Haaga-Helia
University of Applied Sciences

Healthy eating lifestyle guideline with exemplified menu planning based on food science and nutrition

Viet Vo

Bachelor's thesis
01 June 2020
Degree program in
Tourism

Abstract

Haaga-Helia

Date

Author(s) Viet Vo	
Degree programme Bachelor's degree of Hospitality, Tourism and Event Management	
Report/thesis title Healthy eating lifestyle guideline with exemplified menu planning based on food science and nutrition	**Number of pages and appendix pages** 113 + 24

Currently, healthy lifestyle and well-being are increasingly concerned in the youth nowadays, partly due to the frequent occurrence of noncommunicable diseases with the help of media. Along with consumers' concerns, many researchers, doctors, and professors around the world have been studying health-related issues and determinants. As the result, until now, medication and nutrition are the most effective methods to approach the matter of health.

The goal of the thesis is to provide fundamental knowledge about the healthy eating lifestyle based on nutrition and food science, and a pathway for self-designed diets that suit users' purposes best. On a larger scale, professional chefs and event caterers can utilize the materials as a guideline to enrich their knowledge in planning a suitable menu for those under normal and abnormal circumstances. On a personal scale, individuals can lean on the guideline to understand more about the healthy eating lifestyle.

In the theoretical segment, at the beginning of the thesis, the content refers to nutrition and food science in the complex and multilayered relationships with consumer perceptions and behaviors. This becomes the baseline for the application of the practical use which is described in the second part of the thesis. There are two scenarios that can exemplify the practical use of the thesis.

The last chapter of the thesis presents the challenges of the thesis conduct, some discussions, and the potential of the introduced method.

Keywords
Healthy eating lifestyle, menu planning, nutrition, food science, health, well-being, food.

Table of Contents

1 Introduction

1.1 Thesis background

According to the report (World Health Organization 2014, 7-9), the average number of global mortalities every year is about 38 million people because of non-communicable diseases such as cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes. Over 14 million deaths are from the age group from 30 to 70 and the vast majority occurs in the developing countries where the medical technology is still outmoded and public awareness is quite old-school. In 2017, non-communicable diseases accounted for 80% with 4.74 million in 56 million deaths (Ritchie, H. & Roser, M. 2018). Therefore, non-communicable diseases have been a leading cause of causality for centuries and many efforts have been paid to tackle the problem but it seems to be not effective.

The report (WHO 2005, 2-16) said the same thing as what is going on in recent years. There were 58 million deaths, 35 million as 60% was the result of chronic diseases and the percentage was predicted to go up. Approximately, 80% of chronic deaths occurred in low and middle-income countries where most of the world populations are living. Astonishingly, the mainly affected targets were people under the age of 70 with 50%, and the percentage was 25% for those under 60 years old. This number goes along with the increase of obesity in children in these countries, leading to the rise in the premature death of diabetes. Compared to up-to-date statistics on global death, the current situation has not been improved at all, although public concerns have already been shown for decades along with globalization and the advancements in technologies of medicine.

To put it in short, the main cause that may result in noncommunicable diseases is an unhealthy lifestyle. Although most people are born with normal functioning organisms with great potentials for growth – normal DNA sets from both parents, it's mainly dependable on how they live during their lifespan. This can determine whether or not they develop noncommunicable diseases at the older stage. Lifestyle can be broken down into three factors: physical activity, recovery, and diet. (Nazemi, 2017.). If one of these three factors is ignored, it will harm the harmony of the body environment, which are considered as risk factors. Therefore, diet also plays a decisive role in keeping body metabolism and organ functions in a well-controlled manner.

Risk factors leading to non-communicable diseases, in the WHO report (2005, 48-52), can be categorized as common modifiable factors including unhealthy diet, physical inactivity, and tobacco use and non-modifiable risk factors including age and heredity. These contribute to the growth of intermediate-risk factors that comprise raised blood pressure,

raised blood glucose, abnormal blood lipids, and overweight or obesity, which cause chronic diseases. In more detail, the number of deaths from tobacco use is 4.9 million, physical inactivity is 1.9 million, low fruit and vegetable consumption is 2.7 million, being overweight or obese is 2.6 million, raised blood pressure is 7.1 million, and raised total cholesterol levels is 4.4 million. WHO report (2014, 9-11) mentions similar problems, which means that these risk factors need solving with a better approach.

1.2 Thesis objectives

The thesis aims to offer an insightful introduction to a healthy eating lifestyle with scientific approaches and menu planning for individuals and organizers. Initially, the thesis introduces fundamental knowledge of nutrition and food science for a better understanding of how the recommended tools are effective. Additionally, with the provided knowledge, readers can flexibly apply it to any circumstances in which they feel logical, practical, and suitable for themselves most. This can elevate the efficiency of the provided method of menu planning.

The thesis can act as the guideline for restauranteurs or event managers who have an interest in knowing basic knowledge of nutrition and food science so that they can cooperate with chefs for designing beneficial menus. Taking extra steps for calculating nutrient values and involving consumers' health profiles into consideration can boost the efficiency of nutrition in maintaining well-being. This can create a significant impression of how delicate restaurants or events can be. This can be also seen as the advantages to compete with other competitors as one of the most crucial trends in the future. The trend is considered as "conscious consumption", which means that consumers can control their biology profiles through diets with the empowerment of personalized high-tech tools, in the report "Global food and drink trend 2030" (Mintel 2020, 2-5, 26).

For personal use, the thesis can act as an intermediate nutrition course and a fundamental guideline to create a healthy eating lifestyle. While the subtopics of nutrition and gastrophysics provide the knowledge for the wise and flexible adjustment on a personal diet, the subtopics of menu planning show the method and the considerable factors with the exemplified cases. Although the best way of creating a menu is to consult with health-care professionals, nourishing the interest in health and enriching ones' knowledge of nutrition help users to pay more attention to their diet and make it sustainable. Furthermore, combining both personal effort and professionals' advice can result in the most suitable diet for the readers.

The range of practical use based on the thesis topic is versatile, but the exemplified cases in this thesis are set for adults between the age of 20 and 50, who live in the Nordic

region, especially those who are at diet for improving health or preventing certain diseases. Therefore, the introduced ingredients used in the thesis are from the markets and the quality of the ingredient is at a commercialized level. In this case, the described practice is more suitable for normal events or a daily basis diet. However, food and catering professionals can rely on the theoretical parts which act as the foundation of menu planning methods for tailored menus.

1.3 Thesis practical use in Finland

Because most of the referenced books and information in the thesis come from America, the thesis's practical use in Finland can be questioned. However, there is a similar situation about the overweight and obesity rate between the two countries, and the main goals of the nutritional guideline of the two countries are to reduce the overweight and obesity rate. Therefore, the guideline, method, and research on nutrition from America can be used in Finland.

According to data, approximately 75% of the Finnish population is overweight at the age of 30+, in which there are 72% men and 63% women compared to the total number. The obese level is 26% for men and 28% for women. The overweight and obesity level is based on the BMI scale as 25 – 29.9 and 30+ respectively, while the normal range is between 18.5 – 24.9. Moreover, the obesity rate of children maintains at a high level as 27% for boys and 18% for girls aged 2 – 16. (Lundqvist A, Männistö S, Lindström J, Mäki P, Virtanen S & Laatikainen T 2019.)

Comparing the above data with the report of death cause in Finland, it seems that overweight and obesity attribute to the high risks of diabetes type 2 but it is not the main cause of death (Lundqvist & al 2019; Statistics Finland 2018). However, overweight and obesity can be a contributor to other diseases such as circulatory system, neoplasms, and dementia diseases which are the major cause of death. Therefore, the practical usage of the thesis in Finland is guaranteed.

Moreover, the nutrient and energy intake recommendations used in the thesis are retrieved from a reliable source originating from Nordic Council of Minister. This means that the application of the thesis is more practical for Nordic citizens including Finnish people.

1.4 Thesis structure

The thesis consists of an introduction, body, and conclusion. While the introduction describes the background, objective, practical use, and structure of the thesis, the conclusion focuses on the challenges of conducting the thesis, the author's discussion about the

topic, and potential usage of the introduced method. The body of the thesis emphasizes on healthy eating lifestyle concept which covers the aspects of nutrition, body mechanism, gastrophysics, menu planning, nutritional data and guidelines, and exemplified cases.

In the introduction part, the thesis background refers to the global situations associated with the increased incidence of non-communicable diseases, which aims to alarm the readers and consider the healthy eating lifestyle as a solution. The thesis objective is the section described next so that the readers can understand the main purpose of the thesis, what and who it is used for. Since most of the materials used in the thesis are from outside Finland but the exemplified cases occur in Finland, thesis practical use in Finland is discussed after the thesis objective. Finally, the thesis structure is presented for the readers to understand the overall picture of the thesis outline.

The body of the thesis starts with the chapter “Introduction to healthy eating lifestyle” which illustrates all the chapters and their subchapters in a process for a better understanding. It also describes the main ideas and purpose of the following chapters. To manipulate the eating habits for the body optimum health, the introduced knowledge of nutrition, body mechanism toward food, and gastrophysics is the foundation before any action. Therefore, after chapter 2, they are presented as chapters 3, 4, 5, and 6.

After that, chapter 7 as “Practice factors” is analyzed. This chapter includes menu definition, research method, allergies, food safety, diet type, disease, healthy cooking techniques as subchapters. These topics are indispensable in conducting a menu because they add the restriction of ingredients that can be used in the final menu.

To calculate nutritional values for the menu planning, the proper nutritional data should be considered. Because of the differences in nutrition in every ingredient and nutrient intake recommendation in each region around the world, there should not be universal data. Therefore, the thesis introduces the data from Nordic Council of Minister which is suitable for calculating nutritional values for Nordic people.

However, menu planning is a complicated process, so the thesis only describes the process of menu planning based on previous chapters and its subchapters with the assistance of nutritional data and guideline from Nordic Council of Minister in chapter 8. The financial matter and other menu-creating factors are not mentioned in the thesis. The two following chapters – chapters 10 and 11, are the exemplified cases for two different targeted readers, which aims to show the practical application of discussed theoretical parts in previous chapters.

.

The conclusion opens up the topics of the challenges during thesis writing and its limitation. Besides, the author's opinions are also presented to improve the thesis of practical use.

2 Introduction to healthy eating lifestyle

This chapter's purpose is to introduce healthy eating lifestyle theory according to the author's point of view after gathering related knowledge. The chapter covers the concept of the healthy eating lifestyle and the process of achieving it.

2.1 Healthy eating lifestyle

Diet plays an inevitable role in human well-being because the consumed substances are the fuels that body cells and tissues need to survive and perform their tasks. However, due to the overload of information, confusion among those who want a healthy diet is easily spotted. This can result in the failure of dieting, in worse cases, this can result in a negative effect on general health. Therefore, to keep body stamina at a good level, healthy eating should be taken into consideration.

Healthy eating defined by Rudy Mawer (2016) is the science-based diet designed for achieving optimum health and set purpose. Rudy Mawer (2016) also supports a healthy diet characterized by balanced nutrient and calorie intake of whole foods, fish, meat, vegetable, fruit, bean, legume, herbs and spices, while added sugar, trans fat, refined carbohydrate, vegetable oil, and processed products should be avoided. In the thesis, not only is the healthy eating lifestyle scientifically reinforced in terms of Rudy Mawer's aspects, but it also is extended with other researched studies which are cited as references in many nutrition books. Figure 1 shows the main topics including subtopics of the introduced healthy eating lifestyle application of the thesis.

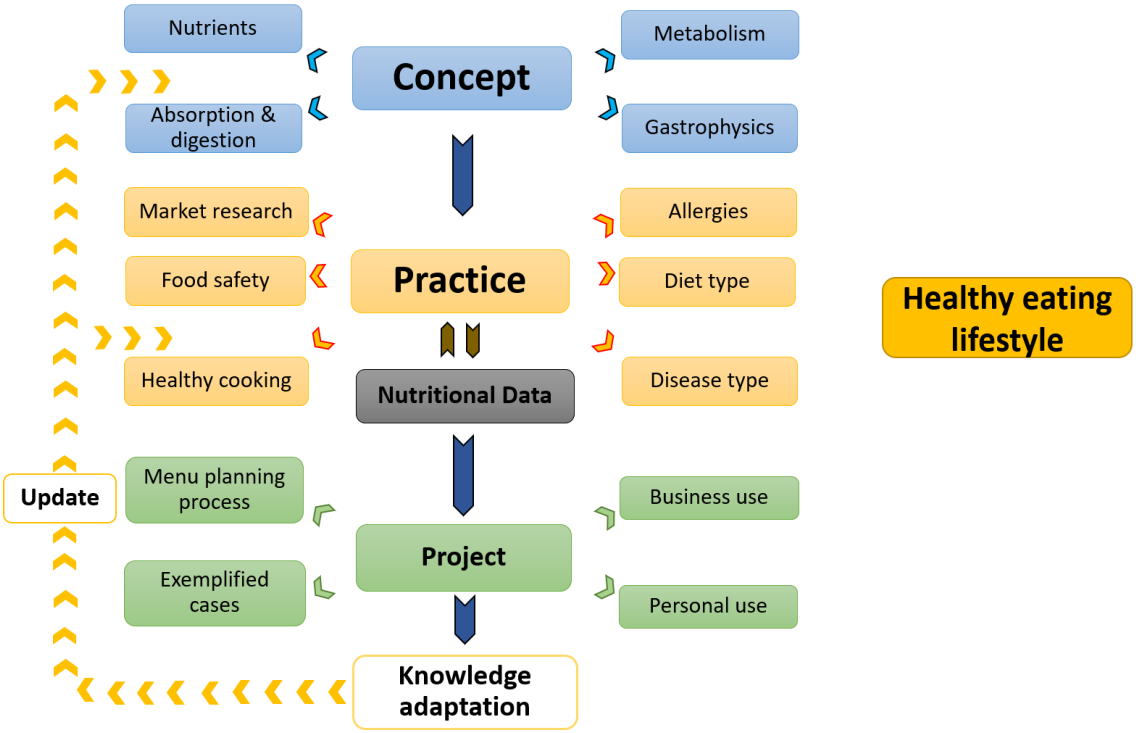


Figure 1: Model of healthy eating lifestyle application.

To provide an insightful explanation about the healthy eating lifestyle, the topic is well explained in many related fields of study and divided into two parts: the concept and the practice. Firstly, the concept of healthy eating is broken down into many scientific aspects such as nutrients, body mechanism, and gastrophysics so that readers can understand fundamentally the relationship of human cells and food effects. This offers in-depth knowledge and allows users to flexibly adjust what they consume or plan for others to consume. Although the load of information in the concept part is huge and requires time to digest, understanding the theories can help them to be more conscious about food choices, leading to more responsible decision-making on their daily intake.

Then, the practice part is extended with the knowledge about menu definition, market research, healthy cooking method, allergies and food safety, diet and disease types. These areas help the readers to understand the methods and necessary considerations when making a menu and executing it. Additionally, to be more precise in terms of nutrition, the calculation of nutritional values should base on the nutrient intake recommendations and guidelines from a proper and reliable source. The provided data in this thesis is from Nordic Council of Minister, so the thesis is more suitable for being applied in the Nordic region.

The nutritional values of a menu are essential in creating a balanced menu for achieving a diet purpose. Therefore, the nutritional calculation needs to base on the data provided by a reliable source. In this chapter, nutritional values originate from Nordic Council of Minister. This means that the practical use of the thesis is far more accurate in Nordic countries.

The elements considered in both concept and practice part are put into use in real scenarios with the introduced menu planning process which is presented in chapter “Introduction to menu planning project” and two exemplified cases as chapter 10 and 11. The introduced method is the suggestion of the author in applying food-related factors to the conduct of a menu for a particular diet purpose.

Because there is a great deal of new research conducted to expand the horizon of science, what most people and scientists believe today can be outdated tomorrow. Therefore, being active in reading the latest news and research about foods is the best way to understand the principles of consuming foods safely. Many other topics can be covered so that the proper food-related decision making is done, but, due to the thesis limitation. These topics can be fat and sugar, supplement, exercise, four-pillar diet, phytochemicals,

so on. The newly gained information needs to be compared and reflected with the foundation knowledge before its diet application. Considering information sources whether the theory is a paradox or has theoretical conflict before applying any new theories is recommended. The most reliable sources are those from governmental departments such as Nordic Council of Minister.

According to the author, the healthy eating lifestyle is a combination of concept, practice, and knowledge adaption, which is the science-based habit for a healthy diet. This seems to be difficult for beginners to approach the author's ideas of the healthy eating lifestyle. Therefore, depending on the readers, they can use a part of the thesis as material for some references. However, it is recommended to complete the whole thesis for a deeper insight into the relationship between food and human.

2.2 Concept

Nutrition is the scientific studying area related to food components themselves, how they react within the body, and how they shape human behavior (Whitney & Rolfes 2016, 3). This means that there are many food-related aspects of nutrition, which can easily confuse readers. To make the topic more understandable, the author breaks down nutrition into nutrient, digestion and absorption, and gastrophysics and categorize them under concept section because they are included in nutrition but nutrition covers many other matters. Therefore, the concept section can be considered as a part of nutrition that is used to understand the practice part which comes next.

Nutrients are vital substances that the body digests and absorbs by eating foods. After that, foods are broken down and turned into materials for the survival and functioning of body cells, especially some that can help to fight against certain diseases. The human body can create some nutrients from other substances from diet. However, in some cases, the quantity is inadequate so the sustainable supply of nutrients is important to normal health. These nutrients in demand are called necessary nutrients. (Whitney & Rolfes 2016, 6-8.).

There are 2 main types of nutrients: macronutrient and micronutrients. While macronutrients refer to the group of large and energy-yielded chemicals which need breaking down in gastrointestinal tract and the body needs them in a large quantity, micronutrients don’t provide any kcalorie. Although the body just needs a small number of micronutrients, it can’t function properly without them. Micronutrient contains vitamins and minerals and these are two different groups. (Drummond & Brefere 2009, 9-15.). Both of these nutrient types are covered as the subtopics in the thesis and their description focuses on chemical structure, function, and food source.

Digestion is the body mechanism for breaking down the consumed foods into absorbable chemical units so that the human intestine can take them into bloodstream or absorption can occur. Both of these mechanisms are operated by the muscles located along gastrointestinal tract – a hollow tube specialized in transmitting food through the body. (Drummond & Brefere 2009, 72.). Since gastrointestinal is a long tube composed of many different parts with varied functions, they are explained in more detail in the chapter “Digestion and absorption”.

Gastrophysics is a scientific area of study of how people taste and what factors influence it. The area is related to neurology, sensory science, psychology, marketing, design, and behavioral economics. Gastrophysics is the foundation and the inspiration of fine culinary experience, which aims to maximize the flavors through the perceptions of human senses. (Spence & Blumenthal 2017, xvi-xx). The topic is divided into subtopics such as “Five senses”, “Social factors” and “Perfect meal”. In Five senses, the taste perception is described under each sense to show its influences on the dining experience. While Social factors refer to the manipulative matters which has control over human food choices, Perfect meal considers the effects of social contexts and intangible phenomena.

2.3 Practice

Menu definition is brought up first because it is the product that the thesis aims to conduct. Then research methods are introduced. Research considers effort and time to be carried out, so, depending on the scale of the event or menu planning the research is not necessary to be conducted like a personal diet. For restauranteurs and event organizers, research is classified by demographic and psychographic ones, which can provide the general information of the local area so that the menu can be tailored for the locals (Traster 2018, 2-8). Another analysis of the inner business company is also discussed in the subchapter “Research” in chapter 7. For personal use, the research can be considered as the health record or local markets and accessible ingredients.

Allergy and food safety are the most common matters to consider when creating a menu. Allergy is the misfunctioning of the body's autoimmunity system toward certain substances, which is easily mistaken by food intolerance that is not involved in immunity system. The difference between them is discussed further in chapter “Allergies and food safety”. Food safety becomes an indispensable factor in foodservice and there is a large number of related rules and principles for restaurant and event operation, which are varied in different nations. Therefore, food safety discussed in the mentioned chapter is specialized more on the viewpoint of personal usage.

Subchapter “Diet type and related disease” mentions the common diets associated with taste preference, weight gain and loss, health nourishment, and special diets for preventing chronic diseases. The introduced diets cannot be a replacement of medicine if the eaters get sicked. However, it can provide natural nutrients for optimum health and disease-fighting.

In addition to what ingredients and what types of diet, the method of preparing and cooking ingredients does matter since it can affect the body's ability to absorb nutrients and the number of nutrients contained inside the foods. This means that knowing the methods to handle the ingredients without distorting the nutrients is essential. However, most of the methods fail to deepen the taste profiles of dishes, leading to a lower level of dining satisfaction. Therefore, not only are healthy cooking techniques are introduced, but healthy enhancing-flavor methods are presented in the subchapter “Foundation of healthy cooking”.

2.4 Project

Menu planning is the process of considering all food-, safety-, and business-related elements for creating a diet that can benefit eaters nutritiously and sustainably (Traster 2018, 1). To achieve the main targets of the thesis, the financial angle of menu planning is not mentioned. Therefore, the practice focuses on the application of concept content with research, allergy and food safety, diet and disease, and healthy cooking to the actual menu planning process.

The introduced method is the author’s works in considering nutrition and food science factors into menu planning so that the created menu can be nutritious, delicious, and achieve the set diet goal. The method is generally introduced in chapter 9. To clarify the introduced method, exemplified cases are presented in the following chapters with two different purposes as business use and personal use.

3 Nutrients

Nutrients are defined as chemical food constituents that have a major influence on the human body's growth and maintenance (Drummond & Brefere 2009, 9-15; Whitney & Rolfes 2016, 6-8). Nutrients and their effect on the human body are the research targets of a field of study named nutrition (Whitney & Rolfes 2016, 3).

There are many types of nutrients which can be grouped into macronutrient and micronutrient. Macronutrients refer to nutrients that can yield energy for body cells after being broken down and the human body needs a huge quantity of them compared to micronutrients to function normally. In contrast, a small number of micronutrients is sufficient for body cell activities. Additionally, the high- or low-level intake of micronutrients can lead to undesirable health conditions. (Drummond & Brefere 2009 ,9-15; Whitney & Rolfes 2016, 6-8.)

3.1 Macronutrient

Macronutrient consists of carbohydrate, protein, and fat with the main role is to provide the energy for the entire body system to operate from breathing days and nights, doing the daily routine activity to intensive exercises. That’s the reason to call this group energy-yielding nutrients. Besides, alcohol also provides energy but the yielded energy from alcohol does not support the normal functions in the human body. (Drummond & Brefere 2009,11-13.). Most of the energy from alcohol is not stored by the body but is used immediately after consumption along with a temperature rise of 20%. (Herz 2018, 217).

3.1.1 Carbohydrate

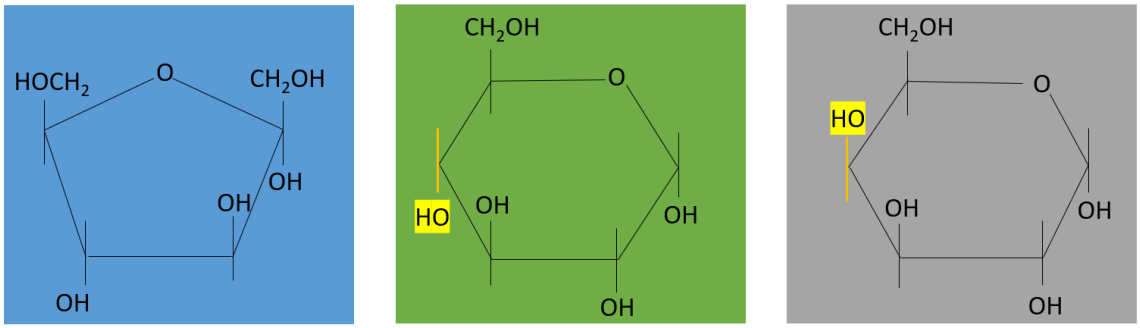
Carbohydrate is a macronutrient composed of hydrogen, oxygen, and carbon under the chemical forms as monosaccharides or multi-monosaccharides, which body prefers to convert it into energy before considering other energy-yielding ones. This compound is mainly discovered in most plants with 60-90% of their dry weight, which contrasts with a small percentage in animals and humans. It is synthesized from carbon dioxide in the air and water in the soil under sunlight through the process known as photosynthesis, contributing to its chemical structure which consists of carbon, hydro, and oxygen. The group is comprised of sugar, starch, and fiber in which sugar is classified as simple form meanwhile starch and fiber belong to a complex form. (Drummond & Brefere 2009, 82; Whitney & Rolfes 2016, 99-104)

Carbohydrate, in the form of glucose as simple form and glycogen as a complex form, is considered as the primary energy source for human organ activity. After serial reactions in

the body, glucose break-down creates high-energy compound ATP – adenosine triphosphate, which is the favorite fuel for most of the body living cells, especially brain cells, nerve cells, and red blood cells. In addition to glucose, glycogen is built by the combination of many glucose molecules in the branched form of amylopectin to store the excess glucose for future use in liver and muscle. Because they have limited capacity, the excess carbohydrate consumption, after fully saved in liver and muscle as glycogen, is converted to fat. (Drummond & Brefere 2009, 82-83; Vieira 1996, 30; Whitney & Rolfes 2016, 109-110, 203-204.)

Within the macronutrient group, the fact that the body metabolism preference on carbohydrate prevents the misuse of protein and muscle. Without the sufficient presence of carbohydrate, protein is burned for energy consumption instead of performing the tasks such as building muscle cells or activating enzymes and fat burning can end up production of ketone bodies and ketosis which may disturb the acid-base balance in blood. Furthermore, carbohydrate is also the chemical structure of various body materials such as connective tissue, certain hormones, and genetic materials. (Drummond & Brefere 2009, 82-83.)

Simple carbohydrate includes monosaccharides with glucose, fructose and galactose, and disaccharides with sucrose, lactose, and maltose. These scientific names are the varied types of sugar found in many ingredients over the world such as fructose in fruits, glucose and fructose in honey, and galactose in dairy products. Glucose is an essential nutrient that bodies can absorb and convert into energy, so fructose, galactose, and other carbohydrate molecules need breaking down and converting into glucose before being used. Although fructose and galactose's chemical formulas are the same as $C_6H_{12}O_6$, their structures or molecule arrangements, as shown in figure 2, are different, which determines their characteristics and reaction abilities. Like glucose, fructose appears in many types of ingredients but galactose naturally occurs in very small quantities. The disaccharides are formed by two different or similar monosaccharides. Sucrose, made of glucose and fructose, is popularly called table sugar, granular sugar, or simple sugar available in every corner of the world. Lactose, made of glucose and galactose, is presented in milk and can be called milk sugar. Maltose, made from two glucose units, appears in human digestion or the alcohol fermentation process. (Drummond & Brefere 2009, 84-85; Whitney & Rolfes 2016, 100-102.)



Fructose Glucose Galactose

Figure 2: The Monosaccharides' chemical structure (adapted from Whitney & Rolfes 2016)

The complex form or polysaccharide is the polymer – a compound of many molecular units, that make up glycogen, starch, and fiber. A polysaccharide is structured under the form of a long chain of ten or more monosaccharides linked by glycosidic bonds. They may contain repeated structures of one simple form or different structures of many simple forms. Instead of being sweet as the simple form, the complex carbohydrate is not sweet but provides the vicious, gelatinous, and tough sensory texture for foods. In nature, polysaccharides are made of a large number of monosaccharide molecules from hundreds to thousands. Due to their big size, human taste receptors in the mouth can't realize their taste. (Vieira 1996, 28)

Starch is made of a large number of glucose units in a linear compound called amylose or a branched compound called amylopectin, which is stored in plants as a part of their structure. It's the human main source of carbohydrate food, found mainly in cereal grains such as rice and wheat, root crops such as potatoes, legumes such as peas and beans. Starch is not water-soluble without heating, because heat makes them combine with water then swell and gelatinize. Amylose structure enhances the stability of the starches at a higher rate compared to amylopectin. (Drummond & Brefere 2009, 91-92; Vieira 1996, 30; Whitney & Rolfes 2016, 103-104.)

Dietary fiber is the non-digestible polysaccharides available in plant-originated foods such as vegetables, fruits, whole grains, and legumes. It's classified into water-soluble and water-insoluble fiber, which has its own significantly nutritional benefits. Soluble fiber presented in cereal grain and citrus fruits is fermentable in colon and can trap the carbohydrates in its structure. This controls the conversion speed of the carbohydrate group to glucose or energy, allowing body to react with the increase of glucose level in bloodstream. Soluble fiber can also reduce cholesterol levels by binding with bile acids and boost the removal of cholesterol in the feces, leading to the reduced risks of diabetes and

heart diseases. Insoluble fiber found in wheat products, wheat grain, and whole grains, is less fermentable in colon and can increase the fecal weight. This improves the smoothness of fecal removal, leading to the reduced risks of constipation, diverticulosis, and hemorrhoids. Additionally, it provides a feeling of fullness, which is helpful in a weight-managing diet. (Drummond & Brefere 2009, 92-96; Vieira 1996, 31-33; Whitney & Rolfes 2016, 104.)

3.1.2 Lipids: fats and oils

In contrast to carbohydrate, lipid, in the most abundant form with over 90% named triglyceride, is not a long chain of repeated molecules but is comprised of one glycerol and three fatty acids, which is described in figure 3. Lipid is the heterogeneous group of water-insoluble substances whose chemical structure also contains carbon, hydrogen, and oxygen like carbohydrate but the more carbons and hydrogens in proportion to oxygen, which generates much more energy in human metabolism. (Drummond & Brefere 2009, 112; Vieira 1996, 33; Whitney & Rolfes 2016, 134.)

There are 4 to 24 carbons in a structural chain of a fatty acid with only the even numbers, and the most common ones in food are with 18 carbons. The fatty acids can be saturated or monounsaturated or polyunsaturated, depending on their chemical structures. The members of the lipid family are fats and oils as the major ones, the others are waxes, phospholipids, sphingolipids, and sterols (Drummond & Brefere 2009, 112; Vieira 1996, 33; Whitney & Rolfes 2016, 134.)

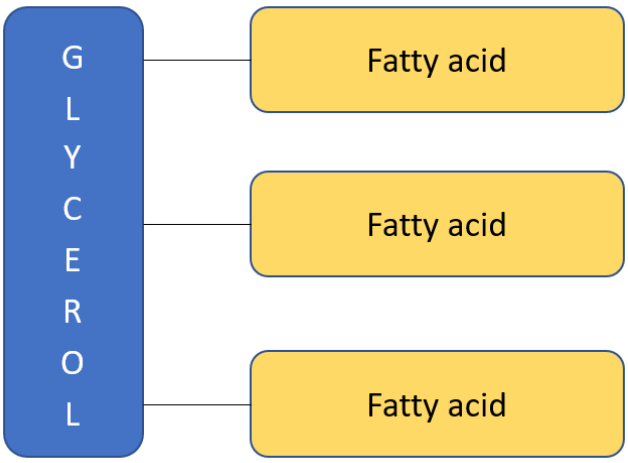


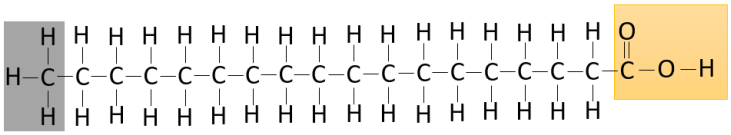
Figure 3: Structure of Triglyceride (adapted from Drummond & Brefere 2009)

Lipid is an essential part of all living cells, accounting for 13-30% of a person's weight. There is approximately 50% of fat located under the skin, creating insulation to maintain the optimum body temperature at which most chemical reactions in the body can occur

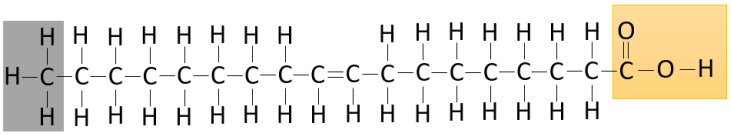
normally. As mentioned above, overconsumption can convert excess energy into glycogen and fat, and both are the reserve forms of energy for future urgent use. Most cells have both of them at a small amount. However, there are adipose cells or fat cells, which can load lots of fat as 20 times in weight, compared to normal cells. Moreover, fat is helpful to prevent protein from burning and transports fat-soluble vitamins in bloodstream for nourishing tissues and organs. Lastly, it can enhance the deliciousness of dishes in most aspects such as taste, aroma, crispiness, and appearance with satiety feeling. (Drummond & Brefere 2009, 126-128.)

In the lipid group, as the major members, fat and oil are available in both plants and animals as the indispensable natural parts. To differentiate these two, fat is the lipid material which is solid at room temperature meanwhile oil appears to be liquid. The reason for this lies in its fatty acid components. (Drummond & Brefere 2009, 126.)

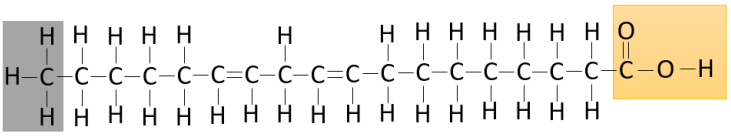
The chemical structure of fatty acids is a chain of hydrogens and an even number of carbons with an acid group (COOH) and a methyl group (CH_3) at both ends of the chain. The differences within fatty acids are not only the number of carbon atoms in the structure but also the point of unsaturation or the number of double bonds. This leads to the classification of saturated, monounsaturated, and polyunsaturated fat. Saturation of fat means that, in their chemical structure, there is a maximum of hydrogen attached to the chain and those with missing hydrogens at certain points are unsaturated. While monounsaturated fat or MUFA refers to one missing hydrogen unit, polyunsaturated fat or PUFA has two or more double bonds because the missing hydrogens in the structure cause the appearance of double bonds. These types are illustrated in figure 4. Additionally, when a triglyceride is classified as a saturated one, its fatty acid accompanies are also saturated, the same principle applies to monounsaturated and polyunsaturated triglycerides. (Vieira 1996, 33-37; Whitney & Rolfes 2016, 134-136.)



Stearic acid, an 18-carbon saturated fatty acid



Oleic acid, an 18-carbon monounsaturated fatty acid



Linoleic acid, an 18-carbon polyunsaturated fatty acid

Figure 4: Chemical Structure of saturated, monounsaturated, and polyunsaturated fat (adapted from Whitney & Rolfes 2016)

Omega-3 or alpha-linolenic acid and omega-6 or linoleic acid, as described in figure 3, are considered as the essential fatty acids which provide vital benefits for human being. They, as a part of cell membranes, maintain the immune system and they play a key critical role in normal growth and development of body, especially heart and brain in the infant or pregnant period with omega-3 docosahexaenoic (DHA) and eicosapentaenoic acid (EPA). DHA and EPA are of importance to heart health by controlling blood pressure, blood clots, heart rate, and blood triglyceride levels in a healthy manner. Good sources of these essential fatty acids are vegetable oil from beans and seeds, and fatty fishes such as salmon, tuna, catfish, and pollock. (Drummond & Brefere 2009, 137-139.)

The outstanding phospholipid is lecithin which has a unique chemical structure of hydrophobic fatty acids and hydrophilic phosphate group and choline (nitrogen-containing group), creating polarity (positive and negative charges) at one end and non-polarity at the other end. This unique formation allows lecithin to be soluble in both water and fat and act as an emulsifier in the food industry. In the human body, lecithin is a vital component of cell membranes allowing fat-soluble substances to travel and keeping fat in solution in body fluid. Rich sources of lecithin are egg, liver, and peanut, but lecithin is not an essential nutrient since it can be made in liver. (Drummond & Brefere 2009, 127; Vieira 1996, 36-37; Whitney & Rolfes 2016, 140.)

Another important member of the lipid group is sterols as functional compounds in body system. Sterol originates from both plants and animals. While significant amounts of cholesterol are found in animals, other sterols naturally occur in plants. The white, odorless, and waxy cholesterol is not a harmful substance. It not only is involved in cell membranes in most of body living cells and in the composition of bile acids which proceeds the fat digestion in intestine, but also contributes to producing vitamin D, sex hormones such as testosterone, androgen, and estrogen or adrenal hormones such as cortisol, cortisone, and aldosterone. Most cholesterol is produced by the body from carbohydrate, protein, and fat, so the consumed cholesterol will be broken down and reformed when it is needed. Unfortunately, cholesterol in bloodstream may build up the plaque on arterial walls, developing atherosclerosis – the significant accumulation of lipid-containing material, which can block the blood supply to the heart causing heart attacks or the brain causing strokes. Other sterols in plants have a similar structure to cholesterol, but they can inhibit cholesterol absorption. (Drummond & Brefere 2009, 140-142; Vieira 1996, 37; Whitney & Rolfes 2016, 140-141.)

Human bodies use waxes as the protective coating on the tissues to prevent water from entering, controlling the evaporation. Besides, another sterol is sphingolipid which is a material found in nerve and brain tissues. (Vieira 1996, 37.)

3.1.3 Protein

Like carbohydrate and lipid, protein is also a macronutrient that has carbon, hydrogen, and oxygen in its chemical structure. What makes it different is that it contains nitrogen as well, which is considered a vital atom for human beings. (Drummond & Brefere 2009, 162-163; Whitney & Rolfes 2016, 171-173.)

Protein is structured by long chains of amino acids and there are 20 types of amino acids, explained in table 1, in which 9 types are labeled as essential ones, meaning that these must be taken from food, and the remaining is labeled as nonessential ones which mean that they can be synthesized by human bodies. The factor that determines the character of an amino acid is the side group attached to the backbone including amino group (NH_2), acid group (COOH) at the two ends, and the link between carbon and hydrogen in the middle, as described in figure 5. Under some circumstances, a few nonessential amino acids may be insufficient due to improper diet, they can become conditionally essential amino acids. Since protein is made of many amino acids linked in a chain, the connection between each amino acid is a peptide bond. If two amino acids link together, it's called a dipeptide, and if the number is three then it's a tripeptide. When the number is more than three, it's considered a polypeptide. (Drummond & Brefere 2009, 162-163; Whitney & Rolfes 2016, 171-173.)

