8 "Fish, chicken, lean meat and eggs can be eaten daily": a food-based dietary guideline for South Africa

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Keywords: fish, chicken, lean meat, eggs, daily, food-based dietary guidelines, FBDGs

Abstract

Food products from animals provide a variety of macro- and micronutrients. Animal sources of food, such as fish, chicken, meat and eggs, constitute high-quantity and high-quality protein, as they contain essential amino acids in the right proportions. In South Africa, eight micronutrients, namely vitamin A, vitamin B_1, vitamin B_2, vitamin B_6, vitamin B_{12}, niacin, iron and zinc, have been identified as lacking in the population's diet. Animal-sourced food is a particularly rich source of these nutrients. Relatively small amounts of these foods, added to a mixed diet, make a substantial contribution to nutrient adequacy. Generally, animal sources of food are associated with nutrients that are less desirable in the diet, such as saturated fat and cholesterol. However, by choosing lean prudent portions of these foods, the intake of such macronutrients can be controlled. Animal sources of food add variety and nutrients to the diet. Adding a small amount of these food products to a plant-based diet can yield considerable improvements in human health. For a variety of reasons, some people choose not to eat meat, but as there is no evidence that a moderate intake of fish, chicken, lean meat and eggs has a negative effect on health, there is no scientific justification to exclude them from the diet. As recommended in global food-based dietary guidelines, when consumed in moderation, fish, chicken, lean meat and eggs can be part of a healthy, South African diet.

Ⓟ **Peer reviewed. (Submitted: 2013-04-09. Accepted: 2013-09-21.)** **S Afr J Clin Nutr 2013;26(3)(Supplement):S66-S76**

Introduction

The food-based dietary guideline (FBDG) "Fish, chicken, lean meat and eggs can be eaten daily" was formulated based on the valuable nutritional contribution that these foods make to a balanced, South African diet. In appropriate amounts, these foods are important sources of complete, high-quality, easily digestible protein, as well as essential micronutrients, such as iron, zinc, vitamin A, vitamin B_{12} and calcium. Animal sources of food are not essential to the human diet, yet they remain desirable and popular.[1] Including small amounts of animal sources of food in the diet of malnourished individuals plays a key role in improving their nutritional status.[2]

The objectives of this article are:

- To discuss the nutritional contribution that fish, chicken, lean meat and eggs can make to the South African diet.
- To review evidence relating to risks associated with the consumption of animal products.
- To compare international FBDGs on animal products.
- To discuss optimal amounts and best practices for the consumption of these foods.

Nutritional considerations

Although the production of livestock has increased in developing countries, undernutrition, including the insufficient consumption of protein, remains a persistent problem in the developing world. Compared with what has been recommended, many diets in developing countries are deficient in energy, protein and other nutrients. Therefore, the quality of the sources of protein is especially important.[1] By contrast, the overconsumption of food, and specifically that which is high in saturated fat and cholesterol, has been linked to overweight, obesity and subsequent diseases of lifestyle.[2]

Important nutrients provided by animal sources of food

Although there has been a longstanding global fight against hunger, it is well documented that the provision of energy, without an adequate intake of critical protein and micronutrients, may increase weight, but not length, promoting adipose tissue gain and obesity. This can contribute to stunting and obesity in a single individual.[3,4]

Protein

According to the World Health Organization, dietary protein intake in developing countries falls significantly short of the recommended 0.66 g/kg/day.[3] In these countries, protein is obtained from staple foods which are mainly cereal-based.[1] These foods contain a lower quantity of protein compared to that in animal sources of protein (Table I), and are often low in the essential amino acids, lysine and tryptophan,[2] and sulphur-containing amino acids. Therefore, the quality of the protein source is compromised.[5] The latter has a direct influence on protein digestibility. Protein that is obtained from food sourced

from animals is of high quantity and quality, as it contains essential amino acids in the right proportions.[2]

Research has shown that adding even small amounts of animal-derived protein to a plant-based diet can yield significant improvements in maternal health and child development.[7,8] Significant associations have been found between animal protein intake and lean mass, but no such association has been reported with vegetable protein. High-quality protein, in combination with the micronutrients provided by animal sources of food, facilitates protein synthesis during normal and active growth, repair after extreme physical activity, and repair in elderly individuals with regard to postponing and treating sarcopenia.[9]

Table I: The protein content of a serving of selected food commonly consumed by South Africans[6]

Selected food	One serving	Protein amount (g)
Meat, chicken and fish	85 g beef (lean, cooked)	28
	85 g chicken (cooked)	26
	85 g sardines (pilchards) with the bone	21
Legumes	172 g (1 cup) cooked soybeans	29
	196 g (1 cup) boiled split peas	16
	256 g (1 cup) red kidney beans	13
Egg	50 g (1 large) boiled egg	6
Dairy	245 g (1 cup) milk	8
	28 g cheddar cheese	7
	30 g low-fat cottage cheese	3
Starch and cereals	158 g (1 cup) white rice (cooked)	4
	219 g (1 cup) oat bran	7
	28 g (1 slice) wholewheat bread	4
Vegetables and fruit	180 g (1 cup) spinach	5
	1 (118 g) banana	1

