International Journal of Innovation Scientific Research and Review
Vol. 03, Issue, 08, pp.1635-1647, August, 2021
Available online at http://www.journalijisr.com

IJISRR

Research Article **ISSN: 2582-6131**

THE ICONIC BAOBAB (ADANSONIA DIGITATA L.): HERBAL MEDICINE FOR CONTROLLING CORONAVIRUS (SARS-COV-2) DISEASE (COVID-19)

[1,*] Ravindra B. Malabadi, [2]Kiran P. Kolkar, [3]Neelambika T. Meti, [1]Raju K. Chalannavar

[1]Department of Applied Botany, Mangalore University, Mangalagangotri-574199, Mangalore, Karnataka State, India.
[1]Miller Blvd, NW, Edmonton, Alberta, Canada (North America).
[2]Department of Botany, Karnatak Science College, Dharwad-580003, Karnataka state, India.
[3]Plant Biotechnology Laboratory, Rajiv Gandhi Institute of IT and Biotechnology, Bharati Vidyapeeth University, Pune-Satara Road, Katraj, Pune - 411046, Maharashtra State, India.

Received 20th June 2021; Accepted 21th July 2021; Published online 30th August 2021

ABSTRACT

This review paper highlights the medicinal properties particularly the immunogenic potentiality of iconic baobab (Adansonia digitata L.) (Kalphavraksha or Wish) tree species belongs to Malvaceae family. During the recent outbreak of second wave of coronavirus (SARS-CoV-2) mutants, Delta variant (B. 1. 617.2) strain and Delta Plus (AY.1) in India has created a major health issue resulted in more hospitalizations and death. Another problem is fully vaccinated people with "breakthrough" infections is rare but reported. This has created a situation and therefore, promoted herbal medicine, fruit pulp of baobab as an immunity booster for controlling the coronavirus (SARS-CoV-2). The baobab (Kalphavraksha or Wish tree) fruit pulp is very rich in vitamin C (280-350 mg/g of the fruit), zinc, and the source of protein and used as a herbal medicine long time ago by local traditional healers in India, Africa, Madagascar and other Asian countries. In addition to this, the baobab fruit pulp is acidic in nature and also known for protease inhibitors which limits the consumption of fruits. Plant protease inhibitors are directly involved in blocking the viral replication and inhibited the viral synthesis. Therefore, two dose vaccination with additional dietary and medicinal therapy will help to prevent the human body against invading viral antigen and improved the overall health condition of the Covid-19 patients. In India, the oral consumption of baobab (Kalphavraksha or Wish tree) fruit pulp with milk as an immunity booster has improved the Covid-19 patients health condition. However, there are no clinical evidences to support the scientific validation. Therefore, clinical experimental studies should be conducted particularly for the scientific validation of immunogenic potentiality of baobab fruit pulp. This will help in developing a novel drug for controlling the coronavirus infections in future pandemic.

Keywords: Adansonia digitata, Baobab, coronavirus, herbal medicine, Kalphavraksha, India, Wish tree.

INTRODUCTION

The African iconic baobab (*Adansonia digitata* L.) belongs to the family *Malvaceae* is one of the oldest medicinal plant and used as a nutritious functional food in Africa, Madagascar, India, and Sri Lanka (1-9, 74, 77, 92-94). Baobab (*Adansonia digitata* L.) fruit trees are indigenous to Africa which is an income generation for the livelihood of rural population in Africa. Baobabs play an important role in providing a balanced nutrition because of their edible parts supply vitamins, mineral, proteins, and energy that are not commonly obtained from the cereal- dominated diets of drylands of Africa (41-47, 49). African baobab is a very long-lived tree with multipurpose uses. The tender root, tubers, twigs, fruit, seeds, leaves and flowers are all edible and they are common ingredients in traditional dishes in rural areas in Africa. The seeds, leaves, roots, flowers, fruit pulp and bark of baobab (*Adansonia digitata* L.) are edible. The African baobab (*Adansonia digitata*) occurs naturally in most of the countries of Sahara as a scattered tree in the Savannah, and is also present in human habitation (1-34, 41-49, 74,77, 92-94, 96-107). The baobab tree is endemic to tropical African countries and also found in Western Madagascar, India, Iran, Sudan, Australia, Pakistan, Sri Lanka and Bangladesh. In South Africa it is found only in the warmer parts of the Limpopo Province (1-28, 44-49, 74, 77). Baobab (*Adansonia digitata* L.) leaves, bark, roots, pulp and seeds are used for multiple medicinal purposes in many parts of Africa and were found to show interesting medicinal properties including antioxidant, prebiotic-like activity, anti-inflammatory, analgesic, antipyretic activity, anti-diarrhoea, and anti-dysentery activity (1-49). The baobab tree has been introduced in many countries used as an ornamental medicinal plant. Baobab (*Adansonia digitata* L.) is also known as the Kalphavraksha or Gorakshi or Wish tree in India, dead-rat tree (from the appearance of the fruits), monkey-bread tree (the dry fruit as food for monkeys), upside-down tree (the bare branches looked like roots), cream of tartar tree (the acidic taste of the fruits), shade tree, Ethiopian sour gourd and Senegal calabash fruit (1-35, 44-49, 77).

The African baobab (*Adansonia digitata*) is one of the best example set for the ecological tolerance growing well in a very hot deserts and dry climatic conditions (7, 8, 20-35, 74, 77). The baobab (*Adansonia digitata* L.) trees can store 50-80,000 liters of water in their trunk. African baobab (*Adansonia digitata* L.) is the oldest tree of about 1000 years and largest surviving angiosperm (1-10, 74, 77, 96-107). Its distribution area is large and this species can be found in most of Sub-Sahara Africa's semi-arid and sub-humid regions as well as in Western Madagascar (1-35). Baobab fruit tree is sensitive to water logging and frost. All locations where the tree is found are arid or semi-arid. Baobab (*Adansonia digitata*) (*Malvaceae*) is a majestic tree grown in Africa for its medicinal and nutritional value (1, 26-35, 44-49, 74, 77). However, there is a significant climatic threat faced by these species due to their high vulnerability to the impending climatic changes and resulted in the endangered species (23-49, 56, 74, 77).

The African baobab (*Adansonia digitata* L.) is a tall deciduous tree (about 20–30 m (m) tall) with a gigantic girth ranging between 25 and 35.10 m (2-49, 56, 74, 77, 96-107). The trunk is swollen and stout, up to 10 m in diameter, usually tapering or cylindrical and abruptly bottle-shaped; often buttressed (11-49,74,77).

***Corresponding Author: Ravindra B. Malabadi,**
1Department of Applied Botany, Mangalore University, Mangalagangotri-574199, Mangalore, Karnataka State, India.
1Miller Blvd, NW, Edmonton, Alberta, Canada (North America).
***Email:** rbmalabadi_b3g@yahoo.com

The baobab (*Adansonia digitata* L.) tree produces extensive lateral root system and the roots end in tubers. The trunk is often of vast girth. The bark is smooth, reddish brown to grey, soft and possesses longitudinal fibers. The baobab (*Adansonia digitata* L.) is highly branched, and produces an extensive lateral root system until 50 m from the trunk. The root tips are often in the form of tubers. But the main roots of old trees are relatively shallow and rarely extend beyond 2 m depth. Therefore, they are very sensitive to strong winds and can be uprooted by storm (11-50, 74, 77).

The inflorescence of baobabs consists of a single large, spectacular, nocturnal flowers, situated in the axils of leaves near the tips of reproductive branches. The flowers are white, large, pendulous, solitary or paired in the leaf axils, large and showy (1-41, 44-49, 74, 77). Flowering begins about the end of dry season or just before the first rains; often when the first leaves appear. The flowers open in late afternoon and fall the next day at dawn. The flowers emit a sulphur fragrance that attracts particularly the bats which play an important role of pollinators (20-41, 44-49, 74, 77). Baobab (*Adansonia digitata* L.) flower is also an edible part of the tree. The flowers have been used as a source of food with high protein content. African baobabs are hermaphrodites where flowers have both male and female reproductive organs within the same flower. The baobab trees' flowers are pollinated by bats, insects and mouse lemurs, depending on where the trees grow.

