Infraspinatus* muscles had higher cholesterol content than other muscles. The same was found to apply to rabbit muscles [51]. The figures reported in Table 3 for cholesterol content of the heart, tongue and poultry wings, would confirm the observation.

The relationship between fibre type and cholesterol content has been interpreted on physical and metabolic grounds. Duckling pectoralis muscle contains a high proportion of red fibres that are smaller in transverse area than white fibres. Therefore, a duckling pectoralis muscle of similar weight to that of a broiler would be

Table 3. Intramuscular fat and cholesterol content of some muscles and species (adapted from various authors)

Type of meat	Fat (%)	Cholesterol (mg/100 g)	Reference
Beef			
<i>Quadriceps femoris</i>	2.2	49.0	[37]
Shoulder	2.9	56.7	[37]
<i>Semimembranosus</i>	3.2	49.5	[37]
Fillet (small end)	3.7	50.8	[37]
<i>Semitendinosus</i>	3.9	53.5	[37]
<i>Longissimus dorsi</i>	6.3	48.5	[37]
Entrecote	11.3	46.7	[37]
Belly (middle part)	13.9	66.5	[37]
Belly (front part)	29.2	68.3	[37]
Heart	6.0	150.0	[24]
Lamb			
<i>Semimembranosus</i>	2.0	50	[38]
	2.2	49	[38]
<i>Rectus femoris</i>	2.6	50	[38]
<i>Biceps femoris</i>	2.1	49	[38]
<i>Gluteus</i>	2.2	50	[38]
Pork			
Round	1.6	51.3	[37]
Fillet	1.6	54.9	[37]
<i>Biceps femoris</i>	1.7	48.6	
<i>Longissimus dorsi</i>	3.3	45.3	[37]
<i>Semimembranosus</i>	3.5	49.9	[37]
Chops	7.0	53.6	[37]
Neck	11.9	62.2	[37]
Belly	27.1	59.0	[37]
Backfat	82.0	59.3	[37]
Tongue	11.3	86.7	[39]
Backfat	70.3	53.6	[39]
Jowl	64.3	60.4	[39]
Stomach	5.79	141.2	[39]
Heart	3.6	150.0	[24]
Poultry			
Breast without skin	0.7	43.4	[37]
Breast with skin	6.2	61.4	[37]
Upper leg without skin	6.5	84.0	[37]
Lower leg with skin	7.3	87.7	[37]
Wings with skin	11.5	95.3	[37]
Upper leg with skin	15.1	84.6	[37]
Heart	5.8	170.0	[24]
Turkey			
Breast without skin (average)	1.0	44.0	[37]
Breast rolled with skin	5.3	50.8	[37]
Lower leg with skin	5.7	71.9	[37]
Upper leg with skin	7.2	60.1	[37]
Wings with skin	8.7	64.9	[37]
Legs rolled with skin	12.4	78.6	[37]
Leg rolled	13.5	80.7	[37]
Ostrich			
<i>M. gastrocnemius</i> (Red necks)	1.3	65.5	[40]
<i>M. iliofibularis</i> (Red necks)	1.4	63.0	[40]
<i>M. gastrocnemius</i> (Blue necks)	1.5	63.4	[40]
<i>M. iliofibularis</i> (Blue necks)	1.5	65.6	[40]

composed, proportionally, of more (red) fibres. An increase of fibre number within a muscle would increase the total sarcolemma perimeter to fibre per volume ratio and, therefore, cholesterol content [48].

The metabolic hypothesis springs from the fact that oxidative muscles are richer in phospholipids and from the finding that the higher the phospholipid content of the muscle, the higher the cholesterol content. The relationship between cholesterol and phospholipids would be largely explained by the physical effects of cholesterol on the ordering of phospholipid chains contributing to maintain the membrane fluidity in a narrow range [51].

Differences in fibre type, therefore, might be the most likely reason for some of the differences observed in cholesterol content among different muscles of the same species and between the same muscles in different species. The observation is important since it provides the most plausible explanation of many observed differences in cholesterol content in meats and has important implications for both dietary and technological purposes.

A point which has raised much interest concerns the cholesterol content of lean and fat. A commonly held view was that fatty meats had higher cholesterol contents than lean ones. The issue has been repeatedly investigated and clear studies in beef have been carried out, among others, by Hoelscher *et al.* [52] and Kinney Sweeten *et al.* [53].

Hoelscher *et al.* [52] observed that in bovine muscle tissue (*L. dorsi*), 60–80% of total cholesterol was located in the membrane component while the cytoplasm contained 20–40%. In subcutaneous adipose tissue, the membrane fraction contained 8–12% of total cholesterol while the cytoplasmic fraction contained 88–92%. Differences in carcass quality grade had measurable effects as cholesterol content in membranes was lower in Prime (11.2% fat) and higher in Select (2.9% fat) ones. Total cholesterol, though, was not significantly different among quality grades. Total cholesterol in muscle was found to vary between 61 and 63.5 mg/100 whereas total cholesterol in adipose tissue was between 113 and 121 mg/100. The authors concluded that the subcellular distribution of cholesterol in muscle tissue changed when intramuscular fat was increased: as the amount of non-membrane lipid increased, cholesterol in membrane component decreased and the lipid storage component of cholesterol increased. This resulted in no overall change in total cholesterol of muscle. In adipose tissue cells the compensation is not as efficient since increased cholesterol (and lipid) content of the cytoplasm can outweigh the relative contribution of membrane cholesterol.

