General Article Chapter- 6

NUTRIENT REQUIREMENTS IN HEALTH AND DISEASE

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Abstract

Food is any nutritious substance that people or animals eat or drink, or that plants absorb, in order to maintain life and growth. There are many socio, physiological and psychological functions of food viz., Social, Psychological and Physiological. Social functions means sharing foods with any person. Food is an integral part of all the body functions. Food is also served for the religious purpose. Psychological functions i.e. Nutrition is the assimilation by living organisms of food materials that enable them to grow, maintain and reproduce. Good nutrition is an important part of leading a healthy life. Nutrition is a biochemical and physiological process by which an organism uses food to support its life. It includes ingestion, absorption, assimilation, biosynthesis, catabolism and excretion. Physiological functions are energy giving, body building, protective and regulatory functions. The energy giving functions of food is performed by carbohydrates and fats. This is why these nutrients are also called body fuels. Food is also required for growth and repair, which is done by proteins. The other major physiological functions performed are the protective and regulatory functions.

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Introduction

Food is any nutritious substance that people or animals eat or drink, or that plants absorb, in order to maintain life and growth. There are many socio, physiological and psychological functions of food viz.,

a) Social
b) Psychological
c) Physiological

Social Functions

It means sharing foods with any person. Food is an integral part of all the body functions. Food is also served for the religious purpose.

Psychological Functions

Nutrition is the assimilation by living organisms of food materials that enable them to grow, maintain and reproduce (Sujatha et al 2010). Nutrition is a set of integrated processes by which cells, tissues, organs and the whole body acquire the energy and nutrients for normal functioning, which can be achieved through dietary supply of the nutrients (Widdowson 1970). Good nutrition is an important part of leading a healthy life. Nutrition is a biochemical and physiological process by which an organism uses food to support its life. It includes ingestion, absorption, assimilation, biosynthesis, catabolism and excretion. The science that studies the physiological process of nutrition is called nutritional science. The organism provide themselves with carbon in one of the two ways:

i. Autotrophy:

The self production of organic food is called Autotrophy. It is the energy chiefly provided by photo chemical reaction.

a) Photolithotrophy – It is dependent on exogenous inorganic H donors.
b) Photoorganotrophy – It is dependent on exogenous organic H donors.

ii. Chemotrophy:

It is the energy provided entirely by dark chemical reaction.

a) Chemolithotrophy – It is dependent on growth of oxidation of exogenous in organic substances.
b) Chemoorganotrophy – It is dependent on growth of oxidation or fermentation of exogenous organic substances (Lwoff et al 1946).

Physiological Functions

These are energy giving, body building, protective and regulatory functions. The energy giving functions of food is performed by carbohydrates and fats. This is why these nutrients are also called body fuels. Food is also required for growth and repair, which is

done by proteins. The other major physiological functions performed are the protective and regulatory functions.

Importance of Nutrients

Food is composed of wide distribution of nutrients which have very specific metabolic effects on the human body. Nutrients are divided into two categories:

Macronutrients and Micronutrients

Macronutrients, needed in large amounts constitute the majority of an individual's diet. Essential nutrients are nutrients that cannot be synthesized by human body and therefore must be derived from food sources. Essential nutrients include vitamins, minerals, amino acids, fatty acids and some carbohydrates. Macro nutrients include carbohydrates, proteins, fats, macro minerals and water. Micronutrients include vitamins and traces. The body requires these vitamins in very small amounts, less than 100 mg/day.

Carbohydrates

They are the hydrates of carbon. These are the organic compounds essentially made up of three elements i.e. carbon, hydrogen and oxygen. Carbohydrates are widely distributed in plant foods. They are present in these foods in the form of three types of compounds called sugar, starches and fibre. Carbohydrates are the major source of energy that is ingested by the human body (Catfall and Mohnen 2009). Fibre in the diet is not digested by human body due to lack of cellulase enzyme.

Glucose is the major energy source in the body. Glycogen is the storage form of glucose and glycogen is stored in skeletal muscles and liver. Riboses are utilised in the formation of deoxyribonucleic acid (Hou and Lowary 2009).

