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Antioxidants rich natural fruit and synthetic fruit products

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Abstract
Fruits are a great source of nutrients. Fruits contain various antioxidants in their composition. Oxidation is a chemical reaction that occurs in many different types of electrons from one substance to another, and has harmful effects, especially in physiological circumstances. An antioxidant is a compound that in a small amount slows or stops a substrate from oxidizing. Natural and synthetic antioxidants are the two broad categories that describe these substances. Studies have shown that antioxidants have several disease-preventing benefits. Many antioxidants function in different ways, such as via binding transition metals, transferring a single electron, or swapping hydrogen atoms (HAT).This review highlights the antioxidants present in fruits and their health benefits, mode of action, and methods to evaluate antioxidant activity.

Keywords: Antioxidants, natural antioxidants, synthetic antioxidants, human health, fruits

1. Introduction
Fruit is a versatile food source since it may be eaten fresh, but also fermented or processed to create wine, juice, jams, and other treats (Lu *et al*., 2021) [40]. Fruits and vegetables, which are food plants, are frequently commended for their purported health benefits (Eastwood, 1999; WHO, 2004; Serna-Saldivar, 2010) [20, 67, 62]. Antioxidants are present in citrus fruits (orange, grapefruit, lime, and lemon), grapes, apples, dates, and pears. (Rice-Evans and Miller, 1995; FSA, 2022) [53, 23].

The free radical's reactivity, chemical composition, and the conditions in which these reactive species are present all have a significant impact on the antioxidant compounds reaction processes. Reactive oxygen species (ROS) and reactive nitrogen species (RNS), which both require in-depth discussion, are made up of precursors and free radicals. (Santos-Sánchez *et al*., 2019) [59].

The value of fruits and vegetables has substantially grown due to the phytochemicals' capacity to defend against diseases brought on by oxidative stress. Numerous illnesses in humans are significantly influenced by oxidative stress. This includes rheumatoid arthritis, diabetes, Alzheimer's, Parkinson's, and cancer (Ndiamaka *et al*., 2019) [45]. Reactive oxygen species (ROS) and reactive nitrogen species are two of the most prevalent oxidants and oxidising agents produced by the human body (RNS). Many different physiologic and biochemical processes and environments contribute to their production. (Rasheed and Azeez, 2019) [51]. The phytochemicals protect cells from free radical damage by acting as antioxidants.

Antioxidants may be either synthetic or natural, as stated by Akbarirad *et al*. (2015) [1]. These antioxidants are mostly poly substituted phenolic compounds. Natural antioxidants, mostly phenolics, may be found in almost every part of plants. (Asif, 2015) [6]. Synthetic antioxidants are artificially created in a laboratory by mixing several compounds. Synthetic medications that are very active at low concentrations (0.01% to 0.02%) and are safe to use are the top qualified for surface accumulation in the fat or oil phase. (Belitz *et al*., 2009) [9]. Some synthetic antioxidant molecules may be supplied orally because of their non-protein composition, which makes them reasonably stable and typically able to enter cells (Li, 2011) [38].

Antioxidant activity or capacity is a measuring tool by which able to know how effective a particular antioxidant is in functioning. It is crucial to understand the differences between antioxidant activity and capacity while researching antioxidant substances and the underlying processes. In general use, both terms refer to the same thing. However, the reaction rate constant between an antioxidant and an oxidant must be taken into account while addressing radicals.

The antioxidant capacity of the sample being used determines how well an antioxidant can scavenge a particular free radical. (MacDonald-Wicks *et al*., 2006) [41]. There are various methods to analyze antioxidant activity or capacity. There are two basic categories of *in vitro* techniques: (1) Reactions involving hydrogen atom transfers, and (2) single electron transfers (SET).The tremendous speed and sensitivity of these techniques make them very popular (Salazar *et al*., 2008) [57].

Despite the fact that antioxidants can be found in a wide range of foods, their potency may vary depending on a number of circumstances, such as storage temperature, food composition, food structure, and the presence or absence of oxygen. For usage in frying oils, antioxidant activity may be required between 180 and 200 °C, and 5 °C for use in chilled goods like margarine or mayonnaise. Depending on the processing and storage temperatures these things are subjected to, water, proteins, carbohydrates, vitamins, minerals, and other food components as well as the structural characteristics of the food may vary. The effectiveness of the antioxidant in numerous food systems may be significantly impacted by this. Non-polar antioxidants like a-tocopherol have been found to be entirely ineffective in oil yet exhibit incredible power in an oil-in-water emulsion. An oil is a better transporter for a polar antioxidant like ascorbic acid or trolox as opposed to an emulsion (a water-soluble derivative of a-tocopherol). The polar paradox describes this scenario. (Yanishlieva *et al*., 2001) [68].

