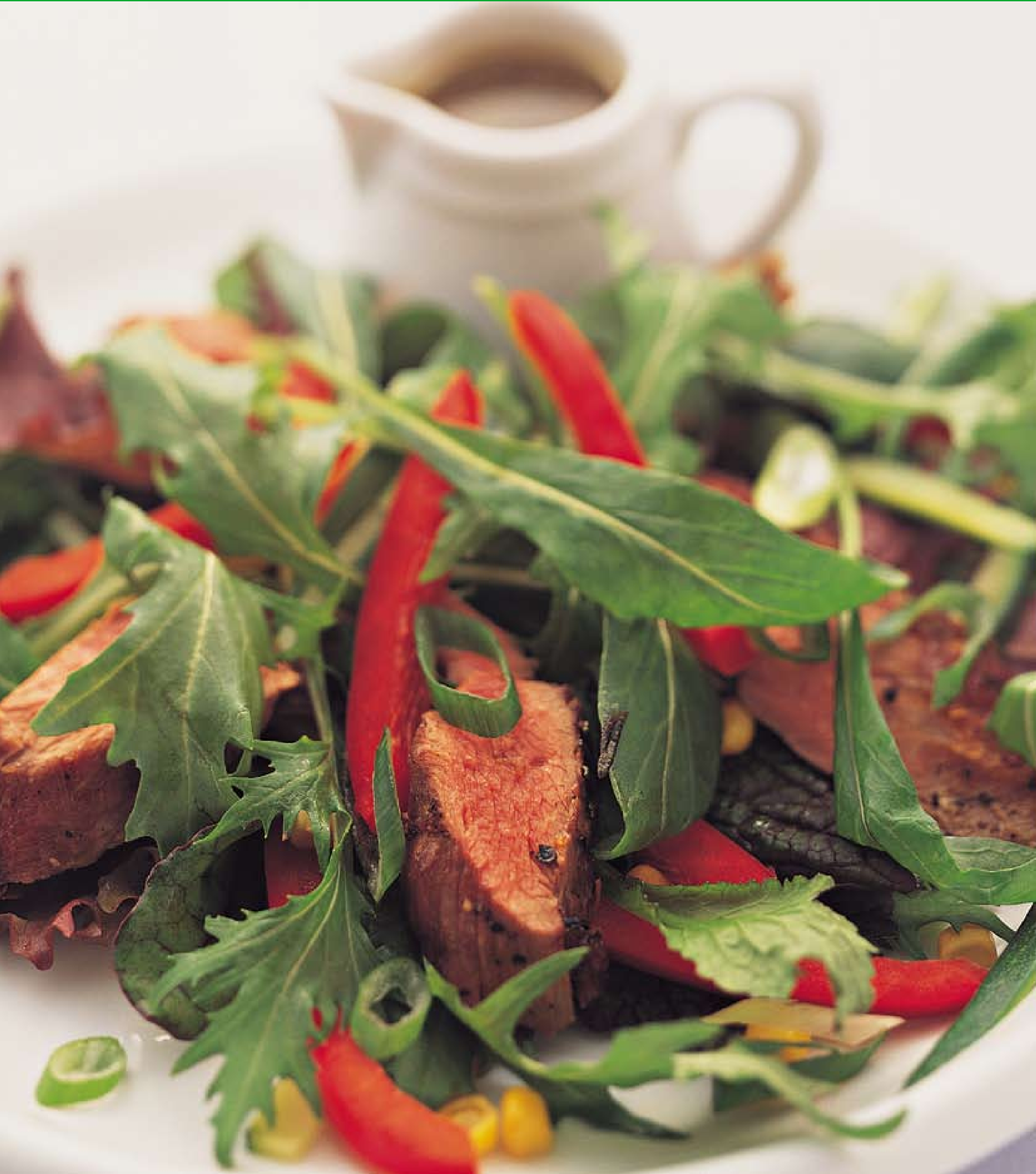
The Role of Red Meat

in a Healthy New Zealand Diet



The Role of Red Meat in a Healthy New Zealand Diet

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SUMMARY

Historically, red meat has played a central role in the human diet.

Around 4 to 5 million years ago, it is believed the ancestral hominid line emerged from the receding forests to become bipedal open grassland dwellers, evolving to require higher-quality foods based around meat protein and fat.

This was accompanied by subsequent physiological and metabolic adaptations involving development of a larger brain and a smaller gastro-intestinal tract.

Evidence from fossil stable isotope analysis demonstrates a growing reliance on consumption of meat as humans evolved.

Meat continues to play an important role in the human diet today; it is an excellent source of protein and, trimmed of visible fat, is low in total fat and saturated fatty acids. It also makes a significant contribution to the healthier monounsaturated and *n*-3 fatty acids in our diet.

In addition, meat from ruminant animals, such as beef and lamb, provides conjugated linoleic acid (CLA), which has been found to have cancer preventive and immunomodulatory properties in animal models.

In terms of micronutrients, red meat (especially beef and lamb) is an excellent source of bioavailable iron and zinc, and also provides selenium, vitamin D and B vitamins, with red meat being one of our major sources of vitamin B_{12}.

Meat also contains bioactive compounds such as taurine, carnitine, creatine and some endogenous antioxidants.

Lean meat has an important role to play in the diets of all age groups in New Zealand, providing nutrients that enable optimal growth and development in childhood as well as maintenance of health and wellbeing throughout adulthood and well into old age.

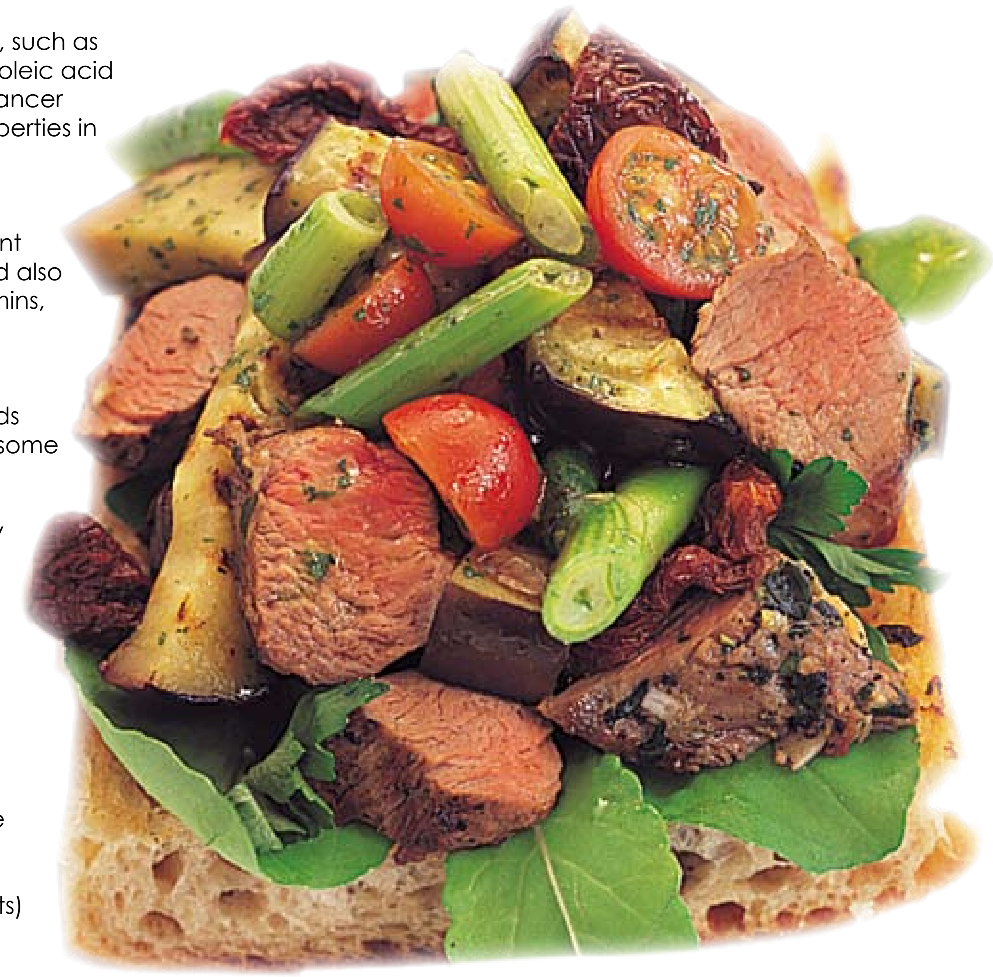
For those who exclude meat, careful consideration needs to be given to the nutritional adequacy of the diet as more restrictive diets are associated with a greater risk of deficiencies. In particular, vegans (who exclude all animal products) need to take extra care to ensure their nutritional needs are met.

The low fat and saturated fatty acid content of lean red meat makes it an ideal food to include in a lipid-lowering diet for those with high cholesterol levels.

The protein content in red meat may play a useful role in weight management, and may be helpful for glycaemic control in people with diabetes.

With respect to cancer, although a small association between high meat intake and colorectal cancer has been found, current average intakes of red meat in New Zealand are below the amount recommended by the World Cancer Research Fund (WCRF, 2007) of up to 500g cooked red meat per week.

Lean red meat is enjoyed by the majority of New Zealanders, providing a unique package of nutrients that make an important contribution to optimal health as part of a balanced diet and active lifestyle.



1. INTRODUCTION

In New Zealand, 94% of the adult population consume animal products, and only 2% avoid red meat completely (Russell et al.,1999). Among children, 95% consume an omnivorous diet (Ministry of Health, 2003a).

As the majority of New Zealanders consume meat, consideration of its contribution to nutritional intakes and its role in health and disease is important.

This report provides background information on human evolution and the increasing importance of meat consumption as humans evolved. It reviews current scientific knowledge on the nutritional content of red meat, its contribution to the diets of New Zealanders and its role in health and disease.

Some of the myths and misconceptions about meat are discussed in Appendix 1. Information about current farming practices in New Zealand, sustainability and risk management at processor level are covered in Appendix 2.

The term 'red meat' in this report refers to beef, veal, lamb and mutton.

2. HUMAN EVOLUTION & MEAT CONSUMPTION

Meat has played a central role in our diets throughout evolution and there is good evidence that over the last 2 million years, the human ancestral line has been consuming increasing quantities of meat (Mann, 2000).

Not only have there been changes in cranio-dental features to enhance our ability to bite and tear animal flesh, but comparative gut morphology shows humans are truly omnivorous (Mann, 2007). In addition, fossil isotope ratios indicate consumption of a high-meat diet in early hominids, as early as 1.8 million years ago (Mann, 2000).

More recent human history, seen in archaeological records of approximately 40,000 years ago, shows use of bone and antler tools such as spears and harpoons.

There is also evidence to suggest animal traps and bows and arrows were used subsequent to this time (Ulijaszek, 2002). Around 9,000 years ago the settling and growth of populations and the domestication of both plants and animals began (Biegert, 1975).

Primates in general, and humans in particular, have larger brain sizes than would be expected for their body size, a phenomenon described as 'encephalisation'. In humans, there has been a dramatic increase in brain size over the last 2-3 million years (Aiello & Wheeler, 1995).

The consumption of meat rich in fats (particularly the unsaturated fats) is thought to be the factor responsible for the threefold increase in brain size over the last 4.5 million years (Chamberlain, 1996; Mann, 1998).

It has been estimated that whenever it was ecologically possible, hunter-gatherers consumed 45-65% of their energy from animal foods, with protein providing 19-35% of energy at the expense of carbohydrates, which provided 22-40% of energy (Cordain et al., 2000).

It has been suggested diets high in meat can be associated with high cholesterol levels and elevated risk of heart disease (Snowdon et al., 1984; Huijbregts et al., 1995; Menotti et al., 1999).

However, a diet high in animal foods does not necessarily elicit unfavourable blood lipid profiles.

An analysis of traditional hunter-gatherer diets found that although 65% of energy was provided by animal foods, hunter-gatherer societies were relatively free of the signs and symptoms of cardiovascular disease (Cordain et al., 2002).

More intense exercise and work patterns are likely to have provided pre-agricultural people with protection against CVD.

In addition, qualitative differences in fat intake, including a higher intake of monounsaturates and polyunsaturates and a lower *n*-6:*n*-3 ratio, would have served to inhibit the development of cardiovascular disease among hunter-gatherers.

Other dietary factors, such as a high intake of antioxidants, fibre, vitamins and phytochemicals and a low intake of salt, along with low levels of stress and no smoking, would further deter the development of cardiovascular disease.

Reverting to the diet and lifestyle of the hunter-gatherer has been shown to result in health benefits.

A study of middle-aged, overweight, diabetic Aborigines in Australia, who reverted to their traditional hunter-gatherer diet for seven weeks, found improvements in all aspects of carbohydrate and lipid metabolism linked with insulin resistance (O'Dea, 1984).

Despite the high contribution of animal foods to energy intake in this study (64%), the diet was low in total fat (13%) due to the very low fat content of the wild animals.

Meat has been a significant part of our diet for millions of years and still makes an important contribution today.

The Paleolithic diet, and that of contemporary hunter-gatherers, has long been recognised as a model for defence against certain Western-lifestyle diseases (Mann, 2007).