Carbohydrates are polyhydroxy alcohol with potentially active carbonyl group which may be aldehyde or keto group. Carbohydrates can be classified on the basis of carbon atom present in the carbohydrates (Stortz 2009). Some examples of polysaccharides include starch, cellulose and glycogen (Heidelberger et al 1942). Glucose is the most important carbohydrate in human body (Paulsen et al 1968).

Carbohydrates are commonly classified as monosaccharide's, disaccharides, oligosaccharides and polysaccharides. Plants produce carbohydrates by photosynthesis. Carbohydrates are the reservoir of energy, they also play an important role in the structure and function of the body organs and nerve cells.

Carbohydrates: source of energy

1. Body distribution
2. Energy supplier
3. Regulation of fat metabolism
4. Regulates gastro intestinal function

Fibre is the non available carbohydrate. Fibres help in the elimination of unabsorbed food and prevention of diseases like cancer, diabetes and heart diseases. Some of the important functions of carbohydrates are energy giving proteins sparing action and utilization of fats the proteins can be broken down in the body to meet the energy requirements.

Proteins

Protein is the abundant component in the human body. It is made up of compounds called amino acids, these are also called building block of proteins. Those amino acids which cannot be manufactured by the body are called essential amino acids and those which can be manufactured by the body are called non-essential amino acids. They help to form, support and form protective structures such as cartilage, skin, nails, hair and muscle. They are major constituents of enzymes, antibodies, many hormones and body enzymes, many hormones and body fluids such as blood, milk and egg white.
Proteins: Body building foods

1. Maintenance and growth
2. Regulation of body processes
3. Energy supplier
4. Protection

Fats and Oils

Fats are a group of chemical compounds that contain fatty acids. They are composed of fatty acids and glycerol. Fats are smooth, greasy substances that are insoluble in water. Fat is associated with other fat soluble vitamins A, D. E and K. Lipids in the blood includes cholesterol low density lipoproteins and high density lipoproteins and triglycerides (Makni et al 2008).

Lipids are defined as hydrophobic biological substances generally soluble in organic solvents (Pereto et al 2004). These chemical properties cover a broad range of molecules such as fatty acid, phospholipids, sterols, sphingolipids, terpenes and others (Christie 2003).

Lipids are essential components of cell structure and play important roles in signal transduction between cells and body metabolism (de Santis et al 2019).
The term lipid has been defined as any of a group of organic compounds that are insoluble in water but soluble in organic solvents (Smith 2000). Lipids are small hydrophobic or amphiphillic molecules that are derived wholly or partially from the condensation of carbocation groups of isoprene units (Fahy 2005). Lipids form a variety of molecules through the combination of different types of building blocks, producing an extremely heterogenous collection of molecules. The functional groups are replaced by other atoms to form various molecular groups (Aro et al 2000). Some common fatty acids are stearic acid, soft acid and arachidonic acid (Lands and Hart 1966).

Lipid metabolism is the process that most of the fat ingested by the body is emulsified into small particles by bile and then the lipase secreted by the pancreas and small intestine hydrolyses the fatty acids in the fat into free fatty acids and mono glycerides.

Fats can be regarded as functional if they help in reducing the risk of disease and promote good health (Roberfroid 2000).

Lipids are known to reduce the risk of chronic disease beyond basic nutritional functions (Moreau 2011). Fatty acids play an important role in brain cell structure as 36-60% of nervous tissue in brain are lipids which include glycerophospholipids rich in DHA and AA, sphingolipids, cholesterol and its esters (Mc Namara and Carlson 2006) which influence the activities of membrane linked functional molecules.

Fats and oils

1. Body consumption
2. Energy store
3. Palatability

Vitamins

They help to protect our body from various kinds of diseases. They help to keep our eyes, gums, bones, and teeth in good shape.