Antioxidants are compounds that, even in very little amounts, dramatically reduce the function of oxidation in the targets (Rasheed and Azeez, 2019) [51]. Substances prevent further free radical production during lipid oxidation by adding hydrogen or electrons to a fatty acid containing an existing free radical. The free radical and fatty acid chain combine to generate this complex (Kaur and Kapoor, 2001) [15]. Antioxidants oxidize themselves to remove the free radical intermediates and stop the chain reactions (Rasheed and Azeez, 2019) [51]. The body's defenses against free radicals, also known as reactive oxygen species (ROS), are quite strong and rely on both high and low molecular weight antioxidants as well as a variety of enzymes. By removing free radicals from the body before they can cause any damage, they serve as scavengers and the body's cleanser (Kaur and Kapoor, 2001) [15]. These ingredients have been given the go-ahead by the American Food and Drug Administration to be used in order to avoid spoiling, rancidity, and discoloration brought on by oxidation (FDA) (Kaur and Kapoor, 2001) [15]. Thiols, ascorbic acid, and polyphenols are only few examples of antioxidants that function as reducing agents. (Rasheed and Azeez, 2019) [51].

2. Types of antioxidants

2.1 Natural antioxidants

Many naturally occurring foods, including fruits, vegetables, nuts, cereals, seeds, animal tissues, and more, include substances referred to as natural antioxidants. They are the chemicals that interact with lipid radicals to create more stable products by breaking chemical chains. (Ndiamaka *et al*., 2019) [45].

2.1.1 Vitamin C (Ascorbic acid)

L-ascorbic acid, also referred to as vitamin C, is crucial for supporting both human and animal health. Because it shields cells from harm by free radicals and is needed as a cofactor in at least 8 enzymatic pathways, ascorbate functions as an antioxidant in organisms. It is also important in the production of collagen; deficiencies in this pathway are responsible for the disease's most severe 185 symptoms. Nonsmoking males and females need to ingest 90-100 mg of vitamin C daily to lower their risk of acquiring chronic 195 diseases; this recommends a recommended dietary allowance (RDA) for vitamin C of 120 mg per day. The recommended daily allowance (RDA) for vitamin C in the US is 90 mg for males and 75 mg for women; most of these quantities are based on biological mechanisms. (Landete, 2012) [34]. Mainly fruit sources of ascorbic acid are papaya, orange, lemon, cherries, and watermelon. It is a volatile chemical that may be removed from food during processing and cooking (Ravimannan and Nisansala, 2017) [47].

2.1.2 Carotenoids

They are principally in charge of producing the compounds that give fruits their distinctive yellow, red, and orange colours. Human diets frequently contain carotenoids such α- and β-carotene, lutein, lycopene, zeaxanthin, astaxanthin, and β-cryptoxanthin. These substances actively shield plants from the harm caused by direct sunlight (Jideani *et al*., 2021) [24]. Provitamin activity and strong oxygen scavenger properties of carotenoids both contribute to the reduction of oxidative stress in the body. (Lu *et al*., 2021) [40]. They also play a preventive function against cancer, obesity, gastrointestinal problems, and cardiovascular diseases (Jideani *et al*., 2021) [24]. Here are several common fruits that are high in carotenoids, such as apricots, tomatoes, and goji berries (Lycium barbarum) (*Prunus armeniaca*). Lycopene makes up 70–90% of the total carotenoids in tomato fruits, whereas β-carotene makes up the remaining 5-26%. At least 12 different carotenoids have been identified in tomato fruits. Lycopene boosts tomato fruits' already impressive antioxidant capacity and excellent nutritional value. (Lu *et al*., 2021) [40].

2.1.3 Flavonoids

The six subclasses of the phenolic compound class known as flavonoids include flavones, flavanols, flavan-3-ols, phytoestrogens, and anthocyanidin compounds (Ravimannan and Nisansala, 2017) [47]. The colouring of many plant parts, such as vegetables, fruits, grains, seeds, leaves, flowers, and bark, is caused by phenolic compounds (Rasheed and Azeez, 2019) [51]. The peels and seeds of berry fruits, such as grapes (Vitis vinifera), citrus fruits (family Rutaceae), and many tropical fruits, are rich in flavonoids. (Lu *et al*., 2021). Antitumor, antibacterial, and anti-inflammation effects are all exhibited by phenolic compounds. Some flavonoids are more powerful antioxidants than vitamin C, glutathione, and beta-carotene (Ravimannan and Nisansala, 2017) [47].