Kinney Sweeten *et al.* [53] went a little further. Working with bovine *L. dorsi* (LD), *Psoas major* (PM), *Semitendinosus* (ST), subcutaneous adipose tissue and intramuscular adipose tissue of *L. dorsi*, they established that cholesterol was present in intramuscular

fat at a rate of 118 mg/100 g and that it was distributed for about 55% in the cytoplasm and 45% in membranes, as opposed to a distribution in subcutaneous adipose tissue of 10% in membranes and 90% in the cytoplasm. The total amount of cholesterol contributed by intramuscular adipose tissue in muscles such as LD, PM and ST was calculated to be, respectively, 2.7, 2.4 and 1.2 mg/100 g of meat. Therefore, marbling adipose tissue depots contribute only minute amounts to the total cholesterol present in an ordinary serving of meat.

Similar conclusions were reached by Browning *et al.* [50] who determined cholesterol content in 10 beef muscles in carcasses of two different fat levels. The relationship between cholesterol content and fat content was not significant. Rhee *et al.* [54] reported a simple correlation coefficient of 0.37 (statistically significant, $P < 0.001$), between fat content and cholesterol content in bovine *L. dorsi* but the low coefficient led the authors to conclude that changes in cholesterol content derived from differences in fat content would be of little significance from a practical standpoint. Lewis *et al.* [47] also concluded that a high fat content of muscles did not always relate with a high cholesterol concentration.

There is a general consensus on a higher cholesterol content of beef depot fat compared with muscle tissue. The same does not appear to be the case with pork (Tables 1 and 3). Lan *et al.* [46] have reported cholesterol contents in pork subcutaneous, intermuscular and internal fat around 100 mg/100 g, similar to the 93 mg/100g (Table 1) of Scherz and Senser [24] for intermuscular fat, while values lower than 60 mg/100 g have been recently observed by other authors in dorsal subcutaneous and belly fat in pigs [37,39]. In the latter cases cholesterol content appears to be very similar to that of the main porcine muscles (Table 3). It is not clear whether such differences are due only to the analytical methods adopted or to other reasons.

Cholesterol content of some meat products, chosen as being indicative of the great variety of products on the market, are presented in Table 2. The most interesting products are obviously those with a high fat content such as sausages, hamburgers and, in general, those based on ground meat mixed with fat. In such products, cholesterol content can vary considerably and the effect of fat on cholesterol content appears to be significant only for the very fatty products [30]. In the case of meat products, therefore, higher fat contents would mean more calories and, only in some cases, higher cholesterol intakes.

Part of the differences observed in cholesterol content among meat products could be ascribed also to the different muscles (red or white) used. This aspect does not appear to have been studied. It is known that products based on ground meat often make use of trimmings or low value cuts such as those derived from the distal end

of the limbs, from the neck, from the head, etc., which tend to be rich in red fibres. The high cholesterol content of some meat products could, therefore, derive not only from the high fat content but also from the relative importance of red muscles. Ingredients other than muscle tissue, such as offal, can also affect cholesterol content. Pig stomach, for instance, is rich in smooth muscle fibres, connective tissue and cholesterol (141 mg/100 g) but it is interesting in mortadella production for the low cost and technological properties (it gives a smooth taste to the finished product) [39].

From the data reviewed, total cholesterol intake from meat consumption has been estimated to be 119 mg/day by Honikel [32] and values between 100 and 150 mg/day can be expected from meat consumption data and from the cholesterol contents reported in Tables 1–3. Such figures would imply that amounts ranging from one third to one half of the daily recommended cholesterol intake (300 mg/day) are provided by meat, in line with data presented by Rourke *et al.* [34]. Percent values could be a little higher if it were confirmed that average daily intake of cholesterol had fallen in recent years. It has been calculated, for instance, that in 1994 cholesterol intake was 245 mg/day in the UK [55].

Low-fat meat and meat products: caloric and cholesterol contents

The considerations reported in the previous sections are useful to place correctly the possible contribution of low fat meats for the reduction of calories and cholesterol intakes.

During recent decades much work has been done in reducing the fat content of carcasses to meet consumers' demands for leaner meat. Selection of breeds and genetic lines inside breeds, changes in animal feeding practices, including some feed additives (probiotics, antibiotics, etc.), and intervention in animal metabolism (anabolic implants, β -agonists, growth hormone, etc.) are the main tools used to achieve a reduction in carcass fat content. In the near future, molecular genetics should bring further impetus for a more targeted control of fat deposition in different tissues.

Such techniques have allowed a substantial reduction of fat dispersed among the muscle fibres (intramuscular), laid down between the muscles (intermuscular), under the skin (subcutaneous) and in the body cavities (visceral). From a dietary point of view, intramuscular fat is the most important one as it cannot be trimmed before or during consumption. The other types of adipose tissue are more an economic issue. They can be removed from carcasses and/or trimmed from the external surfaces of the muscles and excluded from the food chain but, at the same time, they are degraded to a by-product of very little value.

