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REVIEW ARTICLE

The Relationship among Lipids and Human Health

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ABSTRACT

Fats are an important basic nutrient that participates in the structure of the human body and enables it to perform its vital activities. Fats can be taken into the body with many different foods. Since the oils taken from different nutrients contain fatty acids in different concentrations and properties, their effects on health are also different. In particular, the effects of saturated fats and unsaturated fats, which follow different paths in the body, on health are a subject that is frequently emphasized. In addition, the health effects of trans-fats, whose consumption has increased in recent years, are also discussed. The effects of saturated fats on serum cholesterol levels, the effects of unsaturated fats on brain development, and the relationship between fat consumption and obesity have been studied for years. It is known that unsaturated fatty acids, especially omega-3 fatty acids, are more beneficial for heart health, brain development and mental diseases, whereas some saturated fatty acids affect body systems negatively by raising serum cholesterol and causing inflammation in various ways. On the other hand, while the consumption of trans-fatty acids continues to increase, various harmful effects are also emerging. The negative effects of trans-fatty acids are on heart health, and the need for arachidonic acid, an essential fatty acid are increased. In this review study, the relationship of fatty acids with health has been examined from many different perspectives and includes information on the effects of fatty acids on heart and brain health, their relationship with obesity and insulin resistance, and their effects on longevity.

Keywords: *Fatty acids, Trans-fatty acids, Omega-3 fatty acids*

INTRODUCTION

The World Health Organization (WHO) has defined health not only as the absence of disease and infirmity, but as a state of complete physical, mental and social well-being (1). Nutrition, on the other hand, has been defined as the ability of a person to take and use the elements necessary for growth, development, and a healthy and productive life (2). Economic, social and cultural conditions such as geographical location, climate, education, population structure, internal and external migrations, industrialization, and mass media are the factors that affect the nutritional routine and habits of the individual and society. Along with genetic and environmental factors, these changes in nutrition affect human health (3). Nutrition is not just an action to suppress the feeling of hunger. Nutrition should be done consciously in order to get the nutrients by the body in sufficient and at the right time in

order to protect, improve health and increase its quality. The human body needs about 50 nutrients for its life, and in order for a person to have a healthy life, he needs to take all of these elements in certain amounts daily. It is stated that when these elements are not taken or provided more or less than necessary, growth and development are impaired and health cannot be sustained. Adequate and balanced nutrition is defined as adequate intake of each of the energy and nutrients required for the growth, renewal and functioning of the body and their proper use in the body. Plant and animal tissues that are edible and that provide the necessary nutrients when eaten are called nutrients. Nutrients in the composition of foods that are needed by humans can be grouped into 6 groups according to their structures and their effectiveness in body work. These are proteins, fats, carbohydrates, minerals, vitamins and water (2). In this study, it was aimed to examine the different effects of saturated and unsaturated fatty acids and trans-fatty acids in addition to the health effects of fats, which have an important place in our diet. In this context, lipids and their classification will be described and then their consumption including effects on human health will be discussed according to scientific literature findings.

LIPIDS AND THEIR CLASSIFICATION

Some organic substances with fatty acids in their structures and another group of substances associated with them are called lipids. Lipids are slightly soluble in water, but are readily soluble in non-polar solvents such as ether, benzene, and chloroform. Lipids can be divided into three classes: simple, compound and derivative lipids (4). Generally, acylglycerols (triglycerides or neutral oils) and waxes are called simple lipids. Lipids containing substances such as sugar, sphingosine, sulfate, and phosphate are called lipid compounds. Derivative lipids are substances in the structure of lipids such as sterols, fatty acids, mono and di-glycerides. Today, however, lipids are generally classified as fatty acids, neutral oils, waxes, phospholipids formed as a result of the combination of fatty acids with phosphoric acid, sphingolipids and glycolipids, which are the compounds made by fatty acids with sphingosine, terpenes, and finally steroids, cholesterol, bile acids.

Fatty acids

Regardless of their origin, the common building block in all oil types is glycerin. Therefore, the physiological, chemical and physical properties of oils are determined by the type and amount of fatty acids in their structure (5). Physiological, chemical and physical properties of fatty acids varies depending on the degree of saturation and unsaturation depending on the double bond it contains, and the positions of the hydrogens attached to the carbon atoms. It is possible to divide fatty acids into two basic groups as saturated fatty acids and unsaturated fatty acids.

Saturated Fatty Acids

Saturated fatty acids are fatty acids that do not have double bonds between carbons in their chains (5). All of the carbon bonds are saturated with hydrogen, making their structure very stable. The only functional group it contains is the carboxyl group and it does not contain any other functional groups, so it is the least chemically reactive fatty acid among fatty acids. Saturated fatty acids with up to ten carbons in their chains are liquid and volatile at room temperature, but in general, saturated fats are usually solid at room temperature. Palmitic, stearic, and myristic acid are some saturated fats commonly found in foods (5). The human body can synthesize saturated fatty acids, so even if they are not taken with diet, they are also synthesized with molecules formed by carbohydrate metabolism (6). Foods that contain high amounts of saturated fat are dairy products, fatty meats, palm oil, coconut oil, and some processed products (7).

