Chapter 10
Malnutrition of Micronutrients and Brain Disorders

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Abstract Nutrition is the provision of adequate amounts of nutrients and energy needed for all human body that playing an important role in the development and function of all the human body cells. In contrast, the poor nutrition is playing the opposite effects for having brain disorders. The current chapter aimed to cover the link between malnutrition and brain functions and developments with a special focus on the best nutrients needed for brain functions. Previous data have been illustrated that good and enough nutrients especially micronutrients have important role for a healthy brain. For instance, some amino acids, vitamins (V.A and C), and minerals (iron, iodine, and zinc) show good correlation to the cognitive development. However, any lack or deficiency shown changes in behavior, cognitive, and socio-emotional functions in addition to some disturbances in learning and memory. Therefore, it is important to have enough nutrients needed for the human body depending on the activities, age, and gender achieved by the nutritional assessments process and that could be evaluated with different tools in order to decrease the incidence of morbidity and mortality levels. Somedifferentguidelines have beenestablishedthrough many years within different countries and cultures with the main dietary elements (e.g. micronutrients) needed. Some of them have been demonstrated in the current review especially for the brain well-being in addition to some more concepts with different common malnutrition brain disorders that have been correlated well with the balanced and/or unbalanced diets such as Parkinson disease (PD).

Keywords Phytochemicals · Herbal Medicine · Traumatic Brain Injury · Neuro-inflammation · TBI · Oxidative stress

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Abbreviations

A	Anthropometric measurements
Ach	Acetylcholine
B	Biochemical analysis
C	Clinical examinations
CNS	Central nervous system
D	Dietary intake methods
DRA	Daily requirement allowances
FGP	Food guide pyramid
GIT	Gastrointestinal tract
GM	Gut microbiota
IBD	Inflammatory bowel diseases
LC -PUAs	Long-chain polyunsaturated fatty acids
PD	Parkinson disease
PEM	Protein-energy malnutrition
SCFA	Short chain fatty acids
T2D	Type 2 diabetes

10.1 Introduction

Unbalanced gut microbioma (GM) known as dysbiosis have been linked with different health problems. Consuming insufficient nutritional requirements relying on the generation of unhealthy GM so nutritional therapy is necessary for well-being in order to improve the human health stats. Additionally, recently evidence has been shown good correlation especially within unhealthy diets; influenced by either the microbial populations and/or their metabolic activities and that have been correlated in different diseases. Actually, malnutrition could be caused by many other factors such as increase/decrease levels of food intake, malabsorption, and recently GM. Having unbalanced meals show weak immune system that correlated with the immunodeficiency diseases with especial refer to inflammation in both intestinal and peripheral tissues including adipose tissue, muscles, liver, and brain in addition to obesity, type 2 diabetes (T2D), cardiovascular diseases, and inflammatory bowel diseases (IBD), etc. (Rowland et al. 2018; Blumberg and Powrie 2012a, b; Khalil et al. 2013). Such problems have been recognized within the developing areas all over the world and well known by the malnutrition diseases. It is most documented within the infants and children with many effects especially to the brain developments (Muller and Krawinkel 2005; WHO 2013; Tette et al. 2015; Karavida et al. 2019). Such subjects are in high demand for nutritional needs as their nervous system still in the developmental stage, while the older subjects have their own developed brain that controls all the entire body with any nutritional deficiency (Dhopeshwarkar 1983). Consuming poor nutritional diets has been documented

