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Antioxidants for Health Management

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ABSTRACT

Antioxidants are technically reductant molecules that prevent the oxidation of other molecules. Like other living systems, human biological molecules are also prone to oxidation reactions. To repair all of the oxidation damage, the human body naturally produces antioxidants known as endogenous antioxidants. Unfortunately, the body's production of antioxidants declines with age and this is found to be a strong factor in contributing to premature ageing and degenerative diseases. Researchers have found that exogenous antioxidants which are obtained from foods may work together with endogenous antioxidants to maintain the redox reaction balance in the body. There are thought to be hundreds and possibly thousands of substances that can act as exogenous antioxidants including carotenoids, flavonoids, indoles, polyphenols, essential vitamins (A, C, E), and minerals such as copper, zinc, manganese, and selenium. Thus, this paper intended to give insights on the endogenous and exogenous antioxidants, supplements as antioxidants, as well as guide readers to get the benefits of antioxidants from foods for better health management. It was found that diets containing fruits and vegetables link to superior overall health effects. However, fruits and vegetables should be consumed regularly by considering the right cooking method to get the best effect since some antioxidants are sensitive to some cooking methods. Apart from diets containing high antioxidants, adopting active lifestyles with consistent exercise and stress management are also required to ensure good and long-lasting health.

Keywords: *Endogenous Antioxidants, Exogenous Antioxidants, Free Radicals, Reactive Oxygen Species (ROS)*

INTRODUCTION

Oxidants or oxidizing agents are chemicals or substances that oxidize other substances in an oxidation reaction. Oxidizing activities commonly occur through removing electrons, and/or hydrogen atoms, and/or adding oxygen atoms to form other substances. These activities of an oxidant produce free radicals, ions, or reactive molecules which would affect the balance of any system (Lobo et al., 2010). On the other hand, the substance that causes the reduction of the oxidant is known as a reductant. The reductant molecules worked by delaying oxidation reaction by preventing the transfer of electrons,

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hydrogen, or oxygen, inhibiting the formation of new radicals, catching free radicals, and reversing the damage done by free radicals (Nordberg & Arner, 2001). Oxidant and reductant work simultaneously in a chemical reaction known as redox.

Antioxidants are technically reductant molecules that inhibit the activities of oxidants. In other words, they prevent the oxidation of other molecules. The term "antioxidant" is mostly used for two entirely different groups of substances; 1) industrial chemicals that are added to products in preventing oxidation, and 2) naturally occurring chemicals that are either produced by the human body or found in foods. The former group of antioxidants has diverse applications including functioning as preservatives in food and cosmetics and being oxidation-inhibitors in rubber, synthetic plastics, and fuels. The latter group applies to medical fields and nutrition and depending on the origins, they are divided into two types which are endogenous and exogenous antioxidants.

Antioxidants that were produced in the body are known as endogenous antioxidants, while antioxidants that were obtained from diet or supplements are known as exogenous antioxidants (Neha et al., 2019). Endogenous antioxidants repair all oxidation damage in the body by initiating cell regeneration, whereas, exogenous antioxidants repair the oxidation damage from the outside of the cells by stimulating cell regeneration. Unfortunately, the body's production of endogenous antioxidants declines with age (Kozakiewicz et al., 2019). The decrease in endogenous antioxidants is found to be a strong factor in contributing to premature ageing and degenerative diseases. Nevertheless, the help of a balanced diet that contains a high number of exogenous antioxidants could work together with the endogenous antioxidants to help the human body work effectively (Lobo et al., 2010). Since both antioxidants are very important for the body to function well, this paper will focus more on endogenous and exogenous antioxidants. In addition, insight into supplements as antioxidants, and getting benefits of antioxidants from foods are also included in guiding health maintenance.

ENDOGENOUS ANTIOXIDANT

Factors that influence the oxidation reactions in human biological systems include exposures to environmental pollutants and sun, cigarette smoke, consumption of unhealthy foods and alcohols, poor diet, and stress (Kumar et al., 2017). These conditions could induce oxidative stress due to the production and absorption of oxidants or free radicals by the body. The oxidant which has the most significant effect on initiating oxidative stress is reactive oxygen species (ROS) (Neha et al., 2019). Oxygen itself is used by all living cells to produce energy. Having two unpaired electrons in separate orbits in its outer shell makes oxygen more liable for radical formation. When oxygen gains electrons, it leads to the formation of several ROS including hydroxyl radicals (OH•), hydroperoxyl radical (HO_2•), superoxide anion radicals (O_2–•), and other species such as singlet oxygen ($^1O_2$), hypochlorous acid (HOCl) and hydrogen peroxide (H_2O_2) (Neha et al., 2019). Free radicals are formed when a human body breaks down food or uses energy to produce ATP (energy) in the mitochondria, while ROS are produced continuously within most biochemical systems in several organelles that exhibit high metabolic activity including mitochondria, chloroplasts, and peroxisomes (Sharma et al., 2018).