In summary, a diet high in lean red meat has been shown to lower plasma cholesterol, contribute significantly to tissue *n*-3 fatty acids, and provide a good source of iron, zinc and vitamin B_{12} (Mann, 2000).

3. KEY NUTRIENTS IN BEEF & LAMB

The primary components of meat are water, fat and protein. The proportions of these constituents can be highly variable, depending on the species and breed of animal, the age of the animal at slaughter, the season and the types of feed used.

The amount of fat trimming, both before and after purchase, and the cooking method used will also influence the nutritional composition of the meat as eaten (BNF, 1999).

There are a number of valuable vitamins, minerals and trace elements in red meat. In particular, red meat is an excellent source of iron and zinc, which are present in a highly bioavailable form. Red meat also provides a number of B vitamins, along with vitamin D, and offal is a good source of vitamin A.

A summary of the nutrients in selected cuts of beef and lamb can be found in Table 1.

Table 1: Nutritional composition of lean, cooked beef and lamb (per 100g)

Nutrient	Beef* (composite cuts)	Lamb* (composite cuts)	Adult NZ RDI**
Energy (kJ)	757.00	855.00	5,600-18,600
Protein (g)	30.40	27.50	46-81
Fat (g)	6.60	10.50	-
Thiamin (mg)	0.50	0.17	1.1-1.4
Riboflavin (mg)	0.21	0.39	1.1-1.6
Total niacin equivalents (mg)	10.70	10.30	14-18
Vitamin B_6 (mg)	0.34	0.32	1.3-2.0
Vitamin B_{12} (µg)	2.60	2.40	2.4-2.8
Total folate (µg)	11.00	10.00	400-600
Sodium (mg)	55.00	78.00	460-920+
Potassium (mg)	400.00	281.00	2800-3800+
Calcium (mg)	5.00	19.00	1000-1300
Iron (mg)	3.80	2.50	8-27
Zinc (mg)	6.30	4.70	8-14
Selenium (µg)	8.70	6.00	60-75

Sources: *Athar et al., 2006; **NHMRC, 2006

RDI is the Recommended Dietary Intake (the average daily dietary intake level sufficient to meet the nutrient requirements of nearly all (97-98%) healthy individuals in a particular life stage and gender group).

+Adequate Intake (AI), used when an RDI cannot be determined.

Detailed background information on different nutrients and their role in the prevention of deficiency can be found in the National Health and Medical Research Council report, *Nutrient Reference Values for Australia and New Zealand including Recommended Dietary Intakes* (NHMRC, 2006). This report also provides information on optimising diets to reduce chronic disease risk.

3.1 FAT

A small amount of fat can contribute to the palatability and flavour of meat. However, it is advisable to remove the visible fat from meat before eating to reduce overall fat content. Red meat cuts as sold have undoubtedly become leaner in recent years (Laugesen, 2005).

Since 1997, the red meat industry's Quality Mark has required the trimming of beef and lamb cuts to no more than 5mm external fat (see Appendix 2 for further information). This has ensured leaner cuts have become the norm for those buying meat as steaks or chops.

A study into the impact of this initiative found the trimming of fat from red meat before sale (supported by virtually all butchers) decreased the fat and saturated fat content of a red meat carcase by 30% (Laugesen, 2005).

Data from the 1997 National Nutrition Survey revealed adult New Zealanders are obtaining 35% of their energy from fat.

The same survey showed beef and veal contributed 6% to total fat intakes, lamb and mutton contributed 2%, and sausages and processed meats contributed 5% (Russell et al., 1999).

In addition, pies and pasties contributed 5% to fat intakes. This category of foods includes potato top pies, pasties, sausage rolls, savouries and quiche; the contribution of meat to fat intake from these foods is unknown, but likely to be small.

The amount of fat provided by meat today is probably lower than this as a result of the increased trimming of meat. Results from the next National Nutrition Survey are expected in 2010.

The total fat and fatty acid content of selected beef and lamb cuts is shown in Table 2.

3.1.1 Saturated Fatty Acids (SFA)

Saturated fatty acids (SFA) are fully saturated with hydrogen and contain no double bond. They are the main types of fatty acids found in foods such as milk, cream, cheese, meat from most land animals, palm oil and coconut oil as well as in pies, biscuits, cakes and pastries (NHMRC, 2006).

Diets high in SFA increase total and low density lipoprotein (LDL) cholesterol, promote post-prandial lipaemia and, through their action on platelet adhesion, encourage thrombosis (National Heart Foundation, 1999a).

Several other factors may contribute to high blood LDL-cholesterol and/or low high density lipoprotein (HDL) cholesterol levels. These include a lack of physical activity, family history, being overweight, drinking excess alcohol and smoking. In addition, though rarely, high blood cholesterol levels can be caused by a genetic condition, familial hypercholesterolaemia (BNF, 2005).

Only around half the fat in meat is saturated (see Table 2), the rest is mainly monounsaturated, with small amounts of polyunsaturated fats, including some *n*-3 fatty acids. The main saturated fatty acids in meat are palmitic and stearic acid (Higgs, 1999); and stearic acid has almost no effect on blood cholesterol (National Heart Foundation, 1999a).

The density of saturated fatty acids in a 100g portion of lean meat is quite low (see Table 2). For example, one tablespoon of olive oil contains more saturated fat (2.3g) than two slices of lean roast topside of beef (1.8g) (Athar et al., 2006). In total, beef, veal, lamb and mutton only contribute around 8% to our saturated fatty acid intake (LINZ, 1999). It is likely that improved trimming practices since 1997 mean the contribution today may be lower than the 1997 data.

3.1.2 Monounsaturated fatty acids (MUFA)

Monounsaturated fatty acids (MUFA) have one double bond; the main MUFA is oleic acid (NHMRC, 2006). Monounsaturates have been found to help lower the amount of LDL cholesterol in the blood, whilst maintaining HDL blood cholesterol levels. This is likely to be a factor in the ability of Mediterranean diets, which are rich in monounsaturates, to protect against cardiovascular disease (BNF, 2005).

A significant proportion of the fatty acids in meat are monounsaturates (see Table 2), principally oleic acid (Higgs, 1999). In New Zealand, around 9% of our monounsaturated fatty acid intake is provided by beef, veal, lamb and mutton (LINZ, 1999).

3.1.3 Polyunsaturated fatty acids (PUFA)

Polyunsaturated fatty acids (PUFA) contain two or more double bonds. There are two main types of PUFA: omega-3 and omega-6 (abbreviated as *n*-3 and *n*-6). The balance of *n*-3 and *n*-6 in the diet is thought to be important for health.

High intakes of *n*-6 PUFA have been linked with a lower risk of coronary heart disease (CHD) and lower LDL-cholesterol levels (NHMRC, 2006; BNF, 2005). The *n*-3 PUFA have little effect on blood cholesterol, but reduce triglyceride levels and have a beneficial effect on blood clotting. In addition, experimental studies have shown *n*-3 PUFA modify inflammatory and immune reactions (Simopoulos, 2002).

Fish and seafood are the richest dietary sources of *n*-3 PUFA, with concentrations 5 to 15 times higher than meat (Howe et al., 2006); however meat is also likely to make a significant contribution to intakes of *n*-3 PUFA when the relative amounts eaten are considered.

Australian data show meat, poultry and game contribute 43% to overall intakes of *n*-3 PUFA, with beef contributing 22.3% and lamb contributing 5.9% (Howe et al., 2006).

Meat from animals raised on grass, as in New Zealand, contains higher levels of *n*-3 PUFA than meat from animals raised on grain.

One study found, for example, there was 2 to 4 times the amount of *n*-3 PUFA in beef from grass-fed animals (including 18:3) than in meat from concentrate-fed animals, except for 20:4 *n*-3 where there was 10 times the amount in the grass group (Enser et al., 1998). The same study found similar results for lamb from animals grazed on grass.

A significant amount of the *n*-3 PUFA in meat is docosapentaenoic acid (DPA), which is an intermediate in the production of docosahexaenoic acid (DHA) from eicosapentaenoic acid (EPA).

DPA has been shown to be a more potent inhibitor of platelet aggregation than EPA or DHA (Akiba et al., 2000), and in the Kuopio Ischaemic Heart Disease Risk Factor Study, reduction in risk of acute coronary events correlated significantly with serum concentrations of DPA and DHA in individuals whose mercury status was low (Rissanen et al., 2000).

Epidemiological data on DPA are, however, limited and more information is needed on the nutritional and health benefits of DPA consumption (Howe et al., 2006).

Given the evidence linking EPA, DHA and DPA to health, it would seem prudent to encourage increased consumption of these fatty acids in the diet.

An intake in the region of 0.4g/day for women and 0.6g/day for men is recommended (NHMRC, 2006). Overall, red meat in New Zealand could make an important contribution to intakes of *n*-3 PUFA, particularly in those who eat little fish (Knowles et al., 2004).

Table 2: Fat and fatty acid content of lean, cooked beef and lamb (per average 100g serving)

Meat Cut	Total fat (g)	SFA (g)	MUFA (g)	PUFA (g)
Lean beef, cooked, composite cuts	6.6	2.8	2.7	0.3
Beef mince, lean, stewed	6.0	2.6	2.5	0.3
Beef rump steak, lean, grilled	5.5	2.3	2.3	0.2
Beef topside, lean, roasted	5.3	2.3	2.2	0.2
Lean lamb, cooked, composite cuts	10.5	5.4	3.9	0.3
Lamb leg steak, lean, grilled	7.8	3.9	2.8	0.2
Lamb rump chop, lean, grilled	8.8	4.5	3.3	0.2
Lamb shoulder, lean, roasted	12.8	6.3	4.6	0.3

Source: Athar et al., 2006

3.1.4 *Trans* fatty acids

Trans fatty acids (TFAs) are unsaturated fatty acids with at least one double bond in the *trans* configuration. There is good evidence TFAs have a more adverse effect on cardiovascular disease risk than saturated fatty acids (Ascherio & Willett, 1997), although, quantitatively TFAs constitute a much smaller proportion of the diet than saturated fatty acids (NHMRC, 2006).

Most of the *trans* fat in the diet is found in margarines and products such as cakes, biscuits and pastries. Some *trans* fats can also occur naturally at low levels in ruminant animal foods, formed as a result of biohydrogenation by rumen bacteria. However, the predominant ruminant TFA is vaccenic acid (Turpeinen et al., 2002), which has not been associated with coronary heart disease (Willett et al., 1993).

The World Health Organisation has recommended TFAs contribute no more than 1% of total dietary energy (WHO, 2003). In New Zealand, current intakes are around 0.7% of total dietary energy (NZFSA, 2007). It is recommended saturated fatty acids and TFAs together contribute no more than 8 to 10% of total energy (NHMRC, 2006).

3.1.5 Conjugated linoleic acid

The term conjugated linoleic acid (CLA) generally refers to mixtures of positional and geometric conjugated isomers of linoleic acid. The principal dietary form of CLA is the *cis*-9, *trans*-11 isomer (Pariza et al., 2000), which provides over 90% of our intake (Nakamura et al., 2008).

CLA has been shown in animal studies to inhibit carcinogenesis and atherosclerosis, enhance immunologic function, affect body composition change (reducing fat gain and enhancing lean body mass gain) and stimulate growth (Pariza et al., 2000).

More recently, CLA has been found to modulate immune function in humans (O'Shea et al., 2004). However, studies in humans into the effects of CLA are generally less conclusive than animal studies, with conflicting and inconsistent findings (Plourde et al., 2008; Nakamura et al., 2008).

The highest levels of dietary CLA are found in the meat and milk from ruminant animals (Nakamura et al., 2008). The method of feeding may affect the levels of CLA present in the meat, for example, beef from pasture-fed cattle may have a higher CLA content than beef from silage-fed or grain-fed cattle (Mir et al., 2004).

CLA in meat is located in the interstitial, non-visible fat, evenly distributed along the muscle fibres, as well as in the subcutaneous deposits (Eynard & Lopez, 2003).

Whereas visible fats are often, and easily, discarded, interstitial fats will be eaten. Thus, lean meat could potentially make an important contribution to the human intake of CLA.

The current dietary intake of CLA in Western populations is too low to provide the beneficial effects seen in animal studies (Turpeinen et al., 2002) and further research is needed into the potential benefits of dietary sources of CLA. In particular, investigations are needed to develop an understanding of the molecular action of CLA isomers and their potential use in chronic disease therapy (Nakamura et al., 2008).

3.2 PROTEIN

Red meat is an excellent source of high biological value protein; the protein is highly digestible and provides all essential amino acids (lysine, threonine, methionine, phenylalanine, tryptophan, leucine, isoleucine and valine) with no limiting amino acids (Williams, 2007). A 100g portion of cooked lean beef or lamb provides around 25-30g of protein (see Table 1).

On average, beef and veal contribute 14% to protein intakes in New Zealand, and lamb and mutton contribute 3%. Sausages and processed meats contribute a further 4% (Russell et al., 1999).

Diets with as little as 10% energy from protein are adequate to meet basic protein requirements, but intakes above 15% energy from protein appear to be required for ensuring adequate intakes of micronutrients.

