Position paper

Cow milk and human development and well-being

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Abstract

Fifty years ago animal foods were considered complete foods and important for human health. In most developed countries substantial dairy cattle and milk production industries existed which made major contributions to human welfare including the provision of cow milk to infants and young children. Then, over the last forty years, hypotheses have been developed largely by the medical profession and associated fields of research on the unfavourable roles of dietary cholesterol (DC), animal fats and serum cholesterol (SC) in coronary heart diseases (CHD). These postulates resulted in new and strange equalities such as DC + animal fat = SC = CHD. These hypotheses were followed by simplistic dietary recommendations with warnings against animal fats. These warnings have been heeded by the medical profession in many developed countries and under medical authority large sections of the public have made dietary changes and the per capita consumption of milk has fallen. More recently other risk factors have been found for CHD, and knowledge of their relative importance has increased. Understanding has grown over the question of versatility, optima and interactions between nutrients. Other new factors in this field include: the minor effect of DC on SC, the U-shaped effect of SC on total mortality in men with no effect in women less than 50 years of age, positive effects of other milk constituents on SC, different effects of high density C (HDL-C) and low density C (LDL-C) and of saturated, monounsaturated and polyunsaturated fatty acids (SFA, MUFA, PUFA) on CHD risk, the harmful effects of trans-FA, the meaninglessness of the P/S ratio, the medical and non-medical side effects of lowering SC and the high heritability of SC. These new recoveries have not been given the publicity accorded to the original hypotheses. It is the aim of this paper to seek a balanced review of the subject in the light of new scientific evidence. Further the broader implications of the topic for society, human development and well-being are also considered. Thus there are two main theses in this paper. One is to review the hypotheses of the relationship between cow milk and human coronary heart disease. These hypotheses are examined and their original historic deficiencies are discussed. The second major thesis in this paper deals with the impact which these hypotheses have had upon the pattern of human nutrition which are reflected in many important economic, social and other nutritional issues, all of which merit attention. It is considered inadequate to base general recommendations in the field of human health, well-being solely or mainly upon postulations about the relationship between milk and CHD without taking into account the larger and more complex issues. In addition to the general field of human health, the consequences of these hypotheses include the responses of the dairy production and processing industries. For example, if the hypotheses are reliable, tested and to become basic components of human nutrition, then the milk production industry has to reshape its system to produce a product more suited to the changes in consumption. If however, the assumptions are not substantiated permanently the such a re-tooling of milk production is futile. Milk production represents a major component in global food production and the implications of change are enormous. Issues to be considered include the efficiency of dairy cow in converting plant material, inedible to humans, to

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a human food of high nutritional value, the economic and nutritional contribution of dairy cattle production systems to beef production, the strong genetic correlations between the fat content, the protein content and the yield of milk per cow, the slowness of achieving changes in milk composition in bovine species with low reproductive rates and long generation intervals, and interactions between nutrients. Further, there are other broader issues including the incidence of other human conditions and diseases besides CHD, which can be affected by the presence or absence of milk in the diet, the genetic differences between individuals and human races, the need to address the hunger of the world’s human population and further economic, social and psychological factors. Many questions need research to find sustainable breeding goals and milk production systems which are related to the reality of how milk contributes to human development and welfare. The paper concludes by considering the negative impact which the questionable hypotheses have had upon an important component of food production, namely dairy cattle farming which historically has contributed enormously to human development and welfare. The author considers there is a vacuum of knowledge here which cannot be filled simply by expertise in the medical field alone. The issue is a prime candidate for interdisciplinary research.

Keywords: Animal fat; Animal protein; Cholesterol; Diet; Health; Heredity; Interactions, Milk, Mortality, Optimum, Versatility

1. Introduction

Nutritional studies in the first half of the 20th century showed animal products to be complete, versatile and wholesome foods of humans and hence important for health. Milk, especially, appeared to occupy a unique position among the many foods, because it is the sole food for humans and all mammals during the first part of their lives. Therefore, milk contains everything the young organism needs for growth and development including in particular a sufficient concentration of protein and minerals. Historically in Western culture, and in many other cultures, milk and milk products have been considered an important part of a balanced diet also for adults, because they contain all the important nutrients and are rich in those constituents which are important for adult nutrition. Milk and milk products supply the requirements for some nutrients that would otherwise be difficult to meet.

At the anecdotal level, I recall that these facts were taught to students at all levels of education. A 120 h course in human nutrition was included in my studies for the Master of Science degree in animal science in 1953. The professor pointed out what was common knowledge at the time, namely that milk is the most complete of all foodstuffs, being important for both children and adults. The message in animal nutrition was very similar. Milk fat as such, is the most valuable of fat products for health, but in addition it contains vitamins important in the food of northern peoples. The pioneer of Finnish research in biochemistry and green silage making, Nobel prize scientist A.I. Virtanen stated in 1954: ‘Milk has a special position among other food stuffs, since it has the most versatile composition. As abundant a use as possible is economically advantageous from the viewpoints of both an individuals and of whole nations.’

Later it was stressed that milk has a high nutrient density per energy unit, provides possibilities for many kinds of food products and foods in which milk is an ingredient, increases the nutritional value of other foods and the availability of minerals from plant sources. For a long time, fat was considered the most important ingredient of milk, fat content was used as a basis for pricing, and animal production was arranged accordingly. Milk and even milk fat contain very many ingredients (Table 1). Thus, the probability of useful ingredients is higher than in most other foods or drinks.

