Chapter 4

Nutritional Composition of Meat

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Additional information is available at the end of the chapter

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Abstract

Meat ranks among one of the most significant, nutritious and favored food item available to masses, which aids in fulfilling most of their body requirements. It has played a vital role in human evolution and is an imperative constituent of a well-balanced diet. It is a good source of proteins, zinc, iron, selenium, and phosphorus followed by vitamin A and B-complex vitamins. Average value of meat protein is about 23% that varies from higher to lower value according to the type of meat source. Meat fat and its fatty acid profile is point to worry, with respect to its consumption, but its moderate usage is always advised by doctors and nutritionists, in order to lead a healthy life. Fat content of animal carcasses ranges between 8 and 20%. Quality traits of meat along with its nutritional composition become dependent upon animal breed type, feeding source (grains, pasture and grass), genetics of animal and post mortem techniques. This chapter will mainly focus on the variant aspects of nutritional constituents of meat including proteins and essential amino acids, fats and fatty acid profile, carbohydrates, vitamins and minerals along with their health benefits to human health.

Keywords: meat, nutritional value, proteins, saturated fats, minerals, vitamins

1. Introduction

Ingestion of fresh, healthy and wholesome food materials play a crucial role in maintaining the health status of human beings. The term balanced diet has gained immense popularity globally owing to the increasing awareness regarding the maintenance of health status among the masses. Balanced diet ensures the intake of all the essential nutrients, which are required by the human body to perform the daily life functions [1]. In this scenario, awareness of nutritional composition of the food stuffs has become quite significant in having a balanced meal,

which in-turn ensures the health status of individuals. Nutritional composition refers to the comprehensive frame of information regarding vital nutritional components of food items and offers energy values. The nutrients are the elements that provide nourishment essential for the maintenance of life and for growth, which includes both the macro- and micro-nutrient. Macro-nutrients are those that are required by the human body in large amounts and these include proteins, fats and carbohydrates. Micro-nutrients are those elements which are required by the body in small amount and comprising of vitamins, minerals and fiber [2]. All of these are being supplied by number of food stuffs including meat, cereal grains, milk, fruits and vegetables. Among them meat holds a key spot which fulfills most of the protein requirements of the humans. Different types of meats are present including the beef, mutton, lamb, chicken and fish etc. Each and every type of meat is significant in its own value with little differences in its composition [3]. The detailed information regarding its nutritional composition is as follows;

2. Nutritional composition of meat

Meat ranks among one of the most significant, nutritious and energy-rich natural food product, utilized by the humans to fulfill their regular body requirements. It is considered quite important in maintaining a healthy and balanced diet, which is essential in accomplishing optimum human growth and development. Although, few epidemiological studies have also pointed a possible relationship between its consumption and the elevated risks of having cardiovascular diseases, various forms of cancers and metabolic disorders but still its role in the human species evolution, specifically in its brain and intellectual development cannot be ignored [4].

In accordance with European legislation, meat is defined as the edible portions, obtained from domestic animals including caprine, bovine, ovine and porcine, including the poultry meat, farmed and wild animals. It is a rich source of high value proteins, variety of fats including omega-3 polyunsaturated fatty acids, zinc, iron, selenium, potassium, magnesium, sodium, vitamin A, B-complex vitamins and folic acid. Its composition varies with reference to its breed, type of feed being ingested, climatic conditions and also on the meat cut, which imparts a considerable difference on its nutritional and sensorial properties [4].

From the nutritional point of view, meat is considered as a rich essential amino acids source whereas, mineral contents to a lesser extent. Apart from it, essential fatty acids and vitamins also make a part of it. Organ meat like liver is quite an enriched source of Vitamin A, Vitamin B_1 and nicotinic acid. The research is still in progress for the better understanding of the probable differences among the nutritional value of different meat cuts, variant animal species and breeds. It is quite evident from the previous research that the meat having lesser connective tissues is likely to have low scores of digestion and absorption [5]. Moreover, the meat having more connective tissues are supposed to have less contents of essential amino acids, which make them less nutritious as compared to the meat piece having lesser connective tissues and results in more digestibility and nutritional value [3]. Following **Table 1** shows the nutritional composition of different sort of meat products.