Evidence is accumulating that increasing intake of high quality protein to a level above the recommended intake may be beneficial during weight loss (see section 8.3). However, an upper limit of 25% energy from protein has been suggested until more is known about the long-term effects of a high-protein diet (NHMRC, 2006).

3.3 MICRONUTRIENTS

3.3.1 Iron

Iron is needed for the production of a number of proteins in the body, including haemoglobin, myoglobin, cytochromes and enzymes involved in redox reactions. Iron is also important for early brain development and for supporting a healthy immune system.

Iron is present in food in two forms – haem and non-haem. Haem iron (found in meat and fish) is more bioavailable than non-haem iron, with conservative estimates that 25% is absorbed (Hallberg & Rossander-Hulthen, 1991).

Non-haem iron (found in meat, legumes, nuts, cereals, some fruits and dark green vegetables such as spinach) is less bioavailable and absorption is influenced by other dietary components. For example, foods containing vitamin C can increase absorption of non-haem iron. In contrast, foods containing phytates (found in legumes and cereals) can inhibit non-haem iron absorption.

Absorption of iron from vegetarian diets has been estimated to be around 10% (Institute of Medicine Panel on Micronutrients, 2001) and it has been suggested there can be a 10-fold difference in the absorption of iron from different meals with a similar iron content (Hallberg & Hulthen, 2000).

Absorption of iron is about 18% from a mixed diet, so iron requirements for vegetarians, who rely on non-haem sources, will be about 80% higher than for those who eat meat (NHMRC, 2006).

Beef and lamb are among the richest sources of bioavailable iron in the diet and, in addition, meat enhances the absorption of non-haem iron from foods eaten at the same time. The nature of the enhancing effect is thought to be related primarily to the muscle proteins (Hurrell et al., 2006).

In New Zealand, beef and veal have been found to contribute 12% to our iron intake, with lamb and mutton providing a further 2% (Russell et al., 1999) although the actual contribution is much greater, owing to the higher proportion absorbed.

Inadequate intakes of iron can lead to varying degrees of deficiency; from low iron stores (indicated by low serum ferritin and reduced iron-binding capacity) to iron-deficiency anaemia (low haemoglobin and haematocrit as well as reduced mean corpuscular haemoglobin and volume) (NHMRC, 2006).

Iron deficiency is the most common nutritional deficiency in industrialised countries, particularly among infants, children and women (Cook et al., 1994).

Adolescents are at risk with the increased iron demands arising during the pubertal growth spurt, especially young women, who also have menstrual blood loss (Schaaf et al., 2000).

In fact, it has been estimated that globally, over 1.5 billion people are affected by anaemia, which corresponds to almost 25% of the world's population (McLean et al., 2008). The adverse effects of iron deficiency anaemia include poor cognitive development, fatigue, reduced work tolerance and decreased aerobic capacity. Iron deficiency anaemia can also have an impact on behaviour.

In infants, iron deficiency anaemia has been associated with maintaining closer contact with caregivers, showing less pleasure and delight, being more wary, hesitant and easily tired, being less attentive to instructions and being less playful (Lozoff et al., 1998).

Severe, chronic iron deficiency anaemia in infancy has also been associated with reduced mental and motor functioning, and continued developmental and behavioural risk more than 10 years after iron treatment (Lozoff et al., 2000). The recommended intake for iron in different population groups is shown in Table 3.

Approximately 4% (Soh et al., 2004) to 6% (Grant et al., 2007b) of infants and toddlers in New Zealand have iron deficiency anaemia.

However, non-anaemic iron deficiency is considerably more common than iron deficiency anaemia in New Zealand infants and children (Soh et al., 2004), and may be associated with subtle negative effects on cognitive function and fatigue, as well as an increased risk of developing iron deficiency anaemia if exposed to a physiological challenge such as rapid growth, infection, or injury.

A recent study in Auckland children aged 6 to 24 months found 14% were iron-deficient, with the occurrence among Maori and Pacific Islanders even higher at 20% and 17% respectively (Grant et al., 2007b). Iron intake was less than the estimated average requirement (EAR) for 25% of the infants.

Not meeting the EAR increased the risk of iron deficiency for children aged 6 to 11 months (relative risk (RR) = 18.45, 95% confidence interval [CI]: 3.24-100.00) and 12 to 23 months (RR = 4.95, 95% CI: 1.59-15.41). In comparison with New Zealand Europeans, Pacific children had a greater daily iron intake (p = 0.04) and obtained a larger proportion of iron from meat and meat dishes (p = 0.02) (Wall et al., 2008).

Iron requirements in the first year of life are greater than at any other time due to rapid growth and blood volume expansion (Grant et al., 2007a). The depletion of iron stores accrued in utero, and increased demands for growth, mean that after six months of age infants depend on complementary foods to provide iron (Ministry of Health, 2008a).

Meat has been found to play an important role as a complementary food. For example, the addition of powdered red meat to a weaning gruel has been shown to markedly increase total iron absorption (Hallberg et al., 2003). Puréed meat can be introduced once an infant is 6 months of age. Given the risk of iron deficiency in infants and young children, it has been suggested public health campaigns should encourage adequate meat intake to help reduce the problem (Mira et al., 1996).

The importance of both meat and fortified milk for providing iron in toddlers' diets was demonstrated in a recent New Zealand trial, assessing the effect of increased red meat consumption, or the use of iron-fortified milk, for improving iron status in healthy non-anaemic toddlers aged 12 to 20 months (Szymlek-Gay et al., 2007).

Mean dietary iron intakes increased in the meat group from 4.7mg to 5.3mg per day and from 4.3mg to 10.4mg per day in the fortified milk group. Whereas iron stores declined in the control group, both the intervention strategies prevented this decline in body stores (Szymlek-Gay et al., 2007).

Iron deficiency is also prevalent in Auckland high school students (Schaaf et al., 2000), particularly in girls, where iron deficiency and anaemia were each ten times more common (9.6% and 8.7% respectively) than in boys (0.8% and 0.7%). In females, iron deficiency was two to three times more common and anaemia was three to four times more common in Maori, Pacific Islanders and Asians compared with Europeans.

Iron deficiency in this study was defined as any two or more of the following: serum ferritin less than 12µg/L, iron saturation less than 14%, or red cell distribution width greater than 14.5%. Anaemia was defined as haemoglobin less than 120g/L for females and less than 130g/L for males. The level of iron deficiency and anaemia in this study was higher than that reported in an earlier Dunedin longitudinal survey (Fawcett et al., 1998), which found the prevalence of iron deficiency (ferritin less than 12ng/mL) at age 21 was 0.24% in men and 6.7% in women.

The higher prevalence in the Auckland study is likely to be due to the different age group studied; adolescent girls have higher requirements for iron due to growth super-imposed on menstrual losses.

Concern has also been expressed in relation to the sub-optimal iron status of women of childbearing age in New Zealand. One study (Ferguson et al., 2001) estimated the prevalence of sub-optimal iron status among 15 to 49 year old women was between 7% (serum ferritin less than 12µg/L) and 13% (serum ferritin less than 16µg/L). The authors state this situation is unacceptable given the negative consequences of even mild iron deficiency.

Failure to improve the situation could result in a reduction of quality of life for many New Zealand women. For certain high-risk sub-groups of adolescents (for example vegetarians, athletes, pregnant women, Pacific Islanders and Maori), the prevalence of iron deficiency and iron deficiency anaemia is often much higher (Gibson et al., 2002).

Pregnant women in particular are vulnerable to iron deficiency, as requirements are significantly increased to meet the needs of the growing foetus, and increased maternal blood volume. An iron-rich diet, which includes the regular consumption of red meat, chicken and fish, has been recommended (Grant et al., 2007a). Non-haem sources of iron such as grains, cereals, legumes and eggs should also be encouraged, along with foods containing vitamin C to enhance absorption.

Table 3: Recommended daily intakes for iron in New Zealand

Population Group	RDI* (mg/day)
Infants (0-6 months)+	0.2**
Infants (7-12 months)	11
Children (1-3 years)	9
Children (4-8 years)	10
Children (9-13 years)	8
Boys (14-18 years)	11
Girls (14-18 years)	15
Women (19-50 years)	18
Pregnant women	27
Breastfeeding women++	9-10
Women over 50 years	8
Men over 19 years	8

*RDI is the Recommended Dietary Intake (the average daily dietary intake level sufficient to meet the nutrient requirements of nearly all (97-98%) healthy individuals in a particular life stage and gender group).

**This value is the AI, the Adequate Intake, used when an RDI cannot be determined.

+ Amount normally received from breast milk.

++ Assumes menstruation does not resume until after 6 months of breastfeeding.

Source: NHMRC, 2006

In cases of iron deficiency anaemia, iron supplementation is accepted as the most appropriate method of treatment. However, a New Zealand study investigated whether dietary treatment of non-anaemic iron deficiency could improve iron status in pre-menopausal Dunedin women.

The study found that dietary intervention involving increased intakes of both haem iron (from flesh food) and enhancers of iron absorption (such as vitamin C), along with a decreased intake of inhibitors of iron absorption (such as phytic acid), may improve the iron status of pre-menopausal women with low iron stores (Heath et al., 2001).

Although the changes in iron status were less with dietary intervention than with supplements, in motivated women with low iron stores, dietary intervention may be an appropriate first-line treatment as long as they are monitored to ensure the treatment has been effective.

Prevention and treatment of iron deficiency among vulnerable groups within New Zealand is an important public health issue. In particular, we need to ensure optimal intakes of iron among groups such as infants, children, adolescents and pregnant women.

3.3.2 Zinc

Zinc is a component of various enzymes that help maintain the structural integrity of proteins and regulate gene expression (NHMRC, 2006).

It is also known to play a central role in the body's immune system, with zinc deprivation leading to an increased susceptibility to pathogens because of impaired immune response (Shankar & Prasad, 1998). Zinc deficiency can also lead to impaired growth and adverse pregnancy outcomes (NHMRC, 2006).

Those at increased risk of zinc deficiency include older people, vegetarians and people with renal insufficiency (Ibs & Rink, 2003).

For example, a study into the zinc status of Dunedin women aged 70 to 80 years old found 12% had low serum zinc levels (de Jong et al., 2001) and the authors concluded that promotion of nutrient-dense foods or trace element supplements for New Zealand seniors should be considered.

A further study into the zinc status amongst pre-menopausal Dunedin women found zinc status was lower than had been found in earlier studies (Gibson et al., 2001). It is suggested that changes in food selection patterns over time may account for this change.

An example would be the decline in consumption of flesh foods – specifically beef and lamb, which are rich sources of bioavailable zinc. Certainly, in this study, the women who included red meat in their diet had a superior biochemical zinc status to that of those who avoided eating red meat.

It is also important to consider the zinc intake of infants and young children. It has been suggested that for young children, plant-based diets, which are associated with low absolute daily absorbed zinc, may be inadequate to meet requirements (Krebs & Hambidge, 2007). However, by including foods in the diet such as meat, which has a higher zinc content, it is more likely requirements will be met.

To reduce the risk of both zinc and iron deficiency in infants, it is advisable to introduce meat as an early complementary food, as is advocated in the *Food and Nutrition Guidelines for Healthy Infants and Toddlers (aged 0-2 years)* (Ministry of Health, 2008a).

Although zinc is widely distributed in foods, meat, fish and poultry are major contributors, with cereals and dairy foods also providing substantial amounts (NHMRC, 2006). Beef and lamb in particular are among the richest dietary sources of zinc, with a 100g portion providing at least a quarter of adult requirements (see Table 1).

3.3.3 Selenium

Selenium is an integral part of glutathione peroxidase, an enzyme that protects against oxidative damage (NHMRC, 2006). Selenium is also important for the production of other key selenoproteins such as iodothyronine deiodinase (Arthur et al., 1999).

Dietary selenium is essential for the efficient operation of many aspects of the immune system (Arthur et al., 2003; Broome et al., 2004) and for optimal thyroid hormone metabolism (Arthur et al., 1999). It may also be anti-carcinogenic (Combs, 2005).

Intakes of selenium higher than the recommended intake may be required for protection against cancer and may have other health benefits. However, there is an urgent need for more large scale trials to assess any such beneficial effects and to estimate the level of selenium intake that is protective (Thomson, 2004a).

Overt deficiency of selenium in humans is rare but is seen as Keshan disease, an endemic cardiomyopathy in adolescent or pre-adolescent years in low selenium areas of China (Yang et al., 1988). More marginal deficiency may contribute to reduced immune function, some cancers and viral diseases (Broome et al., 2004).

The main sources of selenium in the diet are seafood, poultry and eggs, and, to a lesser extent, other muscle meats (Thomson, 2004b). Fish and seafood provide 29%, and bread provides 11% in the New Zealand diet. Poultry provides 6%, with beef, veal and eggs (all providing 5%) also being useful sources (Ministry of Health, 2003b).

Analysis of data from the 2002 Children's Nutrition Survey showed that among children aged 5 to14 years, selenium was provided by bread and grains (33%), meat (14.8%), poultry (11.2%), and fish and seafood (8.6%) (Thomson et al., 2007).

Regional differences in selenium intake in New Zealand were observed in the Children's National Nutrition Survey (Thomson et al., 2007).