In the decade of the 1950s, new attention was given to increasing incidence of heart diseases in many developed countries and one-sided hypotheses on the roles of C and SFA in this condition were widely distributed (Keys, 1953). It was stated that a food containing plenty of milk would lead to increased SC-content which, in turn, would mean increased risk for CHD. Since the plaques of human arteries contain C, which in nature occurs only in animal fats, strange signs of equality were made: DC + animal fat = SC = CHD. Animal fats were labelled as poisons, production and eating of which should be avoided. Thus, these hypotheses caused
Table 1
Summary of the composition of average cow’s milk in Finland

<table>
<thead>
<tr>
<th>Main component Name</th>
<th>%</th>
<th>Sub components</th>
<th>Sub sub components or remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>86.8</td>
<td>Galactose</td>
<td>Water soluble vitamins (B, C)</td>
</tr>
<tr>
<td>Lactose</td>
<td>4.8</td>
<td>Glucose</td>
<td>Cannot be found elsewhere</td>
</tr>
<tr>
<td>Fat</td>
<td>4.4</td>
<td>Fatty acids</td>
<td>Short chained unique in milk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Glycerides</td>
<td>Altogether c. 400 fatty acids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phospholipids</td>
<td>Tri, di and monoglycerides</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sterols</td>
<td>Lecithins in all animal cells</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vitamins</td>
<td>Cholesterol, important for brains</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Microproteins</td>
<td>A, D, E, K</td>
</tr>
<tr>
<td>Protein</td>
<td>3.3</td>
<td>Casein (80%)</td>
<td>c. 20 amino acids, of which 8 necessary for human</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Whey proteins (20%)</td>
<td>β lactoglobulin, α lactalbumin, Serum albumin, Immunoglobulin Proteosepeptones</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Micro minerals</td>
<td>Enzymes, hormones etc</td>
</tr>
<tr>
<td>Minerals</td>
<td>0.7</td>
<td>Ca, P, K, Cl, Na, Mg</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>Trace</td>
<td>Trace elements</td>
<td>Enzymes, hormones, gasses, NPN compounds, S binding component</td>
</tr>
</tbody>
</table>

* Bold face = an important source of the vitamin/mineral for humans.

decreases in the consumption of animal fats and products containing them in many countries. For specialists in animal production, who had studied the value of these animal products comprehensively and who were also responsible for the long-term development of their production, the situation appeared confusing. It was difficult to see how long time the new trends can survive and to what extent production should be adjusted to these new hypotheses, since the permanent biological laws and the and the long-term needs of humans, which had led to mankind using milk for millennia, were being challenged for the first time.

The problem has been discussed in many international meetings of agricultural scientists in the 1990s (see e.g. Serrano Rios et al., 1994; Mantere-Alhonen and Maijala, 1995; Ravn, 1999). There is a need continuously to follow the development of knowledge on the effects of animal foods on human health and to weigh these together with other aspects. In this paper both aspects will be discussed, namely first the validity of the view that milk products are a cause of CHD and second the impact of this viewpoint upon milk production and society. Clearly there are important issues which need to be resolved to safeguard the well-being of our successors. Based upon valid scientific evidence, the goals and methods for the development of milk production needs to be planned in sustainable ways.

2. Revolution of nutrition ideas by lipid hypothesis

The hypothesis on the role of C and lipids in heart diseases started to gain ground in the latter part of the 1950s. General attention was paid to the possible danger of animal fats, especially to milkfat. The hypothesis was strengthened by a study based on FAO and WHO statistics, claiming that there was a strong association between estimated fat intake of six nations and the reported incidence of CHD-mortality (Keys, 1953). In spite of the fact that these results were based on biased statistics (ch.4.1), the hypothesis continued to thrive and stimulated a lot of research along the same line and thus, affecting nutritional recommendations in many countries.

The C and lipid hypotheses were especially welcomed by medical researchers in Finland, where the people of North-Karelia province showed an exceptionally high incidence of CHD. A special project was started in 1972, in which the population of that
province was given much advice including avoidance of milk fat in daily food. The population of neighbouring province was used as a control. The CHD-mortality of North-Karelian men fell 41% in 1967–87, and that of the control province 47%. For women the figures were 25% and 34%, respectively (Puska et al., 1983). The total mortality of men fell 2.3 and 2.2/1000 in 1972–77, and that of women 0.9 and 1.3/1000, respectively. It is difficult to understand why these results have been used in propaganda against use of milk fat since then.

However, there has been increasing criticism of the original hypotheses in recent years and complete books have been published on the subject (Ravnskov, 1991; Werko and Olsson, 1991; Apfelbaum, 1992; Mann, 1993; Gurr, 1999). There are also many literature reviews including also positive research results concerning the health effects of milk and dairy products (McGill, 1979; Stehbens, 1989; Muldoon et al., 1990; Blaxter and Webster, 1991; Ulbricht and Southgate, 1991; Jacobs et al., 1992; McNamara, 1992; Harper, 1993; Rosenman, 1993; Sieber, 1994; Renner, 1995). Having in mind the slow change in some sectors of animal production, it has thus become topical to consider the extent to which it is desirable to follow these ideas in choosing goals and strategies for the development of animal production in its different phases and sectors.

3. Dietary recommendations

3.1. Appearance

The results of research based on the C and lipid-hypotheses were published widely in the 1950s and 1960s and began to influence consumption patterns in North-America and Northern Europe. Since 1977, recommendations have been given officially, first in USA and Canada (Harper, 1993). Typical of the recommendations was the advice to avoid animal fats and to favour fat-free/low-fat milk products and PUFA instead of SFA with no exception for short-chained FA. The ratio P/S (= PUFA/SFA) was considered a useful measure of an optimal diet (Keys et al., 1957). The desire for simplistic advice which is easily understood by consumers has harmed the image of milk fat and milk and has led to extreme avoidance by people for whom many components of milk are important. Further the situation has been exploited by promoters of competing products.

