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Edible dry fruits and seeds in combating second wave of COVID-19 pandemic

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Abstract

Dry fruits and few edible seeds are very common consumable items with the rich source of polyphenolic compounds. Many other phytochemicals are also present in dry fruits and shows significant antioxidant activity that further correlated to get rid of many health complications. These fruits are commonly known as dry fruits or super foods with the rich content of proteins, vitamins, minerals and dietary fibre. They are well known for their immuno modulatory activities with various medicinal applications, especially as antiviral activity. The ongoing COVID outbreak has posed a serious threat to global health sector. At present, the second wave of coronavirus is already has started and gradually increasing day by day in worldwide which are stronger and much more detrimental for the people including in India. In connection with the previous history, it is obvious to increase immunity to fight against the pandemic virus. In the present manuscript, some important dry fruits and seeds are selected which have dual characters, *i.e.*, potent immune boosting property along with antiviral efficacy. Various phytochemicals like flavonoids, alkaloids, glycosides, sesquiterpenes, benzoic compounds were reportedly isolated from these plant extracts those are having strong antiviral as well as immune boosting properties. Therefore, the detail study of these dry fruits and seeds with their sources, chemicals responsible for the therapeutic efficacy, their structural nature, and potent uses along with their combined preparations as home as remedies in boosting immunity and also to resist the viral infection are discussed. The article will focus to the researchers for detailed ethnopharmacological and phytochemical studies on these dry fruit and seed plants used to treat as immuno modulators as well as in the development of novel antiviral drugs.

1. Introduction

People are assaulted by severe epidemics of infectious disease from the time immemorial and have exacted a terrible toll. Some have changed the course of history too. Of late, COVID-19 outbreak is such a terrible situation throughout the world, caused by a detrimental virus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Around the world, the sudden explosion of the COVID-19 pandemic has taken everybody at all levels a stern in an unprecedented manner. The COVID-19 virus taints humans and animals both and is so deadly that produces severe pneumonia followed by respiratory collapse and finally death. The virus when started to spread first from China (Wuhan city) in December 2019, the researchers and scientists from over the globe are started to know the structural behavior and pathogenesis of the virus and came to know the similarities with the severe diseases like Middle East respiratory syndrome and severe acute respiratory syndrome (SARS) (Wu and McGoogan, 2020). The virus produces the similar symptoms as SARS and named as SARS-CoV-2 in January, 2020 by the Chinese Authority. Furthermore, they also revealed that the novel corona virus is zoonotic type that started to spread from animals (bats or pangolins) (Gao *et al.*, 2020). Even it was also

revealed that the virus is faster spreading to the less immune peoples especially to the elderly people and the people with comorbidity, *i.e.*, with multiple medical diseases. Finally, WHO has declared the COVID-19 as a pandemic on 11th March, 2020 (WHO, 2020). The viruses named corona because of its crown like shape that contained single stranded, enveloped RNA covered with glycoprotein spikes on the surface (Khan *et al.*, 2020). It is a group of beta coronavirus containing identical genome sequence (79%) with SARS-CoV and with MERS-CoV (50%) (Lu *et al.*, 2020). A receptor binding site is present in the spike protein that recognizes the human angiotensin-converting enzyme 2 (ACE2) as its receptor (Li *et al.*, 2005). With the help of the spike proteins on the envelope, binds to their cellular receptors that lead to the fusion between host cells and viral membranes for host cell entry by triggered the process with the help of multiple genes such as cytoplasmic domain (CP), fusion protein (FP), heptad repeats (HP), receptor binding site (RBD), receptor binding motif (RBM), signal peptide (SP), HR1-2 (heptad repeats 1-2), and the transmembrane protein (TM) (Xu *et al.*, 2019) (Figure 1).

The virus rapidly spreads into the humans and further infected human spread infection to other human through various modes such as contact, surface infection, aerosolization of the virus particle during sneezing, coughing, *etc.* (Weijun *et al.*, 2005; van Doremalen *et al.*, 2020). The symptoms are like fever, dry cough and fatigue and in severer cases dyspnea. Particularly in children and young adults, the result is asymptomatic but older people and also people with comorbidities are at higher risk of severe disease, respiratory

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failure and death (Tian *et al.*, 2020). The viral infected persons are confirmed with 2 types of assays such as immunologic assays to identify antibodies (by the double-antigen sandwich method with a recombinant N protein and a partial S protein of SARS-CoV, and results were confirmed by Western blot method) (Towbin *et al.*, 1979) and reverse transcription polymerase chain reaction (RT-PCR) to detect the viral genome which is carried out with virus-specific primers, extracted from blood samples and the total RNA was then reverse transcribed with random hexamers, and cDNA was amplified with a nested PCR method (Chen *et al.*, 2004). Even though, the death toll of more than 27 Lakhs (2.73 M) throughout the world as on 23rd March, 2021, affected with 215 countries and territories worldwide. Among that, 1.60 lakhs death occurs in India only till 23rd March, 2021. Due to global emergency at the earliest basis, numbers of vaccines are come into the market. Among them, Covishield (ChAdOx1 nCoV-19 coronavirus vaccine, Recombinant), manufactured by Serum Institute of India Pvt. Ltd., with collaboration of the Oxford-AstraZeneca, Covaxin (an inactivated vaccine, developed by Bharat Biotech, India) are extremely popular in India against novel coronavirus. These vaccines are exported to Latin America, UK, Canada, Brazil and Mexico. Apart from that, BNT162b2 (mRNA vaccine, developed by Pfizer, Inc., and BioNTech), mRNA-1273 (mRNA vaccine, developed by ModernaTX, Inc.), JNJ-78436735 (Viral vector, developed by Janssen Pharmaceuticals Companies of Johnson and Johnson) are

also applied against COVID-19 virus (Patel *et al.*, 2020; Kaur and Gupta, 2020; Dong *et al.*, 2020). As per WHO, the first mass vaccination programme started in early December 2020. Till now, 1.30% of world population fully vaccinated and among them 0.55% of Indian population fully vaccinated that reduced the death rate as well as actively infected people but again the death count shoots up in the recent month, 2021 and expected as second wave of COVID-19 virus in a new form which is stronger than former strain. Moreover, there are many controversial statements about the effectiveness of COVID-19 vaccine especially in terms of storage of the vaccine and some adverse effects such as soreness at the injection site after the first dose and fatigue, myalgia, arthralgia, headache, pain, and redness at the injection site (2.0%) after the second dose (Kyriakidis *et al.*, 2021) and people are scared to take vaccination but by the time world's lives completely dismantled through this gruesome situation and the proper rules and guidance for cope up the COVID-19 pandemic remains grossly unfulfilled. Therefore, an alternate method for increasing immunity through home remedies are achieved more concentration to fight against Covidvirus. Of late, boosting immunity through dry fruits is really fulfilling the thrust areas and plays a significant role in combating covid-19 virus infection. In this manuscript, such important edible dry fruits and seeds are listed and discussed about their role as immunomodulators and as well as antiviral properties with their responsible phytochemicals.