since 1966 that nutritional deficiencies affected the brain functions; alteration with the brain structures that show low levels of the brain size and growth (Levitskya and StrÃœPP 1995; Karavida et al. 2019). Such data was observed firstly within the animal models (rats, mice and pigs; Dickerson and Dobbing 1966; Winick and Noble 1966; Chase et al. 1967; Culley and Lineberger 1968; Zamenhov et al. 1971; Randt and Derby 1973; Smart and Bedi 1982). Indeed, it affected many young children with different brain's parameters such as changed behavioral in addition to the IQ (intelligence) tests (Dhopeshwarkar 1983; Tette et al. 2015). The most effective nutrient affecting the brain development is protein and its malnutrition is called protein-energy malnutrition (PEM). Interestingly, different studies revealed the effects of PEM on the brain development especially the ones described between the children in their clinical data such as tissue damage and contents in addition to the brain size. It has been also confirmed that long-term PEM affected the maternal and child health negatively (Udani 1991; Black et al. 2008; Karavida et al. 2019). On the other hand, preventive PEM improved the physical growth, mental development additionally to social and academic performances (Udani 1992; WHO 2013). Thus nutrition shown to be a vital factor for the human health worldwide in any age group that has been influenced by consuming either healthy/balanced or unhealthy/unbalanced diets that consequently will increase our community benefits. Indeed, normal healthy infants will have normal healthy life; playing, laughing, and growing free of any diseases (Black et al. 2008; Tette et al. 2015). Additionally, healthy children will gain good levels of education and school achievements especially with normal healthy bodies and brains; ability to communicate well with the environment and learn (Karavida et al. 2019; Guesry 1998). Consequently, they all will grow up in healthy normal socioeconomic styles with healthy life cycles which will affect all fields or sectors of the human community such as educational, healthy, and economic sectors (Karavida et al. 2019; Tette et al. 2015). Therefore, the current chapter is highlighting different concepts of nutrition in correlation to the brain development in health and disease. In order to explain such role, it is important to introduce different related definitions of what the meaning of nutrition and malnutrition are in addition to the food guides established? Explaining the main factors/causes affecting the malnutrition diseases in addition to the different symptoms? Additionally, how the nutritional assessments process could be evaluated with different tools that needed to recognize any symptoms in order to decrease the incidence of morbidity and mortality levels. Finally, the main dietary elements (micronutrients) needed for the brain well-being is illustrated in addition to some more concepts with different common malnutrition brain disorders that have been correlated well with the balanced and/or unbalanced diets such as Parkinson disease (PD).

10.2 Gut Microbiota

Unbalanced colonic microbioma known as alternated gut microbiota or dysbiosis have been linked with many human health problems. It has been shown good or bad effects with especial correlation with the dietary intake depending on the nutrients available. So GM is an important factor for the malnutrition diseases as discussed previously with especial refer to the brain disorders such as Parkinson disease (PD). However, it is important to know what are the nutrition and malnutrition meaning in terms of dietary factors or main consumed nutrients. Our brain needs many nutrients for its development but the main nutrient that is responsible for brain disorders is not well defined. As we have discussed, consumption of western diets (low in fruits, vegetables and dietary fish levels) mainly in developed countries is associated with brain disorders. Also, some researchers worked on different micronutrients such as amino acids, omega-3-fatty acids, V.B, iron, zinc, and iodine, and all of them have shown to play a vital role in the IQ levels and essential for brain health so it is best to control such conditions by following a well-balanced healthy diet.

10.3 Nutrition and Malnutrition Definitions

No doubt that, nutrition is very important factor for human well-being; it is the key point that of course acting importantly in the human health and diseases. The malnutrition concept known as well as many words such as poor nutrition, under-nutrition, unhealthy, imbalanced/unbalanced diets and that has been defined recently by World Health Organization (WHO 2013) either by any deficiencies and/or any excesses in the intake of energy and/or nutrients (protein, carbohydrates, fats, minerals, and vitamins) that could be recognized by different symptoms. Such definition was meant before that by having no enough access to basic daily food needs in order to meet the nutritional well-being and all of that depends on many factors. Previous data illustrated that the malnutrition is the body state that less or more energy, protein, and micronutrients consumptions responsible for measurable adverse influence on the health/body state starting from the body shape, size, composition, and functions (Younis et al. 2015).

In contrast, nutrition has been defined as the provision of adequate amount of energy and nutrients. All in total required for the human cells to enable them functionally healthy by performing their physiological function such as cell growth, reproduction, defense, repair, etc. that could be used as an indicator of the human nutritional status (Stratton et al. 2003; Younis et al. 2015). Having different varieties of enough required nutrients (micronutrients) in addition to the terms of probiotics and prebiotics are needed for all the body health, growth, and activities. These requirements are needed and this depends on many factors such as age, gender, health, and activities, however, all the factors should be laying on a well-balanced diet (have all the required nutrients) in order to maintain appropriate growth and

healthy life (Chapman 2011; Younis et al. 2015). Thus, a well-balanced diet that is required for the prevention of starvation and the treatment of malnutrition should have sufficient nutrients or elements depending on the DRA needed.