Analysis of the selenium status of children aged 5 to 14 years showed children in the upper North Island had mean serum selenium concentrations higher than those in the lower North Island and South Island. Younger children had lower selenium intakes than older children (Thomson et al., 2007).

These differences have been partly attributed to the different levels of selenium found in bread, since the selenium content of bread is lower in the South Island than the North Island where higher selenium wheat from Australia is used.

Another reason for the differences is the high fish and poultry intakes of Pacific children, of whom there is a higher proportion in the north of the North Island (60%) compared with the lower North Island (18%) and the South Island (11%).

As a whole, our children fall in the middle of the range of international serum selenium concentrations. However, the selenium status of South Island children is among the lowest values reported internationally (Thomson et al., 2007).

Pregnant and breastfeeding women may be at risk of low selenium concentrations due to the increased selenium demands of the growing foetus and the increased demands of lactation. In addition, infancy is a vulnerable time, with rapid growth and development also leading to increased selenium requirements.

A study of South Island children, aged 6 to 24 months, and their mothers, found dietary selenium intakes were below recommended levels (McLachlan et al., 2004) with intakes of 7.9 ± 6.2μg/d in infants; 13.7 ± 8.4μg/d in toddlers and 38 ± 25μg/d in mothers.

The low intakes were reflected in blood selenium concentrations, which were at the lower end of international levels. The authors recommend dietary strategies to improve selenium intakes were implemented, for example, the inclusion of selenium-rich foods such as fish, meat and unrefined cereals.

A further study, which looked at older New Zealand women from Dunedin aged 70 to 80 years, found 74% were at risk of sub-optimal selenium status (de Jong et al., 2001).

This may have implications for reducing resistance to infection and increasing risk of cancer and cardiovascular disease. The promotion of nutrient-dense foods such as meat and fish should be considered in this age group.

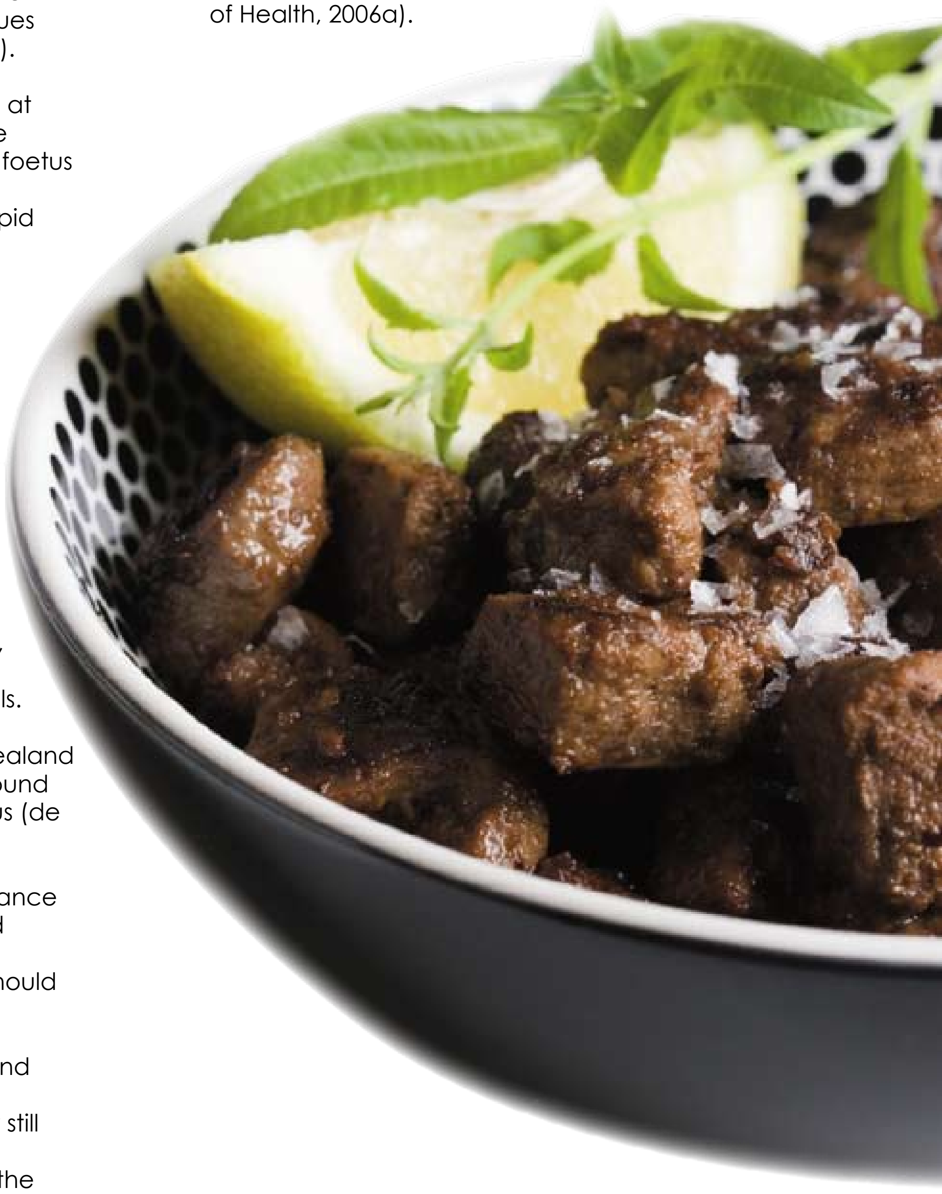
Overall, the selenium status of the New Zealand population remains low compared with the population of many other countries and may still be considered marginal (Thomson, 2004b). In particular, strategies are needed to improve the selenium status of vulnerable groups such as infants and toddlers, pregnant and breastfeeding women and older people.

3.3.4 Vitamin A

Vitamin A is a fat-soluble vitamin, which helps maintain normal reproduction, vision and immune function (NHMRC, 2006). The term vitamin A includes retinol from animal sources, and pro-vitamin A carotenoids, such as beta-carotene, which are precursors of vitamin A.

Carcase meat contains little vitamin A, but liver is a particularly good source of this vitamin in the form of retinol. Chronic intake of large amounts of retinol over time can be toxic and pregnant women should limit their intake of liver as vitamin A can be teratogenic (ie can cause defects in the growing foetus).

In some countries, pregnant women are advised to avoid liver altogether; however, in New Zealand, animal feeding practices are different and levels of vitamin A in liver are likely to be lower. The Ministry of Health in New Zealand advises up to 100g of liver may be consumed per week during pregnancy, although liver pâté is not recommended as there is a risk of food-borne illness such as listeriosis (Ministry of Health, 2006a).



3.3.5 B Vitamins

Meat is an excellent source of vitamin B_{12}, which is only found naturally in foods of animal origin.

Vitamin B_{12} is required for the synthesis of fatty acids in myelin and, in conjunction with folate, for DNA synthesis (NHMRC, 2006). Ensuring an adequate intake of vitamin B_{12} is essential for normal blood function and neurological function.

A 100g portion of cooked beef or lamb provides almost the entire daily requirement for vitamin B_{12} (see Table 1).

For vegans, who avoid all animal products, fortified foods or supplements will be necessary to provide adequate B_{12} (see section 4).

A 100g serving of beef or lamb also provides around half the daily requirement for niacin, along with some thiamin, riboflavin and vitamin B_6, as shown in Table 1.

These B vitamins are important for numerous metabolic functions in the body, particularly as their respective co-enzyme forms, in energy metabolism.

3.3.6 Vitamin D

The main function of vitamin D is to help maintain plasma calcium concentrations by enhancing the absorption of calcium in the small intestine and controlling urinary losses.

Over the past decade, deficiency of this vitamin has been associated with higher risk of multiple sclerosis, diabetes and some cancers, and with poorer immune activation (Holick & Chen, 2008).

Vitamin D status is generally maintained by the exposure of skin to sunlight. Where exposure to sunlight is inadequate, dietary sources of vitamin D become important.

Sub-optimal vitamin D status is associated with low bone mineral density and the risk of osteoporosis later in life (Holick & Chen, 2008).

A high prevalence of vitamin D insufficiency was found in an analysis of the 2002 National Children's Nutrition Survey; with 4% of New Zealand children aged 5 to14 years vitamin D deficient (<17.5nmol/L) and 31% vitamin D insufficient (<37.5nmol/L) (Rockell et al., 2005).

The children studied had a mean serum 25-hydroxyvitamin D concentration of 50nmol/L, with mean concentrations in sub-groups ranging from 32nmol/L in Pacific girls aged 11 to 14 years, to 62nmol/L in New Zealand European and other boys aged 5 to 6 years.

Children of Maori and Pacific ethnicity may be at particular risk of low vitamin D status because of low vitamin D intakes, New Zealand's high latitude (35-47°S) and skin colour (Rockell et al., 2005).

New Zealand adolescents and adults have also been found to be at risk of vitamin D insufficiency (Rockell et al., 2006).

Analysis of serum 25-hydroxyvitamin D levels using data from the 1997 National Nutrition Survey found 3% were vitamin D deficient (< 17.5nmol/L), and 48% and 84% has vitamin D insufficiency based on cut offs of ≤50 and ≤80nmol/L respectively.

The prevalence of vitamin D insufficiency was higher among Maori and Pacific Islanders. Vitamin D status was lower in women than in men, and in women also decreased with age.

A study of elderly Dunedin women also found vitamin D deficiency was common, particularly in women over 70 years of age, who had a high bone fracture risk (McAuley et al., 1997). Deficiency was most marked in winter months.

Red meat provides vitamin D. A study into the vitamin D content of beef and lamb found them to be a source of both vitamin D3 and its active metabolite 25-hydroxyvitamin D3 (Purchas et al., 2007).

25-hydroxyvitamin D3 is suggested to have 1.5 to 5 times the activity of vitamin D3, and the authors of this study estimate (assuming 1µg of 25-hydroxyvitamin D3 is equivalent to 3µg of vitamin D3) that, on average, 100g of beef striploin would contain 1.2µg of total vitamin D3 and 100g of cooked lamb leg steak would contain 2.6µg.

Although this is a small amount compared to the amount needed to improve the vitamin D status of New Zealanders to optimal levels, there is some interest in determining whether meat has a role to play in providing vitamin D.

3.4 BIOACTIVE SUBSTANCES

In addition to the essential nutrients, meat also provides a number of bioactive substances (Williams, 2007).

Meat is a rich source of taurine, an amino acid that may be important during lactation and times of immune challenge, and may offer protection against oxidative stress.

Meat also provides carnitine, which transports long chain fatty acids across the inner mitochondrial membranes to produce energy during exercise; requirements for carnitine may be increased in pregnancy and after strenuous exercise.

Red meat is the principle human dietary source of creatine, which plays a role in energy metabolism.

Meat is also a source of a number of endogenous antioxidants, for example ubiquinone, glutathione, lipoic acid, spermine, carnosine and anserine.

4. NUTRTITIONAL IMPLICATIONS OF A MEATLESS DIET

A diet excluding animal products can be nutritionally adequate, but if an increasing number of foods are excluded it becomes important to plan the diet carefully to ensure nutrient needs are met. Intakes of iron, calcium, zinc, vitamin B_{12} and riboflavin need careful consideration – especially for vegans.

Vitamin B_{12} is of notable concern as it is only found naturally in foods of animal origin (see section 3.3.5). Vegans are therefore at particular risk of deficiency (Mann et al., 1999). Among adults, a diet devoid of vitamin B_{12} may not lead to symptoms of deficiency for many years as most of us have significant body stores. In contrast, newborn infants have only small body stores and breastfed infants of unsupplemented vegan mothers may be at particular risk.

One case study, for example, found a 14-month old boy who was exclusively breastfed until 9 months of age had severe vitamin B_{12} deficiency caused by his mother's, presumably unsupplemented, vegan diet.

Supplemental B_{12} rapidly improved haematological and neurological symptoms, although cognitive and language development remained seriously delayed at the age of two years (von Schenck, 1997). Vegan mothers who are breastfeeding need to ensure an adequate intake of vitamin B_{12} and it is advised they supplement their diet to the recommended level during pregnancy and lactation (NHMRC, 2006).

For vegan infants who are not breastfed, an appropriate soy-based infant formula should be used. Once a vegan infant has started to consume complementary foods, it is important to ensure a daily intake of vitamin B_{12}, with fortified foods or a supplement (Ministry of Health, 2008a).

Diets that exclude animal foods also have the potential to have low iron and zinc bioavailability. Eliminating meat, along with increasing intake of phytate-containing legumes and whole grains, reduces the absorption of both iron and zinc (Hunt, 2003) and a higher intake of these nutrients will be required in order to meet nutritional requirements.

Vegetarians will need iron intakes about 80% higher than non-vegetarians (NHMRC, 2006), and zinc intakes about 50% higher – particularly vegans (Hunt, 2003; NHMRC, 2006).

5. FOOD & NUTRITION GUIDELINES IN NEW ZEALAND

The majority of New Zealanders consume meat, and as meat is such a nutrient-dense food it can be particularly useful in the diets of population groups with high nutrient needs. It is recommended we include 1 to 2 servings a day of iron-containing foods in our diet. For recommended serving sizes, see Table 4.