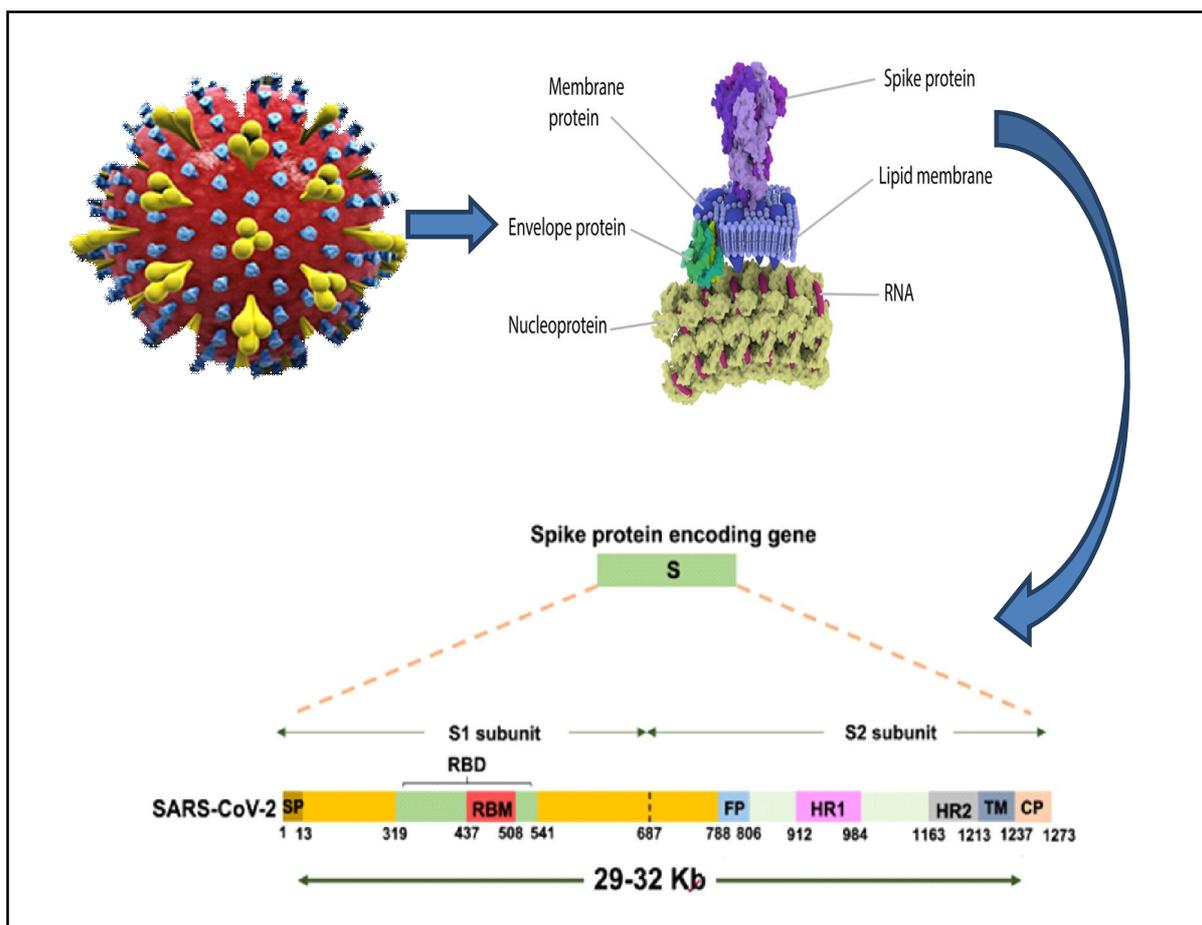


Figure 1: Genetic code of spike protein in novel coronavirus.

2. Methods

The literature search was performed using many electronic databases, viz., EMBASE, PubMed and Google Scholar. Hand searching of the reference lists of the retrieved studies was performed to identify further relevant publications.

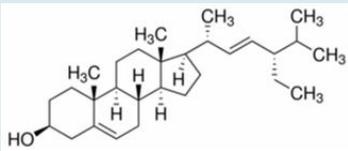
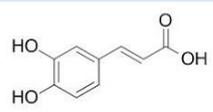
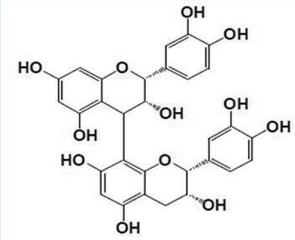
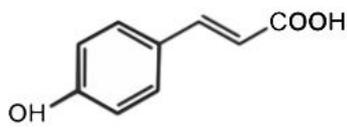
3. Dry fruits

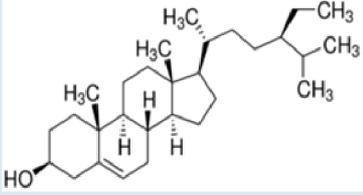
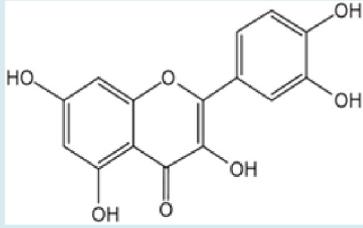
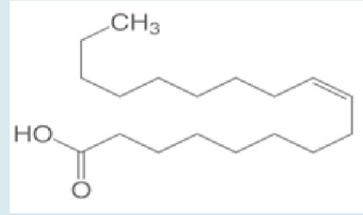
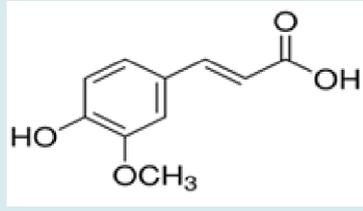
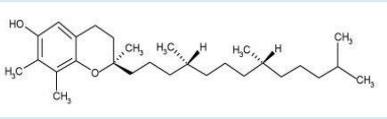
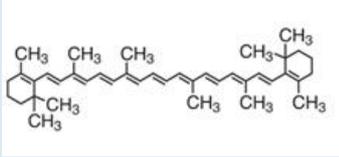
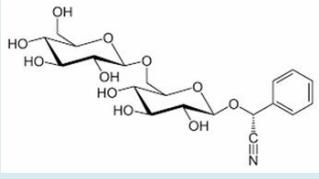
Dry fruits and seeds contain same nutritional values like fresh fruits. Fresh fruits are generally perishable because of the presence of water or moisture. Even they are the source or favorable medium for development of microorganisms and for the progress of certain biochemical processes like fermentation, affected by various enzymes. Hence, for the stability of the fruits, the water content should minimum as the value should be from 18 to 23% that enabling their storage in ordinary conditions. Fruits are dried whole or sliced depending on their size. Plums, cherries, morello cherries, blueberries, blackcurrants and figs are dried whole whereas peaches, apricots are dried sliced.

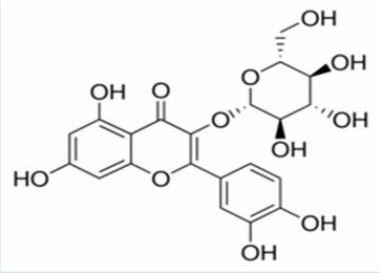
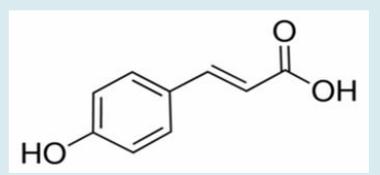
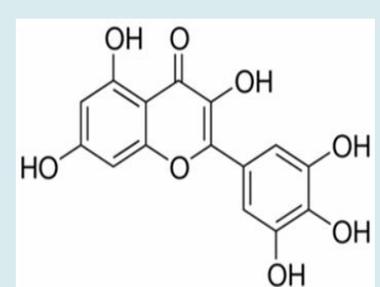
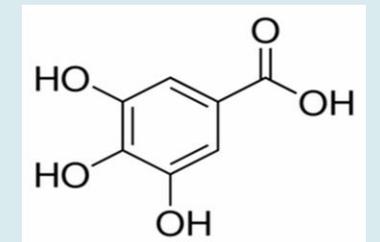
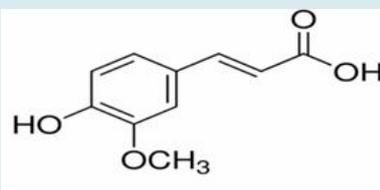
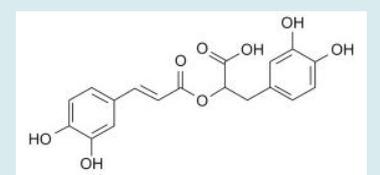
Dry fruits or superfoods are always superior to other food items with respect to the nutritional value. The dry fruits contain abundant nutrition in form of nutrients, fibre, vitamins (Riboflavin, Vitamin