Unsaturated Fatty Acids

Fatty acids containing one or more double bonds between carbons on the chain are called unsaturated fatty acids. Unsaturated

fatty acids with one double bond are called monounsaturated fatty acids (MUFA), while those with two or more double bonds are called polyunsaturated fatty acids (PUFA). The position of the double bond relative to the omega end allows PUFAs to be named omega-3 or omega-6. The monounsaturated fatty acid found in foods is usually oleic acid, while the commonly found polyunsaturated fatty acid is linoleic acid. Most fatty acids can be synthesized in the body, but there are two fatty acids that humans lack the necessary enzymes to produce. These are called essential fatty acids and must be obtained from the diet. These fatty acids are alpha linolenic acid (ALA), an omega-3 PUFA, and linoleic acid, an omega-6 PUFA (5,8,9). The reason why linoleic and linolenic acids cannot be synthesized is that humans and animals cannot form a double bond between the methyl group of omega-1 and the carbon atom of omega-7 (10). Unsaturated fatty acids are generally liquid at room temperature (5). However, MUFAs have a higher melting point than PUFAs, so MUFAs can also exist in semi-solid or solid form when cooled (11). It is stated that unsaturated fatty acids are found in high levels in vegetable oils such as hazelnut, olive oil, corn, canola, sunflower, soybean oil, and especially in fish such as salmon, mackerel and tuna living in cold waters (5). Mammals obtain docosahexaenoic acid (DHA) and intermediates between ALA and DHA, including eicosapentaenoic acid (EPA). Synthesis of DHA and EPA can occur in animals and plankton, but not in plants. The richest sources of DHA and EPA are fish and seafood. The main dietary sources of ALA are soybean, canola, flaxseed oils and some salmons, but these sources are not consistently consumed (12).

Trans-Fatty Acids

Trans-fatty acids are PUFAs or MUFAs that contain one or more double bonds in the *trans* configuration. Fats from ruminant animal products are all found naturally because they are produced by bacteria found in the intestines of ruminant animals to metabolize PUFAs (13). In an oxygen-free environment, the formation of trans-fatty acids is called biohydrogenation, when bacteria use the double bonds in fatty acids as an acceptor for the hydrogen produced during metabolism (14). However, the most common trans-fatty acids in the human diet are industrially produced trans-fatty acids. Industrial trans-fatty acids are produced by partial hydrogenation of vegetable oils or fish oil and are used in the production of various food products (13). Hydrogenation raises the melting point so that oils in liquid form are transformed into solid or semi-solid forms. Margarines and shorts are produced by using liquid oils containing abundant unsaturated fatty acids such as soybean oil and safflower oil by hydrogenation. It has been reported that the ratio of trans-fatty acids in hydrogenated oils can reach up to 34.9% (8). However, they are not the only dietary sources of trans-fatty acids. Industrial trans-fatty acids are also used in the production of biscuits, cookies, cakes, mayonnaise, puff pastry, chips, wafers, pizza and many similar products, and in fast food products produced for deep-fried products. The contents of fatty acids and trans-fatty acids vary (14). The reason for the use of industrial trans-fatty acids in food production is to take advantage of the advantages such as providing better texture, better taste and extended shelf life to the food (15). In addition, in studies conducted in recent years, researchers have determined that trans-fatty acids are formed after the deodorization/steam distillation stages, where high temperature is applied to vegetable oils during their refining. However, trans isomers in refined oils and isomers in partially hydrogenated oils differ in type and amount (14).

LIPID CONSUMPTION AND REQUIREMENTS FROM PAST TO PRESENT

It is difficult to specify the daily lipid requirement of the human body. Depending on the nature of the diet, 20-45% of the daily consumed energy can come from fat. Most of the lipid taken into the body is invisible lipid which is in the composition of food, and the

remaining half is pure, they are visible lipids (16). WHO recommends less than 1% of daily energy intake for trans-fatty acids (17). In studies, unbalanced intake of lipid in terms of quality and quantity has been found to be associated with many degenerative pathologies such as cardiovascular disease, diabetes, and cancer (11). Current recommendations on lipid consumption are that calories from fat should not exceed 25-35% of daily calories, these calories should be mostly from PUFA and MUFA, and calories from saturated fat should not exceed 10% of daily calories (11). The ratio of omega-6 and omega-3 fatty acids in the body (n-6/n-3) is important. The ideal n-6/n-3 ratio that should be present in foods in nutrition is between 5:1 and 10:1 (5). However over the past century, the n-6: n-3 ratio of the early hunter-gatherer diet was between 2:1 and 3:1. The typical Western diet has undergone fundamental changes with the extreme increase in the use of refined vegetable oil whereas omega-3 PUFAs from fish, wild game, nuts, seeds, and green leafy vegetables have been replaced by omega-6 sources (18). In the study of heart disease and risk factors in Turkish adults, it was observed that the part of daily energy taken from lipid increased by 8% compared to previous data (3). The increase in lipid consumption has been attributed to the increased consumption of fast food and fried foods in recent years.