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Meat cut	Protein (g)	Sat. fat (g)	Fat (g)	Energy (kcal)	Vit. B_{12} (mcg)	Na (mg)	Zn (mg)	P (mg)	Fe (mg)
Chicken breast, raw	24.2	0.2	8.5	178	0.39	71	0.9	199	1.2
Beef, steak cuts, raw	21	1.9	4.5	123	1.9	59	1.7	167	1.3
Chicken, raw	22.8	0.6	1.9	113	0.70	78	1.4	202	0.7
Beef, calf, loin, raw	20	3.4	7.3	146	1.1	22	3	193	0.10
Beef, loin, raw	20.9	1.5	3.2	115	2	59	3.7	142	1.6
Pork, chop, raw	18.1	10.8	31.7	353	1	60	1.8	190	1.4
Pork, loin, raw	21.9	1.7	4.9	134	1.1	55	1.9	220	0.7
Pork, leg, raw	20.8	2.8	7.8	155	1.2	84	2.6	164	0.8
Turkey, skinless, raw	19.9	1.8	7.1	136	1.9	42	1.5	209	2.1
Duck meat, skinless, raw	19.4	1.8	6.6	130	2.8	90	1.8	201	2.5
Turkey, breast, skinless, raw	23.6	0.5	1.6	106	1	62	0.5	208	0.6
Chicken breast, skinless, raw	23.8	0.4	1.28	109	0.40	59	0.7	218	0.4
Mutton, chop or meat, raw	20	2.4	4.8	122	2	63	3.6	221	1.9

Table 1. Nutritional composition of meat [4, 6].

2.1. Water

Water is one of the important constituents of all food materials. In general, there are three types of food products depending upon their moisture contents, firstly perishable commodities (having more than 70% moisture content in them), non-perishable commodities (having around 50–60% moisture contents) and stable food materials (with less than 15% moisture). The more the water content of any food material the lesser are the chances of its longer shelf life as micro-organisms have greater chance to grow on them that in turn, limit their lives.

Meat ranks among the perishable food material, as it contain around more than 70% of moisture in it. Apart from reduction in shelf life, its presence imparts a strong impact on the color, texture and flavor of muscle tissues of meat. Adipose tissues (tissues on the abdominal part of the animal) contain less moisture content, which leads to the fact that if the animal is fatter it will be having lower water content in its carcass and vice versa. Younger and leaner animals exhibited around 72% of moisture content [7].

Major portion of water contents in meat tissues exist in free- state within muscle fibers and smaller amount of it is present in the connective tissues. During the processing conditions, such as curing and heat treatment followed by the storage, small percentage of the water remains within the muscle fiber which is termed as the “bound water”. The three dimensional

structure of muscle fiber fortified with the pressure and temperature helps the water to retain in the muscles during the processing conditions, while most of the water "lost" during these circumstances known as "free water". The water holding ability of meat could be altered by the disruptions of its muscle fibers, which resultantly aid in the enhancement of the shelf life of meat products. There are numerous methods involved in this regard containing chopping, grinding, salting, freezing, thawing, breakdown of connective tissues by enzymatic or chemical means, heating application and use of chemicals or organic additives altering the acidity (pH) of meat are the processes that can affect the final water contents of meaty products [8].

2.2. Carbohydrates

The main source of the carbohydrate in the animal body is its liver, which contains about ½ of the total carbohydrates present in the body. They are stored in the form of "glycogen" mainly in the liver and muscles but also in glands and organs to lesser extent. Its substantial quantities are present in blood in the form of glucose. The glycogen has an indirect impact on the meat color, texture, tenderness and water holding capacity of it. The conversion of stored glycogen to glucose; and from glucose to lactic acid is quite a complex process and all these modifications are governed by the action of hormones and enzymes [9].