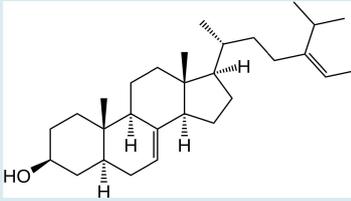
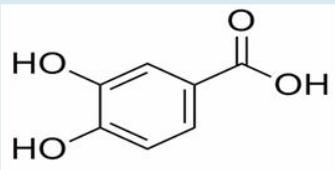
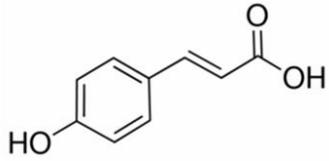
A-C-E-K-B6), minerals (calcium, copper, iron, magnesium, potassium, phosphorus, and zinc) and proteins. Not only that, they have some special characteristic or benefit in providing relief from some ailment or disease, enhances immunity, reduces blood pressure, sugar or cholesterol, any heart diseases and provides internal strength and stamina. Dry fruits just like berries and nuts are high on antioxidants and also nowadays use as dietary supplements (Beyhan *et al.*, 2010). They are mostly used in confectionaries, bakery products and sweet industries. Even some are used in cosmetic industries as prevent ageing, reduce skin tanning, skin glowing effect by resistance of ultraviolet B(UVB), *etc.* (Sachdeva and Katyal, 2011; Li *et al.*, 2020). Perhaps they are potent antiviral agents too. Many literatures revealed the antiviral efficacy of dry fruits (Nikolaeva-Glomba *et al.*, 2014; Musarrapizzo *et al.*, 2019) along with immunomodulatory activity which are more interest in the present COVID-19 situation to build up self immunity. Based on that, in this paper few important edible dry fruits and seeds are documented with their effects. The listed dry fruits and seeds are namely; almond, cashews, raisins, walnuts, pistachio, apricots, dates, peanuts, hazelnuts, sunflower seeds, pecans, chestnuts, prunes, dry figs, fox nuts, flax seeds, chia seeds, pumpkin seeds, betel nuts, and dry coconut (Table 1).

Table 1: Dry fruits with their responsible phytochemicals

Dry fruit name	Biological source	Important chemical constituents	Cultivation in India
ALMOND	Seeds of <i>Prunus amygdalus</i> fruits F: Rosaceae	 Stigmasterol	In hilly states of Jammu and Kashmir and Himachal Pradesh
DATES	Fruits of <i>Phoenix dactylifera</i> F: Asteraceae	 Caffeic acid	Kachchh district of Gujarat, Punjab and Rajasthan are major dates growing states
WALNUTS	Fruits of <i>Juglans nigra</i> F: Juglandaceae	 Proanthocyanidin B2	Jammu and Kashmir, Uttarakhand, Himachal Pradesh and Arunachal Pradesh
PEANUTS	Nuts of <i>Arachis hypogea</i> F: Fabaceae	 p- Coumaric acid	Gujarat, Tamil Nadu, Andhra Pradesh, Maharashtra, Karnataka, and Rajasthan.

HAZELNUTS	Nut of <i>Corylus avellana</i> F: Betulaceae	 <p style="text-align: center;">Beta-Sitosterol</p>	Shimla, Kinnaur and Chamba districts of Himachal Pradesh, a northwestern hilly state
SUNFLOWER SEEDS	Seeds of <i>Helianthus annuus</i> F: Asteraceae	 <p style="text-align: center;">Quercetin</p>	Karnataka, Andhra Pradesh, Maharashtra, Bihar, Orissa and Tamil Nadu
PECANS	Fruits of <i>Carya illinoensis</i> F: Juglandaceae	 <p style="text-align: center;">Oleic acid</p>	Mainly grows in Jammu and Kashmir, and Himachal Pradesh
CHESTNUTS	Fruits of <i>Castanea sativa</i> F: Fagaceae	 <p style="text-align: center;">Ferulic acid</p>	In the mid to lower elevations of the Himalayan region
PISTACHIO	Fruits of <i>Pistaci avera</i> F: Anacardiaceae	 <p style="text-align: center;">Gamma-Tocopherol</p>	Mainly grown in Jammu and Kashmir
CASHEWS	Nuts of <i>Anacardium- occidentale</i> F: Anacardiaceae	 <p style="text-align: center;">Beta-Carotene</p>	Andhra Pradesh, Goa, Karnataka, Kerala, Maharashtra, Orissa, Tamilnadu and West Bengal
APRICOTS	Seeds of <i>Prunus armeniaca</i> F: Rosaceae	 <p style="text-align: center;">Amygdalin</p>	Hills of Himachal Pradesh, Jammu and Kashmir, Uttar Pradesh

RAISINS	Fruits of <i>Vitis vinifera</i> F: Vitaceae	 <p style="text-align: center;">Quercetin-3-o-glucoside</p>	Sangli, Solapur and Nashik districts of Maharashtra and Bijapur and Bagalkot districts of Karnataka
PRUNES	Fruits of <i>Prunus domestica</i> F: Rosaceae	 <p style="text-align: center;">para-coumaric acid</p>	Punjab, Himachal Pradesh, Uttar Pradesh, and Jammu and Kashmir
DRY FIGS	Fruits of <i>Ficus carica</i> F: Moraceae	 <p style="text-align: center;">Myricetin</p>	Maharashtra, Gujarat, Uttar Pradesh, Karnataka and Tamil Nadu
FOXNUTS	Nuts of <i>Euryale ferox</i> F: Euryalaceae	 <p style="text-align: center;">Gallic acid</p>	Bihar, Assam, Manipur, West Bengal, Tripura and Odisha
FLAX SEEDS	Seeds of <i>Linum usitatissimum</i> F: Linaceae	 <p style="text-align: center;">Ferulic acid</p>	Maharashtra, Bihar, Rajasthan, Uttar Pradesh, Karnataka and West Bengal
CHIA SEEDS	Seeds of <i>Salvia hispanica</i> F: Labiatae	 <p style="text-align: center;">Rosmarinic acid</p>	Madhya Pradesh (Mandsaur and Neemuch), in Uttar Pradesh (Amseruva, and Siddhaur)

PUMPKIN SEEDS	Seeds of <i>Cucurbita pepo</i> F: Cucurbitaceae		Odisha, Madhya Pradesh, Uttar Pradesh, Chattisgarh, West Bengal.
BETEL NUTS	Nuts of <i>Areca catechu</i> F: Arecaceae		Karnataka, Kerala, Assam, Tamil Nadu, Meghalaya and West Bengal.
DRY COCONUT	Kernel of <i>Cocos nucifera</i> F: Arecaceae		Kerala, Karnataka and Tamil Nadu, Goa, Maharashtra, Andhra Pradesh, and Orissa

3.1 Almonds

Almonds are edible seeds, native to the Mediterranean region, mainly Iran (Figure 2). They are rich in protein, fibre, vitamin E, calcium, copper, magnesium and riboflavin. Because of presence of many essential phytoconstituents, especially phytosterols (campesterol, beta-sitosterol, 5-avenasterol and stigmasterol), they have rich antioxidants activity. They contain no dietary cholesterol and the high content of monounsaturated fatty acids (MUFAs) (Griel and Kris-Etherton 2006). Hence, they are applied in many health-related issues like constipation, respiratory issues, heart disorders and strengthening of immune system (Richardson *et al.*, 2009), besides it also applied in cosmetic field for hair, skin and teeth nourishment.