Beneficial fatty acids

Fat is generally a valued element in the diet and provides energy and palatability to dry foods, and also serves as a cooking medium. Originally, dietary fat was considered to be a source of energy. Later research introduced the concept of essential fats which need to be provided by the diet to prevent deficiencies. Two dietary fatty acids are classified as essential, namely linoleic acid and α-linolenic acid. Research has also shown that fatty acids play a major role in preventing chronic conditions, such as cardiovascular diseases. This has resulted in an increased interest in the quality of the dietary lipid supply as a major determinant of long-term health and well-being.[10]

The contribution of meat and meat products to the supply of total fat and saturated fatty acids (SFAs) is well known, but their contribution with regard to dietary polyunsaturated fatty acids (PUFAs) is less widely recognised. The fatty acid composition of various products is compared in Table II. Overall, red meat contains similar proportions of monounsaturated fatty acids (MUFAs) and SFAs, although the exact proportions of the fatty acids vary, depending on their fat content. Lean meat is relatively higher in PUFAs, and lower in SFAs and total

Table II: A comparison of the fat content and lipid profile of the edible portion of different animal sources of food

Food (per 100 g, raw, edible portion)	Fat	SFAs	MUFAs	PUFAs	n-3	n-6	n-9	n-fatty acids	C	P:S ratio
	g	g	g	g	g	g	g	g	mg	
Beef[15*]	14.20	5.95	5.29	0.64					76	0.10
Lamb** (lean) (average of shoulder, loin and leg)[16]	6.79	3.62	2.92	0.25	0.04	0.25	3.08	3.37	63	0.07
Mutton (lean) (average of shoulder, loin and leg)[16]	7.85	4.18	3.36	0.31	0.09	0.24	3.45	3.78	49	0.07
Pork (average of shoulder, loin and leg)[17]	5.23	2.08	2.15	1.00	0.05	0.92		0.97	40	0.48
Chicken (fresh, white meat)[6]	2.70	0.75	1.05	0.68					41	0.89
Chicken (fresh, dark meat)[6]	7.60	2.06	3.14	1.98					62	0.96
Eggs, chicken (whole and raw)[6]	10.30	3.01	4.00	1.36					419	0.45
Cheddar cheese[6]	32.30	18.40	8.11	0.75					115	0.04
Low-fat cottage cheese[6]	4.00	2.67	0.98	0.13					5	0.05
Pilchards in tomato sauce[6]	5.40	1.60	1.09	2.13					70	1.33

C: cholesterol, MUFAs: monounsaturated fatty acids, n-3: omega-3, n-6: omega-6, PUFAs: polyunsaturated fatty acids, P:S ratio: polyunsaturated to saturated fatty acid ratio, SFAs: saturated fatty acids.
* A study to determine the nutritional composition of lean South African beef (trimmed of subcutaneous fat) is currently underway. No lean values for South African beef have been determined before.
** The average age of a lamb carcass in South Africa is 5-9 months, and has a weight of 17.18 kg.[16] The younger the animal, the higher the cholesterol content, as most of the cholesterol in the muscle has a definite metabolic or structural function in the cell membranes. Cholesterol content normally has an inverse relationship with fat, e.g. the leaner the meat, the higher the percentage of cholesterol to fat content.[18,19]

fat, than untrimmed meat. Meat and meat products make an important dietary contribution to the intake of linoleic (C18:2 n-6) and α-linolenic (C18:3 n-3) acids, as well as to C20 and C22 PUFAs that are present in meat phospholipids. Ruminant meats and oily fish are the only significant sources of preformed C20 and C22 PUFAs in the diet.[11,12] Although humans have the metabolic capacity to synthesise the latter from the omega-6 (n-6) or omega-3 (n-3) precursors derived from linoleic and α-linolenic acids, respectively, an increase in the consumption of C20 and C22 n-3 PUFAs has the potential to overcome the perceived imbalance in the ratio of n-6:n-3 PUFAs in modern diets. N-3 fatty acids have been shown to reduce the incidence of cardiovascular disease in epidemiological and clinical trials.[13] Large-scale epidemiological studies suggest that individuals at risk of coronary heart disease benefit from the consumption of plant-, animal- and marine-derived n-3 fatty acids, although the ideal intake is still unclear.[13] The data are supportive of the American Heart Association and the South African Heart Foundation[14] dietary guidelines, to include at least two servings of fish per week, and fatty fish in particular.[13]

Animal sources of food contain naturally occurring trans fats. Generally, the results from epidemiological studies have shown an inverse association or no association between ruminant trans-fatty acid intake and coronary heart disease in multiple geographical locations.[20] Conjugated linoleic acid (CLA), a naturally occurring trans-fatty acid, is associated with beneficial health properties, such as a reduction in the risk of cancer, atherosclerosis and diabetes. CLA has also been shown to have positive effects on immune function and body composition. The biological synthesis of CLA occurs through the microbial isomerisation of dietary linoleic acid in the digestive tracts of ruminant animals. Therefore, the products from ruminant species are rich dietary sources of CLA.[11,20,21] According to recent reviews, the trans-fatty acids in the food supply should be limited to the "natural" ruminant fats in meat and dairy products.[11,20,22] However, more clinical studies are warranted, because of the limited number of studies and inconsistencies in the available data.