1. Regulate metabolism
2. Help in growth and maintenance of body

Minerals

These are used by the body to perform various functions like building strong bones, production of hormones etc. The major five minerals are calcium, phosphorous, magnesium, sodium and potassium. Examples are leafy vegetables, fish, beans etc.

Water

It performs the essential function of absorbing nutrients from our food. It also helps to release waste from our body in the form of sweat and urine (Young 2001).

1. It protects your tissues, spinal cord and joints
2. It helps to excrete wastes
3. It helps to prevent constipation
4. It regulates your body temperature
5. It helps to create saliva

Nutrient Requirements

The amount of each nutrient needed is called the nutritional requirement. Nutrients have been commonly regarded as nourishment, providing raw materials needed for cells growth and proliferation and fuel for providing cellular metabolism. It is evident that nutrients and their metabolites are also active in the facilitation, regulation and coordination of the vast number of cellular processes that operate to maintain cellular homoestasis. (Tada et al 2011). Nutrients are substances used by an organism to survive, grow and reproduce.

The seven major classes of nutrients for animals and humans are carbohydrates, fibre, fats, proteins, minerals, vitamins and water. They are grouped as macronutrients (needed in larger quantities) and micronutrients (needed in smaller quantities). Nutrients are the constituents in food that must be supplied to the body in suitable amounts. These include carbohydrates, fats, minerals, vitamins and water.

The elements that are required in large quantities are carbon, hydrogen, nitrogen, oxygen, phosphorous and sulphur. The chemical compounds that are consumed in the largest quantities and provide bulk energy are called macronutrients. e.g. carbohydrates, proteins and fats. Others include calcium, sodium, phosphorous, potassium, magnesium, chloride ions, along with phosphorous and sulphur.

Nutrient requirements are expressed in terms of both the diet (amount per kilogram dry matter or per 1000 kilocalories) and in terms of the animals metabolic body weight. The requirement for an essential nutrient is the amount or concentration that is needed to maintain health or prevent disease.

An essential nutrient is a dietary substance that is required to maintain health or prevent disease in healthy animals. More than 40 essential nutrients have been identified in both dogs and cats. An essential nutrient is a nutrient required for normal physiological function that cannot be synthesized in the body – either at all or in sufficient quantities and thus must be obtained from a dietary source (Vaughan et al 2009).

Estimation of Dietary Reference Values

There is a range of acceptable intakes which is defined by the minimum amount required to prevent adverse effects resulting from deficiency to the adverse effects i.e. toxicity.

Nutrient Requirements are the quantities of nutrients that healthy individuals must obtain from food to meet their physiological needs. The Recommended Dietary Allowances (RDAS) are estimates of nutrients to be consumed daily to ensure the requirements of all individuals in a given population.

The National Academy of Sciences has published recommendations for Dietary Reference Intakes (DRIs) that are specific for the various stages of life. The DRIs apply to healthy people and are not designed for those individuals who are either chronically ill or who are at high risk of illness due to age, genetics or life style factors e.g. smoking, alcohol intake, exercise etc. The vegetables, fruits, whole grains and legumes can help to prevent weight problems and chronic illnesses including cardiovascular disease, diabetes and cancer.

There are 4 types of Dietary Reference values:

1. Estimated Average Requirements (EARs) – The EAR is an estimate of the average requirement of energy or a nutrient needed by a group of people (i.e. approx. 50% of people will require less and 50% will require more) (British Nutrition Foundation 2019). DRI is the general term for a set of reference values used to plan and assess nutrient intakes of healthy people. These values, which vary by age and sex, include:
2. Recommended Dietary Allowance (RDA): The average daily level of intake sufficient to meet the nutrient requirements of nearly all (97- 98%) healthy people.

3. Adequate Intake (AI): This is established when evidence is insufficient to develop an RDA and is set at a level assumed to ensure nutritional adequacy.
4. Tolerable Upper Intake Level (UL): It is the maximum daily intake unlikely to cause adverse health effects.