FUNCTIONS OF LIPIDS IN THE BODY

Fats are an essential nutrient for us to lead a healthy life. First of all, it is an important source of nutrients and calories. One gram of fat provides 9 calories. Fats perform many functions in the body. For example, it helps the transport and absorption of fat-soluble vitamins (A, E, D, and K) and nutrients, and ensures the intake of essential fatty acids into the body. It helps keep blood lipids under control (16). An average of 18% of an adult human body is made up of fat. Since it is stored in the body, it acts as an energy store. Fats leave the stomach slowly, thus delaying hunger (2).

EFFECTS OF LIPIDS ON HEALTH

Dietary Lipid Intakes and Heart Health

Coronary heart disease constitutes an important part of the causes of death in the world and in our country. Coronary heart disease occurs due to atherosclerosis. Atherosclerosis is characterized by endothelial dysfunction associated with factors such as hypertension, diabetes, smoking and elevated homocysteine. Atherosclerosis increases as a result of elevated low-density lipoprotein (LDL), low-high-density lipoprotein (HDL), elevated lipoprotein (a) and remnant proteins. Cholesterol accumulates in macrophages and smooth muscle cells in the wall. Soft muscle proliferation, inflammation and calcification accompany this process. With the thrombosis that occurs with the increase of the fibrinogen concentration, the vessel is completely occluded (19). It is known that different dietary fatty acids affect cholesterol levels and serum lipid levels differently. The plasma lipid levels of people and the incidence of coronary heart diseases and atherosclerosis are also interrelated (10). LDL and atherosclerosis are directly related to each other. It is involved in the transport of cholesterol from the liver to the tissues as LDLs (approximately 60-70% of cholesterol), which are the main carriers of cholesterol. It is known that LDL cholesterol prevents the removal of waste materials and carbon dioxide from the tissues, as it provides the transport of nutrients and oxygen to the tissues by covering the vessels (20).

The relationship between atherosclerosis and dietary lipid and cholesterol has been demonstrated in numerous animal experiments, but the relationship between dietary components and atherosclerosis has not yet been reported in a population-based study in humans. However, the association of dietary fat and cholesterol with atherosclerosis was assessed by a food consumption frequency questionnaire in the Atherosclerosis Risk in Communities Study (ARIC) between 1987 and 1989. When the results were examined by measuring the wall

thickness after adjusting for age and energy intake, it was observed that high consumption of animal fat, saturated fatty acids, monounsaturated fatty acids and cholesterol increased the vessel wall thickness, and consumption of vegetable oil and polyunsaturated fatty acids decreased the vessel wall thickness (21). In 1980, a cohort study of the association of saturated fats with coronary heart disease risk was conducted among 80 082 women aged 34-54. In this study, the intake sources of saturated fatty acids were examined. Comparisons were also made with chicken, fish, and low-fat milk to study red meat and dairy products, which are the main sources of saturated fatty acids, and the risk of coronary heart disease. Full-fat dairy products and red meat were associated with higher risk, while chicken, fish and low-fat dairy products were associated with lower risk. The risk of coronary heart disease was negligibly low with skim milk (22). An intensive multifactorial study lasting 4 years examined whether multiple factors could increase coronary artery lesions. When many factors such as blood cholesterol levels, exercise capacity, body weight and dietary lipid and cholesterol intakes were examined, it was seen that the main factor affecting coronary artery lesions was the ratio of dietary lipid to total calorie intake. The probability of lesion development was found to be 39% when 40% lipid was consumed in the diet, whereas 19% was when there are 20% lipid consumption (23). However, in a cohort study conducted with individuals aged 45-84 between 2000 and 2010, a high intake of saturated fatty acids in dairy products was associated with a lower risk of cardiovascular disease, and a high intake of saturated fatty acids in meat was associated with a higher risk of cardiovascular disease. In this study, it was stated that the risk is not only saturated fat, but also accompanying factors and different fatty acid sources should be examined (24). However, it should not be forgotten that cholesterol is an important molecule for human health because it regulates structural properties such as cell membrane fluidity, permeability, integrity and stability. It also acts as a signal molecule and is needed because it enables the synthesis of molecules such as vitamin D and steroid hormones, which are important for our body (20). In addition, low HDL cholesterol also poses a risk for cardiovascular diseases. HDL protects from atherosclerosis and prevents plaque formation by transporting cholesterol in the blood to the liver. Considering this information, it can be concluded that cholesterol sources should be taken at a certain level. When the differences between saturated and unsaturated fatty acids are examined, it is seen that they have different effects on LDL and HDL and total cholesterol (25). The reason for this is explained as their different effects on Cholesteryl Acyltransferase (ACAT), which causes cholesterol to be esterified and stored, and Sterol Regulatory Element Binding Proteins (SREBP)-2 proteins, which regulate cholesterol levels in the cell (25, 26). For example, palmitic acid partially reduces ACAT release, while oleic acid has the opposite effect. A three-week experiment was conducted with oleic acid, an unsaturated fatty acid, and palmitic acid, a saturated fatty acid (26). In this experiment, 16 adult individuals were given high palmitic acid, high oleic acid and low palmitic acid and the differences were examined. As a result of the experiment, high oleic acid diet decreased serum LDL levels and LDL/HDL levels. In addition, the total cholesterol level in the high palmitic acid diet was found to be 13% higher than the diet containing high oleic acid. Replacing saturated lipids with polyunsaturated lipids in the diet has been shown to reduce total cholesterol and LDL cholesterol by reducing LDL cholesterol production or increasing its clearance (27). It is also said that this situation increases the HDL/LDL ratio and decreases the total cholesterol/HDL ratio. Replacing saturated lipids with monounsaturated lipids has also been associated with reduced total LDL and HDL, but the change is less than for polyunsaturated lipids. Randomized controlled studies have shown that replacing 5% of the energy taken from saturated lipid