Free radicals served essential functions for health including generating energy, fighting infections through the immune cells, fighting cancer cells, activating cell autophagy (cell self-death), strengthening the immune system, providing high tolerance against stress, and escalating wound healing through the promotion of cell growth (Forrester et al., 2018). In normal conditions, free radicals act as important signal substances. However, a very high amount or long-term exposure to free radicals can lead to the emergence of diseases. This is due to their capability to 'capture' electrons from other biological molecules, thus initiating chemical chain reactions (Gulcin, 2020). Among the free radicals, the hydroxyl radical is highly unstable and will react rapidly and nonspecifically with most biological molecules.

The excess free radicals produced in the body will be neutralized by natural defence systems through antioxidant activities. There are two types of endogenous antioxidants in our body which are enzymatic and non-enzymatic. Examples of enzymatic antioxidants are glutathione peroxidase, superoxide dismutase, and catalase, while the non-enzymatic antioxidants include uric acid, lipoic acid, bilirubin, glutathione, and metatonin (Neha et al., 2019). These antioxidants act as radical scavengers, hydrogen donors, electron donors, peroxide decomposers, singlet oxygen quenchers, enzyme inhibitors, synergists, and/or metal-chelating agents. Without antioxidants, free radicals would quickly cause serious harm and eventually could result in death. A surplus of free radicals and ROS would lead to an imbalance between the oxidation process and the production of antioxidants that would, in turn, trigger an oxidative stress response (Sharma et al., 2018).

Prolonged oxidative stress would lead to inflammatory reactions with all biological molecules in tissues and cells. Proteins, nucleic acids, carbohydrates, and membrane lipids are the main targets of free radicals and ROS in cells which will consequently lead to the development of diseases such as inflammatory diseases, neurological disorders, ischaemic diseases, hypertension, hemochromatosis, acquired immunodeficiency syndrome, premature ageing, and cancer (Neha et al., 2019). Thus, this requires the human body to maintain a certain balance of free radicals and antioxidants. Luckily, researchers have found that exogenous antioxidants in foods may work together with endogenous antioxidants in preventing some of the damage caused by free radicals (Pham-Huy et al., 2008). There are thought to be hundreds and possibly thousands of substances that can act as exogenous antioxidants. Each has its role and interaction with other substances to help the human body work effectively.

EXOGENOUS ANTIOXIDANT

There is increasing evidence that exogenous antioxidants are more effective if they are obtained from whole foods. To achieve a healthy and well-balanced diet, it is recommended to eat a wide variety of foods including a serving of fruits and vegetables daily. The Malaysian Diet Guidelines have introduced the concept of "Pinggan Sihat Malaysia" (Malaysian healthy plate) with the hashtag #sukusukuseparuh where the protein and fat portion, and the grain portion are each quarter of the plate, while the vegetables and fruits portion, in turn, is half a plate (Figure 1). This means, for lunch, a quarter of the plate is rice, another quarter is a side dish, and the rest is vegetables and fruits. This concept facilitates the visualization of the plate in the division of food types during meal times. Detailed information on recommended servings and portions for specific ages, life stages, and gender can be obtained from the webpage of the Ministry of Health under the Division of Foods Safety and Quality Malaysia.

Figure 1: The Malaysian Healthy Plate #Sukusukuseparuh (Ministry of Health, Malaysia)

Exogenous or nutritional antioxidants including carotenoids, flavonoids, indoles, polyphenols, essential vitamins (A, C, E), and the minerals copper, zinc, manganese, and selenium are abundantly present in fruits and vegetables, as well as other foods including nuts, whole grains, and some meats, poultry and fish. However, the best sources of antioxidants are plant-based foods, particularly fruits and vegetables. Many often heard about how powerful berries are in antioxidant properties, but merely know that tropical fruits and daily foods that are easily accessible from local markets also contain high amounts of antioxidants. Some of the foods rich in antioxidants that are easily found in local markets in Malaysia are explained in the following parts of the paper.

Tropical Fruits

A study on seven Malaysian tropical fruits including banana, guava, kedondong, langsat, mangosteen, papaya, and starfruit has found that the guava, starfruit, and papaya exhibited higher antioxidant properties compared to orange. The result shows that although the banana's primary antioxidant is weaker than orange, its secondary antioxidant potential is still considered powerful (Lim et al., 2007). All of these antioxidant-rich fruits are easy to grow, thrive in tropical climates like Malaysia, and are available all the time in the market.