(DRIs) are a set of nutrient-based reference values that provide quantitative recommendations by gender, age, life stage, or physiological condition (such as pregnancy or lactation) for nutrient intakes of individuals living in the United States and Canada. The reference values include the estimated average intake (EAR), the recommended dietary allowance (RDA), the adequate intake (AI), the tolerable upper intake level (UL), and, for energy providing nutrients, the acceptable macronutrient distribution range (AMDR). DRIs provide nutrient standards that are used to shape various public policies, such as nutrient standards for school lunch programs, congregate and delivered elderly meal programs, and guidelines for the women, infants, and children supplemental feeding program. The DRIs are the basis for developing dietary advice for patients requiring medical nutrition therapy and to establish the daily values displayed on the nutrition fact panels of packaged food and supplements. (J. Dwyer, N.J. Armstrong, 2016). Dietary reference values comprises a collection of values defined as the recommended optimal nutrient intake to avoid deficiencies and prevent the most common chronic diseases in the population (Vinas and Majem 2019).

Nutritional Diseases

Proper nutrition offers one of the most effective and least costly ways to decrease the burden of many diseases and their associated risk factors, including obesity. (Turnbaugh et al 2007). Nutrition deficiencies or diseases result due to the poor nutritional intake, chronic health conditions, acute health conditions, medications, altered nutrient metabolism, immune function, bone formation and muscle function etc. These deficiencies vary by age, gender, race etc. (Centers for Disease Control and Prevention, 2016). The intake pattern of individuals can lead to nutrient deficiency among the general population. Dietary Reference Intakes (DRI) can lead to a decrease in how much of the nutrient is stored in the body and how much is available for biological functions. DRIs are based on age and sex and include Recommended Dietary Allowance (RDA), Adequate Intake (AI), Estimated Average requirement (EAR) and Tolerable Upper Intake Level (UL).

Toxic Effects of Nutrients

The principal guidelines for nutrient intake have been the Recommended Dietary Allowances (RDA) developed for many nutrients by the Food and Nutrition Board of the National Research Council (FDA 1977).

Our population is exposed to a variety of toxic substances. Some of these are from manufactured goods and some from air and water pollution. Toxins are also normally found in many foods.

Antioxidants are the best protectors of the damage caused by reactive oxygen species (ROS).

The most effective antioxidants are found in highly coloured fruits and vegetables such carrots, tomatoes and berries called carotenoids. Flavonoids (polyphenols) is another class of effective antioxidants that negate ROS, may or may not be coloured.

Nitrogen oxides are also implicated in free radical reactions and add to the destructive action of cells and membranes (Halliwall et al 1995). Other groups of antioxidants are the bioflavonoids and some closely related compounds such as elegic acid (Mimoto et al 2000). These compounds are mainly in the class of polyphenols (Bravo 1998). Flavonoids are the best protectors against deterioration of foods (Miller et al 2000).

Nutrient Allowances

Nutrition is a fundamental pillar of human life, health and developments across the entire life span. Good nutrition is eventual for survival , physical growth mental development , performance and productivity , health etc from the earliest stages of fetal development , at birth, though infancy , childhood adolescence, adulthood and old age, proper food and good nutrition. Food and nutrient security means access by food, diet and nutrients they need for a healthy life (de Onis et al 1998).

Hunger and malnutrition remain among the most devastating problems facing the majority of the world's poor and needy people and, continue to reduce the health of the world's poorest nations.

The nutrients are required throughout the different stages of the human life cycle. Some of the stages are

a) Nutrition during Infancy (0-1 years)

The earliest part of childhood is called the infancy. Good nutrition is essential for healthy growth and development. It is the period from birth to one year age. This effects the brain growth and helps in the development of nervous system, overall growth and development and future health.

b) Nutrition during Preschool years

The nutrition during these years is important for growth and learning and to provide energy for high activity. These types of children need nutrient dense foods, provides a good quality protein, vitamins and minerals to support healthy growth and development.

c) Nutrition during Childhood and Adolescence

Childhood is the time for children to be in school and at play to grow strong with good intake of nutrients. Adolescents are the persons between ages 10 and 19. They undergo a very rapid growth during their puberty. The nutrient needs of every teenager differs to a great extent. The factors that influence food and nutrition during adolescence are body images, media, eating disorders, overeating etc.

d) Nutrition during Adulthood

During adulthood, the adults should enjoy the wide variety of foods, eat regularly, maintain healthy body weight and feel good etc.

e) Nutrition during Old Age

During this age, the requirements once again change. It is a biological process that no one can avoid. People suffer from serious health conditions such as cardiovascular disease and cancer (Diet, Nutrition 1990). It is very important to that we develop new products and refined guidelines which will improve our health through diet (Irmak 2020).