with energy intake from polyunsaturated lipid causes a 10% decrease in cardiovascular disease events (28). In addition, a study was conducted to investigate the effects of MUFA, oleic acid, and PUFA, linoleic acid, on the levels of plasma lipids and lipoproteins, it was found that two unsaturated lipids had almost the same effect on lowering plasma total cholesterol and LDL cholesterol (29). Omega-3 has been shown to be involved in many mechanisms that protect heart health. Omega-3 fatty acids have an anti-inflammatory, antiarrhythmic and antithrombotic properties. Omega-3 fatty acids are thought to stabilize electrical activity in cardiac myocytes by inhibiting sarcolemma ion channels and providing a prolonged relative refractory period. For example, EPA has been shown to provide thrombotic benefits by inhibiting the synthesis of Thromboxane A2, which causes platelet aggression and vasoconstriction. Reduction in fibrinogen and increase in tissue plasminogen activator are some of the other reported antithrombotic effects (30). Since the vasodilator effect of nitrous oxide is increased by EPA, omega-3 fatty acids also positively affect endothelial function. In a study conducted with patients who survived myocardial infarction in less than 3 months, omega-3 supplementation was found to be beneficial in treatment (31). When many randomized clinical studies and epidemiological studies on the Mediterranean diet, where most of the total lipid intake was met with MUFA, the Mediterranean diet was found to be protective for diseases. The MUFA range in the Mediterranean diet varies between 16% and 29%, and 60-80% of oleic acid is met from olive oil (11).

Dietary Lipid Intakes and Obesity

Obesity is a chronic disease characterized by excess lipid storage in the body due to excess energy intake from food (32). In obese individuals, body fat mass increased compared to lean body mass. Obesity is an extremely important and complex health problem that can cause many disorders and even death in all organs and systems of the body, starting with the cardiovascular and endocrine systems. WHO recognizes obesity as one of the ten riskiest diseases (33). It has also been stated by WHO that it is closely related to cancer. The prevalence of obesity continues to increase in many countries. It constitutes an epidemic situation, especially in countries that maintain western lifestyles and habits. Studies support the existence of a genetic component in the obesity epidemic, and the role of environmental factors is also accepted. Nutrition is an important component of these environmental factors. Nutrition is an important component of these environmental factors. Some publications have stated that high-fat diets can lead to obesity (32-34). This is because oil is a calorie-dense macro component. However, the metabolic pathways followed by different fatty acids in the body are also different. The different Carbon numbers and configurations they contain can also have different effects on weight gain. Because their effects on different enzymes involved in fatty acid metabolism are different. Examples of these are SREBP proteins which have functions such as providing the expression of genes involved in fatty acid biosynthesis, regulating cholesterol metabolism, and they have lipogenic effects (34). *In vitro* and *in vivo* studies have shown that the effects of saturated fatty acids (SFA), PUFA and MUFA on these proteins are different. While it was observed that PUFA suppressed the expression of genes that provide lipogenic activity by reducing the expression of SREBP, such an effect was not found in MUFA and SFA (34, 35). Another protein effective in lipid metabolism is the peroxisome proliferator-activated receptors (PPAR) alpha and beta proteins. PPARs regulate fatty acid and carbohydrate metabolism as they are powerful transcription elements and dietary lipid sensors (36). Anti-inflammatory effects of PPARs have also been observed in studies on cells involved in atherosclerotic lesions. In experiments with obese and diabetic animals, PPAR beta and delta isoforms were found to increase HDL-cholesterol, but decrease

triglycerides, fasting insulin, fat stores, and LDL. It is known that when PPARs are activated, it reduces fat storage and suppress the development of obesity. Studies have shown that PUFA is better than MUFA and SFA in activating PPAR proteins (34,36). As a result of some studies, it has been determined that high dietary fat intake has a positive relationship with Body Mass Index (BMI) (37-39). A cross-sectional study was conducted in Samsun city center and it was studied on a total of 420 people, 210 women and 210 men over the age of 20 (37). In terms of daily consumed nutrients, it was observed that the obese received statistically significantly higher amounts of energy, total fat and finally saturated fatty acids than the non-obese.