During the early stage of aging, the lactic acid content of muscles increases, thus lowering the pH. The pH has a very strong influence on the muscle texture, tenderness, color and also on water-holding capacity. The normal pH of the muscle considers being around 5.6. If an animal suffers from severe stress or exercise just before the slaughter and have no chance to regain its normal glycogen levels, then a minute amount of glycogen will be there to convert into lactic acid causing an elevated pH (i.e. 6.5) and as a result, meat muscles get dark, firm and dry (DFD). This type of meat results from exhaustion and then causes depletion of glycogen before slaughter. This occurs not so often in beef (2%), but also affected the other ones that are called as "Dark Cutters". The main reason for the dark colored meat with high pH is owing to the higher water holding capacity. This causes the muscles to absorb more water, which makes them to absorb the incident light rather than to reflect it from the meat surface, thus causing the darker appearance of the meat. This DFD defect is quite disliked by the retailers and customers, affecting heavily on its sensorial and nutritional properties, so stress and rough handling of animals should be avoided just prior to slaughtering [10].

A quite speedy postmortem causes a drop in the muscle pH (i.e. 5.0) is recognized by pale, soft and exudative condition (PSE), which is quite common in pork meat. PSE affected muscle portion is recognized by low water-holding capacity, soft texture and pale yellow color. The softer muscle structure of PSE meat causes its lower water-holding capacity, which is then accountable for more reflectance of incident light, thus making the color of meat as pale yellow [11].

All the above mentioned conditions of DFD and PSE relates to the carbohydrate contents of the meat, which has considerable effect on nutritional value of meat.

2.3. Proteins and its amino acids

Meat ranks among one of the protein-rich foods, providing high biological value to the masses. Proteins are naturally occurring complex nitrogenous compounds having very high molecular

weight consisting of carbon, hydrogen, oxygen and most importantly nitrogen. Few of the proteins also have phosphorous and sulfur in their structures. All these components chemically linked together to form different types of individual proteins, exhibiting different properties. These vary from one tissue to the other within a same living organism and also in corresponding tissues of different species. The proteins are more complex than the carbohydrates and fats from their size and constituents. The percentage of meat protein component varies extensively in different types of meats [12]. In general, the average value of the meat protein is about 22%, but it could range from high protein value of 34.5% in chicken breast to as low as 12.3% protein in duck meat. The protein digestibility-corrected amino acid scores (PDCAAS) which depict the protein digestibility reveals that meat has high score of 0.92 as compared to other protein sources including lentils, pinto beans, peas and chickpeas scoring 0.57– 0.71 [13]. Protein quality is mainly concerned with the availability of amino acids present in it.

Amino acids serve as the building blocks of the proteins. The nutritional value of meat can be varied to great deal by the presence or absence of numerous amino acids. One hundred and ninety two are known among which only 20 are used to prepare the proteins. From these 20 amino acids, 08 are considered as the essential amino acids, as these could not be prepared by the human body, so must be taken by the diet. Other 12 are the non-essential amino acids that could be manufactured by the human body but only if their particular dietary sources are being ingested, otherwise, it could result in the protein malnutrition. The **Table 2** shows all non-essential and essential amino acids present in meat.

The beef meat appears to have higher contents of valine, lysine and leucine as compared to lamb and pork. Studies have revealed that main reason of the difference in essential amino acid proportion lies with the breed, animal age and muscle location. Previous research studies reported that contents of valine, isoleucine, phenylalanine, arginine and methionine in the animal meat increase with its age [16]. The essential amino acid contents also differ with the different parts of the carcass. Their composition could also be affected by the application of processing techniques including heat and ionization radiations, but only when the severe prolonged mode of these conditions are being applied [17]. In some cases, these amino acids are not being available for the human use. In a study, some researchers found out that only 50% of lysine was available at 160°C, while 90% of it was there at 70°C. Sometimes the interaction of the other constituents with the proteins has put an effect on the availability of essential amino acids. Smoking and salting of the meat has also played its role in this regard. Apart from the effect of the processing conditions, the storage has also imparted its effect on amino acids, in case of canned meat [18].