Although, as can be expected, intramuscular fat content varies with muscles and breed or species, the data

reported in Table 3 for the most important muscles and animal species indicate that, today, it is present in lean meat at levels frequently lower than 5%. A further decrease in intramuscular fat content would decrease meat quality attributes, first of all juiciness and flavour, already impaired in some cases (e.g. lean pork loins or lean chicken breast). At such fat levels, total calories from 100g of fresh lean meat would total around 120 kcal [56], a figure which cannot, and should not, be reduced further. Indeed, future developments in the control of fat deposition should be directed at reducing subcutaneous and visceral fat while adjusting intramuscular fat to optimum levels for quality and nutritional requirements.

It is difficult to establish if cholesterol content of fresh meat has significantly changed in recent years due to the decrease in intramuscular fat content. If a hypothesis can be put forward, it is that cholesterol content might have decreased a little in low-fat animals since genetic selection and some metabolic modifiers have changed the balance between red and white muscles. Indeed, the search for fast growth has produced animals with hypertrophied muscles, especially those of the loin, the hind limb and the breast which are rich in white fibres [57,58].

Meat products, especially burgers, sausages and the like, are a different matter. In such products a decrease in fat content can have marked effects on calories intake and, in some cases, also on cholesterol content. The studies conducted in recent years on fat reduction and substitution in meat products are countless. All of them have been concerned with technological and sensory properties, many of them have looked at calories but only a few have also measured cholesterol content.

From the point of view of calorific value, leaving aside the techniques based on fat removal from meat, it might be convenient to classify the substances or molecules used to replace fat in three main groups: proteins, carbohydrates and chemically modified fats or lipid analogues.

Proteins come from many different sources both from the plant (soy, wheat, corn, oat, etc.) and the animal (collagen, milk, etc.) kingdoms. All of them are digested and absorbed in similar ways and have a conventional calorific value of 4 kcal/g on a dry weight basis [59].

Carbohydrates are mainly starch and cellulose derivatives, polydextrose and gums of plant and microbial origin (carrageenan, alginates, konjac flour, xanthan, pectin, etc.). Their calorific value, on dry weight, ranges from 4 kcal/g of starches to less than 1 kcal/g of gums or cellulose derivatives [59]. Oatrim[™] and Leanesse[™], for instance, are oat-based dextrans with less than 1 calorie/g.

Lipid analogues are synthetic molecules with functional and sensory properties similar to fat but resistant to hydrolysis in the digestive system and, therefore, they provide no or very few calories.

In meat products, proteins and carbohydrates are used in combination with water to produce gels to offset the textural problems (elasticity, softness, juiciness, etc.) of low fat formulations. The amounts (in dry weight) of such substances used in low-fat products are very limited as the real fat substitute is the added water held by them. Their contribution to the caloric value is therefore almost negligible in finished products.

Both proteins and carbohydrates employed as fat substitutes are cholesterol free compounds. They have, therefore, an indirect lowering effect on cholesterol content of low-fat meat products through the increase in the relative amount of water and the corresponding decrease in protein and fat content. The same would not happen by simply using leaner meats since, as discussed earlier, cholesterol present in membranes of muscle cells would compensate, wholly or partially, for cholesterol contained in animal fats [30].

A clear example is given by a study on low-fat ground beef [29]. Traditional beef patties with 20% fat would have, after cooking, 55.8% moisture, 19.2% fat, 24.8% protein, 272 kcal/100g and 86.3 mg cholesterol/100 g. Patties produced with lean beef would present 63.3% moisture, 9.8% fat, 26.6% protein, 196 kcal and 83.1 mg cholesterol/100 g, whereas lean patties with added 0.5% iota carrageenan and 0.2% hydrolysed vegetable proteins would have a composition of 66.3% moisture, 8.2% fat, 24.5% protein, 172 kcal and 72.2 mg cholesterol/100 g. That is, lean meat alone can bring about nearly a 30% reduction in calories but would have no significant effect on cholesterol content. The third formulation, instead, would reduce calories further (about 36%) but would also significantly reduce cholesterol content by 16%. Another example is provided by Minerich *et al.* [60] who reported in cooked beef patties a cholesterol content of 74.5 mg/100 g with 12.5% fat (26.5% protein) and a cholesterol content of 79.5 mg/100 g with 19% fat (23.9% protein). Cholesterol content of the patties in which fat had been reduced to 10% (21.3% protein) and 8.3% (18.9% protein) with wild rice was found to be, respectively, 65.0 mg/100 g and 54.5 mg/100 g.

Similar results have been reported for other products and other fat substitutes. With meat products having above 30% fat, it is possible to go down to less than 10% lipids, reducing total calories to less than half the original value and lowering, at the same time, cholesterol content to values similar to those found in fresh meats [31,61].

Effect of cooking

The data reported above refer generally to raw meats. It seems appropriate to mention briefly the effects of cooking. A comprehensive analysis of all the various cooking methods and temperatures is not possible but useful hints can be found in the published literature.

Cooking causes a weight loss which is primarily due to removal of water. Calories and cholesterol per gram, therefore, normally increase on a wet tissue basis but the picture is obviously different on a dry matter one.