5.1 Infants and toddlers

Lean meat can make an important contribution to the diets of infants and toddlers, providing protein, vitamins and minerals, in particular iron and zinc, which are present in a highly bioavailable form (see sections 3.3.1 and 3.3.2).

Once an infant is around 6 months old, puréed meat can be added to the diet with finely chopped, tender meat introduced as swallowing develops (Ministry of Health, 2008a). Iron-fortified infant cereals can be introduced from 6 months and foods containing vitamin C (eg fruits and vegetables) should be offered with meals and snacks, to assist in non-haem iron absorption. If an infant is not breastfed, it is important to use an iron-fortified infant formula until 12 months of age.

Foods containing iron inhibitors such as tea and caffeinated beverages should be avoided by young children. Overall, it is important to offer a wide variety of foods from the different food groups to ensure nutritional needs are met during this period of rapid growth and development.

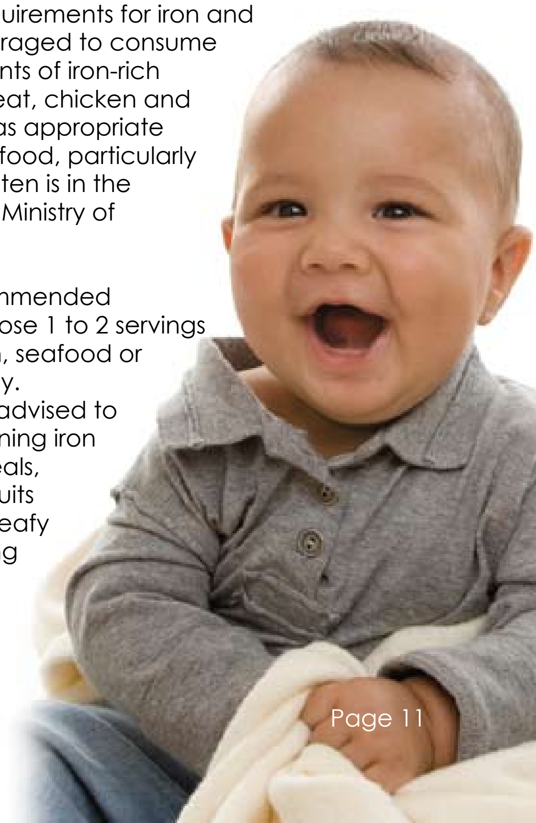
5.2 Children (2 to 12 years old)

Ensuring optimal iron and zinc intake remains important in this age group. The need for iron in the diets of toddlers is relatively high, yet few iron-rich foods may be consumed (Ministry of Health, 1997), especially among fussy eaters. A variety of foods should be encouraged and ideally at least one serving a day of lean meat, chicken, seafood or alternatives should be provided. It is important to offer vegetarian children iron-containing foods such as fortified cereals, lentils or beans, alongside vitamin C-containing foods to promote absorption.

5.3 Adolescents

Healthy eating during adolescence is important to ensure nutritional needs are met during growth; onset of menstruation further increases iron needs of girls. In particular, adolescents have high physiological requirements for iron and should be encouraged to consume adequate amounts of iron-rich foods such as meat, chicken and seafood as well as appropriate combinations of food, particularly when the iron eaten is in the non-haem form (Ministry of Health, 1998).

Ideally, it is recommended adolescents choose 1 to 2 servings of meat, chicken, seafood or alternatives a day. Vegetarians are advised to eat foods containing iron (wholegrain cereals, legumes, dried fruits and dark green leafy vegetables) along with foods rich in vitamin C to help iron absorption.



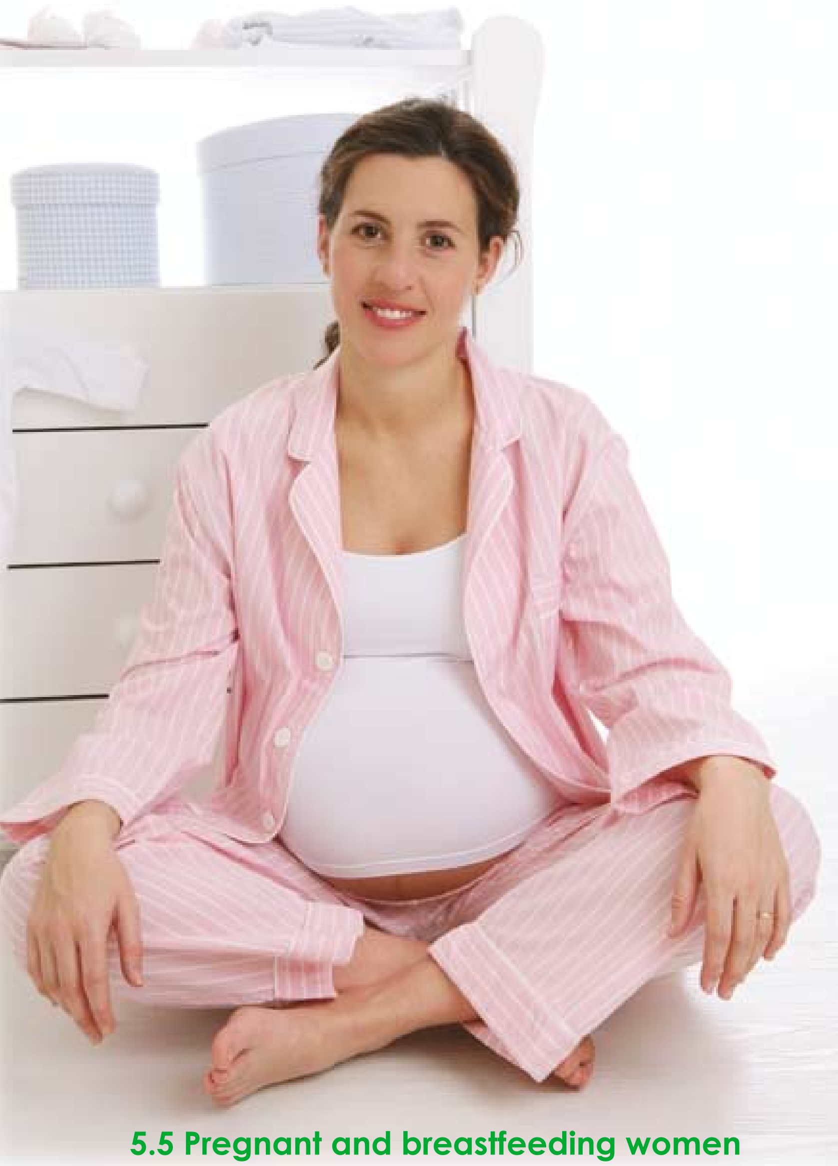
5.4 Healthy adults

The Ministry of Health's Food and Nutrition Guidelines for Healthy Adults recommends maintaining a healthy weight, eating well, and being physically active every day.

A variety of foods from the four main food groups should also be included daily (vegetables and fruits; breads and cereals; milk and milk products; lean meat, poultry, seafood, eggs or alternatives).

In addition, we are advised to choose foods with minimal fat, sugar and salt, to drink plenty of liquids (especially water) and to limit alcohol intake (Ministry of Health, 2003b).

At least one serving a day is recommended from the meat and alternatives group to provide protein, B vitamins, iron, zinc, magnesium, copper, potassium, phosphorus and selenium.



5.5 Pregnant and breastfeeding women

Iron requirements are increased significantly during pregnancy (see Table 3), however, routine iron supplements are not recommended in New Zealand and should only be given after diagnosis of iron deficiency anaemia. Iron requirements during breastfeeding are substantially lower than in pregnancy.

To ensure adequate iron intake among pregnant and breastfeeding women, dietary strategies should include consumption of at least two servings of iron-containing foods a day (Ministry of Health, 2006a).

Beef and lamb can make a particularly useful contribution to iron intakes as they are rich sources of bioavailable iron. Other sources are poultry, seafood, eggs, nuts and seeds, and legumes.

Monitoring of iron status throughout pregnancy is important to identify current or potential iron deficiency and all women should receive advice on dietary sources of iron and factors affecting iron absorption, in order to avoid iron deficiency.

Pregnant vegetarian and vegan women may find it difficult to meet iron requirements and should consume plenty of iron-containing plant-based foods along with foods rich in vitamin C.

Pregnant and breastfeeding women should be advised to consume a variety of nutritious foods from the main food groups to ensure adequate nutritional status.

5.6 Older people

A review of dietary intake studies in elderly people found poor dietary intake became increasingly common with advancing age (Horwath, 1989). However, the author highlights the fact nutritional deficits in elderly people may be the result of not only inadequate dietary intake, but also the presence of disease, drug-nutrient interactions, or decreased digestive and absorptive function.

Part of the reason for a reduced dietary intake may be a declining appetite, making the quality of dietary intake increasingly important with advancing age (Ministry of Health, 1996). Requirements of thiamin, vitamin B_6, vitamin D, vitamin B_{12}, calcium (in women) and folate tend to be higher in older people (Ministry of Health, 1996). It is recommended older people have at least one serving a day of iron-containing foods, such as lean meat, skinless chicken, seafood, eggs and legumes.

Table 4: Recommended serving sizes for meat and alternatives

Serving size for lean meat, chicken, seafood, eggs, legumes
2 slices (100g) cooked meat
¾ cup (195g) mince or casserole
1 egg (50g)
1 medium fillet of cooked fish (100g)
1 medium steak (120g)
¾ cup (135g) cooked dried beans
2 drumsticks or 1 chicken leg (110g)

Source: Ministry of Health, 2003b

6. EATING PATTERNS OF NEW ZEALANDERS

Two significant national nutrition surveys carried out in New Zealand provide a comprehensive picture of New Zealanders' eating patterns; the 1997 survey, *NZ Food: NZ People* (Russell et al., 1999), studied New Zealanders aged 15 years and older, while the 2002 survey, *NZ Food NZ Children* (Ministry of Health, 2003a) looked at New Zealand children aged 5 to 14 years.

Results show 94% of the adult New Zealand population consume animal products, and only 2% avoid red meat completely (Russell et al., 1999).

Among children, 95% consume an omnivorous diet, with just 3.6% avoiding red meat and 0.7% avoiding all meat (Ministry of Health, 2003a). Meat makes a valuable contribution to the intake of a range of nutrients for many New Zealanders (see section 3).

The most common types of meat consumed at least once a week by adults were beef or veal, followed by beef mince dishes and chicken.

Lamb, hogget and mutton were more likely to be eaten by Maori and Pacific Islanders than Europeans. Among children, chicken was the meat most commonly consumed, followed by mince.

In terms of the amount of meat eaten, women consume an average of 31g of beef and veal, and 8g of lamb and mutton per day, and men an average of 60g of beef and veal, and 14g of lamb and mutton per day. The average total intake of beef and lamb for a New Zealand adult is around 57g per day (LINZ, 2001).

7. ARE CURRENT RECOMMENDATIONS FOR MEAT INTAKE ADEQUATE?

Overall, the Ministry of Health's food and nutrition guidelines suggest 1 to 2 portions per day should be eaten from the meat and alternatives food group.

However, in order to optimise health and prevent chronic disease, recommendations on the number of servings consumed from the meat and alternatives food group may need to be reviewed.

A recent dietary modelling exercise (Shrapnel & Baghurst, 2007) demonstrated a marked lack of nutritional equivalence between foods of animal and vegetable origin in the meat and alternatives food group.

In this study, diets incorporating servings of foods of vegetable origin did not meet the relevant nutrient reference values for vitamin B_{12}, long chain *n*-3 polyunsaturated fatty acids, zinc for men and pregnant women, and iron for all women, including pregnant women.

Legumes, nuts and seeds certainly provide valuable nutrients and should be included in a balanced diet, but these foods are not direct substitutes for foods of animal origin in terms of the nutrients they provide.

The recommended number of servings from the meat and alternatives group, along with serving sizes, may need to be reconsidered and recommendations in relation to legumes, nuts and seeds as alternatives to meat may need to be revised.

Specific and separate recommendations and advice may be needed for lacto-vegetarians and vegans to ensure their nutritional requirements are met.

However, the total combination of foods that are consumed over time is a much more important consideration than the intake of individual foods, so further research and analysis of this issue is warranted before firm recommendations can be made.

8. THE ROLE OF RED MEAT IN HEALTH & DISEASE

Meat consumption has been linked to a number of diseases, most notably cancer and heart disease. There is some evidence vegetarians have a lower overall mortality compared to meat eaters (Thorogood et al., 1994; Appleby et al., 1999).

However, vegetarians may be more health conscious than meat eaters, smoking less, exercising more and consuming a diet higher in fruits, vegetables and fibre (BNF, 1999).

The Oxford Vegetarian Study (Thorogood et al., 1994) did attempt to control for these confounding factors by asking members of the non-meat eating cohort to nominate friends and relatives as controls.

In this study, there was a significant reduction in mortality from cancer (40%) and overall mortality (20%) in non-meat eaters, there was also a lower rate of ischaemic heart disease among vegetarians.

But the effect of diet on overall mortality was reduced after adjusting for smoking, body mass index and social class. After adjustment for these factors, the effect of diet on heart disease became insignificant.