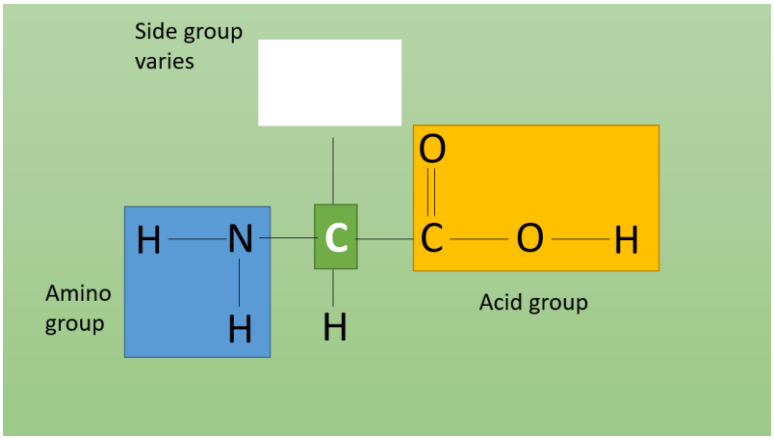


Figure 5: Chemical Structure of Amino Acid (adapted from Whitney & Rolfes 2016)

Table 1: 20 Different Essential and Nonessential Amino Acid (Adapted from Whitney & Rolfes 2016)

Essential amino acids	Nonessential amino acids
Histidine	Alanine
Isoleucine	Arginine
Leucine	Asparagine
Lysine	Aspartic acid
Methionine	Cysteine
Phenylalanine	Glutamic acid
Threonine	Glutamine
Tryptophan	Glycine
Valine	Proline
	Serine
	Tyrosine

The structure of a protein is far more complex than carbohydrate and lipid. Protein primary structure is characterized by the quantity and the sequence of the amino acids. Since there are 20 types of amino acids, the variety of mix-and-match sequences is tremendous. Additionally, some proteins consist of more than one chain of polypeptides. The secondary structure is determined by electrical attraction and repulsion. So, just after a new protein is made, its straight chain is bent into a pleated sheet in some cases. The long polypeptide chains, thanks to interactions within a unique side group of amino acids and between them with the surrounding fluid, can fold and twist into various formations which allow them to perform many vital tasks for the survival of the body system. This is the tertiary structure of a protein. Some twisted or folded proteins can function alone, but some require the cooperation of other amino acid chains to form more complex structures,

which are called the quaternary structure of a protein. Although protein structures are complex and varied, they can be distorted and lose their shape and function when they meet heat, acid, or other destabilizing- factors. This process is denaturation, which makes the eggs harden when cooked, for example. (Drummond & Brefere 2009, 167; Whitney & Rolfes 2016, 173-174.)

Protein performs its structural roles and combines with other nutrients to build all types of cells, forming body materials such as muscle, blood, and skin, and they also are at use when these cells need maintaining and replacing, especially during infancy and pregnancy. Many proteins are the components of many enzymes and hormones which are crucial to body operation. They act as regulators of fluid balance because blood protein albumin and globulin can tract water molecules and keep them inside, preventing them from leaking out of the bloodstream. The acid-base balance in body fluid, between 7.35 and 7.45 pH, needs protein due to its ability to attract and releasing hydrogen ions. Some vitamins, minerals, fat, and oxygen can travel to destined location thanks to proteins such as hemoglobin responsible for oxygen or lipoprotein responsible for fat. Additionally, proteins also play an important role in immune system as antibodies. Last but not least, they are the last resort for metabolism under carbohydrate-and-lipid-exhausted circumstances. They are also helpful with blood clotting and vision. (Drummond & Brefere 2009, 164-166; Whitney & Rolfes 2016, 179-182.)

3.2 Micronutrient

Micronutrient is the nutrients required at the low-level intake for the body to function well. Despite its small amount, its roles in the human body are extremely vital. Micronutrients are categorized into three groups: fat-soluble vitamins, water-soluble vitamins, and minerals and water. A similar characteristic of them is that they provide no energy or glucose, in contrast to macronutrients. While vitamins have carbon molecules in their chemical structure, minerals do not have any carbon molecules. Therefore, vitamins are sensitive to heat and oxygen and can be easily destroyed during preparation and cooking, while minerals are not affected. (Drummond & Brefere 2009, 9-15; Whitney & Rolfes 2016, 6-8.)

3.2.1 Fat-soluble vitamin

Fat-soluble vitamins include vitamins A, D, E, and K, which are stored in liver and adipose cells for the necessary conditions. They are similarly processed in the human body as fat is, and they are transported in the lymphatic system before entering bloodstream with the significant supports from protein carriers. (Drummond & Brefere 2009, 189; Whitney & Rolfes 2016, 343.)

Vitamin A appears to have three active forms named retinoids: retinol, retina, and retinoic acid, in which retinol is the most active one and can be converted reversibly into the retina and irreversibly into retinoic acid. While retinoids are only found in animal sources, which can be converted into vitamin A in the body, carotenoids as vitamin A precursors can be found in plant-derived foods. This relationship is reflected in figure 6. Although vitamin A is well-known for promoting the health of eyes (the crystal-clear layer of the eyes – the cornea) and vision (at the retina where light energy is converted into nerve impulses), most of the consumed vitamin A is transferred to support and maintain the differentiation of epithelial cells – the lining of most organs in human bodies, and goblet cells – specialized cells for developing and producing mucus which coats and protects the cells from antigens. Besides, it also participates in protein metabolism, normal reproduction and growth, and immune system regulation as beta-carotene – the effective antioxidant and a vitamin A precursor. (Drummond & Brefere 2009, 189-191; Whitney & Rolfes 2016, 344-346.)

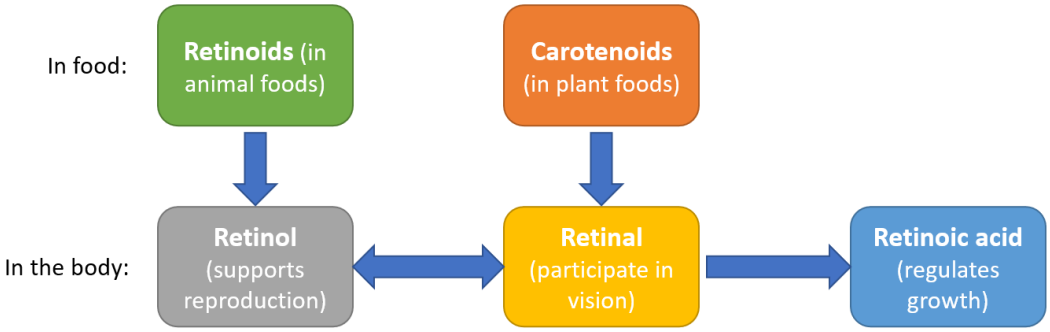


Figure 6: Conversion of Vitamin A compounds (Adapted from Whitney & Rolfes 2016)

Vitamin D or calciferol is a special vitamin, most of which can be absorbed into bodies by being exposed to sunlight. Vitamin D precursors are vitamin D_2 – ergocalciferol from plant-derived foods, and vitamin D_3 – choline calciferol from animal foods and sunlight synthesis. When the ultraviolet rays shine on the skin, sterol compounds such as cholesterol under the skin take approximately 2 to 3 days to be converted into D precursor and absorbed into bloodstream. To turn these two precursors into the active form, they need assistance from both liver and kidney. This conversion is illustrated in figure 7. Vitamin D serves as hormones, which travel in bloodstream and control calcium and phosphorus by affecting absorption rate in intestine, excretion rate in kidney and bone through thyroid activity. Therefore, the role of the vitamin in bone-building is pivotal along with other nutrients and compounds such as vitamin A and K, protein collagen, calcium, and phosphorus. Moreover, it also helpful in protecting cognitive decline, promoting cell growth and differentiation, and assisting immune system. (Drummond & Brefere 2009, 193-194; Vieira 1996, 38; Whitney & Rolfes 2016, 351-353.)

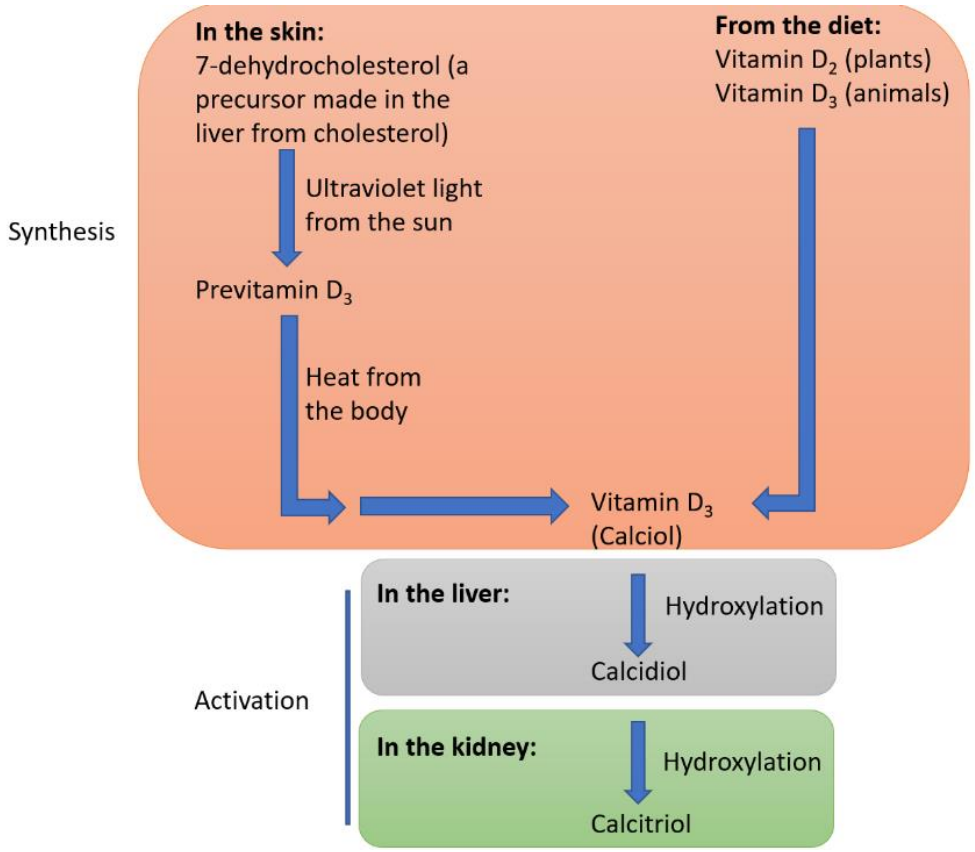


Figure 7: Vitamin D Synthesis and Activation (Adapted from Whitney & Rolfes 2016)

Vitamin E is recognized under the names of tocopherol and tocotrienol, and each of this subgroup has four member prefixes alpha-, beta-, gamma- and delta- with slight differences in their chemical structures. In this big family, alpha-tocopherol is a powerful antioxidant for human bodies since its brothers and sisters can't be converted nor accepted in the human body. As a role of antioxidant, vitamin E prevents the oxidation process from releasing free radicals. The oxidation process can be caused by the excessive consumption of polyunsaturated fatty acid, ultraviolet radiation, air pollution, and smoking. Additionally, vitamin E helps with iron absorption. (Drummond & Brefere 2009, 194-195; Whitney & Rolfes 2016, 357.)

Vitamin K is vital for human beings due to their ability in blood clotting. Normally, blood runs in liquid form in arteries throughout the whole body. However, if there is an impact interfering with the normal blood flow, resulting in bleeding outside of the arteries, a complex series of reactions associated with proteins will take place and stop the bleeding. These proteins need vitamin K to start working for activating fibrin – the blood-clotting protein. The most well-known protein responsible for activating fibrin is prothrombin which is made in liver. The cascade of this process is described in figure 8. Besides, vitamin K is also needed to activate osteocalcin which participates in bone formation. (Drummond & Brefere 2009, 195-197; Whitney & Rolfes 2016, 358-359.)

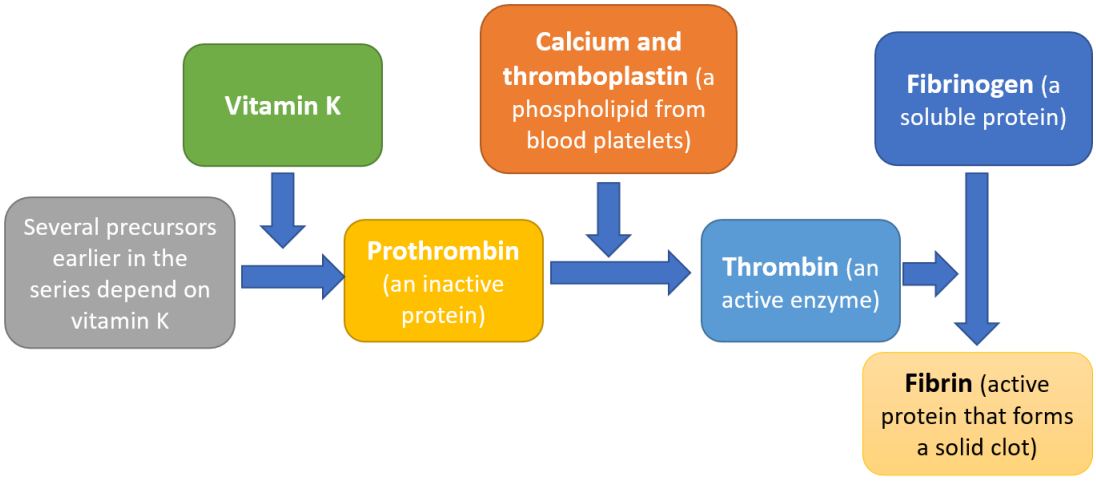


Figure 8: Blood Clotting Process (Adapted from Whitney & Rolfes 2016)

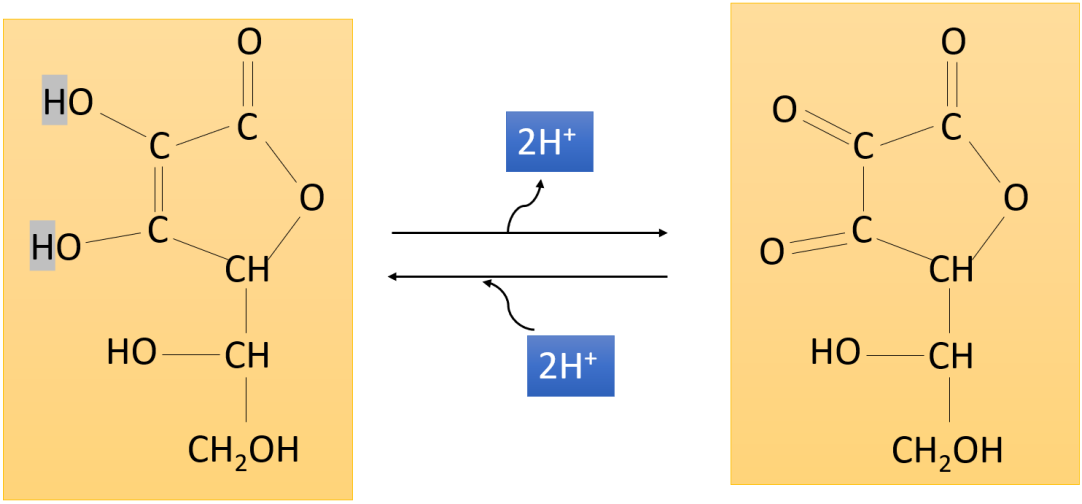
3.2.2 Water-soluble vitamin

Vitamins soluble in water are vitamin C and a complex group of vitamin B including thiamin, riboflavin, niacin, folate, B_6, B_{12}, biotin, and pantothenic acid. They differ in fat-soluble vitamins not only in solubility ability but also in the storing characteristic. Unlike the cousin, vitamin C and series of B are stored in the body in limited quantity, the excessive amount is excreted out of the body except for vitamin B_6 and B_{12}, but overconsumption still leads to toxicities. (Drummond & Brefere 2009, 188-189, 198)

Vitamin C or ascorbic acid has tremendous benefits to human health. First, vitamin C is an antioxidant as one or two electron atoms in its chemical structure is easily movable. So, when it encounters free radicals, the movable electrons can neutralize the highly reactive unpaired electron molecules – free radicals, preventing the oxidation stress. Unlike beta-carotene, when vitamin C accomplishes its job as an antioxidant, instead of disappearing, it becomes dehydroascorbic acid and waits for the right conditions to reverse back to ascorbic acid and ready for fighting against free radicals again. This role is described in figure 9. Resembling vitamin E, it also increases the iron absorption rate in the intestine. (Drummond & Brefere 2009, 199-200; Whitney & Rolfes 2016, 327-329.)

Another important role of vitamin C is a cofactor or coenzyme which is needed for activating or forming many vital body components such as collagen in its synthesis. Irons act as a cofactor to run the process and vitamin C's role is to prevent iron from being oxidized. Furthermore, as a cofactor, vitamin C is a part of the conversion of the amino acids tyrosine and tryptophan to the neurotransmitters norepinephrine and serotonin, respectively. It also plays a role in producing hormones such as thyroxine involved in metabolic rate regu-

lation. Another well-known effect of ascorbic acid is common cold treatment. But the researches about this claim is still controversial as some find no impact between vitamin C and the common cold, whereas some reports record the less severe symptoms and durations after using vitamin C supplements. However, it has a stable connection to immune system because white blood cells contain the highest concentration of vitamin C in the body. (Drummond & Brefere 2009, 199-200; Whitney & Rolfes 2016, 327-329.)



Ascorbic acid protects against oxidative damage by donating its 2 hydrogens with their electrons to free radicals (molecules with unpaired electrons). In doing so, ascorbic acid becomes dehydroascorbic acid

Dehydroascorbic acid can readily accept hydrogens to become ascorbic acid. The reversibility of this reaction is key to vitamin C's role as an antioxidant

Figure 9: The Active Form of Vitamin C (adapted from Whitney & Rolfes 2016)

Thiamin – a member of the vitamin B family, is a component of the coenzyme TPP – thiamin pyrophosphate. Thiamin participates in energy metabolism and it also has a pivotal role in nerve-to-nerve and nerve-to-muscle activity. Like thiamin, riboflavin and niacin assist energy metabolism in the same way. Riboflavin acts under coenzyme forms FMN – flavin mononucleotide, and FAD – flavin adenine dinucleotide, whereas niacin works as coenzymes NAD – nicotinamide adenine dinucleotide and NADP – the phosphate form. Additionally, riboflavin also helpful in producing vitamin B_6 coenzyme and making niacin from amino acid tryptophan. Niacin coenzyme NAD has a role in protecting neurological degeneration. (Drummond & Brefere 2009, 201; Whitney & Rolfes 2016, 305-310.)

Biotin and pantothenic acid act as coenzymes in the metabolism, as well as other cousins. Biotin is also involved in generating glucose, fat, and the catabolism of certain fatty acids and amino acids, while pantothenic acid takes part in a complex process of producing lipid, neurotransmitters, steroid hormones, and hemoglobin. (Drummond & Brefere 2009, 208; Whitney & Rolfes 2016, 312-313.)

Vitamin B_6 is available in three forms: pyridoxal, pyridoxine, and pyridoxamine, which all can be converted to the coenzyme PLP – pyridoxal phosphate, contributing to more than 100 reactions such as in energy metabolism, especially crucial to protein metabolism. PLP is also of importance to the synthesis of niacin, neurotransmitter serotonin, heme (nonprotein part of hemoglobin), nucleic acid (such as DNA or RNA), and lecithin (a phospholipid). Because its impact on nucleic acid and protein metabolism can result in immune system promotion, vitamin B_6 helps keep white blood cells healthy. (Drummond & Brefere 2009, 202-203; Whitney & Rolfes 2016, 313-314.)

Folate or folacin or folic acid with a chemical name as pteroylglutamic acid (PGA for short) has the coenzyme form as THF – tetrahydrofolate. It can cooperate with vitamin B_{12} to synthesize the DNA for all cells and produce the amino acid methionine. Figure 9 shows the folate life in the human body and its relationship with vitamin B_{12}. Figure 10 explains that folate in natural form is polyglutamate which is a large molecule need catabolism to be absorbed. Therefore, in intestine, folate catabolism occurs and turns its natural form into mono-glutamate and a methyl group comes to attach and deactivate the new form of folate. Here, vitamin B_{12} comes to rescue, it attracts the methyl group and sets free folate to become the active form, and both of them take part in DNA synthesis. The excess folate is sent to gallbladder and gastrointestinal tract in the same way as bile and reabsorption occurs. This cycle system is easily disturbed if the gastrointestinal tract is damaged by alcohol abuse for example. Then folate is lost along with the reduced bioavailability of other nutrients. (Drummond & Brefere 2009, 204-205; Whitney & Rolfes 2016, 315-316.)

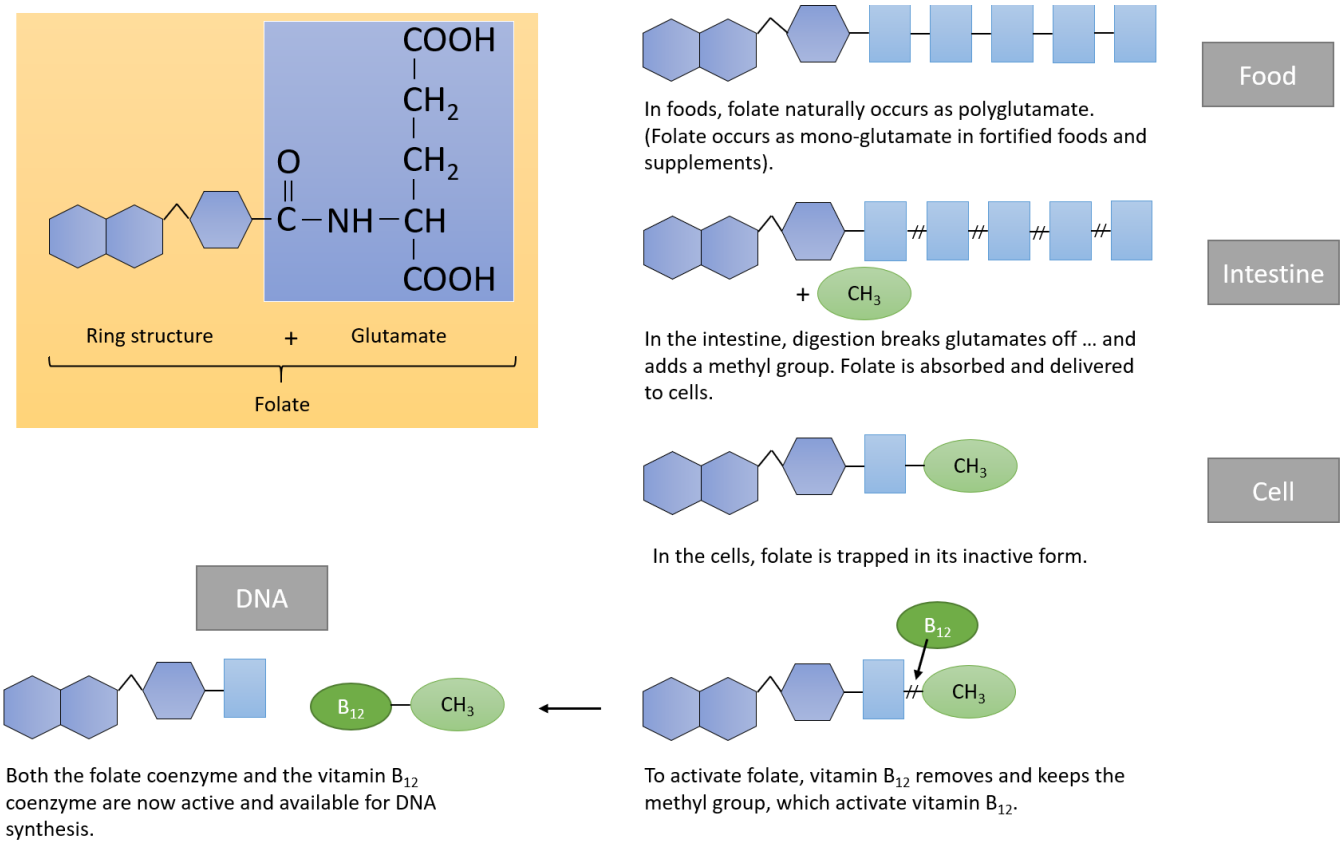


Figure 10: Folate's absorption and activation (adapted from Whitney & Rolfes 2016)

Vitamin B_{12}, as mentioned above, can remove the trapping chemical group (methyl group) that maintains the inactive form of folate. Vitamin B_{12} and folate are essential in synthesizing DNA and RNA and generating amino acid methionine. Independently, vitamin B_{12} is needed to maintain the protective lining surrounding nerve fibers and the nervous system functioning. Lastly, the role of vitamin B_{12} is also important in bone cell activity and metabolism. In term of digestion and absorption, after vitamin B_{12} is separated from the food source in stomach by hydrochloric acid (stomach acid) and enzyme pepsin, it travels to small intestine where it binds with intrinsic factor (stomach secretion) and then it can go through the intestinal wall to the bloodstream. However, without an intrinsic factor, vitamin B_{12} can't be recognized and absorbed. Resembling folate, it enters the bile-related cycle process named enterohepatic circulation. Therefore, with good health, vitamin B_{12} rarely becomes deficient. (Drummond & Brefere 2009, 207; Whitney & Rolfes 2016, 320-321.)

Choline is not a vitamin but a conditionally essential nutrient grouped in the vitamin B family due to insufficient produced amount in the body. Choline is needed for body to produce neurotransmitters acetylcholine and phospholipid lecithin. During fetal development, the structure and function of the brain and spinal cord also need it. Apart from choline, there are many vitamin-like substances involved in energy metabolism and cell components.

However, these compounds can be made by body in the proper amount. Some are carnitine, lipoic acid, inositol, and taurine. (Drummond & Brefere 2009, 208-209; Whitney & Rolfes 2016, 322-323.)

It seems like most B vitamins can work independently, but the fact is that they, in the body environment, are interdependent, so the above description is not perfect. The presence or absence of a vitamin can influence another's processing in the body. The quintessence is the cooperation between folate and vitamin B_{12}, another is the relationship between riboflavin and vitamin B_6 because FMN (coenzyme of riboflavin) can convert vitamin B_6 into PLP (coenzyme of vitamin B_6). Another instance is that the deficiency of either riboflavin or vitamin B_6 can leads to a deficiency of niacin. (Whitney & Rolfes 2016, 323.). the mechanism of energy metabolism is explained further in the metabolism section later.

3.2.3 Mineral and water

Minerals and water are micronutrients without carbon molecules in their chemical structure. This determines their functions in the human body in different ways.

Water, to everyone's knowledge, is vital to the survival of human bodies, because 50%-60% adult weight is water, especially in blood which is 92%, muscle and brain cells have 75% and even bone cell also has 22%. These percentages depend on lean and fat tissue composition. For example, these numbers are lower in females, the obese, and the elderly, due to a smaller proportion of lean tissues. Therefore, water operates every single activity of cells, tissues, and vessel flows. As the major component of blood, water regulates the smoothness and volume of blood, manipulating blood pressure; carries nutritional and secreted compounds throughout the body; excrete the waste through lungs (carbonate) and urine tract (feces). Water is an essential chemical for metabolic reactions and creates an environment for other molecules to react. It lubricates joints, eyes, spinal cord, mouth, and amniotic sac surrounding fetus, in pregnancy, in the womb. It helps in temperature control as evaporation and maintains the chemical structure of large molecules such as glucagon and protein. (Drummond & Brefere 2009, 227-228; Whitney & Rolfes 2016, 372.)

The exact proportion of water in intracellular fluid and extracellular fluid of each type of cell needs to be maintained for the metabolism and functions. This means that the imbalance of water in the bodies leads to devastating consequences. To encounter that problem, there is a mechanism for keeping the water level at a controlled range, which is thirst. The cooperation of mouth, hypothalamus, and nerves are responsible for the feeling of thirst when insufficient water is indicated by the high concentration level of blood. Then, mouth

gets drier and hypothalamus urges nerves to send electrical waves to cause drinking-water behavior. When water consumption is excessive, the stomach stretches and enlarges, then the stomach receptors trigger electrical waves back to nervous system to cause stop-drinking behavior. (Whitney & Rolfes 2016, 372-373.)

Drinking water is classified as hard or soft water, which contains a high concentration of calcium and magnesium or sodium (or potassium), respectively. Soft water is more preferable since it can neutralize certain contaminants such as calcium and lead from the old pipe, but, at the same, it can aggravate high blood pressure level because of sodium content. In this aspect, hard water is more suitable. (Whitney & Rolfes 2016, 372-373.)

Minerals are inorganic chemicals that don't contain carbon in the chemical structure. This means that, unlike the sensitivity of vitamins to heat and oxidation, minerals are not easily destroyed during food preparation and cooking and they also don't undergo any reactions to become active forms. Therefore, after being absorbed, minerals are ready to be used but the bioavailability of each mineral differs to the great extent. For example, 15% iron is normally absorbed and the percentage of absorbed calcium is 30%, while almost all the consumed sodium can enter bloodstream. The reasons for differentiated absorption ratio lie in the interaction between vitamins and minerals or minerals and minerals or binders and minerals, which can inhibit or facilitate the bioavailability of certain minerals. Additionally, minerals are water-soluble. Despite their stable chemical structure, they can be leaked out from food into water. To classify, depending on the necessary daily consumption quantity, those have a number above 100mg/day is considered major mineral or micromineral, and the opposite is called trace minerals or microminerals. (Drummond & Brefere 2009, 226; Whitney & Rolfes 2016, 381-382.)

In general, although the body's demand for minerals is low, they are essential to normal tissue functioning. Sodium, potassium, and chloride are electrolytes that are separated into positive and negative ions when they are dissolved in water. This makes them play a major role in retaining the fluid balance between intracellular and extracellular environments such as water and acid-base balance. Calcium, phosphorus, and magnesium are specialized in skeleton system promotion. (Drummond & Brefere 2009, 234; Whitney & Rolfes 2016, 382.)

Sodium is positive-charged and located mainly in the extracellular fluid as a regulator. In addition to acid-base balance, it participates in nerve impulse transmission and muscle contraction. After being absorbed from intestinal tract, sodium enters bloodstream and reaches kidney where most of sodium is filtered so that the returned amount is reasonably

sufficient and the excess is excreted in urine tract. When salty food is consumed, thirst signals are generated to increase the water intake to the point of sodium-to-water balance. Table salt, as commonly known, is sodium chloride, while chloride molecule alone in nature is available under the form of poisonous gas. Independently, negative-charged chloride is an element in the chemical structure of stomach acid known as hydrochloric acids which help to uncoil protein, activating enzyme pepsin to do protein catabolism, destroying harmful bacteria, and increasing iron and calcium absorption. The last member in the fluid regulation team is potassium which is a positive ion and mainly stays in intracellular fluid. The mechanism of the instant sodium-potassium exchange across cell membranes plays a key role in nerve transmission and muscle contraction. The potassium distribution in the cell environment can also influence the heartbeat due to its effect on homeostasis. (Drummond & Brefere 2009, 20, 234-240; Whitney & Rolfes 2016, 382-387.)

Calcium is available in the body in the largest amount compared to other minerals, because it’s needed for the stable structure of skeleton system. The system helps to hold the body upright, creating a rigid frame so that muscles can attach, and allowing movement. Moreover, the skeleton is the huge storage of calcium to retain the balance of calcium level in blood for other vital functions such as nerve transmitting, protein and enzyme activating, blood clotting, hormone secreting, and muscle contracting. To form a bone, calcium and phosphorus, with the support of collagen matrix, combine with other compounds to build crystal form named hydroxyapatite. The more hydroxyapatites are created, the denser and stronger the bone is. Instead of maintaining their structure, bone cells continuously undergo the remodeling process of building and breaking. The ratio between the two processes is different in certain human life phases. For instance, bone-building is preferable in the growing child, and the ratio is quite balanced in adults, but bone break-down becomes more in the elderly. Therefore, if the growing phase doesn’t get an adequate amount of calcium, it’s more likely to develop bone-related diseases such as osteoporosis when getting old. The normal rate of calcium absorption is 30%, in reality, this percentage varies depending on the body situation and diet. In the case of growing children, the number can reach 50% and then gradually reduce to 30% in adults, and whenever calcium deficiency is detected the absorption rate goes up to fulfill the need. Besides, one of vitamin D's functions is to create calcium-binding proteins which help to increase calcium bioavailability. However, binders phytate and oxalate in fiber can disturb the calcium absorption. Therefore, milk fortified with vitamin D is a more preferable calcium source than vegetables and whole grains. (Drummond & Brefere 2009, 231-232; Whitney & Rolfes 2016, 388-390.)

If calcium is in the first place of the top abundant minerals in the body, phosphorus stays at the second place. 85% of phosphorus is in hydroxyapatite crystals with calcium in bones and teeth. Besides constructing bones, phosphorus participates in metabolism since high-energy compound ATP has three phosphate groups in its chemical structure, in enzymes and B vitamins' activation, in the acid-base balance of body cells, in phospholipid as a stabilizer, and in DNA and RNA component. (Drummond & Brefere 2009, 231-232; Whitney & Rolfes 2016, 394.)

Magnesium is a macromineral with approximately 60% in bone, the remaining is in soft tissues such as muscles, and 1% in extracellular fluid. It's essential for energy metabolism since its presence in soft tissue cells allows necessary protein generation. Its major role is to facilitate the synthesis of protein, fat and nucleic acids, and the transport system of cell membranes. Along with calcium, magnesium promotes muscle contraction system and blood clotting. If calcium allows muscles to contract, magnesium helps muscles relax, regulating the blood pressure and respiratory function. Moreover, magnesium is involved in bone and teeth formation, immune system, nerve transmission, and hundreds of enzyme activations. (Drummond & Brefere 2009, 232-233; Whitney & Rolfes 2016, 395.)

Sulfate belonging to the major mineral group is the oxidized sulfur and occurs plentifully in food and water. It's also found in dietary protein, in amino acid methionine, and cysteine which can stabilize protein structure. Sulfate is also a main part of skin, hair, and nails protein. Due to the various sources, the need for sulfate is easily met. (Drummond & Brefere 2009, 240; Whitney & Rolfes 2016, 397.)

Although trace minerals are needed in an extremely small amount, they have specialized tasks to maintain normal body functioning. All the essential trace minerals, such as iron, zinc, iodine, selenium, copper, manganese, fluoride, chromium, and molybdenum, are the well-researched ones whose primary roles and consequences of deficiency and toxicity are apparent. The nonessential ones, such as nickel, bromine, vanadium, cobalt, and boron, are still out of question, but they are vital to human life as well. Trace minerals are hyper-interactive with each other. The mere overload of manganese may cause iron deficiency. Inadequate selenium in body may aggravate iodine deactivation in the chemical structure of thyroid hormones. The shortages of iron may cause lead poisoning. (Whitney & Rolfes 2016, 408-409.)

Iron exists in two forms in the body: ferrous iron with two positive charges and ferric iron with three positive charges, and these two forms can freely transform into each other because of oxidation and electron return. Therefore, iron can act as a cofactor to enzymes

associated with oxidation-reducing functions. Many enzymes responsible for the synthesis of amino acids, collagen, hormones, and neurotransmitters need iron to perform their jobs. Iron is also involved in energy metabolism and is an essential component of two proteins which are hemoglobin in red blood cells and myoglobin in muscle tissues. It supports the oxygen transport system. The iron absorption depends on the need of the body, when the iron storage falls short then the bioavailability increases and when the storage of iron is full, the bioavailability is limited. In food, iron is classified as heme iron or nonheme iron. Heme iron occurs only in animal food and nonheme iron is found in both animal and plant food. Body absorbs and uses heme iron more effectively than the other one because heme iron is not affected by dietary factors like nonheme iron does. The factors are listed in table 2. MFP factor as a peptide in meat, fish, and poultry helps the nonheme iron absorption. In the list, the MFP factor and vitamin C are outstanding enhancers while phytates are powerful inhibitors. Most iron is stored in liver and bone marrow for the hemoglobin or myoglobin production because the life span of red blood cells is approximately 4 months. (Drummond & Brefere 2009, 241-242; Whitney & Rolfes 2016, 410-412.)

Table 2: Dietary Factors That Influence Nonheme Iron Absorption (adapted from Whitney & Rolfes 2016)

Enhancing factors	**Inhibiting factors**
MFP factor	Phytates (legumes, grains, nuts, seeds)
Vitamin C (ascorbic acid)	Vegetable proteins (soybeans, legumes, nuts)
Acids (citric and lactic)	Calcium (milk)
Sugars (fructose)	Tannic acid (and other polyphenols in tea and coffee)

Zinc appears to be in all kinds of cells, mostly in muscle and bone cells and acts as a cofactor for hundreds of enzymes involved in metabolic reactions and genetic formation. It also plays a role in strengthening antioxidant ability in cell membrane, in immune system, normal growth and development, wound healing and taste perception, blood-clotting with platelets, thyroid activity regulation, behavior and learning performance, and vitamin A active form (retinal) production. The bioavailability of zinc fluctuates the same way as that of iron, depending on the storage and food sources. Binder phytates are its inhibitors as well. After passing digestion and absorption, zinc reaches pancreas and works with numerous digestive enzymes which are released into small intestine for doing their jobs. This makes zinc to be both in food and in released pancreatic juices. So, zinc can be reabsorbed from

small intestine into blood for further use. This process is called the entero-pancreatic circulation of zinc, which keeps the body's demand for zinc at a minimum level. (Drummond & Brefere 2009, 244-246; Whitney & Rolfes 2016, 419-420.)

Iodine requirement is extremely small, but iodine occurs only in sea-related ingredients, so the majority of inland food doesn't contain it. Iodine changes to iodide and becomes an indispensable component of thyroid hormones that are responsible for temperature regulation, metabolism, reproduction development, normal growth, blood cell production, nerve transmission, muscle contraction, and much more. (Drummond & Brefere 2009, 246; Whitney & Rolfes 2016, 422.)

Selenium has the same chemical characteristics as sulfur, so it can replace sulfur's task in amino acids methionine, cysteine, and cystine. Another important role of selenium is being an antioxidant made by the body, serving as a part of the glutathione peroxidase enzymes which work with vitamin E to fight against free radicals. Additionally, other selenium-containing enzymes regulate thyroid hormones. (Drummond & Brefere 2009, 246; Whitney & Rolfes 2016, 424.)

Copper appears in many types of tissues, which is determined by a system of protein for transporting and balancing. Several enzymes have copper in their chemical structure, which promotes metabolic reaction requiring oxygen or oxygen radicals and copper itself also participates in the metabolism. For example, the transformation from ferrous ion to ferric ion needs copper-containing enzymes. Therefore, copper is essential in hemoglobin synthesis. The body's antioxidants also need copper and zinc as the component of the necessary enzymes to work against free radicals. Moreover, without copper, protein collagen production is interrupted. (Drummond & Brefere 2009, 248; Whitney & Rolfes 2016, 425.)

Manganese is found mainly in bones, liver, kidneys, and pancreas and serves as a cofactor for enzymes which is involved in metabolic reactions. It also takes part in the bone-building team with calcium, vitamin D, phosphorus, and others. (Whitney & Rolfes 2016, 426.)

Fluoride, available in drinking water, some fishes, and tea, assists in hydroxyapatite formation, which provides strength for bone and teeth. Additionally, it also helps to protect teeth from bacteria, preventing dental cavities and dental caries. (Drummond & Brefere 2009, 247; Whitney & Rolfes 2016, 426-427.)

As an essential trace mineral, chromium is a member of the metabolism team for carbohydrate and lipid. It has differently charged forms like iron, and three positive charged form is the most stable and most abundant in food. Chromium by facilitating the effect of insulin plays an important role in keeping the balance in glucose homeostasis in bloodstream. (Drummond & Brefere 2009, 248; Whitney & Rolfes 2016, 427-428.)

4 Digestion and absorption

Digestion and absorption are the two different body mechanisms toward food, but they are strongly connected. While digestion refers to the cooperation of muscle, enzyme, and other compounds with the aim of breaking down the food molecules into their simplest chemical form, absorption mentions the different pathways that allow these chemical units to enter bloodstream and reach the destined locations. (Drummond & Brefere 2009, 18; Whitney & Rolfes 2016, 72.).