2.1.4 Vitamin E (Tocopherol)

Most human tissues contain a large amount of α-tocopherol. It is expected to have a 50% bioavailability (Ndiamaka *et al*., 2019) [45]. Vitamin E is composed of both tocotrienols and tocopherols. It is a vitamin that is essential to the diet and is both fat- soluble and water-insoluble. (Ravimannan and Nisansala, 2017) [47]. Vitamin E may help create an antioxidant system by directly removing oxygen (O2), freezing singlet oxygen, and stimulating super oxide dismutase (SOD) (Rasheed and Azeez, 2019) [51]. Vitamin E works as an antioxidant by delivering protons that interact with lipid oxygen and lipid peroxyl free radicals to halt the development of lipid peroxidation. α-Tocopherols and other vitamin E derivatives are essential for preventing lipid peroxidation, scavenging peroxyl radicals, interacting with reactive oxygen species (ROS) and reactive nitrogen species (RNS), and reducing ROS formation from NADPH oxidase. (Jideani *et al*., 2021) [24].

2.2 Synthetic antioxidants
An artificial antioxidant, also known as a synthetic antioxidant, is made in a lab by mixing a number of different chemical compounds (Uzombah, 2022) [66]. Antioxidants made in a lab are phenolic antioxidants that neutralize free radicals and put a stop to further processes (Ndiamaka *et al*., 2019) [45]. Synthetic antioxidants are widely utilized as food preservatives because of their high reactivity and increased effectiveness and efficiency. (Uzombah, 2022) [66]. As natural antioxidants, tocopherol and ascorbic acid are both widely utilized, although their effectiveness is substantially lower than that of synthetic antioxidants (Kaur and Kapoor, 2001) [15].

2.2.1 Butylated hydroxyl anisole (BHA)
Components include Both 3- and 2-tert-butyl-4-methoxyphenols are being used. (Ndiamaka *et al*., 2019) [45]. Waxy white flakes dissolve in oils and fats but not water. When fats containing BHA are treated to high temperatures, their stability reduces. 50–52 °C is the melting point (Andre *et al*., 2010) [40].

2.2.2 Butylated hydroxyl toluene (BHT)
It's a chemical compound known by its formula, 2,6-di-tert-butyl-4-methylphenol. White crystalline material that is naturally occurring.The substance dissolves in oils and fats as well as the vast majority of organic solvents, but it doesn't mix with water. The melting point is 68–70 °C (Ndiamaka *et al*., 2019) [45].

2.2.3 Tertiary butylhydroquinone (TBHQ)
It is a crystalline powder that is beige or white to brown. Alcohol is less soluble than lipids and then less soluble than water. It resists heat and is the best antioxidant for avoiding frying oil oxidation. 126–128 °C is the melting point (Ndiamaka *et al*., 2019) [45].

2.2.4 Nordihydroguaiaretic acid (NDGA)
Its scientific name is 2,3-dimethyl-1,4-bis (3,4- dihydroxy phenyl) butane. The crystals in this solid are pure white. The water barely dissolves it, although it is soluble in weak alkali. The melting point is between 184 and 185 °C (Ndiamaka *et al*., 2019) [45].

2.2.5 Octyl gallate
Octyl gallate is a crystalline powder that ranges in colour from white to creamy and has a melting point of 91 to 92 degrees Celsius (Ndiamaka *et al*., 2019) [45].