Figure 2: Almond nuts.

Due to presence of polyphenolics and flavonoids, they are strong antioxidant agents. Research literatures results the potent antioxidant activity of the fractions of almond aqueous extract due to the presence of isolated various polyphenols such as vanillic, caffeic, p coumaric, ferulic acids, quercetin, and kaempferol (Amarowicz *et al.*, 2005; Oliveira *et al.*, 2018). Earlier literature revealed high levels of cytokine production with almond seeds such as interferon- α (INF- α), interleukins (IL-12), INF-gamma and tumour necrosis factor (TNF- α). The seeds improve the immune surveillance of the peripheral blood mono nuclear cells towards viral infections. It significantly decreases in the Herpes simplex virus (HSV-2) replication and stimulates the immune response and helps in an antiviral immune defense (Arena *et al.*, 2010; Mandalari *et al.*, 2010). With its vital applications, during COVID situation, it is used as an ingredient in boosting immunity and fighting against COVID-19 virus.

3.2 Cashews

Cashew is a tropical fruit native of South and Central America (Brazil) and grown well in the North and Northeast regions (Figure 3). The cashew nuts are rich source of vitamins E and B6. Apart from that, the nut also contains high amount of carbohydrates, proteins, phosphorous, iron, zinc, magnesium, fibers, and mono and poly unsaturated fatty acids. Apart from that, many phytoconstituents like alkaloids, flavonoids, saponins, tannins, sterols, mainly β carotene, lutein, zeaxanthin, α tocopherol, γ tocopherol, thiamin, stearic acid, oleic acid, and linoleic acid are present (Trox *et al.*, 2010).

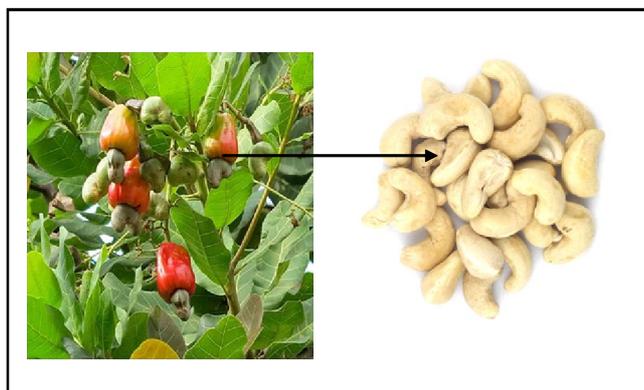


Figure 3: Cashew nuts.

Due to such plant constituents, it shows many medicinal activities especially, increase bone mineral density (Rivas *et al.*, 2013), decreased risk of metabolic syndrome (Fernández Montero *et al.*, 2013). It contains high number of polyphenols that shows antioxidant activity (Soares *et al.*, 2013) and recently showed potent immunomodulatory activity (Mattison *et al.*, 2020). It also shows significant antiviral activity against cowpea mild mottle virus on soybean (Andayanie *et al.*, 2019). It is used to bring a rich texture and flavour to various dishes. It has commercial value due to its edible hypocarp and nutritious kernel. With its vital applications, it is used as an ingredient in booting immunity against COVID-19 virus.

3.3 Raisins

Raisins are dried grapes, made from dehydrated grapes (Figure 4). The grape is the native of North America. They are used in both sweet and savoury food preparations. They are good for health and have been known to reduce acidity and help in digestion. They contain micronutrients, vitamins, folate, potassium, magnesium, and also fibres. They are rich dietary source of flavonol glycosides, triterpenoids, phenolic acids, stilbenoid, flavonoids, proanthocyanidins, hydroxybenzoic acid. Caffeoyl tartaric acid (CTA) and quercetin 3-0-glucuronide are also present in high amounts.

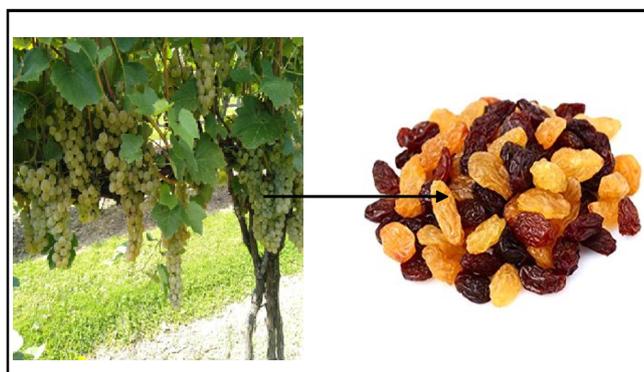


Figure 4: Raisins.

Many medicinal applications such as treatment of obesity and diabetes, gastric cancer prevention, dental decay reduction, and decrease in total cholesterol, and LDL cholesterol, *etc.*, are reported with the presence of many phytochemicals in raisins (Jeszka-

Skowron and Czarczynska-Goslinska, 2020). Due to presence of polyphenols (flavanol, (+)-Catechin, phenol acid, transcaftaric acid, flavonol, quercetin-3-O-glucoside, anthocyanin and malvidin-3-O-(6-O-p-coumaroyl-glucoside), they act as antioxidants in the body (Hardin-Fanning, 2008; Williamson and Carughi, 2010; Kelebek *et al.*, 2013). It also showed potent immunomodulatory activity by upgrade the secretion level of tumor necrosis factor- α (TNF- α) in mice serum due to presence of proanthocyanidins (Tong *et al.*, 2011). Significant antioxidant and antiviral activity are also reported for chloroform fraction against Herpes simplex virus type-1 (HSV-1) and Parainfluenza viruses (PIV) (Orhan *et al.*, 2009). With its multiple medicinal applications, it is used as an ingredient in booting immunity against COVID-19 virus.

3.4 Walnuts

This shelled nutty delight is native to North and South America, southern Europe, Asia, and the West Indies. These nuts are extremely nutritious (Figure 5). There are two types of walnuts, *viz.*, black or Persian and English walnuts. It is rich with Omega-3 fatty acids, dietary fibres, proteins, antioxidants, vitamins and minerals. Apart from that, bioactive compounds such as flavonoids, phenolic acid (ellagic acid), phenolic compounds (catechin), melatonin, folate, gamma tocopherol (vitamin E), selenium, juglone, phytosterols, and proanthocyanidin B2 (condensed tannin) are rich (Segura *et al.*, 2006; Yang *et al.*, 2009). But in comparison, the black walnut contains higher levels of monounsaturated fatty acids, polyphenols and γ -tocopherol than English walnut (Câmara and Schlegel, 2016).

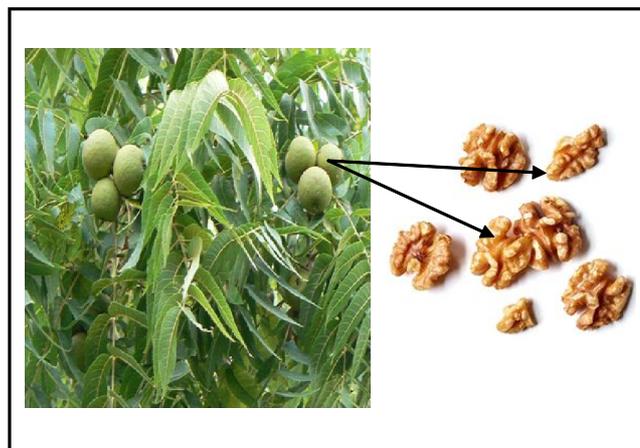


Figure 5: Walnuts.