4.1 Gastrointestinal tract

Chewing and swallowing food in the mouth is just the start of the long process of digestion. Theoretically, digestion means the body's physical and chemical reactions happen in body to break down food into its simplest forms which can be easily processed in the absorption phase. The latter phase refers to the transporting ways of nutrients from the small intestine to the targeted cells, tissues, and organs. And metabolism is the living activities of cells and tissues in the form of chemical reactions between nutrients. (Drummond & Brefere 2009, 18; Whitney & Rolfes 2016, 72.). The understanding of how and what happens to food and its components can clear out the overall relationships within the body, and between nutrients and tissues.

Throughout thousands of years of evolution, the human body has many selective organ structures that assist automatically digestion and absorption without considerate efforts. Stomach tube and air tube are on the same road. However, food and liquid are directed into stomach, and oxygen-and-carbon-dioxide exchange happens in air tube instead of mixing with food in lungs. Since stomach is in the belly, body needs a way for food and liquid to go through the diaphragm which separates the upper half and the lower. The contraction of digestive tract requires adequate speed so that there is sufficient time for enzymes to break down and direct them to the small intestine. The combination of stomach acid, enzymes, and hormones in catabolizing and anabolizing needs to be in harmony. At the end of the digestive tract, waste needs to be stored and excreted at the appropriate time instead of excreting continuously. These mechanisms automatically work and require little energy to carry on, even when they perform their tasks on the daily basis. (Whitney & Rolfes 2016, 72.)

The gastrointestinal tract is a middle hollow tube from mouth to anus where feces are stored. It can do its job thanks to flexible muscles tagging along the tubes, namely peristalsis, which is the key contributor to the one-way direction of food and liquid. It’s commonly acknowledged that nutrients and other compounds need to pass through the digestive tract lining in order to enter bloodstream, the remaining is forced to leave out of the

body along with excreted waste from cells and tissues through the lining. (Drummond & Brefere 2009, 19; Whitney & Rolfes 2016, 72.)

The place food begins with is the mouth or oral cavity and is the start of the digestion process. This is the place where chewing and crushing occur to tear apart the food and fuse it with saliva secreted from salivary gland to dissolve the food. The secreted fluid is composed of digestive enzymes that help to break down the food into small pieces at the molecular level and enhancing taste bud activity. This is also the reason we can taste sweet, bitter, sour, salty, and umami flavor from food. While 32 permanent teeth are designed to be tough enough to do the grinding part, tongue acts as the controller as it rolls the ground wet substances called bolus – food ball. After being crushed down into pieces and mixed with saliva, bolus is swallowed into the throat gate – pharynx, where oral and nasal passages meet up at the point split to esophagus – gateway to stomach and epiglottis – airway to lungs. (Drummond & Brefere 2009, 19; Whitney & Rolfes 2016, 73.)

To prohibit the mixing of air and digestive substances, at esophagus, there is a lower esophageal sphincter which acts as a specialized bodyguard for only food and liquid. This muscle tube often closes during the breaths, but when we swallow, nasal cavity becomes inactive and lower esophageal sphincter opens, allowing food and liquid to pass and reach the stomach. This result is a part of peristalsis which refers to the involuntary and complex contractions in favor of pushing food through the entire gastrointestinal tract and breaking food physically. (Drummond & Brefere 2009, 19-20; Whitney & Rolfes 2016, 73.)

The next location is stomach after the sphincter. Under the form of a J-shaped muscular sac, stomach holds the bolus in the upper part contemporarily and then moves it into its lower part gradually by contractions for digesting. With the maximum capacity is 4 liters, the stomach acid called hydrochloric acid and its enzymes are secreted from the lining of the stomach, proceeding the food break-down. Since the acid is harmful, the mucus lining covering the inner layer of stomach plays a protective role. Then the bolus is churned into chyme – semiliquid substances which are forced down into small intestine little by little through the pyloric sphincter. There is a small number of nutrients are absorbed, and so does the alcohol. The digestion in stomach takes from 1.5 to 4 hours to empty the meal. (Drummond & Brefere 2009, 19-20; Whitney & Rolfes 2016, 73.)

Small intestine is a long tube that can be divided into three different parts depending on their roles: duodenum, jejunum, and ileum. On the small intestinal wall, there are countless tiny finger-like projections called villi and the structure of the villi is composed of nu-

merous microvilli. This design aims to the maximum exposed surface so that more nutrients can be absorbed in the tube. Most of the compounds passing duodenum and jejunum wall enter blood or lymph vessels to reach liver and body cells. Duodenum is the first part which receives chyme from the stomach and does most of the digestion. Since the stomach acid presented in the chyme can cause damage to the rest of digestive tract, in duodenum, bicarbonate is secreted from pancreas to neutralize it. Besides, fat is a tough substance to dissolve due to its insolubility to water, liver needs to secret a specialized compound named bile which is kept in gallbladder to the duodenum for aiding lipid catabolism. There is also the presence of two types of digestive enzymes, one comes from liver and the other comes from intestinal brush border. Jejunum is the next section where the well-digested chyme goes to and where most of the absorption occurs. The last part is ileum that does the majority of fat-soluble vitamins and vitamin B_{12} absorption. (Drummond & Brefere 2009, 19-20; Khan Academy a; Whitney & Rolfes 2016, 73.)

After traveling the long way in small intestine, the remains are passed to large intestine or colon through ileocecal valve which helps the substances maintaining their one-way movement. The main mission of colon is to reabsorb water from the waste content and also take some minerals such as sodium and potassium and some colon-bacteria-made vitamins. These bacteria or microorganisms living in the colon are a necessity for human well-being as they can produce vitamin K, digest some fiber, and more. After being processed in the colon, semisolid waste now comes to the rectum to be stored and excreted through anus at a proper time. (Drummond & Brefere 2009, 21; Whitney & Rolfes 2016, 73-74.)

4.2 Macronutrient absorption and digestion

Common diet usually contains carbohydrate, protein, lipid as the energy-yielding nutrients, and minerals and vitamins. These classes of compounds are processed in different ways in the body, which is illustrated in figure 11.

Carbohydrates are long-chain molecules. To absorb them into bloodstream, body needs to turn them into the simplest form of carbohydrate or monosaccharide. In mouth, saliva gland produces the enzyme amylase which can cut down the polysaccharides into shorter chains and disaccharides. Since chewing occurs in a short time, digestive reactions of carbohydrates do not take place much in mouth but small intestine. In stomach, the hydrochloric acid and protein digestive enzymes deactivate amylase, so the carbohydrate digestion is delayed and fiber as its nondigestive ability provides the feeling of fullness. Small intestine continues the catabolizing jobs as pancreatic amylase is secreted via pancreatic duct for further break-down so that carbohydrates become short glucose chains and maltose. Brush border – villi and microvilli now make maltase, sucrase, and lactase to

break down maltose, sucrose, and lactase respectively to their monosaccharide components which are absorbed and are carried to liver where galactose and fructose are converted to glucose-like compounds. These compounds along with glucose are then ready for metabolism. (Drummond & Brefere 2009, 99; Whitney & Rolfes 2016, 105-107.)

In contrast to hydrophilic traits of digestive enzymes, fat is hydrophobic – insoluble in water, which requires a unique way of digesting. In the mouth, salivary enzyme lingual lipase is released for fat digestion in infants but it doesn't help much for adults. The powerful contractions of stomach disperse fat into tiny droplets, allowing gastric lipase enzyme to do its job but not so effectively. At the time fat reaches small intestine, the encounter triggers a specialized hormone, signaling gallbladder to release the stored bile. Bile serves as an emulsifier which does the fat splitting tasks, hereby turning these droplets into tiny fat globules. At this scale, the presence of pancreatic lipase and intestinal lipase can digest completely a lipid to a glycerol, three fatty acids or a monoglyceride and two fatty acids without any extra step. Phospholipid undergoes the same process and the results are a glycerol, two fatty acids and a phosphate fragment. Glycerol, short- and medium-chain fatty acids can go through the intestinal wall and enter bloodstream. Monoglycerides and long-chain fatty acids combine with bile to form spherical complexes or micelles which can pass the intestinal cells and restructure into triglycerides. This time, the molecules and other lipids, such as cholesterol and phospholipid, are wrapped in a protein known as water-soluble chylomicrons. Since chylomicron is a big unit, so instead of entering directly bloodstream, it uses lymph system as a backdoor to get back to bloodstream. Then chylomicrons carry lipid groups to destined tissues and liver for further processes. (Drummond & Brefere 2009, 142-144; Whitney & Rolfes 2016, 142-144.)

The consumed proteins are not directly converted into body proteins, they need to go through a catabolizing process to become amino acids, then body can use them to anabolism necessary proteins. In the mouth, protein does not undergo chemical reactions but only physical reactions as crushing and tearing into small pieces. As mentioned in subchapter "Protein" in chapter 3, proteins have many different twisted and folded shapes that are not easily touched by the digestive enzymes. Before entering small intestine, these proteins are reacted with hydrochloric acid in the stomach, leading to their denaturation. Moreover, the gastric acid also activates the enzyme pepsinogen which becomes pepsin. As they are uncoiled and can be reachable, pepsin cleaves the large polypeptide chains into smaller ones and amino acids. The break-down continues in the small intestine with the presence of several pancreatic and intestinal proteases, resulting in tripeptides, dipeptides, and amino acids. However, the existence of pepsin in the small intestine ceases because it only works well in the low pH environment as stomach not in the higher pH area

as small intestine. Then the brush border secretes enzyme peptidase to finish the protein catabolism by breaking almost all tripeptides and dipeptides into single amino acids which are absorbed through the intestinal wall. Some amino acids are used for metabolism or necessary synthesis, the rest are carried to liver. (Drummond & Brefere 2009, 168-169; Whitney & Rolfes 2016, 175.) Figure 11 is an example of the digestion and absorption process of whole-wheat sesame bread with peanut butter.

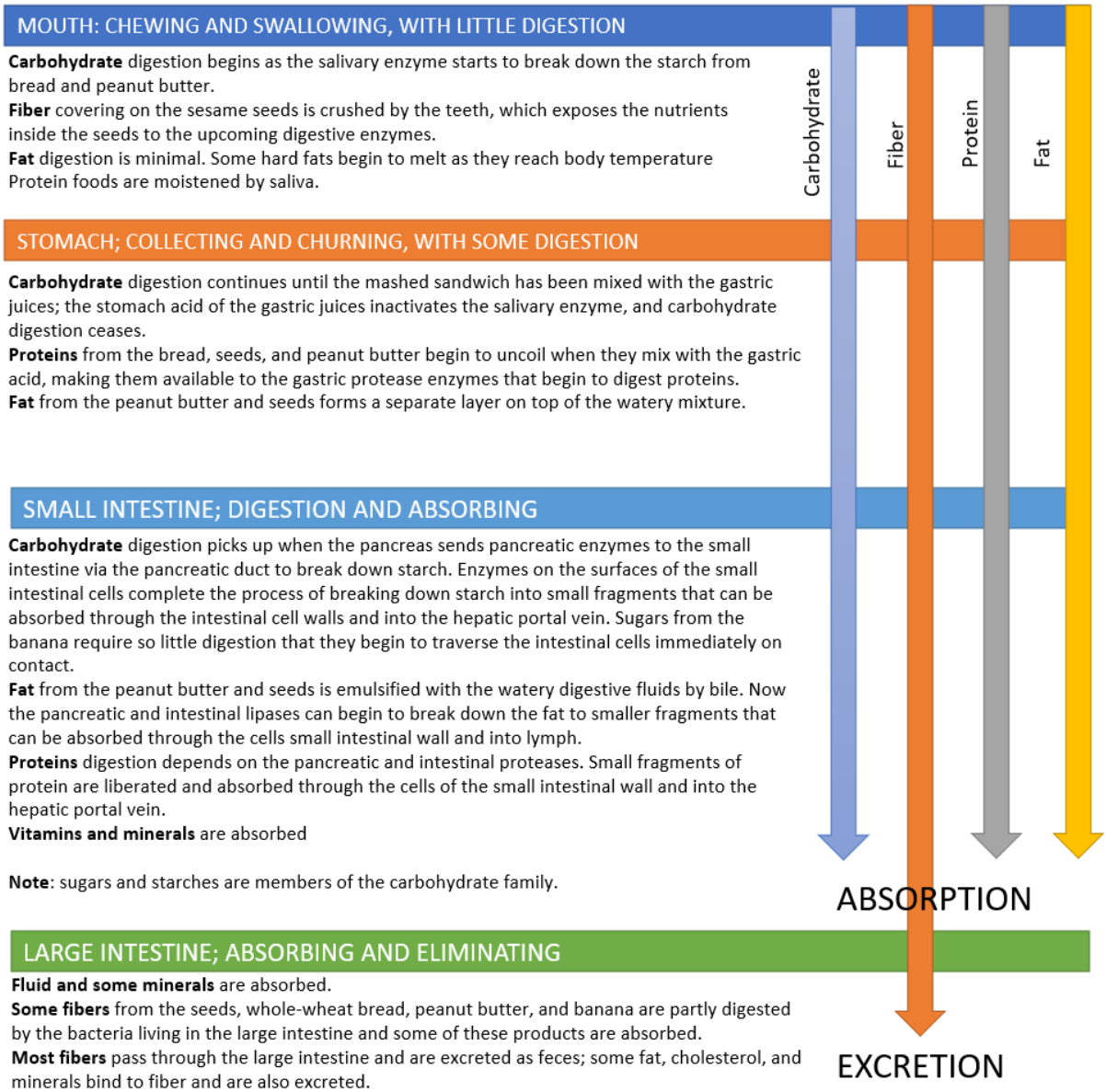


Figure 11: Nutrients digestion and absorption process as an example of a sandwich. (adapted from Whitney & Rolfes 2016)

5 Metabolism

Metabolism refers to the chemical reactions that happen inside a living cell. Energy metabolism is related to the energy production made by breaking down and converting macronutrients. (Drummond & Brefere 2009, 10-11; Whitney & Rolfes 2016, 201-202.)

5.1 Energy

The food consumption is usually calculated as the number of kcalories, and this becomes a measuring method for adjusting diet in this modern age. The daily energy requirement is dependable on many factors which are basal metabolism, the intensity level of physical activity, and the thermic effect of food. Basal metabolism is the minimum energy required for all the automatic activities when body is at rest and awake, and the food thermic effect refers to the energy consumption for food digestion, absorption, and metabolism. (Drummond & Brefere 2009, 10-11.)

The basal metabolic rate (BMR) is the major factor in energy expenditure, approximately 65% in inactive people and it is varied in each person due to the differences such as gender (BMR in men is higher than that in women), age (BMR declines after the age of 30), growth (children, women in pregnancy and lactation have higher BMR), height (the taller one is, the higher BMR is), temperature (BMR increase in both hot and cold environment), fever and stress (BMR is higher), exercise (BMR increases several hours after), smoking and caffeine (both increase BMR), and sleep (BMR is at the lowest). Physical activity is the strong influencers in daily energy requirement, accounting for 25-40% of total energy needs, especially for those who are active or who are the athletics. Lastly, the thermic effect of food takes up a small proportion of energy expenditure from 5-10%. (Drummond & Brefere 2009, 10-11.)

The kcalorie term used daily refers to ATP compound in the chemical structure which presents in metabolic reactions. Metabolism includes catabolism and anabolism or the breaking and constructing of the energy-yielding substances in terms of chemical structure and energy metabolism indicates the energy-used activities in the body. Some profound processes of anabolism and catabolism are presented in figure 12. While anabolism requires energy for the building, catabolism releases it as a sub-product. (Whitney & Rolfes 2016, 202-204.)

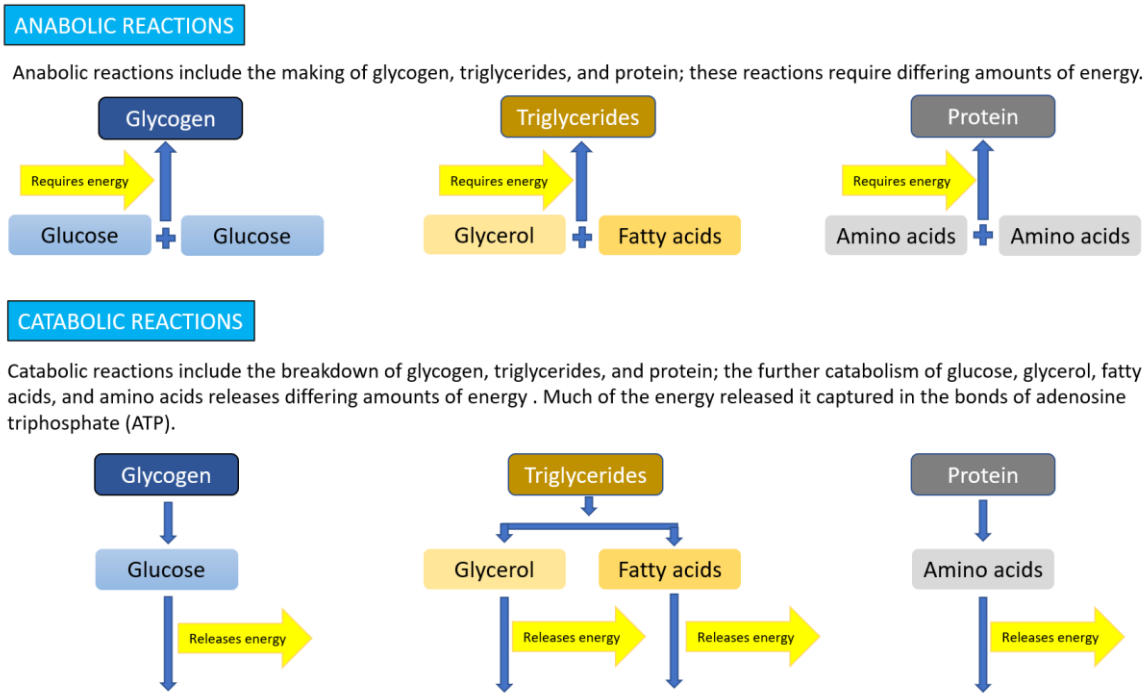


Figure 12: Anabolism and catabolism of the energy-yielding nutrients. (adapted from Whitney & Rolfes 2016)

As described in figure 13, energy is needed to forming the chemical bonds and` is released after breaking the chemical bonds. The mentioned energy is ATP – the high energy compound containing three phosphate groups. Phosphate groups have negative charges which attract water molecules to perform hydrolysis reactions, then one or two phosphate groups are cut off from ATP, releasing energy and the reverse equation can happen in the presence of free phosphate groups and sufficient energy, which is described in figure 13. In high frequency, metabolic duet named coupled reactions happen with ATP-involved reactions, which means that the released energy, from phosphate group detachment, fuel the anabolic reactions through a shared intermediate. The conversation rate from consumed food to ATP is approximately 50%, the remaining energy is presented as heat and dissipates in the environment. The same fate occurs to residue energy from ATP-involved reactions such as muscle contraction, compound synthesis, and transport. (Khan Academy b; Whitney & Rolfes 2016, 202-204.)

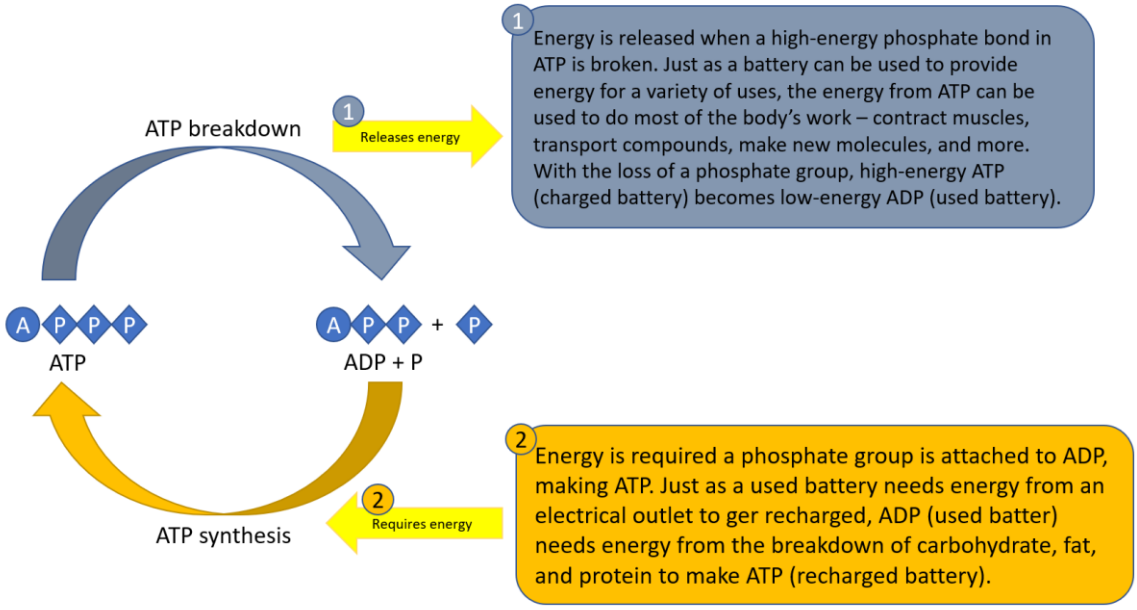


Figure 13: ATP breakdown and synthesis. (adapted from Whitney & Rolfes 2016)

5.2 ATP synthesis

In the previous paragraphs, the high-energy compound – ATP is mentioned as the primary fuel for all cell activities. Therefore, understanding the process of converting macronutrients into ATP is necessary to identify the difference in macronutrients' roles and abilities, leading to better decision-making in menu planning.

ATP synthesis or the process of producing ATP is a complicated process composed of many steps. Therefore, the explanation is divided into three main phases classified as its subchapters.

5.2.1 Conversion to Pyruvate and Acetyl CoA

To produce ATP compounds, the yielding-energy nutrients are processed through many stages differently. Figure 14 describes simply the varied pathways which lead to ATP from polysaccharide, lipid, and polypeptide. The mechanism can explain the reason why 1 gram of carbohydrate and protein only produce 4 kcalories, meanwhile, 1 gram of fat can make 9 kcalories.

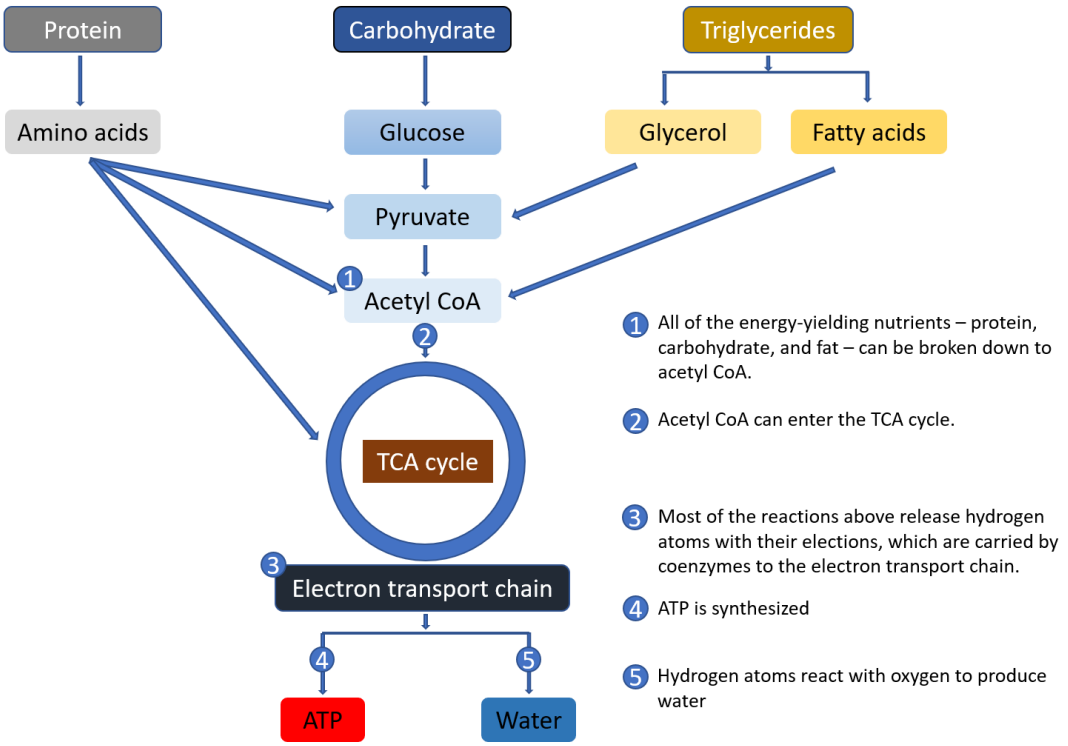


Figure 14: Simplified Overview of ATP Synthesis. (adapted from Whitney & Rolfes 2016)

The first thing to mention is the carbohydrate, after being broken down and converted to glucose, it enters metabolic breakdown – glycolysis, including several steps and participation of some enzymes. As the result, one 6-carbon glucose molecule produces two 3-carbon pyruvate molecules and a hydrogen and electrons that are carried by coenzymes to the electron transport chain. Under some circumstances, the reaction can be reversed to make glucose to meet the need of the human body. Pyruvate can also be converted to 3-carbon lactate which provides the necessary energy for muscle contraction immediately without the participation of oxygen – anaerobic energy. The energy production in this way can be quick but not sustained, maximumly a couple of minutes. However, if the muscle contraction works in a less intensive way, oxygen can participate in the conversion of pyruvate, helping its breakdown into 2-carbon acetyl attached with the coenzyme CoA molecule, leading to acetyl CoA formation which provides more energy sustainably in a long time. The pyruvate-to-acetyl-CoA is irreversible, unlike many reactions in the body. (Whitney & Rolfes 2016, 206-211.)

Glycerol has a 3-carbon structure like pyruvate, so the conversion either to pyruvate or glucose is much easier compared to other ones. On the other hand, fatty acids go through series of reactions named fatty acid oxidation which refers to a 2-carbon unit is cut and restructures with a molecule of CoA to build acetyl CoA, producing a hydrogen and electrons that are released and picked up by coenzyme to electron transport chain. This

means that if the fatty acid that has a 16-carbon structure produces 8 acetyl CoA molecules. Because of this conversion, a diet rich in lipid cannot generate a sufficient quantity of glucose for red blood cells, and brain and nerve cells activities. Glycerol can be made into glucose but it only has 3 carbon compared to 50 in a normal triglyceride, meaning 5 percent in total, hereby not meeting the need of necessary cells' energy requirement. (Whitney & Rolfes 2016, 206-211.)

Before metabolic conversions, amino acids are deaminated, which means that the amino-containing group is detached from amino acids and then it produces ammonia (NH_3). Ammonia units are the nitrogen source for generating nonessential amino acids and other nitrogen-containing substances. As described in figure 14, the amino acids can enter in the conversions to pyruvate or acetyl CoA or even participate in the TAC cycle for contributing to ATP synthesis. This also means that some amino acids turning to pyruvate can make glucose when an insufficient glucose source is presented. Therefore, unlike triglyceride, protein is considered a good alternative glucose source in place of carbohydrates. Figure 15 summarizes the conversions of these energy-yielding nutrients to pyruvate and acetyl CoA. (Whitney & Rolfes 2016, 206-211.)

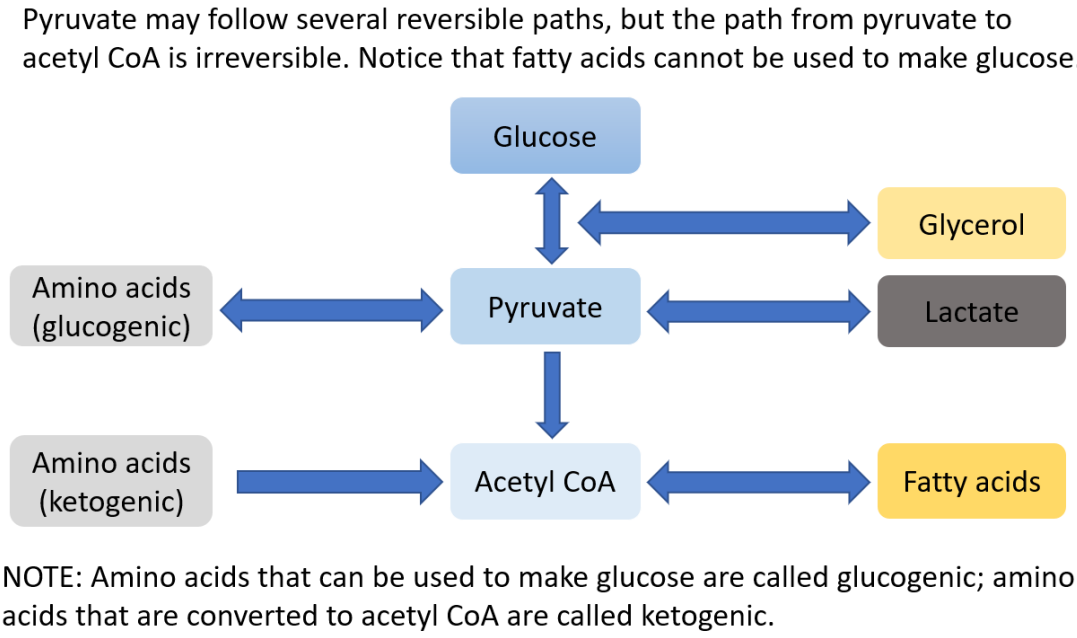


Figure 15: The Paths of Pyruvate and Acetyl CoA. (adapted from Whitney & Rolfes 2016)

As illustrated in both figures 14 and 15, all three macronutrients can be transformed into acetyl CoA. At this point, depending on the demand for ATP, if ATP is sufficient then the produced acetyl CoA will be converted to fat – energy-stored structure, and if ATP is insufficient, acetyl CoA will enter the TCA cycle for ATP synthesis. TCA is the final common

energy metabolism of energy-yielding nutrients occurring in the inner compartment of mitochondria which is shown in figure 16. (Whitney & Rolfes 2016, 213.)

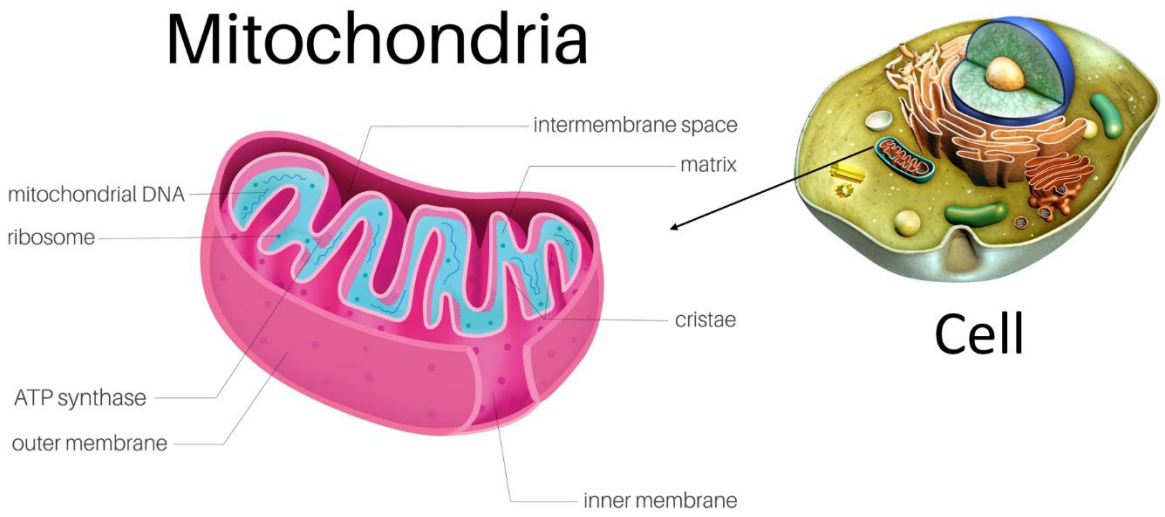


Figure 16: A Mitochondrion.

5.2.2 TCA cycle

The cycle of TCA is demonstrated in figure 17. The first step of the cycle is the participation of acetyl CoA, but it doesn't mean that at the end of the cycle there is acetyl CoA generation. The path of the acetyl CoA process is a one-direction way. (Khan Academy c; Whitney & Rolfes 2016, 213.)

The cycle formation is based on the role of oxaloacetate which is made from pyruvate and specific amino acids but not fat. The role of 4-carbon oxaloacetate is to attach to acetyl CoA to form a 6-carbon molecule then it enters the TCA cycle, on the journey to get back its 4-carbon chemical structure and then starts the whole cycle again. The new 6-carbon atom formed by oxaloacetate and acetyl CoA is oxidized, causing the removal of one carbon and energy release (hydrogen protons and electrons release) and the new 5-carbon unit is formed. Then the same thing happens, reducing the number of attached carbons to four in the chemical structure. After that, the 4-carbon structure itself undergoes rearrangement processes with the aid of non-carbon groups to become oxaloacetate again. And these processes also produce some energy. The cycle releases carbons, which become a part of carbon dioxide, hydrogen protons, and electrons, which are then carried into the electron transport chain by coenzyme niacin and riboflavin – B vitamins. (Khan Academy c; Whitney & Rolfes 2016, 213.)

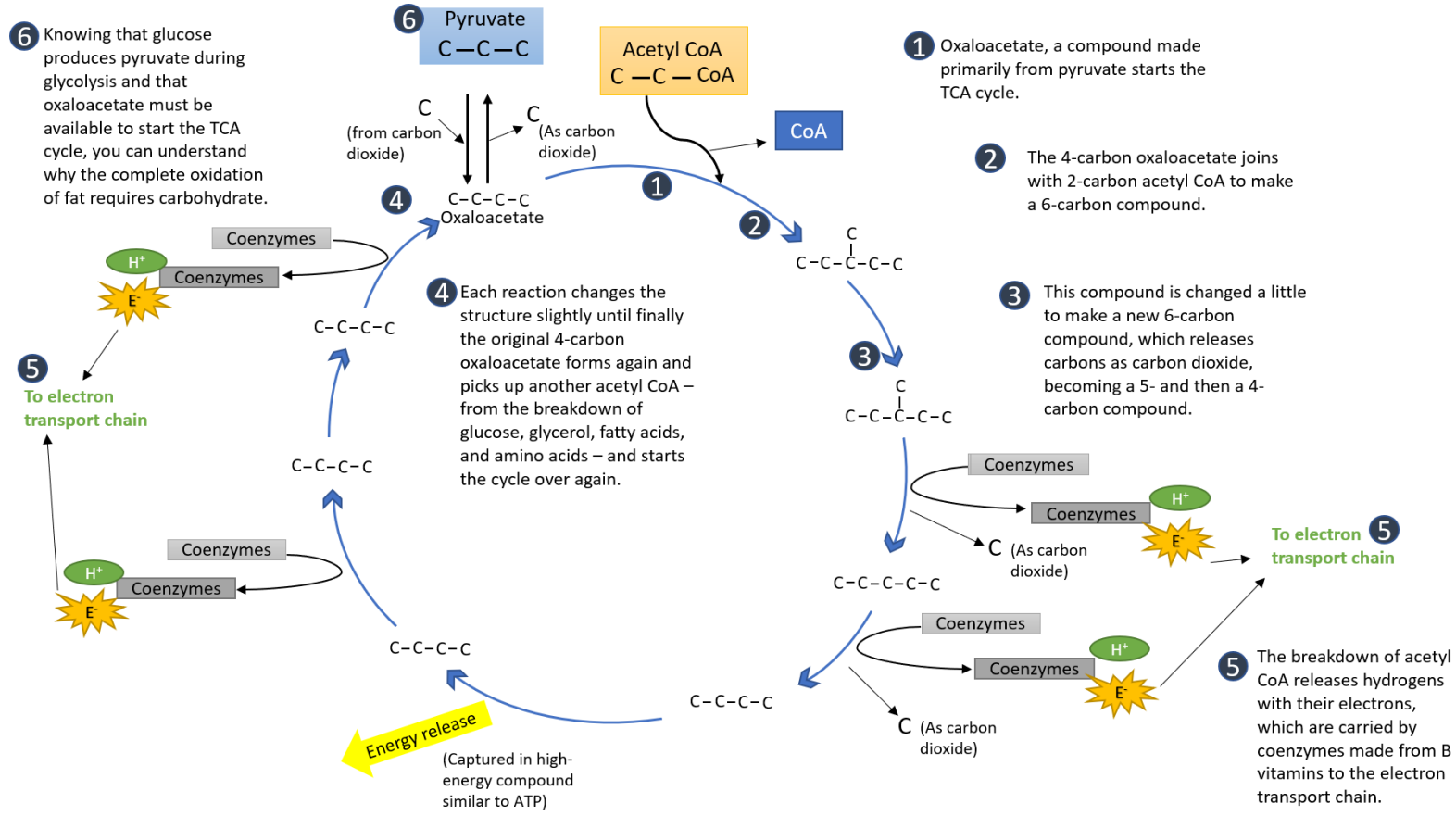


Figure 17: The TCA Cycle. (adapted from Whitney & Rolfes 2016)

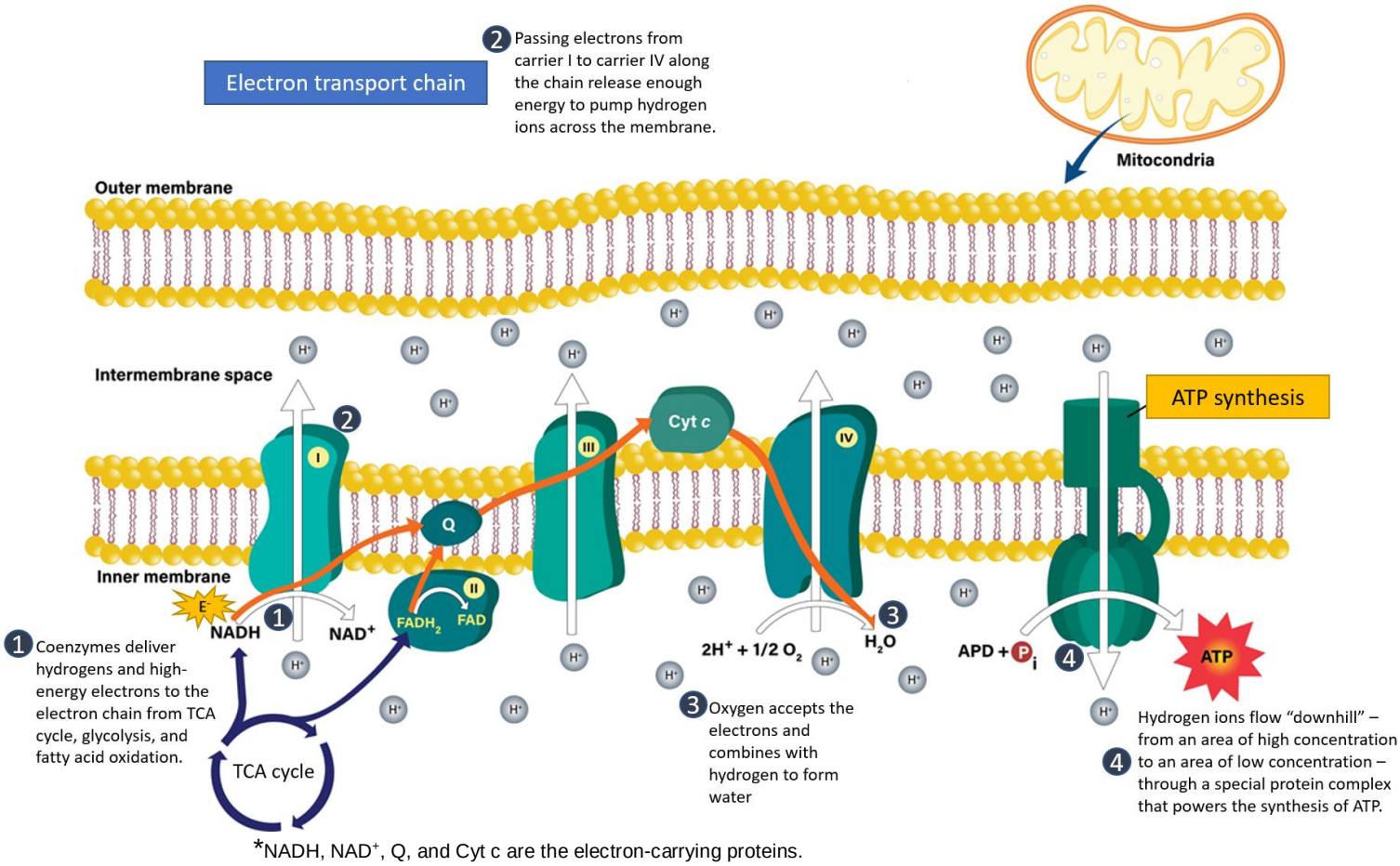
5.2.3 Electron transport

The mission of the electron transport chain is to gather the energy and form high-energy bonds of ATP, and the process is described in figure 18. The chain comprises numerous electron-carrying proteins such as coenzyme Q and cytochrome, lying in sequence on the

inner membrane or the matrix of the mitochondria. (Lue, R. 2017; Khan Academy d; Whitney & Rolfes 2016, 213.)