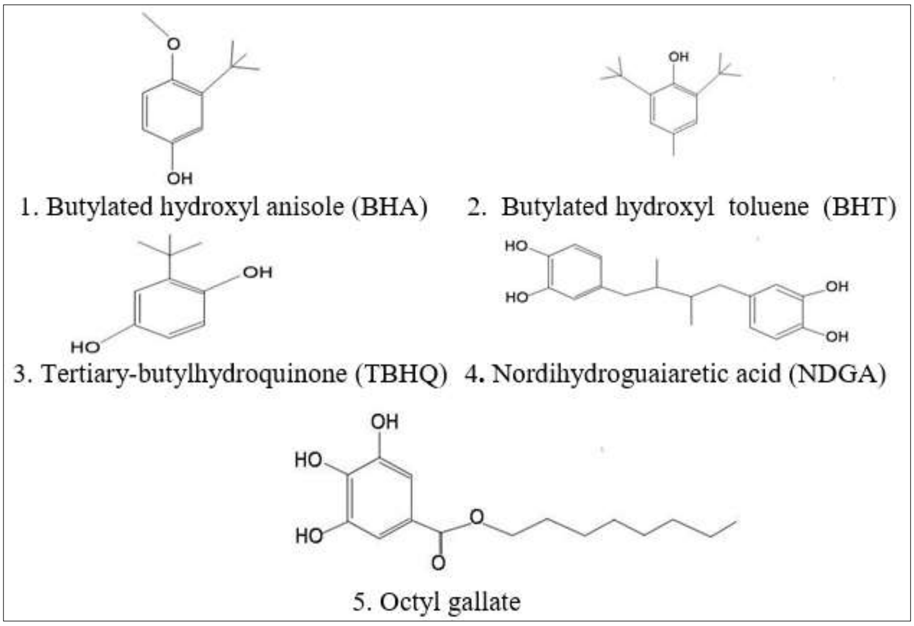

Fig 1: Chemical structures of synthetic antioxidants

Table 1: Synthetic antioxidants and their applications in food products

Synthetic antioxidant	Limit	Foods
Butylated hydroxyanisole (BHA)	<200 mg/kg	Chips, cookies, cakes, pastries, sugar, honey, meat, cereal, milk, spices, and so on are all examples of foods.
Butylated hydroxytoluene (BHT)	<100 mg/kg	Numerous sorts of food, including meat, potato sticks, gum,spices, milk, vegetable oil, etc.
Tertiary butylhydroquinone (TBHQ)	120 mg/kg	Meat products, spices, milk and milk products, chewing gum, seafood, honey, etc.
EDTA	75 ppm	Sandwich spread, soft drinks, salad dressing, mayonnaise, processed fruits, vegetables, etc.
Octyl gallate	<200 mg/kg	Cereals, milk and milk products, meat products, honey, etc.
Propyl gallate	<200 mg/kg	Foods such as meat and potatoes as well as other items such as gum, spices, milk, vegetable oil, etc.

(**Source:** Uzombah, 2022) [66]

Table 2: Advantages and disadvantages of natural and synthetic antioxidants:

Antioxidant	Advantages	Disadvantages
Natural	a. Various antioxidant activities b. There are no legal restrictions on common culinary ingredients c. In the human diet, there are several chemical substances d. Pure, effective, and affordable e. Easily accessible	a. A poor antioxidant performance b. The high degree of utilization c. Complex mixes of several substances with a variety of activities are thus prone to physical/chemical interactions. d. Costly e. The assay could take a long time
Synthetic	a. If added at a Concentration allowed by law, it is safe b. Pharmaceuticals that are efficient against many disorders c. Shorter test time	a. Significant toxicity b. Low water solubility c. Suspected to be chemical d. Sensitized to radioactivity

(**Source:** Ndiamaka *et al*., 2019) [45]

2.3 Endogenous Antioxidants
Antioxidants in the diet aren't the only thing keeping free radical-induced cell damage at bay; the body has its own set of defensive systems. Micronutrient cofactors including selenium, iron, copper, zinc, and manganese are needed for antioxidant enzymes like glutathione peroxidase, catalase, and dismutase (SOD) to boost their catalytic activity and eliminate oxidatively dangerous intermediates (Alejandro *et al*., 2016) [3]. It has been hypothesized that these antioxidant defense systems might be weakened by insufficient dietary intake of certain trace elements. The amino acids glycine, glutamate, and cysteine are the building blocks for the production of glutathione, a crucial water-soluble antioxidant. Additionally to its central function in xenobiotic metabolism, glutathione acts as a direct quencher of reactive oxygen species (ROS) such lipid peroxides. During the Krebs cycle, an essential endogenous antioxidant called lipoic acid catalyses the oxidative decarboxylation of alpha-keto acids like pyruvate and alpha-ketoglutarate. This process is catalyzed by thiols, or sulfur-containing molecules (Saccà *et al*., 2013) [60].

2.4 Exogenous Antioxidants
Antioxidants found in the environment are called exogenous antioxidants (vitamins, flavonoids, anthocyanins, some mineral compounds). Antioxidants are gaining popularity as a way to shield the body from the effects of free radicals and to delay the oxidation of lipids and other dietary components (Bouayed & Bohn, 2010) [12].

2.5 Enzymatic Antioxidants
The "primary" and "secondary" enzymatic defences are additional divisions of the antioxidant effects of enzymes. Superoxide dismutase, catalase, and glutathione peroxidase are the body's first line of defence against free radicals. The secondary enzymatic defence involves both glucose-6-phosphate dehydrogenase and glutathione reductase. Although none of these enzymes are capable of eliminating free radicals on their own, they might help other natural antioxidants do their job (Ahmad *et al*., 2010) [70].

2.6 Non-Enzymatic Antioxidants
Albumin, bilirubin, N-acetylcysteine (NAC), melatonin, vitamins E and C, nitrogen compounds (such uric acid, which scavenges peroxynitrite in plasma), and peptides are all examples of non-enzymatic antioxidants (glutathione).These substances directly react with ROS to create disulfides (Mironczuk-Chodakowska *et al*., 2018) [44].

3. Mechanism of antioxidants
Antioxidants have been broken down into their component parts, the initiation, propagation, and termination phases of a chain reaction. (Uzombah, 2022) [66].