Micronutrients

In many developing countries, including South Africa, aside from the low energy intake in many communities, there is a deficit in iron and vitamin A status, especially in vulnerable groups such as children and women of childbearing age. In South Africa, mandatory fortification of cereal-based staple foods with a combination of micronutrients has yet to be successful in improving the vitamin A or iron status of individuals.[23] Many current programmes aimed at improving food security promote a sustainable, food-based approach to combat malnutrition.[24]

The nutrient levels in selected foods are presented in Table III. Animal sources of food tend to be richer sources of nutrients that cause concern (i.e. those that are lacking in the diet), such as iron and zinc. Although the nutrient density of animal-derived food products provides ample reason to promote the inclusion of these in optimal diets, the quality and bioavailability of the specific nutrients that cause concern should also be considered.[25,26] According to the 1999 National Food Consumption Survey, the five foods consumed most often are maize porridge, brown bread, black tea, sugar and a small amount of full-cream milk.[27] The naturally present fibres, phytates, oxalates and tannins in the three foods consumed most often may interfere with the absorption of nutrients. Although essential minerals, such as iron and zinc, are also present in cereal staples, they have a lower bioavailability in plant-based foods owing to their chemical form and the presence of inhibitors within the food source, such as phytic acid and dietary fibre.

As an example, animal and plant food sources contain different types of iron. Plant sources of food, such as the popularly referenced spinach, contain only non-haem

Table III: The composition of selected foods (per 100g) compared with the nutrient reference intake for individuals aged four years and older

Nutrient	Unit	Fortified maize porridge (stiff)[6]	Fortified brown bread[6]	Spinach (boiled)[6]	Chicken with skin (frozen, (boiled)[6]	Egg and chicken (boiled)[6]	Beef fillet (cooked, not trimmed)[6]	Pilchards in tomato sauce[6]	Lamb loin (cooked, untrimmed)[16]	NRI[28]
Energy	kJ	455	1 029	134	923	616	803	531	1171	-
Protein	g	2.7	9.0	2.7	26.8	12.6	30.9	18.8	23.5	56.0
Fat	g	0.6	1.4	0.3	12.6	10.3	7.5	5.4	20.9	-
Vitamin B_1	mg	0.13	0.46	0.02	0.08	0.11	0.24	0.02	-	1.20
Vitamin B_2	mg	0.05	0.11	0.07	0.15	0.38	0.19	0.29	-	1.30
Vitamin B_6	mg	0.12	2.13	0.04	0.17	0.04	0.44	-	-	1.70
Vitamin B_{12}	µg	0	0	0	0.3	1.6	2.3	12	-	2.40
Calcium	mg	2	14	104	11	39	7	300	-	1 300
Iron	mg	1.30	4.10	2.20	0.80	1.80	2.50	2.70	2.87	18.00
Zinc	mg	0.63	4.49	0.49	1.78	1.15	7.45	1.60	3.11	11.00

NRI: nutrient reference intake

iron, while animal food sources contain both haem and non-haem iron. The bioavailability of ingested iron (the amount which is absorbed and available for bodily functions) differs significantly between the type of iron. In general, the rate of non-haem iron absorption relates to its solubility in the upper part of the small intestine. Thus, the presence of soluble enhancers and inhibitors consumed during the same meal will have a significant effect on the amount of non-haem iron that is absorbed. Haem iron is much less affected by other dietary factors, and contributes significantly to absorbable iron. Animal sources of food are considered to be good sources of the more bioavailable haem iron.[29]

The high nutrient density of animal food has an advantage in food-based interventions that target vulnerable groups such as infants, children and people living with HIV/AIDS, who may have difficulty consuming the large volumes of plant sources of food needed to meet their nutritional requirements.[30]

Cooked beef (100 g) provides almost an entire day's recommended intake of vitamin B_{12} and half the recommended intake of protein and zinc, and contributes substantially to meeting the vitamin B_1, vitamin B_2, vitamin B_6 and iron recommendations. Similarly, two large eggs supply more than 20% of daily protein requirements, nearly 30% of daily vitamin B_2 requirements, and two thirds of daily vitamin B_{12} requirements (Table III).

Furthermore, animal sources of food provide multiple micronutrients simultaneously, which may be important in diets that are marginally lacking in more than one nutrient. For example, vitamin A and riboflavin are needed for iron mobilisation and haemoglobin synthesis, and iron supplements may not reduce the prevalence of anaemia if the intake of these other nutrients is low.[31] Thus foods, such as liver, which contain substantial levels of both iron and preformed vitamin A, may be more effective than single-nutrient supplements in alleviating poor micronutrient status. This emphasises the delivery of nutrients within a specific food matrix.