The electrons (negative charged) and the hydrogen protons (positive charged) available in the chain are from the TCA cycle, glycolysis, and fatty acid oxidation by coenzyme deliveries. Then, received electrons are continuously passed from one electron-carrying protein (or electron carrier) to another through the series of interconnective actions within four protein complexes (complex I, II, III, and IV). At this point, the electrons end up in protein complex IV (an electron carrier) and meet oxygens. Then they combine with hydrogen protons to form water molecules. Therefore, without the presence of oxygen, the chain activities halt and ATP cannot be generated. This is the reason why human being needs to breathe to get oxygens, otherwise, living cells cannot do the respiration and produce energy for growth and reproduction. (Lue, R. 2017; Khan Academy d; Whitney & Rolfes 2016, 213.)

During the active-to-less-active-electron transitions within the electron carriers, the process produces energy, fueling the four protein complexes to act as a pump. These pumps use energy to force hydrogen protons from the inner compartment to the outer compartment, and due to the impermeability of membrane lining, this creates electric and acid-base potential so that the outer compartment is more positively charged and acidic than the base environment of the inner compartment. Because hydrogens cannot go through the membrane to the matrix, they need to across a special gateway named ATP synthase, triggering the synthesis of ATP by combining ADP with a free phosphate. Then the new ATP gets out of the mitochondria and is ready for cell activities. (Lue, R. 2017; Khan Academy d; Whitney & Rolfes 2016, 213.)



*NADH, NAD^+, Q, and Cyt c are the electron-carrying proteins.

Figure 18: Electron Transport Chain and ATP Synthesis. (adapted from Whitney & Rolfes 2016)

According to chemical structure and energy metabolism mechanism, fat is the one providing the most energy per gram. Because the chemical structure of fatty acid contains mostly carbon-hydrogen bonds, as shown in figure 4, oxygens (O_2) can react with both other the component molecules (C and H) to form carbon dioxide (CO_2) and water (H_2O) in the ATP synthesis. Unlike fat, glucose has some oxygen molecules in its chemical structure, as shown in figure 2, so fewer hydrogens are released as energy for coenzymes to deliver to the electron transport chain because hydrogens react immediately with its oxygens when the chemical bonds are broken. Therefore, fat generates more ATP than glucose, meaning that consumed fat generates more kcalories which can be extensive and converted to the stored fat. For example, while one glucose can make 30 to 32 ATP at most, 16-carbon fatty acid can yield 129 ATP at most. (Whitney & Rolfes 2016, 213-216.)

Moreover, the excess consumption of either fat or carbohydrate even protein can lead to fat formation in body, but the dietary fat undergoes a much more convenient conversion without much effort than the others. In the chemical structure, two of three fatty acids attached to glycerol is cut off and absorbed then restructured to be fatty acids and triglyceride can be stored in the adipose cells. (Whitney & Rolfes 2016, 213-216.)

Carbohydrate needs breaking down to glucose, then converting to pyruvate then to acetyl CoA. After that, body continues converting acetyl CoA into fatty acids and tries to find glycerol for attaching, then triglycerides are formed. In detail, while body uses 5% of consumed kcalorie for converting dietary lipids into stored fat, the percentage for carbohydrate conversion is 25%. Therefore, body prefers the fat-to-fat pathway. Protein is also needed for maintaining muscle tissues. When protein overeating happens, instead of building more muscle cells, it is converted to necessary compounds and becomes triglyceride in adipose tissues the same way as carbohydrate. Muscle building is dependable on hormones which are generated by doing physical activities. (Whitney & Rolfes 2016, 213-216.)

6 Gastrophysics

There is a misbelief that flavor is the sole factor for consumers to choose a dish over another for dining. However, there are many other factors directly and indirectly contribute to the perception of food selection.

Gastrophysics relates to the research area associated with the relationship between what and how people perceive taste through body and environmental factors (Spence & Blumenthal 2017, xvi-xx). These factors are introduced in the following subchapters.

6.1 Five senses

6.1.1 Taste and the basics

There is a misconception in taste anatomy that tongue possesses specific regions for detecting each taste. The fact is that every taste receptor can detect five basic tastes as long as their chemical forms are simple enough after being broken down by teeth and salivary enzymes. Taste receptors are found not only in 5000-10000 taste buds in tongue but also on the roof of mouth, throat, brain, pancreas, liver, lung, stomach, and so on. However, there is a “bald spot” located in the center of the tongue, which tastes nothing. The number of taste buds in the tongue classify people as Non-taster (or Intolerant Taster), Taster, and Supertaster (or Hypertaster). This widespread of tast buds throughout the body helps to protect itself from toxins and to direct corresponded behavior of eating if the body is in short of certain nutrients. Besides the “taste map” in tongue, there is an actual taste map in the brain for taste perception – one brain region is for each basic taste. In fact, without tongue, brain can still perceive the sense of taste. (Herz 2018, 5-7; Spence & Blumenthal 2017, 1-3; Stuckey 2013, 19-43.)

The set of basic tastes is still under controversy, but sweet, bitter, sour, and salty are the four that are widely known and they meet the four criteria for being a basic taste. The four criteria are distinction and uniqueness, explication through salivary breakdown, taste-perception mirroring in the form of chemical reactions, and innate response as love or hatred as nutrients or toxins. Apart from the four, umami is also considered as the fifth basic taste in many articles, but it doesn’t meet all the mentioned conditions, so it’s described in the latter section. The impact of basic tastes is not only on the food preference but also on behavior and judgment. (Herz 2018, 8-35; Stuckey 2013, 31-38.)

The ability to detect sweetness is believed as a contributor to human evolution as the chemical structure of sweet is sugar or glucose – the main energy currency, especially for brain cells and blood cells, which is naturally in the form of starchy food. Sweetness can

suit most people's palate as everyone enjoys it, but not the intensive sweetness such as Swedish Fish candy. To counter sweetness, sourness is the best candidate. Not only does it mitigate the sweet taste in the tongue, but it is also the best partner to achieve a better level of deliciousness with sweetness. When detecting sweetness, a considerate amount of hormone dopamine and endorphin is released, bettering the mood in any case, even in pain. Therefore, sugar or sugary products are used for their analgesic effect, and the effect correlates with the intensity of one's liking. Those having sweet teeth are often more altruistic than the others who don't have, so they are friendlier, more cooperative, and willing to help. However, depression can reduce the sensing of sweetness. (Herz 2018, 8-35; Stuckey 2013, 216-225.)

Bitter taste comes from a pH level over 7 and indicates the toxic level of the substances. Facial expression and impulsion after detecting bitter is a protective mechanism for avoiding poisons. Furthermore, bitter taste buds belong to 25 types, which are more than any other taste. In culinary experience, bitterness is usually avoided as an unpleasant flavor, but many bitter vegetables contain phytonutrients such as polyphenols, flavonoids, isoflavones, terpenes, and glucosinolates. Therefore, these bitter vegetables are recommended to consume in moderation. To counter bitterness, not only do other basic tastes like sweet, salt, and sour tastes can help, but other elements such as fat and vanilla also can work well. (Herz 2018, 8-35; Stuckey 2013, 198-211.)

In contrast to bitterness, sourness is determined by the level of pH which is under 7. It is also related to toxin as with pH 4, substances can decay human tooth enamel. So, the less pH it is, the larger the damage it can cause to not only the tooth enamel but also digestive tract. When tasting sourness or even just thinking about it, saliva is released to reduce the acidity of the substances, which helps to digest. Fatty acids can block sourness receptors as it does to chili. Physical activity can increase the amount of released saliva and the emotion of winning can reduce sourness perception, meanwhile, the negative feeling can increase this level. As sourness refers to acidity and microbe cannot survive in high acidic level, sourness applies to food preserving along with salt and sugar. The sourness has a special relationship with saltiness because their detection mechanism is the same and it is different from sweetness and bitterness. Therefore, saltiness can enhance sourness and vice versa. (Herz 2018, 8-35; Stuckey 2013, 229-238.)

Last but not least, the chemical compound that human taste receptors realize as saltiness is sodium chloride. Saltiness is the necessary taste to be detected because it leads to protein-rich foods which are vital to human evolution in ancient times. The more frequently taste receptors detect it, but do not consume, the more saltiness liking is. So, individual

preference for saltiness can be adjusted to achieve a low-sodium diet. Besides the ability to add a salty taste to the dishes, salt can enhance the browning edge of food during cooking, or Maillard reaction, adding extra layers of flavor. Moreover, it has a taste suppression effect which can reduce bitterness and sourness, while it can increase sweetness and umami. Because of these effects, it's indispensable for seasoning food in daily life. Most importantly, salt has preservative properties that contribute to food storage in the old times and it's still currently applicable. (Herz 2018, 8-35; Stuckey 2013, 177-197.)

6.1.2 Smell – aroma

The taste of food is misperceived in daily communication because the culinary experience term which people usually mention is flavor, not taste. While tastes are those that belong to basic tastes and extra other ones which are explained in section "Other taste" later on, most of what people perceive during chewing and swallowing is flavor – a combination of predominant aromas at the sense of smell and tastes at the tongue. It's about 75-95% flavor that we realize is from smelling through the mouth. So, bacon is only salty without the sense of smell. This happens due to the anatomy of mouth and nose. (Herz 2018, 61-65; Spence & Blumenthal 2017, 21-22; Stuckey 2013, 53-54.)

Chewing and enzyme cooperation at the start of digestive process helps stomach work in the next step easier. This process also helps to taste the flavor of and create the enjoyment of eating, reinforcing eating behaviors so that nutrition profile is ensured. As the food is chewed, the enzyme and physical exertion of tooth break down food into smaller molecules which can be tasted on the tongue. But before the food comes to the mouth, nose detects the food aroma, connects to brain, and creates some expectations of food flavor profiles. This way of sniffing is orthonasal olfaction. However, another sniffing also occurs during the chewing, when the aroma from the chewed food runs to the back of the nose during exhaling. This is a process named retronasal olfaction, which is the prime factor responsible for most of the flavor. Nevertheless, this process is unconscious and mistaken with chewing. That is the reason why most thoughts mention the tongue as the primitive factor in detecting flavors, meanwhile, retronasal olfaction plays the key role. (Herz 2018, 63-68; Spence & Blumenthal 2017, 21-22; Stuckey 2013, 54-57.)

Smell can be tasted because the brain areas – anterior insula and orbitofrontal cortex that are responsible for the taste and smell respectively, integrate. Therefore, taste experience can be stimulated through scent, for example, vanilla can create a sweet taste for plain water and sugar can make grape juice grapier. This learning process is quick and dependable on culture, so the associations between aroma and taste can be varied for each individual. Furthermore, orbitofrontal cortex is also a hud where information about pleasure, memory, emotion, and motivation is processed. This creates a strong connection between

aroma, feeling, experience, and memory, which can be harnessed for a better culinary experience. This is already applicable in The Fat Duck restaurant with “Jelly of Quail with Langoustine Cream and Oak Moss”. (Herz 2018, 61-85; Spence & Blumenthal 2017, 21-38; Stuckey 2013, 54-75.)

Although the sense of vision is completely developed in three years, the sense of smell is fully functional at birth. So, the scent ability of a fetus already works and can detect what inside the amniotic fluid which is influenced by the mother's diet during pregnancy. This means that the variety of diet for pregnant mothers can help the child after birth more willing to try other ingredients and flavors, ensuring nutrition intake of the child, especially with healthy foods. For the elder, from approximately the age of 55 to 80, scent ability reduces gradually until it’s gone, negatively affecting the elder’s palate and hereby leading to malnutrition. Additionally, depression and seasonal affective disorder negatively affect the ability to smell. (Herz 2018, 65-91.)

6.1.3 Touch – texture

The most convenient way to enrich the eating experience is through sense of touch. The feeling of texture can help eaters to identify the quality and characteristics of a dish like crispiness, softness, and bounciness. Some food characteristics of food are associated with one’s like and dislike, depending on one’s related memories and experience in the past. (Herz 2018, 177-183; Spence & Blumenthal 2017, 88-109.)

Some characteristics trigger warning signals and cause body innate reactions to get rid of the food in mouth. For instance, the slimy texture of an oyster can make itself a poor-quality one or the texture of the particles from seeds in the grapes can make a child refuse to eat. These textures are usually difficult to control in human oral cavity, posing a danger as choking or contaminated-like substances. On the positive side, with proper textures, the deliciousness can be elevated such as the consistency of the sauce or the super crispy skin of pan-seared duck breast. Moreover, soft food requires less effort to crunch than hard food, making it naturally more preferable than other textures. However, the speed of eating soft food is faster with less satisfaction and filling than hard food. As a result, whole roasted vegetables are eaten fewer in quantity than vegetable soup. (Herz 2018, 177-183; Spence & Blumenthal 2017, 88-109.)

Temperature is another factor that can change the perception of taste. At a high degree of Celsius, the dish is less salty, bitter, and sweeter than those at room temperature. (Herz 2018, 177-183; Spence & Blumenthal 2017, 88-109.)

For all chefs, texture contrast is a pivotal element in menu planning as it facilitates the enjoyment of eating. There are four approaches to differentiate textures of food: within the meal, on the plate, within a complex food, and within a simple food. “Within the meal” refers to different textures of different dishes in a tasting menu, like soup as a liquid for starter and crunchy pan-seared scallops. “On the plate” means the components of a dish can be cooked to produce different textures, like the crispiness of the outside and juiciness of the inside of a steak and soft and fluffy mashed potato. “Within a complex dish” links to different textures with the same ingredient, like salmon with different points of cooking from raw to well-done state in a same dish. Last but not least, “within a simple dish” is the choice of served ingredients or cooking method which allows the food to change texture when it hits the consumers’ mouth such as chocolate or fat, because of body temperature. (Stuckey 2013, 89-100.)

Years before the metal production of industrialization, human use bare hand to hold and deliver food into mouth. And now, the most profitable dish over the word is burger which is eaten by hands, most of the Indian use hands to eat daily and many 2 and 3 Michelin-star restaurants such as The Fat Duck in Bray or Noma in Copenhagen also apply this style of eating to many of their dishes. Therefore, the feeling of holding food or cutlery can influence strongly the dining experience. The cutlery has the potential for expanding the horizon of the eating experience, but the practices require much attention so that it doesn’t backfire. Textured spoons are designed by William Welch and top chef Jozel Youssef, for example, or unusual textured wooden spoons from Noma restaurant, or even furry cutlery. The textured cutleries are under more researches so that their practical application can be commercial. Besides, the feeling of heavy and high-quality cutlery improves the dining experience, leading to better consumer satisfaction. (Herz 2018, 183-184; Spence & Blumenthal 2017, 88-109.)

6.1.4 Sight – appearance

“Eat with the eyes” is a norm in the culinary field in today's world, but before the appearance of nouvelle cuisine in the 1960s, restaurant dishes had no difference from homemade ones in the aspect of visual attraction. The reason for this is that the visual appealing of a dish has a tremendous effect on the dining experience. It seems that the aesthetic look offers a better enjoyment at the table, which influences the consumers’ expectations. In some studies, beautiful food boosts consumers’ mood, activating chemicals, and neural circuitry responsible for pleasure and reward in the brain, thereby enhancing the received flavor profiles. (Herz 2018, 125-127; Spence & Blumenthal 2017, 51-54.)

To advance the food aesthetic, the plate shape and colors, the arrangement of food components, and the color contrast within the food components and between ingredients and

the plate are all counted. Not only does food aesthetics can please consumers' eyes, but it can be shot perfectly in a convenient way to be uploaded to Instagram and other social media platforms. This way of food decoration is called the foodography style. Some examples can be the specially designed plates for photo shooting and 360 food plating style, which help shooting a perfect picture with a smartphone. (Herz 2018, 125-127; Spence & Blumenthal 2017, 51-54.)

As mentioned, color on both foods and containers has a great impact on tastes. Many research shows that the high-level color contrast can impact consumers' behavior to have more pleasure at eating and eat more than low-level color can do. So, utilizing color in food can change the perception of taste without adding any condiments. Red color can make food sweeter, while white can make it saltier. The same occurs to the association between green and sourness, black and bitterness. The mechanism lies in the link between human experience and interacted features. Salt has a white color and it's a staple feature most of everyone every day, or the red-colored white wine tastes more red-wine than the normal white wine. It also means that the effects are different to individuals, depending on their cultures and beliefs. If consumers acknowledge the phenomenon, the impact will be dull. This influence is called "sensory dominance", which refers to the experience through one sense infers other senses. Although the red color on the tableware can sweeten the food without adding more sugar, it also indicates the dangers and makes consumers eat less. To conclude, the color implication into food can help promote healthy eating by reducing sugar and salt intakes. (Herz 2018, 131-133; Spence & Blumenthal 2017, 40-43; Stuckey 2013, 106-108.)

In addition to the color, the shape of the plate itself also has an influence on taste perception. Studies show that carbonation and bitterness refer to the feeling of being under threat, meanwhile, saltiness and sourness are associated with overripe and spoiled foods or toxics. These flavors appear to be enhanced by the angular shapes of the serving wares in comparison with the round shapes. In contrast, sweetness linked to positive feeling is elevated in the round shape containers. (Herz 2018, 61-85; Spence & Blumenthal 2017, 43-46; Stuckey 2013, 109-113.)

Additionally, the portion size and the feeling of eating satiation can be estimated by the sense of sight. This means that, with the same amount of food, the smaller the bowl is, the less food a person wants to consume and feel satiated. Therefore, to lose weight, the strategy of distributing all the snacks into small packages and using small tablewares is a good idea. Another factor that takes part in consumers' experience is the eating partners, especially their facial expressions. This practice bases on "embodiment theory" which

mentions the sentimental influences from one to another. So, if consumers see the negative expression on the partners' face when eating a dish, their taste for that dish will be worse and vice versa. (Herz 2018, 61-85; Spence & Blumenthal 2017, 43-46; Stuckey 2013, 109-113.)

"Eating in the dark" is one of the main trends in the culinary world. The idea is to temporarily deactivate the sense of sight to elevate other senses for an exotic experience. The results are different to individuals but there is a common matter – neophobia. Neophobia is a human innate mechanism to be wary of the unknown, especially food, to protect the body. Therefore, those experiencing "eating in the dark" consume less food than usual and for those who are at a higher level of neophobia, the blind-eating experience is worse. (Herz 2018, 135-159; Stuckey 2013, 102-106.)

6.1.5 Hearing – sound

The sound of the atmosphere or even the sound from the chewing mouth does have an effect on the taste perception of a dish, especially in terms of texture. This impact is demonstrated to the public by the dish "Sound of the sea" from The Fat Duck restaurant. The dish is fresh seafood presented on top of a box of sand and the diners eat it while listening to the sound of the sea from the provided iPod. The food is feedbacked to be more delicious, which originates from the diner's concentration on the sound, the sea-related memories about the beach and ocean, and the neglect of companions to focus on the taste of the dish. (Herz 2018, 160-167; Spence & Blumenthal 2017, 66-87; Stuckey 2013, 121-131.)

Besides, the high-pitch sound does make the food sweeter than the low-pitch note as the high-frequency notes create a positive feeling and by contrast, the low-frequency ones do the opposite. The tempo of the music playing as the background can be influential as the fast tempo shortens the time diners spend to eat in the restaurant and the low tempo prolongs it. The loud noise can also indicate how crispy the food is, which correlates with positive feedbacks. Because hearing is a dominant factor for the human brain in perceiving the crispiness level of the food in mouth, while the sense of taste is the other factor, no sense of touch. Therefore, extra loud noise from the outside, not just from the oral cavity, can provide an extra feeling of crispiness, like the rattling package of potato chips affects the crunchiness of the chips themselves. Lastly, the correlation between crispiness and the positive feeling of taste is learned, not innate. So, this association can different in the future. (Herz 2018, 160-167; Spence & Blumenthal 2017, 66-87; Stuckey 2013, 121-131.)

Practically, soup added some croutons or salad with some seeds for extra crispiness can put the dish on a higher level in the satisfaction scale. Another practical use of music is

wine tasting. Through the study named “Montes Wines” in Chile, a heavy metal song can elevate the robust flavor of the cabernet sauvignon. Pop and orchestra also imbed the different flavors into the wine as zingier, refreshing, and more subtle, refined, respectively with “Just can’t get enough” by Nouvelle vague and “Waltz of the Flowers” by Tchaikovsky’s Nut Cracker Suite. The theory refers to the activated brain areas caused by listening to the music, then affecting the taste of wine. The table indicates some wines coming along with the suggested songs for a better taste. (Herz 2018, 170-173; Spence & Blumenthal 2017, 81-83; Stuckey 2013, 121-125.)

Table 3: Suggested songs with wines.

Wine varietal	**Suggested songs for optimizing the experience of the wine**
Cabernet sauvignon	All Along the Watchtower (Jimi Hendrix) Honky Tonk Woman (Rolling Stones) Live and Let Die (Paul McCartney and Wings) Won’t Get Fooled Again (The Who)
Chardonnay	Atomic (Blondie) Rock DJ (Robbie William) What’s Love Got to Do with it (Tina Turner) Spinning Around (Kylie Minogue)
Wine varietal	Suggested songs for optimizing the experience of the wine
Syrah	Nessun Dorma (Puccini) Orinoco Flow (Enya) Chariots of Fire (Vangelis) Canon (Johann Pachelbel)
Merlot	Sitting on the Dock of the Bay (Otis Redding) Easy (Lionel Ritchie) Over the Rainbow (Eva Cassidy) Heartbeats (Jose Gonzalez)

Loud noise can make the taste of potato chips crispier and better, but too much noise can do the opposite. The impact is more obvious while dining on the airplane. It causes the taste of food to be less tasted by the human brain, especially in the aspect of sweetness, saltiness, and sourness with the exception of bitterness. However, umami flavor of the food is elevated. It’s explained that chorda tympani – branch of facial nerve, which is one of three cranial nerves responsible for the sense of taste, transporting the taste information from tongue to brain crosses the tympanic membrane of the middle ear. So, the loud noise causes disturbances at the interacting point between chorda tympani and tympanic membrane, dampening the food taste. Another contributor to the dampening effect

of taste at 30000 feet is the lack of humidity which dehydrates passengers, resulting in less secreted saliva for dissolving and tasting food. Therefore, umami-rich food is an excellent choice for meals on airplanes. (Herz 2018, 167-170; Spence & Blumenthal 2017, 43-46, 146-159; Stuckey 2013, 118-120.)

6.1.6 Other tastes

Not to mention the four basic tastes, there are at least 20 other mouth sensations including electric, metallic and soapy, but among them, umami, fat, calcium, and spiciness are the unofficial tastes which have significant influences on the dining experience. (Herz 2018, 36.)

Umami is described as “brothy”, “savory” and “meaty” and as a holy element to add depth to the flavor of a dish, which is a top preference for chefs around. In terms of chemical structure, umami is a natural amino acid glutamate – block of protein. It’s also considered as a fifth taste as it meets the condition of being a basic taste, but it’s difficult to be detected by tongue and easily mistaken as “salty” so it lacks uniqueness and distinctiveness. Unlike other basic tastes, the perception of tasting umami occurs in gut instead of tongue, because the molecular size of umami is larger than the taste receptors. The catabolism of salivary enzymes and chewing is not enough to break down glutamate-containing protein in food, but the digestion process in gut can. Therefore, after glutamate break-down, taste receptors located in gut can detect and transmit the signals of flavor to the brain, which explains the better feeling of satisfaction after eating meat or glutamate-rich food than other types of food. The break-down in cooking, fermenting, drying and aging contributes to umami enhancement. On the other hand, excess umami flavor can cause fatigue feeling, so to reduce the intensity, acidity from lemon can help. That is the reason why sushi needs pickled ginger and a cheeseburger comes along with pickled red onions. Besides, monosodium glutamate (MSG), in industrial production, is blamed for the symptoms of Chinese restaurant syndrome, but there is no link between these two as the high intake of glutamate-rich ingredients, such as cheese, tomato, and bread, leads to no symptom. (Herz 2018, 36-41; Stuckey 2013, 245-258.)

Fat has no taste but it can provide a distinctive feeling in mouth, enhance and prolong other tastes, and improve the texture, appearance, and aroma of a dish. When taste receptors detect fat, the hormone dopamine is released and the dopamine-influenced brain areas (anterior cingulate cortex and amygdala) are activated as well. Because these brain areas are responsible for emotions and other functions, depression or high mood can reduce the perception of fat. (Herz 2018, 41-47; Stuckey 2013, 265-268.)

The taste of calcium can be referred to as sourness and bitterness and there is a correlation between bitterness in vegetables and calcium amount it contains. It can be detected by receptor T_1R_3 which is also involved in umami detection, so it doesn't meet the distinctiveness criteria as a basic taste. Additionally, T_1R_3 preferably detects sweetness, so calcium in sweet food can't be realized. Calcium naturally binds with fat and protein in food, and those can't be tasted as well. Therefore, even though calcium is an essential nutrient, but the taste is not easily recognizable. Researches show that those deficient in calcium are drawn to salty and fatty flavor, which is physiologically considered to go along with calcium by the mind. However, due to the industrialized food production, harmful food with high-level content of salt and fat is widespread. As a result, low-calcium status is often collated with body weight. (Herz 2018, 47-53.)

Last but not least, the taste of spiciness is obvious to taste receptors, but instead of activating brain areas responsible for flavors, it triggers the trigeminal system which is in charge of pain, burn, and cool feeling from peppermint, wasabi, onion, and hot sauce. In chili, capsaicin is the active substance causing a feeling of heat, and it also contains many healthy properties such as antioxidant, anti-inflammatory, and antimicrobial compounds. The feeling of heat can deactivate pain-sensing neurons by triggering body to produce the hormone dopamine, which is applied to the medical field as an opioid. (Herz 2018, 53-60.)

6.2 Social factor

Everyone loves delicious food, but cooking at home or choosing a restaurant for dining is a decision based not only on food taste but also other factors.

Food cost – the daily expense for ingredients is a major consideration for food selection. If all the healthy goods are cheaper than unhealthy ones, life will be much more pleasurable and will not require much hospitals and pharmacies as in today's world. However, due to industrialization, the cost of manufactured food is dropped and is easily accessible for everyone, while organic food is more limited at a higher price. Industrialization also leads to a retailing system with many markets and supermarkets, which have the same product brands locating throughout the whole country, and this provides accessibility to the population for the demand for purchasing. Therefore, availability and familiarity become the ones that can influence locals' purchasing decisions. In this social context, people become dependent on industrialized sources. The ingredients with appropriate prices available in local markets become the main elements for comfort foods and even the price tag on the products can manipulate the human mind. For the 45 dollars wine, the orbitofrontal cortex – the center of processing smell and flavor in the brain becomes more active compared to the same wine with 5 dollars label. Besides the price tag, nutritional information is also

printed in most of the products, but instead of looking for a better nutritional value, a product without a nutritional table is much better, since it indicates its freshness and naturality. Besides, some people are affected by health consciousness toward appearance and disease protection, so, with sufficient knowledge, a person's behavior may be changed. (Herz 2018, 128-130; Whitney & Rolfes 2016, 3-7.)

Another factor that strongly influences consumers' behavior is culture and religion. Culture is a difficult term to define, which can be considered as "the behaviors and beliefs of a certain social, ethnic or age group". Since each culture has its own set of behavioral patterns and principles that contribute to the group of dishes with different cooking styles which occur in both daily life meals and on special occasions for events and celebrations. Therefore, culture sets a decent mindset and attitude toward food belief, for example, horsemeat is edible for French people but not Americans. The same happens to religion, the quintessence is the Jewish community. They have their law about food choice as Kashrut that doesn't allow to eat pork and to mix meat with dairy products. There are also Roman Catholicism, Eastern Orthodox Christianity, Protestantism, Mormonism, Seventh-Day Adventist Church, Islam, Hinduism, and Buddhism, so the diversity of allowed food choices based on religions is huge. (Whitney & Rolfes 2016, 5-7.)

The fact that eating alone or together, eating at home or restaurant, or social context can influence one's food choices as well. So, the social contexts create the surrounding atmosphere that can affect one's behaviors and appetite. The difference can be easily seen as one put into a table with their family members and a table full of strangers. Or if the one eats with classmates and all of them are vegetarian, the one's food preference will more toward vegan foods. Especially, when paying attention to eating partners, ones can unconsciously mimic partners' behaviors. The more the one wants to impress and establish a relationship, the higher level of mimic is, and the less food is consumed. This shows that the desire for creating a good impression relates to the fact that the one pays more attention to the partners, not the food. And the same thing occurs if dining is under observed dining by others, so simply being watched can reduce the food intake. (Herz 2018, 200-206; Whitney & Rolfes 2016, 7-8.)

As being mentioned above, industrialization is an astonishing factor influencing human eating behaviors on a global scale. Besides, industrialization also brings up social media – a powerful connecting tool, leading to globalization, along with its impressive effect on the human mindset. The immersive information spreading over the whole world through social media under the forms of television channels, newspapers, magazines, and radio can reach everyone, and especially children, who are effortlessly vulnerable in both mental

and physical aspects, are strongly under its impact. Because of tons of food commercial advertisements about cookies, candy, and fast food, they can instill unhealthy manners in children, causing them to overeat unhealthy foods, there are also health-conscious commercials, reports, and related news that can direct more people to a better eating lifestyle. The effect of food image and advertise on human behavior is called “food porn”, or the South Korean trend named “Mukbang” – the act of watching a person eating and talking online through a smartphone. (Herz 2018, 251-282; Spence & Blumenthal 2017, 51-60; Whitney & Rolfes 2016, 8.)

Another example is the advertisement of Mark & Spencer, which was designed to be presented in motion like the melting chocolate liquid in the center that is falling. Those watching “food porn” or just exposed to food commercials through social media easily get hungry and indulge in unhealthy foods that have a higher level of fat, especially saturated fat, sodium, and sugar with high calories. Many studies show the association between “food porn” and Body Mass Index (BMI), as those having high BMI levels are exposed to “food porn” more than those having a normal level of BMI. Moreover, the fact that “food porn” actually activates the human brain, particularly the nucleus accumbens which is responsible for the neurotransmitter dopamine, the same way as sex, as the brain cannot distinguish between the real food or food image. Therefore, by triggering more dopamine, “food porn” creates temptation and deplete one’s will power gradually, and the more dopamine, the more likely ones give in to temptation. (Herz 2018, 251-282; Spence & Blumenthal 2017, 51-60; Whitney & Rolfes 2016, 8.)

6.3 Perfect meal

By considering multisensory elements, some purposes can be achieved by setting up the proper environment for the offered dishes. As fast-food restaurant chains want as many customers as possible, the fast tempo with bright light and the not-so-comfortable dine-in furniture are good ideas for shortening the unconscious customer time spending inside. If the restaurateurs want to deliver the best customer experience, paying attention to the background as round-edged tables and chairs with proper textures, themed music with proper light ambiance for the maximum flavor profiles. However, the star of the night is always the dishes themselves, they need to be prioritized above other factors. (Spence & Blumenthal 2017, 110-129.)

There are more to consider like building the woody features for the enhanced woody aftertaste of the wine enjoyment or providing the comfortable restaurant setting for a better culinary experience with less amount of food. Both of these conclusions are drawn from the experiments, but the applicability is not completely predictable in the future, due to the in-

tercultural exchanges at the global scale. However, human senses are sensitive to environmental factors, so the dining experience can be modified for a specific purpose, especially for a better healthy lifestyle. (Spence & Blumenthal 2017, 110-129.)

While restaurant dine-in is limited to most people, and the extra budget for renovating the surrounding scenes at the meal table is also a problem and is considered a waste, there are some tips for bettering the home eating experience. Comfort food, which is the childhood-exposed ones that can evoke nostalgia and homely feeling, is one of the mental-healing foods according to the researches. They can trigger the release of hormone endorphin, a vital factor contributing to human health and well-being. Moreover, this inner catalysis is learned, not genetic, and the local culture, religion, and family diet preference are the determinants. However, comfort food is usually high in carbohydrates and overeating to high-carb food results in a high risk of inflammation and cardiovascular diseases, metabolic syndromes and depression. (Spence & Blumenthal 2017, 130-140, 192-195.)

Besides these starchy dishes, some are considered positive mood enhancers, especially chocolate. Not to mention its sweetness effect and the memorial associations with positive feelings from special events, holidays, gifts, and the symbol of romance and love, chemically, chocolate possesses antioxidants, mood-enhancer substances that trigger the hormones dopamine, serotonin, and endorphin. Nevertheless, only high-quality chocolate can do this. (Spence & Blumenthal 2017, 130-140, 192-195.)

Another factor that helps to better the home-eating experience is the engagement in the ritual of the meal. The ritual refers to the before-meal series of actions required to be done on special occasions or every single meal. An example can be the “thank you” message which is often said before every meal to honor those who grow the ingredients and cook the dishes in Japanese culture. It’s also effective for those who are preparing their food and focus on the meal enjoyment without any distractions such as television or smartphone. Another consideration is eating together. (Spence & Blumenthal 2017, 130-140, 192-195)

Many types of research show that the involvement in group eating releases hormone endorphin, helping a better social connecting at the round table, which is reflected in many cultures such as Chinese culture, while the alone eaters are a part of a food-waste group and have an unhealthy lifestyle compared those eat with partners. However, due to the increasingly hectic life, solo dining in a restaurant has become more frequent, so there is an opportunity for this niche market. (Spence & Blumenthal 2017, 130-140, 192-195.)

As restauranteurs and event organizers, customer satisfaction is the ultimate goal. To achieve it, the experience during the day requires tremendous efforts from both back- and front-of-the-house staff, and one of the trendy ways is through personalization. It can be said that all healthy people love personalized services and products, for instance, the hot chocolate in the lovely favorite mug magically taste superior to that in the other nameless ones. This is what gastrophysicists call the “self-personalization effect”. (Spence & Blumenthal 2017, 176-281.)

Therefore, providing the tailored-made experience becomes a key strategy in nurturing customer loyalty, so that the interacting moments become memorable and become the words that are passed to others’ ears. For example, the staffs in The Fat Duck restaurant carefully observe the guests’ handedness and align the dining services accordingly or simply just remembering the guests’ names. In the era of technology, some restaurants google their guests and provide them with special childhood-related presents and some use online tools such as Venga and OpenTable to track customers’ information about food choices through the past visits and then create unique experiences for them. (Spence & Blumenthal 2017, 176-281.)

Talking about experience delivery, chef’s table concept is well-known for the restaurant due to its exotic feature – showcases of chef cooking skills in front of the eyes of customers. Some restauranteurs go further in delivering an exotic experience, such as Dive restaurant in Los Angeles with a submarine-themed building. However, the lighting of the restaurant was too extreme and the sound was too loud, so, instead of being exotic, it became too intense, ending up closedown. Therefore, the star of the night is still the dishes and its flavor, the others come along as the attachments for enhancing effects. (Spence & Blumenthal 2017, 176-281.)

7 Practice factors

This chapter aims to introduce the factors that can help readers to personalize their diet for themselves or the others. The factors that need considering are menu, research, allergy, food safety, diet type, related disease, and foundation of healthy cooking are presented. All of these need to be involved in menu conducting which is presented in chapters 9, 10, and 11. Because the method can apply to both business use and personal use, there are some elements that are important to one and some are not necessary to be concerned for the other.

The definition of menu and market research is brought up firstly for foodservice and event organizers. Because they need to prepare the menu with extra cautions, if not, the success of the menu in practice is less secured. For personal use, both of the topics is not so important. The menu is of no use for them and the research for personal use is mainly the health record. If one's health record reports the signals of illnesses, they should get the advice and treatment from doctors instead of independently adjusting their diet to cure the illnesses. The role of nutrition is to prevent disease, not to cure it.

The following topic is allergy and food safety. This topic is the top concern in the foodservice industry and home-cooking because the neglect and violation of allergy and food safety principles can cause a severely negative impact on eaters' health, even death in the worst cases. Therefore, the topic should be discussed and taken into consideration when planning a menu.

The next presented topic is diet type and related disease. In addition to the avoidance of allergic foods and the proper application of food safety principles, diet types and certain diseases are the secondary conditions for designing a menu. Diet type is related to a set of criteria for the eating habit with the aim to achieve a specific target. For example, those who want to change normal diet to vegetarian diet for ethical reason need to add protein-rich bean, legume, and others into their daily meals to gain sufficient amount of complete protein that is not easily found in plant-derived ingredients. The disease can be the reason for someone to change their diet. For instance, diabetes needs to have a low-fat and vegetable-focused menu instead of a normal one to improve their illness status. Therefore, diet type and illness have a great impact on choosing ingredients in the final menu.

Lastly, since the nutrients, especially vitamins, are easily destroyed in the preparation and cooking, the more careful food handling and cooking are, the more nutrients can be saved after being cooked. The subchapters introduce the flavor-enhancing and healthy cooking

techniques so that the final dishes can maintain nutrients in good quantity, and the dish flavor profiles are tasteful.

7.1 What is the menu?

The menu is a list consisting of many different products that are introduced to consumers for choosing at food service establishments. Therefore, it is a communication tool describing details about introduced dishes, such as prices, components, nutrition information, and history. To deliver the best service, the contents of the menu need to lighten the interest of customers in all aspects of deliciousness and nutrition. With those characteristics, it can help to boost the business development efficiently since food is the core product after all. (Traster 2018, 1.)