It shows many medicinal or therapeutic efficacy due to the presence of essential bioactive compounds such as polyphenols promote neuronal calcium homeostasis in the striatum and hippocampus of the brain crucial for primary and secondary memory functions (Oliveira *et al.*, 1997), carotenoids, alkaloids, nitrogen-containing or organosulfur compounds helps in direct neuroprotection (Willis *et al.*, 2009). It has potent antiviral activity due to presence of juglone which was established by the computational method (Vardhini, 2014). Potential immunomodulatory activity and antioxidant activities are reported for walnuts (Soussi *et al.*, 2018). The immunomodulatory activity of walnuts are determined for oligopeptides *via* innate and adaptive immunity, spleen T lymphocyte subpopulations, serum cytokine and immunoglobulin levels and result revealed significant improvement of humoral and

cell-mediated immune responses, macrophage phagocytosis and natural killer cell activity (Mao *et al.*, 2020).

3.5 Pistachios

Pistachios are native of Central Asia, especially in Iran, United States, and Mediterranean countries. They are edible fruits, important source of energy (Figure 6). They contain nutrients, minerals (sodium, calcium, phosphorus, iron, magnesium), antioxidants (tocopherols, carotenes, lutein, selenium, flavonoids), fibres, phytoestrogens (5,6beta-carotene, alfacarotene, and cryptoxanthin) and vitamins (Vit-A, Vit-B6) (Ghaseminasab *et al.*, 2015).

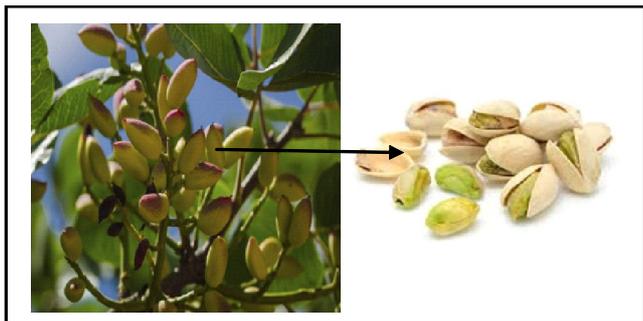


Figure 6: Pistachio fruits.

Due to presence of many essential chemicals, they have multiple health benefits and shows versatile therapeutic applications. It boosts the immunity with the rich source of vitamin B6 and some minerals such as zinc, copper, iron, selenium, and folate. The fruits showed potent antioxidant activity due to the presence of polyphenols especially, tocopherols, gamma tocopherol (Gentile *et al.*, 2007; Taghizadeh *et al.*, 2018). They also have bioactive compounds like flavonols, flavanones, isoflavons, flavan-3-ols, proanthocyanidins and anthocyanin, phenolic acids and stilbenes. They are effective for the heart as they lower the bad cholesterol level (Casas-Agustench *et al.*, 2011). They also help to prevent diabetes and boost immunity. Antiviral activity of pistachio extracts (*Pistaciavera* L.) was reported by resists the Herpes Simplex Virus 1 (HSV-1) replication due to the presence of polyphenols (Musarra-Pizzo *et al.*, 2020).

3.6 Apricots

Apricots are belonging to genus *Prunus*, native to Asia especially in China, and are hugely popular in Middle Eastern countries, with Turkey and Iran. They are also known as stone fruit because the single seed is enclosed in a hard, stony shell (Figure 7). They are rich in fibres, and are a good source of vitamin A, C, E and copper. Apart from that, it contains minerals especially potassium, iron, magnesium and Phosphorus (Gupta *et al.*, 2018). Vitamin E, like all anti-oxidant vitamins (A and C), is vital in protecting the cells from damage caused by free radicals. Dried apricots are good for the skin, eyes and the immune system.

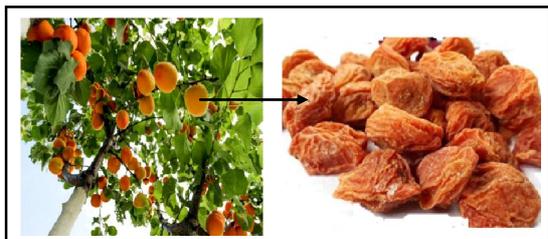


Figure 7: Apricot fruits.

The fruit contains carotenoids, flavonoids like quercetin-3-rutinoside, quercetin-3-galactoside and quercetin-3-glucoside. It shows many therapeutic efficacies especially antiparasitic, anticancer, antiaging, antiatherosclerating, antianginal, cardioprotective, hepatoprotective, renoprotective, antitussive, antiinflammatory, antinociceptive and antioxidant due to the presence of beta-carotene (Sharma *et al.*, 2014; Minaiyan *et al.*, 2014). Apricot shows potential antioxidant activity due to the presence of beta carotene, ascorbic acid and polyphenols (Wani *et al.*, 2017). The antiviral potential of apricot extract reported against herpes simplex virus type 1 (HSV 1) and type 2 (HSV 2), enveloped DNA viruses due to the presence of higher content of phenolics (Nishide *et al.*, 2019). Thereafter, ethanolic apricot seed extract showed potent antiageing and immunomodulatory effect due to presence of amygdalin (Ramadan *et al.*, 2020).

3.7 Dates

Dates are the one seeded fruit obtained from dates palm trees. The plant is native to Persian Gulf area (Iran), mainly grown in the Canary Islands, northern Africa, the Middle East, Pakistan, India, Mexico, and the U.S. state of California (Figure 8). They are used in different types of sweet dishes and can also be consumed on their own. The dry fruit is rich in vitamins (Vitamins B-complex and C), proteins, minerals (selenium, copper, potassium, and magnesium) and natural sugar (fructose and glucose) (Al-Farsi and Lee, 2008). The plants are naturally wind pollinated. Dry dates are used as a snackfood, in sweet and savory dishes, and in many dessert items.

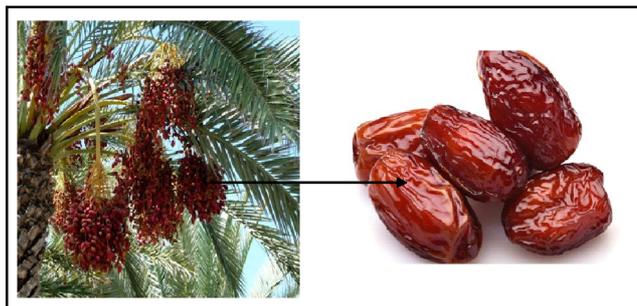


Figure 8: Date fruits.

Date fruits show many therapeutic activities, *viz.*, antioxidant, anti-mutagenic, anti-inflammatory, gastroprotective, hepatoprotective, nephroprotective, anticancer, immunestimulant activities, *etc.*, due to presence of flavonoids, and phenolic compounds (Tang *et al.*, 2013). Antioxidant activity of dates is reported with the presence of flavonoids and phenolic contents (Biglari *et al.*, 2008). It shows immunomodulatory activity with the presence of phenolic compounds (Hasan *et al.*, 2010). It also shows potent antiviral activity by inhibited the infectivity of *Pseudomonas* phage ATCC 14209-B1 and prevented bacterial lysis (Jassim and Naji, 2010).

3.8 Peanuts

Peanut or “groundnuts” are the edible seeds of a legume (Pea family), belongs to the native to tropical South America (Figure 9). It is an annual herbaceous plant. They are rich in protein, oil, monounsaturated fat and fibers and are widely used for production of peanut butter, confections, roasted peanuts, snack products, soups and desserts. It has antioxidant activity and anti aging property due to the presence of resveratrol. It contains various bioactive compounds such as flavonoids (catechin, epicatechin, apigenin, and luteolin),

carotenoids, phenols (p-coumaric acid), and phytosterols (alpha and beta-Carotene, beta-cryptoxanthin, lutein, and zeaxanthin) (Oliver-Chen and Blumberg, 2008).