In this study, it was difficult to disentangle which particular features of the vegetarian diet were responsible for the protective effect. The authors concluded their data did not provide justification for encouraging omnivores to change to a vegetarian diet as there were several attributes of the vegetarian diet, apart from not eating meat, which might reduce risk (Thorogood et al., 1994).

Obesity has also been studied in relation to meat consumption. Further research using data from the Oxford Vegetarian Study found that non-meat eaters were thinner than meat eaters (Appleby et al., 1998).

The authors could not exclude the possibility that leaner individuals are more likely to adopt a meatless diet, however, their data suggest non-meat eaters are thinner partly due to a lower intake of animal fat, a higher intake of dietary fibre and, only in men, a lower intake of alcohol.

More recent research has evaluated the role of high-protein diets in promoting satiety and aiding weight loss (see section 8.3). Red meat is an excellent source of protein (see section 3.2) and could make a valuable contribution to protein intakes (along with other protein foods).

This may be helpful for those managing their weight. The effects of a diet high in protein have also been evaluated in those with Type 2 diabetes and insulin resistance, with initial results showing such diets may be helpful (see section 8.4).

The role of meat in health and disease has been evaluated in a number of studies, as follows.

8.1 Coronary heart disease (CHD)

Health messages in relation to meat can be confusing and misleading (Li et al., 2005) and advice to reduce red meat as part of a cholesterol-lowering diet is inappropriate. A number of studies show lean red meat can be included in a cholesterol-lowering diet.

A study aiming to differentiate between lean beef and beef fat as risk factors for elevated plasma cholesterol, found total cholesterol concentrations fell significantly within one week of commencing a low-fat diet that included lean beef, and rose as beef drippings were added in a stepwise manner (O'Dea et al., 1990).

This demonstrates clearly it is the beef fat and not the lean beef that is associated with elevations in cholesterol levels and shows lean beef can be part of a cholesterol-lowering diet.

A further study, which looked at dietary determinants of ischaemic heart disease (IHD) in health conscious individuals, concluded that dietary saturated animal fat and cholesterol are important in the aetiology of IHD (Mann et al., 1997a).

These factors, rather than simply meat, appeared to explain the higher IHD rates reported in meat eaters compared with vegetarians.

Substituting poultry for lean red meat is unlikely to have any effect on total or LDL cholesterol levels. A randomised controlled trial among hypercholesterolaemic free-living men and women comparing lean red meat with lean white meat found both produced similar reductions in LDL cholesterol and elevations in HDL cholesterol (Davidson et al., 1999).

A further randomised crossover study, with two 36-week phases separated by a 4-week washout period, compared the effects of lean red meat and poultry in reducing cholesterol in people with hypercholesterolaemia (Hunninghake et al., 2000).

Results showed both had an identical effect, with a 1% reduction in total cholesterol and a 2% reduction in LDL cholesterol. In this study, the lean meat was part of a diet providing less than 30% energy from fat and 8-10% energy from saturated fatty acids.

A more recent study on hypercholesterolaemic men (Beauchesne-Rondeau et al., 2003) found diets containing lean beef or poultry reduced plasma total and LDL cholesterol concentrations by 8% each, with a 5% reduction in the lean fish-containing diet. It has been suggested iron can contribute to oxidative stress and inflammation, which are possible risk factors for heart disease and diabetes.

One recent study investigated the effects of lean red meat on markers of oxidative stress and inflammation in humans (Hodgson et al., 2007). Sixty subjects were randomised to either maintain their usual diet, or to partly replace energy from carbohydrate with 200g of lean red meat daily. No elevation of oxidative stress or inflammation was found among the meat eating group.

A review of 54 studies of meat consumption and CHD risk factors, found substantial evidence lean meat trimmed of visible fat does not raise blood cholesterol and LDL cholesterol levels (Li et al., 2005), as long as the overall diet is low in fat and saturated fat. In fact, the overall effect was that diets low in saturated fatty acids, which included lean red meat, were associated with a reduction of LDL cholesterol levels in both hypercholesterolaemic and healthy subjects.

Thrombotic risk factors such as thromboxane and prostacyclin production, platelet function and haemostatic factors also remain unchanged with the inclusion of lean red meat (Mann et al., 1997b). Where lean meat is eaten, there appears to be little difference between meat-eaters and vegetarians in terms of blood lipid levels, as long as the overall diet is low in fat and saturated fatty acids.

There is no evidence to exclude moderate amounts of lean meat from the diet, particularly given its valuable contribution to intake of nutrients, especially iron (National Heart Foundation, 1999b).

The National Heart Foundation of New Zealand recommends a guideline intake of up to 100-150g cooked meat per day for women and up to 150-200g per day for men. Intake of fatty meat and meat products (eg meat pies, sausage rolls, canned corned beef and salamis) should be low, and all visible fat should be trimmed from meat before consumption (National Heart Foundation, 1999b).

8.2 Cancer

Colorectal cancer is relatively common in New Zealand, with approximately 2,500 new cases each year and 1,100 deaths (Ministry of Health, 2006b). Some scientific studies suggest a link between red meat consumption and colorectal cancer, however this remains controversial and the subject of scientific debate.

Diet is remarkably difficult to measure, and the separation of the effects of individual food components is extremely complicated, given the multiple correlations that exist between the different elements (Boyle et al., 2008).

Three significant meta-analyses have estimated the risk of consumption of fresh red meat and processed meat in relation to colorectal cancer (Sandhu et al., 2001; Norat et al., 2002; Larsson et al., 2006).

The meta-analysis by Sandhu et al. (2001), found a daily increase of 100g of all meat or red meat was associated with a significant 12-17% increased risk of colorectal cancer. A significant 49% increased risk was found for a daily increase of 25g of processed meat. However, as only a few of the studies reviewed attempted to examine the independent effect of meat intake on colorectal cancer risk, the overall association may have been confounded by other factors.

A further meta-analysis by Norat et al. in 2002 also found a high intake of red meat, and particularly processed meat, was associated with a moderate but significant increase in colorectal cancer risk.

Average relative risks and 95% confidence intervals (CI) for the highest quantile of red meat consumption were 1.35 (CI: 1.21-1.51) and for processed meat were 1.31 (CI: 1.13-1.51). No significant association was found for total meat consumption and colorectal cancer risk. The relative risks for total meat and red meat were higher in studies including processed meat in the definition of these two meat groups, than in studies that evaluated fresh meat and fresh red meat.

Similar results were found in a more recent meta-analysis in 2006 by Larsson et al., which found consumption of red meat and processed meat was positively associated with risk of both colon and rectal cancer. The summary relative risks of colorectal cancer for the highest vs lowest intake categories were 1.28 (95% CI: 1.15-1.42) for red meat and 1.20 (95% CI: 1.11-1.31) for processed meat.

One of the largest studies of diet and health ever undertaken is the European Prospective Investigation into Cancer (EPIC). Results from this study, based on 478,040 men and women, support the hypothesis that colorectal cancer risk is positively associated with intake of red and processed meat (highest intake was over 160g per day, versus the lowest intake which was less than 20g per day) (Norat et al., 2005). The association with colorectal cancer was stronger for processed than for unprocessed red meat.

Other studies have found different results. The association between fatal colorectal cancer and a number of dietary factors has been studied in 25,493 Seventh Day Adventists, with 21 years of follow-up (Phillips & Snowdon, 1985).

No clear relationship between colon or rectal cancer and meat consumption was found. Further to this, a collaborative analysis of five prospective studies found no significant difference between vegetarians and non-vegetarians in mortality from colorectal cancer (Key et al., 1999).

An expert workshop in New Zealand in 1999, concluded there is no convincing evidence from published epidemiological studies that moderate intakes of lean red meat increase the colorectal cancer risk when eaten as part of a mixed diet including carbohydrates, vegetables and fruits, and dairy products (Tasman-Jones et al., 2000).

Similar conclusions were drawn in an Australian expert workshop, where the consensus view was that consumption of a moderate amount of meat in a diet containing adequate cereals and grain foods, vegetables and fruit, is not associated with an increased risk of bowel cancer (Truswell, 1999).

The recent World Cancer Research Fund report (WCRF, 2007), which provides a comprehensive review of the literature on diet, physical activity and cancer, has concluded red and processed meats are a convincing cause of colorectal cancer. The WCRF report does, however, recommend an intake of up to 500g of cooked red meat per week – this is higher than the current average intake of red meat in New Zealand of around 57g per day (LINZ, 2001) (see section 6).

There are a number of possible mechanisms for a link between meat consumption and colorectal cancer, including the promotion of carcinogenesis by high-fat diets, the production of carcinogenic heterocyclic amines (HCAs) and polycyclic aromatic hydrocarbons (PAHs), the formation of carcinogenic N-nitroso compounds (NOCs) both within meat and endogenously, and the promotion of carcinogenesis by haem iron (WCRF, 2007; Baghurst, 2007; Santarelli et al., 2008).

Although fat intake from meat has been suggested to explain a link between colorectal cancer and meat intake, experimental studies show inconsistent results and epidemiological studies have failed to confirm a link (Santarelli et al., 2008). There is now little support for the notion that fat in meat promotes carcinogenesis (Baghurst, 2007).

HCAs are produced during high-temperature cooking of meat, such as frying and when using a barbecue. Such high cooking temperatures cause amino acids and creatine to react together to form HCAs (WCRF, 2007). PAHs are produced from the incomplete combustion of organic compounds; the main sources are cooked and smoked meat and fish (notably barbecued meat) and tobacco smoke (Santarelli et al., 2008).

Around one third of meat consumed on a daily basis in New Zealand is cooked by methods likely to result in the formation of HCAs (Thomson, 1999). However, a recent review of HCAs concluded there is not sufficient scientific evidence to support the hypothesis that human cancer risk is specifically due to the intake of HCAs in the diet (Alaejos et al., 2008). Data on PAHs in overcooked meat suggest these may be a risk factor, but there is insufficient evidence to draw firm conclusions (Santarelli et al., 2008).

NOCs are alkylating agents that can react with DNA and are produced by the reaction of nitrite and nitrogen oxides with secondary amines and N-alkylamides (Santarelli et al., 2008).

NOCs are present in certain processed meats (eg grilled bacon), smoked fish, cheeses and beer, and can be formed endogenously after red and processed meat consumption (Santarelli et al., 2008).

NOCs have been found to induce colorectal cancer in humans; a Finnish cohort study of 9,985 adult men and women found a significant positive association with intake of N-nitrosodimethylamine (NDMA) and colorectal cancer risk; the relative risk between highest and lowest quartiles of intake being 2.12 [95% CI: 1.04-4.33] (Knekt et al., 1999).

The main sources of NDMA were smoked/salted fish, cured meat/sausages and beer. In this study, there was a non-significant elevated risk of colorectal cancer among persons with a high intake of cured meat and sausages, with a relative risk of 1.84 (95% CI: 0.98-3.47).

Although some research links NOCs to cancer, it is not yet clear whether red and processed meat-induced NOCs are colon carcinogens (Santarelli et al., 2008). Further research is needed in this area.

Haem iron may catalyse the formation of NOCs from natural precursors in the gut. Red meats are a richer source of haem iron than white meats, so this effect may theoretically explain a stronger association between red meat and colorectal cancer, than between white meat and colorectal cancer. It would not explain, however, why white meat and fish (which also contain haem iron) appear to be protective against colorectal cancer (Baghurst, 2007). Further research into this possible mechanism is needed.

Many dietary and lifestyle factors can influence the development of cancer. The key focus for cancer prevention should be to: avoid smoking, limit sun exposure, maintain a healthy body weight and be physically active as part of everyday life.

In terms of diet, it is recommended we eat at least five portions of a variety of fruits and vegetables each day, along with relatively unprocessed cereals and pulses, and limit intake of alcohol to no more than 1 unit a day for women and 2 units a day for men (WCRF, 2007).

Lean beef and lamb can make an important nutritional contribution to a balanced diet and complete avoidance is unnecessary in terms of cancer prevention; however it may be prudent to avoid very high intakes, particularly of processed meats, and to limit cooking at very high temperatures. Current average intakes in New Zealand are below the recommended intake suggested by the WCRF, so a reduction in average intakes is unnecessary.

8.3 Obesity

Conservative estimations suggest over 1 billion people worldwide are overweight or obese (Simpson & Raubenheimer, 2005). Obesity is a significant problem in New Zealand, with the recent New Zealand Health Survey finding one adult in three is overweight and a further one in four is obese (Ministry of Health, 2008b). The same survey found that among children, body size is also of concern, with one in five children overweight and a further one in twelve obese.

Evidence is accumulating that increasing intakes of high-quality protein to a level above the recommended intake may be beneficial during weight loss (Layman, 2004). For most of our existence, the human diet has consisted of a high proportion of animal foods, with meat consumed from wild animals typically having a low fat content (see section 2). This has resulted in limited evolutionary experience of excess carbohydrates or fats and it has been suggested natural selection against over-consumption of these nutrients would not have been strong; this may account for their high level of palatability and may predispose us to their over-consumption today (Simpson & Raubenheimer, 2005).

A number of specific mechanisms have been suggested for the beneficial role of protein during weight loss. Firstly, proteins have been found to suppress food intake more than fats or carbohydrates, and do so more than can be accounted for by their energy content alone.