An effective menu pleases not only customers but also managers. Additionally, the menu is a feature contributing to the themed atmosphere of the food service providers. Menu planning is a process of creating an effective menu that fits the aforementioned foals through sufficient researches so that the introduced products can attract the targeted customers. (Traster 2018, 1.)

7.2 Research

Demographic studies refer to the data published by the local governments, reflecting the population in a specific area such as a zip code area, a city, or a state. The accuracy of data is better at a smaller scale, usually including age, marital status, housing type, gender, ethnicity, religion, education, occupation and income, and vehicle. After getting the general view from demographic data, psychographic studies need to be conducted. The studies are related to the activity, habit, and interest of the population. For example, most population of a city like sport, and usually eat out on special occasion or the emerging trends such as farm-to-table and less-meat dishes. This data is a key element for planners to design an effective menu that fits into the local community. However, both of these types of studies cause difficulty for those who are not familiar with the local area. Therefore, competitive analyses should be conducted to have a better understanding of the market potential by analyzing other competitors. The ability to utilize these studies is necessary for menu planners to follow the trends and have a better chance to create a successful menu. (Traster 2018, 2-8.)

After researching the market, inner analysis is another consideration. To meet the demand of the locals and their interests, the staff, equipment, and product availability are the three factors that have to be on track. Firstly, employees are the ones doing all the tasks, front-of-the-house members need to understand the core values of the menu so that they

can describe listed products properly and carefully to the customers, whereas the back-of-the-house team needs to prepare the dishes in the theme-matched ways. At this, point, menu planners need to pay attention to employees' proficiency that whether they can manage at the expected level or not. If it's not, the training section needs to open and the labor cost will increase, or the menu has to be modified. The next topic is equipment, which is the most obvious limitation for the foodservice employees to perform well. For instance, the layout of the kitchen and service area can affect the workflow, the storage capacity of raw and dried ingredients, kitchen tools and utensils, cutleries, and working stations need to be sufficient. Some dishes require special equipment like a steam pot for steamed dishes, or a deep-fried machine for extra-crispy foods. Lastly, the best choice is to use the local ingredients for cost efficiency and high-quality ingredients with logistical convenience. However, transporting exotic ingredients with the least quality depletion is possible nowadays, but it is costly. Besides, the menu planners have to codesign with other stakeholders for the best results. (Traster 2018, 8-9.)

For personal use, the mentioned research is not necessary to be conducted. The research, in this case, is the health record which can be retrieved from specialized health care departments. This record reflects personal health status so that the persons can know the issues and adjust the diet to improve their health according to doctors and nutritionists' advice.

7.3 Allergies and food safety

Food allergy is the most concerning matter when designing a menu. However, food allergy is easily mistaken for food intolerance because of its complicated effect on the human body. Simply, food allergy occurs when immune-system responsible units react with the absorbed substances from a specific food as they are harmful antigens by releasing antibodies, histamine, and other units for combating. However, the substances are not harmful at all and the reason for this serious mistake is still under research without solid proof. It's tricky to diagnose food allergy as the symptoms are not stable and obvious, even there is no symptom in some cases and the allergic reactions can be immediate or postponed from minutes to hours after consumption. Some symptoms may appear but it is not certain to be caused by an allergic reaction, but skin rash, respiratory difficulty, diarrhea, vomiting, and other severe symptoms are the ones that need more attention. There are 4% - 8% of children less than 4-year-olds that are truly suffered from allergy and the allergic reactions gradually weaken and disappear as they age. The food source that potentially causes the allergy is peanut, tree nuts, dairy products, beans, wheat, fish, and shellfish. (Traster 2018, 19; Whitney & Rolfes 2016, 527-528.)

Allergic food is a danger due to its reaction with immune system, and fortunately, it accounts for a small percentage of food-sick cases, the rest is under the name “food intolerances”. Food intolerances also cause unpleasant symptoms such as stomachaches, diarrhea, headache, bronchial irritation, coughing, constipation, and so on. The reasons causing food intolerances are not involved with the immune system like food allergy, but they are varied. For example, lactose intolerance from milk consumption occurs due to a lack of the presence of lactase enzyme in small intestine. The considerable causes are pesticide level used in farmed food, which is under control through government policies. (Traster 2018, 19; Whitney & Rolfes 2016, 527-528.)

Besides food allergy and intolerance, foodborne infection, and intoxication is a common problem to address. Foodborne infection occurs when the consumed food is infected by harmful microbes such as Salmonella, norovirus, and other pathogens due to improper storing and handling of food. The symptoms are varied according to the digested amount of infected food and the health condition of the sufferers, arranging from diarrhea, abdominal cramp or fever to death. Foodborne intoxication indicates toxins that are produced by the microbes and are absorbed into the body with the exceeded level compared to the body intolerant level. The well-known ones are Staphylococcus aureus and Clostridium botulinum, and both of them are very dangerous. Appendix 1 shows more details about the microbes that are responsible for foodborne illnesses. (Whitney & Rolfes 2016, 626-630.)

To avoid foodborne diseases, the best way is to pay more attention to the food journey from farm to table. The used amount of pesticide on the field, the food transporting method, food storage condition, and handling food in the kitchen need to be aligned with the principles of food safety that are regulated by the government. Examining the recent related cases such as Samonella infection in 2010, Listeria in 2011, Cyclospora in 2013, and E. Coli in 2014, the pivotal practices for foodborne illness prevention is food handling in a safe manner. For example, the use of Hazard Analysis Critical Control Point (HACCP) plan in all food-related venues need to be conducted with care, and those working in the kitchen or just cooking at home need to have the awareness of keeping the hand and kitchen utensils clean after use. (Whitney & Rolfes 2016, 630-633.)

Therefore “clean” is one of the four main principles of handling food and a must in controlling foodborne illnesses. The others are “separate”, “cook” and “chill”. The rule in the kitchen is not to place different raw ingredients together, especially with cooked ones, so separating them in different food preparing processes is necessary, preventing cross-contamination from occurring. As a norm, food needs to be cooked before being

consumed, so that all the potentially harmful bacteria can't survive. As the last one, chilling food products right after it comes to the foodservice providers' venue is vital and the same applies to leftovers. Appendix 2 explains detailed practices about the four principles. (Whitney & Rolfes 2016, 630-633.)

7.4 Diet type and related disease

After considering food allergy, food intolerance, and food safety principles in the menu planning, the next criteria are diet type and related disease. For those who have illnesses, ethical and religious reasons, or financial issues, they can adjust their eating habit to fit with some diet types such as low-sodium diet or vegetarian diet or to prevent the development of some diseases such as high-level blood pressure or overweight. The following content introduces certain diet types and related diseases that are commonly found when planning a menu.

7.4.1 Diet type

Low-sodium (or low-salt) diet: Most sodium intake comes from salt which has a chemical name is sodium chloride, so minimizing the amount of salt in meat times can achieve this goal. This means that the processed foods which have high a content of salt are the main target to be left out. Canned, cured, or smoked fishes and meats are good examples due to their high salt content needed in the production method for prolonged storing. Others that should be mentioned are processed cheeses, salted snack foods like potato chips, brined foods like pickled cucumber, canned vegetable products such as canned tomato, frozen convenient foods like pizza, dried cube for seasoning, and salty seasoning like soy sauce, ketchup. (Drummond & Brefere 2009, 374-378.). Reading the nutritional value information for more details about the products is recommended to control the salt intake better.

Vegetarian diet: This diet focuses on plant-derived foods and becomes increasingly popular in today's world because of many reasons. Those in favor of ecology protection prefer a vegetarian diet because livestock and poultry need more resources to raise. They need much more water, land, and plant foods compared to fertilizer and water that plants need. Some want to spend less on foods and most plant-derived foods are cheaper, so economics is another reason. Many people feel sympathy for animals as they need to be slaughtered and prepared to become a product. This ethical viewpoint also becomes a reason to give up on meats. Lastly, some religions choose vegetables as their staple foods on a daily routine or special occasions. The major group of vegetarians excludes meat, poultry, fish, egg, and dairy products from their diet, but lacto-ovo vegetarians accept egg, milk, and dairy products as normal foods or lacto vegetarians who do consume milk and dairy products but not egg. Additionally, pesco vegetarians are those who allow themselves to

eat seafood as the exception. In general, vegetarian diets can provide sufficient energy and most nutrients such as protein with a low level of fat, saturated fat, and cholesterols. However, vitamins and salt minerals, which need to be considered, can be vitamin B_{12}, vitamin D, calcium, iron, and zinc because some are found mainly in animal products such as vitamin B_{12}. (Brown 2014, 16-2 – 16-8; Drummond & Brefere 2009, 378-38; Whitney & Rolfes 2016, 64-65.)

Low-lactose diet: lactose intolerance is one of the common diets that can be found around the world due to the lack of the presence of enzyme lactase in small intestine, which helps to break down disaccharide lactose. Because lactose is only available in milk and milk products, so those who have lactose intolerance should avoid these products in their meals. Some foods to consider are ice cream, cottage cheese, sherbet, and cream. Yogurt and some hard cheese are exceptional because living bacteria in digestive tract absorb lactose to grow and contribute to the final taste of these products. However, be more careful with frozen yogurt because of its low quantity of cultured bacteria compared to the fresh ones, and some yogurts are even added with solid milk, which can cause negative symptoms. Fortunately, a small amount of lactose can do nothing to most lactose-intolerant people. (Drummond & Brefere 2009, 381.)

Gluten-free diet: The case of gluten is much more dangerous compared to lactose intolerance. With the name celiac disease, the inherited autoimmune system reacts violently with wheat, barley, rye, and oat in foods by many symptoms: diarrhea, bloating, weight loss, abdominal pain, and many more. Sometimes, there is no symptom. Therefore, a gluten-free diet excludes wheat, barley, rye, and oat and includes rice, potato, whey powder, cassia, bean, and tapioca products as alternatives. (Drummond & Brefere 2009, 381-382.)

7.4.2 Disease

Cardiovascular disease: Cardiovascular disease (CVD) includes all the defects related to heart and blood vessel, which means coronary artery disease, high blood pressure or hypertension, stroke, rheumatic heart disease, congenital heart defects, and congestive heart failure. And the most common reason leading to these diseases is atherosclerosis – the build-up of plaque on the artery walls, and plague – the deposits on artery walls and they are made of fat, cholesterols, and other debris. The controllable risk factors for cardiovascular diseases are cigarette smoking, alcohol abuse, high blood pressure, and cholesterol level, physical inactivity, obesity and overweight, diabetes mellitus, and high intake of salt. Therefore, to mitigate these risk factors, the TLC diet is recommended with a high intake of the soluble fiber under the weight and physical activity management. The TLC diet is the designed diet with low saturated fat and cholesterol, approximately less

than 7% saturated fat of total energy, and less than 200-milligram cholesterol per day. Fiber has a role in adjusting the ratio of cholesterol level positively through its binding ability with cholesterol. So, food sources rich in fiber are recommended: barley, oats, apples, bananas, broccoli, Brussels sprout, and many more. Both weight balance and physical activities are the keys to controlling high-density and low-density lipoprotein, as these are the two signals for diagnosing cardiovascular disease potentials. To improve hypertension, the cutdown of salt and alcohol intake is the most effective practice, along with physical activities at least 30 minutes per day and 5-6 days a week. (Drummond & Brefere 2009, 392-406.)

Cancer: Cancer is a state that cell division and growth go out of control and interfere with the normal functions of tissues or organs where it occurs. In serious cases, the cancerous tumor goes wild, it detaches from original place and enters the bloodstream where it can spread the cancerous cells throughout the entire body or land somewhere else, this state is called metastasis. Cancer formation includes two steps: The gene mutation occurs by carcinogens – cancerous substances, and when mutated cells become a tumor, metastasis takes place. Normally, when a gene is disrupted, it is repaired or replaced by body mechanism, but, promoters – cancerous catalysts such as fat, can fasten the cell-tumor transformation process. Apart from internal factors such as genetics and hormones, external ones are more considerable in terms of prevention. They can be tobacco usage or radiation and chemical exposure. The major fatal types of cancer are lung cancer, colorectal cancer, prostate cancer, and breast cancer, with the exception of skin cancer because it is not related to diet. The risk factors leading to cancer mainly are alcohol, red meat, physical inactivity, and being overweight. To lower the incidence of cancer, a menu characterized by low fat, low salt, high fiber, high vegetable and fruit, focused vitamins C, E, and beta-carotene, and non-alcohol is highly recommended. (Brown 2014, 22-2 – 22-6; Drummond & Brefere 2009, 409-411.)

Diabetes: Diabetes mellitus is a disease related to the malfunctions of enzyme insulin, resulting in high glucose levels in bloodstream or hyperglycemia. As glucose is made from carbohydrates, after meals, the consumed food is partly converted into glucose for ATP synthesis and glucose starts accumulating in bloodstream, raising the blood sugar level. This level needs to be kept within the controlled range, so pancreas releases enzyme insulin to transform glucose to an energy-stored form, which needs to wait for enzyme glucagon secreted by pancreas to turn it back to glucose when the blood sugar level is low. There are two types of diabetes. Type 1 diabetes occurs when the body's autoimmune system deactivates pancreatic beta cells which are responsible for insulin release, leading to no insulin production. The causes can be genetics and environmental factors such as

radiation or chemicals, so most of the suffers are children and adolescents and this type accounts for less than 10% in America. Type 2 diabetes is the major one and can occur at any age. The mechanism can be either pancreatic beta cells release little or no insulin, or body cells are unable to use insulin effectively. In most cases, it begins with insulin resistance which refers to the inefficiency of insulin for storing glucose in body cells, resulting in high both insulin and glucose levels in bloodstream because pancreas keeps releasing more insulin in response to hyperglycemia. Gradually, pancreas loses its ability to secrete insulin, and then little or no insulin is produced after meals, leading to type 2 diabetes. The main causes of insulin resistance are overweight status and physical inactivity. Diabetes is a backstep for many other diseases development such as cardiovascular diseases, hypertension, blindness, kidney diseases, nervous system diseases, amputation, dental diseases, complications of pregnancy, and other complications. Besides exercise and medication, the menu for diabetics is more complicated depending on medication treatment, but the goal is to maintain the glucose level within the controlled range, so a diet high in fiber, and low in saturated fat is recommended. This type of diet also helps to protect from diabetes. (Brown 2014, 13-2 – 13-10; Drummond & Brefere 2009, 411-415.)

Osteoporosis: Osteoporosis is a disease related to low bone mass and strength, leading to bone fragility and other weak bone illnesses. The bone loss occurs to most people older than 30 without obvious symptoms, until the age of 45 or older, many suffer osteoporosis with back pain, loss of height, or severely stooped posture. Other than unchangeable factors such as gender, age, body size, ethnicity (White and Asian have a higher risk than African American and Latino), and family history, a diet with sufficient calcium and vitamin D can reduce the risk of osteoporosis, along with smoking and alcohol avoidance, and physically active lifestyle. (Drummond & Brefere 2009, 416-418.)

7.5 Foundation of healthy cooking

The idea of the subchapter is to introduce the knowledge and techniques that can maintain the balance of the menu nutrient and flavor. There are many other culinary techniques to complicate the depth of taste in a dish, but they are not introduced in the subchapter because of the huge requirement of effort and time. This is not suitable for home cooks who are also the targeted readers of the thesis. Therefore, the introduced knowledge and techniques are simple and understandable, but they can have an effect on final dish nutrition and flavor profiles.

7.5.1 Flavor-enhancing method

A healthy diet can be vegetable and fruit-focused with a low amount of saturated fat, salt, and sugar. However, these three are a staple in every kitchen due to their ability to en-

hance the flavor and make dishes more mouth-watering. Therefore, to achieve both nutritional goal and deliciousness, there are many other seasonings and flavorings can be used as alternatives.

Herbs and spices are one option for elevating the dish flavor without adding more butter, salt, or sugar. Herbs are the leaves of certain plants, and each has a unique flavor and aroma which can be used independently or together with others. Spices do the same thing but they come from the roots, barks, seeds, … which cannot be eaten raw. More importantly, they are countless since every region has its herbs and spices available, depending on the climate, so there are unlimited ways of pairing flavor and aroma with herbs and spices in the way of maximizing the deliciousness of a dish. Common herbs are sage, oregano, dill, Italian parsley, curly parsley, basil, sweet basil, holy basil, thyme, tarragon, mint, rosemary, and chives. Common spices are black, white, green, and pink peppercorn, star anise, allspice, cinnamon, juniper berry, cardamom, and saffron. While fresh herbs and spices provide a fresh and clean flavor with heat intolerance, so they are used for dish finishing, dried ones have fewer flavors but can be infused with stock or sauce due to its heat-withstanding ability. These herbs and spices can be used to make bouquets and sachets which is a set of certain herbs and spices tied together. While bouquet garni composes of fresh herbs and vegetables, sachet content is spices and herbs in a cheesecloth bag. (Drummond & Brefere 2009, 266-272; The Culinary Institute of America 2011, 240-241.)

Juice is a fruity liquid that can be used as another alternative. Before being used as a flavor enhancer, juice needs to be cooked and reduced for a more intensive taste and more condensed texture like syrup. This is an excellent way to add depth of flavor to the sauce, glazing sauce, marinade sauce, stock, or salad dressing. Any good-quality premade juice can do this. (Drummond & Brefere 2009, 272.)

Flavor-infused vinegar and oils are the common enhancers for dishes for many chefs around the world. The tangy and light flavor that comes from vinegar adds extra layers of taste to the dishes, especially salads or cold, fresh dishes. Wine vinegar is the most popular ranging from red wine vinegar to white wine vinegar, or cider vinegar and balsamic vinegar are commonly used for certain dishes. Besides, flavor-absorbed vinegar such as chili pepper, roasted garlic, herbs, vegetables, and fruit vinegar is also widely known. Oil has the same applications and can be infused with different ingredients for an extra taste like herbs and spices. To make infused oils, neutral oils such as canola, safflower, and grapeseed oil are the best choices. (Drummond & Brefere 2009, 272-273.)

Stock is one of the most versatile liquid as a flavor builder because it can be used to make all kinds of soups, sauces, and braised dishes. There is a variety of stock which are made from animal bones, chicken bones, fish bones, or vegetables with the mirepoix – a well-paired set of ingredients for stock-making, such as onion, carrot, celery, and tomato are the component of regular mirepoix, another version includes onion celery, leek, and fennel, namely white mirepoix. There is also brown stock which is prepared by browning both the bones and mirepoix before prolonged cooking. The animal stock has an extremely rich flavor and gelatinous texture compared to vegetable one, but it requires a much longer time to extract the substances from the bones to the liquid, meanwhile, vegetable stock is much more neutral and just needs approximately about one and a half-hour. A good stock is characterized by no fat and solid matter, pleasant smell, and flavorful. To make a good stock, raw bones need to be cleaned well before cook, especially, fat should be trimmed off. When cooking, cold water is a good start, which helps to produce a clearer stock, and the stock should simmer all the time of cooking, not boiling. Skimming the impurities floating while cooking is necessary for a good stock. A tall and narrow pot is a good tool for simmering stock due to its low evaporation. (Drummond & Brefere 2009, 272-273; The Culinary Institute of America 2011, 240-243.)

Rubs and marinade is the other way to introduce more flavors into the dishes healthily. Dried rub is a mix of chopped herbs and dried spices such as chili, coriander seed, juniper pepper that are ground finely or coarsely. Additionally, wet rubs or paste is also a blended mix of many spices and herbs with liquid. These two are a technique to form a flavorful crush coating the dish to enhance its tastes. Most of the time, the technique well applies to a large cut of meat, and the larger the cut is, the more time it takes to let the spices go deeply into the meat. Marinade has similar purposes but it is waterier and its ability to deliver flavor into the dish is much more powerful. As it can penetrate through the tough tissues of the meat, it can tenderize it as well. However, fish is considered a soft texture, so it should not be marinaded for a long time. (Drummond & Brefere 2009, 279; The Culinary Institute of America 2011, 362-363.)

Aromatic vegetables are stapled ingredients in the kitchen and are largely used to build the background flavor for the main ingredients to shine. They are garlic, scallions, shallot, ginger, onion, and the likes. They are so versatile that most of the dishes are cooked with them for the depth of the flavor profile. Some are less strong than the others like onion versus garlic and ginger, so the less flavorful ones are usually used in a greater quantity. Fresh aromatic vegetables are not the only option, there are also dried and powdered ones that can be used for different purposes. Additionally, mirepoix is a set of certain aromatic vegetables that can perfectly enhance the flavor of stock and sauce. The standard

mirepoix has onion, carrot, and celery. Oignon Brûlé is another way of browning and adding more flavor into stocks and sauces by halving a peeled onion and then charring it. (Drummond & Brefere 2009, 279-280; The Culinary Institute of America 2011, 240-243.)

Classic sauces like brown sauce, white sauce, and cheese sauce, are usually high in fat content, so to reduce the fat intake, vegetable puree, coulis, salsa, relish, chutney, compote, and mojo can be utilized as the alternatives. With vegetable purees, the sauces are lighter and healthier with less flavorful, but the extra aromatic ingredients such as herbs can bring back the flavor profile to the sauces. Before pureeing, vegetables can undergo such methods as grilling, sauteing, and steaming for the depth of taste. Coulis comes from the same idea of vegetable puree, and it includes also fruits. While hot vegetable coulis is usually served with entrée, cold fruit coulis is paired with desserts. The difference between coulis and normal vegetable purees is that, to prepare coulis, its main ingredients need to be cooked in stock with aromatic vegetables or starchy ingredients such as potato or rice for better texture. Then all of them are blended. Salsa and relish have a similar concept as they are made by mixing chunks of fresh vegetables and fruits with other spices and herbs. Salsa is a Spanish tomato-focused fresh sauce paired with strong flavor ingredients such as shallot, garlic, lemon zest, … and its texture is almost-pureed or small chunk mix. Meanwhile, relish is usually spicier and its components include pickled ingredients. Chutney is the salsa from India with a stronger taste of spices and compote is a dessert made by cooking fresh or dried fruits in a syrup flavored with spices and herbs. Lastly, from the Caribbean and South America, like salsa, it is a fresh vegetable-fruits sauce but it is mainly made with sour orange combined with garlic, oil, and herbs. (Drummond & Brefere 2009, 280-281.)

Wine and spirit have a role in cooking as a flavor-building factor. It elevates other tastes when being used at the beginning of the cooking process. In this case, cooking wine usually has a higher salt content than a normal one, making it impropriate for drinking. This practice is popular among Asian countries. In French cuisine and food cultures affected by it, wine is added at the end of the cooking process for a touch of wine flavor on the dish. Moreover, the wine adding usually goes with a flame for the presentation. (Drummond & Brefere 2009, 281.)

7.5.2 Healthy cooking method

The cooking techniques are varied, depending on the living cultures. However, they should be taken into consideration to maintain the stored nutrition which is easily destroyed by heat. To boost the dish flavor, reduction, searing, deglazing, sweating, and pureeing are techniques for healthy eating styles. Reduction means to reduce the volume of the liquid food such as soup for more intensified flavor and thicker texture. Searing aims to

Mallard reaction – browning, for more complicated taste and attractiveness of color. Deglazing refers to making the sauce by adding liquid into a hot pan which is already used for searing to gather the searing flavor from the pan. Sweating means slow cooking in a small amount of fat or flavor liquid. Pureeing is to blend the ingredients for thickening purposes. (Drummond & Brefere 2009, 284; The Culinary Institute of America 2011, 488-489.)

Dry-heat cooking methods are highly accepted in terms of healthy eating. The method delivers temperature into the ingredients through the hot air circulating them without added fat. Moreover, the cooked dish's saturated fat content also reduces during cooking. Roasting in an oven is the common method that can easily apply to most ingredients, and the flavorful jus excreted from the cooked dishes can be used to make the sauce. For a more complex flavor profile, rubs, marinades, and smoking can be used as a complementary factor. A good smoky taste usually comes from hardwoods or fruitwoods. The high radian heat application from above is called broiling and from under is called grilling. With the exceptionally high temperature of these methods, cooking time needs to be paid more careful attention to like the thicker the meat cut is, the longer it takes to cook. Heterocyclic amines (HCAs) – a cancerous factor, is created when beef, poultry, and fish are being grilled because of the high heat. More importantly, fat from the meat exposes to the hot charcoal can also produce another cancerous substance or polycyclic aromatic hydrocarbon, PAH. To minimize the cancer-causing effect of these two, the cooking temperature should not exceed 400 F or 205 C without direct contact between food and flame; blacken spots should be removed; marinades, trimming excess fat, and turning food often help reducing HCAs. Besides, sauté and stir-fry with little or no fat is highly recommended. (Drummond & Brefere 2009, 284-288; The Culinary Institute of America 2011, 424-425.)

Moist-heat cooking is another method to maintain the good nutrition of the dish. The method transfers the heat through the water particles as the liquid submerges the ingredients or evaporates. Unlike dry-heat cooking, moist-heat cooking cannot produce any extra complicated flavor through browning or deglazing, but the freshness and nutrients of the ingredients are mostly kept. To deliver the best result with moist-heat cooking, the fresher the ingredients are, the better. The liquid used in cooking can also be seasoned with aromatic herbs and spices. Importantly, the accompanying sauce needs to be flavorful enough to satisfy the tasters. The con of this cooking style is that the excreted fat is infused with the cooking liquid, which can be easily removed by chilling. Except for boiling and steaming, braising or stewing has a stronger flavor outcome with the longer cooking time. The method usually goes with a tough cut of the meat. (Drummond & Brefere 2009, 289-290; The Culinary Institute of America 2011, 532-533, 572-573.)

8 Nutritional data

This chapter is created for presenting the nutritional data which is the backbone of ingredient listing and nutrition calculation in the “Selection” and “Prototype” phases, respectively, in menu planning.

The first topic is presented is eating principles that can help one’s diet become healthier. These are simple rules for the readers to follow if they want to off-road to adjust the diet. This is recommended for healthy people. The next topic is the data of nutrient and energy intake set for specific ages and genders. The last topic is the practical views on food sources and their benefits to human health.

Besides, all the data in the chapter is sourced from Nordic Council of Minister, so the practical application of these data is reliable for designing a menu in Nordic region.

8.1 Principles for a healthy diet.

The main principles for a healthy diet are variety, balance, adequacy, and moderation under energy and nutrient control. As commonly known, there is no set of food that suits all the people around the world and provides all the necessary nutrients for a healthy well-being status. Therefore, variety comes into play, referring to the wide array of food types which can provide not only necessary nutrients and disease-fighting phytochemicals but also improve the satisfaction of food enjoyment. Balance in this context means that the food intake should focus more on the nutrient-dense ingredients such as whole grains, fruits, and vegetables instead of choosing energy-dense products such as chips, cakes, and cookies so that the ratio consumed energy to weight is suitable. While adequacy reflects sufficient energy and nutrients following one’s need, moderation refers to the limitation of energy-dense food overeating like fatty and sugary food. (Drummond & Brefere 2009, 16; Traster 2018, 17-18; Whitney & Rolfes 2016, 38-40.)

To reduce the diet-related disease risks mentioned in section “Disease” in the subchapter “Diet type and related disease” under chapter 7, some changes in the diet need to be done for Nordic population. The main idea is to decrease energy consumption from animal and added sugar products while increasing the high-quality and rich-nutrients carbohydrates such as whole grains and whole-grain flour which have more fiber and essential fat. Adjusting the fat proportion to consume more unsaturated fatty acids from fishes and plant-derived products, and limit saturated fat from animal products. The limits of process and red meat, and salt intake is highly recommended for promoting health and wellbeing. (Nordic Council of Minister 2014, 22-23.). Table 4 shows the summary of the dietary shifts for Nordic population.

Table 4: Dietary changes for potentially promoting health in Nordic region. (adapted from Nordic Council of Minister 2014)

Increase	Exchange		Limit
	From	To	
Vegetables, pulses	Refined cereals	Wholegrain cereals	Processed meat, red meat
Fruits and berries	Butter, butter-based spreads	Vegetable oils, vegetable-oil-based fat spreads	Beverages and foods with added sugar
Fish and seafood	High-fat dairy	Low-fat dairy	Salt
Nuts and seeds			Alcohol

The introduced nutritional data retrieved from Nordic Nutrition Recommendation 2012 emphasized dietary composition and source for providing sufficient macro- and micro-nutrients from healthy and accessible sources. Even though the Recommendation provides the exact number of each classified type of food for intake, it does not mean that the requirement needs to be fulfilled in a day but approximately over several days or a week. Therefore, it's completely normal for individuals to take in a specific nutrient much higher in one day and lower on the other days. (Nordic Council of Minister 2014, 22-23.) The mechanism for this "real eating" is the body's ability to store nutrients, which allows flexible intakes in daily life.

8.2 Guidelines and dietary data

For a better understanding of dietary guidelines for Nordic region, table 5 and appendix 5 showcase the necessary recommendations of macronutrients and micronutrients for both adults and children from the age of 2. All of the numbers are counted in daily consumption.

8.2.1 Data for macronutrients

There is strong evidence from many types of research that the replacement of saturated and trans-fatty acids with mono- and polyunsaturated ones can improve the low- and high-density lipoprotein ratio, contributing to the decreased incidence of chronic diseases. However, the total consumption of fat is vital for the human body functioning as mentioned in the "Lipid: fat and oil" part, so the percentage of fat in the diet needs to be sufficient. If fat consumption is below 20%, the fat-soluble vitamins' bioavailability will be badly affected. It's also recommended that the intake of necessary fatty acids as omega-3 and

omega-6 need to be adequate for normal brain functioning. To achieve this goal, the dietary shift from animal products to vegetables and fishes is unavoidable. (Nordic Council of Minister 2014, 25-26.)

In the “Digestion and absorption” part, the paragraph about the lipid pathway mentions chylomicrons as a transporter of lipid components in bloodstream after they exist lymph system. Chylomicron is a lipoprotein that is used as a measurement for estimating the current risk of chronic vascular disease. Lipoprotein is a group of 4 members: chylomicron, very-low-density lipoprotein (VLDL), low-density lipoprotein (LDL), and high-density lipoprotein (HDL). Like their cousin chylomicron, the others are also transporters but different destinations. (Drummond & Brefere 2009, 142-145; Whitney & Rolfes 2016, 145-147.)

Chylomicron carrying mostly triglycerides and some cholesterols goes from small intestinal to feed every cell in body by the lymph system and bloodstream with the assist of enzyme lipoprotein lipase. Meanwhile, in the liver – the most active place for lipid synthesis, lipid components from cells are carried and reformed into lipid which is shipped through the body for cell metabolism by very-low-density proteins (VLDL). After triglyceride content is depleted, VLDL turns into low-density lipoprotein (LDL) which contains mostly cholesterol. (Drummond & Brefere 2009, 142-145; Whitney & Rolfes 2016, 145-147.)

LDL circulates in bloodstream and serves as material for cell membrane, hormone, and other compound syntheses. Liver has an important role in controlling LDL since it can absorb the whole LDL particle. (Drummond & Brefere 2009, 142-145; Whitney & Rolfes 2016, 145-147.)

Liver also synthesizes high-density lipoprotein (HDL), containing mostly protein, for getting cholesterol waste from cells to liver and remove it. Furthermore, HDL has anti-inflammatory properties for preventing cholesterol formation on arterial walls, reducing heart attack, and stroke risks. (Drummond & Brefere 2009, 142-145; Whitney & Rolfes 2016, 145-147.)

Figure 19 illustrates the pathways of these lipoproteins. Unlike public belief, the high level of both low- and high-density lipoprotein can elevate the risk of heart diseases since both of them has important roles in the body. However, some beliefs consider HDL and LDL as so-called “good” and “bad” cholesterol, respectively. The chemical structures of cholesterol in both of them are the same. (Drummond & Brefere 2009, 142-145; Whitney & Rolfes 2016, 145-147.)

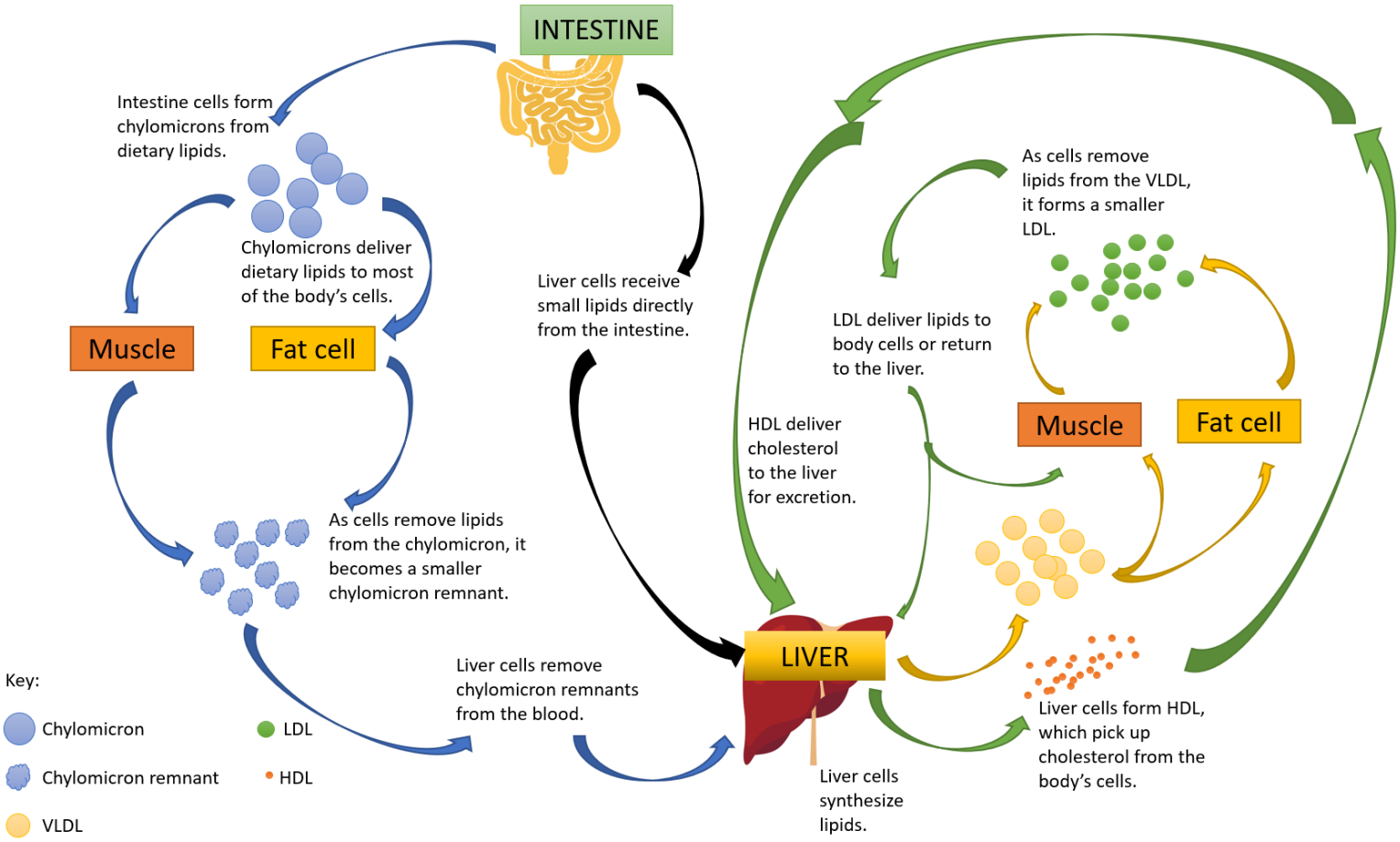


Figure 19: Lipoproteins pathways in the body.

Carbohydrate sources are varied from whole and refined grains to vegetables, nuts, legumes, and fruits. The adequate intake of this type of food is considered vital, which is mentioned in the "Carbohydrate" subchapter in chapter 3. Besides, the dietary fiber in the group has significant effects on health and wellbeing and can reduce the risk of constipation, colon cancers, and other chronic diseases. Since the carbohydrate group can provide sufficient glucose along with other healthy properties, the intake of added sugar should be limited. Sweetened beverages, cookies, cakes, and the likes are the main source contributing to diabetes type 2 and weight gain. (Nordic Council of Minister 2014, 26-27.). The recommended intake of fiber is explained in detail in table 5.

Protein is available in both animal and plant-based products, so the combination of both is necessary so that other recommended goals, such as saturated fat limit and unsaturated fat elevation, are reached. When choosing meat products, lean cuts should be preferable to limiting unsaturated fat consumption. While animal sources such as meat, poultry, seafood, milk, and milk product can offer high-quality protein or complete protein which refers to all necessary amino acids in the content and a high level of absorption (90-99%), plant-derived sources often contain incomplete protein - not enough necessary amino acids and

lower level of absorption (70-90%) with the exceptions of soya bean, quinoa, and some legumes. Therefore, complementary proteins are created to solve the issues by combining two or more plant-derived sources so that together they provide complete protein such as whole wheat and legumes, rice and beans, legumes and grains, … (Drummond & Brefere 2009, 169-171; Nordic Council of Minister 2014, 27-28; Whitney & Rolfes 2016, 185-186.). The recommended intake of protein and fat is explained in detail in table 5.

Table 5: Recommended intakes of macronutrients from the age of 2. (adapted from Nordic Council of Minister 2014)

Fatty acids (expressed as triglycerides)
Intake of cis-monounsaturated fatty acids should be 10–20% of the energy intake (E%).
Intake of cis-polyunsaturated fatty acids should be 5–10 E%, of which n-3 fatty acids should provide at least 1 E%.
Cis-monounsaturated and cis-polyunsaturated fatty acids should constitute at least two thirds of the total fatty acids in the diet.
Intake of saturated fatty acids should be limited to less than 10 E%.
Intake of trans-fatty acids should be kept as low as possible.
The total fat recommendation is 25–40 E% and is based on the recommended ranges for different fatty acid categories.
Linoleic (n-6) and alpha linolenic (n-3) acids are essential fatty acids and should contribute at least 3 E%, including at least 0.5 E% as alpha linolenic acid. For pregnant and lactating women, the essential fatty acids should contribute at least 5 E%, including 1 E% from n-3 fatty acids of which 200 mg/d should be docosahexaenoic acid, DHA (22:6 n-3).
Dietary fibre
Adults: Intake of dietary fibre should be at least 25–35 g/d, or approximately 3 g/MJ.
Children: An intake corresponding to 2–3 g/MJ is appropriate for children from 2 years of age. From school age, the intake should gradually increase to reach the recommended adult level during adolescence.
Added sugars
Intake of added sugars should be kept below 10 E%.
Protein
Adults and children from 2 years of age: Protein should provide 10–20% of the total energy intake (E%).
Elderly (≥65 years): Protein should provide 15–20 E%, and with decreasing energy intake (below 8 MJ/d) the protein E% should be increased accordingly.

Last but not least, the intake of alcohol should be limited to 10g and 20g per day for women and men, respectively. And extra attention should be paid to those in infancy, growing period, and pregnancy, who shouldn't take in any alcohol at all. It is believed that

drinking alcohol poses some beneficial health effects as reduced incidence of chronic diseases. This is true if only those are at the age of 35 and older. For the young, the detrimental effects outweigh the benefits. However, limited alcohol consumption is still recommended for those over 35 due to the increased sensitivity to toxic substances from growing old. (Nordic Council of Minister 2014, 28; Whitney & Rolfes 2016, 222.)