Humanity is currently suffering from one or more of the multiple forms of malnutrition (Global Agenda 2000). The major consequences of malnutrition include death, disability, stunted mental and physical growth and as a result, retarded national socio-economic development. Some 60% of the 10.9 million deaths each year among children aged under five years in the developing world are associated with malnutrition (Childhood Nutrition 2002).

Methods for Assessment of Nutritional Status

Nutritional status refers to the state of health of an individual as it gets affected by the intake and utilization of nutrients (proteins, carbohydrates, fats, vitamins and minerals).

The direct methods used for assessment of nutritional status are given as under:

1. Anthropometric measurements
2. Biochemical assessment
3. Clinical methods
4. Dietary assessment

Anthropometric Measurements

It is the measurement of human body at various ages and level of nutritional status. The most commonly used measurements include:

a) Measurement of body weight
b) Measurement of crown heel length
c) Measurement of body circumferences
d) Body fat

The commonly used anthropometric indices to assess their growth status in children are weight, according to age, height/length for age and weight for height.

a. Weight for Age

Body weight means body mass and it constitutes all the body constituents like water, minerals, fats , proteins etc. Any small changes in body weight of individuals, mainly children over a short period of time due to poor diet or infection (such as diarrhoea etc.) may be due to malnutrition. Thus, weight is a good indicative of malnutrition.

b. Length/height for Age

This is commonly used to measure nutritional status. Length or height reflects the total increase in the size of individual in case of infants and children less than 2 years of age, length is known as crown heel length.

c. weight for Height

it is a very good index for short duration malnutrition. The low weight for height is indicative of wasting and of short duration malnutrition.

d. Anthropometric Indices in Adults

In case of adults, Body Mass Index (BMI) is used to assess the nutritional status. It is used to classify underweight, overweight and obesity in adults. BMI is defined as the weight (in kg) divided by the square of the height in meters.

BMI= weight (kg)/ height (m^2)

In children, mid upper-arm circumference (MUAC) is measured to assess the nutritional status of infants and children. It is useful measure to assess the thinness or muscle wasting in children.

Waist and Hip- Circumference measurement

Waist circumference (WC) as a tool is used to assess abdominal fat and health status in adults. Waist is measured around the navel in a standing position using a flexible non- stretchable tape. Men ratio is greater than 102 cm and women for it is 88 cm.

Clinical Assessment

It is one of the simplest and practical methods used to assess nutritional status. It is associated with physical signs and symptoms which we call as clinical signs to detect malnutrition. The clinical exam of mouth, eyes, skin, nails, tongue, muscle, bone etc is useful. This method of assessment is fast and is very easy to perform.

Biochemical assessment

It deals with measurement of level and essential dietary constituents which is helpful in evaluating the possibility of malnutrition. Anaemia is the most important widespread of all the nutritional deficiency found among individuals in our country. It is due to iron deficiency. This process is time consuming and expensive. It requires trained personnel and facilities.

Toxicity

The routine consumption of large amounts of vitamin A over a period of time can result in toxic symptoms, including liver damage, bone abnormalities and joint pain, headaches, vomiting and skin problems (Tucker 1996).

The potential toxicity of excess doses of vitamin C effects the metabolites in the urinary system. The intake of 2-3 gm/day of vitamin C produces unpleasant diarrhoea from the osmotic effects of the unabsorbed vitamin in the intestinal lumen in most people (Kubler and Gehler 1970).