3.2. Unfortunate consequences of recommendations

The recommendations were in conflict with previous ideas about the value of milk as a healthy foodstuff and its economical/biological advantage-ousness, which had been central to the development of specialist dairy cattle production for a century or more. However the new ideas, often exaggerated, have had considerable influence on milk production. Because of the decreased consumption, the production of butter in Europe has decreased by 29% in 1980–98 (Fig. 1). The opposite trend for cheese (+35%) has not compensated in milk production, which has declined by 13%, which means ca. 700 million kg decrease in production of milk protein and corresponding decreases in supplies of many other valuable ingredients of milk. Fig. 2 shows that the development has been somewhat different in different parts of Europe. In Eastern European countries the fall became greater in the 1990s due to the political changes which also reduced cheese production. In the Mediterranean countries both butter and cheese production increased. The decreased consumption of dairy products has contributed to unemployment and economic depression in many countries in the 1990s.

The demands for decreasing the fat content of milk have confused the setting of breeding goals in cattle, which should be long-term (Maijala, 1976). Since each additional trait in a breeding programme will retard the progress in main goals, the number of traits to be improved should be kept as small as possible giving stability and predictability. In meat production, genetic programmes to decrease fat content is much easier, since animals can be slaughtered before the accumulation of fat. Up to 60% of the contents of milk fat and protein are up determined by the same genes. The corresponding figure for fat and protein yields is 80%, since the contents and milk yields are genetically negatively correlated with each other \( r = -0.3 \). Thus, the recommendation to avoid animal fats makes milk
Fig. 1. Changes in European dairy production in 1980–98 (based on FAO Production Year Books).

Fig. 2. Changes of milk production in different regions of Europe in 1980–98 (based on FAO Production Year Books).

production difficult. Another consequence is the difficulty in preserving cattle breeds and genetic variation within breeds for unpredictable future needs, since cows with concentrated milk move out of favour.

3.3. Problems of dietary recommendations

The strict dietary recommendations of recent decades in many countries appear very narrow, being based only on the alleged danger of C and animal
fats. Too little attention has been paid to other aspects of health, to different needs of different age classes, genetic differences between individuals, aspects of national and private economies, physiological and social needs, preservation of open landscapes and future needs of the world population, especially in regions where millions are nutritionally in need. Many nutritional and health aspects of animal products, interactions between nutrients, as well as balance, versatility and moderation of daily food have been entirely forgotten. The campaign to simplify so that ‘the people could understand’ has been taken too far and it is easy to see that the awakening of exaggerated fears has not served the overall well-being of humans.

One problem connected with the recommendations is that they have been developed mainly by medical researchers, especially by those on heart diseases. The coverage of nutrition in their education is rarely large: for example in the five medical faculties in Finland the number of hours given for nutritional education varied from 24 to 58, the average being 43 h (Virtanen and Salo, 1991). Many animal researchers have much more education, but their views have seldom been listened to when dietary recommendations are being designed. There are examples where the views of animal scientists have been precluded from publication or expression in discussion. Broadening the points of view to obtain the best possible conclusions and recommendations needs collaboration between different sciences and sectors of life. Human nutrition ought not to be regarded as the preserve only for one discipline whose main training and preoccupation has been disease.

3.4. Dietary recommendations conflict with other aspects

In formulating recommendations, many aspects have been disregarded. These include the following:

(a) Milk production is the most efficient form of animal production.
(b) Milk protein is versatile, balanced, easily digestible and biologically valuable.
(c) Milk contains many valuable nutrients.
(d) A dairy cow produces a calf per year + own beef, thus increasing the biological and economical efficiency.
(e) Cattle converts roughages to valuable products, helps in preserving green, open landscape and in utilizing unarable areas.
(f) Cattle can utilize residues of agriculture and industry.
(g) Dairy production promotes sustainable agriculture and is characterized by some basic biological, economic and social facts, for example the numbers of cows cannot be increased quickly, the fat of milk takes half of the feed energy eaten by the cow, continuation of milk production is difficult if fat is not used, and ceasing milk production has unfortunate social and economic consequences.

4. Changing ideas on the significance of C and fats in heart diseases

4.1. Lipid hypothesis for CHD based on biased statistics

The medical literature of the 1950s reveals that the strong condemnation of animal fat was largely based on the study by Keys (1953), in which he compared consumption of animal fats and CHD-mortality of six countries and obtained a close correlation between them. Yerushalmy and Hilleboe (1957) observed that Keys would have had available data from 22 countries, which would have given a much weaker correlation (Fig. 4). It has also turned out, that the data on consumption of animal proteins in the same FAO and WHO statistics would have given similar correlation. It is not known why Keys chose consumption of fat instead of protein. In the simulation study by Wood (1981) on the consumption statistics of 21 countries a total of 116 280 different samples of six countries were found, and the correlation between consumption of animal fat and CHD-mortality varied from \(-0.9\) to \(+0.9\), the average being \(-0.04\). In the sample chosen by Keys the correlation was \(+0.84\). It is difficult to understand why the selection of country sample by Keys has been hushed up.
4.2. The list of risk factors of CHD greatly lengthened

Keys (1953) spoke only about two risk factors of CHD (C and total fat of food). In the first dietary recommendations given by the American Heart Association, in 1961, seven risk factors were mentioned (SC, blood pressure, fatness, smoking, age, sex and heredity). Hopkins and Williams (1986) listed altogether 270 risk factors. Even after that several factors worth attention have been found. Menotti et al. (1991) investigated the effects of 12 CHD-risk factors on total mortality. Many of these were more important than SC.