10.4 Micronutrients

The nutrients needed for the human well-being could be found mainly in two categories. The first one is called the macronutrients as it is required and needed in big amounts daily for all the human subjects. While the other called micronutrients and that are needed in little tiny amounts for all the peoples (Black et al. 2008). The provision and required daily amounts of both sets always help to modify and reduce the malnutrition diseases depending on the human health status, activities, age, and gender. They also have different dietary sources that can be found from the main dietary food groups. The macro ones mainly can be found within carbohydrate, protein, fat, and fiber groups while the micro mainly found in both fruit and vegetable groups (WHO 2013). Previously, the food guide pyramid (FGP) and any guided tool designed to explain all such food groups needed for human health stats and it has been designed to cover the required serving size for adult healthy subjects (Sarac and Butnariu 2020).

10.4.1 Food Guides History

The different guides especially the FGP have long established history especially the USDA guides (Fig. 10.1). The first established guide was from 1916 to 1930s and that was focusing on the protective foods based on the food groups and household evaluations. Afterwards within the 1940s, they developed the previous guide to be depended on the serving needed from the sevens food groups and that was considered complex. Later on and especially from 1956 to 1970, the guide has been changed to have basic four food groups and mainly was meant by food for fitness so excluded the fats, sugars, and calorie amounts. However, the following guide that was excited at 1979 included a fifth group that recommended to moderated levels of fats, sweets, and alcohol. By 1984, a new guide was designed as a circle and has been called the food wheel (Welsh et al. 1992; Haven et al. 2006). It was including the five main food groups formed the FGP with three calorie levels for all the food provided. So the following guide was the FGY at 1992 that was established by the US department of Agriculture and used for most last two decades so it is closer to the current used one as it was developed with the consumer searching the awareness of new food patterns. Additionally, such guide was including the daily amounts of the foods across three levels of calories (Sarac and Butnariu 2020). Such FGP was later on updated at 2005 and known as Mypyramid which meant the *Dietary guidelines for Americans* with 12 levels of calories with simplified illustration with each daily

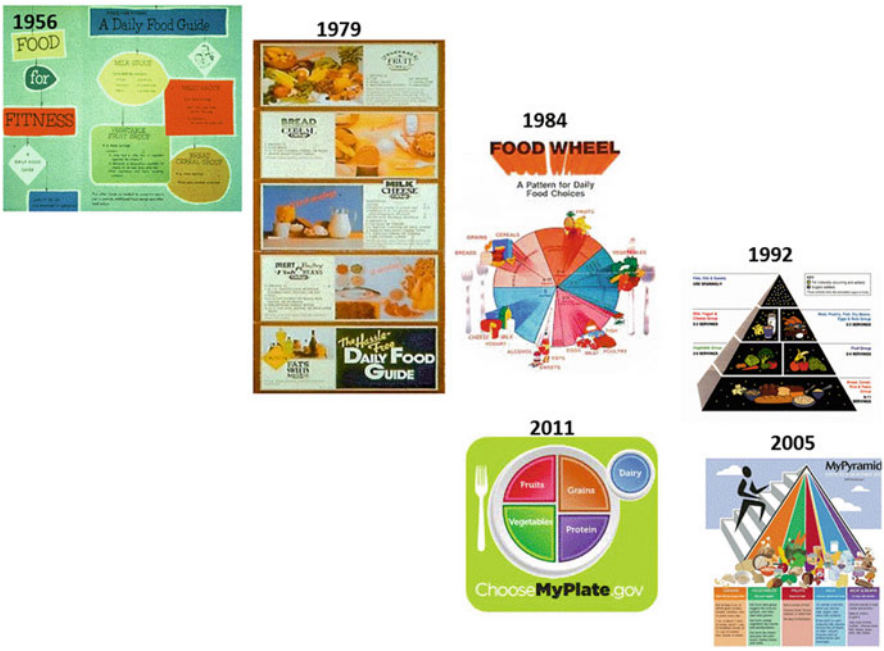

Fig. 10.1 Modified from Center for Nutrition Policy and Promotion (2011).

serving size for all the food groups. Recently, the updating USDA guide was established at 2011 with different shape and has been known as Myplate as especial *Dietary guidelines for Americans* as well (Fig. 10.1).