In addition, the bioavailability of carotenoids, such as vitamin A precursors, is now believed to be lower than that indicated in traditional food composition tables.[32-34] Thus, more fruit and vegetables are needed to meet vitamin A requirements than was previously thought in diets that depend on plant sources for provitamin A carotenoids. All vitamin B_{12} requirements must be met from animal sources of food or from supplementation, as there is virtually no vitamin B_{12} in plant food sources.[31]

Product-specific nutritional considerations

Animal sources of food, as a concentrated nutrient source, were traditionally considered to be essential for optimal growth and development. This reputation diminished as the fat versus health debate increased. Generally, animal sources of food also supply nutrients that are less desirable in the diet, such as saturated fat and cholesterol. A concentrated source of macronutrients, such as fat and protein, is often desirable in children in developing countries, although excessive consumption of energy-dense foods may lead to overconsumption of energy in people in more affluent countries. As populations urbanise, an increase in the intake of animal sources of food is observed. Consequently, there is an increased need to educate the population on nutritional concerns about the excessive consumption of macronutrients in these foods.

In response to consumer demand, progress has been made in both total fat reduction and modifications to the fatty acid profiles of animal sources of food, including South African red meats and eggs. Furthermore, recommending lean portions, i.e. trimming excess visible fat and reducing the addition of fat during preparation and cooking, could reduce overconsumption of energy and total and saturated fat from these food types. The consumed portion size is also of importance.

Chicken

At present, poultry is one of the leading meat products that is consumed in South Africa. Poultry meat is a nutritious food of high-nutrient density. It has a high protein content and is an excellent source of water-soluble B vitamins and minerals, such as iron and zinc.[6] The fat in chicken is mostly subcutaneous. Therefore, the fat content of chicken, as with all poultry, can easily be lowered by removing the skin. Chicken (white and dark meat) has a fat content < 10%. However, it is of concern that chicken is often deep fried with the skin on, which increases the fat content considerably. It is strongly advised that consumers are educated about the meaning of "lean".

Fish

The importance of fish as part of a balanced diet, especially in the diet of infants, young children and pregnant women, is widely recognised. The contribution of fish to the supply of protein and micronutrients is particularly important (Table III), as well as to the supply of fatty acids necessary for the development of the brain and body.[35]

Aquatic animals contain a high level of protein (17-20%), with an amino acid profile that is similar to that of meat. The flesh of fish is also readily digestible and immediately utilisable by the human body, which makes it suitable when needing to complement the high-carbohydrate diet of maize porridge and brown bread that is prevalent in most of the country. Compared with land animals, with exceptions like shellfish, aquatic animals have a high percentage of edible flesh, and there is little wastage.[36]

Oil-rich fish are higher in saturated fat than white fish and shellfish. However, a significant proportion of additional fatty acids derive from the long-chain, n-3 PUFAs group, which has been linked to health benefits. The human body cannot produce these essential fatty acids, so it is very important that these are consumed in the diet. N-3 fats are important for good health.[35] There are two types of n-3s:

long-chain fatty acids found in oily fish [docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA)], and the fatty acid α-linolenic acid (ALA), found in vegetable oils such as flaxseed, walnut, rapeseed and soya oils. The long-chain n-3 fatty acids are beneficial to the body. The current recommendation is to eat two portions of fish a week. The short-chain, n-3 fatty acids may not have the same benefits.

As very few other foods contain the essential n-3 PUFAs, EPA and DHA, fish intake is strongly recommended. Oil-rich fish includes herring, trout, mackerel, sardines and salmon, but n-3 fatty acids are also present in lean fish, albeit at lower concentrations. There is scientific evidence that a regular intake of EPA and DHA reduces the risk of heart attacks. Limited evidence also indicates that non-salted fish is protective against colorectal cancer.[36]

The key micronutrients provided by fish are the mineral phosphorus, selenium, potassium, iodine, zinc and magnesium and vitamins B_2, B_{12} and D. Because of the presence of small edible bones, tinned sardines are a source of calcium, particularly in people who choose not to consume dairy products.[36]

Beef

Significant differences in the nutritional composition of beef carcasses of varying ages, and even more noteworthy disparities within a specific age group, and among different fat classes were reported by Schönfeldt.[37] There is a larger variation in the fat content of varying cuts within the same carcass than in beef carcasses of different age groups and fat levels. For instance, a cooked fillet of an A-age animal (i.e. a young animal with no permanent incisors) with a fat level of 2, contains 8% fat on average, compared to 34% fat in the thin flank of the same carcass.[37] South Africa has not escaped the obesity epidemic. Thirty per cent of adult men and 52% of adult women are overweight or obese, and the figures continue to increase.[23] Health, as a driver in the consumption of beef, and a consumer preference for leaner meat has led to a significant reduction in the fat level of beef carcasses from 32% in 1949, to 18% in 1981, and 13% in 1991. Cuts that are low in both fat and SFAs can be included in a low-fat, balanced diet.[15]

Lamb and mutton

In a series of research studies conducted by the University of Pretoria, in collaboration with the Agricultural Research Council, it was found that lean South African lamb and mutton, trimmed of external fat, contains less than 10% fat on average, and can be included as part of a healthy, well-balanced diet. Forty-seven per cent of the fat in South African lamb and mutton is in the form of healthy MUFAs and PUFAs. Lamb and mutton are natural sources of CLA. CLA has been shown to protect the body from cancer and heart disease and to lower cholesterol levels.[16] These studies were based on carcasses that are consumed most often in South Africa, namely lamb and mutton with a fatness code of 2, according to the South African carcass classification system.