4.3. Cholesterol has important tasks in human body

Discussions on C have often neglected many important positive features. According to Sieber (1994) C is an important steroid in all cells and tissues. A normal adult person contains ca. 150 g of C and synthesizes 700–1500 mg of it daily. In the intestines, C regulates the absorption of fat. It is the main constituent of cell membranes and nerves, the precursor of the steroid hormones of renal cortex, sex hormones and D-vitamin. It is necessary for the growth and development of young mammals.

Schoknecht et al. (1994) found that piglets receiving C supplementation in their feed, grew 25% faster than the control group, and that their proper brains contained more free C. The conclusion was that newborn piglets are unable to produce enough C and are thus dependent on the supply in mother’s milk.

4.4. Sex and heredity important to consider in recommendations

Dietary recommendations have usually been directed to the whole human population, irrespective of sex, age and descent. In the last two decades it has become clear that the effects of SC levels on CHD-mortality and total mortality are very different in men and women. In a review by Jacobs et al. (1992), based on 19 cohort studies, the U-shape curve for total mortality in men and the flat curve for women were considered to result from a positive relation of TC with CHD-deaths and an inverse relation with deaths for other causes.

Even though heredity was already recognized as a risk factor of CHD 30 years ago, its decisive importance has been realized only more recently. The great differences between animal species are important, since suspicion began to fall on DC as important risk factor on the basis of Russian experiments with rabbits in 1913. Keys (1953) realized that the SC of rabbit reacts to DC 50-fold more strongly than that of human. This important point has hardly been mentioned in C discussions.

Individual differences were given attention by Keys et al. (1965). They were concerned with the content of SC in a given diet and the reaction to a given change in food. The distributions of human reactions would thus be worth of knowing. McGill (1979) found heredity to be the most important factor regulating the reactions of humans to DC. On the basis of correlations of SC values between family members obtained in the extensive study by Nambodiri et al. (1984), the heritability (h²) of SC content was ca.50%. There was almost no correlation between spouses, even though these often eat same food. Also Hopkins and Williams (1989) estimated that genetic factors explain 50–60% of the variance of SC content. Similar h²-estimates were reported for TC, LDL-C and HDL-C by Lusis (1988). This does not leave much space for systematic environmental factors, since the majority of the remaining variation is caused by random factors. The h² is about the same as that of highest heritable traits with which animal breeders work namely the quality traits, which have not long been under artificial selection for long. For these traits individual selection is effective. Also Howell et al. (1997) observed large individual variability in responses to changes in dietary fat quality and DC.

In recent years, some single genes affecting SC have been found. The major gene for familial hypercholesterolemia would account for 1%-unit of the variation of SC. Some other single genes affecting SC have been found, but their combined share of its variation is still small (Hopkins and Williams, 1989). Thus, the polygenic approach used widely in animal breeding, leading to large progresses for
many traits in many countries, deserves serious attention in the search for protection against CHD.

There is reason to ask: What would be the correlations between intake of animal fats and SC or CHD, if the patients with inherited disturbances of C metabolism were excluded? It might be a fundamental recommendation to focus dietary advice against high-risk foods to those individuals with C problems. This is the normal medical and nutritional practice with diabetes, keliakia and lactose intolerance.

From the viewpoint of the future of milk production it would be important to know the percentage of people having such genes and how the potential effects of these genes could be countered.

4.5. The effect of DC on SC is minor

Keys (1953) realized, that man has a great ability to handle C. When taken in food the synthesis stops in the liver. Only 20–50% of the C taken through the mouth is absorbed. Thus, the level of SC is largely independent on that of DC. Keys et al. (1965) found the effect of large additions of C to a food containing C to be small and to decrease with increased supply of C. There have been differences between studies. For example, Pyörälä (1987) considered that the changes in supply of C in food influence the levels of TC and LDL-C, while Stehbens (1989) concluded that there is no decisive proof of a causal connection of DC with SC. According to him the pathology of blood vessels of animals fed with C have been misinterpreted in individuals with genetical C problems. Renner (1995) considered that the lipid hypothesis deserves a serious reassessment, since DC has only a small effect on SC, due to the regulatory mechanisms of the body. Among others, Blaxter and Webster (1991) were convinced that DC has now been shown to have negligible effect on SC and can be ignored. In children, the level of SC is still less sensitive to DC than in adults.

The fact that a part of C can be oxidized in food could explain differences between laboratories and could decrease the importance of pure C in hardening of the arteries. According to Renner (1990) there has been an exaggerated discussion in some countries on this issue; the small influence of DC on SC is caused by the regulatory mechanisms of the body.

Howell et al. (1997) considered that the existence of precise feedback mechanisms balancing the input of exogenous DC and endogenous synthesis of SC in the majority of individuals is a main reason why a reduction in DC has a relatively small effect on SC concentrations in most diet sensitive patients. The data supporting a relation between the intake of dietary fat and C on the one hand and elevated plasma lipid concentrations on the other should be evaluated not as mean values but on the basis of individual responses.

One of the mechanisms compensating increased intake of DC is the increased secretion of absorbed C in the bile system through the retardation of C synthesis of the whole body. The increased accumulation of C in body reserves is also considered an explanation. It has been thought, that DC can change the construction and composition of blood lipoproteins and through this action the risk for CHD. The possibility of it affecting the levels of SC by manipulating this most important source of DC is considered restricted (McGill, 1979).

4.6. TC, LDL-C and HDL-C have different meanings

It has become clear, that the different parts of C have different effects: LDL-C increases and HDL-C decreases the risk for CHD (Rudel et al., 1998). Thus, the ratios HDL-C/LDL-C or HDL-C/TC can be used as indicators of CHD risk (Khosla and Sundram, 1996). SFA can increase both LDL-C and LDL-C and does not essentially change HDL-C/TC-ratio. MUFA can lower HDL-C as much as they increase LDL-C, so that the HDL-C/TC-ratio does not always change. The level of TC is less important than HDL-C/LDL-C ratio (Renner, 1995). Blaxter and Webster (1991) stated that LDL-C has a stronger positive relationship with CHD than SC, while low HDL-C may increase CHD risk.