2.4. Fat and fatty acids

Fats rank among one of the three major macro-nutrients, including carbohydrates and proteins. Fat contents are known as triglycerides that are esters of three fatty acid chains and the alcohol glycerol. Meat contains fatty tissues (fat cells filled with lipids) that have varying amount of fat. In meat, fat content functions as energy deposits, protective padding in the skin and around organs especially heart and kidney as well as provides insulation against body temperature losses [19]. Fat content in animal carcass varies from 8 to 20% (latter is only in pork). The fatty acid and fat composition of fatty tissue differs significantly in different locations among poultry

Essential amino acids				
Amino acids	**Category**	**Beef**	**Lamb**	**Pork**
Lysine	Essential	8.2	7.5	7.9
Leucine	Essential	8.5	7.2	7.6
Isoleucine	Essential	5.0	4.7	4.8
Cystine	Essential	1.5	1.5	1.2
Threonine	Essential	4.2	4.8	5.2
Methionine	Essential	2.2	2.4	2.6
Tryptophan	Essential	1.3	1.2	1.5
Phenylalanine	Essential	4.1	3.8	4.3
Arginine	Essential	6.4	6.8	6.6
Histidine	Essential	2.8	2.9	3.1
Valine	Essential	5.6	5.1	5.2
Non-essential amino acids				
Amino acid	**Category**	**Beef**	**Lamb**	**Pork**
Proline	Non-essential	5.2	4.7	4.4
Glutamic acid	Non-essential	14.3	14.5	14.6
Aspartic acid	Non-essential	8.9	8.6	8.8
Glycine	Non-essential	7.2	6.8	6.0
Tyrosine	Non-essential	3.3	3.3	3.1
Serine	Non-essential	3.9	3.8	4.1
Alanine	Non-essential	6.3	6.2	6.4

Table 2. Amino acid composition in fresh meat [6, 14, 15].

and other meat products such as offal, sausages and ham etc. External body fat is softer than the internal fat that surrounds the organs owing to the higher content of unsaturated fat in external animal parts. Skin is the main fat source in poultry meat. In the main retail cuts, fat content in chicken and turkey ranges between 1 and 15% and meat cuts with skin have higher percentage. Cooking can have a significant effect on fatty acid composition and meat fat content. Scientific evidence reported the considerable losses of fat in numerous meat cuts which were referred to broiling, grilling and pan-frying without added fat [20].

Among the fatty acid composition, meat contains unsaturated fatty acids; oleic (C-18:1), linoleic (C-18:2), linolenic (C-18:3) and arachidonic (C-20:4) acid appear to be essential. They are necessary constituents of mitochondria, cell wall and other active metabolic sites. Linoleic acid (C-18:2) is abundantly present in vegetable oils such as soya and corn oils with its concentration 20 times in meat and linolenic acid (C-18:3) occurs abundantly in leafy parts of plants. Eicosapentaenoic acid (C-20:5) and docosahexaenoic acid (C-22:6) are normally

present at low concentration in meat tissues, but these are present in high concentrations in fish and fish oils [21]. Polyunsaturated fatty acids concentrations as well as cholesterol in muscular and offal tissues of common meat species are shown in **Table 3**.

It is obvious that the linoleic acid concentration is more in lean meat of pig than in ox or sheep meat. These variations in concentration of fatty acids composition among different species are also revealed in kidney and liver fatty acid profile. The liver tissue in all the mentioned animal species is suggested as a rich source of polyunsaturated fatty acids. On the other hand, brain has distinctively high concentration of C-22 polyunsaturated fatty acids. It is tabulated that the concentration of cholesterol in offal tissues, particularly brain is more than the concentration in muscle tissues [26].

From the number of polyunsaturated fatty acids, omega 3 fatty acids justify their special attention as they play a protective role in general human health particularly cardiovascular diseases. Seafood is the main source of omega 3 fatty acids. Though, meat can contribute up to 20% of long chain omega 3 polyunsaturated fatty acids intake. This polyunsaturated omega 3 content in meat depends on the feeding source and it is higher in forage-based and grass diet. It is also suggested that polyunsaturated fatty acids of animal fat are indispensable for the development of brain, particularly in the fetus. When linoleic and linolenic acids are ingested, they can be digested by animal liver and produce polyunsaturated fatty acids. Furthermore, the chain elongation of linoleic acid gives rise to the prostaglandins which are very important for the regulation of blood pressure. Prostaglandins are mostly found in organs and tissues and synthesized in the cell from essential fatty acids. They are produced by all nucleated cells and known as autocrine and paracrine lipid mediators that act on endothelium, uterine and platelet cells [27].