Figure 9: Peanuts.

Due to presence of vitamin E, caffeic, coumaric acid, flavonoids, stilbenes and polyphenolic compounds, it shows powerful antioxidant activity (Limmongkon *et al.*, 2017).

With the presence of resveratrol, it shows immunomodulatory activity. The antiviral activity of ethanol extracts of peanut skins was evaluated against various influenza viruses using cell-based assays and affirmed the activity due to the presence of high content of polyphenols (Makau *et al.*, 2018).

3.9 Hazelnuts

Hazelnuts are a member of genus *Corylus*, of hazel deriving from species *avellana*. It is very expensive nut and needs cold and hilly terrain. The tree nut is native to Europe and western Asia (Figure 10). It is a deciduous tree with attractive flowers. It contains rich source of proteins, carbohydrates, unsaturated fatty acid (mainly Oleic acid), dietary fibre, vitamins (vitamin E, B1, B2 and B6 complex), minerals (potassium, phosphorus, calcium, magnesium, boron, copper, manganese and selenium) and other fatty acids like palmitic acid, stearic acid, linoleic acid and linolenic acid (Kornstriner *et al.*, 2013). It also contains many essential amino acids namely; amino acids like glutamic acid, arginine, alanine and aspartic acid, *etc.* Due to presence of the minerals, it maintains healthy nerve function and balanced body system (Ozkutlu *et al.*, 2011).



Figure 10: Hazelnuts.

Various bioactive compounds such as tocopherols (alpha-tocopherol), phytosterol (beta-sitosterol, squalene), phenolics (mono and oligomeric flavan-3-ols), filbert (principal flavor compound), flavan-3 ol, anthocyanins, isoflavones, *etc.*, are present. Antioxidant activity of fresh or dry hazelnuts was evaluated due to presence of content of polyphenols and tocopherols (Arcan and Yemenicioglu, 2009; Pycia *et al.*, 2020).

3.10 Sunflower seeds

The seeds are mainly the fruits of the sunflower plant, situated inside the round flower head. The perennial plant is mainly the native of North and Central America. Seeds are used as snack, as a confectionary nut, salad garnish and mainly for oil production. Seeds contain protein, unsaturated fats, fiber, essential amino acids (phenylalanine and tyrosine, leucine, methionine, cysteine), vitamin-E, selenium, copper, zinc, folate, iron, *etc.* Edible seeds are also rich in poly unsaturated fatty acids (approximately 31.0%), flavonoids, phenolic acids (Pasko *et al.*, 2009). Traditionally, the seeds are used for the treatment of bronchial, laryngeal and pulmonary infections, coughs and colds and in whooping cough (Bashir *et al.*, 2015).

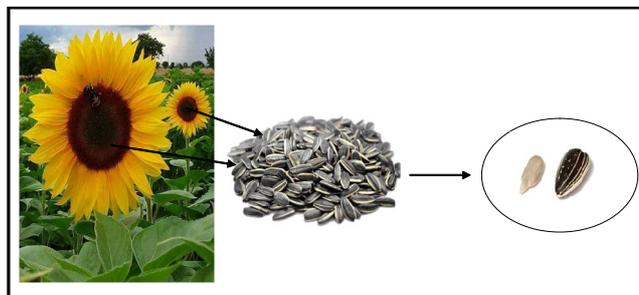


Figure 11: Sunflower seeds.

The main bioactive components are flavonoids (heliannone, quercetin, kaempferol, luteolin, apigenin) and phenolic acids (caffeic acid, chlorogenic acid, caffeoylquinic acid, gallic acid, protocatechuic, coumaric, ferulic acid, and sinapic acids), polyunsaturated fatty acids, and vitamins (Kamal, 2011) and due to presence of these constituents, the seed shows versatile therapeutic applications, *viz.*, antioxidant, antimicrobial, anti-inflammatory, antihypertensive, wound-healing, and cardiovascular actions. The seeds show immune boosting activity with the presence of high content of selenium mineral and vitamin E. Due to presence of phenolic compounds, it showed potent antioxidant capacity (Giada and Mancini-Filho, 2009). Other literature also revealed high antioxidant potential of sunflower seed with the presence of polyphenols (*e.g.*, caffeic, chlorogenic, caffeoylquinic, sinapic, ferulic, gallic, coumaric, and protocatechuic acids) (Pajak *et al.*, 2014).

3.11 Pecans

Pecan nuts are the seeds, native to North America (Mexico) and the southern United States in the region of the Mississippi River (Figure 12). The seeds are rich in fats (unsaturated or saturated fatty acids), source of thiamine, folate, niacin, riboflavin and vitamin B6, as well as minerals like calcium, iron, magnesium, phosphorus, and zinc. Oleic acid is the most significant mono unsaturated fatty acid, others constituents like oleic acid and linoleic acid are also present. It contains also a dietary source of alpha-tocopherol, gamma-tocopherol and squalane.

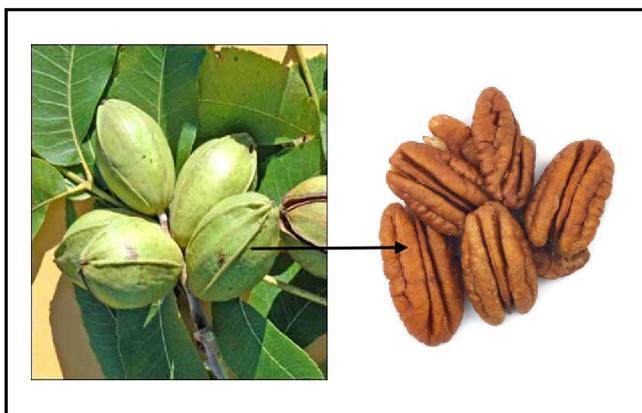


Figure 12: Pecan nuts.

Bioactive constituents like sterols (campesterol, stigmasterol, beta-sitosterol), phenolic acids, flavonoids, glycosylated phenolic acids, glycosylated flavonoids and (epi) catechin are present. Due to these active constituents, it showed antimicrobial as well as antioxidant activities (do Prado *et al.*, 2014). It also showed potent antiviral activity due to the presence of phenolics in pecan kernels (Flavan-3-ol, anthocyanidins, proanthocyanidins and phenolic acid). It reduces the risk of developing cancer, diabetes, cardiovascular disease and Alzheimer's disease with the presence of abundant polyphenolic compounds (Li *et al.*, 2014).

3.12 Chestnuts

There are four different types of chestnuts, namely; American, European, Japanese and Chinese chestnuts. European chestnut is also known as sweet chestnut, native to Southern Europe, Western Asia and North Africa whereas American chestnuts are native to the Appalachian forests of the United States from Maine to Georgia (Figure 13). The nut contains mainly carbohydrates (mostly in starch and sucrose form), mineral nutrients (Ca, Mg, P and K), other essential fatty acids, several vitamins (vitamin C, E, thiamine, riboflavin, niacin, pyridoxine, folate) (Aguilar *et al.*, 2016). They are used in inflammation and swelling, bacterial infections, diarrhea and cardiovascular disorders.