Leaves are alternate and foliate. Overall mature leaf size may reach a diameter of 20 cm (11-24, 44-49, 74, 77). The leaves are staple food for rural population in Africa especially for the central region of the continent (74, 77). The leaves contain 13-15% protein, 60-70% carbohydrate, 4-10% fat and around 11% fibre and 16% ash. Energy value varies from 1180-1900kJ/100g of which 80% is metabolized energy. The leaves are rich in pro-vitamins A and C (1-46, 74, 77, 96-107). Baobab leaves are used in the preparation of soup. *Adansonia digitata* L leaf could serve as a significant protein and mineral source in the staple food of the African local population. The highest level of pro-vitamin A was detected in young leaves especially when used as dried material. In terms of mineral content, baobab leaf is said to be an excellent source of calcium, iron, potassium, magnesium, manganese, molybdenum, phosphorus, and zinc (1-49, 74, 77).

The fruit of the baobab tree hangs singly on long stalks with an ovoid, woody and indehiscent shell of about 20 to 30 cm long and up to 10 cm in diameter (11-26, 44-49, 74, 77). The shell contains numerous hard, brownish seeds, round or ovoid, up to 15 mm long, which are embedded in a yellowish-white, floury acidic pulp. The ripe fruit pulp appears as naturally dehydrated, powdery, whitish colored and with a slightly acidulous taste (11-25, 74, 77). The baobab fruit pods are also good for burning and a potash-rich vegetable salt may be obtained from this ash for making soap. The acidic pulp is rich in pectin, contains a high amount of carbohydrate, is low in protein, and extremely low in fat (1-41).

Baobab seed withstand drying and remain viable over long periods, as it has a hard seed coat. It can potentially be dispersed over long distances, and its germination potential is improved when it has passed through the digestive tract of an animal. The plant is widespread throughout the hot and drier regions of tropical Africa (1-41, 47, 77). Seeds were also used as a thickening agent in soups, but they can be fermented and used as a flavoring agent or roasted and eaten as snacks (11-28, 39-41, 77). Oils extracted from the seeds of the African baobab are of immense use. The oil is extracted by first pounding the dry seeds then pressing. Oil extracted from the seeds have also been processed into oil meal and used as feed stuff in several regions of Africa (1-47, 49). Therefore, the economy of the rural people in Africa is very much influenced by baobab tree since the plant provides income and employment to the rural and urban households (11-28, 41-49, 74, 77).

The fruits of baobab (*Adansonia digitata* L.) is consumed as a nutritional food in the most of the African countries for example, Senegal, Mali, Burkina Faso, Namibia, Ghana, Tanzania, Zimbabwe, South Africa, Congo, Mozambique, Ethiopia, Malavi, Sudan, Somalia and Nigeria (2-28, 40-77). The baobab tree products such as leaf, fruits has been incorporated as food products in the diet (2, 11, 20-49, 77). The African baobab (*Adansonia digitata* L.) tree is commercially very important since the tree produces food and non-food products such as medicines, fuel, timber, and fodder (11-25, 44-49, 74, 77). All the parts of the baobab tree is reported to be useful and the different parts of the baobab (*Adansonia digitata* L.) provide food, shelter, clothing, medicine as well as material for hunting and fishing (1-11, 74, 77, 92-94). The pulp is either sucked or made into a drink while the bark is used in making ropes (11-27, 30-49, 74, 77, 92-94). Fruit pulp is important in local diets as a seasoning component and appetizer. The pulp has recently become a popular ingredient in ice products in urban areas in different kinds of juices and jams. The pulp is never cooked as the hot drinks are being prepared; rather it is added at the end of the preparation process after the drinks are allowed to cool (1-41, 47, 74, 77, 92-94, 96-107). The baobab pulp is usually used in the preparation of fruit juice, snacks, sweets, as a fermenting agent in local brews porridge, and in food recipes. The African baobab pulp has been used as a hair-rinse, while the burnt fruits have found applications as cattle flies' repellent (1-47, 74, 77, 92-94). The fruit pods are also used for making fires as well as soaps, usually by extracting the potash-rich vegetable salts from it (1-39, 44-49, 77, 92-94, 96-107). In West Africa, the young tender leaves are commonly consumed fresh as a substitute for commercial vegetables or used to prepare sauces or even as dried powder. Baobab fruits can contribute substantially to the African local diets and improved the health of African local communities (1-49, 74, 77, 92-94, 96-98). The roots were also used as a source of red dye (soluble), and the green bark is also used for decorations in Africa. The inner bark is a good source of strong fibre used for making ropes in local Africa (1-47, 49, 74, 77, 92-94).

THE GENUS BAOBAB ADANSONIA

Baobab**,** (*Adansonia*), genus has nine species of dry deciduous trees belongs to the family *Malvaceae*. Six of the *Adansonia* species are 1) *Adansonia grandidieri*, 2) *Adansonia madagascariensis*, 3) *Adansonia perrieri*, 4) *Adansonia. rubrostipa*, 5) *Adansonia suarezensis*, and 6) *Adansonia za* are endemic to Madagascar (1-49, 74, 77). The six Madagascan baobab species feature compact crowns and gray-brown to red trunks that taper from top to bottom or are bottle-shaped to cylindrical. The flowers range from red to yellow to white and have five petals. Some species are pollinated by bats and lemurs, while others rely on hawk moths. Given the threats of habitat loss and their slow generation time, three species 1) *Adansonia grandidieri*, *Adansonia perrieri*, and *Adansonia suarezensisare* has been listed as endangered on the IUCN Red List of Threatened Species (1-49). The remaining three species of *Adansonia* such as *Adansonia madagascariensis*, *Adansonia rubrostipa*, and *Adansonia za* are considered to be near threatened. Two *Adansonia* species, *Adansonia digitata* and *Adansonia kilima* are native to mainland Africa and the Arabian Peninsula. There are few in vitro studies of micropropagation of *Adansonia digitata* were reported (96-100).The recently identified *Adansonia kilima*, which occurs in the highlands of eastern and southern Africa, is very close to *Adansonia digitata* and is sometimes considered within this broad species (1-49).

Further one *Adansonia* species commonly known as bottle tree, *Adansonia gregorii* is native to Western Australia. *Adansonia gregorii*, commonly known as the Australian baobab, is the only baobab to occur in Australia (one species in the Kimberley region of

North western Australia, known as the boab). The white flowers are large, perfumed, and pollinated by hawk moths. Reaching heights of about 12 metres (39 feet), the *Adansonia gregorii* tree features the characteristically swollen trunk of the genus and bears compound leaves that are completely shed during drought periods. The other *Adansonia* species being native to Madagascar (six species) and mainland Africa and the Arabian Peninsula (one species). They have unusual barrel-like trunks and are known for their extraordinary longevity and ethnobotanical importance (1-49, 74, 77).

The African baobab (*Adansonia digitata*) is the oldest known angiosperm tree of about 1,275 years year old in Namibia. This baobab is known as the "Tree of Life," the species is found throughout the drier regions of Africa and features a water-storing trunk that may reach a diameter of 9 metres (30 feet) and a height of 18metres (59 feet) (1-49, 74, 77, 92-94). The tree's unique pendulous flowers are pollinated by bats and bush babies. Its young leaves are edible with medicinal value and the large gourd like woody fruit contains a tasty mucilaginous pulp from which a refreshing drink can be made (1-49, 74, 77).

Distribution of Baobab (*Adansonia digitata* L.) in India

In India, according to Hindu mythology, baobab (*Adansonia digitata* L.) is well known as Kalpavraksha or Gorakshi or Wish tree (1-31, 39, 41). This is a very rare and special tree species in India and only few tree species of about 94 were planted long time ago either by traders from Africa or Madagascar or British regime or Portugese during or before colonization of India (29-31, 39). But Hindu mythology believed that Kalpavraksha or Wish tree were in India 1000 years ago might be planted during spice trading between India, Persians, Madagascar, and Africans (29-39, 41, 74, 77). Baobab is a very long-lived tree with multipurpose uses.