3.1 Initiation stage
Free radicals are produced when the hydrogen atom is removed from the system, starting chemical processes that include oxidation. In the system RH shown below, the loss of one hydrogen atom, H*, results in the formation of a free radical, R*.

$$RH \rightarrow R^{*} + H^{*} \quad (1)$$

$$R^{*} \rightarrow R^{*} + O_2 \rightarrow ROO^{*} \quad (2)$$

$$2ROOH \rightarrow ROO^{*} + RO^{*} + H_2O \quad (3)$$

3.2 Propagation stage
When free radicals and other reactive species connect to an oxygen molecule in the environment during the propagation phase of the free radical chain reaction, peroxides and peroxy radicals can be created. Furthermore, Brewer (2011) [13] and Atta *et al*. have proposed that antioxidants limit the propagation of free radicals through intermediates because of the antioxidants' supply of hydrogen (2017).

$$R^{*} + O \rightarrow ROO^{*} \quad (4)$$

$$ROO^{*} + RH \rightarrow ROOH + R^{*} \quad (5)$$

$$RO^{*} + RH \rightarrow ROH + R \quad (6)$$

3.3 Termination stage
The process shown below takes place either when antioxidants give free radicals a hydrogen atom (H*) to interrupt the chain reaction or when two free radicals join to create a stable or non-radical species. A stable peroxy-antioxidant molecule may then be formed from the antioxidants' free radicals (Brewer, 2011) [13].

$$R^{*} + R^{*} \rightarrow R + R \quad (7)$$

$$R^{*} + ROO^{*} \rightarrow ROOR \quad (8)$$

$$ROO^{*} + ROO^{*} \rightarrow ROOR + O_2 \quad (9)$$

$$\text{Antioxidants} + O_2 \rightarrow \text{Oxidized antioxidants} \quad (10)$$

4. Methods to evaluate antioxidant activity

There are two main categories in which to classify the techniques for measuring antioxidant capacity. The categorization here is based on the reactions that take place during the reduction of free radicals. Different from the second group of methods, which are grounded in the HAT, the first group is founded on the SET. While the rate of this process and the nature of the secondary reactions that accompanied it varied, their overall effect was always the same: the neutralization of free radicals. SET-based methods are used to identify a potential antioxidant's capacity to transport chemical species like metals, carbonyls, and radicals. The oxidant is decreased by the antioxidant, demonstrating SET by a change in colour. The collection of HAT-based techniques assesses an antioxidant's capacity to render a free radical inactive by giving up an atom of hydrogen. The type of solvent and pH are not thought to affect HAT reactions. These are quick reactions that last no more than a few minutes (Santos-Sánchez *et al*., 2019) [59].

4.1. DPPH (1,1 diphenyl-2-picrylhydrazyl)

The most common method of conducting the DPPH test involves using a free radical scavenger to neutralize a colored free radical in a methanolic solution. The process includes detecting the reduction in DPPH absorbance at its highest absorption frequency of 516 nm to ascertain how much of a free radical scavenger was given to a reagent solution. The half-maximal effective concentration is often used to describe activity (EC50). (Chen and Schopfer, 1999) [16].

4.2. Ferric reducing antioxidant power (FRAP)

According to this method, an increase in the reaction mixture's absorbance implies an increase in antioxidant activity. This approach allows for the 700 nm detection of a colourful complex formed by trichloroacetic acid (TCA), ferric chloride (FeCl3), and a potent antioxidant agent (Potassium ferricyanide). A higher absorbance in the reaction mixture indicates that the samples have greater reducing power. (Jayprakash *et al*., 2001) [31].

4.3 Total radical-trapping antioxidant parameter (TRAP)

A radical generator called 2,2′-azobis(2-amidinopropane) hydrochloride (ABAP) prevents R-phycoerythrin from fluorescent dyes. Delay in decolorization measurement is used to evaluate antioxidative capacity. (Ghiselli, 1995) [25].

4.4 Oxygen radical absorbance capacity (ORAC) method

The test evaluates the Trolox equivalent, a water-soluble vitamin E alternative (TE). The ORAC value is then expressed in ORAC units or value after conversion to a Trolox equivalent. This experiment demonstrates that the "antioxidant power" increases with increasing ORAC values. The free radical damage marker in an automated ORAC test was b-phycoerythrin (b-PE), the peroxy radical generator was AAPH, and the standard control was Trolox. Following the addition of AAPH to the test solution, the fluorescence is measured, and the results are shown as the Trolox equivalent, which represents the antioxidant activity. (Ronald, 1998) [54].

4.5 Thiobarbituric acid (TBA) assay

The TBA test includes isolating rat liver microsomes and inducing lipid peroxides using ferric ions to produce a modest quantity of malondialdehyde (MDA). A pink chromogen is created when TBA combines with MDA and may be seen at 532 nm using spectrophotometry (Gutteridge and Wilkins, 1986) [28].