4.7. SC curves of healthy and CHD individuals largely overlapping

There is almost no disagreement on that the level of SC has importance from the viewpoint of CHD risk. However, the distributions of CHD patients and
healthy persons have been found to be largely overlapping, so it is difficult in individual cases to draw right conclusions about the risk for CHD (Fig. 3). The small bend on the right hand side of the CHD curve may be caused by patients with genetically disturbed C metabolism. In the Framingham study the risk for CHD at the age of 65–74 years was almost independent of the TC level 30 years earlier, except in its highest quintile (Jacobs et al., 1992). Thus, the upper limit of 5.0 mmol/l for TC, recommended in many countries, appears too low, giving a sick label to 80% of people.

4.8. Effects of dietary fats and FA on SC vary greatly

The statements of Keys in the relationship of food to CHD show considerable changes over a period of four decades. His selected statistics about the connection between the proportion of fat calories in food and CHD-mortality is already referred to in Ch.2. Fig. 4 shows that there is no difference between the effects of the amounts of fat and protein calories in food on the CHD-mortality. It has been found that the population of the USA obtains the largest part (43%) of its fat from spreads, salad sauces, soup and frying fats, while 30% has arrived from meats and 11% from milk products (Connor and Connor, 1994). In a Finnish study with men who smoke there was no association between intakes of SFA or cis-MUFA, linolenic or linoleic acid or DC, and the CHD risk (Pietinen et al., 1997). According to Blaxter and Webster (1991) there are complex interrelations between individual FA.

4.9. Opinions about the effects of different FA have changed

There are considerable differences between different edible, unhardened fats and oils in their contents of different FA. When 10% of carbohydrates are replaced by FA of a certain class, diets rich of SFA, MUFA and PUFA have different effects upon different blood lipids and lipoproteins (Mensink, 1994). Opinions about the roles of FA in CHD have changed during the last decade. Renner (1995) thought that there is reason to consider the effects of different FA with regard to the increase of SC. An excessive supply of PUFA can lead to decreased values of ‘good’ or HDL-C. SC-values under 200 mg/100 ml are associated with increased total mortality in 35–50 year old men. A diet containing 14% SFA, but only 4% PUFA led to a decreased risk for CHD, resulting from use of energy adjusted food and since a large supply of Ca from milk products decreased the LDL-C/HDL-C ratio.

According to Blaxter and Webster (1991) a simple distinction between SFA and unsaturated fats is inadequate. MUFA may be as effective as PUFA in lowering SC. It is useful to recall that milk fat contains ca. 270 g/kg oleic acid. To state that all SFA increase and only PUFA depress SC is incorrect.

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![Fig. 3. Distribution of SC concentrations among patients with CHD (n = 193) and those without (1378) in the Framingham study (Kannel et al., 1979). Reproduced with permission of American College of Physicians-American Society of Internal Medicine.](image-url)
Fig. 4. Keys’ (1953) selection to show relationship of fat intake to heart disease deaths of 55–59 yr. old men in 1951–53 (open circles left) and the 15 other available countries (closed circles). The relation of heart diseases to animal protein intake is on the right (Mann, 1993). (Adapted from WHO Ann. Epid. and Vital Statistics).

Thus, there are MUFA and PUFA in vegetables, which increase SC, and SFA in animals, which decrease SC (Kok, 1994). Khosla and Sundram (1996) concluded that the attention has shifted from the effects of dietary FA classes on TC, to the effects of specific FA on specific lipoprotein fractions. They reviewed recent studies which have advanced our knowledge on how plasma lipid and lipoprotein metabolism is affected by individual FA. It has also turned out, that the trans-FA developed in hardening of vegetable fats in preparing margurines can increase LDL-C and decrease HDL-C (Zock and Katan, 1992; Berner, 1993; Pietinen et al., 1997). The increasing effect of trans-FA of milk on SC is not known, but is not likely to result from natural evolution.

According to Lefevre (1999) milkfat is less hypercholesterolemic than would be predicted based on its total SFA content. It is known that the short-chain FA and stearic acid, which comprise 1/5 of FA of milk, don’t increase SC.

4.10. P/S-ratio has lost its importance

The lipid hypothesis postulated that SFA tend to increase the level of SC, while the PUFA have an opposite effect. Hence, the ratio between them, so-called P/S-ratio of the diet was used as sign of CHD-risk. The recommended value for P/S was > 2.0 at the beginning, but later it was decreased to 1.0. Now it is not seriously considered, since excessive intake of PUFA has negative effects on lipid metabolism (Renner, 1995). The SFA with 4–10 carbon atoms do not affect SC, palmitic acid containing 16 carbon atoms does not always increase SC, stearic acid containing 18 carbon atoms as well as MUFA decrease SC. Bonanome and Grundy (1988) reported that the saturated stearic acid lowers TC and LDL-C, but not HDL-C. Thus, its total effect is positive.

A remarkable change was caused by the finding that hydrogenated plant MUFA lower the level of HDL-C (Ch.4.9). Thus, changes have taken place in
both the nominator and denominator of the P/S-ratio. Only 14% of the FA of milk fat are now considered SC-raising, 45% SC-decreasing and 41% neutral (Renner, 1995). There is no relationship between the incidence of CHD and dietary fat or the P/S ratio (Blaxter and Webster, 1991).