Spinach

Spinach is a common vegetable available in almost all markets in Malaysia. The components of spinach associated with its antioxidant activity are carotenoids, ascorbic acid, flavonoids, and phenolic acids. To acquire the most benefit from spinach, it is best to be eaten raw. However, concerns about food safety require some to cook the green leaf. The longer it is cooked, the more antioxidants deteriorate depending on temperature and time. To keep blanched spinach at its highest antioxidant level, it is advisable to cook spinach for less than 10 minutes at a temperature less than 95°C (Amin et al., 2006).

Tea, Coffee, and Cocoa

Tea, coffee, and cocoa are beverages well known for their antioxidant properties in raw conditions. However, tea, coffee, and cocoa that are available in the market have gone through several processes. As the amount of antioxidants varies through each process, the concern is to know the amount of antioxidants in tea, coffee, and cocoa in the form of beverages. Research conducted on the beverages in the forms of 0.7-2.5% soluble coffee, 1.5-3.5% coca and 1 teabag infused for 5 minutes in 220 mL of hot water concluded that all these preparations contain polyphenols with high antioxidant activities. This study also found that the addition of milk did not alter the beverages' antioxidant activities but consumers have to take extra caution on the amount of sugar added (Richelle et al., 2001).

Snake Fruits

Salacca zallaca also known as snake fruits is a nutrient-dense fruit that contains a substantial amount of antioxidants, particularly flavonoids and carotenoids (Aralas et al., 2009; Čepková et al., 2021). The nutritional profile of this fruit is comparable to those of better-known fruits like kiwi and apple. In comparison, snake fruit contains five times more beta-carotene than that found in watermelon and mangoes. The beta-carotene content in snake fruit is a powerful antioxidant and works well to prevent cardiovascular disease, strokes, and cancer (Čepková et al., 2021).

Honey

Honey is proven to possess therapeutic potential as it is rich in phenolic acids, flavonoids, vitamins, and enzymes that are associated with its antioxidant capacity. The use of honey as a therapeutic remedy has been practised for the past 5000 years, which is much older than the history of medicine itself. The properties and compositions of honey are affected greatly by various factors including its nectar source, the territorial site of the floral source, collection season, mode of storage, and harvest technology and conditions (Kek et al., 2014).

Research conducted involving *Apis* spp. (honeybee), *Trigona* spp. (kelulut), and commercial honey from local supermarkets shows that honey harvested from kelulut exhibits superior antioxidant potential far better than the honeybee. It was also observed that the amount of total phenolic content of kelulut honey was 33% higher and its colour intensity is 111% higher compared to the honeybee. Colour intensity corresponds to the antioxidant pigments such as carotenoids and flavonoids present in honey. Meanwhile, for commercial honey, the findings are quite surprising as it has the lowest amount of total phenolic content as well as colour intensity (Kek et al., 2014).

Dried Fruits

Dried fruits provide a range of phytochemicals such as phenolic acids, flavonoids (anthocyanidins, flavan-3-ols, flavones, flavonols, and isoflavones), phytoestrogens, and carotenoids which contribute toward antioxidant activity. Dried fruits are nutritionally equivalent to fresh fruits in smaller serving sizes as they undergo a drying process that condenses nutrients in the fruit. They are rich in vitamins, minerals, fibres, and phytochemicals and are pleasingly delectable. Though dried fruit had undergone the drying process, the quality of the antioxidants in dried fruit is equivalent to that of fresh fruit. Among commercially dried fruits, dates are found to have the highest concentration of polyphenols, while dried figs and plums contain notable amounts of vitamins C and E (Chang et al., 2016).

When choosing dried fruits, it is advisable to read the label carefully as some of the dried fruits in the market are laced with sugar. Candied fruits should be avoided to obtain optimum nutrients from dried fruits. Despite their nutrient contents, dried fruits are not recommended as the main source of nutrition as fruits, whether dried or not, still contain calories and natural sugars. Once consumed in excess, it may do more harm than good. It is best to consume them moderately with other healthy foods (Alasalvar & Shahidi, 2012).

ANTIOXIDANTS IN THE FORM OF SUPPLEMENTS

Research is divided over whether antioxidant supplements offer the same health benefits as antioxidants in foods. Although antioxidant molecules seem to be having multiple positive effects counteracting oxidative stress in laboratory experiments, there is debate as to whether consuming large amounts of antioxidants in supplement form benefits health. There are also some concerns about drug-supplement interactions and consuming antioxidant supplements in harmful doses. This is because too much antioxidants can induce reductive stress. The body will experience a loss of energy, prone to infections, and delayed wound healing (Fisher & Mentor, 2017).

Toxicity associated with high doses of water-soluble antioxidants such as ascorbic acid is less of a concern since this compound can be excreted rapidly through urination. However, lipid-soluble antioxidants are more in the spotlight due to their bioaccumulation. Misuse of undiluted essential oils containing a significant amount of eugenol may cause damage to the liver (Fujisawa et al., 2002). Lavender oil may disrupt the normal functioning of hormones, leading to idiopathic prepubertal breast development (Ramsey et al., 2019).