Cholesterol values in meat do not change appreciably on cooking, since negligible amounts are lost from membranes [47]. Indeed, Rhee *et al.* [62] measured very limited losses of cholesterol in the cook drip: from 0.29 to 2.60% depending on the marbling level of beef *L. dorsi* steaks. The higher cholesterol loss in steaks richer in marbling fat could be attributed to the cholesterol fraction present in the cytoplasm of the adipocytes. Cooking can have more measurable effects in meat products, especially in the minced ones rich in fat. As the fat level of ground pork increased from 4 to 23%, cooking drip composition moved from only moisture ~15% to about 50–50 water–fat and cholesterol content of drip from about 2 to 7% [63]. Cooking caused a small cholesterol loss in beef patties up to 25% fat content but the loss was more pronounced in the 30% fat ones. Similarly, total fat and the saturated, mono-unsaturated and polyunsaturated fatty acids were significantly reduced by 31 to 35% from cooking and draining and reduced by an additional 25 to 30% from rinsing of ground beef in a school foodservice setting, but cholesterol was not affected [64].

Other studies have reported [65] that, whereas cooking loss was substantially constant around 30% in ground pork, irrespective of fat contents ranging from 4 to 23%, the percentage of fat in the drip moved from 0.35 to 44.20%. The cooking loss of ground beef patties, on the other hand, varied from about 22 to 33%, as fat content increased from 5.76 to 18.22% [66]. The relationship between caloric decrease and fat content of beef patties was seen to be direct up to 20% fat and curvilinear from 20 to 35%, varying from less than 10% to 30–40% [30].

Cooking loss, and the decrease in calories associated with it, could be important for comparative evaluations between full-fat and low-fat products. Indeed, the difference in total calories between the former and the latter might be lower in the cooked versus raw state since the loss of fat during cooking would be greater in traditional than in low-fat products. The latter would lose more water with a relative increase in the relative fat content [30], just as would happen in lean muscle cuts, and total calories introduced by a full-fat serving might not be so different from a low-fat one.

Conclusion

Meat and meat products seem to account for about 10–20% of the total calories in industrialized countries. The caloric contribution of meat does not appear to be a determinant in the pathogenesis of chronic metabolic disorders. Meat fatty acid composition has been criticized for its high content of saturated fatty acids (up to

50% in beef and around 40% in pork) and for being low in polyunsaturated fatty acids, especially of the ω -6 series. Stearic acid, though, is credited with a lowering effect on plasma cholesterol and LDL cholesterol levels [67,68].

The contribution of meats to cholesterol intake is higher, compared with the caloric effect, ranging from one third to one half of the total, but the role of dietary cholesterol on serum cholesterol concentrations, although disputed in some cases, appears to be important only for people genetically predisposed to hypercholesterolemia.

Consumption of fresh meat low in intramuscular fat does not appear to be an effective way of reducing dietary cholesterol but it reduces fat and caloric intake. On the other hand, trimming of subcutaneous fat could be effective for reducing both dietary cholesterol and fat (and calories).

Low-fat meat products can exert a bigger effect in reducing dietary fat intake as many traditional meat products have high fat contents. The decrease of fat in the ingredients and the use of fat substitutes can cut down meat calorific value by up to, or more than, half.

Using leaner meat might have the advantage of modifying the fatty acid composition. There would be a reduction in saturated and an increase in polyunsaturated fatty acids, as the latter are included in structural components of membranes and their absolute values cannot change, whereas the effect on cholesterol would be negligible. A significant decrease in cholesterol can be obtained with the use of fat substitutes mainly as a consequence of their effect on moisture retention and muscular tissue dilution.

It is important to realize, furthermore, that current views on the pathogenesis of cardiovascular diseases, and of atherosclerosis in particular, have dropped to a significant degree the simple and one-way relationship with total cholesterol and fat intakes. Oxidative insults are very important for the occurrence and development of such diseases. Epidemiologic studies have provided evidence of an inverse relationship between coronary artery disease and antioxidant intake, and vitamin E supplementation in particular [69].

Among lipid oxidation products, cholesterol oxides (COPs) are probably the best known for their toxicity. Only a few of the 70–80 compounds identified, though, have been observed in animal foods [70]. In meats, in particular, the most frequently found oxysterols are 7-ketocholesterol, 7 β -hydroxycholesterol, 5,6 α -epoxycholesterol, 25-hydroxycholesterol, 20 α -hydroxycholesterol and cholestanetriol (3 β ,5 α ,6 β -trihydroxycholesterol [2,71,72].

Indeed, the notion that cholesterol is toxic or a toxin *per se* seems remote given the preponderance of data to the contrary. Oxysterols should be viewed as toxic, in particular, with regard to coronary heart disease [73] since they, not pure cholesterol, cause dysfunction of

vascular endothelial cells [74,75] and atherosclerotic lesions not only contain cholesterol but also a series of cholesterol oxidation products [76]. Moreover, it has been shown that COPs are able to affect negatively the regulation of some genes involved in the maintenance of cell viability and, in such a way, they seem to play determinant roles in lymphoid cell death known as apoptosis [77].