While a relationship was found between BMI and total fat, SFA and PUFA intake per day, no correlation was found between BMI and daily intake of MUFA, cholesterol, vitamins A, C and E, and dietary fiber. In an experiment with mice, no significant change was found in body fat gain between mice that received high saturated fat, omega-3, omega-6 diets, and low-fat diets in the first week. In contrast, mice fed omega-3 rich diets at week 4 had significantly lower body weight compared to the other 3 groups (38). A 4-week experiment showed that a diet low in fat instead of saturated lipid did not significantly reduce body fat whereas a diet high in omega-3 instead of saturated lipid did significantly reduce it. As a result of these experiments, it can be concluded that there is a positive correlation between diets containing high amounts of total fat, saturated fat and high BMI. Therefore, high obesity prevalence and the opposite is observed when omega-3 fatty acids are examined. However, there are still conflicting studies on this subject as animal experiments with different fatty acid types as well as in human and animal experiments with fish oil (39). Various results were found regarding the negative or positive effect on weight gain.

Dietary Intake of Lipids Effect on Brain Development and Health

The fatty acid composition of the human brain is affected by dietary fatty acids. The human brain contains a high percentage of lipids, which can reach 60% of its dry weight. PUFA constitutes 35% of the phospholipids of this oil composition, which consists mostly of phospholipids (40).

Phospholipids and cholesterol are the main components of the cell membrane. These lipids affect membrane function and are sensitive to dietary effects, as their composition changes membrane fluidity and interacts with membrane proteins. The most abundant fatty acids in the brain cell membrane are arachidonic acid (AA) (20:4n-6), adrenic acid (22:4n-6) and docosahexaenoic acid (22:6n-3). In the human body, fatty acids are collected in the testes, placenta, and eyes, apart from the brain. Accordingly, the intake of long-chain polyunsaturated fatty acids can directly affect mood and behavior (41, 42).

An adult human brain consumes 17.8 mg of AA and 4.6 mg of DHA per day. If there is insufficient amount of DHA in the diet, the DHA need of the brain can be met by the liver by synthesizing DHA from alpha linolenic acid, if adequate alpha linolenic acid is provided with the diet (43). Regular and adequate intake of DHA and AA should be provided for brain development until late adolescence and for the central nervous system to function properly throughout life (9). Adequate nutrition is important because the foundations of cognitive, motor and socio-emotional skills are laid during pregnancy and infancy. Essential fatty acids are important for healthy brain development (44). In an experiment, mothers were given 10 ml fish oil supplement (1183 mg/10 ml DHA, 803 mg/10mL EPA) and some corn oil (4747 mg/10mL linoleic acid, 92 mg/10mL

α-linolenic acid) starting from the 18th month of pregnancy.) was supplemented.

The process was continued during the first three months of lactation after birth. When the intelligence scores of the children at the age of 4 were examined, it was seen that the children of mothers who took fish oil supplements were higher than those who took corn oil (45). In a randomized study with 44 mature infants, 2 infants and one group from birth to 4 infants were taught long-chain PUFA-enriched formula, while undistributed formula was given to all (46).

Children who came 10th were evaluated because they did not cause any problems. This is because they have overall improved problem abilities with fortified formula. Studies draw attention to the fact that DHA inhibits the formation and apoptosis of oxidative stress-induced pro-inflammatory genes in the brain and retina. Recent studies have shown that DHA has free radical scavenging properties. It protects lipids and proteins in the brain from pro-oxidative damage by reducing neuronal loss and cognitive-locomotor deficits (12). Dietary EPA and DHA may alter the risk of developing certain degenerative or neuropsychiatric disorders in the body. Studies have found a relationship between decreased blood concentrations of omega-3 fatty acids and increased Alzheimer's disease, schizophrenia, and depression (9). In conclusion, the role of omega-3 fatty acids in brain development and healthy brain aging is an area of intense scientific research and is extremely important in terms of public health. A better understanding of omega-3 fatty acid requirements is needed to support optimal brain development and function (12). In addition, various studies have been conducted on serum cholesterol and psychological health. In this context, it has been concluded that it is related. In a meta-analysis, interventions to reduce serum cholesterol tended to decrease the rate of deaths from cardiovascular disease, while there was a significant increase in deaths from accidents, suicides, or violence (42). To explain the relationship between cholesterol and psychology, it has been suggested that low cholesterol levels cause changes in cell membrane composition and fluidity and decrease serotonin transmission.