8.2.2 Data for micronutrients and energy level

Although the recommended intake of all necessary vitamins and minerals seems to be complicated and difficult to achieve, the diet meeting with the introduced principles of variety, balance, adequacy, and moderation can fulfill this goal. The content of appendix 5 can cover almost everyone's nutritional demand if they have normal health status. Reminding that, with low-energy intake, the consumed nutrients cannot be absorbed efficiently, so the recommended intake calculation is not accurate anymore. (Nordic Council of Minister 2014, 29-33.)

The recommended energy intake is a phenomenon that is impossible to be accurate since the number needs to involve energy-yielding nutrient consumption, level of physical activity, basal metabolism, and thermic effect of food. So, the content of appendix 6 is a recommendation. Sufficient energy intake is associated with nutrient bioavailability, so the excessive or deficient intake poses a harmful effect on the body. Additionally, physical activity is also an indispensable element in counting the proper amount. The described values are adjusted to be higher than the actual requirement, which can be suitable for menu planning. (Nordic Council of Minister 2014, 33-34.). The MJ is an energy-measuring unit that stands for megajoule and 1 megajoule equals approximately 238.85 kcalories.

8.2.3 Data for deficiency and toxication of vitamins and minerals

The recommended intakes for nutrients and energy consumption are the necessity for planning what would be on the menu for optimal health. However, some other data supports the planning process, which are the estimated average requirement (AR), lower intake level (LI), and upper intake level (UL).

While the AR indicates the risk of inadequate intake, which signals that the diet needs to be adjusted for a better result, IL refers to the minimum amount for normal functioning. Long-term intake that is below IL can lead to deficiency symptoms that interrupt normal life. On the other hand, overconsumption also causes damage to the body as well, so keeping the vitamin and mineral intake under the UL is a key to prevent toxication symptoms. However, the listed values are obtained by surveys, so the deficiency and toxication symptoms can occur to some individuals although their intake is above the values. (Nordic

Council of Minister 2014, 37-41.). Appendix 7 and 8 small shows the LI and AR, and UL values respectively for vitamin and mineral consumption.

8.3 Food sources and health implications.

Vegetables, fruits, and berries are rich sources of dietary fiber and vitamin C, A, E, K, folate, potassium, and magnesium. Moreover, not only are beans and peas rich in protein, but they also contain many B vitamins except B_{12}, fiber, and carbohydrate. Nuts and seeds contain a considerable amount of unsaturated fat, protein, magnesium, zinc, copper, potassium, vitamin E, B_6, niacin. Potatoes are one of the most staple ingredients used in the Scandinavian region, which is rich in carbohydrates, minerals such as potassium and magnesium, vitamins such as C. However, most plant foods are low in energy level and nutrient concentration per weight unit because of their high-water content. Exceptionally, nuts, seeds, olives, and root vegetables have high energy and nutrient density level. Consuming vegetables, fruits, and berries is consistently proved to help to reduce the risk of cardiovascular diseases and their causes. The high intake of vegetables and nuts is also associated with a reduced incidence of coronary heart disease and myocardial infarction. There is a statement that this group helps to protect against gastric-system-related and lung cancer, the other types of cancers are still under further investigation. (Nordic Council of Minister 2014, 105-114.)

Whole grain or dietary cereal is the unprocessed ingredient that still maintains its fractions of endosperm – the largest area rich in starch, bran – the protective shell containing most fibers, and germ – nutrient supply for germination. Refined grain refers to the removal of bran and germ for long-term preservation purposes because there is oil in germ which turns rancid and diminishes the seed's quality and nutrition values during storage. Therefore, whole grain easily surpasses refined grain in all aspects of nutrients, which offers fiber, starch, minerals such as iron, zinc, phosphorous, and magnesium, vitamins such as vitamin E, thiamine, riboflavin, niacin and B_6, and phytochemicals. However, there is phytic acid presenting in the grains' content, which inhibits the bioavailability of iron and zinc. To solve this, fermentation and germination are the best methods and the supply of vitamin C can also enhance iron absorption. The high consumption of whole grain is strongly related to the prevention of cardiovascular disease, coronary heart disease, stroke, and diabetes type 2. Until recently, its relationship with cancers lacks evidence so there is no confirmation about this matter. As an opposite site, refined grains don't have much effect compared to whole grains, because the majority of micronutrients and bioactive compounds occurs in germ and bran. (Nordic Council of Minister 2014, 105-114.)

Plant-derived foods are blessed with phytochemicals, some in countless numbers of which are explicitly known and recommended for protective effects against noncommunicable diseases. (Drummond & Brefere 2009, 433). This is the reason why most nutritionists and dietarians around the world put a strong preference on a vegan-focused menu rather than a meat-focused one.

From oily seeds such as sunflower seed, flaxseed, soy and olives, vegetable oil and fat spreads, and margarine are made along the side of butter which is made from fat in milk cow. They contain dietary fat and fat-soluble vitamins. As every raw material consists of all types of fat from saturation to poly-unsaturation, the composition of fat type is dependable on the source used in manufacture. Soybean-, maize- and sunflower-seed-based products are rich in polyunsaturated fatty acids, while rapeseed- and olive-based products are full of monosaturated fatty acids. Moreover, rapeseed and soybean oil contain much omega-3, so do fishy oils, which have a high content of unsaturated fat compared to inland animals but possess very long and brain-healthy omega-3. Other sea-derived oils are also rich in unsaturated fatty acids, similarly to palm and coconut oils. (Nordic Council of Minister 2014, 106-107.)

Fish and seafood contain 20%-35% protein, vitamin B_{12}, iodine, selenium and are categorized into three types based on the fat composition. Lean fish such as cod, haddock, saithe, plaice, and pike provide under 2g fat/100g and those providing 2-8 g fat/100g are considered as medium-fat fishes including winter-mackerel, halibut, catfish, and tuna. Above 8 g of fat in every 100g of meat helps herring, summer-mackerel, trout, salmon, and eel to become fatty fishes. Besides the fact that medium-fat and fatty fishes contain saturated and monounsaturated fatty acids, they are rich sources of omega-3. Fatty types are also rich in vitamin D and vitamin A as retinol, and lean fishes such as pike-perch contain a high amount of vitamin D. Marine sources can pose some risks due to its content of toxin such as methyl mercury, especially those from the Baltic Sea and Norwegian fjords compared to those from the open sea. Some fishes from the sea like large tuna and halibut or freshwater possess a high level of this toxin. Lean fishes also contain POPs – persistent organic pollutants in a low concentration. Therefore, limited and controlled fish consumption is recommended to those in infancy and pregnancy. The dietary shift from saturated fatty acids in animal to unsaturated in fish, nut, and vegetable products are associated with health improvement. The sufficient consumption of fish is proved to lead to reduced incidence of cardiovascular diseases especially myocardial infarction and stroke. There is also evidence for blood pressure reduction and protective effect on type-2 diabetes, impaired cognitive function, and age-related macular degeneration. Breast cancer prevention is also linked with dietary marine omega-3 consumption but the relationship

between dietary marine vitamin D and colorectal cancer is still unclear. (Nordic Council of Minister 2014, 105-114.)

Milk is a popular source of nutrients like protein, fat, vitamin A, B_{12}, riboflavin, calcium, and iodine. Skim and low-fat milk are often fortified with fat-soluble vitamins. The fat presented in milk mostly is saturated fat and the major unsaturated fat component is oleic acid. Besides being consumed as a product, milk is also the main ingredient for producing cheese, butter, fermented milk, yogurt, and cream. Cheese has a very high amount of calcium compared to whole milk and low-fat milk, 790-940 mg/100g in comparison with 120 mg/100g. Milk is rich in minerals as well, but it lacks iron. There is plant-based "milk" enriched with calcium, vitamin $B_{12,}$ and vitamin D are available in the market. Many kinds of research about milk have been done and some show that the consumption of milk helps to reduce the risk of metabolic syndrome, type-2 diabetes, hypertension, and stroke. (Nordic Council of Minister 2014, 105-114.)

Meat is classified as red meat including beef, pork, mutton, game, and white meat including chicken and turkey. Processed meat often means that meat from red type undergoes smoking, curing, salting or other preservation methods and well-known products are ham, bacon, salami, sausage, and smoked meat, while meat through boiling, frying, drying, fermenting, and freezing is not considered as processed meat. Meat and meat products are a source of protein, vitamin B_6, B_{12}, iron, zinc, and selenium. The saturated fatty acid percentage in chicken is 30%, in pork is 35%-40%, in beef and mutton is 40%-55%, and trans fatty acid percentage in chicken and pork is under 1%, and in beef and mutton is 3%-5%. Salt concentration in unprocessed meat is low but in processed meat is much higher. Additionally, game meat has lower fat content compared to other types of meat. A high intake of processed meat is associated with an increased risk of type-2 diabetes, coronary heart diseases, so does the intake of red meat but at a weaker level. In terms of cancer, the high consumption of red meat and processed meat poses a danger that leads to colorectal cancer but not other types of cancer such as lung cancer. Therefore, the replacement of red and processed meat with white meat, fishes, and vegetables are recommended. Egg is a rich nutrient source of protein, fat, riboflavin, vitamin A and D. Along with dairy products, meat and fish, egg yolks provide cholesterol. (Nordic Council of Minister 2014, 105-114.)

9 Introduction to menu planning project

This chapter aims to offer the readers an aspect of applying all the knowledge mentioned in previous chapters and subchapters to the practice. This is the author's approach to the practicality of a healthy eating lifestyle.

9.1 The general view of the menu planning process

The planning process is illustrated in figure 20.

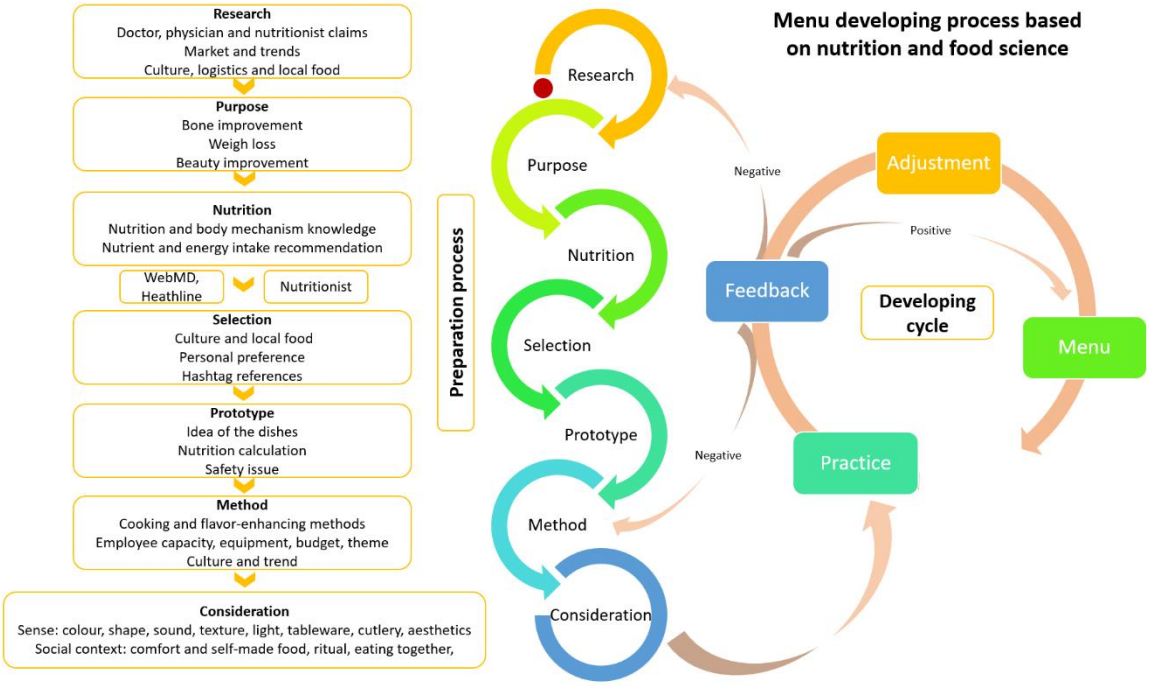


Figure 20: Thesis's introduced menu planning process.

The primary idea of the method is to build a menu that offers beneficial properties to consumers in a personal healthy manner. To achieve the goals, the introduced dishes should be personalized and have all the necessary health-boosting ingredients included and disease-causing ingredients excluded. For example, those who have lactose intolerance should not be provided with dairy-containing dishes, indeed, vegetables with high calcium amount is a good substitute. Therefore, depending on one's purpose, the ingredients in the menu should be tailored, mixed, matched, prepared, cooked, and served in the appropriate ways.

First of all, research data about the market, logistics, culture, population, … should be collected to select the theme and the target customers for the foodservice and event organizers. Meanwhile, those who use the method for themselves can get reliable health records and discuss with the health-care professionals about diet adjustment. After that, the purpose and target of the diet should be set.

After identifying the conditions and purposes of the menu, the next step is to select the key ingredients that meet all the requirements of health issues and personal taste. The selected ingredients include all types such as vegetables, beans and legumes, fruits, meats, fishes, dairy products, herbs, and spices. The more listed ingredients are, the better the menu will be. Because, the variety allows more possibilities in the mix-and-match concept of cooking, helping daily menus become more interesting, exotic, and surprising, especially when being on diet. The dishes should be built around personal preference to maximize the comforting effect of food which is described in the “Perfect meal” section.

The data which is used to identify raw food properties has to be trustworthy enough, the example of the website can be webmd.com or healthline.com. The websites provide wide and in-depth knowledge about medical issues, nutritional values, and calculation tools.

Founded in 2005 in United State, webmd.com or WebMD Health Corporate is a branch of WebMD Health Network which covers the large areas of the medical field and user experience with different purposes. The company has a large number of certified physicians and journalists responsible for the information updated on the website. (Bloomberg; WebMD 2014; WebMD 2018). Healthline Media is also founded in the United States with two offices located in San Francisco and New York. The company has many experts in the health-related fields with the aim to support one’s well-being. (Healthline Media 2020.). When searching ingredients on the websites, not only are the nutritional values of the ingredients displayed, but the content also includes history-related background, health benefits in fighting against certain diseases, risks of eating under some specific circumstances and preparing method along with some recipes, which are shown in appendix 3 and appendix 4.

When the lists of necessary ingredients and nutrition calculation are done, proper taste-enhancing and cooking methods are considered to create dishes which can deliver the best outcome – the balance between nutrient preservation and bioavailability, and personal taste. There are many ways to prepare, shape, cook, and enhance flavor without disturbing the balance of the menu. Being creative and experimenting can prolong one’s cooking interest at home.

The next step of the process involves environmental factors from the cutleries to social context. As discussed in chapter “Gastrophysics”, the practices of eating scenario can be used so that all or part of consumer’s senses are involved, leading to better satisfaction. Investment in special cutleries and tableware creates a unique atmosphere for the restaurants and events, stimulating the appreciation of the guests, but at home, it can be costly

and unachievable. However, considering the other elements such as music, brightness, and social context such as eating with others, or having a ritual before the meal, or cooking from scratch can elevate the satisfaction of a meal, contributing to the prolonged diet and having the set goal maintaining.

The introduced method in this thesis takes a step further for home cooks and restaurateurs to build a new menu or modify the existing ones so that the menu provides sufficient nutrients with high satisfaction. The data retrieved from WebMD Health Corp is one of the important elements which are utilized in the introduced method, as well as related sections described in the previous parts such as micronutrients, macronutrients, absorption, digestion, gastrophysics, and recommended intake requirement. Figure 22 is the exclusive demonstration of the menu planning which the thesis focuses on. Starting with the Research stage to the final menu product, the process involves all the related topics that are fully explained throughout the thesis. The whole process can be divided into two main sections which are the preparation process and the developing cycle. The preparation process begins with the Research stage to the Consideration stage and then the developing cycle continues until the final menu product is created. Unlike loop characteristics of the developing cycle, where the steps can be repeatable for the more desirable outcome, usually, the preparation process is one-time done. However, there is a possibility that the whole process is on the wrong track, which means from the Feedback section, the process can be started over from the beginning, at the Research stage, for the whole new products, or from the Prototype stages.

9.2 For foodservice and event organizer

For the restaurants, where the menu is already decided and under operation, the applied method bases on the same background principles mentioned in the previous paragraph with a few modifications. The information about the guest's special diet, which should be gathered before any modifications take place, defines the introduced dishes. Before the changes, examining the components of dishes in the menu is important so that the modifications happen with the minimum effort. Then the components violating the guest's requirements are replaced with the more appropriate ones. After that, the cooking methods and environmental factors are involved in decision-making. As restaurants have a better budget, designing the dining atmosphere with color, shape, texture, sound, and light can provide a better eating experience for the guests. However, the star of the meal is always the introduced dishes, which cannot be overwhelmed by other factors.

For foodservice and event organizers who want to establish themselves in a new place, much research and analysis should be made to gather information related to local culture and behavior, ingredient transporting systems, and trends so that the created products

meet the demand of the targeted customer groups. For the more tailored-made menu for a better personalized experience, collected customer's health data is necessary for adjusting the current menu to be more nutritious or creating a more suitable one. It's better to get the data from professionals' claims like doctors, physicians, and nutritionists and to carefully read the chapter "Nutrients", "Absorption" and "Metabolism".

The research and the gathered information are the foundation for setting the main goals of the menu. The goal can be to maximize the guests' experience through gastrophysics application or to provide a healthy menu that suits the guests best.

Then, the focused nutritional values need to be identified. The needed information of this stage can be gathered from nutritionist's recommendations from health records or the standard nutrient intake recommendations from the local nutrition guidelines. Especially, knowing what and how nutrients benefit the body is the solid background to set the goals for the diets to better one's life. However, since the menu is usually used for a period of time, the nutrition calculation in this case does not have to be precise. Besides, the main nutrients set in the menu goal should be met.

At the "Selection" stage, the potential ingredients for the menu are listed without violating the set goal in the previous part. With the assistance of nutritionists, the efficiency of the chosen ingredients is better, and WebMD can be a reference source. The listed ingredients should be hashtagged with keywords that describe their health benefits and diet types they belong to. Since one ingredient can be prepared and cooked in different ways, the categorization can ease the complexity of the menu planning process for future use.

The list of qualified ingredients is the base for nutrition calculation in the "Prototype" phase. The calculation goals should base on the nutrient and energy intake recommendation at a suitable age and gender. The tools used for the calculation can be found online, like inlivo.com, eatthismuch.com, fatsecret.com… However, the organizers have to access the nutrition information from the suppliers, which is a more reliable source for calculating the ingredients.

With the listed ingredients, chefs and nutritionists can work together to figure out which preparation and cooking methods that achieve both nutrition and deliciousness of the dishes within the capacity of a restaurant or event. When the theory work is done, the dishes can be called prototypes which have to be tested for their practical application. Importantly, the dishes need preparing in a safe manner which is described in the thesis subchapter "Allergies and food safety" of chapter 7.

After that, considering five senses and social context in atmosphere design for an exotic and unique experience. This step is optional, depending on the organization's budget. The next step is that the tested prototypes enter the developing cycle with a practice-feedback-adjustment-menu loop, and the cycle keeps going until the model of the final menu can please both customers and organizers. However, after testing in a practical situation, the feedback can indicate the wrong results, leading to the start-over or the come-back to the Prototype section for a better outcome.

9.3 For personal use

For personal use, the steps in the menu planning process need slightly different approaches, since the planner is now in the same position as the customer.

The Research stage for individuals does not require market and population or culture and area researches, instead, the in-depth acknowledgment of health records is indispensable. This matter can be eased with a personal doctor or physician. From the personal health record, the planner can set the diet goal which can be associated with the advice about nutrition from nutritionists or other health-care professionals. The diet can be designed for healthy skin or disease prevention or allergy avoidance.

The personal nutritionists are the best people to lean on when choosing the proper ingredients for the set diet, but if none, then WebMD is a reliable site to count on, along with chapter “Nutrients” and chapter “Nutritional data” in the thesis. Researching on the website can take a moderate amount of time to list all the qualified ingredients. Instead of a nutrient-perfectly-calculated meal, an eating schedule and a plan to change the dishes on daily basis gradually is a better option for personal use. Since the diet can create a constrained feeling, dieters can experience uncomfortable and frustrating emotions, easily giving in temptation and giving up the diet. Therefore, preparation and cooking methods should not be a stressful matter, instead, creativity and fun play a main role in the adventurous cooking experience.

The combination of the lists of suitable ingredients, the nutrient calculated sheet of a daily meal, and the plan to change everyday meals is a prototype. To calculate the nutritional value, the usage of tools such as inlivo.com, eatthismuch.com, fatsecret.com… or reading the labels on a food product is necessary. After that, depending on the planer status, the implementation of the new diet to eating schedule should be considered. For example, if the planners are students, the ideal day to try new healthy dishes is Saturday or Sunday. Then, the prototype containing the dishes with careful nutrition calculations is proceeded with the most suitable preparation and cooking methods before being tested.

For the starters, the simpler methods, the better they are, and the new technique can be learned gradually. Learning new cooking techniques should not be rushed. Simple cooking skills such as steaming, boiling, roasting is a good start for the starters. For those who have more interest in cooking, simple or complicated methods are not the matter.

After that, the ideas are shaped and move to the “Consideration” phase where considering environmental factors can add an extra boost in flavor enjoyment. For most people, the eating budget is heavy on ingredients, not the cutlery and tableware, but they should not be ignored either. Familiarity and uniqueness, from the eating atmosphere, are the opposite feelings but they can be supportive of each other and offer the dinning satisfaction to a great extent. Therefore, a little twist in a certain meal of the week can extremely improve the eating experience. For instance, instead of eating alone on the weekends after lone-eating on every weekday, a little gathering with friends combines with cooking is much more interesting or changing the table linen and eating table position can also help eating more deliciously. After that, the try-out loop starts with the same stages as for restauranteurs and event planners.

10 Exemplified case of menu planning for business use

10.1 Scenario

The scenario can be that a special event is going to take place in a casual Finnish restaurant located in Kallio region, in Helsinki. The event is the celebration party for the 10th anniversary, so all the guests come from the same company and they know each other. There are 20 guests in total ranging from the age of 30. The event takes place in the evening.

10.2 Preparation process

10.2.1 Research

At the starting of menu planning, researches about eating-related health issues should be done before any other steps. In this case, the factors that need considering are lactose and gluten allergy, in which, one person has gluten allergy, two persons have lactose intolerance, and one has both, and some elders in the group have some symptoms that are diagnosed as pre-diabetes. Additionally, any information about personal preference is welcome for a better personalized experience delivery.

In the young group, at the age of 32, Annie has a high concern about the healthy matter so she is keen on exercising and eating clean. She also pays attention to environmental matters and likes bio-products. At the age of 35, Lasse is a tall guy and his diagnosed with hypertension. He likes deep-fried foods because of their crunchiness and strong flavor. Besides, Maku is a guy at the age of 49 and has pre-diabetes, moderate risk of vascular disease, osteoporosis, and weak teeth. This information should be utilized in creating a tailor-made dining experience. The general menu should be fresh, less fat, vegetables-focused, gluten- and lactose-free. The sauce should be strong and the texture of food needs crunchiness. These characteristics favor Anne, Lasse, and the rest of the guests with the exceptional case of Maku whose menu should be designed toward soft food and soups with high calcium and bone-building nutrients.

After that, gathering menu feedbacks about the anniversary events in previous years is useful not to repeat the mistakes and the dishes. In this case, since the restaurant is on the stable run and a scenario is a special event, there is no need for conducting market researches. However, in other cases, when the area of organizing the event is new to the organizers. Some research has to be done. For example, in this case, the demographic and psychologic studies can be found in section “Statistics and research news” at website hel.fi of which city of Helsinki is in charge (City of Helsinki a). These materials are usually written in the native language and this can be the barrier for business development if the

events take place or the restaurant-opening plan is in countries other than the original organizer nation. But in this case, the material “Helsinki facts and figures 2020” is written in English, while “Helsinki alueittain 2019” is written in both English and Finnish.

Figure 22: The materials used for market research. (adapted from City of Helsinki a; City of Helsinki b)

While the material “Helsinki facts and figures 2020” focuses on the Helsinki location, more details about Kallio region can be retrieved from the material “Helsinki aluettain 2019”. To be more precise, the information in “Helsinki aluettain 2019” is much more accurate because it provides information related to Kallio region, not the whole Helsinki city in “Helsinki facts and figures 2020”. Besides these two, there is “The Finnish property market 2019” material which emphasizes the business industry in Finland, which is also useful in the planning process.

The population of Helsinki is approximately 650 thousand with the balance in gender (52.5% for female and 47.5% for male), most of them are living in the central part of Helsinki including Kallio. The large percentage population is in the age group of 20-44, which accounts for more than 40% population in Helsinki. The most popular event is the Helsinki Festival and the second one is the Flow Festival with an attendance record up to 240 thousand and 83 thousand, respectively. In Kallio, the majority are the young who are employed and live singly, which means there are not so many families with children. Especially, Kallio has Hakaniemi market square which can be considered as the heart of Kallio. These are some information that can be taken into consideration when opening a restaurant or event in Kallio region. (City of Helsinki b, 8-20; City of Helsinki c, 13-22, 82.)

10.2.2 Purpose

It is clear the main purpose of a restaurant or event organizer catering is to deliver a satisfying dining experience, but it doesn't mean ignoring the well-being of the guests. Putting all the health-related information into consideration, the menu, in this event, should be friendly for pre-diabetics with rich bone-building nutrients, limited in fat, salt and added sugar, and lactose- and gluten-free. Therefore, the menu can be designed as low fat, vegetable-focused, calcium-rich with soft texture for Anne, Maku, and the rest. A special low-fat, low-salt, and alcohol-free menu for Lasse. The menu is also lactose- and gluten-free.

The decisive factors of an ideal menu are the principles that are introduced in the "Principles for healthy diet" section. Therefore, the focus on plant-derived foods and seafood, and the limited consumption of processed and red meat, added sugar, salt and alcohol should be applied. Then related illnesses or chronic diseases like diabetes or cardiovascular diseases can set the narrower direction of menu planning. In this case, pre-diabetes is the one directing the normal menu, exceptionally in Lasse's and Maku's cases with reduced saturated fat, increased bone-building nutrients, and texture notices. Hypertension can also be included but low-salt and non-alcohol traits easily cause discomfort to the eaters, so it should be personalized. The final one is the allergy and food intolerance since they are varied for individuals, so they should be personalized as well otherwise the whole menu has to avoid allergic ingredients.

10.2.3 Nutrition

Moving to the next step, nutritional demands need to be fulfilled. Without a nutritionist's assistance, accessibility to nutrient recommended intake tables is significantly pivotal. According to introduced table 5 and appendix 5, 6, 7, and 8 mentioned in the subchapter "Guideline and dietary data", the age 30-50 falls within the group 31-60, so the necessary nutritional and energy-consuming information for the guest can be calculated as the values in the tables.

Fortunately, the values indicated in the tables not only works for healthy individuals or those like Annie but also for Lasse and Maku, they just need extra modifications in their meals. Lasse already has hypertension, which means that in his menu, his meal needs to be low in salt and alcohol, and high in fiber for increased cholesterol removal, reducing the incidence of cardiovascular disease and stroke. And for Maku, his health issues are worse than Lasse, the limited consumption of fat, alcohol, salt, and the high intake of fiber, vegetable, and calcium-rich food sources can be helpful. The nutrition consideration just a small contribution to the health improvement of the guests, and should goes along with their daily meals for a better outcome.

Based on table 5 and appendix 5, 6, 7, and 8, the dinner should meet approximately one-third of the recommended intake. However, the accuracy of the nutrient intake, in this case, is difficult to calculate since the recommended intake listed in the tables is for one day, not for one meal. Another reason is that it is impossible to consider previous meals that the guests have before the event into the calculation. So, the main aim of the calculation, in this case, is to provide the necessary nutrients in an adequate amount for one meal.

Firstly, the needed energy of a whole day for this age group is for a female is 8.8MJ which equals to 8.8 x 240 = 2112 kcalories and for a male is 11MJ which equals to 11 x 240 = 2640 kcalories with BMI (body mass index) 23. Because 1MJ approximately equals 240 kcalories. In this case, there are some diagnosed with pre-diabetes which means that some have a BMI within 25-29.9. However, the menu is designed to contribute to weight loss in protecting the body from diabetes. This makes the value 2100-2600 kcalories a day a standard number for energy consumption in this case.

The next step is to consider the proportion of protein, carbohydrate, and fat in the serving. According to “Guidelines and dietary data”, the standard percentage of total energy for fat is 20-35%, for protein is 10-20%, and the rest is carbohydrate. This doesn’t mean half of the dish is a roasted potato or cooked rice, because vegetables, beans, legumes also contain carbohydrates as well, not to mention fiber percentage in the carbohydrate proportion. Therefore, from the percentage of total energy, the energy requirement of protein, fat, and carbohydrate can be calculated by:

[total energy] / 100 x [macronutrients %] = [macronutrient energy a day]

For example, 2100 / 100 x 10 = 210 kcalories and 210 / 100 x 20 = 420 kcalories. Indeed, carbohydrate energy equation is different from the other two for a faster process:

[total energy] – [max of protein] – [max of fat] = [min of carbohydrate]

[total energy] – [min of protein] – [min of fat] = [max of carbohydrate]

In the equation, “min of protein”, “min of fat” and “min of carbohydrate” is the minimum values of energy from protein, fat, and carbohydrate intake, respectively, and “max of protein”, “max of fat” and “max of carbohydrate” is the maximum values of energy from protein, fat and carbohydrate intake. Then:

[protein or carbohydrate energy] / 4 = [protein or carbohydrate weight in gram]

[fat energy] / 9 = [fat weight in gram].

The part “ATP synthesis” explains the difference in energy-yielded quantity when digesting macronutrients as followed: 1 gram of protein and carbohydrate can yield 4 kcalories, and 1 gram of fat can yield 9 kcalories. All of the calculated values are illustrated in table 6.

Table 6: Recommended intake of macronutrients for the whole day.

Gender	**Total energy (Kcalories-100%)**	**Macronutrient (Kcalories)**					
		Protein (10-20%)		**Fat (20-35%)**		**Carbohydrate**	
Female	2100	210-420	53-105g	420-735	47-82g	945-1470	236-368g
Male	2640	264-528	66-132g	528-924	59-102g	1188-1848	297-462g

Any values that fall outside the calculated range can start harming the body. Because each of the macronutrients has a unique role in nurturing body cells in irreplaceable ways, the insufficiency of one macronutrient in the long-term not only causes it not to perform its tasks appropriately but also can interrupt other nutrients’ performance. For example, the lack of fat can result in low availability of fat-soluble vitamins or lack of carbohydrate can lead to fat-to-ATP conversion, which disrupts the acid-base balance in bloodstream due to the keto body release from fat breakdown.

Since they usually have three meals a day, the dinner menu needs to cover 30-35% as usual. So, the total energy needed for the dinner is 630-735 kcalories for a female and 792-924 kcalories for a male. For more convenience, the values can be adjusted to be 700 kcalories for females and 850 kcalories for males. Considering the factors that the group has pre-diabetes, the menu should focus on more protein with less fat from meat and poultry and less carbohydrate from added sugar and starchy foods.

The values indicated in table 6 expresses two values suitable for female and male. The restauranteurs or event organizers can decide to prepare two different sets of menus with a different portion for female and male guests or to prepare one universal menu. In this case, the author chooses the latter for exemplifying. Calculating the proper values for the universal menu by:

[min of macronutrient weight for male] = [min of macronutrient weight for universal menu]

[max of macronutrient weight for female] = [max of macronutrient weight for universal menu]

The calculation of macronutrient energy is not needed, because any calculations in the next steps depend on solely the weight values. The menu macronutrient values are indicated in table 7.

Table 7: Recommended intake of macronutrients for the dinner.

Gender	**Total energy (Kcalories-100%)**	**Dinner (Kcalories)**					
		Protein (10-20%)		**Fat (20-35%)**		**Carbohydrate**	
Female	700	70-140	17-35g	140-245	15-27g	315-490	79-122g
Male	850	85-170	21-42g	170-297	19-33g	383-595	96-149g
Menu			21-35g		19-27g		96-122g

Appendix 5 shows the necessary micronutrient intake that needs to be absorbed daily, so dinner cannot provide full of the indicated numbers in table 5, because it can easily cause toxication. However, the menu can focus more on nutrients that assist in protecting the guests from diseases such as vitamin A, vitamin D, vitamin K, and calcium. Additionally, water-soluble vitamin intake such as vitamin C is prioritized rather than fat-soluble vitamin intake because of its limited capacity of storage.

10.2.4 Selection

If the organizers decide to make more than one type of menu, the normal menu for the largest number of guests should be assembled first, then it can be modified to fit the other personalized options. In this case, there is just one menu for 20 people.

Following the “Principles for health diet”, considering the guest’s health issues, and doing researches on WebMD, the selected ingredients can be calcium-rich vegetables like broccoli, Brussels sprout, spinach, kale, okra, collard, soybean, white bean, and fish like sardine, perch with high vitamin D and calcium and less fat. With these ingredients as main dish components, the main nutrients such as fiber, calcium, vitamin D are sufficient.
These choices are beneficial mainly for Maku’s menu, but since the intake of calcium and vitamin D of Swedish and Finnish is at a low level, the listed ingredients are healthy to the rest of the group as well (Ramnemark, Norberg, Pettersson-Kymmer & Eliasson 2009).

Besides, bean, legume, and whole grain are high in fiber but also high in fat, vegetables like potato, especially sweet potatoes which has many vitamins but also is high in starch, fatty fishes like salmon, tuna are high in vitamin D and calcium but high in both saturated and unsaturated fatty acid, meats and dairy products like pork, beef, milk, and egg has protein which is necessary for bone building but can be high in saturated fat, lastly fruits are high in vitamins, fiber and phytochemicals which are extremely beneficial but sweet ones can provide a high amount of sugar under overconsumption. More information about the nutritional values is explained in the part “Food sources and health implications” in the thesis. Animal bone is also a great source of bone-building nutrients. These are some examples that can be added to the menu for variety and taste but they need extra cautions and should be consumed in a controlled quantity.

Because all the listed ingredients need to provide the within-range nutrient amounts, another step for quantity calculation is using the WebMD or any other reliable nutrition-related sites such as Healthline.com or USDA (United States Department of Agriculture) main website to estimate the nutrients per weight. These calculated numbers should be recorded for future use. For instance, in WebMD, one serving of beef-four-ounce weight which equals to roughly 115 grams, can include 21 grams of protein and 19 grams of fat. So, the maximum quantity of beef, in this case, can be 230 grams which can provide 42 grams of protein and 38 grams of fat or the combination of beef, pork, poultry, and fish, but the fat and mineral contents in the meat also need to be put into consideration.

The list of ingredients for the menu of the anniversary is illustrated in the table represented in appendix 9. These listed ingredients should meet the requirements discussed in previous phases. Additionally, the ingredients should be described in detail, for example, instead of chicken meat, it should be chicken leg or chicken breast. The “nutrient” column indicates a noticeable amount of certain nutrients in specific foods, meanwhile, the “notice” column expresses the nutrients that have the potential to exceed the upper intake limit, leading to toxication if the situation continues in the long run. Finally, the “hashtag” column is meant for categorizing the ingredients for future use. While the category bone-healthy is set for foods that are high in vitamin D, vitamin K and calcium, the category healthy-heart indicates the potential effect foods may have, not the absolute result. As a result, diet plays a part in preventing illnesses, not curing them.

Appendix 9 exemplifies the ingredient list structure for the dinner, and the reference links are listed in appendix 11. There are some blank-space columns to show that there is the possibility of adding more ingredients as long as the criteria are met. In practice, this list

can be created from starch and expanded more in the future or this list can be retrieved from the original one that was created before with all the ingredients that may appear in the restaurant kitchen. The more ingredients in the list, the more creative and flexible chefs and executive chefs can be with menu designing.

As a reminder, because the guests are lactose intolerant and gluten allergic, so gluten-containing flour such as wheat flour and milk and dairy products are excluded from the menu. In the case of Lasse, he needs to avoid processed, cured, smoked, or canned meat, because they contain a large amount of salt. For Maku, he needs the accurate accounting for carbohydrate and fat consumption, so added sugar should be replaced by sourness from a roasted lemon flavor, and added cream should be replaced by a fruity sauce.

10.2.5 Prototype

In this stage, chefs and executive chefs play the main role in choosing the ingredients from the created list to think, calculate, prepare, assemble, cook and taste to create dishes that can be put on the final menu. Come to the thinking process, there should not be any limits so that creativity can take place, so all ideas about starters, main dishes, and desserts are welcomed. After that, chefs and executive chefs can select those ideas to form a new menu for calculation.

In this case, from the ingredients in appendix 9, the starter can be vegetable tapas from boiled quinoa and cooked tiger prawn on top of bok choy leaves, buckwheat bread with sundried tomatoes, and roasted tiger prawn. Main dishes can be pan-fried perch with chili-orange-mustard sauce with roasted Brussels sprout, broccoli, and sweet potatoes, and steamed potato. Desserts can be poached pear and strawberry jam in the center of the pear.

It seems that ideas mention some ingredients are not listed in the ingredient list created in phase “Selection”. These extra ideas should be noticed but no need to be listed in the list. Since the menu is designed for a night gathering, which cannot have a strong impact on the guests’ nutrition profile, so high accuracy in calculating nutrients in “Selection” is not worth investing in. The weight calculation of these ingredients bears the same point, which is not necessary to be accurate. However, this calculation process still needs to be done to ensure there is no nutrient toxication or deficiency caused by the menu miscalculation.

To calculate the nutrition, using any nutrition calculating tools is necessary for the restauranteur and event organizers. Some of the free tools that can be found online with reliable

sources are inlivo.com, eatthismuch.com, fatsecret.com … These tools help the calculation process to process without much effort. Some sources use IU, which stands for International Units, as the measuring unit for vitamins. The equation is 1 IU = 0.3 µg or mcg (microgram).

Table 8 shows the weight calculation of macronutrients and micronutrients that are counted as necessary nutrients that need to be noticed in this case. The minor details that are left out are sauce, herb, and dairy products which are selected within the range of criteria set in the "Purpose" phase. Additionally, the protein amount of vegetables is not necessary to be counted because vegetable protein is an incomplete form that ineffective functions as a protein. The values of fiber and micronutrients are from table 5 and appendix 5 respectively, and these values are for daily consumption. Therefore, they are highlighted for notice. The values are counted and compared to table 7 in the "Nutrition" phase.

Table 8: Macronutrient and nutrient control in the menu.