Secondly, proteins make a strong contribution to satiety, promoting a feeling of fullness. Thirdly, a high-protein diet supports the maintenance of lean body mass whilst energy intake is restricted. Fourthly, protein digestion stimulates many physiological and metabolic responses known to be involved in food intake regulation (Anderson & Moore, 2004).

In terms of specific research studies on protein, one randomised 6-week trial on 20 women and men found low-fat, energy-restricted diets, providing either 15% energy or 30% energy as protein, both promoted steady weight loss (Johnston et al., 2004).

However, subjects on the higher protein diet reported less hunger and a greater degree of diet satisfaction than those on the lower protein diet.

Another randomised study on 100 women over 12 weeks compared two isocaloric diets (providing around 5600kJ/d); one high in protein (34% energy from protein; 46% energy from carbohydrate; 20% energy from fat) and the other high in carbohydrate (17% energy from protein; 64% energy from carbohydrate; 20% energy from fat), with protein provided from mixed sources (Noakes et al., 2005).

Weight loss was 7.6 ± 0.4kg in the high protein group and 6.9 ± 0.5kg in the high carbohydrate group. These values were not statistically different, however the high protein diet resulted in a greater reduction in triacylglycerol concentrations and improvements in haemoglobin and vitamin B_{12} status.

A further study on the effects of protein placed 19 subjects sequentially on a weight maintenance diet with 15% energy from protein, an isocaloric diet with 30% energy from protein, and an ad libitum diet with 30% energy from protein (Weigle et al., 2005). Increasing dietary protein intake from 15% to 30% at a constant carbohydrate intake produced a decrease in ad libitum calorie intake.

More evidence for the effect of protein is provided by a meta-analysis of 87 studies comprising 165 intervention groups, which found low carbohydrate, high-protein diets affected body mass and composition favourably, independent of energy intake (Kreiger et al., 2006). This supports the proposed metabolic advantage of such diets.

A critical review of the effects of high-protein diets on thermogenesis, satiety and weight loss concluded there is convincing evidence for protein exerting an increased thermic effect when compared to fat or carbohydrate (Halton & Hu, 2004). This effect is probably too small to have a visible effect on weight loss in the short term.

However, over months or years, the effect may be significant. The same review reports convincing evidence that higher protein diets increase satiety compared with lower protein diets, and decrease subsequent energy intake at the next meal.

Concern has been expressed about the effects of high-protein diets on renal function; however, there is little evidence high-protein diets pose a serious risk to kidney function in healthy people (Halton & Hu, 2004).

Similarly, the impact of high-protein diets on markers of bone turnover has not been found deleterious (Noakes et al., 2005; Farnsworth et al., 2003).

Many studies into protein and weight loss have been relatively small. Optimal amounts and sources of protein cannot be determined, but the weight of evidence suggests it may be beneficial to partly replace refined carbohydrate intake with low-fat protein sources (Halton & Hu, 2004).

The inclusion of lean red meat in a balanced diet would contribute to protein intakes, and may help weight loss as part of a reduced-energy diet.

8.4 Type 2 Diabetes

High-protein, low-carbohydrate diets have also been examined for treatment of Type 2 diabetes mellitus. Positive effects have been found on glycaemic regulation, including reductions in fasting blood glucose, post-prandial glucose and insulin responses, and a reduced percentage of glycated haemoglobin (Layman et al., 2008).

A study comparing a high-protein diet (28% of energy) with a low-protein diet (16% of energy) in 54 obese men and women with Type 2 diabetes, during 8 weeks of energy restriction and 4 weeks of energy balance, found both diets improved the cardiovascular disease risk profile as a consequence of weight loss (Parker et al., 2002).

However, there were greater reductions in total and abdominal fat mass in women, and greater LDL cholesterol reduction in both sexes, with the high-protein diet. This suggests high-protein diets are a valid choice for reduced risk of cardiovascular disease in people with Type 2 diabetes. Subjects in this study derived their protein from foods such as beef, chicken and dairy products.

A further study on overweight and obese hyperinsulinaemic men and women found no difference in weight loss or fat-mass loss between subjects fed a high-protein diet (27% of energy) compared with a lower protein diet (16% of energy) during 12 weeks of energy restriction and 4 weeks of energy balance (Farnsworth et al., 2003).

However, in women, total lean mass was significantly better preserved with the high-protein diet (-0.1 ± 0.3kg) than with the standard protein diet (-1.5 ± 0.3kg). Further, those on the high-protein diet had significantly less glycaemic response and a greater reduction in triacylglycerol concentrations than those on the standard protein diet.

Long-term studies are required to determine the optimal macronutrient intake for preventing and managing Type 2 diabetes. Further studies are also warranted into the effect of high-protein diets on delaying the progression to Type 2 diabetes in obese adults with insulin resistance. Initial indications are, however, that for some individuals, a diet providing an increased level of protein and a reduced level of carbohydrate may be effective for weight management, may improve lipid profiles, and may improve glycaemic regulation (Layman et al., 2008).

9. CONCLUSIONS

Meat has been an important part of the human diet throughout our evolutionary history and today most New Zealanders include meat in their diet.

Lean New Zealand beef and lamb are nutrient-dense foods that play a pivotal role throughout the life cycle – from young infants and children, through to adults and older people.

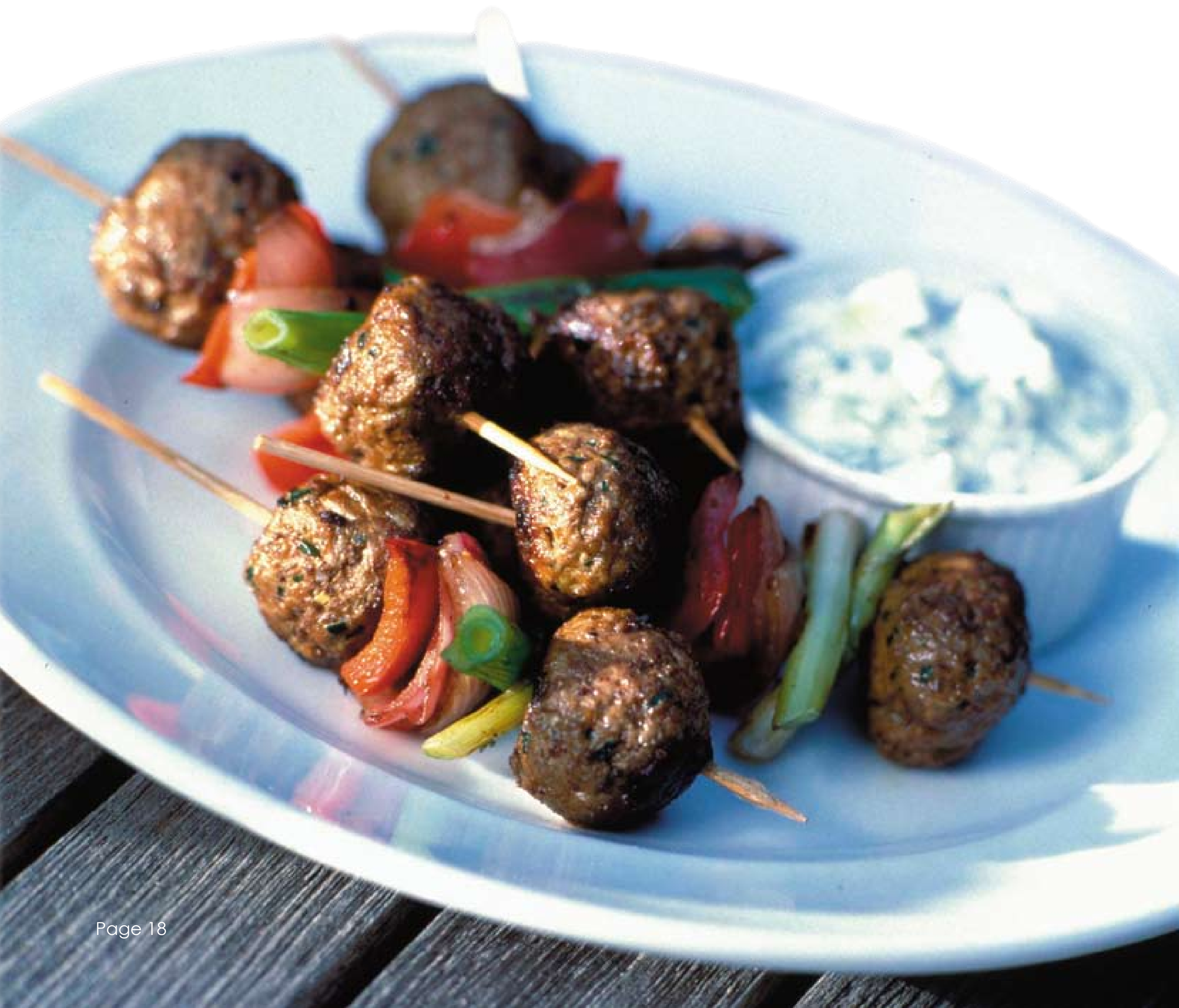
In particular, red meat is a rich source of iron, which is important for vulnerable groups such as infants and toddlers, adolescents and women of childbearing age.

Meat also provides zinc, selenium, B vitamins (particularly vitamin B_{12}), vitamin D and *n*-3 fatty acids, and liver is an excellent source of vitamin A. Red meat is a very good source of protein and, when fully trimmed, is low in fat and saturated fatty acids.

The combination of nutrients in beef and lamb plays an important role in the health issues facing New Zealanders today. For example, lean meat can be a helpful part of a lipid-lowering diet for those at risk of cardiovascular disease, can form a part of a weight-reducing diet for obese and overweight people, and may have beneficial effects in preventing and managing Type 2 diabetes.

In terms of cancer prevention, the key focus should be to avoid smoking, limit sun exposure, maintain a healthy weight, and be physically active. In relation to diet, the emphasis should be on fruits, vegetables and unprocessed cereals and pulses, as well as limiting alcohol intake.

A reduction in red meat intake in New Zealand is unnecessary based on current scientific evidence; however it may be prudent to avoid very high intakes, particularly of processed meats, and to limit cooking at very high temperatures.



Appendices

and

References

APPENDIX 1:

Common Myths and Misconceptions about Meat

MYTH: Red meat is high in fat

When trimmed of all visible fat, lean red meat is low in fat. For example, a 100g portion of cooked beef topside contains 5.3g fat. Also, only around half the fat in meat is saturated; the rest is mainly the beneficial monounsaturated and polyunsaturated fats. Since 1997, the red meat industry's Quality Mark has required the trimming of beef and lamb cuts to be no more than 5mm of external fat.

MYTH: People with heart disease should avoid red meat

A number of studies have shown lean red meat can be included in a cholesterol-lowering diet. Intake of fatty meat and meat products should be low for people with heart disease and all visible fat should be trimmed from meat before consumption.

MYTH: Weight-loss diets should exclude red meat

Lean red meat is low in fat and calories, and moderate amounts can be included in a weight-reducing diet. Evidence is accumulating around the important role high-quality protein may play in weight management. For example, proteins have been found to suppress food intake as they contribute to satiety, promoting a feeling of fullness. The inclusion of lean red meat as part of a balanced diet may, therefore, help weight loss as part of a reduced-energy diet.

MYTH: Red meat causes cancer

Some scientific studies suggest an association between red meat consumption and colorectal cancer; however, expert workshops in New Zealand and Australia have concluded a moderate intake of lean meat as part of a balanced diet, which also provides adequate cereals and grain foods, fruit and vegetables, is not associated with an increased risk of colorectal cancer.

There are many dietary and lifestyle factors that influence the development of cancer and the key focus in terms of cancer prevention should be to avoid smoking, limit sun exposure, maintain a healthy body weight, be physically active, eat at least five portions of a variety of fruits and vegetables each day, along with relatively unprocessed cereals and pulses, and limit intake of alcohol.

The recommendation of the World Cancer Research Fund is to consume up to 500g cooked red meat per week; current average red meat intakes in New Zealand are below this amount.

MYTH: Meat takes a long time to digest

From an evolutionary perspective, man is naturally an omnivore and our digestive system is well adapted to digesting meat. Around 94% of the protein in meat is digested; this compares with 86% in whole wheat and 78% in beans (Williams, 2007). Meat is therefore an easily digested food, and in addition, the nutrients in meat are well absorbed and utilised by the body.

MYTH: Meat-eaters should become vegetarian if they want to be healthy

A diet excluding animal products can be nutritionally adequate, but as more foods are excluded it becomes important to plan carefully to ensure nutrient needs are met. In particular, intakes of iron, calcium, zinc, vitamin B_{12}, niacin and riboflavin need careful consideration – especially for vegans.

In terms of chronic disease, vegetarians have a lower mortality rate than omnivores, although it is likely much of this effect can be achieved by not smoking, by exercising more and by consuming a diet higher in fruits, vegetables and fibre. It is difficult to disentangle which features of a vegetarian diet may be protective, and there is currently no evidence to suggest meat eaters should change to a vegetarian diet for health reasons.

MYTH: Spinach is the best source of dietary iron

Spinach is a good source of iron, but the iron is present in the poorly-absorbed non-haem form. Also, spinach contains substances that inhibit absorption of iron, such as polyphenols and oxalic acid. As a result spinach is a relatively poor source of iron, especially when compared with red meat, which contains the more readily-absorbed haem iron.