Another theory is that the baobab trees in India might be due to the migration of African population to India particularly in Gujarat and Karnataka state (29-31, 39-47). The seed pods of Baobab might have been swept by sea currents and reached India. Thus, the Baobab trees which love arid zones have been found growing as stragglers in the Indian subcontinent, including Sri Lanka (29-39, 41-47). This enormous baobab tree supposedly has its origin in the African continent and brought in by sailors who came to establish trade links with India; they thereafter planted them across the Indian subcontinent. The subsequent expansion of the Indian Ocean trade between Africa and India occurred through Swahili-Arab networks. The arrival of the Portuguese and the establishment of their colonial bases in Mozambique and Western and Southern India contributed to new flows of Africans between India and Africa. The genetic analysis showed that the Indian baobabs were the same species as the African species *Adansonia digitata*, and that there was less genetic diversity in the Indian baobab populations compared to the African populations. This has also confirmed that the baobabs had not been in the Indian subcontinent long enough for the populations to diversify, and that their dispersal by ocean currents was less likely than introduction by humans. The cultural practices and beliefs associated with baobabs in particular places in India showed striking similarity with those from specific regions of Eastern and Southern Africa. Therefore, geographical distribution of baobabs in the Indian subcontinent are living reminders of the long history of African across the Indian Ocean. Indian baobabs had private alleles that were not present in the African populations. This implied that they could have been from other African baobab populations and brought by humans to the subcontinent much earlier than assumed. Further it was also assumed that there were multiple introductions of baobabs to the Indian subcontinent, and that these were not from just one, but several bio-geographic regions of Africa. Although many of the Indian baobabs showed close relationship with populations from coastal areas of Kenya and Tanzania, there were some showed closer relationships with baobabs from coastal and inland Mozambique, and also, surprisingly, from West Africa. However, a handful of Indian scientists believe that Baobab trees to be a part of Indian culture and attribute their existence to have been influenced by various mechanisms of evolution (29-39, 41-47).

The baobab trees can tolerant to high temperatures and long spans of drought, and are grown for their sour fruit and leaves. The fruit consists of pulp and large seeds embedded in the dry acidic pulp and shell. *Adansonia digitata* L. (Malvaceae) which offers protection and provides food, clothing and medicine as well as raw material for many useful items (39-41, 47, 49). Baobab (*Adansonia digitata* L.) fruit contains nutritionally significant levels of essential nutrients including fiber, protein, and minerals. The pulp which can be considered as naturally dry and purely organic food is a rich dietary source of fiber, potassium, calcium, magnesium, iron, and zinc. The levels of these nutrients in the pulp are much higher than those found in commonly consumed fruits such as guava, mango, berry, and bananas (44-47).

The Kalpavraksha tree (baobab) is a very rare long-lived tree with multipurpose uses and Baobab tree (Gorakshi) is a living monument. In India it is found in Karnataka, Rajasthan, Puducherry (Pondicherry), Telangana, Tamil Nadu, Andhra Pradesh, Maharashtra, Madhya Pradesh, Kerala, Uttar Pradesh and other coastal regions of the country (29-31, 39, 41). It is restricted to hot, dry woodland on stony, well drained soils, in frost-free areas that receive low rainfall (29-39). *Adansonia digitata* (Kalpavraksh) popularly known as the upside down tree, monkey bread tree, cream of tartar tree, lemonade tree can attain a height of upto 25 meters but the main stem of the baobab tree can reach a girth of up to 28 meters (29-39). The massive cylindrical trunk resemble the root system the very reason why it is called the upside down tree (29-31, 41). There is a belief in many African tribes that the tree of Baobab, *Adansonia digitata* actually grows upside down. In India, it is reported that baobab pulp is used externally with buttermilk for the relief of diarrhea and dysentery, while the young leaves are crushed and used to treat painful swellings. Baobab (*Adansonia digitata* L.) (*Adansonia digitata* L.) leaves when crushed can be used as tonics, anti- asthmatic, anti-histamine with an anti-stress property. *Adansonia digitata* leaves were also used for the treatment of kidney and bladder diseases, asthma, diarrhea and insect bites (1-47). The baobab fruit is also rich in zinc, iron (Fe), potassium (k) and essential blood clotting ingredients that supports the circulatory system, while the high Fiber content aids the digestive system (1-47). The major interest in baobab products is as a result of its ascorbic acid and dietary fiber content. Following are the places in India where the baobab trees, *Adansonia digitata* (Kalpavruksh) have been identified by the project known as Landmark Trees of India (29-39, 41-47).

1. **Savanur Baobabs:** Savanur, a town located in the Haveri District of Karnataka state, India boasts of its three majestic baobab (Dodda hunase mara-matha) trees reputed to be the oldest in the country. Each of them is allegedly over 5000 years old. Another baobab (Dodda hunase mara) tree is found in Vijapur city (Near Yogapur Masjid), Karnataka state, India (Landmark Trees of India, 2021) (29-31).
2. Two baobab (Adansonia digitata L) tree were found in Dharwad, Karnataka state, India. One big tree is located at **Karnatak Science college** (KCD) campus, Dharwad, and another tree has been planted at the Botanical Garden, Karnataka University Campus, Pavate nagar, **Dharwad**, Karnatak University, Dharwad, Karnataka state, India.
3. One gigantic baobab tree of about 1300 year old is found in **Puducherry** (Pondicherry) Union Territary of India, maintained by the Department of Forests and wild life (Urban

Forest Trials) Puducherry, India (Landmark Trees of India, 2021) (29-31).