Ingredient	**Serving**	**Protein**	**Fat**	**Carb**	**Fiber**	**Vitamin A**	**Vitamin D**	**Vitamin C**	**Calcium**
Menu (100%)		**21-35g**	**19-27g**	**96-122g**	**25-35g**	**900mcg**	**10mcg**	**75mg**	**800mg**
Tiger prawn	60g	9.6g	0.5g						15mg
Perch cooked	110g	22	12g	11g		24mcg	3.1mcg	1.2mg	110mg
Roasted sweet potato	55g		0.5g	10g	2g	600mcg		5mg	40mg
Steamed potato	100g			20g	1.6g				
Quinoa cooked	50g			11g	1.4g				8.5mg
Buckwheat bread	50g			22g	2g				
Sundried tomato	15g		0.5g	7.5g	2.5g	150mcg		3mg	66mg
Brussels sprout	100g		2g	7g	3g	62mcg		60mg	34mg

Broccoli	50g		1.1g	3.5g	1.6g	93.6mcg		31mg	20mg
Bok choy	50g			1.8g	0.9g	201mcg		24mg	54mg
Pear	70g			11g	2.2g			3mg	6.7mg
Straw-berry jam	10g			5.9g				2mg	
Total		**31.4g**	**16g**	**111g**	**17.2g**	**1130mcg**	**3.1mcg**	**130mg**	**354mg**
Menu (100%)		**21-35g**	**19-27g**	**96-122g**	**25-35g**	**900µg**	**10µg**	**75mg**	**800mg**

Comparing the values of the total column with the value of the menu column, it seems that the protein and carbohydrate quantity is within the range, while fat is off the range. Since the menu is designed to be low fat, this value is ideal. Fiber intake is in the same situation as fat intake, but the required value is for daily consumption, so the fiber quantity the menu provides is at a good level. The requirement of micronutrients is also meant for daily consumption, not to mention the loss during preparation and cooking, so the provided micronutrients are ideal.

As a result, table 9 is qualified as a nutritious menu with the potential for being served during the event. This is a prototype that needs testing out and enhancing for a better dining experience. Usually, there should be more than one prototype so that if things go wrong, a replacement can be considered.

Table 9: Menu prototype.

Menu	Name	Component
Starter	Green tapas	Shrimp, quinoa, bok choy
	Exotic tapas	Shrimp, sundried tomato, buckwheat bread
Main dish	Pan-seared perch	Perch
	Roasted vegetable	Brussel, broccoli, sweet potato
	Steamed potato	White potato
Dessert	Poached pear	Poached pear, strawberry jam

10.2.6 Method

The next step is to select the preparation and cooking methods that can both maintain the most nutrients and deliver a flavorful taste profile. All the recommended methods are described in the part “Foundation of healthy cooking”. The combination of these methods with creativity can surprise the guests and benefit them at the same time. Base on the prototype which is shown on the table .. and the food preferences of the guests like Annie likes fresh food, Lasse likes crispiness, and Maku likes soft texture, the methods of preparing and cooking food need to be decided. Chefs and executive chefs are the experts in this process, since cooking skills and techniques originate from science, especially in French cooking.

Firstly, the first starter – green tapas can be enhanced by the quinoa mixed with vinaigrette which is made by vinegar, lemon juice, sugar, olive oil, parsley, and coriander, while the shrimp can be pan-seared with butter and garlic then they can be on the top and bok choy leaves can be placed under. The second starter – exotic tapas, can be enhanced by a layer of pesto oil, and the sundried tomatoes and shrimps can be chopped up into small cubes mixed with yogurt and cheese cream, and dills on the top.

Pan-seared perch can be enhanced by marinaded in a brine made with bay leaf, juniper pepper, and salt. The perch can also be eaten with chili-orange-mustard sauce. Brussels sprout, broccoli, and sweet potato can be roasted with some nuts or red onions while white potato can be steamed. The roasted vegetable can also be seasoned with lemon-thyme-garlic vinaigrette.

Since the dessert is pear and strawberry, fruit juice can be used to deglaze the poached pear for a more flavorful profile. The flavor can be enhanced further by adding a little cream or jelly strawberry cubes plating around the pear.

Extra crispiness for healthy choices can be croutons, nuts, raw celery, and carrot, … or they can also be deep-fried onion, garlic, shallot, carrot julienne basket, vegetable tempura, ... There are many different ways to achieve food preferences without adding more sugar, salt, and oil into every meal. Especially when it comes to environmental factors which have a strong influence on the way people taste the food.

10.2.7 Consideration

The last factor to consider is the environmental elements during the dining. Since the special event has a good amount of budget, an extra investment on tableware and cutleries

can put a great impression on how the guests taste the food. If the dishes are characterized with less added sugar and salt, the theme color of the dishes can be red and white. Redness makes the food sweeter and whiteness does the same to saltiness. The usage of a round plate makes the foods sweeter as well. The cutleries need to be heavy, because it triggers the feeling of high-quality materials, leading to better satisfaction. The application of plate sizes can be practical. Because, with the same amount of food, the smaller plate provides the more satiating than the bigger ones, which means that rice and other starchy food can be served on the smaller plate and salad can be served on the bigger plate. For soup, bowl works best because it offers a better aroma concentration so that eaters can receive the concentrated flavor of soup through nose. Brightness and music can be modified to promote vegetable-based dishes to be eaten more than protein- and carbohydrate-based dishes, which are described in chapter “Gastrophysics”.

Because of the “sensory dominance” effect, the unity of the whole event menu should be stable, if not, the notice of the big differences between the normal menu and modified menu can provoke customer acknowledgment of the effect, leading to its inefficiency. So, the plate styles, lighting, music, and color pairing should be applied to everyone’s dishes, not just to Lasse and Maku.

In this case, the choice for a heavy red round plate for desserts to enhance sweet taste and a white round rough plate for main dishes to enhance salty flavor and crispy texture. Because the event is the anniversary of a company, the cozy feeling should be elevated by the dim light and the light music so that conversations between co-workers can run smoothly without talking too loudly. If the restauranteurs and event organizers can spend a large budget on this aspect, hiring a gastrophysician is necessary to design the eating hall as a theme synergy with the experience the menu is supposed to provide.

10.3 Developing cycle

After the preparation process completes, the ideal results are many tested ideas of foods that are made from listed ingredients that are most beneficial to the targeted customers in a healthy-designed setting. At the start of the developing cycle, every considered element in the plan should be carried out. In this case, the event organizer is also the restaurant, so they can test the menu and environment setting with their regular guests and get feedback from them. In other cases, if event organizers don’t have any regular guests, the practice can apply to the employees for feedback.

The feedbacks are the most critical step for further decision-making. If the feedbacks are all positive, the menu can be carried out on the event day. In the circumstance that the

gathered feedbacks have a few negative ones with little or no consequence, the components of the menu can be modified. In the case of many negative ones, especially those with consequences, it means that the process should start over from the Prototype step or Research step. For instance, if the received feedbacks are about the strawberry jam flavor does pair well with poached pear deglazed in pear juice, then mango pureed with mint leaves can be another choice. Therefore, instead of strawberry jam, mango pureed should be added in the nutrient control for the calculation, which starts over from the Prototype phase. However, if the light is too dim for the guests because they have eye-related defects, it's better to brighten the atmosphere, which is the modification, not a start-over.

The most common outcome from the Feedback step is to modify a few elements in the menu planning. The adjustment can be anything from taste pairing to unexpected flavors perceived through environmental settings like the ocean wave sound can make the guests taste flavorless instead of saltier because they have heavy sea sickness. This modification can take place permanently or on an individual scale, depending on what consequences it causes. For example, the ocean wave sound can be turned into Hawaii beach music for saltier taste without reminding of sea-sickness-related memories.

After satisfying both customers and organizers, the menu is ready to run on a special day. On the event day, things may turn out to be different than the expectation from the menu planning process. This means that the modification or the quick start-over from the Prototype step can occur, so being flexible with an open mind for these situations is helpful.

11 Exemplified case of menu planning for personal use

11.1 Scenario

The general idea of this second practice is to plan the menu for personal use. Considering that the target is a female at the age of 20, named Sara, and she is a university student and has a desire for improving her beauty. She lives alone and since she moved out, she has been neglecting her diet and eats what she likes. She likes salty and oily foods such as deep-fried chicken wings and hot buffalo sauce. Besides she is very active in the sport.

11.2 Preparation process

11.2.1 Research

The Research stage for personal menu planning is usually considered as a health record. Because the planner is also the customer, they already know themselves. However, it is advisable to get accurate information about health issues from doctors or physicians. So, before moving to the next step, doing a health check-up is essential for developing an effective menu.

Sara is a young and energetic girl with diet problems which may be the cause of her beauty improvement desire. She went to the hospital for the health care check which resulted in normal status. It seems that there is no problem with her health yet, which considers diet as the ideal solution for her desire instead of medicine.

In this case, Sara does not know much about her whereabouts because of her moveout and her way of eating. It would be better for her to go and check the local markets to know what products she can access. She lived in Porvoo and now she moved to Helsinki, Hakaniemi in Kalio region. In the region, Hakaniemi market hall is an ideal place for shopping for food. Around the market hall, there are also many Asian markets such as Vii-voan and Jiahe market. This means that she can prepare and cook with fresh ingredients in many cuisine styles.

11.2.2 Purpose

Sara has good health, which commonly happens to most active girls at the age of 20, but if she maintains her bad eating habits, her health will deteriorate as she ages. The main role of nutrition is to prevent, so providing sufficient nutrients can help to maintain her performance at school at her best. The diet should get a balanced nutrient for future illness protection, and it also needs to focus on bone-building nutrients and protein collagen for beauty improvement.

The biggest challenge for Sara, and to most dieters in general, is to keep up with the new eating habits sustainably. This means that the new diet has to comfort and excite her in the long-term so that she naturally enjoys it with little or without any effort, not the feeling of reluctance. To achieve it, the plan should be flexible, inspiring, and encouraging to her.

The menu planning for personal use is the weekly menu schedule with different dishes within a versatile range. This means that the menus for breakfast, lunch, and dinner do not need to be calculated well, which does not pose stress on dieters, allowing them to feel more enjoyable. The planning focuses on what and how many ingredients should be bought at the start of the week so that the values in the nutrient intake recommendation are met.

11.2.3 Nutrition

In terms of nutrition, Sara is in the age group 18-30 in table 5 and appendix 5, 6, 7, and 8. However, as she does spot often, she needs more minerals and energy than usual people due to the leak of minerals in sweating. Another factor to consider is calcium because playing sport means that there are chances the accident may happen like falling onto the ground, so her bone needs strengthening. The ideal way to do this is to consume bone-cooking dishes such as beef stew, or animal stock because it contains a great number of bone-making nutrients. More importantly, bone-cooking dishes contain a great deal of protein collagen which is the main factor in skin and hair health.

Although the recommended micronutrient intake stated in appendix 5 is the standard value for Sara's diet, it is not necessary for Sara to prepare and calculate the sufficient quantity of all the micronutrients in one meal or daily meals. This means that a few days in a week can contain more or less vitamin A and vitamin E without any harm if, on other days, these nutrients are taken less or more for the balance. However, the daily consumption of water-soluble vitamins such as vitamin C and B complex, with the exception of vitamin B_6 and B_{12}, is recommended. This is explained in the section “Water-soluble vitamin” in chapter “Nutrient” and subchapter “Micronutrient” that the storing capacity of these vitamins is limited, unlike fat-soluble vitamins which can be stored in the liver for a longer period.

As she is young and active, the values of recommended nutrients intake are slightly different than those in practice 1. Table 10 shows the data for Sara’s menu planning. Because, she is active in sport, which leads to her recommended energy consumption is 10.5MJ instead of 9.4MJ. The number means: 10.5 x 240 = 2520 kcalories. The same equations in chapter 10 are utilized in the case:

[total energy] / 100 x [macronutrients %] = [macronutrient energy a day].

For instance, 2520 / 100 x 10 = 252 kcalories and 2520 / 100 x 20 = 504 kcalories protein. This equation applies to fat as well. More conveniently, carbohydrate energy can be calculated by:

[total energy] – [max of protein] – [max of fat] = [min of carbohydrate]

[total energy] – [min of protein] – [min of fat] = [max of carbohydrate].

In the equation, “min of protein”, “min of fat” and “min of carbohydrate” is the minimum values of energy from protein, fat, and carbohydrate intake, respectively, and “max of protein”, “max of fat” and “max of carbohydrate” is the maximum values of energy from protein, fat and carbohydrate intake. Then:

[protein or carbohydrate energy] / 4 = [protein or carbohydrate weight in gram]

[fat energy] / 9 = [fat weight in gram]

The explanation for the different equations between protein or carbohydrate and fat can be found in the “ATP synthesis” part. The calculation for the whole day menu is presented in table 10.

Table 10: Recommended intake of macronutrients for the whole day in case “practice 2”.

Total energy (Kcalories-100%)	**Macronutrient (Kcalories)**					
	Protein (10-20%)		**Fat (20-35%)**		**Carbohydrate**	
2520	252-504	63-125g	504-882	56-98g	1134-1764	236-368g

The recommended micronutrient intake is presented in appendix 5. Additionally, the nutrients that need to be noticed to achieve the set goals are bone-healthy and skin healthy nutrients.

Besides the balance of water-soluble and fat-soluble vitamins, and minerals, calcium and collagen intake cannot be neglected.

11.2.4 Selection

This phase should run gradually so that there is no stress or discomfort for Sara. This means that every weekend, she can search broccoli and its health-related information or

consult with a nutritionist. Then she can create a table for remembering what broccoli can do. Appendix 10 shows her progress for several weeks. This table has nearly the same information in appendix 9 without diet type hashtags. The reference links are also presented in appendix 11.

The “Food sources and health implications” subchapter in the thesis can be helpful to Sara. WebMD and Healthline is an example of the websites having much health-related information which can enrich Sara's knowledge about food as well. Therefore, Sara needs to be active in checking the ingredients available in the Hakaniemi market hall to select which one could benefit her health best. For example, in the market hall, she can easily find egg, beef chunk, salmon, canned tuna, carrot, broccoli, kale, cauliflower, mozzarella, and parmesan cheese, green apple, orange, grapefruit, and red grape. Then she can put the ingredients into her list according to her personal preference and other factors described in the subchapter “Social factor” under chapter “Gastrophysics” in the thesis.

While “type” and “ingredient” columns are obvious with their meaning, the “nutrient” column refers to the main nutrients that the ingredients contain. If certain substances in the ingredients listed in the table presented in appendix 10 can easily exceed the upper limit intake indicated in appendix 8, those ingredients should be listed under the “notice” column. The “Hashtag” column, in this case, can be considered as benefits the food may have with its nutrient content and it also can be used as categorization for future use.

Adding the ingredients to the list gradually helps Sara to have time to get familiar with the new dishes and the new cooking methods so she doesn’t feel stress and difficulty in a new diet. In the first several weeks, the new diet doesn’t need to be completely different than normal meals, some changes are enough. For example, if Sara’s usual meals can contain French-fries and beef steak, her first-week diet can replace French-fries with mashed potato and her second-week can have roasted sweet potato as the substitutes in several meals of the week. When she feels comfortable with the new dishes, then beef steak can be alternated by beef stew or chicken breast. A one-by-one modification menu schedule is a friendly method for applying new diets into one’s life. The same applies to fruits as a snack.

11.2.5 Prototype

What makes the difference between the menu for personal use and the menu at the restaurants or events is the menu schedule. While the restauranteurs and event planners just need to plan carefully and design a menu that can be used for several months, Sara’s menu is for her everyday life. This means the menu has to be varied on each day and on each meal, which is a real challenge. So, menu planning should emphasize several week

meals instead of one meal. To achieve Sara's goals and overcome the challenge, nutrition calculation for a one-day meal should be made for macronutrients only.

The table presented in appendix 12 is a schedule for one week of Sara's diet. Because she is a university student, she usually has lunch at school, so the record is taken on a week's holiday.

It seems that her eating habits throughout the whole week do lack vegetables, while most of her foods include chicken, beef, potato, and butter. It is also noticed that she sometimes skips breakfast, which can harm her health. Therefore, a diet with more vegetables, fruits, and more varied types of meat can help Sara.

To adjust her diet, firstly, Sara needs to eat a healthy menu with balanced nutrients contend for one day of the week, and she needs to maintain this way of eating until she gets familiar enough. Because she is at school on the weekdays, so the healthy eating day can be Sunday. She should come up with the ideas of what dishes she wants to cook first and then calculate the nutritional information by using nutrition calculation tools such as are in-livo.com, eatthismuch.com, fatsecret.com…

At breakfast, oat porridge can go with blueberry, banana, and walnut. The menu can be for lunch pasta with tomato sauce and meatballs, and salad with iceberg lettuce, broccoli, kale, and cherry tomato. At dinner, the menu can be steam potato with rosemary olive oil, roasted sweet potato cubes and roasted cherry tomato, pan-seared asparagus, and salmon. Table 11 shows the nutrition calculation of the listed ideas.

Table 11: Nutrition calculation for Sara's one-day meal.

Type	**Ingredient**	**Weight**	**Protein**	**Fat**	**Carb**	**Fiber**	**Vitamin A**	**Vitamin C**	**Calcium**
Menu			**63-125g**	**56-98g**	**263-368g**	**25-35g**	**700mcg**	**75mg**	**800mg**
Breakfast	Oat porridge	200g	34g	14.4g	120g	7g			38mg
	Blueberry	50g			5g	1g		4mg	
	Banana	80g			19g	2.1g		7mg	4.1mg
	Walnut	20g	3g	13g	2.7g	1.3g			20mg

Lunch	Spa-ghetti cooked	300g		12g	63g	6g			15mg
	Meat ball	340g	48g	18g	12g				
	Tomato sauce	130g			8g	2g	120mcg	4.8mg	
	Iceberg lettuce	70g			2g	0.9g	108mcg	2mg	13mg
	Broccoli	50g			3.3g	1.3g	93.6mcg	45mg	24mg
	Kale	20g			1.8g	0.7g	600mcg	24mg	30mg
	Cherry tomato	50g			1.9g	0.9g	187mcg	9.3mg	5mg
Dinner	Steamed potato	300g			60g	5.1g			
	Roasted sweet potato	55g		0.5g	10g	2g	600mcg	5mg	40mg
	Cherry tomato	50g			1.9g	0.9g	187mcg	9.3mg	5mg
	Aspara-gus	80g		1.4g	3.2g	1.5g	56mcg	6mg	1.6mg
	Salmon	170g	43g	15g			66mcg		15mg
Menu			**63-125g**	**56-98g**	**263-368g**	**25-35g**	**700mcg**	**75mg**	**800mg**
Total			**128g**	**74.3g**	**314g**	**31g**	**1400mcg**	**116mg**	**210mg**

From table 11, it seems that the intake of macronutrients is ideal, while vitamin A and vitamin C intake are higher than the recommended ones. Take a look at appendix 10, roasted sweet potato is the main ingredient providing vitamin A and broccoli is the main ingredient providing vitamin C. Therefore, these two ingredients should be left out of this menu and can be used for other dishes on another day.

Table 12 shows the tested menu or a prototype menu for Sara on Sunday. Sara does not need to create many prototypes, which helps to lessen the stress on menu planning for herself.

Table 12: Sara's tested menu or prototype menu.

Menu	Name	Component
Breakfast	Oat porridge	Oat, milk, and butter
	Fruit	Berries, banana
	Nut	Walnut
Lunch	Pasta	Spaghetti, meal ball, tomato sauce
	Salad	Iceberg lettuce, cherry tomato, kale
Dinner	Pan-seared Salmon	Salmon
	Steamed potato	Potato
	Pan-seared asparagus and cherry tomato	Asparagus and cherry tomato

More importantly, safety in cooking is always a primary matter to consider, which is described in the thesis part “Allergies and food safety”.

11.2.6 Method

Since many nutrients are sensitive to heat and oxygen, apply the part “Foundation of health cooking” is essential to get the balance of both nutrient content and good taste. Although there are many new techniques and skills unfamiliar to normal people, steaming, roasting, grilling, boiling, or stewing are excellent methods for treating the listed ingredients. However, if Sara has interests in cooking or wants to improve her cooking skills, she still can learn one by one at a time in her free time. Besides, depending on cooking equipment at home, Sara can choose the suitable preparation and cooking methods so that she doesn’t need to buy more.

At the breakfast, blueberries and banana topping on the oat porridge can be altered with other types of fruit such as orange, strawberry, dried grape, and other nuts for the variety. The dish can go with fruit juice as well, enhancing the fruity taste of the dish.

At lunch, a meatball can be pan-seared first for the flavor of Mallard's reaction, then mix with the sauce for flavor absorption. Meatballs can be made with beef and tofu for less fat and more nutritious content. Tomato sauce can be enhanced with tomato juice, tomato paste, and basil. The salad can be added more nuts and seeds such as sunflower seeds and croutons for crispiness.

At dinner, salmon can be marinated with teriyaki sauce before being pan-seared, then the used pan can be used for making the deglazed teriyaki sauce. Asparagus can be pan-seared with butter, garlic, and thyme.

Being creative in preparing and cooking can keep Sara's interest in the new diets without forcing her because she has her freedom to create her dishes. Therefore, home-cooking is encouraging to Sara, which is proved in terms of gastrophysics.

11.2.7 Consideration

Lastly, cooking from scratch is the best way to enhance the satisfaction of eating without spending more money. So, Sara can have a small gathering at the weekend and prepare the food with her friends. When she is at home alone, distraction while eating is advisably avoided because it can distort her appetite and make her uncontrollably eat more than she intends to. "Eating with eyes" is never outdated, she can learn food decoration skills and apply them to her dishes. Buying some new heavy plates and cutleries is a good idea to improve occasional meals by creating a different atmosphere at the eating table. Adding some music while eating can contribute to the unique dining experience. There are more environmental factors considered in menu planning, which are well described in chapter "Gastrophysics".

11.3 Developing cycle

After doing researches, calculating, and considering many elements to better the dining experience for Sara, she can apply the new menu to her daily schedule. In the first several weeks, she can have times to get used to the new menu including going to the market, finding the ingredients, learning new recipes and cooking techniques, and cooking for the whole day. After that, instead of one day per week, she can apply the new diets two days per week, then three days per week, and more.

Since Sara is the only customer, she designs the menu for, she can practically taste, feel, and feedback on the new application. Then she is the one who adjusts the ingredients or cooking methods so that the next healthy day gives her more pleasure. Therefore, she can start over from the "Selection" phase to choose a different set of ingredients that she is interested in or from the "Prototype" phase with different dishes. As long as she keeps making a menu plan for herself, she will gain more knowledge about food and health, which can motivate her to continue updating her knowledge and menu.

In other cases, when the dieters suffer non-communicable diseases or are potential to suffer. The meaning of menu planning is significantly important to them. Therefore, the developing cycle is taken into careful consideration to estimate the efficiency of the diet toward health improvement. The Feedback phase refers to not only the feeling of the dieter but also the health check-up values such as blood tests in the hospital. Because the values

can indicate health status if the result is negative, adjustments need to be implied immediately or the diet needs to be stopped for further investigation. However, in these cases, it is not recommended to build a health-improving menu by oneself, the best way is to ask the professionals such as doctors, physicians, and nutritionists for more accurate advice and better health supervision.

12 Conclusion

The author designs the thesis as the guideline with a similar arrangement of chapters and subchapters as a reference book. The idea of the guideline is to introduce the concept of the healthy eating lifestyle by approaching many foods- and health-related scientific studies and exemplifying the theoretical application according to the author's opinions. The main targeted readers of the thesis can be divided into two groups: restauranteurs and event planners who need the thesis for developing their business, and individuals who read the thesis for references to improve their diet.

Because of the limitation of the author’s knowledge and experience in the field study, the practice of the guideline is also limited. The healthy eating lifestyle, in terms of science, is the matrix of many interconnected complicated areas related to food, chemistry, human anatomy and physiology, gastronomy, and human behavior. Therefore, within a short period of conducting the thesis, there are many challenges during thesis progress and many topics that are not yet discussed.

12.1 Challenge

Author bachelor’s degree in hospitality management which refers to the practical knowledge about service industry management including tourism, event, restaurant, and hotel industry. It means that the thesis topic is irrelevant to the author's expertise. However, the a-few-year experience in the food industry inspires the author to do research and gather more knowledge about nutrition and food science, then conduct this thesis. To compromise the lack of knowledge and experience in the field study, the author paid a huge amount of time to read many scientific books and participate in the online course associated with nutrition, gastrophysics, human biology, and scientific cooking. The information sources are reliable and trustworthy due to the continuous updates on the source contents which are used as the theoretical backbone of the thesis.

The data and the information illustrations in the thesis are borrowed from other sources and adjusted to fit with the context of the thesis without biasing the main content. This means that copyright is a matter to solve. Due to the complexity of the presented topics, the explanations and information introduced in the thesis need illustrated figures and tables for clearer comprehension. Therefore, most of the figures and tables are reformed and attached to their sources.

Lack of professional tools in designing a menu causes many problems to the author. The nutrients quantity and quality are varied, depending on hundreds of factors such as origins

of the ingredients, environmental effects, storing conditions, and so on. Therefore, the accuracy of the conducted nutrition calculations in the thesis is at a low level.

The content of the thesis is on the scientific level, resulting in complicated definitions and explanations. This can easily discourage readers to continue till the end of the thesis. However, the outline of the thesis separates the main topics as chapters and subchapters so that readers can flexibly use the material to fulfill their purposes. Some can only read the chapter “Gastrophysics” to understand the human perception toward food and environmental elements. Some can only read the chapter “Introduction to menu planning project” to understand the process of conducting a healthy menu based on nutrition and food science. There is no limit to utilize the material as a guideline.

12.2 Discussion

The introduced approaches to the healthy eating lifestyle in this thesis context are not suitable for those who are not interested in science-based knowledge. Because the topic of healthy eating lifestyle is associated with human health, it is necessary to involve many complicated study fields so that the results have fewer negative effects on readers and can improve readers’ health eventually. This does not confirm the guaranteed health improvement as the outcome of the thesis application. The main idea of the thesis is to introduce the healthy eating lifestyle and its application to real-life scenarios according to the author's ideas, not a health claim.

As a guideline with separated related topics, the thesis can be used flexibly depending on readers’ desires. Instead of going through all the introduced contents, readers can read partly the presented topics to gain the necessary knowledge. However, because there is a logical connection within the topics, the chapter “Introduction to healthy eating lifestyle” is recommended to read first before the actual reading. The chapter provides a general view of the thesis content, which helps readers to easily understand the relationships between the introduced topics and their branches.

During the process of gathering related knowledge and information, there are many sources that open up theoretical conflicts to modern nutrition beliefs, along with many researched evidence and analytical reasons. Because these conflicted theories are under study for further understanding, all the theories and practices of the thesis rely on modern nutrition. This means that readers should read more sources about food and health to have more conscious thinking in menu planning. Due to the limitation of the author's expertise, matters cannot be clarified. However, the author recommends reading topics on phytochemical, supplement, exercise, fat, sugar, the Four Pillar Diet, … which can have an influence on food selection and lifestyle.

The theoretical conflicts in the field study of nutrition and food science appear due to the complexity of the research areas and the limitation of modern scientific technology. The relationship between food and human is more understandable than that in ancient times as many types of research are conducted for the past hundred years. However, the connection between food and human still poses many questions for scientists to solve in the future. Since the development of technology is advancing day by day, there is a bright future that the mysteries of the impact of food and its components are all cleared.

12.3 Potential

The introduced menu planning process is the work of the author, which is not perfect and should be adjusted flexibly to achieve a personal diet goal. However, this can be considered as an example of applying science-based knowledge into the menu planning process.

In the era of technology, instead of writing down the list of food selection or nutritional calculation onto a paper or typing it in computer word and excel application. The proper applications with the set formula of nutritional calculations and the vast and diverse data of all ingredients with category hashtags can be designed for more convenient usage. This can be a website or a mobile application created by non-profitable organizations, which opens for public excess. If this can happen, many people can excess to the knowledge of food and health, leading to better lifestyle choices they can make. However, due to the complexity and uncertainty of the science-based information, a huge effort from scientists is required and the information should be classified as recommendations, not as a treatment.

References

Ramnemark, A., Norberg, M., Pettersson-Kymmer, U. & Eliasson, M. 2009. Adequate vitamin D levels in a Swedish population living above latitude 63°N: The 2009 Northern Sweden MONICA study. Int J Circumpolar Health, 74. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4432023/#. Access: 11 November 2020.

Bloomberg. WebMD health corp. URL: https://www.bloomberg.com/profile/company/WBMD:US. Access: 22 October 2020.

Brown, E. J. 2014. Nutrition now. 7th ed. Cengage Learning. Wadsworth.

City of Helsinki a. Statistics and research news. URL: https://www.hel.fi/helsinki/en/administration/information/statistics/statistics-news. Access: 10 November 2020.

City of Helsinki b. Helsinki fact and figure 2020. City executive office. Urban research and statistics.

City of Helsinki c. Helsinki allueittain 2019. City executive office. Urban research and statistics.

Drummond, K. E. & Brefere, L. M. 2009. Nutrition for foodservice and culinary professionals. 7th ed. John Wiley & Sons Inc. New Jersey.

Healthline Media 2020. About us. URL: https://www.healthline.com/about. Access: 22 October 2020.

Herz, R. 2018. Why you eat what you eat. 1st ed. W. W. Norton & Company. New York & London.

Khan Academy a. Gastrointestinal system introduction. Unit: human anatomy and physiology. Heath and medicine. Lecture. URL: https://www.khanacademy.org/science/health-and-medicine/human-anatomy-and-physiology. Accessed 02 September 2020.

Khan Academy b. ATP and reaction coupling. Energy and enzymes. Biology library. Lecture. URL: https://www.khanacademy.org/science/biology/energy-and-enzymes/atp-reaction-coupling/a/atp-and-reaction-coupling. Accessed 03 September 2020.

Khan Academy c. krebs / citric acid cycle. Krebs (citric acid) cycle and oxidative phosphorylation. Biomolecules. MCAT. Test prep. Lecture. URL: https://www.khan-academy.org/test-prep/mcat/biomolecules/krebs-citric-acid-cycle-and-oxidative-phosphorylation/v/krebs-citric-acid-cycle. Accessed 05 September 2020.

Khan Academy d. Electron transport chain. Krebs (citric acid) cycle and oxidative phosphorylation. Biomolecules. MCAT. Test prep. Lecture. URL: https://www.khan-academy.org/test-prep/mcat/biomolecules/krebs-citric-acid-cycle-and-oxidative-phosphorylation/v/electron-transport-chain. Accessed 05 September 2020.

Lue, R. 2017. Electron transport chain. HarvardX. Harvard University. Lecture. URL: https://www.youtube.com/watch?v=LQmTKxI4Wn4&ab_channel=HarvardX. Accessed 05 September 2020.

Lundqvist A, Männistö S, Lindström J, Mäki P, Virtanen S & Laatikainen T 2019. The WHO's goal of preventing obesity requires more effective prevention measures. Department of Health and Welfare, Helsinki

McVety, P. J., Ware, B. J., Lévesque Ware, C. & Lévesque, C. 2009. Fundamentals of menu planning. 3rd ed. John Wiley & Sons. New York.
Mintel 2020. Global food and drink trends 2030. Mintel food and drink. London. URL: https://downloads.mintel.com/private/vKd7N/files/817369/. Accessed: 17 August 2020.

Nordic Council of Minister 2014. Nordic nutrition recommendations 2012: Integrating nutrition and physical activity. 5 ed. Copenhagen.

Nazemi, N 2017. The pyramid of health: exercise, healthy diet and rest. URL: https://www.ywcasaskatoon.com/the-pyramid-of-health-exercise-healthy-diet-and-rest/. Accessed: 17 August 2020.

Ritchie, H. & Roser, M. 2018. Cause of death. Published online at OurWorldInData.org. URL: https://ourworldindata.org/causes-of-death. Accessed: 6 August 2020.

Rudy, M. 2016. Healthy diet – a detailed guide for beginners. URL: https://www.healthline.com/nutrition/healthy-eating-for-beginners. Accessed: 7 November.

Shanahan, C. & Shanahan, L. 2017. Deep nutrition: Why your genes need traditional food. Flatiron Books. New York.

Spence, C. & Blumenthal, H. 2017. Gastrophysics: The new science of eating. Viking. London.

Statistic Finland 2018. Causes of the death. URL: https://www.tilastokeskus.fi/til/ksyyt/2018/ksyyt_2018_2019-12-16_kat_001_en.html. Accessed: 9 September 2020.

Stuckey, B 2013. Taste: Surprising stories and science about why food tastes good.1st ed. Atria. New York.

The Culinary Institute of America 2011. The professional chef. 9th ed. John Wiley & Sons Inc. New Jersey. Canada.

Time 2014. Ending the war on fat. URL: https://time.com/2863227/ending-the-war-on-fat/. Accessed: 11 October 2020.

Traster, D. 2018. Foundations of menu planning. 2nd ed. Pearson Education. Boston.

Vieira, R. E. 1996. Elementary food science. 4th ed. Chapman & Hall. New York.

WebMD 2014. What we do for our users. URL: https://www.webmd.com/about-webmd-policies/about-what-we-do-for-our-users. Access: 22 October 2020.

WebMD 2018. Our business. URL: https://www.webmd.com/corporate/our-business. Access: 22 October 2020.

Whitney, E. & Rolfes, R. S. 2016. Understanding nutrition. 14th ed. Cengage Learning. Canada.

World Health Organization 2005. Preventing chronic diseases a vital investment. URL: https://www.who.int/chp/chronic_disease_report/full_report.pdf. Accessed: 6 August 2020.
World Health Organization 2014. Noncommunicable diseases country profiles 2014. URL: https://apps.who.int/iris/bitstream/handle/10665/128038/9789241507509_eng.pdf?sequence=1. Accessed: 6 August 2020.

Appendices

Appendix 1. Foodborne organisms. (adapted from Whitney & Rolfes 2016).

Common organism name	Most frequent food sources	Onset and general symptoms	Prevention methods
Foodborne infections			
Campylobacter bacterium	Raw and undercooked poultry, unpasteurized milk, contaminated water.	Onset: 2-5 days. Diarrhea, vomiting, abdominal cramps, fever; sometimes bloody stools; lasts 2-10 days.	Cook foods thoroughly; use pasteurized milk; use sanitary food-handling methods;
E. coli (O157:H7) bacterium	Undercooked ground beef, unpasteurized milk and juices, raw cookies dough, raw fruits and vegetables, contaminated water and person-to-person contact.	Onset: 1-8 days. Severe bloody diarrhea, abdominal cramps, vomiting; lasts 5-10 days.	Cook ground beef thoroughly; use sanitary food handling methods' use treated boiled or bottled water.
Norovirus	Person-to-person contact; raw foods, salads, sandwiches.	Onset: 1-2 days. Vomiting: lasts 1-2 days.	Use sanitary handling methods.
Listeria bacterium	Unpasteurized milk; fresh soft cheese; luncheon meats; hot dogs.	Onset: 1-21 days. Fever, muscle aches; nausea, vomiting, blood poisoning, complications in pregnancy, and meningitis (stiff neck, severe headache, and fever)	Use sanitary food-handling methods; cook foods thoroughly; use pasteurized milk.
Clostridium perfringens bacterium	Meats and meat products stored at between 120°F – 130°F or 50°C – 55°C.	Onset: 8-16 hours. Abdominal pain, diarrhea, nausea; lasts 1-2 days.	Use sanitary food-handling methods; use pasteurized milk; cook foods thoroughly; refrigerate foods promptly and properly.
Salmonella bacteria (more than 2300 types)	Raw or uncooked eggs, meats, poultry, raw milk and other	Onset: 1-3 days. Fever, vomiting, ab-	Use sanitary food-handling methods; use pasteurized milk;

	dairy products, shrimp, frog legs, yeast, coconut, pasta, and chocolate.	dominal cramps, diarrhea; lasts 4-7 days; can be fatal.	cook foods thoroughly; refrigerate foods promptly and properly.
Food intoxications			
Botulism Botulinum toxin produced by Clostridium botulinum bacterium, which grows without oxygen, in low-acid foods, and at temperatures between 40°F – 120°F or 5°C – 50°C; the **botulinum toxin** responsible for botulism is called **botulin**.	Anaerobic environment of low acidity (canned corn, peppers, green beans, soups, beets, asparagus, mushrooms, ripe olives, spinach, tuna, chicken, chicken liver, liver pate, luncheon meats, ham, sausage, stuffed eggplant, lobster, and smoked and salted fish).	Onset: 4-36 hours. Nervous system symptoms, including double vision, inability to swallow, speech difficulty, and progressive paralysis of respiratory system; often fatal; leaves prolonged symptoms in survivors.	Use proper canning methods for low-acid foods; refrigerate homemade garlic and herb oils; avoid commercially prepared foods with leaky seals or with bent, bulging or broken cans. Do not give infant honey because it may contain spores of Clostridium botulinum, which is a common source of infection for infants.
Staphylococcal food poisoning Staphylococcal toxin produced by Staphylococcus aureus bacterium.	Toxin produced in improperly refrigerated meats; egg, tuna, potato, and macaroni salads; cream-filled pastries.	Onset: 1-6 hours. Diarrhea, nausea, vomiting, abdominal cramps, fevers; lasts 1-2 days.	Use sanitary food-handling methods; refrigerate foods promptly and properly; use proper home-canning methods.
Toxoplasma parasite	Raw or undercooked meat; unwashed fruits and vegetables; contaminated water.	Onset: 7-21 days. Swollen glands, fevers, headache, muscle pain, stiff neck.	Use sanitary food-handling methods; cook foods thoroughly.