10.4.2 Food Guides Groups

It can be seen that, Fig. 10.1 illustrated that the food groups cover the main macronutrients and micronutrients have been divided on all the guides levels (Good eating, Foods for fitness, Hassle-free daily food guide, Food wheel, FGP, Mypyramid, and Myplate). Currently, different many countries and societies have their own guide over the past decade as their needs are vary depending on their cultures and traditional. For instance, the Australian has their own Australian Dietary Guidelines that has been established by 2013 and advised for a balanced healthy diet in addition to encouraging Australians to have different food choices within every food groups (Nutritional Australia Vic Division 2015). Additionally, the Saudi Arabian society has it is own related figure but it has been designed in the tree shape called the Nutritional Naghla (El-naghla Al-ghzaia; Fig. 10.2) that has been

Fig. 10.2 The Nutritional Naghla (El-naghla Al-ghzaia; the healthy food palm). The healthy food palm created by El Bcheraoui et al. (2013)

created by El Bcheraoui et al. (2013). All guides meant to cover the healthy adult daily requirements over all the past years.

All the food guides and pyramids established and developed with their food groups in order to eat well for obtaining good health with healthy eating patterns with the principles and ability to improve the quality of life additionally to reduce the chronic diseases levels. Any food guide is the best tool for being aware of the required nutrients needed for our body in adequate levels depending on the daily requirement allowances. The pyramids should be observed from the bottom to going up to the top as shown with all the food groups with required serving sizes.

10.4.3 Food Groups Serving Sizes

The food serving sizes listed in the pyramids illustrated by big amounts or serving sizes of the required and consumed nutrients in the bottom (carbohydrates; cereal group). However, it is declined toward the top of the pyramids with small consumed amounts. Such serving size levels have been illustrated within the following table (Table 10.1) in all the required food groups.

It is important to follow the serving sizes recorded within each age group as listed in Table 10.1 in order to keep well with healthy health stats. Also it is vital factor to

Table 10.1 Food serving size needed for each group of ages

	Food groups serving size needed						
Age (Y)	Cereal (B)	Vegetable (S)	Fruit (S)	Meat, fish, and Eggs (g)	Milk and milk products (S)	Fats	Liquid (G)
Children (2–5)	1.5–3	At least 1.5	At least 1	60–120	2	Very little	4–5
Children (6–11)	3–4	At least 2	At least 2	120–200	2	Little	6–8
Teenager (12–17)	4–6	At least 3	At least 2	200–300	2	Little	6–8
Adult	3–8	At least 3	At least 2	200–320	1–2	Little	6–8
Elderly	3–5	At least 3	At least 2	200–250	1–2	Little	6–8

The above used letters indicated that Y: years, B: bowls, S: servings, g: grams, G: glasses. Table and data modified (modified from Sarac and Butnariu 2020).

reduce the risk of any diseases especially the chronic malnutrition diseases that are in high prevalence levels worldwide such as diabetes, cardiovascular diseases, cancers, obesity, etc. (Sarac and Butnariu 2020).