4.6 Nitric oxide radical inhibition activity

Nitric oxide, like other free radicals, reacts aggressively with particular protein types because it has an unpaired electron. The capacity to stop the *in vitro* generation of nitric oxide radicals is another sign of antioxidant potency. The Griess reagent is used because it detects the reduction of the nitric oxide radical formed when sodium nitroprusside is dissolved in a saline solution. Scavengers at 546 nm are used to measure the chromophore's absorption. The degree of activity is shown as percentages of decreasing nitric oxide. (Babu *et al*., 2001) [8].

4.7 β-Carotene linoleate model

According to the idea, oxygenated water produces "reactive oxygen species" (ROS), which then oxidise linoleic acid, an unsaturated fatty acid. This is one of the quick approaches to screen antioxidants. The discolouration will result from the oxidation of β-carotene, which will be started by the products generated. When evaluated for activity at 434 nm, antioxidants are shown to reduce the degree of discolouration (Kanner, 1994) [32].

4.8 Conjugated diene assay

Real-time statistical assessments of the conjugated dienes created by the initial oxidation of PUFA are possible using the UV absorbance at 234 nm (polyunsaturated fatty acids). In the process of oxidising linoleic acid, conjugated double bonds are formed, which have a high UV absorbance at 234 nm. This is the main concept of the examination.According to the inhibitory concentration, the activity is expressed (IC50) (Bennion, 1995; Ashok 2001; David *et al*. 2000) [10, 5, 18].

5. Impact of oxidative stress

5.1 Diabetes

In humans, diabetes is a condition linked to elevated oxidative stress. The exact cause is unclear, although it is believed to be a combination of factors including glucose autooxidation, NADPH oxidase activation, mitochondrial malfunction, and the direct inhibition of enzymes by hyperglycemia. Elevated lipid peroxidation products, brittle erythrocytes, and a decline in the antioxidant enzyme systems are all indications of oxidative stress (CAT, GSH-PX, and SOD) (Mattia *et al*., 1993; Bondy and Komulainen, 1988; Cutler, 1991; Harman, 1992) [43, 11, 17, 29].

5.2 Brain aging

Research supports the idea that oxidative damage is a primary contributor to ageing by demonstrating that it may cause major alterations in macromolecules (DNA, lipids, and proteins), particularly in the brains of old people. Normal developmental and metabolic processes in mammals are assumed to cause aging symptoms such as gray hair, slower wound healing, increased susceptibility to illness, and eventually death. (Mahadik and Scheffe, 1996; Tsai, *et al*. 1998; Lebel *et al*. 1990) [42, 65, 35].

5.3 Parkinson’s disease

According to postmortem examinations of PD patients, OS is the primary factor contributing to the degradation of the pigmented dopaminergic neurons in the substantia nigra pars compacta (SNpc) (Hoffman *et al.*, 1991) [30]. One of the proposed origins of OS in the SNpc is the production of reactive oxygen species (ROS) during normal dopamine metabolism. The oxidation products of dopamine produced by the human SNpc may polymerize into the potentially dangerous pigment neuromelanin (Goodwin *et al.*, 1983; Perry *et al.*, 1997) [26, 49]. GSH levels in the SNpcs of PD patients were significantly lower (by 60%) after death, while reduced glutathione levels were slightly elevated (29%). (Fahn and Cohen *et al.*, 1992; Offen *et al.*, 1995) [21, 48].

5.4 Alzheimer's disease

Alzheimer's disease (AD) is a progressive neurodegenerative brain ailment for which there is presently no therapy. Particularly prevalent among the elderly, it is marked by mental deterioration and neural degeneration (Zachwieja *et al.*, 2000. Leszek *et al.* (2003) [69, 36] state that postmortem examinations have shown several abnormalities, such as increased lipid peroxidation, in specific brain areas that have been associated to oxidative stress and the development of AD. (Flynn and Runho, 1999) [22].

5.5 Inflammation

The term "respiratory burst" is used to describe the rapid spike in oxygen demand that occurs during phagocytosis. Patients with rheumatoid arthritis have increased activation-induced production of reactive oxygen species (ROS), hypoxanthine concentration, xanthine oxidase activity, and NADPH through the hexose monophosphate shunt. (Niki, 2004) [46].

5.6 Cancer

According to Gordon *et al.*, oxygen (Dioxygen)-reduction oxygen free radical intermediates cause certain types of endogenous damage by damaging the bases and the deoxyribosyl backbone of DNA (1986). When OFR attacks lipids or other biological components, it leaves reactive species that may link to DNA bases.

5.7 Lung disease

Due to the large endothelium surface's ongoing exposure to numerous air toxins such cigarette smoke, gasoline emissions, ozone, and nitrogen dioxide, the lung is constantly at risk of oxidative stress (e.g., 21 percent O2) (Duthie, 1996) [19].