4. This is followed by another baobab tree found in **Tamil Nadu** state, India known as Blavatsky Baobab: Madame Blavatsky was a Russian psychic who founded the Historical Theosophical Society campus area, Adyar, Chennai, Tamil Nadu, India (Landmark Trees of India) (29-31).
5. In Hyderabad city, Telangana state, India, 2 km away from Golconda Port, one massive baobab (*Adansonia digitata* L) tree is found which is about 700 years old planted by Mughal King regime (Aurangazeb) from Madagascar island (Landmark Trees of India, 2021) (29-31).
6. *One massive Baobab tree was found in* **Kadapa** , Andhra Pradesh state, India *(Landmark Trees of India) (29-31).*
7. Rani Bagh Gateway Mumbai Baobab: A plump baobab tree at the entrance of Rani Bagh, greeting visitors to the Zoo and Botanical gardens of Mumbai, Maharashtra state, India (Landmark Trees of India, 2021) (29-31).
8. Along the by lanes of Marol-Maroshi in Andheri East, Mumbai, Maharashtra, India one can spot a strange looking 'upside down' tree. With a swollen base and sparse foliage, the African-origin tree, called Baobab, looks like it has been planted with its roots jutting out in the air. The Mumbai city, Maharashtra state, India has over 40 of them. "These trees were found wherever the Portuguese settled in India. They considered these trees auspicious and so carried a seed or a sapling wherever they travelled and planted them. It is likely that baobab trees were brought them from Africa (Indian Express, 2018; Landmark Trees of India, 2021) (29-31).
9. In Santacruz Electronics Export Processing Zone **(SEEPZ)** is a Special Economic Zone in Mumbai, India situated in the Andheri East area. According to Dr Rajendra Shinde, Head of Botany department, St Xavier's College, Mumbai, India, there are 26 of Baobab trees were found in SEEPZ area, Mumbai, India. In SEEPZ area, seven Baobab trees are in St John The Baptist Church. In the over 500-year-old, quaint church, built by the Portuguese, the Baobabs stand distinctly among the leafy 100-acre premises. Known to live for up to 1,000 years, the Baobabs have snugly grown against the heritage walls of the church since four centuries (Indian Express, 2018; Landmark Trees of India, 2021) (29-31). Bearing the scientific name *Adansonia digitata* and locally known as 'Gorakh-chinch', it holds massive amount of water in its hollow trunk. It's fruit is called 'Monkey-bread'. "At the end of the dry season, it produces white flowers. These flowers bloom at night and are pollinated by bats," reported by Dr Rajdeo Singh, a researcher from the Bombay Natural History Society (BNHS) (Indian Express, 2018; Landmark Trees of India, 2021) (29-31).
10. A few Baobab trees can also be spotted in Mumbai city area, Bandra, Santacruz, Malad, Colaba and Byculla Zoo, Mumbai, Maharashtra state, India. These are 'Green Monuments' of the Mumbai city (29-31). The exact age of these trees is unknown, and it is likely that the oldest Baobab in Mumbai is the one outside Bhabha Hospital in Bandra, Mumbai, Maharashtra state, India, which would be at least 450-500 years old," by Dr Ashok Kothari, president, National Society for the Friends of Trees (Indian Express, 2018; Landmark Trees of India, 2021). While their roots were covered by tar, their trunks face scars from years of nailing advertisements and hoardings (29-31, 40). The civic authority needs to ensure that they leave soil around the root while tarring the road. Most of the Baobabs today have tar all around their roots. Meanwhile, people find the Baobabs ideal to nail their placards and hoardings," and an Instagram page has been created called 'Baobabs of Mumbai' to conserve them. The Baobabs were planted in 1579 when the Portuguese constructed this church (29-31, 40). These are medicinal plants. For those living in this village earlier, this area with huge trees was like a picnic spot," by Nicholas Almeida, president of St John The Baptist Church Save Committee (Indian Express, 2018; Landmark Trees of India, 2021). Known to live for up to 1,000 years, the Baobabs have snugly grown against the heritage walls of the church since four centuries (29-31). One of the Andheri East, Mumbai, Maharashtra state, India, resident who has named the seven trees as the 'Seven Sisters' (Indian Express, 2018; Landmark Trees of India, 2021) (29-31, 41).
11. In Gujarat state, India, Baobab (Adansonia digitata L.) were found in Kutch and Junnagadh region. One or two Baobabs grow in Gujarat's cities of Kutch, Bhavnagar, and Baroda. One live example of 950 year old Baobab (Adansonia digitata L.) is found in Ganapatpura village, Padra, Vadodhara, Gujarat state, India (Landmark Trees of India) (29-31, 41).
12. Diu Rukhda Baobab, Diu Island, Nagoa beach, **Gujarat state**, India A superbly squat, elderly, and elephantine Baobab is hidden in the woods near Nagoa beach (Landmark Trees of India) (29-31).
13. The Celestial Tree**:** A Celestial Wishing Tree baobab (Adansonia digitata) can be found– behind a cage- at the Dilwara Jain Temple in Mount Abu, Rajasthan state, India (Landmark Trees of India) (29-31).
14. One small baobab tree is in the Zoological and Botanical garden of Thiruvananthapuram, **Kerala** state, India (Landmark Trees of India) (29-31).
15. In Bihar state, India, The Sanjay Gandhi Biological Park maintains one Baobab tree as part of its conservation efforts to preserve the baobab (Landmark Trees of India) (29-31).
16. Mallanimli Baobab, Orchha, **Madhya Pradesh** state, India**:** One of the most spectacular trees in India, a monstrously proportioned giant African Baobab standing in a field near Orccha, Mallanimli, Madhya Pradesh state, India reputedly planted by the Maharaja Bir Singh Deo almost 500 years ago (29-31). In addition to this, along with these landmarks, a few baobabs grow in Mandavgad city, Madhya Pradesh state, India. Just a few kilometers distant from the amazing Mallanimli Baobab – which locals say is the only tree of its kind in the world — is another immediately recognizable Baobab. Orchha, Madhya Pradesh state, India, Near the Laxmi temple, visible ~200m away (Landmark Trees of India) (29-31).
17. At presently, A massive, magnificent Kalpavraksha tree (Baobab) on the bank of river Ganga is available in Jhunsi area (Pratishthanpuri) of **Allahabad**, Uttar Pradesh state, India. This Kalpavraksha tree (Baobab) is probably one of the largest and longest living trees in India reportedly over 2000 years old which was described by Chinese traveler Hieun Tsang during his visit (629-644 AD) about 1400 years ago. Mughal king Akbar had also seen it in 1575. The District Gazetteer of Allahabad (1968), Uttar Pradesh state, India contains an account of this tree which says: "A gigantic tree supposed to be more than 500 years old locally called Vilaiti immli which has not been identified botanically. It is growing on the left bank of the Ganga at Prayag and is sacred to Hindus and Muslims alike". Another tree of this species is found at Chandra Shekhar Azad Park of Allahabad, Uttar Pradesh state, India which is about 150 years old (Landmark Trees of India) (29-31).
18. There are three baobabs at the entrance to Doranda college, Ranchi, **Jharkand** state, India were incorrectly reported to be

rare members of the Kalpavrish, of which only nine exist in India. Fortunately, there are many more baobabs than just nine (Landmark Trees of India) (29-31).

19. Broken Branch Baobab: At Mandu, **Madhya Pradesh state**, India: This big old baobab near an old palace has recently lost a big branch (Landmark Trees of India) (29-31).
20. In **Rajasthan state**, India, the old very big Baobab trees were located as follows: Two trees in Banswara, Two trees in Mangaliyawas near Ajmer One tree in Udaipur RNT medical college campus, Thirty years old Baobab tree was introduced as a sapling in Bambulia Fort near Baran by Manoj Kulshreshtha. In Kota one tree is present in Sukhdham Kothi Civil Lines planted by owner Jaiwardhan, some trees near Kesar Garh (Rajasthan Patrika head office) in Jaipur, Rajasthan state, India (29-31).

Adansonia digitata / Kalpavriksh /Baobab Plant: Purchase of seedlings in India

- **Taruvar Nursery:** Dr. SS Bhatotia, village Isaka, near Harchandpur, Haryana state, House no-612, HBH Colony, sector-46, Faridabad, Haryana state, India
- **Green India** Adansonia digitata / Kalpavriksh /Baobab Plant/ Kalpavruksk Seed Pack Of 50 G Seed (50 per packet). Green India - Adansonia digitata / Kalpavriksh /Baobab Plant/ Kalpavruksk Seed Pack Of 25 Seed: Buy Green India - Adansonia digitata / Kalpavriksh /Baobab Plant/ Kalpavruksk Seed Pack Of 25 Seed Online at Low Price - Snapdeal
- **Joginder Nursery**, Padam Chand Saini, Palla Village, Bakhtawarpur, Dahisar Road, Near Machhli Farm, Palla, Delhi - 110036, India
- **SankalpTaru** - Plant trees online (www.sankalptaru.com)- Bangalore, Karnataka state,

Phytochemistry of Baobab fruit tree (*Adansonia digitata* L.)

Phytochemical investigation revealed the presence of flavonoids, phytosterols, amino acids, fatty acids, vitamins and minerals (1-49, 74,77). Baobab (*Adansonia digitata* L.) leaves are being rich in secondary metabolites such as phenolic acids, flavonoids, particularly quercetin, kaempferol glycosides and procyanidins (1-49, 74, 77). A phytochemical study of a Nigerian baobab fruit pulp confirmed to the isolation of hydroxycinnamic acid glycosides, iridoid glycosides, and phenylethanoid glycosides (1-49, 74,77). Further, procyanidin B2, gallic acid, and epicatechin has been identified in a Malawi baobab fruit pulp. Malian baobab fruit pulp and leaves were also the rich source of procyanidins and flavonol glycosides, with different in a qualitative composition compared to those of other African countries, indicating that growing region has affected their chemical profile (14-39, 74, 77, 92-94).

Stem bark and leaves contain a glycoside adansonin, scopoletin, tannin and friedeline (1-49, 74,77, 92-94). Seeds contain steroid, terpenoid, alkaloids and saponin. Roots have fatty oil containing oleic, palmatic, stearic, linoleic and linolinic acid. Fruit pulp contains mucilage, gum, glucose, and tartrate (1-41, 47). Baobab also contains fat, potassium, carbohydrate, fibre, protein, vitamin-C, calcium, iron, magnesium, phosphorous and thiamine (1-49, 74, 77). The ascorbic acid content was evaluated in the fruit of *Adansonia digitata* and it was found to contain 337 mg/100 g of ascorbic acid (1-41, 47, 49, 92-94). The fruit pulp have a very high vitamin C, calcium, phosphorus, carbohydrates, fibers, potassium, proteins and lipids content, which can be used in seasoning as an appetizer and also make juices (1- 49, 74, 77). Seeds contain an appreciable quantities of phosphorus, magnesium, zinc, sodium, iron, manganese, whereas they have high levels of lysine, thiamine, calcium and iron (1-41, 47-49, 92-94). The alkaloid 'adansonin' in the bark is thought to be the active principle for the treatment of malaria and other fevers, as a substitute for quinine (1-41, 47, 49). Saponins present in the leaves of African baobab exhibited a good antibacterial, anti-inflammatory, and immune-boosting properties (1-47, 49, 77, 92-94). The flavonoid is considered to have good antioxidant abilities, antiviral, anticancer, anti-inflammatory, and anti-allergic properties with good therapeutic agents. Total phenols possessed anti-carcinogenic and anti-mutagenic effects by acting as protective agents of DNA against free radicals (1-47, 49, 77).