Nutrient Profiling

It is defined as the science of classifying or ranking foods according to their nutritional composition related to preventing disease and promoting health (WHO 2015). The purpose of nutrient profiling is to provide a tool to classify food and food products that are in excess of free sugars, salt, total fat, saturated fat and trans fatty acids (Louzada et al 2015).

Dietary needs are met by the consumption of a variety of foods in a balanced manner. Nutrients, energy and phytochemicals are needed for good health throughout the life, but nutritional needs are still higher during childhood and adolescence, pregnancy and lactation. Growth and development of the body and its organs represent the first major challenges for obtaining sufficient amount of essential nutrients.

References

A global agenda for combating malnutrition: progress report. Geneva, World Health Organization, 2000 (document WHO/NHD/00.6)

Aro A, Mannisto S, Salminen, I., Ovaskainen, ML, Kataja, V, Uusitupa, M2000. Inverse association between dietary and serum conjugated linoleic acid and risk of breast cancer in postmenopausal women. Nutr. Cancer38: 151–157

Bravo, L. 1998. Polyphenols: Chemistry, dietary sources, metabolism and nutritional significance. Nutr. Res.56:317–333

British Nutrition Foundation, 2019. J. of Nutrition Science

Catfall KH and Mohnen D 2009. The structure, function, and biosynthesis of plant cell wall pectic polysaccharides. Carbohydrate Res. 344(14):1879-1900

Centers for Disease Control and Prevention [Internet]. Georgia: [updated 2016 Mar; cited 2016 Dec 5]. CDC's second nutrition report: a comprehensive biochemical assessment of the nutrition status of the U.S. population; [about 4 screens]. Availablefrom:https://www.cdc.gov/nutritionreport/pdf/4Page_%202nd%20Nutrition%20Report_508_032912

Childhood nutrition and progress in implementing the International Code of Marketing of Breast-milk Substitutes. Geneva, World Health Organization, 2002 (document A55/14)

Christie, WW. 2003. Lipid Analysis. 3rd edition. Oily Press, Bridge-water, UK

De Onis M, Blossner M and Villar J1998. Levels and patterns of intrauterine growth retardation indeveloping countries. European Journal of Clinical Nutrition. 52:S83–S93

De Santis CE , Ma J, Gaudet, MM, NewmanLA, Miller, KD, Goding Sauer A, JemalA, Siegel, RL2019.Breast cancer statistics.CA Cancer J. Clin.69: 438–451

Diet, nutrition, and the prevention of chronic diseases. Report of a WHO Study Group. Geneva, World Health Organization, 1990 (WHO Technical Report Series, No. 797).

Dwyer J, Armstrong N J 2016. In: Encyclopedia of Food and Health

FahyE, Subramaniam S, Brown HA, Glass CK, Merril, AH, MurphyRC, Raetz CR, Russell, DW, SeyamaY, Shaw W2005. A comprehensive classification system for lipids.J. Lipid Res.46: 839–861

Food and Drug Administartion, 1977. Fed. Regis.44:47688-47729

Halliwall BM A, Marcia S, Chirico A and Aruoma O L. 1995. Free radicals and antioxidants in foods and *in vitro*: What they do and how they work. Crit. Rev. Food Sci. Nutr.35:7-20

Heidelberger M, Hobby GL 1942. Oxidized Cotton, an Immunologically Specific Polysaccharide. Proc. Natl. Acad. Sci. 28(12):516–518

Hou D and Lowary TL 2009. Recent advances in the synthesis of 2-deoxy-glycosides, Review Article. Carbohydrate Res. 344(15):1911-1914

Institute of Medicine2006.Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients). Washington, DC: National Academies Press

Irmak S.*2020.* Comparative analysis of Nutrition Policies in WHO. European Member States. WHO Regional Office for Europe (Copenhagen, 1998).