Pork

A significant study that was carried out by the Agricultural Research Council in 2008 revealed that South African-produced pork is scientifically bred to be leaner and to provide a lower fat content. The fat in pork is mostly visible as subcutaneous fat, and can be trimmed without much difficulty.[17] The fat in pork is a combination of SFAs, PUFAs and MUFAs, in varying amounts. It contains less than 50% of SFAs, while the rest comprises MUFAs and PUFAs. Pork is an excellent source of thiamine (vitamin B_1) and a good source of niacin (vitamin B_3).

Offal

In general, offal is richer than lean meat in iron, copper and certain B vitamins. Liver is a particularly rich source of vitamins A, B_1, B_2, B_6, B_{12}, niacin and pantothenic acid, with traces of vitamin D.[6] The amount of vitamin A that is present in liver can be variable and, indeed, very high. It depends on the age of the animal and the composition of the consumed feed. As fat-soluble vitamins are not excreted by the body, very high doses can have adverse health effects.[33] Kidneys are a rich source of vitamin B_1, B_2 and B_{12}. Pancreas meat is a good source of vitamins B_1, B_2 and C and pantothenic acid. Other organ meats compare well with lean meat as sources of vitamins. All meat products are good sources of zinc and iron. The liver, lungs and spleen are especially rich in iron.[38]

Eggs

In the past, research on eggs focused on associations with serum cholesterol levels and heart health. However, many of these studies are now considered to be methodologically weak, since they had not adequately controlled for potential confounders such as pre-existing hypercholesterolaemia, saturated fat intake or smoking.[39]

Eggs are a rich source of protein and several essential nutrients, such as vitamin A, the B vitamins, including thiamine, riboflavin, folate, B_{12} and B_6, and vitamin D, selenium and choline, when compared with other protein foods.[6] They provide a nutrient-dense source of energy (approximately 314 kJ per large egg) derived from protein and fat. Eggs have traditionally been used as the standard of comparison for the measurement of protein quality because of their essential amino acid profile and high digestibility, which is important for children, adolescents and young adults, since protein is required to sustain growth and build muscle.[39] High-quality protein may prevent the degeneration of skeletal muscle[19] and protect against health risks associated with ageing in older adults.[35,36] In addition, the antioxidants (lutein and zeaxanthin) that are found in egg yolk may help to prevent age-related macular degeneration.[40,41]

Although eggs are a rich source of cholesterol (419 mg/100 g), they have a low SFA content.[6] Epidemiological

studies have consistently shown a non-significant relationship between egg intake and the risk of cardiovascular heart disease. Emerging evidence suggests that eating eggs is associated with satiety, good weight management and better diet quality.[31]

Processed meats

According to Linseisen, processed meat includes meat that has been preserved by methods other than freezing, such as salting, smoking, marinating, air drying or heating. Examples include ham, bacon, sausages, hamburgers, salami, corned beef and tinned meat.[42] According to the South African national standard (SANS 885:2012), processed meat is meat that has been subjected to any process which alters its original state, excluding sectioning and freezing, with or without other ingredients, and which, as a result of this process or these processes, is irreversibly changed. It excludes raw processed meat, as defined in the current relevant legislation.[43]

The composition of different processed meat varies widely between type and producer. Overall, processed meat is more likely to have a higher content of sodium and nitrites than that of lean meat. Sodium is added to meat products to enhance and modify the flavour, physical properties and sensory attributes of the food, and to contribute to preservation of the product. Legislation has recently been promulgated within the country to reduce and control the amount of salt in processed meat products, because of adverse health effects associated with a high intake of sodium.

Nitrites have been consumed since the beginning of time in a variety of foods, including those that occur naturally in vegetables and cured meat. Nitrites are considered to be essential curing ingredients, responsible for developing colour, creating a unique flavour profile and controlling lipid oxidation. They are also effective antimicrobial agents. Despite controversies about the safety of nitrites, ongoing research focused on the metabolism of nitrites, nitrates and nitric oxide is re-evaluating the possible benefit of nitrates and nitrites in human health.[44,45]

It was indicated that it is important to distinguish between meat groups in a cross-sectional study of Irish adults, as there is a large variation in dietary quality between consumers of red, white and processed meat. For example, increasing processed meat intake has been found to be associated with a lower intake of wholemeal bread, fruit, vegetables and fish, as well as poorer overall dietary quality.[46] Other factors, such as fruit, vegetable and fibre intake and physical activity, are also important. The risk of cancer may be more effectively reduced by taking both diet-related and lifestyle risk factors into account.

Although meat intake has been associated with an increased risk of colon cancer in some studies, processed meat appears to be a stronger predictor of this than unprocessed fresh meat. The contribution of meat to improved nutrient intake more than offsets this uncertain association with cancer, particularly in developing countries.[11,47,48]

Other constraints on the consumption of animal sources of food

Although consumer attitudes to animal sources of food are influenced by a number of factors, such as price and availability, major variations in the volume and type of product consumed in different countries are thought to be primarily because of differences in culture and traditional eating habits.[49] As populations have urbanised, a corresponding increase in animal product consumption has been observed.[50]

Furthermore, some individuals choose to avoid meat altogether or certain types of animal food sources for a variety of reasons, including taste, ethical or religious reasons, health concerns about additives, hormones, fat and cholesterol, or because of socio-economic factors.[11,51] The consequences of production and consumption, such as greenhouse gas emissions, the water footprint and land use, are also receiving considerable attention.[52]

The delicate balance between adequate, over- and underconsumption of animal sources of food remains a very complicated aspect of ensuring healthy and nutritionally adequate, yet environmentally sustainable, diets.