5.8 Atherosclerosis

It is well known that LDL may be oxidized by several oxidants via different pathways (Pieper, 1995) [50]. The pathophysiology of atherosclerosis has been connected to the phagocyte-secreted myeloperoxidase (MPO). Another species that could have a role in atherosclerosis is the reactive nitrogen species. Although nitric oxide (NO) itself isn't truly an oxidant, it quickly interacts with oxygen to make peroxynitrite, which oxidises LDL into an atherogenic form.

6. Antioxidants of fruits and human health:

Nowadays, there is a huge demand for natural products because of the phytochemicals present in them which have a lot of health benefits. Acai berries, wolfberries, pomegranate concentrates, and pomegranate, cranberry, and blueberry extracts are just a few of the newer high-antioxidant fruit components that are making waves in the medical world. Wolfberries, which are rich in carotenoids, lutein, and zeaxanthin, are analogous to acai berries since both are high in anthocyanins and resemble other dark-colored fruits. (Liu, 2004; Sanjust *et al.*, 2008; Toure *et al.*, 2011) [39, 58, 64]. Fruit juice and other beverages have been demonstrated to benefit from the bio-fortification of vitamin C.

Table 3: Natural antioxidants present in fruits with their health benefits

Fruit	Antioxidants	Health Benefits	References
Apple	Campesterol, catechin, quercetin, ferulic acid, ascorbic acid	Reduce cholesterol, lipid oxidation, asthma	(Jideani *et al.*, 2021) [24]
Berries	Gallic acid, catechin, quercetin, resveratrol, anthocyanins, polyphenols	Growth inhibition, chemo-preventative, and chemotherapeutic actions were seen on the human lung epithelial carcinoma cell line A549.	(Jideani *et al.*, 2021; Ndiamaka *et al.*, 2019) [24, 45]
Carrot	Lycopene, α-carotene, β-carotene, selenium	NA	(Jideani *et al.*, 2021; Ndiamaka *et al.*, 2019) [24, 45]
Guava	Ascorbic acid, polyphenols, lycopene	Maintain blood pressure	(Jideani *et al.*, 2021; Ndiamaka *et al.*, 2019)
Grape	Gallic acid, p- coumaric acid, ferulic acid, lycopene, and lycopene	lowering blood sugar levels, lowering LDL cholesterol, blocking platelet aggregation, and acting as an antifungal agent	(Jideani *et al.*, 2021; Li *et al.*, 2014; Akbarirad *et al.*, 2015) [24, 71, 1]
Mango	α-carotene, β- carotene, lycopene, xanthophylls	Protecting human cells from damage, aids in the fight against degenerative illnesses like cancer and heart disease.	(Jideani *et al.*, 2021) [24]
Orange	α-carotene, β- carotene, ascorbic acid	Have anti-inflammatory, antitumor, antiviral, antiatherogenic, and the capacity to prevent human platelet aggregation capabilities.	(Jideani *et al.*, 2021) [24]
Papaya	β-carotene, xanthophylls, ascorbic acid, lycopene	NA	(Jideani *et al.*, 2021; Ndiamaka *et al.*, 2019) [24, 45]
Pineapple	Sterols, ferulic acid, gallic acid,	Antitumor, anti-invasion, anti-metastatic, and anti- inflammatory	(Jideani *et al.*, 2021) [24]
Pomebgranate	Gallic acid, campesterol	NA	(Jideani *et al.*, 2021) [24]
Tomato	Lycopene, β-carotene, ascorbic acid, flavonoids	Avoid diseases like Parkinson's and Alzheimer's	(Li *et al.*, 2014; Ndiamaka *et al.*, 2019; Akbarirad *et al.*, 2015) [71, 24, 1]

7. Future direction on natural antioxidant-rich fruits

According to recent studies, certain fruit seeds and peels, such as those from mango, pomegranate, grape, and wampee trees, have antioxidant capabilities (Sagar *et al*., 2018) [55]. To ensure the extraction and utilisation of these antioxidants in a range of food systems, all fruit plant parts including the peels, rind, seeds, core, rag, stones, pods, vine, skin, pomace, shell, and stem are being taken into consideration for glorification. (Saini *et al*., 2019) [56]. Research into antioxidant chemicals and the functional, nutraceutical, and prebiotic functions they play in individuals in the battle against cancer, neurological illnesses, and cardiovascular diseases has increased as a result of rising interest for and support for natural and minimally processed food items (Carocho and Ferreira, 2013) [14]. In an effort to optimize their advantages and relevance for human health, people are paying more and more attention to both conventional and exotic fruits as well as visually beautiful plants. It has also been recommended that one of the study fields should focus on growing genetically engineered plants that can generate larger levels of certain chemicals, generating higher levels of antioxidants (Jideani *et al*., 2021) [24].