Recent views propose that antioxidants may act by slowing down the progression of the atherosclerotic lesions and may protect against the endothelial dysfunction associated with atherosclerosis by preserving endothelium-derived nitric oxide activity [78]. In such a context, it is significant that a strict relationship has been reported between low mortality rate from coronary heart disease in the Sami (or Lapp) area in the north of Finland and high serum contents of α -tocopherol and selenium in spite of high serum cholesterol concentration, higher LDL-cholesterol and lower HDL-cholesterol:cholesterol ratio [18].

Finally, it has been proposed that the falls in cardiovascular mortality rate that have been noted in the last few years might come from various factors such as improved medical care, blood pressure control and reduction, dietary changes (fresh vegetables rich in antioxidants and dietary fibre), physical activity, body weight control, reduction in smoking and drinking alcohol [17,79].

References

- WHO (World Health Organisation) Study Group (1990) Diet, Nutrition and the Prevention of Chronic Diseases, in *WHO Technical Report Ser. 797*
- Reddy, B.S. (1995) 'Nutritional Factors and Colon Cancer' in *Critical Reviews in Food Science and Nutrition* 35, 175–190
- Hegsted, D.M., McGandy, R.B., Myers, M.L. and Stare, F.J. (1965) 'Quantitative Effect of Dietary Fat on Serum Cholesterol in Man' in *American Journal of Clinical Nutrition* 17, 281–295
- Consensus Conference (1985) 'Lowering Blood Cholesterol to Prevent Heart Disease' in *Journal of the American Medical Association* 253, 2080–2088
- Vergoesen, A.J. and Crawford, M.A. (1989) in *The Role of Fats in Human Nutrition*, Academic Press, New York
- Nelson, G.J., Schmidt, P.C. and Kelley, D.S. (1995) 'Low-fat Diets do not Lower Plasma Cholesterol Levels in Healthy Men Compared to High-fat Diets with Similar Fatty Acid Composition at Constant Caloric Intake' in *Lipids* 30, 969–976
- Wiseman, M.J. (1997) 'Fat and Fatty Acids in Relation to Cardiovascular Disease: an Overview' in *British Journal of Nutrition* 78 (Suppl. 1), 3
- Austin, M.A. (1997) 'Triacylglycerol and Coronary Heart Disease' in *Proceedings of the Nutrition Society* 56, 667–670
- Keys, A., Anderson, J.T., Mickelsen, O., Adelson, S.F. and Fidanza, F. (1956) 'Diet and Serum Cholesterol in Man, Lack of Effect of Dietary Cholesterol' in *Journal of Nutrition* 59, 39–56
- Morris, J.N., Marr, L.W., Heady, L.A., Mills, G.L. and Pilkington, T.R.E. (1963) 'Diet and Plasma Cholesterol in 99 Bank Men' in *British Medical Journal* 1, 571–576
- Kahn, H.A., Medalie, J.H., Neufeld, H.N., Riss, E., Balogh, M. and Groen, J.J. (1969) 'Serum Cholesterol, its Distribution and Association with Dietary and other Variables in a Survey of 10,000 Men' in *Israel Journal of Medical Science* 5, 117–1127
- Nichols, A.B., Ravenscroft, C., Lamphier, D.E. and Ostrander Jr., L.D. (1976) 'Daily Nutritional Intake and Serum Lipid Levels. The Tecumseh Study' in *American Journal of Clinical Nutrition* 29, 1384–1392
- Hu, F.B., Stampfer, M.J., Manson, L.E., Rimm, E., Colditz, G.A., Rosner, B.A., Hennekens, C.H. and Willet, W.C. (1997) 'Dietary Fat Intake and the Risk of Coronary Heart Disease in Women' in *The New England Journal of Medicine* 337, 1491–1499
- Campbell, T.C., Parpia, B. and Chen, J. (1998) 'Diet, Lifestyle and the Etiology of Coronary Artery Disease: The Cornell China Study' in *American Journal of Cardiology* 82, 18–21
- Buff, M.L. and Butland, B.K. (1988) 'Heart Disease in British Vegetarians' in *American Journal of Clinical Nutrition* 48, 830–832
- Gorder, D.D., Bartsch, G.E., Tillotson, J.L., Grandits, G.A. and Stamler, J. (1997) 'Food Group and Macronutrient Intakes, Trial Years 1–6, in the Special Intervention and Usual Care Groups in the Multiple Risk Factor Intervention Trial' in *American Journal of Clinical Nutrition* 65, 2585–2715
- Shimamoto, T., Iso, H., Eda, M. and Kornachi, Y. (1996) 'Epidemiology of Cerebrovascular Disease: Stroke Epidemic in Japan' in *Journal of Epidemiology* 6, S43
- Luoma, P.V., Nayha, S., Sikkilä, K. and Hassi, J. (1995) 'High Serum α -tocopherol, Albumin, Selenium and Cholesterol, and Low Mortality from Coronary Heart Disease in Northern Finland' in *Journal of Internal Medicine* 237, 49–54
- Kuivenhoven, L.A., Jukema, L.W., Zwinderman, A.H., De Knijff, P., McPherson, R., Bruschke, A.V.G., Lie, K.I. and Kastelein, L.L.P. (1998) 'The Role of a Common Variant of the Cholesteryl Ester Transfer Protein Gene in the Progression of Coronary Atherosclerosis' in *The New England Journal of Medicine* 338, 86–93
- Simopoulos, A.P. (1997) 'Diet and Gene Interactions' in *Food Technology* 51, 66–69
- Hafs, H.D. and Zimbelman, R.G. (1994) *Low-fat Meat Products. Design Strategies and Human Implications*, Academic Press, New York
- Brisson, G.J. (1987) 'Dietary Cholesterol and Blood Cholesterol in Humans' in *Pig News and Information* 8, 9–14
- Lawrie, R.A. (1998) *Meat Science*. 6th Edition, Woodhead Publishing, Cambridge
- Scherz, H. and Senger, F. (1989) *Food Composition and Nutrition Tables 1989/1990*. Wissenschaftliche Verlagsgesellschaft mbH, Stuttgart
- Slover, H.T., Lanza, E. and Thompson Jr., R.H. (1980) 'Lipids in Fast Foods' in *Journal of Food Science* 45, 1583–1591
- Newkirk, D.R., Sheppard, A.J., Hubbard, W.D. and Osgood, T. (1978) 'Individual Lipids and Proximate Analysis of Various Foods. 2—Frankfurters and Other Meat and Poultry Products' in *Journal of Agriculture and Food Chemistry* 26, 348–350
- Novelli, E., Zanardi, E., Ghirelli, G., Campanini, G., Dazzi, G., Madarena, G. and Chizzolini, R. (1997) 'Lipid and Cholesterol Oxidation in Frozen Stored Pork, Salame Milano and Mortadella' in *Meat Science* 48, 29–40
- Cipolla, M. (1990) 'Problemi Pratici nell'Alimentazione Dello Sportivo: I Plus Delle Carni e dei Salumi' in *Rivista della Società Italiana della Alimentazione* 19, 103–111
- Egbert, W.R., Fluffinan, D.L., Chen, C.M. and Dylewski, D.P. (1991) 'Development of Low-fat Ground Beef' in *Food Technology* 45, 64–73
- Hoelscher, L.M., Savell, J.W., Harris, J.M., Cross, H.R. and Rhee, K.S. (1987) 'Effect of Initial Fat Level and Cooking Method—Cholesterol Content and Caloric Value of Ground Beef Patties' in *Journal of Food Science* 52, 883–885
- Keeton, J.T. (1994) 'Low-fat Meat Products—Technological Problems with Processing' in *Meat Science* 36, 261–276