10.5 The Prevalence of Malnutrition Diseases

The estimated malnutrition disorders worldwide are different from area to area over the years. Most prevalence under-nutrition has been seen mainly within the developing countries with different micronutrients deficiencies. Previously and especially in 2008, it has been estimated that about 14% of the population worldwide had poor nutritional health state. For instance, deficiencies recognized with different minerals and vitamins such as iron, zinc, and vitamin A (V.A). Iron deficiency conducted with five billion subjects while V.A was shown nearly between 130 million pre-school children. Additionally, about 33% people from the developing areas show low zinc levels (Younis et al. 2015). Also, increased unhealthy children numbers less than 5 years of age was illustrated in different areas such as Africa, Asia, Latin America, and the Caribbean. Again, malnutrition subjects that were mostly from children and women were higher than 2000 million subjects especially who were on poor dietary supplementations; micronutrients deficiencies mainly again iron, V.A in addition to the iodine. Additionally, other data show that being ill and/or death have been contributed with under-nutrition state globally; about 53% deaths with little children. Moreover, the World Bank, UNICEF, and WHO proved that 161 million globally of children less than 5 years of age were stunted in 2013 with one-third of them in only Africa. Consequently, such malnutrition disorders should be controlled by different dietary supplementations that should have balanced diet with all the required nutrients (Carbohydrates, proteins, fats, vitamins, and minerals; Sarac and Butnariu 2020) needed depending on their required serving sizes for each age groups. Otherwise, high levels of infections and death worldwide will be increased in addition to increase the risks of delayed cognitive development, high levels of other diseases such as stunting, wasting, and underweight in addition to the micronutrient deficiency either from minerals or vitamins (Calcium, Iron, Iodine with Vitamin A, B, and C deficiencies). Consequently, it can cause low income and low economic growth (Tette et al. 2015). Therefore, it is important to know what the different factors are affecting such unhealthy nutritional state in order to control and promote it in order to improve the human nutritional states within healthy diets consumptions.

10.6 Factors Affecting the Malnutrition State

There are many different factors contributed to the malnutrition disorders over the entire world. For instance, the income especially the low levels that known as poverty. The families are unable to provide the required amounts for their members of foods such as high quality dietary protein sources (meat, eggs/milk), vegetables, and fruits. Again the education levels, the well-educated parents always care about their children health state with controlling their healthy eating patterns. Also, different circumstances such as the starvation or the wars that will affect the economic levels with all the country in order to provide the required amounts of foods for all the society (Black et al. 2008). However, the unfound or unproven nutrients will cause different response/symptom or diseases. So all different factors affecting the unhealthy human state coming to the same point at the end; not consumed the adequate amounts of the dietary foods with no place in the societies having high levels of both knowledge and educations (Sarac and Butnariu 2020). Thus the provision of the optimal nutrition is an important factor for good health; otherwise different symptoms will be elevated depending on the shortage of the nutrients and founded disease (Cusick and Georgieff 2016). Additionally and most important is the recognition process of any malnutrition disease (nutrient deficiency evaluation; it is a long process that called nutritional assessment process).

10.7 The Nutritional Assessments Process

In order to recognize any of the previous malnutrition symptoms, there is a required process called nutritional assessment that is needed to analysis and evaluated the nutritional health state of any individual. It could be evaluated and measured with different tools and it is normally used to decrease mainly the incidence of morbidity and mortality worldwide. As it has been reported previously such nutritional assessment method has been used in order to know or even expect the prevalence of any disease that could be resulted in avoiding and decreasing deaths levels. Additionally, early detection means early cure plane as it could be used to help identify and decrease the incident of different illnesses such as diarrhea and Malaria. Therefore, evaluating the health state will help in choosing the suitable nutrients for different treatments to recover from illness, increase the quality of life and overall good outcomes. There are four tools for such assessments which are Anthropometric measurements (A), Biochemical analysis (B), Clinical examinations (C), and Dietary intake (D). All the examinations A, B, C, and D will be used as an indicator for the human health state in relations to nutrition state to avoid different malnutrition disease such as the brain disorders that could be resulted by some nutrient deficiency and in contrast could be avoided by different nutrient supplementations as the following.

10.8 Malnutrition and the Brain Disorders

Different nutritional deficiency diseases have been linked to the brain development throughout the effects on the brain neurons; the main brain cells. Also, the interactions between the neurons will be vary and affecting the memories and actions in addition to the transmissions between the cells by its neurotransmitters (Gundersen et al. 2015; Altomare et al. 2017). They are consist mainly of two sets, the first is the inhibitory while the other is excitatory which exogenous components are the main produced for both of them and that of course leads will be shaped by the supplemented nutrition needed for the brain developments (Szabadi 2013). For instance, the world health organization (WHO) demonstrated that the mental disorders ranging from 4.3 to 26.4% all parts of the world with high levels in the developed countries especially consuming the western diets as they are in low levels of fruits and vegetables consumptions additionally to less in dietary fish as well (Lakhan and Vieira 2008; Altomare et al. 2017). Additionally, different studies measured the nutrients either macro or micro ones that can affect the brain developments especially within the earlier ages. For example, Altomare et al. (2017) highlighted the effects of some macronutrients and micronutrients as follows (Table 10.2).