Kubler W, Gehler J1970. On the kinetics of the intestinal absorption of ascorbic acid: a contribution to the calculation of an absorption process that is not proportional to the dose. International Journal of Vitamin and Nutrition Research. 40:442–453

LandsWE, Hart P1966. The control of fatty acid composition in glycerolipids. J. Am. Oil Chem. Soc.43:290–295

Louzada ML, Martins AP, Canella DS, Baraldi LG, Levy RB, Claro RM2015. Impact of ultra-processed foods on micronutrient content in the Brazilian diet. Rev Saude Pub. ;49:1–8. DOI:10.1590/S0034-8910.2015049006211

Lwoff A, Van NielCB, RyanPJ , Tatum EL1946. Nomenclature of nutritional types of microorganisms (PDF). Cold Spring Harbor Symposia on Quantitative Biology. XI (5th ed.). Cold Spring Harbor, N.Y.: The Biological Laboratory. pp. 302–303

MakniM., Fetoui H, Gargouri N K, El M. Garoui 2008. Hypolipidemic and hepatoprotective effects ofusing wheat biscuits diet followed by mustard biscuits flax and pumpkin seed mixture rich in n-3 and n-6and defatted mustard diet. Chemical Toxicol., 46: 3714-3720

Mc Namara, SE Carlson2006. Role of omega-3 fatty acids in brain development and function: potential implications for the pathogenesis and prevention of psychopathology Prostaglandins Leukot. Essent. Fatty Acids, 75 pp: 329-349

Miller, HE, Riedhof F, Marquart L, Prakash A, and CantorM.2000. Antioxidant content of whole grain breakfast cereals, fruits and vegetables. J. Am.Coll.Nutr.19S:312S–319S

Mimota, J, Kiura K, and Matsuo K. 2000.Epigallocatechin gallate canprevent cisplatin-induced lung tumorigenesis in A/J mice. Carcinogenesis. 21:915–919

Moreau, RA, 2011. An overview of functional lipids. In: 102nd AOCS Annual Meeting and Expo, Duke Energy Center, Cincinnati, Ohio, USA

Paulsen H, Todt K 1968. Cyclic monosaccharides having nitrogen of sulfur in the ring, Adv Carbohydr Chem Biochem 23(4):115-232

PeretoJ, Lopez-Garcia P, and MoreiraD. 2004. Ancestral lipid biosynthesis and early membrane evolution. Trends Biochem. Sci. 29: 469–477

Roberfroid 2000. Concepts and strategy of functional food science: the European perspective Am. J. Clin. Nutr., 71 pp.:1660S-1665S

Smith AD. Oxford Dictionary of Biochemistry and Molecular Biology. Oxford University Press, Oxford: 2000

Stortz CA, Johnson GP, French AD, Csonka GI 2009. Comparison of different force fields for the study of disaccharides. Carbohydrate Res. 344(16):2217-2228

Sujatha J, Kumar A, Lathaa B 2010. Prenatal diagnosis of glycogen storage disorder type III, Indian Pediatr. 47(4):354-355

Tada N, Maruyama C, Koba S, Tanaka H, Birou S and Teramoto T2011. Japanese dietary lifestyle and cardiovascular disease. J. Atheroscler Thromb.18(9):723–34

Tucker K L1996. Folic acid fortification of the food supply. Potential benefits and risk for the elderly population. Journal of the American Medical Association, 2776:1879–1885

Turnbaugh PJ, Ley RE, Hamady M, Fraser-Liggett CM, Knight R and Gordon JI2007. The human microbiome project. Nature 449:804–10

Vaughan JG, Geissler C, Nicholson B, Dowle E, Rice E 2009. The new Oxford book of food plants. Oxford University Press US. pp. 212–. ISBN 978-0-19-954946-7. Retrieved 13 October 2010.

Widdowson, E. M. 1970. The harmony of growth. The Lancet 1:901-90

World Health Organization2015. Guiding principles and framework manual for the development or adaptations of nutrient profile models. Geneva: WHO; (in press)

Young VR. W.O. Atwater Memorial Lecture and the 2001 ASNS President's Lecture. Human nutrient requirements: the challenge of the post-genome era. Journal of Nutrition, 2002, 132:621–629