- 32 Honikel, K.O. (1992) 'Fleisch- und Fleischfettverzehr' in *Fleischwirtschaft* 72, 1145–1148
- 33 Klurfeld, D.M. (1994) 'Human Nutrition and Health Implications of Meat with More Muscle and Less Fat' in *Low-fat Meat Products. Design Strategies and Human Implications*, (Hafs, H.D., Zimbelman, R.G., eds), pp. 35–51, Academic Press, New York
- 34 Rourke, T.L., Ramsey, B.C., Davis, G.W., Clark, J.R. and Wheeler, T.L. (1992) 'Consumption and Plate Waste of Regular and Total Trim Roasted Pork Loins' in *Journal of Muscle Foods* 3, 341–354
- 35 Breidenstein, B.C. (1984) *Contribution of Red Meat to the U.S. Diet*. National Livestock and Meat Board, Chicago
- 36 Rathje, W.L. (1985) 'Where is the Beef?' in *American Behaviour* 28, 71–91
- 37 Honikel, K.O. and Arneht, W. (1996) 'Cholesteringehalt in Fleisch und Eiern' in *Fleischwirtschaft* 76, 1244–1253
- 38 Garcia, P.T., Casal, L.L., Margaria, C.A. and Pensel, N.A. (1995) 'Cholesterol Content in Different Meats' in *Proceedings of the 41st International Congress of Meat Science and Technology*, pp. 54–55 A21, S. Antonio, Texas
- 39 Chizzolini, R. (1999) unpublished results
- 40 Horbańczuk, J., Sales, J., Celeda, T., Konecka, A., Zièba, G. and Kawka, P. (1998) 'Cholesterol Content and Fatty Acid Composition of Ostrich Meat as Influenced by Subspecies' in *Meat Science* 50, 385–388
- 41 Dorado, M., Matin Gómez, E.M., Jiménez-Colmenero, F. and Masoud, T.A. (1999) 'Cholesterol and Fat Contents of Spanish Commercial Pork Cuts' in *Meat Science* 51, 321–323
- 42 Feeley, R.M., Criner, P.E. and Watt, B.K. (1972) 'Cholesterol Content of Foods' in *Journal of the American Dietetic Association* 61, 134–149
- 43 Eichhom, L.M., Coleman, L.J., Wakayama, E.J., Blomquist, G.J., Bailey, C.M. and Jenkins, T.G. (1986) 'Effects of Breed Type and Restricted versus ad libitum Feeding on Fatty Acid Composition and Cholesterol Content of Muscle and Adipose Tissue from Mature Bovine Females' in *Journal of Animal Science* 63, 781–794
- 44 Wheeler, T.L., Davis, G.N., Stoecker, B.J. and Hannon, C.J. (1987) 'Cholesterol Concentration of *Longissimus* Muscle, Subcutaneous Fat and Serum Level of Two Beef Cattle Breed Types' in *Journal of Animal Science* 65, 1531–1537
- 45 Baker, L.F. and Lunt, D.K. (1990) 'Comparison of Production Characteristics from Birth through Slaughter of Calves Sired by Angus, Charolais or Piedmontese Bulls' in *Journal of Animal Science* 68, 1562–1568
- 46 Lan, Y.H., McKeith, F.K. and Novakofski, J. (1993) 'Effects of Tenth Rib Fat Thickness on Moisture, Lipid and Cholesterol Content of Subcutaneous, Intermuscular and Internal Fats' in *Journal of Muscle Foods* 4, 291–303
- 47 Lewis Jr., P.K., Rakes, L.K.Y., Brown, H.G., Brown Jr., A.H., Johnson, Z. and Brown, C.J. (1993) 'Effects of Maturation Rate, Marbling and Cooking on the Fat, Cholesterol and Lipid Phosphorus Composition of Beef Muscle' in *Journal of Muscle Foods* 4, 41–56
- 48 Smith, D.P., Fletcher, D.L., Buhr, R.T. and Beyer, R.S. (1993) 'Pekin Duckling and Broiler Chicken Pectoralis Muscle Structure and Composition' in *Poultry Science* 72, 202–208
- 49 Fernandez, X., Mourot, J., Mounier, A. and Ecolan, P. (1995) 'Effect of Muscle Type and Food Deprivation for 24 hours on the Composition of the Lipid Fraction in Muscles of Large White Pigs' in *Meat Science* 41, 335–343
- 50 Browning, M.A., Huffirian, D.L., Egbert, W.R. and Jungst, S.B. (1990) 'Physical and Compositional Characteristics of Beef Carcasses Selected for Leanness' in *Journal of Food Science* 55, 9–14
- 51 Alasnier, C., Rémignon, H. and Gandemer, G. (1996) 'Lipid Characteristics Associated with Oxidative and Glycolytic Fibres in Rabbit Muscles' in *Meat Science* 43, 213–224