To avoid the possible harmful effects on health from the consumption of the meat of ruminant animals, there must be introduced a greater potential of unsaturation into their fats and fatty tissues. Generally, feeding of vegetable fats to sheep and cattle would be nullified because of the reduction or condensation by rumen bacteria. But, when they are firstly treated with

Meat source	Cholesterol (mg/100 g)	C-18:2	C-18:3	C-20:3	C-20:4	C-22:5	C-22:6
Mutton	81	2.4	2.4	Nil	Nil	Trace	Nil
Beef	62	2.1	1.4	Trace	1.1	Trace	Nil
Pork	71	7.5	1.0	Nil	Trace	Trace	1.1
Brain	2200	0.5	Nil	1.6	4.1	3.5	0.4
Pig's Kidney	415	11.6	0.4	0.5	6.72	Trace	Nil
Sheep's Kidney	399	8.2	4.1	0.6	7.2	Trace	Nil
Ox's kidney	401	4.9	0.6	Trace	2.7	Nil	Nil
Sheep's Liver	429	5.1	3.9	0.7	5.2	3.1	2.3
Pig's Liver	262	14.8	0.4	1.2	14.4	2.4	3.9
Ox 's Liver	271	7.5	2.4	4.5	6.5	5.4	1.3

Table 3. Polyunsaturated fatty acids and cholesterol in lean meat and offal [22–25] (as % total fatty acids).

formaldehyde, there would be the resistance in reduction and then results in increased potential of unsaturation in fat stores of ruminants. Because of the important role of meat in human diet, increasing its consumption rate through the years and considerable role in human health, numerous research studies were concentrated on different ways of fatty acid composition improvement in meat. Meat fatty acid composition can be changed through animal diet (feeding), certainly in single-stomach poultry and pigs where the alpha-linolenic, linoleic and long-chain polyunsaturated fatty acid contents respond suddenly to elevated dietary applications. Significant difference was found between grain and pasture-fed animal's fatty acid composition that gives higher polyunsaturated fatty acid concentration in pasture-fed animal groups [28].

Digestive characteristics of animals may affect composition of meat fatty acids. Microbial enzymes encourage the hydrolysis of unsaturated fatty acids that leads to an increased stearic acid concentration that reaches in small intestine and gets absorbed there. Trans-fatty acids are formed in beef as a result of the bio hydrogenation by rumen bacteria. The most common and well known in meat from ruminant animals is conjugated linoleic acid (CLA), which has been proved to prevent cardiovascular diseases, obesity and diabetes [29].

2.5. Minerals

Minerals are the nutrients present in food materials that do not contain the element carbon in them and required for the proper growth, development as well as maintenance of human body. They are divided into two categories i.e. macro- and micro-minerals, on the basis of their requirement by the human body. Macro-minerals are those ones, which are required by the body in larger amount. These include sodium, calcium, phosphorus, magnesium, chloride potassium and sulfur, while micro-minerals refers to those who are required in smaller amounts including iron, zinc, iodine, copper, cobalt, manganese, selenium and fluoride [30]. The following **Table 4** represents the micro- and macro-minerals of meat and meat products.