Studies have shown that consuming vitamin E supplement, another lipid-soluble antioxidant, in high dosage could increase mortality, whereas a high dose of vitamin A (beta-carotene) increases the risk of lung cancer in smokers (Alpha-Tocopherol, Beta Carotene Cancer Prevention Study Group, 1994). The antioxidant in the form of vitamin E supplements is also found to react with anticoagulant drugs causing bleeding (Podszun & Frank, 2014). Also, antioxidant minerals or vitamins can act as pro-oxidants or damaging 'oxidants' in the body if consumed at levels significantly above the recommended amounts for dietary intake (Sotler et al., 2019). The United States National Institute of Health has warned on excess antioxidants intake as nutritional supplements could cause an imbalance in human biological systems and should be avoided. Nevertheless, if supplements are in need, it is recommended to seek advice from health experts or dietitians and it is wise to choose supplements that provide all nutrients at recommended levels.

GETTING THE BENEFITS OF ANTIOXIDANTS FROM FOODS

There are many ways to get the benefits of antioxidants from foods. Fruits are better to be eaten with the skin on as it contains more antioxidants than the pulp. Fruits and vegetables with different colours are not only attractive and would provide fibres, but they are also packed with antioxidants and often referred to as 'superfood' or 'functional food'. Carrots, peas, corn, spinach, mangoes, papaya, oranges, and watermelon contain beta-carotene, lycopene, and/or lutein the essential antioxidants that are unable to be produced by our body. Guava, oranges, papaya, tapioca shoots (pucuk ubi), cashew shoots (pucuk gajus), sweet leaf (cekur manis), kale, red cabbage, bell peppers, and broccoli are easily accessible fruits and vegetables that are rich in antioxidants particularly vitamin C (Fenech et al., 2019).

The way to consume vegetables by knowing their benefits will help to decide whether they should be taken raw or cooked. The nutritional compositions of cooked and raw vegetables are different. Cooking particular foods can either increase or decrease the antioxidant levels. Fat-soluble vitamins (A, D, E, K) are more stable to heat, whereas water-soluble vitamins are less stable including vitamins C and B. For instance, vitamin C is easily destroyed by heat thus its content will reduce from 0 – 91% depending on the cooking method. Thus, vegetables that contain a significant amount of vitamin C are advisable to be eaten raw as ulam. Nevertheless, if a person wants to enjoy the cooked taste of the vegetables, then steaming can be a good option as the loss of vitamin C or other nutrients is the lowest through this cooking method (Lee et al., 2018).

In addition, the antioxidant lycopene that gives tomatoes their rich red colour becomes more bio-available (easier for our bodies to process and use) when tomatoes are heat-treated (Bose & Agrawal, 2007). Spices and herbs such as turmeric, ginger, cinnamon, cumin, oregano, clove, black pepper, oregano, and parsley do not only enhance the flavour of food but also add antioxidants to our daily meals (Yashin et al., 2017). Adding chia seeds, sunflower seeds or sesame seeds to overnight oats as breakfast will add texture as well as antioxidants to the healthy breakfast (Ullah et al., 2016). Last but not least, vinegar can also be added to our food as was mentioned in Sahih Muslim 2051; Aisha reported: The Prophet, peace and blessings be upon him, said, "The best of condiments or toppings is vinegar." Many studies have also provided scientific evidence for the medicinal uses of vinegar (Johnston & Gaas, 2006).

Food rich in antioxidants must be taken in an adequate amount. This is because each antioxidant serves different functions and is not interchangeable with another. This is why it is important to have a varied well-balanced diet that includes fruits and vegetables (cooked and raw). Overeating should be avoided, as stated in a hadith narrated by al-Tirmidhi, 2380; Ibn Maajah, 3349; classed as saheeh by al-Albaani in Saheeh al-Tirmidhi, 1939: "A man does not fill any vessel worse than his stomach. It is sufficient for the son of Adam to eat enough to keep him alive. But if he must do that, then one-third for his food, one-third for his drink and one-third for his air."

CONCLUSION

Although a diet containing fruits and vegetables has good links to better overall health effects, they should be consumed regularly to get the best effect. It should be noted that some antioxidants are sensitive to heat, thus caution should be taken on choosing the right cooking method to get the benefits. Depending on the level of health and acceptance of the body, each different individual will experience different effects of antioxidants in food. For supplementary antioxidants, it is wise to seek advice from health experts or dietitians and choose supplements that contain all nutrients at the recommended levels. Apart from consuming fruits and vegetables of high antioxidant content, adopting an active lifestyle with consistent exercise and stress management is also required to ensure good and long-lasting health.

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