The most low prevalence three minerals used as examples for the micronutrients are iron, zinc, and iodine which show a vital role within the IQ levels that have been amplified by ten points worldwide. Additionally, three different vital vitamins used as examples as well for the brain development and their deficiencies demonstrated different symptoms as shown in Table 10.2. Data obtained from different previous studies as mentioned below the table (Mendoza-Salonga 2007; Altomare et al. 2017; Karavida et al. 2019).

Additionally, different studies show that some nutrients such as the amino acids are the main component of the neurotransmitters which is essential for brain and mood health and any deficiency will be resulted in different mental disorders (Altomare et al. 2017). Again, different vitamins and minerals such as V.B in addition to the omega-3-fatty acids are precursors for the neurotransmitters. Table 10.3 illustrates the main neurotransmitter dietary sources in addition to their functions and the symptoms of their declined levels. Table 10.3 shows that the nervous system main neurotransmitters are acetylcholine (Ach), adrenaline in addition to serotonin and endorphines. The first one which is the acetylcholine (Ach) is not presented in the food as it is but is built from choline (found in lecithin and phosphatidylcholine). It is very important for the brain development and memory processes with special help in the process of digestion and breathing. As it is illustrated in Table 10.3, the rich dietary sources are Yolk, Peanuts, Wheat germ, Meat, Fish, Cheese, and vegetables such as Cruciferous. Again, adrenaline which is mainly synthesized from phenylalanine is vital element for the gastrointestinal (GI) relax in addition to the heart rate increases. It is also important for the blood flow rate to the muscles, liver, and brain. The most dietary sources for such element has been found in many foods such as Walnuts, Almonds, Meat, Cheese in addition

Table 10.2 Some nutrients needed for the brain development, their dietary sources and deficiency symptoms

	Macronutrient		Micronutrient					
	Protein	LC-PUFAs	Iron	Zinc	Iodine	V.A	V. B6	V. D
Deficiency symptom	Smaller brain, low RNA/DNA contents, less neurons, low neurotransmitter and growth factor levels.	Cognitive and attention with neurotransmitter system problems	Brain development as it is modifies the epigenetic landscape of the brain.	Poor learning, attention, memory and mood.	Low neurogenesis, neuronal migration, brain weight. Poor hearing, speech and IQ levels.	Malformations of the fetal brain and hydrocephalus	Cofactor for developing CNS, alteration in the glutaminergic neurotransmitter system	Brain development, Schizophrenia and child autism
Dietary sources	Meats, fish, and all protein dietary sources	Fish sources	Dietary iron heme-sources	Green protein and vegetable sources	Dietary supplementations	Green vegetables and fruits	Beans and legumes	Exposure to the sun

LC-PUAs: long-chain polyunsaturated fatty acids, CNS: central nervous system (modified from Mendoza-Salonga 2007; Altomare et al. 2017; Karavida et al. 2019)

Table 10.3 Some different dietary neurotransmitters sources with their functions and declined symptoms

	Substrate	Jobs and functions	Declined symptoms	Food sources
1	Acetylcholine (ach; choline)	1. Helps digestion and breathing. 2. Memory processes.	Mental disorders	Yolk, peanuts, wheat germ, meat, fish, cheese, and cruciferous
2	Adrenaline (phenylalanine)	1. GIT health (relax). 2. Heart rate. 3. Blood flow (muscular, liver, and brain).	Mental retardation	Walnuts, almonds, meat, cheese and most fish (cod, crab, lobsters, mussels, oysters, tuna, salmon, and sardines).
3	Serotonin (tryptophan)	1. Acts on sleep manner. 2. Stimulates the intestinal peristalsis. 3. Sexual performance and perception of appetite.	Pain, hunger, depression, hypertension, poor memory, and migraine	Tryptophan; coca, bananas, green vegetables, almonds, whole grains, meat, legumes, yeast, and fish.
4	Endorphins	4. Transmits the sensations of pain to all the body parts and in the brain.	Migraines and headaches	Chocolate, sweet, sugar, and also chili with spicy foods.