MYTH: Eating too much meat can lead to an excess iron intake

Absorption of iron from dietary sources is well controlled by the body. Although red meat is an excellent source of iron, including it regularly in the diet will not lead to an excess iron intake for most healthy people. In fact, iron deficiency is much more likely to be a problem.

The most common iron overload condition in New Zealand is hereditary haemochromatosis, a genetic condition that causes poor control of iron absorption. This condition is managed by therapeutic phlebotomy; in other words, the removal of blood on a regular basis, not by the avoidance of meat.

APPENDIX 2:

Production of Red Meat in New Zealand

Farming practices

The unique climate and landscape in New Zealand has set the global benchmark for pastoral farm production. Most meat is produced using naturally available resources – grass, rain and sunshine. In New Zealand, there is year-round access to grass, including hay, silage and feed crops.

Sustainability

Researchers in the USA have suggested a meat-based diet requires more energy, land and water resources than a lacto-ovo-vegetarian diet (Pimentel & Pimentel, 2003) implying the lacto-ovo-vegetarian diet is more sustainable. However, these suggestions often assume land used for grazing animals can be diverted to other uses, such as crop production (Thomason, 2007).

Furthermore, these studies are likely to have made the comparison with feedlot beef, rather than pastoral systems. In New Zealand, most livestock production takes place on land unsuitable for crops. If this land were not used for grazing, it would essentially be wasted. As such, beef and lamb production in New Zealand is highly sustainable.

Greenhouse emissions

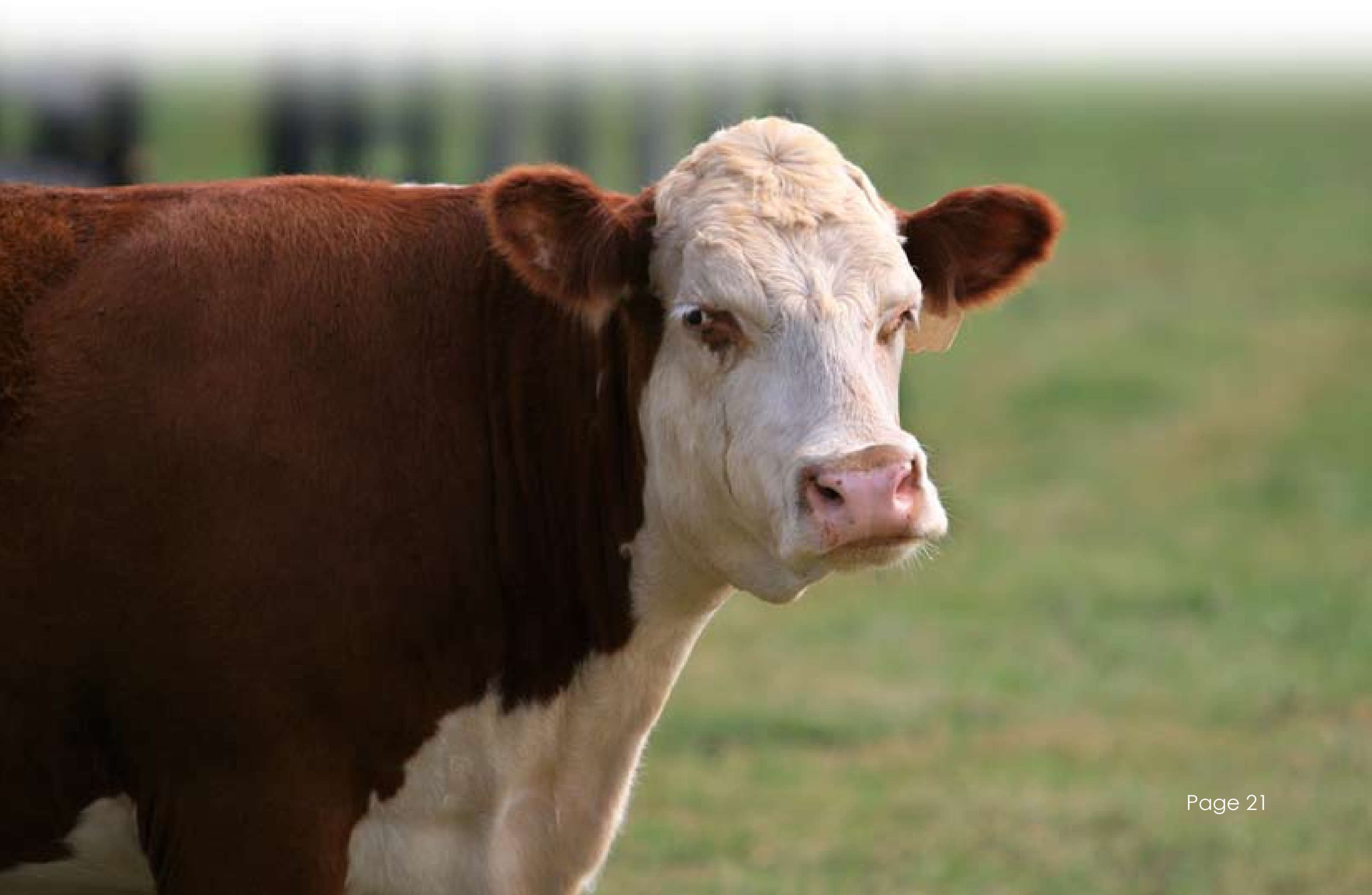
New Zealand is a signatory to the Kyoto Treaty on climate change and has made a commitment to reduce greenhouse emissions to 1990 levels. To help achieve this aim, the Pastoral Greenhouse Gas Research Consortium (PGgRc) was set up in 2002.

A key goal of the PGgRc is to develop strategies to reduce and mitigate the two greenhouse gases associated with livestock: methane and nitrous oxide.

The contribution of agriculture to New Zealand's carbon emissions profile is currently 48.5%. Emission levels from the beef and sheep sector have been decreasing and are now 17% lower than in 1990.

Over the same period, emissions from agriculture have been increasing, therefore the sheep and beef sectors' contribution as a proportion is lower than it was 15 years ago.

Breeding programmes along with the production of fewer, but larger, animals are largely responsible for the increase in efficiency in this sector to date.



Other environmental issues

The foundation of the New Zealand farming industry is fertile land, clean water and fresh air, and a number of programmes are in place in New Zealand aimed at supporting environmental sustainability. A significant environmental challenge is maintaining soil fertility while limiting nutrient run-off into waterways.

A recent high-profile project, funded by industry, farmers and Government was 'The Wise Use of Nitrogen Fertiliser' project; a four-year project aimed at promoting the sound use of nitrogen fertilisers in a range of hill farming situations, in order to encourage practices that enhance long-term profitability while minimising any detrimental effects to the environment.

A further initiative established by the Government in 2003, along with primary sector partners, is the 'Sustainable Water Programme of Action' (SWPoA), which aims to protect and improve New Zealand's freshwater resources.

Having a plentiful supply of clean water is an integral part of New Zealand's heritage and this programme aims to raise awareness of the need for freshwater management and to develop targets to address water quality and availability.

The New Zealand economy is dependent on the environment to support activities such as agriculture. To sustain the environment, a range of policy initiatives are currently being implemented in the beef and sheep sector to ensure the industry remains economically profitable and environmentally sustainable in future years.

Antibiotics

In New Zealand, antibiotics are used sparingly in animals for therapeutic reasons only. Any treatment with antibiotics is recorded and statutory declarations are made. Animals treated with antibiotics are required to be withheld from the market for a specified period of time.

Hormonal growth promotants

Hormonal growth promotants are only used in a very small number of livestock (less than 1%) and are only provided under veterinary supervision.

Their use in New Zealand is very tightly controlled and any animals which have received such hormones must be tagged and included in a central Government database.

There is no evidence of any adverse effect on human health through consumption of meat and meat products produced from animals given hormonal growth promotants.

Any beef or lamb products displaying the Quality Mark have come from animals not treated with hormonal growth promotants.

Risk management

The Animal Products Act 1999 requires all animal products to be "fit for intended purpose" and this is achieved through risk management programmes, which involve identifying and managing hazards and other risks (NZFSA, 2006).

Individual plants must operate a risk management programme that is independently audited, usually by the Ministry of Agriculture and Forestry Verification Agency (MAF VA).

Risk management programmes must comply with the required industry standards. Plants may also operate ISO (International Organisation for Standardisation) standards that incorporate HACCP (Hazard Analysis and Critical Control Points).

If a plant is to supply the overseas market, then the appropriate standards for the destination country must be met; for example meat exported to the USA must meet United States Department of Agriculture market access standards, and meat being exported to the European Union (EU) must meet EU standards.

New Zealand Beef and Lamb Quality Mark

The New Zealand Beef and Lamb Quality Mark was introduced in 1997 to ensure consistent quality of New Zealand beef and lamb. The Quality Mark is a black, red and gold rosette and it provides assurance the highest standards have been met for leanness, tenderness and food safety.

Meat must be trimmed to a maximum of 5mm external fat along with the removal of internal fat where practical. Often cuts are trimmed completely and have no visible fat at all. To be eligible for the Quality Mark, mince must contain less than 10% fat.

A significant amount of New Zealand beef and lamb (ie cuts containing less than 4% saturated fat with a maximum 5mm fat trim) also qualifies for the Heart Foundation 'Tick'.

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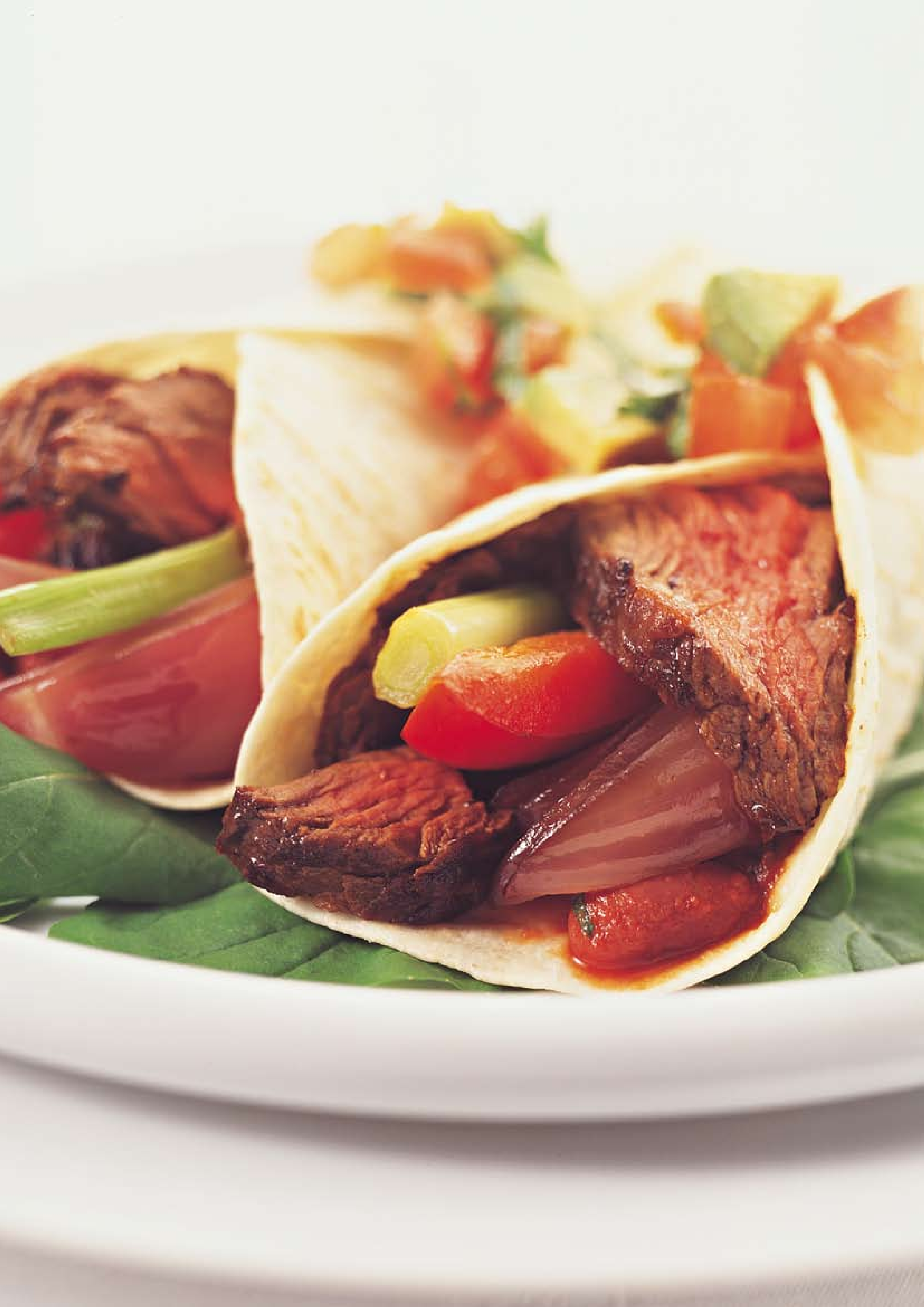

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