African baobab (*Adansonia digitata* L.) seeds contain trypsin inhibitors, tannins, cyanogenic glycosides, oxalate, phytic acid, and alkaloids (1-47, 49, 74, 77). The trypsin inhibitor has been implicated to cause adverse effects on the utilization and availability of protein. The African baobab seed also contains about 13 mg/100 g of phytic acid and 23.5 mg/ 100 g catechin (1-47, 49, 74, 77). These anti-nutritional factors can be decreased by varying processing factors and methods consequently increasing the bioavailability of essential nutrients (1-49, 74, 77). These methods include thermal processing, soaking, sprouting, boiling, fermentation, dehulling, germination or a combination of two (2) or more (1-47, 49). The acceptability and optimal utilization of baobab parts as a nutrient source is limited by the presence of anti-nutrients such as protease inhibitors, tannins and phytates but the processing techniques may reduce or destroy the anti-nutrient profile (1-47, 49, 74, 77, 92-94).

Pharmacology of Baobab (*Adansonia digitata* L.)

The fruit pulp of baobab (*Adansonia digitata* L.) has been characterized by very high natural content of Vitamin C and therefore, showed antioxidant properties (1-31, 41-47, 92-94). Antioxidants could help to prevent the oxidative stress related diseases such as cancer, aging, inflammation and cardiovascular diseases as they might eliminate the free radicals which contribute to these chronic diseases (1-49, 92-94). The baobab (*Adansonia digitata* L.) fruit was also found to have the highest content of vitamin C at 280 to 300 mg/100 g of all fruits investigated (1-49, 74, 77, 92-94). This has been compared to a vitamin C content of 46 mg/100 g in oranges, a well-documented source of Vitamin C (11-30, 77, 92-94). Vitamin C is a powerful antioxidant and extremely important in human nutrition. Vitamin C has been shown to be related to lower the blood pressure, enhanced immunity against many tropical diseases, lower incidence of cataract development and lower incidence of coronary disease (11-30). The high Vitamin C and antioxidant content of the baobab fruit pulp may have a role to play in the extension of shelf-life for foods and beverages, as well as cosmetics (1-49, 74, 77). The food/beverage industry could also introduced baobab fruit pulp into foods in order to act as a preserving ingredient by preventing the oxidation of lipids in the food (11-31, 41-47). In addition to this, the fruit pulp of baobab (*Adansonia digitata* L.) has a similar anti-inflammatory properties to phenylbutazone used as a standard in rats. This activity may be attributed to the presence of sterols, saponins and triterpenes in the aqueous extract of baobab fruit pulp (11-28). Baobab fruit pulp and seeds were also widely used for anti-pyretic properties. The consumption of a mash containing dried baobab bark as a febrifuge in order to treat the fever associated with this illness has been reported in Africa, India, Sri Lanka and West Indies (11-28, 41-47, 74, 77, 92-94). The analgesic, hepatoprotective, source of fibers with prebiotic-like activity, anti-trypanosoma activity, antidiarrhoea activity**,** antimicrobial, anti-viral effect of baobab pulp has been well documented (11-28, 41-47, 74, 77, 92-94). *Adansonia. digitata* leaves, fruit-pulp and seeds have shown an antiviral activity against influenza virus, herpes simplex virus, respiratory syncytial virus and polio (11-28, 16, 40-49, 77, 92-94). Studies highlighted that the water-soluble fraction of the fruit pulp has a stimulating effects on

the growth of lactobacilli and bi-fidobacteria (11-31, 49, 74, 77). Bark, fruit pulp and seeds of baobab appear to contain an antidote against the poison. According to Wickens (11, 17-19) baobab contains an alkaloid "adansonin", which has a strophanthus-like action. Baobab bark, fruit pulp and seeds appear to contain an antidote to poisoning by a number of Strophanthus species (1-30, 40-49, 77). The juice of these species has been used widely as an arrow poison especially in East Africa. In Malawi, a baobab extract is poured onto the wound of an animal killed in this way to neutralise the poison before the meat is eaten (11, 17-19, 39, 41, 74,77).

In another report, the root part is used as a cosmetic treatment in Zimbabwe for smoothening the hard skin. Seed oil is used to treat skin disorders (11-27, 38-49, 77). Baobab fruit pulp powder has a good lubricating, binding agent, and diluting characteristics (11, 30-49, 74, 77, 92-94). In some studies, it was used as a hydrophilic excipient for the tablets preparation of paracetamol and theophylline with long lasting effect (11-28, 39-41, 49,74,77). Dry leaf powder and leaves were also used as leafy vegetable to prepare spicy sauces and consumed with boiled rice (11, 20-41, 47-49, 74,77).

Baobab (*Adansonia digitata* L.): Coronavirus

During the recent outbreak of second wave of coronavirus (SARS-CoV-2) mutants, Delta variant (B. 1. 617.2) strain and Delta Plus (AY.1) has raised a major public health issue and creates pandemic situation in India (82-91). The outbreak of second wave of coronavirus (SARS-CoV-2) mutants, Delta (B.1.617.2) and Delta Plus (AY.1) with mucormycosis has devastated India by more number of hospitalizations and increased death rates (82-91). The Delta variant (B.1.617.2) rapidly spread after it was first detected in India when 70% of sequenced COVID cases were the Delta variant (88). As of August 2021, Kerala state, and Maharashtra state of India has been witnessing a surge in the cases, with 49.85 per cent of the total COVID-19 cases. Coronavirus infections are spiking due to the Delta variant (B.1.617.2) (88). In communities with lower vaccination rates, particularly rural areas with limited access to care, the Delta variant (B.1.617.2) could be even more damaging. According to WHO report, Delta variant (B. 1. 617.2) has so far been detected in 132 countries and that the pandemic's current worsening infection rate and death toll are being driven by the highly transmissible Delta variant (B. 1. 617.2) (88). The Delta variant of coronavirus (SARS-CoV-2) is becoming the globally dominant version of the disease (82-91). But Delta (B. 1. 617.2) variant has already been spreading around the world, now accounting for 84% of cases in Australia, 72% of cases sequenced in South Africa, and 82% of cases in the U.S., according to research report from John Hopkins' Coronavirus Resource Center. The Delta variant (B. 1. 617.2) is the most common variant and increases the viral load by about one-thousand-fold (88). If the Alpha variant infects two people on an average, the Delta (B.1.617.2) mutant infects three.

The Delta (B.1.617.2) variant also accounted for an 80% increase in deaths across Africa in the last four weeks as of August 2021 (88). Japan has seen a sharp increase in coronavirus cases. Tokyo reported a record 4,166 new cases on 6th August 2021. The Delta variant of Coronavirus infections were surging at an unprecedented pace as new cases hit a record high in Tokyo unseen in past. Japan newly reported cases totaled a new record of over 14,200. South Korea has also detected its first two cases of the new Delta Plus (AY.1) COVID-19 variant. Indonesia has become the new epicenter of the pandemic, surpassing India and Brazil to become the country with the world's highest count of new viral infections in non-vaccinated people (88-91). The precautions to contain Covid-19 infection remain in place, and even so, the number of cases and deaths increased every day in India (88).

According to UC Davis (USA) Health Experts reports, 1) Delta variant is highly contagious, 2) Delta variant symptoms are the same, 3) Delta variant is affecting more unvaccinated people, 4) Breakthrough cases for vaccinated people are rare, but do happen, 5) Delta variant could be catastrophic in some communities, 6) Many unvaccinated patients with COVID-19 wish they had gotten the vaccine,7) Most of the health experts are recommending to wear masks, even if you're fully vaccinated, 8) More COVID-19 variants are likely to come.

According to the Health Expert reports every infected person, anywhere in the world, offers the coronavirus another opportunity to morph into a new variant. The more infections there are globally, the more likely new variants will arise. Therefore, unvaccinated people who are at a tremendous risk of developing severe disease are not protected and will set the country on fire over and over again. Vaccinated people will be protected from severe illness and death, but there may be other consequences. According to UC Davis health reports and news, the Delta variant (B.1.617.2) is currently the most prominent strain of COVID-19, but the Lambda variant out of South America is also emerging. Health experts also urged that if people want to get back to normal, a significant portion of the population needs to be vaccinated. As long as a chunk of people across the world are unvaccinated, new strains of the virus will continue to develop and cause problems (UC Davis Health Expert Physicians news).