Relationship between Dietary Lipids and Diabetes Mellitus, Insulin Resistance, Inflammation Including Non-Alcoholic Liver Disease

Diabetes Mellitus (DM) is a metabolic disease with a group of chronic complications characterized by hyperglycemia resulting from impaired insulin secretion or use. In the long term, chronic hyperglycemia damages many organs, including the kidneys, eyes, heart, nerves and vessels, and even causes them to lose their function. Many pathogenic processes are responsible for the development of diabetes. Type-1 diabetes occurs as a result of the failure of insulin secretion as a result of the destruction of the beta cells of the pancreas, and type-2 diabetes occurs as a result of insufficient secretion of insulin or insulin resistance (47). DM is a very common disease with a worldwide prevalence of 9%. Diabetes type-2 diabetes is more common than diabetes types, and 90% of diabetes patients have type-2 diabetes (48).

In conclusion, it was observed that there was no relationship between total fat intake and the incidence of type-2 diabetes. However, when fats or fatty acids were examined specifically, significant associations with type-2 diabetes were observed. In particular, the incidence of type-2 diabetes was inversely correlated with high vegetable oil intake. For this reason, it is said that a diet containing vegetable oil rather than animal fat may be more beneficial in preventing type-2 diabetes (48). Current dietary guidelines recommend the use of low total fat, animal fat and high vegetable oil to prevent type 2 diabetes. In addition, it is

recommended to reduce the consumption of monounsaturated fatty acids, polyunsaturated fatty acids, and especially omega-3 fatty acids, as well as saturated fatty acids and trans fatty acids.

While insulin resistance is defined as the decrease in the response of peripheral tissues to insulin, the role of inflammatory reactions in the formation of insulin resistance and type-2 DM has been studied and found to be related. It is known that insulin resistance is a chronic inflammatory disease and inflammation has an important effect on the formation of insulin resistance. Diet affects insulin sensitivity and inflammation (49).

Inflammation is a response to tissue damage to protect the tissue from further damage. While it is a desirable situation under normal conditions, if the response is exaggerated, misdirected or prolonged, it may lead to further tissue damage (9). In experiments, it has been shown that oils and different fatty acid types have different effects on inflammation markers in the blood (50). For example, in an experiment designed with trans fat, stearic acid, trans fat+stearic acid and saturated fats with 12-16 carbons, fibrinogen concentrations were found to be 4.4% higher after feeding a diet rich in stearic acid when a carbohydrate diet was compared with stearic acid. Long chain omega-3 PUFA reduce the production of inflammatory mediators and the secretion of adhesion molecules (eicosanoids, cytokines and reactive oxygen species). It also increases Resolvins, one of the anti-inflammatory mediators (51). For these reasons, it can be said that they are anti-inflammatory agents for long-chain PUFAs. Therefore, it is thought that it can be used as a therapeutic agent in inflammation.

The feature that causes dietary lipid intake to affect insulin activity is largely the type of fatty acid. Mono and polyunsaturated fatty acids are less harmful to insulin resistance, but consistently high consumption of saturated fatty acids is associated with insulin resistance (52). Overloading of adipocytes with SFA causes accumulation of diacylglycerol. This activates Protein Kinase C and renders adipocytes insensitive to insulin. Protein Kinase-C activates Kappa Beta Kinase-1 (IKK) and Jun-Terminal Kinase (JNK) pathways (7). This pathway stimulates the production and secretion of proinflammatory cytokines. In addition, excessive intake of saturated fats causes ceramide accumulation in adipose tissue, which has been reported to activate IKK and JNK. Accelerated beta-oxidation of saturated fats causes excessive electron flow in mitochondria and causes excessive reactive oxygen production, which has been reported to cause insulin resistance and inflammatory response in adipocytes. Saturated fats activate Toll Like Receptor-4 (TLR-4) on the surface of adipocytes, which in turn activates the IKK pathway and JNK pathway. Thus, SFAs that are both transported to adipocytes and bound to TLR-4 impair insulin signaling and stimulate the secretion of proinflammatory factors in adipocytes. Cellular dysfunction of adipocytes in white adipose tissue due to overload of saturated fats is termed lipotoxicity. This is a chronic low-grade inflammation of white adipose tissue, but it not only impairs insulin signaling in white adipose tissue, but also affects insulin signaling in distant tissues, resulting in insulin resistance throughout the body. Lipotoxicity induced by saturated fats is one of the underlying pathophysiological factors in the formation of obesity and type-2 diabetes.

In an experimental study, three different diets were applied to obese individuals without diabetes and the results were examined (53). The diets were designed as MUFA diet with mean fat and 20% MUFA, low fat diet and control diet with mean fat and 15% saturated lipid. After 6 months, MUFA diet reduced fasting glucose, insulin value and insulin resistance score. The control diet high in

saturated lipid increased the insulin resistance value by 1.4% compared to the MUFA diet. As a result of the experiment, it was concluded that the diet rich in monounsaturated lipid is more beneficial in controlling glucose homeostasis than the classical Western diet rich in saturated lipid.