It is quite evident that potassium is quantitatively quite dominant mineral as compared to others i.e. followed by phosphorus, sodium and magnesium. Meat is also a very good source

Meat source	K	Cu	Fe	P	Zn	Mg	Na	Ca
Chopped Mutton, (raw)	244	0.15	0.99	174	4.2	18.8	74	12.5
Chopped Mutton, (grilled)	303	0.25	2.5	205	4.2	22.7	101	17.9
Beef, Steak (raw)	335	0.1	2.4	275	4.2	24.4	68	5.5
Beef, Steak (grilled)	369	0.22	3.8	302	5.8	25.1	66	901
Bacon (raw)	267	0.2	1.0	95	2.4	12.2	976	13.6
Bacon, (fried)	516	0.2	2.7	228	3.7	25.8	2792	11.6
Pork (raw)	399	0.1	1.5	224	2.5	26.2	44	4.2
Chopped Pork, (grilled)	259	0.1	2.5	179	3.6	14.8	60	8.2

Table 4. Mineral contents (mg/100 g) of meat and meat products [31, 32].

of iron, zinc and selenium. All these minerals perform variant functions for the growth, development and maintenance of human body that are described as follows.

2.5.1. Potassium

Potassium helps in metabolism, nerve impulses transmission, growth, muscle building and maintaining of acid–base balance in the human body.

2.5.2. Phosphorus

Phosphorus is an important mineral element that gives energy, forms phospholipids along with Ca, which involves the formation of bones and teeth.

2.5.3. Sodium

Regulates water content of the body, aids in transport of CO_2 and maintains osmotic pressure of body fluids.

2.5.4. Magnesium

Magnesium repairs and improves the growth of human body, maintains blood pressure, prevents tooth decay and helps to keep bones healthy.

2.5.5. Zinc

Zinc is the part of many enzymes, required for the body immune system, having role in cell division, growth and wound healing.

2.5.6. Selenium

Prevent cancer, poisonous effect of heavy metals and helps the body after vaccination.

2.5.7. Iron

Iron is one of the key mineral present in meat, which plays a vital role in human health and its deficiency causes several hindrances in the normal functioning of human body, particularly disturbs child growth and development [33]. The mode of metabolism of iron is quite different from the other mineral contents in the sense, that it is excreted and more than 90% of it is utilized internally in the body. Obligatory sources of iron and red blood cells disruption or losses are intestines, urinary tract, skin and also during menstrual bleeding among females. Its deficiency could be overcome primarily by the diet [34]. Iron is available in a number of food stuffs and occurs in two forms like heme and non-heme iron. The former one comes from the hemoglobin and myoglobin, so it is present in animal foods only and has a high degree of bioavailability that could easily be absorbed in the intestinal lumen [35].

2.5.7.1. Organ meat as a mineral source

It is quite evident that the offal organs are quite rich in the mineral contents like iron, zinc, and copper as compared to the minerals that are present in muscular tissues. The children on the fully vegetarian diet could lead them to retarded cognitive activity owing to zinc deficiency, so the ingestion of meat stuff has been emphasized [7]. Mineral contents of offal organs are depicted in **Table 5**.

2.6. Vitamins

Vitamins are a group of organic substances that function in a variety of dimensions in human body. These constituents although required in minute amounts and are very important for the proper growth, development and maintenance of the human body. They are especially required at the early age of life by the children. They partake in various metabolic processes involving series of chemical and biochemical reactions. One of their distinguishing features is that they generally cannot be prepared by the mammalian cells, so must be supplied through the diet [37]. They are generally classified into two groups on the basis of their solubility in water and fat i.e. water soluble vitamins and fat soluble vitamins. Water soluble vitamins include the B-complex vitamins (thiamin, riboflavin, nicotinic acid, pyridoxine, choline, biotin, folic acid, cyanocobalamin, inositol, vitamin-B_6 and vitamin-B_{12}) and vitamin C. Fat soluble vitamins of meat including vitamin A, vitamin D and vitamin K also participate in the nutritional importance of meat [38].

Meat is a good source of five of the B-complex vitamins including thiamin, riboflavin, nicotinic acid, vitamin B_6 and vitamin B_{12}. It also contains pantothenic acid and biotin, but a poor source of folacin [39]. Vitamin content of various raw meats is illustrated in **Table 6**.