This new Delta plus variant (AY.1) replicated due to the mutation of the existing Delta strain (B.1.617.2) variant first detected in India and this new mutant fuelling an upsurge in infections (88). The delta Plus (AY.1) strain is characterized by K417N mutation in the spike protein of the SARS-CoV2 virus that causes the Covid-19 disease which is also found in the Beta variant first identified in South Africa (88). With vaccination rates on the rise across India, COVID-19 cases are also slowly decreasing (82-91). The Delta Plus (AY.1) variant has been detected in several countries, including Britain, the United States, Portugal, and India. It is found that current COVID-19 vaccines are still effective against the mutation. Delta Plus (AY.1) has the ability to bind more easily to lung cells and might be resistant to therapies that are used to treat COVID-19 (83-91). Delta Plus (AY.1) appears to spread more easily than Delta, and can potentially bind more easily to lung cells or resist antibody drugs (88-91).

New variants form as a result of the virus mutating its own genetic code, and essentially making mistakes when replicating that code, which leads to different variations of the virus. Some mutations in the genetic code make the virus weaker, while others have little effect. But some make it stronger, as is the case with the Delta variant (B. 1. 617.2) and now the Delta Plus (AY.1) variant (88). They found similar viral loads in vaccinated and unvaccinated patients with levels often high enough to allow shedding of infectious virus. "A key assumption" underlying current regulations aimed at slowing COVID-19 transmission "is that those who are vaccinated are at very low risk of spreading the virus to others (88-91). The two things people can do to prevent the second wave from getting "very high" is get vaccinated and avoid indoor crowded spaces without a mask. Therefore, wearing a medically approved mask is mandatory for all the people even for the fully vaccinated people. Vaccinations are really protecting people from the worst ravages of this disease (82-91). Many health experts throughout the world have recommended the wearing of masks even though they are fully vaccinated against COVID-19. They are also advising vaccinated people to avoid large gatherings and mask up indoors where the vaccination status of other people is unknown. Vaccines are highly effective at preventing COVID-19 infection and are also effective in fighting against the Delta variant (B.1.617.2).

Among people infected by the Delta (B.1.617.2) variant of the coronavirus, fully vaccinated people with "breakthrough" infections

may be just as likely as unvaccinated people to spread the virus to others. When a vaccinated person tests positive for COVID-19, the most either have no symptoms or have very mild symptoms, and it rarely results in hospitalization or death. Their symptoms are more like those of a common cold, such as cough, fever or headache, with the addition of significant loss of smell. No vaccine is 100% effective. With the COVID-19 vaccines averaging about 90% efficacy, health experts expected about 10% of those vaccinated could be infected. According to the U.S. Center for Disease Control and Prevention, about 0.005% of the vaccinated population has been reported breakthrough cases of COVID-19. However, as the pandemic lingers and more transmissible variants of the virus circulate widely, it is expected that the number of breakthrough infections will rise. Yet studies have shown that most cases in vaccinated people are mild, if a person develops symptoms at all and research indicated that Covid-19 vaccines still provide strong protection, even against the known variants. The reality is that a lot of these breakthrough infections have been with vaccinated people who test positive, but there's a difference between testing positive and getting sick. In other words, people who test positive may have tiny amounts of the virus in their bodies enough to be detected with Covid-19 tests but not enough to make them ill. The health experts also confirmed that the vaccines work by giving the immune system a boost, it can more quickly recognize and attack any invading pathogens. If a person have a lot of good antibodies, they are potentially able to bind to the virus before it can cause trouble, and that can mitigate or decrease your odds of getting sick. Therefore, breakthrough infections are expected because no vaccine is 100 percent effective. In rare cases, fully vaccinated people can get seriously ill and die from Covid-19, but the vast majority of breakthrough cases have been mild or asymptomatic.

According to Virologists' and Immunologists' the vaccines act like screens to block the most but not necessarily all virus particles from invading the body. Different factors influence the strength of the screen and how many tiny virus particles are able to make it through the barrier. These variants are more transmissible, so they are better at getting through the screens. The other factor is how much virus is out there trying to get in, and that is determined by vaccination rates in the local community in the particular area. Vaccines can also lower the amount of virus in the body, which may limit the ability of people with breakthrough infections to spread it to others, although the effect is not yet well understood. Health Experts also assumed that more research is needed to gauge what effect asymptomatic breakthrough cases, in particular, have on transmission. Further, vast majority of vaccinated people who get infected, they just do not make enough virus to infect another person.

According to the report of CDC (Centre for Disease Control and Prevention, USA) more than 100 million people in the U.S. had been fully vaccinated, and the CDC tallied more than 10,000 cases of breakthrough infections. There are few breakthrough infections in which patients were hospitalized or died. Three-quarters of the cases involved with people over the age of 65. While they are tracked as breakthrough infections, it is not necessarily the case that Covid-19 caused the hospitalizations or deaths, particularly among patients who were asymptomatic. The higher rates of hospitalization and death in older adults are not surprising because older people are generally more vulnerable to serious illness from Covid-19. Immunocompromised people or those with underlying conditions such as hypertension, diabetes and congestive heart failure are at higher risk. Recently Israel has also reported breakthrough infections in people with underlying conditions. There will be a small percentage of fully vaccinated people who still get sick, are hospitalized, or die from COVID-19.

One good news is that the recent rise in breakthrough infections has not been associated with a similar increase in hospitalizations or deaths, which is encouraging evidence that vaccines seem to be holding up well, in spite of new and emerging variants. While the vaccines remain highly effective, there is also reason for the growing concern is that if these outbreaks continue to smolder across the country. The more that the virus is left to circulate, the more chances the pathogen has to mutate in a way that could make it more transmissible, enable it to cause more severe disease or help it evade the protection of vaccines. Every pathogen arms race ends badly, because this is fundamentally evolution. Therefore, the virus is trying to not go extinct, and evolution is going to favour transmission. Evolution is going to favour vaccine escape.

Another good news is that the world's first **Covid-19 DNA vaccine, ZyCoV-D,** developed by Zydus-Cadila's, Pharma Inc, Ahmedabad, Gujarat, India against the coronavirus (SARS-CoV-2) has been approved and the Drug Controller of India (Central Drugs Standard Control Organization, CDSO, Ministry of Health and Family Welfare, Government of India) has granted the emergency use in adults and children aged 12 years and above (95). The approval by the Drug Controller of India, Government of India, New Delhi gives a boost to India's vaccination programme, which aims to inoculate all the eligible adults by December 2021 and will provide the first shot for those under 18 since India still struggles to contain the virus spread in some states (95). The DNA vaccine, ZyCoV-D, uses a section of genetic material from the coronavirus that gives instructions as either DNA or RNA to make the specific protein that the immune system recognises and responds (95).

Unlike the most COVID-19 vaccines, which need two doses or even a single dose, **ZyCoV-D DNA** vaccine is administered in three doses. Zydus Cadila's DNA vaccine by Cadilla Health care Inc., Ahmedabad, Gujarat, India is developed in partnership with the Department of Biotechnology, Government of India, New Delhi, India is the second home-India- made vaccine to get emergency authorization in India after Bharat Biotech's Covaxin.

The vaccine, ZyCoV-D is a needle free three-dose DNA COVID-19 vaccine. This DNA vaccine is an intradermal vaccine, which is applied using The PharmaJet needle-free system (95). Needle-free injectors deliver the DNA vaccine using a narrow stream of fluid to penetrate the skin and deliver the vaccine to the proper tissue depth. The Indian pharmaceutical company Cadilla Health care Inc., Ahmedabad, Gujarat, India confirmed that this methodology can eliminate chances of needle stick injury and will also lead to a significant reduction in any kind of side effects (95). It will also help the people suffering from trypanophobia, a common condition marked by an irrational fear of blood or needles. It's estimated that fear of needles affects up to 25 percent of adults.