Non-alcoholic liver disease is a disease characterized by increased intrahepatic triglyceride production and predisposes to type-2 diabetes and cardiovascular diseases. In the experiment designed to examine intrahepatic glyceride production and dietary factors, saturated fats, unsaturated fats and simple sugars were studied (54). Participants were given an extra 1000 calories of saturated fat or unsaturated or simple sugar for 3 weeks. As a result, the intrahepatic triglyceride levels of the participants given extra saturated fat increased by 55%, while those given unsaturated fat increased by 15%. The addition of saturated fat increased lipolysis, while unsaturated fat decreased it. In addition, saturated fat has been shown to significantly increase insulin resistance and endotoxemia, and multiple plasma ceramides.

Dietary Intake of Lipids Effect on the Quality of Life and Survival

In a study conducted with rats for 27 months to examine the effects of fats and lifespan, a group of rats was fed a high-saturated fat diet, while the control group was fed a high-carbohydrate diet (55). The content of the high saturated fat diet is adjusted to contain 60% fat; 45% of the fat is composed of lard and 15% is soybean. Also, 15% of the high-carbohydrate diet given to the control group consists of fat and all is soybean oil. As a result of the experiment, half of the mice on the high-fat diet developed obesity, while the other half showed resistance to obesity. However, when the mice were 15 months old, there was a difference in the life cycle of the mice in the fatty diet and the control group. While no difference was observed between those who developed obesity or those who showed resistance, the survival rate was reported as 75% in the control group, while 40% of the mice fed high saturated fat survived. Although different states of weight gain or glucose tolerance were observed in the high-fat group, the memory task performance or mortality curves were similar. The mechanism of why high-fat diet increases mortality is not known exactly, but it can be estimated as increased reactive oxygen production and oxidative stress in the organism with high saturated fat intake for 27 months. These may be the main sources of aging and neurodegeneration. Reactive oxygen species and other oxidants, which increase with age, play an important role in the pathogenesis of degenerative diseases such as Alzheimer's disease and atherosclerosis, as well as in conditions that are the result of the aging process such as tissue atrophy (56).

Omega fatty acids have many functions such as strengthening the immune system, preventing coronary heart diseases, and providing brain development. It is said that when taken insufficiently, people may experience growth retardation, arthritis, some skin diseases such as dry skin, asthma, diabetes and some types of cancer, in addition to learning deficits. Omega-3 fatty acids are involved in the synthesis of prostaglandins, which are hormone-like substances. They are responsible for regulating pain, swelling, inflammation and blood pressure in the body. The reason for this is that prostaglandins have important effects on the regulation of kidneys, heart, digestive system organs and body temperature. They are also important for blood coagulation, allergic reactions and the synthesis of many hormones (10). Omega-6 fatty acids are important for healthy skin. They makes the skin smooth and flexible, protects the skin from wounds and inflammations, and contributes to the regulation of body temperature and water loss. Various skin problems and disorders such as eczema can be seen in omega-6 deficiency (16). Studies on the therapeutic properties of omega-3 fatty acids EPA and DHA, which are dominant in fish and all

seafood, are still the subject of research. However, these fatty acids, which are important in many respects, have been found to have important effects on the prevention of many diseases such as cardiovascular diseases, heart attacks, rheumatoid arthritis, migraine-induced headaches, high cholesterol and blood pressure, diabetes, depression, some types of allergies, and cancer (41). It is stated that a diet rich in fish oil reduces the risk of death from heart attack. Because the decrease in the efficiency of platelets or disruption of heart rhythm due to vascular occlusion are the most important causes of death as a result of heart attack. Essential fatty acids have natural blood-thinning properties and can prevent blood clotting, which can lead to a heart attack (10). As a result of the experiment conducted in patients whose diet omega-3 consumption was increased by feeding with foods high in omega-3 content the risk of death due to heart diseases was reduced by 95% (41). Further, sudden deaths were observed in the control group whose PUFA amount was not increased. DHA, an omega-3 fatty acid, contributes to the regeneration of cells in the human brain and ensures the proliferation of retinal cells and brain cells. Diseases such as vision disorders, memory loss, depression, and schizophrenia occur when the decreasing intake for DHA levels in nerve cells. When prostate cancer was studied, the rate of developing prostate cancer was found to be higher in those who were fed poorly in EPA and DHA. Inflammation prepares the ground for many diseases such as cardiovascular diseases, diabetes and cancer. Omega-3 fats reduce inflammation through a variety of mechanisms. EPA and DHA suppress the release of interleukin, which has various toxic effects in many systems of the body (57, 58).

Cancer is a complex disease that requires many gene mutations to occur over the years. When taken from various organs, some fatty acids have the ability to prevent the formation of cancer cells, inhibit their progression, or directly kill cancer cells in vitro. However, some fatty acids may also induce carcinogenesis, so the mechanism behind any possible association between total dietary fat and cancer is unclear. In addition, clear results could not be reached when specific fatty acids were examined (33). Taking into account the putative dietary causes of major cancers and the composition of the traditional Mediterranean diet, estimates can be made of the rates of cancer occurrence in developed Western countries and the replacement of the Western diet with the Mediterranean diet. In the estimated calculations, it was thought that 25% of the incidence of colorectal cancer, 15% of the incidence of breast cancer and 10% of the incidence of prostate, pancreatic and endometrial cancers could be prevented with the transition to the Mediterranean diet (59).