- 52 Hoelscher, L.M., Savell, L.W., Smith, S.B. and Cross, H.R. (1988) 'Subcellular Distribution of Cholesterol within Muscle and Adipose Tissues of Beef Loin Steaks' in *Journal of Food Science* 53, 718–722
- 53 Kinney Sweeten, M., Cross, H.R., Smith, G.C. and Smith, S.B. (1990) 'Subcellular Distribution and Composition of Lipids in Muscle and Adipose Tissues' in *Journal of Food Science* 55, 43–45
- 54 Rhee, K.S., Smith, G.C. and Dutson, T.R. (1988) 'Relationships of Ether-extractable Fat versus Folch Fat and Fat Content Versus Cholesterol Content for Beef *Longissimus* Muscles' in *Journal of Food Science* 53, 969–970
- 55 Anonymous (1995) Information Section: Diet and Cardiovascular Disease. Summary of: Nutritional Aspects of Cardiovascular Disease. Report of the Cardiovascular Review Group, Committee on Medical Aspects of Food Policy, DoH Report on Health and Social Subject 46, HMSO, London, 1994, in *Food Chemistry and Toxicology*, 33, 427–432
- 56 Rogowski, B. (1978) 'Meat Consumption from the Health Angle' in *Fleischwirtschaft* 58, 1258–1262
- 57 Monin, G. and Ouali, A. (1991) 'Muscle Differentiation and Meat Quality,' in *Developments in Meat Science* (ed. R. Lawrie), pp. 89–157 vol. 5. Elsevier Applied Science, London
- 58 Sainz, R.D. and Cubbage, L.S. (1997) 'Growth Production and Meat' in *Proceedings 43rd International Congress of Meat Science and Technology*, P. 25. pp. 144–156 Auckland, New Zealand
- 59 Keeton, L.T. (1991) 'Fat Substitutes and Fat Modification in Processing' in *Proceedings of the 44th Reciprocal Meat Conference*, pp. 79–91
- 60 Minerich, P.L., Addis, P.B., Epley, R.J. and Bingham, C. (1991) 'Properties of Wild Rice/Ground Beef Mixtures' in *Journal of Food Science* 56, 1154–1157
- 61 Osborn, W.N. and Keeton, L.T. (1994) 'Konjac Flour Gel as Fat Substitute in Low-fat Prerigor Fresh Pork Sausage' in *Journal of Food Science* 59, 484–489
- 62 Rhee, K.S., Dutson, T.R., Smith, G.C., Hosteder, R.L. and Reiser, R. (1982) 'Cholesterol Content of Raw and Cooked Beef *Longissimus* Muscles with Different Degree of Marbling' in *Journal of Food Science* 47, 716–719
- 63 Reitmeier, C.A. and Prusa, K.J. (1987) 'Cholesterol Content and Sensory Analysis of ground pork as Influenced by Fat Level and Heating' in *Journal of Food Science* 52, 916–918
- 64 Snyder, M.P., Obarzanek, E., Montgomery, D.H., Feldman, H., Nicklas, T., Raizman, D., Rupp, L., Bigelow, C. and Lakatos, E. (1994) 'Reducing the Fat Content of Ground Beef in a School Foodservice Setting' in *Journal of the American Dietetic Association* 94, 1135–1139
- 65 Berg, P.T., Marchello, M.J., Erickson, D.O. and Slinger, W.D. (1985) 'Selected Nutrient Content of Beef *Longissimus* Muscle Relative to Marbling Class, Fat Status and Cooking Method' in *Journal of Food Science* 50, 1029–1033
- 66 Lium, M.N., Huffman, D.L., Egbert, W.R., McCassey, T.A. and Liu, C.W. (1991) 'Soy Protein and Oil Effects on Chemical, Physical and Microbial Stability of Lean Ground Beef Patties' in *Journal of Food Science* 56, 906–912
- 67 Bonanome, A.M.D. and Grundy, S.M. (1988) 'Effect of Dietary Stearic Acid on Plasma Cholesterol and Lipoprotein Levels' in *The New England Journal of Medicine* 318, 1244–1248
- 68 Hassel, C.A., Mensing, E.A. and Gallaher, D.D. (1997) 'Dietary Stearic Acid Reduces Plasma and Hepatic Cholesterol Concentrations without Increasing Bile Excretion in Cholesterol-fed Hamsters' in *Journal of Nutrition* 127, 1148–1155
- 69 Diaz, M.N., Frei, B., Vita, J.A. and Keane, J.F. (1997) 'Mechanisms of Disease: Antioxidants and Atherosclerotic Heart Disease' in *The New England Journal of Medicine* 337, 408–416
- 70 Nourooz-Zadeh, J. (1990) 'Determination of the Autoxidation Products from Free or Total Cholesterol: A New Multistep Enrichment Methodology Including the Enzymatic Release of Esterified Cholesterol' in *Journal of Agricultural and Food Chemistry* 38, 1667–1673