4.11. Lowering SC has harmful side effects on health and other aspects

Most studies on risk factors in elderly suggest that a high SC does not mean an increased risk for CHD. In a study comprising 31 countries SFA did neither increase CHD-mortality in women nor total mortality in either sex. In the review of 19 cohort studies by Jacobs et al. (1992) the increase of SC caused a U-shaped effect on total mortality, increased CHD-mortality in men, but not in women, and decreased mortalities for other reasons. In the Finnish auto-clinic study SC values under 7 mmol/l were optimal from the viewpoint of CHD mortality. They had no connection with cancer mortality. The connection with total mortality was U-shaped (Aromaa and Maatela, 1981). In the MRFIT study and an Israeliic study SC clearly increased the CHD-mortality, but the effect on total mortality was a little U-shaped (Goldbourt and Yaari, 1990). In a Finnish study during 15 years of follow-up both the cumulative total and the CHD-mortalities were larger in the treatment than in control groups (Strandberg et al., 1991). Muldoon et al. (1990) demonstrated convincingly that intervention has not been effective in reducing overall mortality.

In two dietary treatment experiments CHD-mortality decreased a little, but the mortality for other reasons increased, and the total mortality did not change (Blaxter and Webster, 1991). In four medical treatment experiments the total mortality increased, even though CHD-mortality decreased. Hulley et al. (1992) described results of an extensive study on association between level of SC and subsequent mortality, comprising ca. 68 000 deaths. Men in the left-hand limb of the U-shaped curve had a 20% higher rate of cancer deaths than those with SC-levels between 160 and 199, plus a 40% higher rate of non-cardiovascular noncancer deaths. Among women the pattern was similar, but the excess in cancer mortality was smaller. The right-hand limb of the C X total mortality curve was almost flat in women, meaning that high SC is not associated with all-cause mortality nor even with CHD mortality.

Muldoon et al. (1990) considered total mortality as the best index for CHD risk, since it obviates problems related to uncertainty about the precise cause of death. The results showed no treatment effects and there was no decline in CHD mortality.

5. New ideas on positive health effects of milk

5.1. Milk and milk products have many kinds of health effects

According to Renner (1995) an optimal nutrition means that all nutrients and food components important for human body are available in needed concentrations and optimal mutual relations. Optimal nutrition is important for efficiency and well-being and has a decisive influence on maintenance of health and on recovery from illness. Optimal nutrition requires a variety of foods to provide different components. Milk and milk products fulfill these requirements for the supply of nutrients with their special characteristic. Gurr (1999) has emphasized the important traditional role of milk as a supplier of nutrients, because of its versatility and high nutrient density per calorie. The special characteristics of soured products help in preventing diarrhoeas.

The FA composition of cow’s milk differs from that of human milk, especially with regard to FA containing 4–8 carbon atoms. The effects of individual FA of milk fat on SC show that most of them are neutral or decrease C. The ratio between FA which are advantageous and those which are disadvantageous for SC has decisively improved on the basis of recent studies. Accordingly only 2–3(14–42 weight-%) of the different FA of milk would be harmful, when earlier only oleic acid (26 weight-%) was considered to belong to the favourable and linoleic acid (3 weight-%) to the neutral group (Renner, 1995). There are many studies, in which people consuming milk and especially yoghurt daily have had lower SC than other people. In an extensive British study also the incidence rate of
CHD decreased with increase of daily consumption of milk. A partial explanation of this result was offered proposing that those who consumed more milk also took more physical exercise (Med. Res. Counc., 1991). No study has shown that whole milk increases SC. Inclusion of milk fat in a versatile diet has only little effect on SC and CHD.

5.2. Calcium (Ca) has a dietetic and protecting importance

The supply of Ca from milk and milk products in babies and children is decisively important for the development of an optimal bone mass and prevention of osteoporosis (Renner, 1995). Further Ca prevents increases of blood pressure.

According to Arvola (1995) this is caused by the fact that Ca corrects changes in the activity of the soft arterial muscle by improving it. It is suggested that the supply of Ca is related to the incidence of and mortality due to cancer in the large intestine. Ca has a preventive effect on CHD, since a Ca supplementation to a low-fat diet which positively affects the metabolism of lipoprotein. Miller (1999) stated that a body of research accumulated since the early 1980s indicates that Ca and dairy food intake can positively impact blood pressure, which is a major risk factor for stroke, cardiovascular disease and kidney failures. A sufficient supply of Ca is necessary in preventing the formation of kidney stones, since it binds oxalate and decreases its absorption and secretion in urine. Because of its high Ca content milk, especially cheese products, is important for dental health and protection from dental cares.

5.3. A SC-lowering factor supposed in milk

Several studies in the 1970–1980s supported a hypothesis that some dairy products may lower SC. In studies with humans, existence of this factor has not been proved with certainty proved; but also exclusion has not been possible. In animal experiments it has been observed that skim milk, sour milk and even whole milk have decreased blood lipids, but it is not known what kind of milk or milk product would be the most important. It has been suggested that a given ‘milk factor’ would cause the effect in question. Several suggestions have been made, for example that fat globule membranes, different stocks of milk acid bacteria and antioxidative characteristics of milk may be involved, but no clear individual factor has been identified. The effect could be caused by interaction of many factors affecting metabolism. Thus, each suspected factor has shown to be less effective than versatile milk or yoghurt (Eichholzer and Stühelin, 1993). There is evidence from free-living populations and animal studies that whole milk may not affect blood lipids as would be predicted from its fat content and composition (Berner, 1993). No study has yet shown that milk as a whole is a risk factor for heart diseases.

5.4. Promising results concerning prevention of cancer

Signs of protective effects of milk against some types of cancer had already been seen in 1933, but in the 1990s persuasive evidence has accumulated (Gurr, 1999). The protective effect on colon cancer is assumed to be based on Ca phosphopeptides which bind to bile acids thus preventing their toxic effects. In some studies whey proteins have reduced tumour numbers.