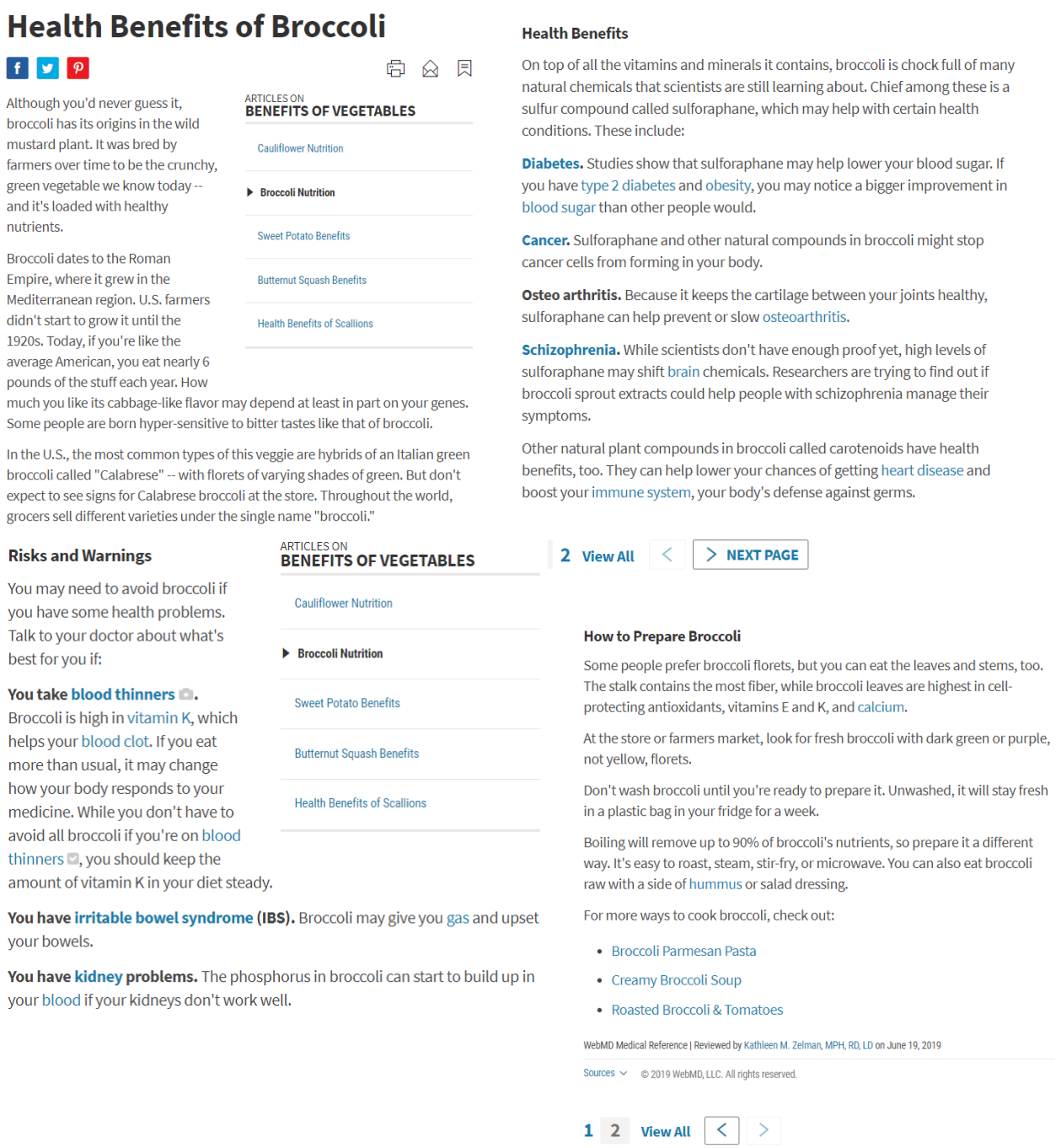
Appendix 2. Foodborne illness preventing practice. (adapted from Whitney & Rolfes 2016)

Rule	Content
Clean	Wash fruits and vegetables in a clean sink with a scrub brush and warm water; store washed and unwashed produce separately.
	Use hot, soapy water to wash hands, utensils, dishes, nonporous cutting boards, and countertops before handling food and between tasks when working with different foods. Use a bleach solution on cutting boards.
	Cover cuts with clean bandages, before food preparation; dirty bandages carry harmful microorganisms.
	Mix foods with utensils, not hands; keep hands and utensils away from mouth, nose, and hair.
	Anyone may be a carrier of bacteria and should avoid coughing or sneezing over food. A person with a skin infection or infectious disease should not prepare food.
	Clean sponges every day by microwaving wet sponges at full power for one minute or running them through the dishwasher. Wash dish cloths and dish towels regularly and use fresh, cleans ones every day.
	Clean up food spills and crumb-filled crevices.
Separate	Wash all surfaces that have been on contact with raw meats, poultry, eggs, fish, and shellfish before reusing.
	Serve cooked foods on a clean plate with a clean utensil. Separate raw foods from those that have been cooked.
	Don't use marinade that was in contact with raw meat for basting or sauce.
Cook	When cooking meats or poultry, use a thermometer to test the internal temperature. Insert the thermometer between the thigh and the body of a turkey or into the thickest part of other meats, making sure the tip of thermometer is not contact with bone or pan. Cook to the temperature indicated for that particular meat; cook hamburgers to at least medium well done. (don't keep food between 5°C – 60°C for more than 2 hours; 63°C is the minimum temperature for whole cut meat such as steaks, roasts, chops of pork, beef, veal, lamb, and fish; 71°C is the minimum temperature for ground meats; 74°C is the minimum temperature for stuffing, all poultry including ground chicken and turkey, casseroles and reheated leftovers; 77°C is the minimum temperature for well-done meats).
	Cook stuffing separately, or stuff poultry just prior to cooking.
	Do not cook large cuts of meat or turkey in a microwave oven; it leaves some parts undercooked while overcooking others.
	Cook eggs before eating them (soft-boiled for at least 3,5 minutes; scrambled until set, not runny; fried for at least 3 minutes on one side and 1 minute on the other).
	Cook seafood thoroughly.
	When serving foods, maintain temperatures at 60°C or higher.

	Heat leftovers thoroughly to at least 74°C. Do not reheat leftovers in crock pots, slow cookers or chafing dishes.
	Bring sauces, soups and gravies to a boil.
Chill	When running errand, stop at the proceri store last. When you get home, refrigerate the perishable groceries such as meats and diary products immediately. Do not leave perishable in the car any longer than it takes for ice cream to melt.
	Put packages or raw meat, fish, or poultry on a plate before refrigerating to prevent juices from dripping on food stored below.
	Buy only foods that are solidly frozen in store freezers.
	Keep cold foods at 4°C or least; keep frozen food at 0°C or less (keep a thermometer in the refrigerator).
	Marinate meats in the refrigerator, not on the counter.
	Refrigerate leftovers promptly; use shallow containers to cool foods faster; use leftovers within 3-4 days.
	Thaw meats or poultry in the refrigerator, not a room temperature. If you must hasten thawing, use cool water (changed every 30 minutes) or a microwave oven.
	Freeze meat, fish, or poultry immediately if not planning to use within a few days.
General	Do not reuse disposable containers; use non-disposable containers or recycle instead.
	Do not taste food that is suspect. “If in doubt, throw it out”
	Throw out foods with danger-signaling odors. Beware, though, that most food-poisoning bacteria are odorless, colorless, and tasteless.
	Do no buy or use items that have broken seals or mangled packaging; such containers cannot protect against microbes, insects, spoilage, or even vandalism. Check safety seals, buttons, and expiration dates.
	Follow label instructions for storing and preparing packaged and frozen foods; throw out foods that have been thawed or refrozen.
	Discard foods that are discolored, moldy, or decayed or that have been contaminated by insects or rodents
For specific food item	Canned goods: carefully discard food from cans that leak or bulge so that other people and animals will not accidentally ingest it.
	Milk and cheese: Use only pasteurized milk and milk products. Aged cheese, such as cheddar and Swiss, do well for an hour or two without refrigeration, but they should be refrigerated or stored in an ice chest for longer periods.
	Eggs: Use clean eggs with intact shells. Do not eat eggs, eve pasteurized eggs, raw; raw eggs are commonly found in Caesar salad dressing eggnog, cookie dough, hollandaise sauce, and key lime pie. Cook eggs until whites are firmly set and yolks begin to thicken.
	Honey: Honey may contain dormant bacterial spores, which can awaken in the human body to produce botulism. In adults, this poses little hazard, but infants younger than 1 year of age should never be fed honey. Honey can accumulate enough toxin

	to kill an infant; it has been implicated in several cases of sudden infant death. (Honey can also be contaminated with environmental pollutants picked up by the bees.)
	Mayonnaise: Commercial mayonnaise may actually help food to resist spoilage because of the acid content. Still, keep it refrigerated after opening.
	Mixed salads: Mixed salads of chopped ingredients spoil easily because they have extensive surface area for bacteria in invade, and they have been in contact with cutting boards, hands, and kitchen utensils that easily transmit bacteria to food (regardless of their mayonnaise content). Chill them well before, during, and after serving.
	Picnic foods: Choose foods that last without refrigeration, such as fresh fruits and vegetables, breads and cracker and canned spreads and cheese that can be opened and used immediately. Pack foods cold, layer ice between foods, and keep foods out of water.
	Seafood: Buy only fresh seafood that has been properly refrigerated or iced. Cooked seafood should be stored separately from raw seafood to avoid cross-contamination.

Appendix 3. Illustration of website WedMD.com interface and content



Health Benefits of Broccoli

Although you'd never guess it, broccoli has its origins in the wild mustard plant. It was bred by farmers over time to be the crunchy, green vegetable we know today -- and it's loaded with healthy nutrients.

Broccoli dates to the Roman Empire, where it grew in the Mediterranean region. U.S. farmers didn't start to grow it until the 1920s. Today, if you're like the average American, you eat nearly 6 pounds of the stuff each year. How much you like its cabbage-like flavor may depend at least in part on your genes. Some people are born hyper-sensitive to bitter tastes like that of broccoli.

In the U.S., the most common types of this veggie are hybrids of an Italian green broccoli called "Calabrese" -- with florets of varying shades of green. But don't expect to see signs for Calabrese broccoli at the store. Throughout the world, grocers sell different varieties under the single name "broccoli."

ARTICLES ON
BENEFITS OF VEGETABLES

- Cauliflower Nutrition
- Broccoli Nutrition
- Sweet Potato Benefits
- Butternut Squash Benefits
- Health Benefits of Scallions

Health Benefits

On top of all the vitamins and minerals it contains, broccoli is chock full of many natural chemicals that scientists are still learning about. Chief among these is a sulfur compound called sulforaphane, which may help with certain health conditions. These include:

Diabetes. Studies show that sulforaphane may help lower your blood sugar. If you have type 2 diabetes and obesity, you may notice a bigger improvement in blood sugar than other people would.

Cancer. Sulforaphane and other natural compounds in broccoli might stop cancer cells from forming in your body.

Osteo arthritis. Because it keeps the cartilage between your joints healthy, sulforaphane can help prevent or slow osteoarthritis.

Schizophrenia. While scientists don't have enough proof yet, high levels of sulforaphane may shift brain chemicals. Researchers are trying to find out if broccoli sprout extracts could help people with schizophrenia manage their symptoms.

Other natural plant compounds in broccoli called carotenoids have health benefits, too. They can help lower your chances of getting heart disease and boost your immune system, your body's defense against germs.

Risks and Warnings

You may need to avoid broccoli if you have some health problems. Talk to your doctor about what's best for you if:

You take blood thinners. Broccoli is high in vitamin K, which helps your blood clot. If you eat more than usual, it may change how your body responds to your medicine. While you don't have to avoid all broccoli if you're on blood thinners, you should keep the amount of vitamin K in your diet steady.

You have irritable bowel syndrome (IBS). Broccoli may give you gas and upset your bowels.

You have kidney problems. The phosphorus in broccoli can start to build up in your blood if your kidneys don't work well.

ARTICLES ON
BENEFITS OF VEGETABLES

- Cauliflower Nutrition
- Broccoli Nutrition
- Sweet Potato Benefits
- Butternut Squash Benefits
- Health Benefits of Scallions

2 View All NEXT PAGE

How to Prepare Broccoli

Some people prefer broccoli florets, but you can eat the leaves and stems, too. The stalk contains the most fiber, while broccoli leaves are highest in cell-protecting antioxidants, vitamins E and K, and calcium.

At the store or farmers market, look for fresh broccoli with dark green or purple, not yellow, florets.

Don't wash broccoli until you're ready to prepare it. Unwashed, it will stay fresh in a plastic bag in your fridge for a week.

Boiling will remove up to 90% of broccoli's nutrients, so prepare it a different way. It's easy to roast, steam, stir-fry, or microwave. You can also eat broccoli raw with a side of hummus or salad dressing.

For more ways to cook broccoli, check out:

- Broccoli Parmesan Pasta
- Creamy Broccoli Soup
- Roasted Broccoli & Tomatoes

WebMD Medical Reference | Reviewed by Kathleen M. Zelman, MPH, RD, LD on June 19, 2019

Sources

1 2 View All

Appendix 4. Illustration of website Healthline.com interface and content

SUBSCRIBE

healthline

Broccoli 101: Nutrition Facts and Health Benefits

Broccoli (*Brassica oleracea*) is a cruciferous vegetable related to cabbage, kale, cauliflower, and Brussels sprouts.

These vegetables are known for their beneficial health effects.

Broccoli is high in many nutrients, including fiber, vitamin C, vitamin K, iron, and potassium. It also boasts more protein than most other vegetables.

This green veggie can be enjoyed both raw and cooked, but recent research shows that gentle steaming provides the most health benefits (1, 2).

This article tells you everything you need to know about broccoli.

Nutrition facts

Raw broccoli contains almost 90% water, 7% carbs, 3% protein, and almost no fat.

Broccoli is very low in calories, providing only 31 calories per cup (91 grams).

The nutrition facts for 1 cup (91 grams) of raw broccoli are (3):

- **Calories:** 31
- **Water:** 89%
- **Protein:** 2.5 grams
- **Carbs:** 6 grams
- **Sugar:** 1.5 grams
- **Fiber:** 2.4 grams
- **Fat:** 0.4 grams

Carbs

Broccoli's carbs mainly consist of fiber and sugars.

The sugars are fructose, glucose, and sucrose, with small amounts of lactose and maltose (4).

However, the total carb content is very low, with only 3.5 grams of digestible carbs per cup (91 grams).

Fiber

Fiber is an important part of a healthy diet.

It can promote gut health, help prevent various diseases, and aid weight loss (5, 6).

One cup (91 grams) of raw broccoli provides 2.3 grams of fiber, which is about 5–10% of the Daily Value (DV) (7).

> **SUMMARY**
>
> Broccoli is low in digestible carbs but provides a decent amount of fiber, which promotes gut health and may reduce your risk of various diseases.

Protein

Proteins are the building blocks of your body, necessary for both growth and maintenance.

Broccoli is relatively high in protein, which makes up 29% of its dry weight, compared to most vegetables.

However, because of its high water content, 1 cup (91 grams) of broccoli only provides 3 grams of protein.

> **SUMMARY**
>
> Broccoli is higher in protein than most vegetables. That said, the amount of protein in each serving is relatively low.

Vitamins and minerals

Broccoli contains a variety of vitamins and minerals, including (8, 9, 10, 11, 12, 13):

- **Vitamin C.** An antioxidant, this vitamin is important for immune function and skin health. A 1/2-cup (45-gram) serving of raw broccoli provides almost 70% of the DV.
- **Vitamin K1.** Broccoli contains high amounts of vitamin K1, which is important for blood clotting and may promote bone health.
- **Folate (vitamin B9).** Particularly important for pregnant women, folate is needed for normal tissue growth and cell function.
- **Potassium.** An essential mineral, potassium is beneficial for blood pressure control and heart disease prevention.
- **Manganese.** This trace element is found in high amounts in whole grains, legumes, fruits, and vegetables.
- **Iron.** An essential mineral, iron has many important functions in your body, such as the transport of oxygen in red blood cells.

Broccoli also contains numerous other vitamins and minerals in smaller amounts. In fact, it provides a little bit of almost every nutrient you need.

> **SUMMARY**
>
> Broccoli is high in many vitamins and minerals, including folate, potassium, manganese, iron, and vitamins C and K1.

Other plant compounds

Broccoli is rich in various antioxidants and plant compounds, which contribute to its health benefits. These include (14, 15, 16, 17, 18, 19, 20):

- **Sulforaphane.** One of the most abundant and extensively studied plant compounds in broccoli, sulforaphane may protect against various types of cancer.
- **Indole-3-carbinol.** A unique nutrient found in cruciferous vegetables, this compound may help fight cancer.
- **Carotenoids.** Broccoli contains lutein, zeaxanthin, and beta carotene, which may all contribute to better eye health.
- **Kaempferol.** An antioxidant with many benefits for health, this compound may protect against heart disease, cancer, inflammation, and allergies.
- **Quercetin.** This antioxidant has numerous benefits, including lowering blood pressure in people with high levels.

> **SUMMARY**
>
> Broccoli is high in many plant compounds that have been associated with health benefits. The most abundant one is sulforaphane.

Health benefits of broccoli

Cruciferous vegetables like broccoli provide sulfur-containing compounds that are responsible for their often pungent taste (21).

These bioactive compounds may have numerous health benefits.

Cancer prevention

Cancer is characterized by the rapid growth of abnormal cells and is often linked to oxidative stress (22).

Broccoli is loaded with compounds that are believed to protect against cancer.

Observational studies suggest that the consumption of cruciferous vegetables, including broccoli, is linked to a reduced risk of many cancers, including lung, colorectal, breast, prostate, pancreatic, and gastric cancers (23, 24, 25, 26).

A unique family of plant compounds called isothiocyanates sets cruciferous vegetables apart from other veggies.

Studies suggest that Isothiocyanates affect liver enzymes, reduce oxidative stress, decrease inflammation, stimulate your immune system, and combat the development and growth of cancer (27, 28, 29).

The main isothiocyanate in broccoli, sulforaphane, acts against the formation of cancer at the molecular level by reducing oxidative stress (16, 30, 31).

Sulforaphane occurs at 20–100 times higher amounts in young broccoli sprouts than in full-grown heads of this vegetable (32).

Though broccoli supplements are also available, they may not contribute an equivalent amount of isothiocyanates and thus may not give the same health benefits as eating whole, fresh broccoli (33, 34).

Lower cholesterol levels

Cholesterol has many important functions in your body.

For example, it is a key factor in the formation of bile acids, which help you digest fat. Bile acids are formed in your liver, stored in your gallbladder, and released into your digestive system whenever you eat fat.

Afterward, the bile acids are reabsorbed into your bloodstream and used again.

Substances in broccoli bind with bile acids in your gut, increasing their excretion and preventing them from being reused (35).

This results in the synthesis of new bile acids from cholesterol, reducing total levels of this marker in your body.

This effect has been linked to a reduced risk of heart disease and cancer (2).

According to one study, steamed broccoli is particularly useful for lowering cholesterol levels (2).

Eye health

Impaired eyesight is a common consequence of aging.

Two of the main carotenoids in broccoli, lutein and zeaxanthin, are associated with a decreased risk of age-related eye disorders (36, 37).

Vitamin A deficiency may cause night blindness, which can be reversed with improved vitamin A status (38).

Broccoli contains beta carotene, which your body converts into vitamin A. This vegetable may thus boost eyesight in individuals with a low vitamin A intake.

> **SUMMARY**
>
> Broccoli's isothiocyanates may improve many risk factors for disease and reduce your risk of cancer. What's more, this vegetable may help lower cholesterol and boost eye health.

Potential downsides

Broccoli is usually well tolerated, and allergy is rare. However, some considerations are worth mentioning (39).

Thyroid problems

Broccoli is considered a goitrogen, which means that high amounts may harm the thyroid gland in sensitive individuals.

Cooking this vegetable on high heat can reduce these effects (40).

Blood thinners

Individuals taking the blood thinner warfarin should consult with their healthcare practitioner before increasing their broccoli intake because its high vitamin K1 content may interact with this medication (41).

> **SUMMARY**
>
> Broccoli is usually well tolerated. Still, it may have undesirable effects on the thyroid in some people and may interfere with blood-thinning medicine.

The bottom line

Broccoli is one of the world's most popular vegetables. It is easy to prepare and edible both raw and cooked.

It is high in many nutrients, including a family of plant compounds called isothiocyanates, which may have numerous health benefits.

It is also a decent source of fiber and higher in protein than most other vegetables.

If you're looking for a health boost, consider adding this cruciferous vegetable to your diet today.

Appendix 5. Micronutrient intake recommendation (adapted from Nordic Council of Minister 2014.)

Age mo/ years	Vit. A RE [c]	Vit. D [d] µg	Vit. E α-TE [e]	Thiamin mg	Riboflavin mg	Niacin NE [f]	Vit. B_6 mg	Folate µg	Vit. B_{12} µg	Vit. C mg
<6 mo [b]	-	-	-	-	-	-	-	-	-	-
6–11 mo	300	10	3	0.4	0.5	5	0.4	50	0.5	20
12–23 mo	300	10	4	0.5	0.6	7	0.5	60	0.6	25
2–5 y	350	10	5	0.6	0.7	9	0.7	80	0.8	30
6–9 y	400	10	6	0.9	1.1	12	1.0	130	1.3	40
Females										
10–13	600	10	7	1.0	1.2	14	1.1	200	2.0	50
14–17	700	10	8	1.2	1.4	16	1.3	300	2.0	75
18–30	700	10	8	1.1	1.3	15	1.2	400	2.0	75
31–60	700	10	8	1.1	1.2	14	1.2	300[g]	2.0	75
61–74	700	10	8	1.0	1.2	13	1.3	300	2.0	75
≥75	700	20	8	1.0	1.2	13	1.3	300	2.0	75
Pregnant	800	10	10	1.5	1.6	17	1.4	500	2.0	85
Lactating	1100	10	11	1.6	1.7	20	1.5	500	2.6	100
Males										
10–13	600	10	8	1.1	1.3	15	1.2	200	2.0	50
14–17	900	10	10	1.4	1.7	19	1.6	300	2.0	75
18–30	900	10	10	1.4	1.6	19	1.5	300	2.0	75
31–60	900	10	10	1.3	1.5	18	1.5	300	2.0	75
61–74	900	10	10	1.2	1.4	16	1.5	300	2.0	75
≥75	900	20	10	1.2	1.3	15	1.5	300	2.0	75

Age mo/ years	Calcium mg	Phosphorus mg	Potassium g	Magnesium mg	Iron [h] mg	Zinc [i] mg	Copper mg	Iodine µg	Selenium µg
<6 mo [b]	-	-	-	-	-	-	-	-	-
6–11 mo	540	420	1.1	80	8	5	0.3	50	15
12–23 mo	600	470	1.4	85	8	5	0.3	70	20
2–5 y	600	470	1.8	120	8	6	0.4	90	25
6–9 y	700	540	2.0	200	9	7	0.5	120	30
Females									
10–13	900	700	2.9	280	11	8	0.7	150	40
14–17	900	700	3.1	280	15[l]	9	0.9	150	50
18–30	800 j	600 [j]	3.1	280	15[l]	7	0.9	150	50
31–60	800	600	3.1	280	15[k]/9[l]	7	0.9	150	50
61–74	800	600	3.1	280	9	7	0.9	150	50
≥75	800	600	3.1	280	9	7	0.9	150	50
Pregnant	900	700	3.1	280	-- [m]	9	1.0	175	60
Lactating	900	900	3.1	280	15	11	1.3	200	60
Males									
10–13	900	700	3.3	280	11	11	0.7	150	40
14–17	900	700	3.5	350	11	12	0.9	150	60
18–30	800 [j]	600 [j]	3.5	350	9	9	0.9	150	60
31–60	800	600	3.5	350	9	9	0.9	150	60
61–74	800	600	3.5	350	9	9	0.9	150	60
≥75	800	600	3.5	350	9	9	0.9	150	60

[a] Refers to the consumed amount, and losses during preparation, cooking, etc. must be accounted for.

[b] Exclusive breastfeeding is the preferable source of nutrition for infants during the first six months of life. Therefore, recommendations for single nutrients are not given for infants <6 months. If breastfeeding is not possible, infant formula formulated to serve as the only food for infants should be given (see Chapter on breastfeeding). If complementary feeding has started at 4–5 months, the recommended intakes for 6–11 month old infants should be used.

[c] Retinol equivalents; 1 retinol equivalent (RE) = 1 µg retinol = 12 µg β-carotene.

[d] From 1–2 weeks of age, infants should receive 10 µg vitamin D_3 per day as a supplement. For people with little or no sun exposure, the recommended intake is 20 µg per day. This can be achieved by taking a daily supplement of 10 µg vitamin D_3 in addition to the dietary intake or by choosing foods rich in vitamin D. For the elderly ≥75 years of age, the recommended intake can be achieved by selecting foods naturally high in vitamin D and vitamin D-enriched foods in combination with a supplement if necessary.

[e] α-tocopherol equivalents; 1 α-tocopherol equivalent (α-TE) = 1 mg RRR α-tocopherol.

[f] Niacin equivalent; 1 niacin equivalent (NE) = 1 mg niacin = 60 mg tryptophan.

[g] Women of reproductive age are recommended to have an intake of 400 µg/d.

[h] The composition of the meal influences the utilization of dietary iron. The availability increases if the diet contains abundant amounts of vitamin C and meat or fish daily, and it is decreased with simultaneous intake of polyphenols or phytic acid.

[i] The utilization of zinc is negatively influenced by phytic acid and positively influenced by animal protein. The recommended intakes are valid for a mixed animal/vegetable diet. For vegetarian cereal-based diets, a 25%–30% higher intake is recommended.

[j] 18–20 year olds are recommended to consume 900 mg calcium and 700 mg phosphorus per day.

[k] Menstrual flow and its associated iron losses can vary considerably among women. This means that some women require a larger iron supply than others. At an availability of 15%, 15 mg/d will cover the requirement of 90% of women of reproductive age. Some women require more iron than the habitual diet can supply.

[l] Recommended intake for post-menopausal women is 9 mg per day.

[m] Iron balance during pregnancy requires iron stores of approximately 500 mg at the start of pregnancy. The physiological need of some women for iron cannot be satisfied during the last two thirds of pregnancy with food only, and supplemental iron is needed.

Appendix 6. The reference values of energy intakes (adapted from Nordic Council of Minister 2014.)

Age, years	Reference weight[b] kg	REE[c] MJ/d	Average PAL[d] 1.6 MJ/d	Active PAL 1.8 MJ/d
Females[f]				
18–30	64.4	5.8	9.4	10.5
31–60	63.7	5.5	8.8	9.9
61–74[e]	61.8	5.0	8.1	9.1
Males				
18–30	75.4	7.3	11.7	13.2
31–60	74.4	6.9	11.0	12.4
61–74[e]	72.1	6.1	9.7	10.9

Age	Reference weight, kg	REE MJ/d	Estimated energy requirement MJ/d
2–5 y	16.1	3.6	5.3
6–9 y	25.2	4.4	6.9
Girls			
10–13 y	38.3	5.0	8.6
14–17 y	53.5	5.7	9.8
Boys			
10–13 y	37.5	5.4	9.3
14–17 y	57.0	6.8	11.8

[a] It should be noted that these estimations have a large standard error due to inaccuracy in estimation of both REE and PAL. Therefore, the results should be used only for estimation on the group level. See chapter on Energy for more details.

[b] Reference weight corresponds to a body mass index (BMI) of 23 kg/m^2; data based on actual heights of populations in all Nordic countries.

[c] REE = Resting Energy Expenditure.

[d] PAL = Physical Activity Level.

[e] The REE for 61–74 year olds was calculated by using the equation for 61–70 year olds.

[f] During pregnancy the energy requirement increases, mainly during the second and third trimesters. An increase in energy intake of approximately 0.4, 1.4 and 2.2 MJ/d in the first, second and third trimester, respectively, is applicable for both activity levels provided that the level (1.6 or 1.8 MJ/d) is unchanged. During lactation the energy requirement increases by approximately 2–2.8 MJ/d for the reference woman provided that the level of physical activity is unchanged. For many pregnant and lactating women, the increased energy requirement is compensated for by a decreased amount of physical activity.

Appendix 7. The lower intake level and average requirement (adapted from Nordic Council of Minister 2014.)

Nutrient		Women		Men	
		LI	AR	LI	AR
Vitamin A	RE	400	500	500	600
Vitamin D	µg	2.5[a]	7.5	2.5[a]	7.5
Vitamin E	a-TE	3	5	4	6
Thiamin	mg	0.5	0.9	0.6	1.2
Riboflavin	mg	0.8	1.1	0.8	1.4
Niacin	NE	9	12	12	15
Vitamin B6	mg	0.8	1.1	1.0	1.3
Folate	µg	100	200	100	200
Vitamin B_{12}	µg	1	1.4	1	1.4
Vitamin C	mg	10	50	10	60
Calcium	mg	400	500	400	500
Phosphorus	mg	300	450	300	450
Potassium	g	1.6	-	1.6	-
Iron	mg	(5)[b, c]	10 (6)[b]	7	7
Zinc	mg	4	5	5	6
Copper	mg	0.4	0.7	0.4	0.7
Iodine	µg	70	100	70	100
Selenium	µg	20	30	20	35

a Primarily for individuals >60 years of age.
b () Refers to post-menopausal women.
c A lower limit cannot be given for women of fertile age without considering the woman's iron status as determined by clinical and biochemical methods.

Appendix 8. The upper intake level (adapted from Nordic Council of Minister 2014.)

Nutrient		UL per day
Preformed vitamin A[a]	µg	3,000[b]
Vitamin D	µg	100
Vitamin E[c]	α-TE	300
Niacin[c]		
nicotinic acid	mg	10[d]
nicotinamide	mg	900
Vitamin B_6[c]	mg	25
Folic acid[c]	µg	1,000
Vitamin C	mg	1,000
Potassium[c]	g	3.7
Calcium	mg	2,500
Phosphorus	mg	3,000
Iron	mg	25[e]
Zinc	mg	25
Copper	mg	5
Iodine	µg	600
Selenium	µg	300

a As retinol and/or retinylpalmitate.
b Intake of retinol above 3,000 µg/d in pregnant women has been associated with an increased risk of foetal malformations. The upper tolerable level might not adequately address the possible risk of bone fracture in vulnerable groups. Postmenopausal women who are at greater risk for osteoporosis and bone fractures should, therefore, restrict their intake to 1,500 µg/d.
c In the form of supplements and fortification only.
d Not applicable for pregnant and lactating women.
e 10 mg in addition to habitual dietary iron intake.

Appendix 9. List of qualified ingredients. (adapted from appendix 11)

Type	Ingredient	Nutrient	Notice	Hashtag
Meat & poultry	Chicken breast	Protein, vitamin B_6, minerals	Fat	Low-fat diet
Seafood	Sardine	Protein, unsaturated fat, calcium, vitamin D, minerals	Fat, salt, cholesterol.	Bone-healthy, vitamin-D-rich
	Perch	Protein, calcium, minerals		Low-fat diet, bone-healthy
	Shrimp	Protein, vitamin B_{12}, minerals	Cholesterol	Low-fat diet
	Oyster	Protein, vitamin D, vitamin B_{12}, minerals	Minerals (zinc, copper, selenium)	Low-fat diet, nutrient-dense
Dairy food				
Vegetable	Broccoli	Carb, fiber, vitamin A, vitamin C		Vegetarian diet, low-fat diet, fiber-rich, heart-healthy, antioxidant-dense, nutrient-dense
	Kale	Carb, fiber, vitamin A, vitamin C, vitamin K, calcium, minerals	vitamin A, vitamin C, vitamin K (easily exceed the upper limit)	Vegetarian diet, low-fat diet, fiber-rich, bone-healthy, heart-healthy, antioxidant-dense, nutrient-dense
	Brussels sprout	Carb, fiber, vitamin A, vitamin C, vitamin K, calcium	Vitamin C, vitamin K	Vegetarian diet, bone-healthy, low-fat diet, fiber-rich, pregnant-diet
	Spinach	Carb, fiber, vitamin A, vitamin C, vitamin K,	Vitamin A, vitamin K	Vegetarian diet, low-fat diet, fiber-rich, bone-healthy, heart-healthy, antioxidant-dense, nutrient-dense

	Bok choy	Carb, fiber, vitamin A, vitamin C, vitamin K		Vegetarian diet, low-fat diet, bone-healthy, heart-healthy, antioxi-dant-dense, nutrient-dense
	Sweet po-tato	Carb, fiber, vita-min A, minerals	Vitamin A (Ex-tremely high)	Vegetarian diet, low-fat diet, nutrient-dense
Legume	Tofu	Protein, fiber, cal-cium and minerals	Fat, cholesterol	Vegetarian diet, low-fat diet, fiber-rich, bone-healthy
	Pea	Carb, fiber, vita-min		Vegetarian diet, low-fat diet, fiber-rich, bone-healthy
Grain	Buckwheat bread	Carb, fiber, vita-min B complex, minerals	Fiber, minerals	Vegetarian diet, low-fat diet, heart-healthy nutrient-dense
	Quinoa	Carb, fiber, vita-min B complex, minerals		Vegetarian diet, low-fat diet, heart-healthy
Fruit	Orange	Fiber, vitamin C	Vitamin C, sugar	
	Strawberry	Fiber, vitamin A, vitamin C	Vitamin C	
	Pear	Carb, fiber, vitamin C, vitamin K	sugar	

Appendix 10. Sara's ingredient list for a new diet. (adapted from appendix 11)

Type	Ingredient	Nutrient	Notice	Hashtag
Meat & poultry	Chicken breast	Protein, vitamin B_6, minerals	Fat	
Seafood	Sardine	Protein, unsaturated fat, calcium, vitamin D, minerals	Fat, salt, cholesterol.	Bone-healthy, vitamin-D-rich
	Perch	Protein, calcium, minerals		Bone-healthy
	Shrimp	Protein, vitamin B_{12}, minerals	Cholesterol	
	Oyster	Protein, vitamin D, vitamin B_{12}, minerals	Minerals (zinc, copper, selenium)	Nutrient-dense
Dairy food				
Vegetable	Broccoli	Carb, fiber, vitamin A, vitamin C		Fiber-rich, heart-healthy, antioxidant-dense, nutrient-dense
	Kale	Carb, fiber, vitamin A, vitamin C, vitamin K, calcium, minerals	vitamin A, vitamin C, vitamin K (easily exceed the upper limit)	Fiber-rich, bone-healthy, heart-healthy, antioxidant-dense, nutrient-dense
	Brussels sprout	Carb, fiber, vitamin A, vitamin C, vitamin K, calcium	Vitamin C, vitamin K	Bone-healthy, fiber-rich
	Spinach	Carb, fiber, vitamin A, vitamin C, vitamin K,	Vitamin A, vitamin K	Fiber-rich, bone-healthy, heart-healthy, antioxidant-dense, nutrient-dense
	Bok choy	Carb, fiber, vitamin A, vitamin C, vitamin K		Bone-healthy, heart-healthy, antioxidant-dense, nutrient-dense
	Sweet potato	Carb, fiber, vitamin A, minerals	Vitamin A (Extremely high)	Nutrient-dense

Legume	Tofu	Protein, fiber, calcium and minerals	Fat, cholesterol	Fiber-rich, bone-healthy
	Pea	Carb, fiber, vitamin		Fiber-rich, bone-healthy
Grain	Buckwheat bread	Carb, fiber, vitamin B complex, minerals	Fiber, minerals	Heart-healthy nutrient-dense
	Quinoa	Carb, fiber, vitamin B complex, minerals		Heart-healthy
Fruit	Orange	Fiber, vitamin C	Vitamin C, sugar	
	Strawberry	Fiber, vitamin A, vitamin C	Vitamin C	
	Pear	Carb, fiber, vitamin C, vitamin K	sugar	

Appendix 11. The reference links

Topic	Source
Healthy ingredient	https://www.healthline.com/nutrition/14-healthiest-vegetables-on-earth#TOC_TITLE_HDR_16
Calcium-rich ingredient	https://www.webmd.com/diet/qa/what-are-good-food-sources-of-calcium
	https://www.webmd.com/food-recipes/features/10-calcium-rich-foods
	https://www.webmd.com/baby/qa/what-are-calciumrich-foods
Gluten-free ingredient	https://www.healthline.com/nutrition/gluten-free-foods#4551.-Beverages
Tofu	https://www.webmd.com/food-recipes/benefits-tofu#1
	https://www.healthline.com/nutrition/what-is-tofu#other-benefits
Chicken wing	https://www.healthline.com/nutrition/calories-in-chicken#wing
	https://www.webmd.com/diet/health-benefits-chicken#1
Sardine	https://www.healthline.com/health/food-nutrition/are-sardines-good-for-you#How-to-select-sardines
Shrimp	https://www.healthline.com/nutrition/prawns-vs-shrimp#TOC_TITLE_HDR_8
	https://www.healthline.com/nutrition/is-shrimp-healthy#TOC_TITLE_HDR_2
Oyster	https://www.healthline.com/nutrition/oysters#risks
Broccoli	https://www.healthline.com/nutrition/foods/broccoli#nutrients
	https://www.webmd.com/food-recipes/features/betting-on-broccoli#2
Kale	https://www.webmd.com/diet/health-benefits-kale#1
	https://www.healthline.com/nutrition/10-proven-benefits-of-kale#TOC_TITLE_HDR_2
Brussel sprout	https://www.healthline.com/nutrition/benefits-of-brussels-sprouts
Spinach	https://www.healthline.com/nutrition/foods/spinach#vitamins-and-minerals
	https://www.webmd.com/diet/health-benefits-spinach#1
	https://nutritiondata.self.com/facts/vegetables-and-vegetable-products/2626/2
Bok choy	https://www.medicalnewstoday.com/articles/280948#diet
	https://www.webmd.com/diet/health-benefits-bok-choy#1

Sweet potato	https://www.healthline.com/nutrition/sweet-potato-benefits#TOC_TITLE_HDR_3
	https://nutritiondata.self.com/facts/vegetables-and-vegetable-products/2666/2
Buck wheat	https://www.webmd.com/diet/health-benefits-buckwheat#1
	https://www.healthline.com/nutrition/foods/buckwheat#vitamins-and-minerals
	https://nutritiondata.self.com/facts/cereal-grains-and-pasta/5681/2
Quinoa	https://nutritiondata.self.com/facts/cereal-grains-and-pasta/10352/2
	https://www.healthline.com/nutrition/11-proven-benefits-of-quinoa#TOC_TITLE_HDR_2
	https://www.healthline.com/nutrition/foods/quinoa#vitamins-and-minerals
	https://www.webmd.com/diet/health-benefits-quinoa#1
Orange	https://www.healthline.com/nutrition/foods/oranges#vitamins-and-minerals
	https://nutritiondata.self.com/facts/fruits-and-fruit-juices/1968/2
Strawberry	https://www.webmd.com/diet/health-benefits-strawberry#1
	https://www.healthline.com/nutrition/foods/strawberries
	https://nutritiondata.self.com/facts/fruits-and-fruit-juices/2064/2
Pear	https://www.healthline.com/nutrition/benefits-of-pears#TOC_TITLE_HDR_2
	https://nutritiondata.self.com/facts/fruits-and-fruit-juices/2005/2
Green pea	https://www.healthline.com/nutrition/green-peas-are-healthy#TOC_TITLE_HDR_3

Appendix 12. Sara's eating schedule on the week holiday.

Date	Menu		
	Breakfast	**Lunch**	**Dinner**
Monday	Oat porridge: Oat, milk, and butter.	Meat ball: beef, egg, wheat flour. Pepper sauce: cream, red wine sauce, butter, pepper. Mashed potato: potato, milk, butter. Bread with butter.	Pizza: Mozzarella cheese, wheat flour, tomato sauce, tomato, rucola. Coke.
Tuesday	Sandwich: Ham, butter, tomato slice.	Chicken nugget. Roasted potato with olive oil and rosemary. Fried red onion.	French fries. Half of roasted whole chicken.
Wednesday	Oat porridge: Oat, milk, and butter.	Hamburger: Beef, pickle red onion, salad, tomato, may-onnaise and parmesan cheese. Coke.	Mashed potato: potato, milk, butter. Half of roasted whole chicken.
Thursday	Skip.	Soup: carrot, potato and beef minced meat.	Pasta: bacon, cream, pasta noodle. Salad: tomato, cucum-ber, iceberg lettuce, and ready-made dressing bottle.
Friday	Scrambled egg.	Pasta: bacon, cream, pasta noodle.	Deep-fried chicken wing. French fries.

	Bread with cheese and tomato.	Soup: carrot, potato and beef minced meat.	Salad: tomato, cucumber, iceberg lettuce, and ready-made dressing bottle.
Saturday	Skip	Pasta: tomato sauce, beef minced meat, pasta noddle.	Pizza: pepperoni, tomato sauce, rucola, mozzarella cheese.
Sunday	Sandwich: Ham, butter, tomato slice.	Pizza: pepperoni, tomato sauce, rucola, mozzarella cheese.	Beef stew: beef chunk, carrot, onion, potato Rice