Vegetarian diets

People choose to follow a vegetarian diet for a variety of reasons. Well-planned vegetarian diets can be both nutritious and healthy. These have been associated with a lower risk of heart disease, type 2 diabetes, obesity and certain types of cancer, and lower blood cholesterol levels.[53] However, restrictive or unbalanced vegetarian diets may lead to nutritional deficiencies, particularly in situations of high metabolic demand. The nutrients of major concern in a vegetarian diet are protein, iron, calcium, vitamin B_{12} and n-3 fatty acids.

While proteins from animal sources contain the complete mix of essential amino acids, few plants do.[2,5,53] Plants provide some protein. Each plant contains a different combination. Provided that a mixture of different plant proteins is consumed over the course of a day, all of the necessary essential amino acids will be provided in the diet. Vegetarian protein sources include beans, lentils, soya, soya products, seeds, nuts and whole grains.

Although red meat is the richest and most easily absorbed source of iron,[29] a number of plant foods can make a significant contribution. To increase iron intake levels in a vegetarian diet, it is necessary to eat plenty of fortified breakfast cereals, beans, lentils, leafy green vegetables, seeds and nuts. Fortified maize meal porridge and brown bread should be included on a regular basis. To aid the absorption of iron from plant foods, when having a meal, a source of vitamin C should be included, such as a glass of fruit juice.[29,53]

Tinned sardines and dairy products are rich sources of calcium. If none of these are consumed, a diet that is rich in tofu (soya), calcium-fortified foods, green leafy vegetables, seeds, nuts and dried fruit must be consumed. Although spinach contains calcium, it is bound to a compound called oxalate. This greatly reduces its absorption, making it a poor source of usable calcium.[54]

Consuming eggs and dairy foods will ensure enough vitamin B_2 and B_{12} in the diet. Vegans should consider including fortified foods that contain vitamin B_2 and B_{12}. To increase the content of these vitamins in the diet, it is important to eat plenty of yeast extract, soya milk and breakfast cereals. With regard to fatty acids, the body has the ability to convert some ALA into the n-3 PUFAs, EPA and DHA, yet this conversion isn't very efficient. If no fish is consumed, a supplement of DHA should be considered.[53]

The FBDG guideline "Fish, chicken, lean meat and eggs can be eaten daily" was formulated to indicate that animal sources of food should be eaten daily to help meet nutrient needs during the life cycle. Extra care must be taken to ensure that nutritional needs are being met when animal foods are omitted from the diet.

Current intake and recommended portion sizes

Apart from deciding what and when to eat, the amount of food that is consumed plays a significant role in the amount of nutrients and energy consumed.

According to the previous FBDG on animal sources of food, the recommended amounts that should be consumed include:[55]

- Two to three fish portions per week (80-90 g per portion).
- Three to four eggs per week.
- Not more than 560 g red meat per week (approximately a 80-90 g portion per day).

Urbanisation is a growing phenomenon in South Africa. People are continually moving from rural areas into urban settlements in search of better work and income-generation opportunities. These changes in lifestyle are often accompanied by acculturation and an increase in the utilisation of animal sources of food.[56]

Table IV indicates the consumption of red and white meat and eggs over the last decade. According to data extrapolated from the *Abstract of Agricultural Statistics,* there has been an increase in beef, veal, pork and chicken meat and egg consumption. Sheep meat consumption during the same period decreased, but the total consumption of eggs and red and white meat increased.[57]

Publications such as the *Abstract of Agricultural Statistics,*[57] *The South African Agricultural Baseline*[59] and *FAO Fishery Statistical Collections,*[60] from which production and consumption data are extrapolated, provide broad statistical data on population, food production and consumption figures. Such statistics can be used to obtain estimates of food consumption, but these estimates are not fully representative of actual food intake. Food balance sheets are based on statistical data on the production, import and export of carcasses, and eventual shifts in stock. Because of the large quantities of discarded material prior to meat reaching the table for consumption (e.g. bones and cartilage) and at the table (e.g. trimmed fat and wastage), the apparent supply from this source will always be an overestimation of the true meat intake in a population. From the time of slaughter to actual consumption, up to 70% of the slaughtered product is wasted.[61]

Table V calculates the estimated actual consumption of animal products, including meat and offal, from the consumption data reported from agricultural statistics using yield factors,[62] when wastage is taken into consideration. The data presented in Table V do not include food waste from possible spoilage or plate loss from production to consumption, reported to be up to 40% in the UK.[61]

Table IV: Per capita consumption (g/day) of red meat, white meat and eggs over the last decade[58]

Protein source	2000/2001	2010/2011
Beef and veal	35	47
Pork	7	13
Lamb and mutton	10	5.5
White meat	59	96
Eggs	19	23

Table V: Estimated edible portion available for consumption (g/capita/day), calculated from agricultural statistics using yield factors