Special interest has recently been directed to the effects of conjugated linoleic acid (CLA), which in animal experiments has proved to inhibit cancers (Parodi, 1997, 1999) and has given promising results also in preventing breast cancer in humans (Bougnoux and Lavillonnère, 1998). The interest in CLA is increased by the fact that CLA can be formed from PUFA only by ruminant animals and the synthesis can be increased manyfold by nutritional means (Griinari and Bauman, 1999).

Knekt et al. (1996) found a significant inverse relationship between milk intake and the risk of breast cancer in a 25-year follow-up of Finnish women. Also Lipkin (1999) stated that a majority of studies have reported decreased risk of cancer with dairy food, and inverse associations among several components and tumour development. Several components of dairy foods (e.g. Ca, vitamin D, milk protein, butyric acid) have inhibited colonic tumour
development in many experiments. Ca intake has also decreased development of breast cancer.

6. Lactose intolerance and milk allergy

Some concerns about the involvement of milk in some health disturbances have been voiced (Gurr, 1999). One of these is lactose intolerance, caused by incomplete secretion of lactase enzyme. This is common in countries in which historically milk has not been part of the daily diet. In countries with traditional use of milk lactose intolerance is more rare, for example in the Nordic countries in the range 5–17% (Vesa, 1997). The intolerance is often incomplete: a lactose intolerant person can take 5–10 g of lactose daily without problems. Soured milk is less problematic than fresh milk. Marteau et al. (1999) concluded from the available literature that ingestion of milk products with lactose in doses of normal to fairly high consumption (200–500 ml at a time) leads to mainly non-disturbing gastrointestinal symptoms in lactose maldigestors.

Another disturbance is ‘milk allergy’, occurring in 1–3% of children under three years of age. However, 10–50% of infants allergic to cow’s milk proteins may also develop signs of allergy to soya. Milk proteins are usually blamed, because they are the first ‘foreign’ proteins to be encountered by most infants (Gurr, 1999).

Gurr considers that the general validity of many contentions on milk can be effectively countered on scientific grounds, although it is clear that some individuals may have specific intolerance to milk constituents.

7. Some biological and general aspects deserve serious attention

7.1. Role of cattle in food chain

The rumen is a major factor in giving importance to cattle: with the aid of the rumen and the microbes it contains, the cow can digest fibrous material and thus convert valuable food raw material otherwise not useable by man. Grasses (directly from cultivated or uncultivated pasture or as conserved products), beet tops, marrow kale, straws, residues from shifting of grains, brewery residues and from the sugar industry. Cattle can utilize even non-protein-nitrogen. Digestibility of organic material decreases only by 0.74% per 1% increase in fibre content, while the corresponding figures for horse, pig and hen are 1.25, 1.55 and 1.96. In digesting fibre-free feed cattle show no advantage, but at 30% fibre content of feed cattle and sheep are clearly superior to the other species. In many countries the ability of cattle to harvest its feed directly from the place of growth without human labour and from areas where no cultivation is possible is important. There are about twice as many permanent grasslands and pastures than cultivated areas or tree plantations in the world. Forest areas, of which a part is used for grazing, comprise almost three times the cultivated area. In northern latitudes the relative competing-ability of grass crops is better than of grain crops, since grasses can better utilize the spring moisture and long summer days and do not suffer from the autumn rains. The further north one goes the more important grassland farming becomes.

7.2. Animals don’t always compete with human for food

Because of the natural ‘bioreactor’ of its rumen cattle do not necessarily compete with man for food. However, because of the fixed costs, like maintenance feed and buildings, man has attempted to increase the yield and growth rate of cattle above the levels which can be achieved with plain roughages. So, food useable for humans is used also for cattle production as a ‘catalyzer’, especially in industrial countries. This type of food contributes increasingly to the total feed energy of a cow as production increases.

So, a cow producing four thousand kg milk/yr receives is 5–10% of its total energy from catalyzer type feed, at 8000 kg 15–30% and in beef cows 10–20%. The corresponding percentages for veal calves, pigs and broilers are 70–95, 60–90 and 60–80 respectively. In an American study with 1500 cows, 96% of the protein of grain and oilseed parts of crops were recovered, when the protein yield was
corrected on the basis of by-products unsuitable for man. Both cattle and pigs can utilize large amounts of agricultural and industrial by-products. Cattle are particularly suitable for promoting sustainable agriculture.

7.3. Milk is the most important product of cattle

By far the most important task of cattle in developed countries is the production of high-quality food, especially protein, for mankind. In many countries milk is the most important product, and the share of cow of the total milk production in the world is ca. 90%. The human organism can utilize milk protein twice as efficiently as from grains, and the many-sided animal protein contributes valuable supplements to the biological value of the vegetable foods consumed.

7.4. Milk protein and fat are genetically correlated

It is important to stress the problem of close genetic correlation between fat and protein contents of milk and the still closer one between their yields, mentioned in section 3.2. Attempts to decrease the fat content generally reduce also protein content. When the solids content of milk is the component most appreciated, the amount of them does not necessarily increase with decreasing fat content and the increased amounts of water needed to produce a certain amount of solids cause increased stress for the udder and increased risk for mastitis.