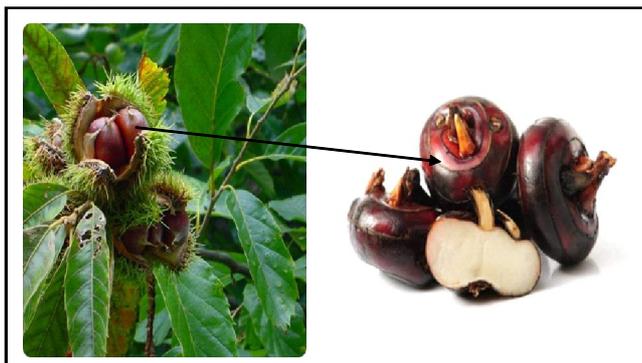


Figure 13: Chestnuts.

The main bioactive components such as phenolic compounds in terms of phenolic acids (Ellagic and gallic acids), flavonoids (quercetin derivatives), and tannins are present in nuts (Braga *et al.*, 2015). *In vitro* antiviral activity against human viruses (avian reovirus and avian metapneumovirus) was revealed by MTT assay with the presence of tannins in the nuts (Lupini *et al.*, 2009). The extracted

nut shell showed potent immunomodulatory activity using blood and intestinal leukocytes of *Oncorhynchus mykiss* models with the presence of phenolic compounds (Coccia *et al.*, 2019). Due to the presence of phenolic constituents, they are microbial resistant and potent antioxidant (Silva *et al.*, 2020).

3.13 Prunes

Prunes are dried plums, contain high dietary fibre. It is native to Europe, Asia and America. Mainly two species like, European plum and the Japanese plum are commercial significant across the globe. Fruits are medium size, globose to oval and the flesh is firm and juicy (Figure 14). It contains carbohydrate, protein, fats, minerals (Ca, Mg, P, K, Zn, Cu and Mn), vitamins (Vitamin A, B1, B2, B3, B5, B6, E and K), carotenoids, *etc.* It also has sugar alcohol sorbitol and phenolic compounds, predominantly chlorogenic and neochlorogenic acids (Stacewicz Sapuntzakis *et al.*, 2001). Traditionally, it is used as a remedy for constipation.



Figure 14: Prune fruits.

Many bioactive components are also present and due to that it shows many therapeutic activities. It contains polyphenolic compounds (chlorogenic acid, neochlorogenic acid, caffeic acid, coumaric acid) and flavonoids (rutin, proanthocyanidin) which shows anticancer and antioxidant activity (Madaru *et al.*, 2010). It shows effective antiviral action against HIV-1 (Oh *et al.*, 2011). Apart from that dry prunes also contain benzaldehyde, 2-furancarboxyaldehyde and ethyl cinnamate. It also shows potent immunomodulatory activity due to the presence of protocatechuic acid (water soluble monomeric phenolic acid) (Rasne *et al.*, 2018).

3.14 Dry figs

Fig is one of the tropics and subtropics area fruit. The fruit is hollow and fleshy structured (Figure 15). It is native to southwest Asia and the Mediterranean region (Afghanistan, Portugal). The fruit is having economic importance and also eaten as bushfood. Dry figs contain high amount of protein, lipids, dietary fiber, minerals (Cu, Mg, K), vitamins (riboflavin, thiamine, B6, K) and sugars. It contains many important phytoconstituents, *viz.*, phenolic compounds (gallic acid, chlorogenic acid), flavonoids (rutin, quercetin-3-O-rutinoside, epicatechin) (Vinson, 1999).

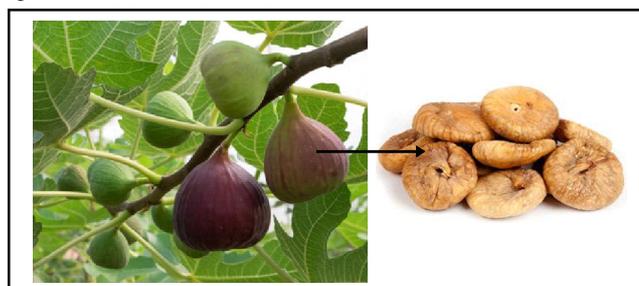


Figure 15: Dry figs.

Due to presence of versatile phytoconstituents such as alkaloids, flavonoids, terpenes, saponins, coumarins, sterols, and terpenes, it shows multiple therapeutic action. It shows highest antioxidant activity due to the presence of polyphenols, flavonoids and anthocyanins (Caliskan and Polat, 2011). The latex of fig fruits showed potent antiviral action against human viruses (caprine herpesvirus-1) (Camero *et al.*, 2014). Immunomodulatory action of fermented fig fruits is revealed due to the presence of coumaric acid, aconitic acid, and polyphenols (Zhao *et al.*, 2020).

3.15 Fox nuts

Fox nuts are aquatic nut, commonly known as makhana or gorgon nut or prickly water lily. One fox nut plant produces more than 100 seeds which contains mainly essential amino acids. The seeds are used as stuffy dish. Roasted fox nuts are also used as snacks. It is native to tropical and subtropical regions of South East and East Asia (Figure 16). It has rich source of carbohydrate, proteins and minerals (mainly Fe).

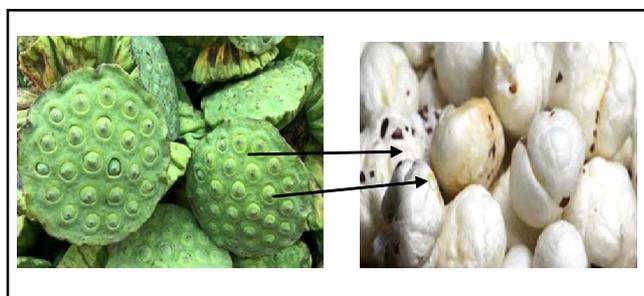


Figure 16: Dried fox nuts.

Apart from these constituents, many other bioactive components are also available like flavonoids (mainly kaempferol), phenols, ascorbic acid, sugars. Due to presence of many phytochemicals, it is used as antidiabetic, antioxidant activities (Song *et al.*, 2011).

3.16 Flax seeds

Flax is an annual herbaceous plant, native to southern Mexico and northern Guatemala. The seeds are consumed grounded or as whole grain in fruit juices, milk, in refreshing drinks and salads (Figure 17). It has high content of polyunsaturated fatty acids especially, alpha-linolenic acid, linoleic acid, oleic acid, minerals, proteins, and dietary fiber (soluble flaxseed fiber mucilage- d-Xylose, L-Galactose, L-Rhamnose, d-galacturonic acid), *etc.* (Porrás-Loaiza *et al.*, 2014).

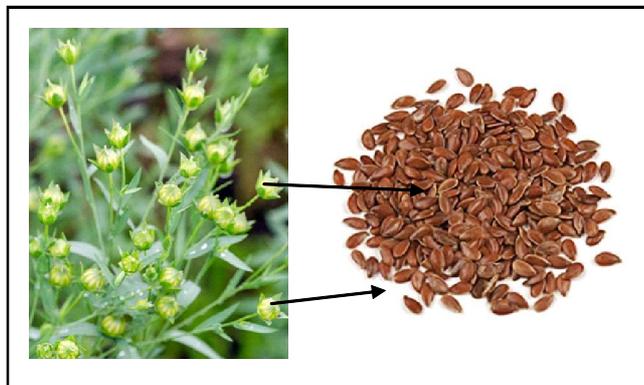


Figure 17: Flax seeds.

It contains the main bioactive compounds such as lignans (secoisolaricresinol-diglycoside (SDG), cyanogenic glycosides (linamarin, linustatin, neolinustin). Immunomodulatory activity of flaxseed extract was evaluated with the presence of phenolics (Kasote *et al.*, 2012). Potent antioxidant activity of flax seed reported due to presence of ferulic acid and butylated hydroxyl toluene (Slavova-Kazakova *et al.*, 2016).