Meat source	Fe	P	Na	Ca	Cu	Mg	Zn	K
Ox (Kidney)	5.6	231	182	9	0.5	16	1.8	232
Ox (Liver)	7.1	362	80	6.1	2.4	19.2	4.1	321
Sheep (Kidney)	7.5	242	221	10.2	0.5	17.1	2.5	272
Sheep (Liver)	9.5	371	75	7.1	8.8	19.1	4.0	291
Pig (Kidney)	5.1	272	191	8.1	0.7	19.1	2.7	291
Pig (Liver)	21.2	372	88	6.2	2.8	21.3	7.0	319
Brain	1.5	341	142	12.2	0.4	15.1	1.3	269

Table 5. Mineral content of offal tissues [22, 36].

2.6.1. Water soluble vitamins

2.6.1.1. Thiamin

It works along with other B-complex vitamins to carry out numerous chemical reactions required for the growth and maintenance of the human body. They are involved in the metabolic processes necessary for energy production to perform various body functions. Deficiency of thiamine could cause loss of appetite, fatigue, constipation, irritability and depression. Meat in general is a good source of thiamine with especial reference to fish which provides larger quantities of it as compared to other meat sources except pork.

2.6.1.2. Riboflavin

It is essential to release energy from the major food constituents like proteins, fats and carbohydrates. It helps in retaining good eye sight and healthy skin. It also aids in the absorption and utilization of iron. Moreover, it is required in the conversion process from tryptophan to niacin. Poultry meat, lamb and beef are considered among the good sources of riboflavin.

2.6.1.3. Niacin

Together with other B-vitamins, niacin functions in a variety of intracellular enzyme systems, including those involved in energy production. Its sources are meat, fish and poultry etc. Its deficiency causes the disease called as "pellagra" which is characterized by the rough or raw skin. Other problems include memory loss, vomiting and diarrhea.

Vitamin units/100 g raw meat	**Beef**	**Bacon**	**Mutton**	**Veal**	**Pork**
A (Inter. Unit.)	Trace	Trace	Trace	Trace	Trace
D (Inter. Unit.)	Trace	Trace	Trace	Trace	Trace
B_1 (mg)	0.06	0.39	0.14	0.11	1.2
B_2 (mg)	0.21	0.16	0.24	0.26	0.21
Nicotinic acid (mg)	5.1	1.6	4.99	7.1	5.2
Pantothenic acid (mg)	0.5	0.4	0.6	0.5	0.5
Biotin (μg)	2	8	4	6	5
Folic acid (μg)	9	Nil	2	6	2
B_6 (mg)	0.2	0.3	0.3	0.4	0.4
B_{12} (μg)	2	Nil	2	Nil	2
C (mg)	Nil	Nil	Nil	Nil	Nil

Table 6. Vitamin content of various raw meats [31, 36].

2.6.1.4. Vitamin B_6

Vitamin B_6 plays a vital role in the functioning of approximately 100 enzymes that catalyze the essential chemical reactions in the human body. It helps in the synthesis of the neurotransmitters and important in the synthesis of heme iron i.e. a component of hemoglobin. Additionally, it also helps in the synthesis of niacin from tryptophan. Important meaty sources of vitamin-B_6 are fish, poultry and meat.

2.6.1.5. Vitamin B_{12}

This vitamin is important for the synthesis of deoxyribonucleic acid (DNA), which is a gene-containing component of cell's nucleus, vital for proper growth and development of the human body. Vitamin-B_{12} is found only in foods of animal origin; therefore, vegans (vegetarians who consume no animal products) might have been needed to supplement their diet with this vitamin. Individuals who have pernicious anemia (inability to absorb vitamin-B_{12} from food) and do not consume vitamin-B_{12} can be treated successfully with injections of vitamin-B_{12}. Liver, beef, lamb and pork are rich sources of this vitamin. Some other sources are oysters, fish, egg yolk and cheese.

2.6.2. Loss of B complex vitamins during meat processing

Vitamins present in the meat get lost during its processing by both methods of conventional heating and microwave heating especially in case of vitamin B_1 [40]. The retention of both the vitamins B_1 and B_2 from different kinds of the meat by conventional cooking is shown in the table. The loss of vitamin B_1 was mainly observed by leaching. These losses are about 15–40% by boiling, 40–50% by frying, 30–60% through roasting, and 50–70% on canning [40]. Other vitamins of B complex family including B_6, B_{12} and pantothenic acid also exhibit same issues like B_1. Contrary to it, vitamin A has the ability to retain even at the temperature of 80°C. Loss or retention of B complex vitamins during conventional and microwave cooking is illustrated in **Table 7**.