7.5. Beef is another important product, supporting milk production

The demand for beef has increased with increasing standard of living. Hence, calves of dairy cows are used for beef production in many countries. A medium size cow produces 70–80 kg of its own beef and 150–200 kg of beef from its calf per year of life. In addition, many of the internal organs are valuable food. A big part of these tissues is based on plant material produced by the aid of solar energy and thus on renewable natural resources. From cattle bodies one also gains ca. 100 valuable by-products (a.o. medicines), the use of which decreases the price of beef. Because of the relatively low reproductive rate of cattle which results in relative high costs of beef per kg, the beef share of per capita meat consumed has decreased in all parts of the world, including Europe. Moving meat production more and more to grain-eating animals cannot be considered a sound development from the viewpoint of food chain, especially with the rapid growth in the world human population. These additional people may need an increasing share of the world grains currently used by animals. The importance of cattle manure as fertilizer and thus contributing to the human food chain may regain status in new moves to promote sustainable development.

The supply of cheap calves for beef production depends on the number of cows. Utilization of calves from dairy cows for beef improves the biological and cost efficiency of beef production. The efficient production of milk protein would be easier if beef production is also based on breeds able to produce milk protein efficiently. Thus, milk and beef support each other both simultaneously and levelling out the differences between years.

7.6. Biological efficiency best in milk production

Biological efficiency measures the ratio of input and output of food value. In other words how large a part of feed nutrients given to animals are regained in human food products. The studies on these feed efficiencies (FE) have shown, among others, the following:

(a) It is difficult to exceed FE = 40%;
(b) The best protein FE is achieved in milk production of cow, in which FE = 35% can be obtained with a yield of 6000 kg/year.
(c) FE increases with yield level, in milk production by ca. 1%/500 kg.
(d) In the production of farm animals other than milking cows the protein FE is below 30%, in many cases below 15%.
(e) In beef production, protein FE is much lower than in milk production, in self-recruiting beef production even 75% lower (Pettersson and Olsson, 1966).
(f) Beef production using calves from milking cows has a higher FE than from specialized beef cows Hvidsten, 1974).
The input/output-ratios have also been estimated by including in inputs only those parts of the feed suitable for humans (van Es, 1979). In good times humans eat only the best part of the grain crop, at crises almost all grain. The results show that on roughage feed, a dairy cow, a beef cow and a ewe produce about 2.5 times as much protein and energy as they consume in feed useable for humans. Even with a dairy cow on concentrate feeding the result is over 100% while a beef cow and a ewe achieve 80%. Single-stomach animals never reach 40%. Thus, ruminants increase the amount of protein and energy useable for humans and further the quality is essentially improved. In addition the need for fossil energy per unit in intensive production is lowest for milk. In egg, broiler, pork and beef production it is 1, 2, 4 and 5 times higher respectively.

7.7. Outlooks for food needs of world

The slow reproductive rate of cattle calls for caution in decreasing the population of milking cows. This should be a factor in planning for the future nutrition of mankind. According to the FAO statistics, the human population will be doubled within 50 years. Protein needs of the world population will increase by 1.7%/year. (Matassino et al., 1991). Cattle able to convert grass and other feeds unsuitable for humans and renewable plant material produced by solar energy to many-sided protein, will thus have great importance in meeting these needs. Further cattle production also helps in maintaining green, open landscape.

8. Discussion

8.1. Strategies for dietary recommendations

The distributions of SC values would be important in assessing the effects of changes in food on populations (McGill, 1979). They are important also in determining, whether a certain dietary change should be recommended to the whole population or only to very susceptible individuals. In the latter case, it would be important to recognize the extreme individuals who react and to recommend the change of diet only for them. Restricting the supply may suit for individuals with disturbed C metabolism, not in recommendations concerning the whole population (Harper, 1993).

According to Renner (1995) the best solution is to apply the general principles of food science:

1. Versatile = containing all food groups in the daily food. Exclusion of some group would lead to one-sided food.
2. Balanced = no individual food group is favoured strongly or avoided entirely.
3. Full-value diet = versatile, balanced, containing necessary nutrients in needed concentrations.
4. Energy-adapted = prevents fatness, which is a known risk factor for CHD and other illnesses.

8.2. Questions for research (food science, medicine, animal science)

On the basis of the issues discussed above it appears important to study nutritional and health aspects of milk and meat in a larger context by taking into account of the many factors which are involved and the interactions among nutrients, balance, variety and moderation. Answers are awaited on the following questions:

(a) What is more important in a healthy nutrition: avoidance or removal of some nutrients, or supplementation of some otherwise valuable food-stuffs?
(b) Are different recommendations needed for different age classes, professions, sexes, people practising different levels and kinds of physical exercise, with different genetic background or genes? Who should have the power to give dietary recommendations? What should be bases for choosing the committee members?
(c) Is the consumer really a king? Who or what turns his head and how fast? When should the changing whims of consumers be followed (sector and phase of production, sight and time schedule)?
(d) How can the public learn about the versatility of milk and meat?
(e) Is the kind of fat important? Why has nature developed the short-chain and ‘unwholesome’ FA
of milk? Which FA should be avoided or favoured? How do milk proteins and fats interact? (f) What is the sense of measuring TC? Does it deserve continuous attention and regular screening? In which cases should one aim at its lowering? Where are the sensible limits? How many% of different peoples have C-problems? (g) How does C lowering or avoidance of milk affect other aspects of health, psychological, social and economic welfare of people, production of vital foodstuffs now and in future, landscape, environment, sustainable development? (h) Can milkfat really be equated with straw, for which there is no valuable use? (i) Are Cola drinks more recommendable than milk? Reasons? (j) Which life-style factors are biasing epidemiological studies?

9. Notation

C = cholesterol
CHD = coronary heart disease
CLA = conjugated linoleic acid
DC = dietary C
FA = fatty acid
HDL-C = high density lipoprotein C
LDL-C = low density lipoprotein C
MUFA = monounsaturated FA
PUFA = polyunsaturated FA
SC = serum C
SFA = saturated FA
TC = total SC

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