ZyCoV-D DNA vaccine is not very sensitive to temperature, unlike its competitors. The prescribed storage temperature is between 2 to 8 degrees centigrade but has shown good stability at temperatures of 25 degrees centigrade as well for at least three months (95). The thermostability of the ZyCoV-D DNA vaccine will help in easy transportation and storage of the DNA vaccine and reduce any cold chain breakdown challenges leading to vaccine wastage. The plasmid DNA platform provides ease of manufacturing with minimal bio safety requirements. It can be manufactured at a BSL-1 grade lab which brings down the cost of production and ensures that the cost of expanding production units. In comparison, to Covaxin, which needs a Bio-Safety Level 3 lab to manufacture the jab. The Plasmid DNA platform also allows generating new constructs quickly to deal with mutations in the virus, such as those already occurring. ZyCoV-D is a plasmid DNA vaccine which when injected produces the spike protein of the SARS-CoV-2 virus and elicits an immune response mediated by the cellular and humoral arms of the human immune system, which play a vital role in protection from disease as well as viral clearance. In simpler words, it means that the vaccine is manufactured by creating a close enough

copy of the virus' DNA sequence so that no harm or disease is caused, but the immune system response is triggered when the body encounters the real virus the next time (95). The plasmid DNA vaccine platform is ideally suited for dealing with COVID-19 as it can be easily adapted to deal with mutations in the virus. Moreover, the DNA vaccines offer a number of potential advantages over traditional approaches that include stimulation of both B and T cell responses, improving the vaccine stability (95).

The Lambda variant of the coronavirus, first identified in Peru and is now spreading in South America, is highly infectious and more resistant to vaccines than the original version of the virus they emerged from Wuhan, China. The higher the amount of coronavirus in the nose and throat, the more likely the patient will infect others. Therefore, Lambda being labeled a "Variant of Interest" by the World Health Organization, rather than a "Variant of Concern," people might not realize it is a serious ongoing threat. Although it is not clear yet whether this variant is more dangerous than the Delta now threatening populations in many countries, Lambda can be a potential threat to the human society. The WHO revealed that the Alpha variant was still the most prevalent, having been detected in 182 countries, while the Beta strain had been reported in 132 nations, Delta in 135 and Gamma in 81. But the Beta variant first detected in South Africa is particularly concerning to the UK due to the evidence that it can escape the immune response better than others and vaccines may therefore, be less effective against it. Third mRNA dose may boost antibody quantity, but not quality. Among fully vaccinated people who never had COVID-19, getting a third dose of an mRNA vaccine from Pfizer /BioNTech or Moderna would likely increase levels of antibodies, but not antibodies that are better able to neutralize new virus variants. They noted that in COVID-19 survivors, the immune system's antibodies evolve during the first year, becoming more potent and better able to resist new variants.

Another good news is that India's indigenously developed Covid-19 vaccine **Covaxin** (India's indigenous COVID-19 vaccine by Bharat Biotech, Hyderabad, Telangana, India is developed in collaboration with the Indian Council of Medical Research (ICMR) and National Institute of Virology (NIV), Pune, Maharashtra, India neutralises the mutant (B.1.167. 2 and B.1.168) Delta variants of SARS-CoV-2 and works against new strain. Therefore, Bharath Biotech, Covaxin has now received Emergency USE Authorizations for covid-19 treatment in India. In addition to this, another Covid-19 vaccine, Covishild (Serum Institute of India, Pune, Maharashtra, India) also neutralises the mutant (B.1.167 and B.1.168) and B. 1. 617.2 (Delta variant) variants of SARS-CoV-2. This has been tested only in few blood samples of the infected people. Large scale clinical trials are undergoing and results are yet to be confirmed. There are many plant secondary metabolite compounds being directly involved in blocking the viral replication and acts as immunity booster too (82-91). This has increased Covid-19 patient survival rate in India in infected and non-infected people, and therefore, herbal folk medicine has been practiced and found successful (82-91). Therefore, two dose vaccination with additional diet and herbal medicine therapy has been recommended for the protection of human life against viral diseases (82-91).

There are many local and international branded baobab powder is available in India. In addition to branded baobab products, local traditional healers are also selling baobab crude extract and helping many covid-19 patients during the recent outbreak of coronavirus in India. However, the price of the baobab powder was very high due to the shortage of supply, and poor people cannot afford to buy the baobab powder at their urgent needs. The baobab powder can be purchased in India at 1) MRM, Organic Baobab Powder, (240 g) (USA) on Amazon.in or Flipkart.com 2) White Baobab Fruit Extracts, For Ayurvedic, 5Kg from Green Heaven India (A Herbal Manufacturing Unit), Hingna, MIDC, Nagpur, Maharashtra state, India, 3) Natural herbal extract of baobab (www.indiamart.com), 4) Vital Herbs Baobab Fruit Extracts, 10 Kg to 25 kg at Vital Herbs, Mohan Garden, Uttam Nagar, Delhi-110059, India, 5) Natural baobab powder (www.powbab.com), 6) Urban Platter Organic African Baobab Fruit Powder, 50g at Urban Flatter, Mahim West, Mumbai, Maharashtra state, India, 7) Baobab Powder (www.ubuy.co.in).

The rationale behind the consumption of baobab fruit powder during the outbreak of coronavirus is to increase the immunity of person. The baobab fruit is very rich in vitamin C (280 to 300 mg/100 g of all fruits), zinc, and protein which are essential nutrients for the covid-19 patients. Covid-19 patients are suffering from malnutrition and therefore, dietary and herbal medicine therapy might play an important role in building the immunity of the covid-19 patients (82-91). Furthermore, dietary ingredients are significant determinants of gut microbial composition and consequently can shape the characteristics of immune responses in the body (80). An adequate intake of iron, zinc, and vitamins A, C, E, B6, and B12, melatonin rich food is predominantly vital for the maintenance of immune function (78-81, 82-91). Vitamin C (280 to 300 mg/100 g of all fruits) helps in the protection of viral infections and inflammation by supporting various cellular function of both innate and adaptive immune system (81). Vitamin C boosts antibodies as well as white blood cell (leukocytes, lymphocytes, T cells) and macrophages, prolonging their function, and can stimulate the release of the signaling molecule interferon, which is involved in the defense against viruses (81). Vitamin C has an important role in wound healing and as an antioxidant, potentially protecting cells from oxidative damage caused by free radicals (81).

Protein deficiency is linked to impaired immune system function, mainly due to its negative effects on both, the amount of functional immunoglobulins and Gut-associated lymphoid tissue (GALT) (78-80). Besides quantity, the quality of proteins is also an important factor with regard to the relationship of this macronutrient with immune system (78-81). It has been highlighted that including proteins of high biological value containing all the essential amino acids may exert an anti-inflammatory effect (78, 79, 81). In addition, some amino acids, such as arginine and glutamine are well known for their ability to modulate the immune system. Protein is crucial to regulate immune system, especially for building and repairing body tissue and fighting viral and bacterial infections. Immune system powerhouses such as antibodies rely on protein and impairment of protein in the diet may lead to symptoms of weakness, fatigue, apathy, and poor immunity (78-81). Vitamins A, C, D, E, B6, B12, and folate, iron, magnesium and trace elements including zinc, selenium and copper play a pivotal role in disease susceptibility and the maintenance of immune function (78- 81). Deficiencies and/or inadequate status in these nutrients may negatively affect immune system, resulting in the decreased resistance against infections (7881).

Velthuis et al. (2010) (78, 79) demonstrated that increasing Zn2+ (Zinc) concentration inhibits the replication of SARS-coronavirus (SARS-CoV-2) (78). On the other hand, zinc deficiency is linked with defective cell-mediated immune response, as well as with increased susceptibility for various infections (78-81). Indeed, it has been suggested that increased zinc intake may exert beneficial effects on COVID-19 infections by reducing gastrointestinal and lower respiratory symptoms (78-81). The replication of RNA viruses can be impaired efficiently with the increase in the concentration of intracellular zinc with zinc-ionophores like pyrithione. Composite of zinc and pyrithione in at low concentrations inhibits the replication of SARS coronavirus (SARS-CoV-2) (78-81).