Animal products	Raw product (kg/capita/year)[63]	Raw (g/capita/day)	Yield factor (edible portion)*[62]	Edible portion (cooked product g/capita/day)
Beef and veal	17.07	46.77	± 0.60	28.06
Pork	4.60	12.60	± 0.60	7.56
Sheep and goat	2.90	7.95	± 0.50	3.98
White meat	34.91	95.64	± 0.40	38.26
Eggs	8.48	23.20	± 0.90	20.9
Fish	7.60	20.82	± 0.60	12.5
Total	75.56	206.98		111.26

* Following cooking loss, bone, fat and plate waste

Table VI: Estimated food consumption data (g/day) from agricultural statistics (2000/2001) over the last decade, compared to data from food consumption surveys during the same periods*

Group (g/day)	2000/2001				2010/2011			
	Agricultural statistics[57,63]		Summary of food consumption surveys[58]		Agricultural statistics[57,63]		Adopted from Food Consumption Surveys (2000-2010)[58]	
	Raw slaughtered product	Edible portion**	Children (aged 1-5 years)	Adults and children aged ≥10 years	Raw slaughtered product	Edible portion**	Children (< 9 years)	Adults
Meat***	119	63.6	45	86	163	77.9	58	44 - 60
Fish and seafood	17	10.2	10	12	21	12.5	7	15
Eggs	19	17.1	7	15	23	20.9	-	16.5

* The data were adopted from combined databases, using secondary data analyses to show the dietary intake of adults and children[58]
** The edible portion is calculated using yield factors[62]
*** The value includes the consumption of red and white meat, meat products and offal

Table VII: Production and consumption data on red meat (beef, sheep and pork), white meat (poultry), fish and seafood and eggs[59]

Year	Total South African production and imports (1 000 tons)				Per capita consumption (g/day)			
	Fish and seafood	White meat	Red meat	Eggs	Fish and seafood	White meat	Red meat	Eggs
2000/2001	667	869	833.4	329	16.76	58.85	51.95	19.42
2001/2002	785	896	881.9	330	19.08	59.32	53.56	18.96
2002/2003	798	925	940.6	340	19.10	62.22	56.36	18.85
2003/2004	847	928	999.9	328	19.36	63.84	59.15	18.00
2004/2005	917	1 019	1 044.4	348	27.03	70.82	61.97	19.34
2005/2006	830	1 143	1 161.7	375	23.33	80.79	67.92	20.85
2006/2007	634	1 200	1 252.4	412	21.64	85.01	71.70	22.63
2007/2008	697	1 276	1 128.3	438	20.87	86.36	63.75	23.84
2008/2009	662	1 358	1 151.3	473	-	87.70	63.67	25.26
2009/2010	529	1 430	1 238.4	450	-	91.40	68.38	23.56
2010/2011	642	1 488	1 225.2	453	-	95.64	67.04	23.23

Agricultural data, such as those reported in the *Abstract of Agricultural Statistics*, also do not differentiate between population groups and affluent and less affluent communities, but present an available average for each individual in the total population per day. Table VI compares the estimated values from the *Abstract of Agricultural Statistics* (raw slaughtered product and estimated cooked product available for consumption using yield factors).[62] The values derive from food consumption surveys.

The production of animal sources of food

Data from the Food and Agricultural Organization of the United Nations shows that global meat production has more than tripled, and that egg production has increased by nearly four times since 1960.[64] Population growth estimates indicate that the demand for meat will double by 2050. This will be because of increasing demand in developing countries, on par with population growth and increased rates of urbanisation.[65]

According to data extrapolated from the *Abstract of Agricultural Statistics* (Table VII), in the last decade there was an increase in the production of red and white meat and eggs in South Africa.[57] However, South Africa is a net importer of beef and sheep (mainly mutton), as the annual average growth in production has been outpaced by consumption growth.[59,63] South Africa produces 85% of its meat requirements, with 15% being imported.[12] Chicken production will increase to 1.9 million tons over the next decade. Approximately 350 000 tons of chicken meat will be imported in 2020. In 2011, local egg producers were able to comfortably match the increase in local egg consumption.[59] Only 10% of anchovy fish that is caught is used for human consumption. There is an opportunity for growth in this sector (Department of Agriculture, Forestry and Fisheries Anchovy for Human Consumption Task Team, personal communication, August 2012).

Dietary guidance on animal sources of food

In order for dietary guidance to be effectively formulated, the nutritional contribution of the products to the diet needs to be considered, both in terms of critical nutrients and risk exposure. A comprehensive definition of the product at hand must be presented, and clear quantity and best practice recommendations provided. As previously mentioned, the delicate balance between adequate, over- and underconsumption of animal sources of food remains a significant challenge to ensure healthy and nutritionally sufficient, yet environmentally sustainable, diets. Underconsumption of animal sources of food could result in a diet that is low in protein, iron, zinc, calcium and vitamins A and B_{12}, which might lead to anaemia, vitamin A deficiency and poor physical and cognitive development. The overconsumption of animal sources of food that are high in saturated fats and kilojoules is associated with an increased risk of obesity, coronary heart disease and other noncommunicable diseases.