Sepsis is a disease that increases morbidity and mortality in patients in intensive care units, which can lead to advanced inflammation and organ loss as a result of impaired response to infection. Omega-9 is a natural PPAR agonist. It has been shown that rats fed omega-9 MUFA oleic acid, the main component of olive oil, increase survival after sepsis and reduce the loss of organ function (60).

Cooking of fast food is performed by deep frying. When the vegetable oils used are exposed to high temperatures for a long time and during cooking, food particles accumulate in the oil. On the other hand, it has been reported that the toxic effects of cyclohexane dimer and monomer derivatives, hydroperoxides, and polymerization occurring in the food and frying oil prepared due to all these have been observed *in vitro* and *in vivo* studies (61). It has been revealed that the consumption of fried potatoes is closely related to stomach, colon and breast cancers, and fried and grilled meats are closely related to pancreatic cancer.

Effects of Trans-fatty Acids Intake on Human Health

In a study conducted to examine the effect of saturated fat oleic acid and trans-fatty acids on blood fat levels, 47 of 56 subjects

consuming a diet rich in trans-fatty acids had higher blood serum lipoprotein levels than subjects consuming saturated fat. A decrease of 0.10 mmol/L was observed when the serum LDL cholesterol levels were compared with the subjects consuming a saturated fatty acid diet (62). This situation creates a tendency to atherosclerosis and coronary heart disease. It is accepted that lowering LDL reduces the risk of coronary heart disease (5). Essential fatty acids are converted into long chain polyunsaturated fatty acids with many reactions in the body. These include arachidonic acid, which is necessary for tissue growth and development, but trans-fatty acids compete with essential fatty acids for inclusion in these enzyme steps (8). With the increase in trans fatty acid consumption, the need for essential fatty acids also increases (5). One study examined the total content of trans fat isomers and C18:1 trans isomers in the subcutaneous adipose tissue of 34 subjects with ischemic heart disease and 46 without coronary disease symptoms who had undergone aortocoronary bypass surgery. Although the ratio of total trans-fatty acids in cardiac patients was higher than in non-patients, it was not statistically significant, but the ratio of C:18 trans-fatty acids in cardiac patients was significantly higher (63). An important source of these trans-fatty acids is solid margarine (64).

Trans-fatty acids have harmful cardiovascular effects. In a study, 11 states that restricted the use of trans-fatty acids by the FDA and states that were not restricted were compared. There was an average 7.8% decrease in myocardial infarction and a 3.6 percent decrease in stroke. A total reduction of 6.2% was observed in the combination of myocardial infarction and stroke. Observing the harmful effects of trans fatty acids, the United States has also planned to introduce other restrictions (65). Trans-fatty acids are not only effective in heart diseases in human health, but also cause low birth weight and can adversely affect the immune system, breast milk and diabetes (5). In a randomized controlled study, it was observed that trans-fatty acids increased the level of C-Reactive Protein when consuming a diet rich in trans-fatty acids (8% of the diet) was compared with a carbohydrate-heavy diet. Thanks to such studies, it is thought to be proinflammatory and cause various diseases, but there are conflicting studies (15). The relationship between cancer and trans fats has not yet been clarified. In the meta-analysis, when the experiments on the relationship between trans-fatty acids and cancer were examined, a significant positive relationship was found between cancer and trans fat consumption in 14 of 48 studies (66). When specific cancers were examined, a significant positive correlation was observed between prostate and colorectal cancer, but no significant results were found between breast, ovary and Non-Hodgkin lymphoma.

CONCLUSION

As a result, lipids are of great importance for our body as they contribute to the functioning of our body by contributing to the structure of the cell membrane on a cell basis, organs on an organ basis, and hormones on an organism basis. Since the composition of the fat in our body is affected by diet, it is a fact that we need to consume healthy lipids to be healthy. Individuals must consume enough essential fatty acids for our body and get them from quality sources. Conflicting results can still be found in studies, but when many diseases are examined, it has been seen that lipids originated from vegetables are better option than lipids originated from animals. Among animal lipid sources, while fish oil has many benefits, red meat may predispose to various diseases, and it poses a risk in various cardiovascular diseases due to increasing LDL cholesterol. In addition, the Mediterranean diet, which is rich in fish oil, creates healthier societies. With adequate fish consumption, we can benefit from omega-3 fatty acids, which have benefits for many systems of our body, especially heart health. The consumption of trans-fatty acids should be limited due to various harms and

increasing the need for essential fatty acids in the body. Excess intake of total lipids increases the total calorie intake, thus increasing the body adiposity, which creates a predisposition to obesity, organ lubrication and insulin resistance. As a result, if the recommendations are followed in lipid consumption, the body's needs are met, and a predisposition to various diseases may occur by feeding more than saturated and trans fatty acids. Recommendations on this subject are that total lipid intake should be between 25% and 35% of daily calories, saturated lipids intake should be 10% and trans lipids intake should be below 1%.

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