3.17 Chia seeds

Chia seeds are very small seeds, black oval shaped, belongs to mint family. They have high nutritional and medicinal values (Figure 18). The plant is native of Southern Mexico and Northern Guatemala. They have omega-3 fatty acids, polyunsaturated fatty acids, dietary fiber, proteins, vitamins (Vitamin A, B1, B2, niacin, K, E and D) and important minerals (Ca, P, K, Mg).

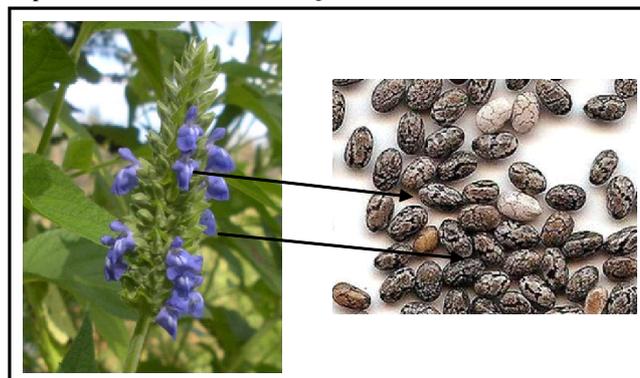


Figure 18: Chia seeds.

They have important bioactive compounds like polyphenols, antioxidant compounds like caffeic acid, rosmarinic acid, myricetin, quercetin, isoflavones like daidzein, glycitein, genistein, *etc.* Due to presence of the important phytoconstituents, they are used in reducing heart disease, diabetes, anticancer, hypotensive, *etc.* It shows antioxidant activity due to presence of phenolic acids and isoflavones (Martinez-Cruz and Paredes-Lopez, 2014). Immunomodulatory activity of hexane extract of chia seed was evaluated on phagocytosis and stimulation of neutrophils (Gayathiri *et al.*, 2017).

3.18 Pumpkin seeds

Pumpkins are gourd family, native to Central America and Mexico. The seeds are flat, asymmetrically oval, inside kernel is light green colour (Figure 19). The seed contains mainly oil (mostly linoleic and oleic acid), minerals (particularly, phosphorus, potassium, magnesium, calcium, iron, zinc), proteins and amino acids, carbohydrates (6-10%), and vitamins (thiamine, riboflavin, niacin, pyridoxine, and pantothenic acid).

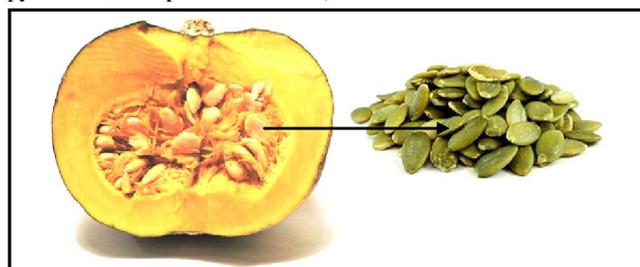


Figure 19: Pumpkin seeds.

Apart from that, it contains many phytochemicals, namely; alkaloids, glycosides, carbohydrates, fixed oil and fats, phytosterols, saponin, phenolic compounds, tannins, proteins, amino acids, gums, and mucilage. The constituents are “7 sterols (avenasterol and spinasterol) and “5 sterol (sitosterol and stigmasterol) are also present in the seed. Because of the presence of high content of phenolic and flavonoids, it shows potent antioxidant activity (Pal *et al.*, 2018). Because of the presence of many active principles, it shows various therapeutic activities such as in treatment of sore chests, hemoptysis, bronchitis, in the management of benign prostatic hyperplasia and fever. It modulates immunobiochemical pathways induced by interferons (Acosta-Patiño *et al.*, 2001). Due to presence of flavonoids, it has significant antioxidant capacity (Abdel-Rahman, 2006).

3.19 Betel nuts

Betel nuts are also known as areca nut is a type of seed of Areca palm. It is hard, rounded, and grayish in colour (Figure 20), native to West Indies. It grows in tropical Pacific, Southeast and South Asia and East Africa. The nuts are chewed with betel leaf shows mild stimulant effect. It has protein, little fibers, fats, carbohydrates, minerals like Ca, K, Fe, *etc.* The areca nut contains the tannins, namely; arecatannin and gallic acid, terpineol, flavonoids, lignin and three main alkaloids, *viz.*, arecoline, arecaidine and guvacine. Arecoline helps in increased stamina.



Figure 20: Betel nuts.

Methanolic extract of betel nut was evaluated for antioxidant activity with the presence of phenolic and flavonoid compounds (Hamsar *et al.*, 2011). The ethanol extract of areca nut was evaluated for immunomodulatory activity and revealed potent immune boosting property due to the presence of catechin and quercetin (Sari *et al.*, 2020).

3.20 Dry coconut

It is the coconut fruit when the milk within coconut hardens with its maturity; it becomes the copra and known as dry coconut (Figure 21). It is off-white to white in color. The coconut tree is a palm tree family, native of the Malay Archipelago or the South Pacific. Dried coconut has more calories than fresh one, rich sources in saturated fats, dietary fibers, sugars, and minerals (Na, K, Fe and Ca).

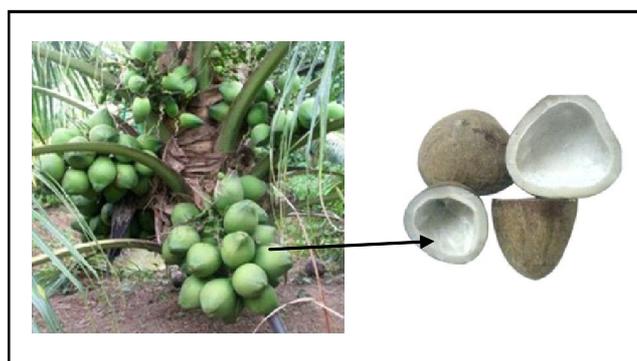


Figure 21: Dry coconut.

It has rich sources of many active constituents like phenols, flavonoids, glycosides, tannins, alkaloids, and saponins. Antibacterial and immunomodulatory activity of coconut protein was investigated by immune suppressed with cyclophosphamide (Geo Vigila and Baskaran, 2008). Due to presence of these constituent especially tocopherols, tocotrienols and phenolics, it shows powerful antioxidant property (Prakruthi *et al.*, 2015; Prakruthi *et al.*, 2016).

4. Discussion

The present article provides a proper information about the nutritional values, multiple bioactive components, scientific literatures imparting versatile therapeutic applications. Especially antioxidant, immunomodulatory and antiviral activities of dry fruits and seeds are reported with the presence of high content of flavonoids, phenolics, sterols. Therefore, the manuscript is the current focus for the basic utilization during the covid situation for boosting the immunity and fights against covid virus. Many literatures are reviewed and based on the significant medicinal properties, twenty important dry fruits and seeds are selected and their significant role in human health are discussed. All the selected edible dry fruits and seeds are showed potent antioxidant activities which plays important role in combating viral infection through body defense mechanism.

5. Conclusion

The herbal remedies are the best solution that are employed for the treatment and management of various chronic health disorders. Dry fruits and dried seeds are used traditionally for many therapeutic activities and based on the research surveys some important dry fruits and seeds are selected in this manuscript which all are having potent immune boosting activities. These dry fruits and seeds are used either in combinations or in sole in many food additives or as nutraceuticals or in any dietary supplements. Hence, in current year with the rich sources of flavonoids, polyphenolic compounds they are used in powder form or as a whole are used for boosting immunity and will bestow significant health benefits especially to protect the health from COVID-19 virus infection.

Conflict of interest

The authors declare that there are no conflicts of interest relevant to this article.

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