Modified from Altomare et al. (2017)

to most fish such as Cod, Crab, Lobsters, Mussels, Oysters, Tuna, Salmon, and Sardines (Table 10.3). Serotonin is also can't be found in the foods but it is synthesized from the tryptophan that is an essential to be driven from the foods. It is important for the brain development as it is inhibitory neurotransmitters. Tryptophan is needed for many important processes such as sleep manners and it stimulates the intestinal peristalsis, sexual performance, and perception of appetite. The main foods for tryptophan are coca, bananas, green vegetables, almonds, whole grains, meat, legumes, yeast, and fish (Table 10.3,k). Finally, endorphins are important neurotransmitters that are mainly founded in the spinal cord. It promotes the body and the brain functions especially by transmitting the sensations of pain to all the body parts and in the brain. It can be produced by eating different foods such as chocolate, sweets, and sugar and also consuming chili with spicy foods can promote its production as well (Table 10.2). Finally, different brain disorders have been correlated well with the balanced and/or unbalanced diets such as (PD).

10.8.1 Dietary Intervention and Parkinson Disease (PD)

The human diet consists of nutrients like fats, carbohydrates, protein, vitamins, and minerals, in different percentages (Wakabayashi et al. 1992). Microbial populations colonize and influence many aspects of healthy nutrients and energy in the human

large intestine through the fermentation of non-digestible oligosaccharides known as prebiotics (Roberfroid 1997; Shen et al. 2011). Probiotics are a practical and efficient alternative for adjusting the colonic bacteria composition by raising the levels of bacteria (such as Bifidobacteria and Lactobacilli) that are also the targets of prebiotics (Collins and Gibson 1999; Bouhnik et al. 2004). The prebiotic concept was re-defined recently as "a selectively fermented ingredient that results in specific changes in the composition and/or activity of the gastrointestinal microbiota, thus conferring benefit(s) upon host health" (Roberfroid et al. 2010). Total microbiota and relative species levels depend on many factors such as illness, antibiotics, the host immune system, digestive and other secretions, stress, and diet. Some studies indicate that the composition of the gut microbiota can either promote a healthy or inappropriate immunological response leading to disease (Shen et al. 2011). However, their beneficial impacts lead to their use as probiotics in the food industry. Severe malnutrition leads to immune-deficiency and over nutrition also has been linked with diseases such as diabetes and obesity that are well known to affect immune functions. The fermentation end products are in large part composed of short chain fatty acids (SCFAs, e.g. acetate, propionate, and butyrate) that are rapidly absorbed and represent 40–50% of the available energy within the dietary fiber (Roberfroid et al. 2010). The composition of the gut microbiota and the substrates available influence the amounts and the types of SCFA produced.

Parkinson disease (PD) is the second most common neurodegenerative disorder after Alzheimer's disease (AD) which affects approximately seven million people worldwide and its incidence is between 8 and 18 per 100,000 person–years Additionally, the prevalence (proportion in a population at a given time) of PD is about 0.3% in industrialized countries of the whole population. The prevelance of it between the elderly people is at high risk; about 1% in those over 60 years of age to 4% of the population over 80 of the prevalence rises. Many risk factors and protective factors have been proposed, sometimes in relation to theories concerning possible mechanisms of the disease, however, none have been conclusively related to nutritional evidence. Dietary protein has been in a great advance for those patients as they use the same transportation system in the intestine and the blood–brain barrier, thereby competing for access and these results in a reduced effectiveness of the drug. Therefore, well-balanced Mediterranean diet is recommended and low-protein products such as bread or pasta is recommended for similar reasons. However, protein intake should be restricted during breakfast and lunch but was being allowed in the evening. A balanced diet, based on periodical nutritional assessments, is recommended and should be designed to avoid weight loss or gain and minimize consequences of gastrointestinal dysfunction. Thus nutritional therapy is necessary in different brain disorders such as PD patients for alleviating malnutrition caused by the decrease of food intake, malabsorption, accelerated nutrient loss, and increase of nutritional requirements. Recent studies indicated that nutritional supplementation could not only improve nutritional states but also promote the reconstruction of mucosa and regulate the immune function. For example, Li et al. (2009) shown that a greater bacterial diversity promoted and improved working and reference memory after beef diet supplementation.

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