- 71 Zanardi, E., Novelli, E., Nanni, N., Ghiretti, G.P., Del Bono, G., Campanini, G., Dazzi, G., Madarena, G. and Chizzolini, R. (1998) 'Oxidative Stability and Dietary Treatment with Vitamin E, Oleic Acid and Copper of Fresh and Cooked Pork Chops' in *Meat Science* 49, 309–320
- 72 Zanardi, E., Novelli, E., Ghiretti, G. P., Chizzolini, R. (1999) 'Lipids and Cholesterol Oxidative Stability in Salame Milano, Coppa, Parma Ham and Dietary Supplementation with Vitamin E and Oleic Acid' in *Meat Science* (submitted for publication)
- 73 Guardiola, F., Codony, R., Addis, P.B., Rafecas, M. and Boatella, J. (1996) 'Biological Effects of Oxysterols: Current Status' in *Food Chemistry and Toxicology* 34, 193–211
- 74 Henning, B., Toborek, M. and Cader, A.A. (1994) 'Nutrition, Endothelial Cell Metabolism and Atherosclerosis' in *Critical Reviews in Food Science and Nutrition* 34, 253–282
- 75 Ross, R. (1993) 'The Pathogenesis of Atherosclerosis: A Perspective for the 1990s' in *Nature* 362, 801–809
- 76 Chisolm, G.M., Ma, G., Irwin, K.C., Martin, L.L., Gunderson, K.G., Lindberg, L.F., Morel, D.W. and Di Corleto, P.E. (1994) '7 β -hydroperoxycholest-5-en-3 β -ol, a Component of Human Atherosclerotic Lesions, is the Primary Cytotoxin of Oxidised Human Low Density Lipoproteins' in *Proceedings of the National Academy of Sciences, U.S.A.* 91, 11452–11456
- 77 Thompson, E.B. and Ayala-Torres, S. (1999) 'Oxysterols and Apoptosis: Evidence for Gene Regulation Outside the Cholesterol Pathway' in *Critical Reviews in Biochemistry and Molecular Biology* 34, 25–32
- 78 Diaz, M.N., Frei, B., Vita, J.A. and Keaney, J.F. (1997) 'Mechanism of Disease: Antioxidants and Atherosclerotic Disease' in *The New England Journal of Medicine* 337, 408–416
- 79 Bennet, S.A. and Magnus, P. (1994) 'Trends in Cardiovascular Risk Factors in Australia. Results from the National Heart Foundation's Risk Factor Prevalence Study, 1980–1989' in *Medical Journal of Australia* 161, 519–527

Any Suggestions?

Articles published in TIFS are usually **specially invited** by the Editor, with assistance from our International Advisory Editorial Board. However, we **welcome ideas** from readers for articles on exciting new and developing areas of food research. A brief synopsis of the proposal should first be sent to the Editor, who can provide detailed guidelines on manuscript preparation.

Mini-reviews focus on promising areas of food research that are advancing rapidly, or are in need of re-review in the light of recent advances or changing priorities within the food industry. Thus they are shorter than conventional reviews, focusing on the latest developments and discussing likely future applications and research needs.

Features are similar in style to mini-reviews, highlighting specific topics of broad appeal to the food science community.

The **Viewpoint** section provides a forum to express personal options, observations or hypotheses, to present new perspectives, and to help advance understanding of controversial issues by provoking debate and comment.

Conference Reports highlight and assess important developments presented at relevant conferences worldwide.

TIFS also welcomes **Letters** to the Editor concerned with issues raised by published articles or by recent developments in the food sciences.

All Review-style articles are subject to editorial and independent **peer review** by international experts in the appropriate field.