Meat samples	Cooking method involved	Cooking losses water and fat (% initial weight	Vitamin B_1 retention in meat and dripping (%initial)	Internal temperature (°C)
Beef	Conventional	19–20	82–87	62.5
Beef	Microwave	28–38	70–80	70.5
Beef loaves	Conventional	24.2	76.5	85.5
Beef loaves	Microwave	27.3	79	84.5
Pork	Conventional	34.1	80.3	85
Pork	Microwave	36.7	90.8	86
Ham loaves	Conventional	18.4	91.4	85
Ham loaves	Microwave	27.8	87.2	84

Table 7. Comparison of cooking losses and vitamin B_1 retention in conventional and microwave cooking [31].

Meat source	B_1 (mg)	B_2 (mg)	B_3 (mg)	B_6 (μg)	B_9 (μg)	B_{12} (μg)	Vit. C (mg)	Vit. D (μg)	Vit. A (I.U.)
Brain	0.06	0.02	2.99	0.10	6.0	8.9	23.0	Trace	Trace
Sheep's kidney	0.5	1.9	8.4	0.32	31.0	54.9	6.9	Nil	99
Ox 's kidney	0.38	2.2	6.1	0.33	77.2	31.2	10.1	Nil	150
Pig 's kidney	0.33	2.0	7.4	0.24	42.1	14.2	14.3	Nil	110
Sheep's liver	0.28	3.4	14.1	0.43	220	83	9.9	0.49	20,000
Ox 's liver	0.22	3.2	13.5	0.84	330	109.7	23.0	1.14	17,000
Pig 's liver	0.32	3.1	14.7	0.69	110	24.8	13.2	1.14	10,000
Sheep's lung	0.13	0.5	4.8	Nil	Nil	4.8	31.2	Nil	Nil
Ox 's lung	0.10	0.4	4.1	Nil	Nil	3.2	38.7	Nil	Nil
Pig 's lung	0.10	0.3	3.3	Nil	Nil	Nil	13.1	Nil	Nil

Table 8. Vitamin contents (units/100 g raw tissue) of various offal tissues [22, 36].

2.6.3. Fat soluble vitamins

Vitamin A is a fat-soluble vitamin necessary for the maintenance of healthy tissues and for maintaining the normal vision and eyesight. Green and yellow vegetables provide most of the vitamin A and it occurs in the form of carotene (a precursor which the body converts to vitamin A). Milk and margarine are often fortified with vitamin A. Liver is suggested as the greatest single food source of vitamin A. It is also a good source of the other fat-soluble vitamins such as vitamin D and vitamin K [41]. Vitamin contents (water and fat soluble) of various offal organs are shown in **Table 8**.

3. Conclusion

This chapter concludes that meat and meat products have significant role in fulfillment and maintenance of human health. Studies indicated that strong nutritional composition (fats, proteins and carbohydrates) with minerals, vitamins and other functional compounds have a preventive role against major and minor nutrients deficiency diseases. This food material must be included as important proportion in balanced diet to meet the required health benefits. Proteins and amino acids are beneficial for growth and building of muscles in humans. Owing to the fats and fatty acid profile composition of meat, there is a point to be concerned about the consumption of meat because of the presence of saturated fats that cause coronary heart diseases and elevated cholesterol level if taken in higher than normal amount. Thus, intake of meat in balanced proportion must be according to the prescription of nutritionist and health practitioners. Additionally, minerals and vitamins including zinc, iron, selenium, sodium, copper, magnesium, calcium, potassium, phosphorus and vitamin A along with ample amount of B complex vitamins are considered as important constituents of meat, respectively, that are beneficial for overall human health stratum.

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Conflict of interest

The authors declare no conflict of interest.

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