Considering the nutritional contribution of food sources

Fish, meat and eggs provide many important nutrients, particularly protein, long-chain n-3 fatty acids, iron, zinc, selenium, vitamin D and vitamin B_{12}. Meat is a well-recognised source of bioavailable iron and zinc. In light of the current low levels of iron and zinc intake in South Africa, particularly in women and children, meat has the potential to make an important contribution to the intake of these nutrients. Fish, meat and eggs also contain a range of B vitamins, although levels vary between the different food products. Red meat and fish, in particular, are a good source of vitamin B_{12}. As this vitamin is only naturally found in foods of animal origin, subgroups of the population who do not consume meat or animal products may have an inadequate intake of vitamin B_{12}.

Although meat and eggs are seen as contributors to SFA intake, lean meat contains a higher proportion of unsaturated fatty acids. Fish contains high levels of the long-chain n-3 fatty acids, EPA, DPA and DHA. Work is currently underway to identify methods through which the fatty acid profile of meat can be altered, in order to reflect a more positive fatty acid profile in terms of heart health. Various research studies have been conducted to establish if there is link between red and processed meat intake and the risk of chronic disease. Obtaining definitive evidence to confirm diet-risk relationships is a challenging process because of complex interactions and confounding factors, including genetics, lifestyle, and infectious and environmental factors.

Defining lean meat

Meat is the flesh and organs of animals and fowls. Numerous legal definitions of meat in different countries have been created to control the composition of products made with meat. The flesh of cattle, pigs and sheep is distinguished from that of poultry, with the exception of ostrich, by the term "red meat", while the flesh of poultry (chicken, turkeys, ducks, pigeons and guinea fowl) is termed "white meat". Red meat mostly refers to beef, veal, pork, mutton and lamb (fresh, minced and frozen), but also includes

Table VIII: Examples of dietary guidance recommendations on animal-derived protein sources in various countries

Country	Recommendations	Guideline
USA	• Eat a variety of foods from the protein group each week. • Eat seafood in place of meat or poultry twice a week. • Select lean meat and poultry. • Trim or drain the fat from meat and remove poultry skin before cooking or eating. • Try grilling, broiling, poaching or roasting, as these cooking methods do not add extra fat. • Drain fat from ground meats after cooking. • Avoid adding bread to meat and poultry, e.g. breadcrumbs.	*Dietary Guidelines for Americans*[68]
European region	• Eat a nutritious diet that is based on a variety of foods that originate from plants, rather than from animals. • Replace fatty meat and meat products with beans, legumes, lentils, fish, poultry or lean meat. • Use milk and dairy products (kefir, sour milk, yoghurt and cheese) that are low in both fat and salt. • Choose a low-salt diet. Total salt intake should not be more than one teaspoon (6 g) per day, including the salt in bread and processed, cured and preserved foods. (Salt iodisation should be universal when iodine deficiency is endemic.)	*Food-Based Dietary Guidelines in the WHO European Region*[69]
Pacific countries	• Choose a variety of foods from the three food groups (energy foods, protective foods and body-building foods). • Local produce is best.	*Healthy Eating in the Pacific*[70]
Canada	• Choose lower-fat dairy products, and leaner meats and foods that are prepared with little or no fat.	*Canada's Guidelines for Healthy Eating*[71]

WHO: World Health Organization

goat, ostrich and venison.[11,37,38] Other animal products include offal, fish, eggs and dairy products such as milk, cheese and yoghurt.

There is no international definition of "lean" meat, but standards seem to be similar in different countries:

- Australia and New Zealand: Meat containing less than 10% fat meets the Heart Foundation's approval.[66]
- Denmark: Meat containing 5-10% fat is classified as "lean".[66]
- The USA: Less than 10 g of total fat, 4.5 g or less of saturated fat, and less than 95 mg of cholesterol.[67]
- South Africa: Minced meat and processed meat products with less than, ≤ 10% of total fat can be classified as "lean". Meat with ≤ 5% of total fat can be classified as "extra lean".[28]

Considering international guidelines on animal product consumption

Globally, guidelines on the consumption of these foods also differ, but remain consistent in terms of the message that protein foods such as chicken, fish, lean meat and eggs should form part of a diet that is varied and balanced and which provides adequate amounts of fibre and other nutrients from alternative food groups, such as vegetables, pulses and whole grains. In Table VIII, dietary guidance on animal-derived protein sources in different countries is presented. It should be noted that, generally, the recommendations include the preparation of food without the addition of fat.

Conclusion and recommendations

The challenge in the context of this paper, as part of a series of background papers for the revised South African FBDGs, is to aim for an optimal and diverse diet for all South Africans from all socio-economic groups.

Based on evidence on nutritional considerations which advocate the inclusion of these products as part of a healthy, balanced diet, together with a review of current international FBDGs, it is therefore recommended that: "Fish, chicken, lean meat and eggs can be eaten daily".

Diets should include:

- Two to three fish servings per week, and preferably oily fish, such as sardines, pilchards, tuna, anchovies and mackerel (including tinned versions).
- Approximately four eggs per week.
- A serving of lean meat, as defined by the regulations,[8] can be eaten daily, but should be limited to 90 g/day. Trim the visible fat from red meat and remove the skin and fat from chicken. Prepare the meat with little or no added fat and salt.

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