8. Application

Natural and synthetic antioxidants both found wide use in the food industry. Many foods have a longer shelf life and seem more consistent because fats and oils are used as an extra ingredient. The primary utilization of plant extract with antioxidant pursuit in food processing were probed to there uses for heats paybacks conservation process changes for the better and shelf life add-ons. Polyphenols are one of the crucial compounds for antioxidant. Medically rich plant parts are commonly contains phenolic compounds likely stilbenes, lignins, coumarins, lignans, flavonoids phenolic acids etc. these compounds holds tons of biotic effects including antioxidant activity (Sindhi *et al*., 2013) [63].

Natural antioxidant are in favour of strategies act against the strategies outcome of oxidative stress. Oxidadative stress recognized as one of crucial factor in the expansion and onward movement of several diseases. The synthetic phenolic antioxidants similarly as butulated hydroxyaisole (BHA) which extensively includes antioxidant in the food industry. The economical range of synthetic antioxidant and the proper harmony with dietary intake and no detrimental effects in human todays (Leyva-Porras *et al*., 2021) [37].

Green and black teas preserve up to 30% of their dry weight as phenolic components as phenolic acids, flavonols, and flavandiols because they have historically been consumed in large quantities, notably for their antioxidant properties. Not only does it play an important function in preventing unpleasant alterations in the taste and nutritional content of food, but it also plays a part in preventing tissue damage in a wide variety of human illnesses. Almost every food and drug on the market today has an artificial antioxidant (Rodríguez-Varela & Labarta, 2020) [52]. These substances' primary function is to extend storage life, primarily by blocking the anti-oxidant activity of unsaturated double bonds in fatty acids. Information about N- acetylcysteins (NAC) frequently root in onion. There (NAC) is mainly used in cosmetics and food supplements. In a broder perspective, strong antioxidant activities obtained in citrus, berries, prunes, olives and cherries etc. temperature condition(1c and 20c) by taking the consideration of films namely nanoactive polyethyleneterephalate (Saso & Firuzi, 2014) [61].

As a food additive in oils and fats, antioxidants can extend the storage life of food and improve its aesthetic appeal. Antioxidants are being added to more and more foods in an effort to lower oxidation levels. In both fresh and processed foods, lipid oxidation is a leading cause of spoilage. For the most part, it should be avoided since it promotes the formation of rancidity and other potentially harmful reaction products in most foods (Kebede & Admassu, 2019) [33]. By adding antioxidants as a preservative, food can be protected from lipid oxidation, which can be a major health risk. Synthetic phenolic antioxidants such as propyl gallate (E310), tertiary butylhydroquinone (TBHQ), butylated hydroxyanisole (E320), and butylated hydroxytoluene are very effective at preventing oxidation (E321). Metals may attach to certain chelating substances, such as EDTA, preventing them from taking part in the oxidation process. polyphenols are the most significant compounds when it comes to the antioxidant properties of raw plant resources. Numerous phenolic compounds are present in medicinal plant components, including flavonoids, phenolic acids, stilbenes, tannins, coumarins, lignans, and lignins. One of the various biological effects of these chemicals is antioxidant activity (Aguiar *et al*., 2016) [2].

9. Conclusion

Antioxidants are substances that, even in extremely small quantities, significantly lessen the function of oxidation in the targets. Substances prevent further free radical production during lipid oxidation by adding hydrogen or electrons to a fatty acid containing an existing free radical. The free radical and fatty acid chain combine to generate this complex. Antioxidants oxidize themselves to remove the free radical intermediates and stop the chain reactions. Natural antioxidants are compounds found in a variety of naturally occurring foods, including fruits, vegetables, nuts, cereals, seeds, animal tissues, and more. They are the substances that interact with lipid radicals to break chemical chains and produce more stable products. In a lab, several chemicals are chemically combined to produce synthetic antioxidants. The best candidates for surface accumulation in the fat or oil phase are synthetic drugs that are safe to use and extremely active at low doses (0.01% to 0.02%).

The methodologies used to gauge antioxidant capacity can be divided into two groups. The classification used here is based on the processes that occur during the elimination of free radicals. The first group of approaches is based on the SET, in contrast to the second group, which is founded on the HAT. The neutralisation of free radicals was always the overall result of this process, regardless of its speed or the type of the accompanying secondary reactions. A putative antioxidant's ability to transport chemical species like metals, carbonyls, and radicals is evaluated using SET-based techniques. The antioxidant reduces the oxidant, which causes a shift in colour to show that SET has occurred.

Natural products are in high demand nowadays because of the phytochemicals they contain, which have numerous positive health effects. Acai berries, wolfberries, pomegranate concentrates, and pomegranate, cranberry, and blueberry extracts are just a few of the more recent high-antioxidant fruit ingredients that are creating waves in the medical community. Acai berries and wolfberries, which are both high in anthocyanins and resemble other dark- colored fruits, are comparable because they both contain lutein, zeaxanthin, and carotenoids

10. References

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