The baobab trees' flowers are pollinated by bats, insects and mouse lemurs, depending on where the trees grow. This is another important factor noting that bats are the primary hosts of SARS-CoV-2, and other pathogens too. Therefore, during pollination

process of baobab, bats saliva might be attached or mixed with the fruits. After pollination, the fruits might be containing viral particles and remain inactive in the fruits since coronavirus are zoonotic infecting only animal and human beings. The virus will not grow on the fruits. Therefore, according to the local traditional healers concept is that consumption of baobab fruits indirectly refers to the self immunization for the particular antigen. Hence consumption of baobab fruits itself is the natural immunization for many viral, fungal and bacterial disease. This will protect the human body against viral infections since human body has developed antibodies against the viral antigen due to the consumption of baobab fruit pulp. Therefore, in India, the consumption of baobab fruit pulp has been promoted during the recent outbreak of coronavirus (SARS-CoV-2) in order to develop the strong immunity against viral infections. The bats-saliva-pollination concept is a local traditional healers belief and lacks scientific evidence. However, there are no clinical evidence to support the scientific validation. Local traditional healers particularly in Karnataka, Maharashtra, Goa, Tamil Nadu, Telangana, Andhra Pradesh, Kerala, Gujarat, Rajasthan, Uttar Pradesh states of India were practicing the use of baobab (Kalphavraksha) fruit pulp as a herbal medicine long time ago as an immunity booster.

However, the acceptability and optimal utilization of baobab fruit pulp or any other part of the baobab tree as nutrient source is limited by anti-nutrients such as protease inhibitors, tannins and phytates (11, 1-13, 77). Plant protease inhibitors can inhibit the main protease (Mpro or 3CL) of SARS-CoV-2 essential for processing of the polyproteins of the virus into functional proteins (50-77). Plant proteases inhibitors are known for antiviral properties and hence act as inhibitors of viral replication process (50-69, 77). Hence consumption of baobab fruit pulp is helping the covid-19 patients in controlling the further spread of the virus due to the presence of high activity of protease inhibitors in the baobab fruit pulp. However, there are no reports of clinical studies of baobab fruit pulp consumption for controlling coronavirus (SARS-CoV-2) for the scientific validation. Therefore, a detailed study of secondary metabolites of baobab fruit pulp should be conducted for the scientific validation of results particularly in controlling coronavirus (SARS-CoV-2). Protease inhibitors are highly active diverse family of poly(peptides) that are generally present in high concentrations in the storage tissues of the plants such as seeds and tubers including baobab fruit pulp (50-67). They play important roles in the regulation of proteases and the defence mechanism of plants against pathogens and display antimicrobial, antitumor and antiviral properties (50-69). Protease inhibitors have proved to be pharmacologically efficient tools in curing infections and systemic diseases via control of proteolysis. Protease inhibitors are highly active compounds which are involved in important physiological reactions related to metabolism, cell physiology and regulation of proteolytic action (50-69). In a number of biological pursuits like blood clotting, apoptosis, hormone processing and inflammation, the protease inhibitors are now treated as very important signalling molecules. They are widely distributed in plants and animals (50-67). Several recent investigations reported novel biologic activities for plant protease inhibitors such as antimicrobial activities, anticoagulant activities, antioxidant action as well as inhibition of tumor-cell growth; thus marking them potent molecules for inactivating proteases involved in several human diseases like arthritis, pancreatitis, thrombosis, emphysema, hypertension, cardiovascular morbidities, neurodegenerative diseases (such as Alzheimer's disease) and muscular dystrophy (50-67). They have been employed in several fields of biotechnology and agriculture and control of the spread of several pathogens that cause life threatening diseases like cancer, AIDS, hepatitis, malaria and various others have proved to be prevented by using plant protease inhibitors in drug design (50-69).

TMPRSS plays a major role in 2019-nCoV infection as it is the main protease which allows the fusion of the virus particles with human cells (50-69). Hence, because TMPRSS is required by the COVID-19 virus to enter into the human cells, the inhibition of this protease by non toxic plant serine protease may prove to be potential treatment options in 2019-nCoV infection (50-69). The plant proteases are effective tools in inhibiting proteases associated with a number of diseases. They are also highly efficient in inhibiting viral proteases, they can be employed as a potential therapeutic in the treatment of the ongoing COVID-19 pandemic (50-67). Further docking and in vivo studies are required for finding the possible use of these plant proteases in the treatment of COVID-19 (50-69).

Plant-derived proteases, bromelain, papain, and ficin, are broad-acting enzymes with generally recognized as safe status for foods and have current application in several food industries. These proteases have also been reported to have antimicrobial properties. One of the study reported that the efficacy of commercially prepared bromelain, papain, and ficin have individually and combined (2,500 ppm of crude extract), inactivated the hepatitis A virus (HAV) and human norovirus surrogates, Tulane virus (TV), and murine norovirus (MNV) (50). The lack of or limited efficacy of bromelain, papain, and ficin on HAV, TV, and MNV, even at elevated temperatures and exposure times, suggested that the plant-derived proteases are not commercially applicable for inactivation of virus on commodities or materials that could not also withstand mild heat treatment (50). Therefore, glycoside adansonin a secondary metabolite might be promising antiviral agent against coronavirus (SARS-CoV-2). However, there are no clinical trials particularly adansonin antiviral activity for coronavirus for the scientific validation. We propose this study should be conducted for the scientific validation.

CONCLUSION

The iconic baobab (*Adansonia digitata*) tree of Africa is an important nutritional and medicinal resource**.** Baobab (*Adansonia digitata*) is a multi-purpose tree with tender root, tubers, twigs, fruit, seeds, leaves, flowers which are edible and were widely used by the indigenous people for human and animal medicines. In India, the iconic Baobab (*Adansonia digitata*) is also known as Kalphavraksha tree or Wish tree and found distributed or planted long back ago in India. There are of about 94 Kalphavraksha tree or Wish tree have been identified and recorded in India according to the project, Landmark Trees of India. During the recent outbreak of second wave of coronavirus mutants Delta variant (B. 1. 617.2) strain and Delta Plus (AY.1) in India, the fruit pulp of baobab was consumed with milk as an immunity booster for controlling the coronavirus. The iconic Baobab (*Adansonia digitata*) is also known as Kalphavraksha tree or Wish tree was in big news in India since plants were overexploited for the different parts of the tree as a herbal medicine for the treatment of Covid-19. The price of the baobab fruit pulp in powder form has reached very high (10 times higher than normal price) during coronavirus outbreak and there was shortage of supply, and poor people were struggling to get the baobab as a medicine. In India, people were exhausted in reaching the local traditional healers to get baobab as the herbal medicine for Covid-19. According to the local traditional healers in India particularly in Karnataka, Tamil Nadu, Maharashtra, Kerala, Telangana, Andhra Pradesh state, the consumption of fruit pulp of baobab has helped many Covid-19 hospitalization patients in reducing the further spread of the virus since fruit pulp acts as a immunogenic agent and helped in developing the immunity against the pathogen. The local traditional healers in India are practicing folk baobab medicine for a long time ago under the medical domain Ayurveda. Further baobab fruit pulp is very rich in vitamin C, zinc and protein content. Another important factor is baobab fruit-pollination-bats-saliva concept which also

helped in developing the immunity in healthy and Covid-19 infected people. In addition to this, baobab plant also contains protease inhibitors. Therefore, baobab plant protease inhibitors might be involved in blocking the replication of virus or inhibited the virus growth. Therefore, according to local traditional healers in India, two dose vaccination with additional consumption of baobab fruit pulp has resulted in the complete recovery of Covid-19 patients. The immune boosting property of baobab fruit pulp is a known fact and well documented. However, clinical evidences to support the immunogenicity of baobab fruit pulp particularly in protecting Covid-19 is lacking. The literature data presented is not sufficient for the scientific validation. Therefore, we strongly recommend that clinical experiments should be conducted in order to support the baobab fruit pulp as a immunogenic agent which will help in developing the novel drug for controlling the viral diseases of future pandemic situations.

REFERENCES

1. Patrut A, Woodborne S, Patrut T, Rakosy L, Lowy A, Hall G, Roden F. The demise of the largest and oldest African baobabs. Nat. Plants 2018; 4: 423–426. (doi: 10.1038/s41477-018-0170-5).
2. Asogwa IS, Ibrahim AN, Agbaka JI. African baobab: Its role in enhancing nutrition, health, and the environment. Trees, Forests and People. 2021; 3: 1000 43 (https://doi.org/10.1016/j.tfp.2020.100043).
3. De Caluwe E, Halamova K, Van-Damme P. 2010. *Adansonia digitata* L.- A review of traditional uses, phytochemistry and pharmacology. Afr. Focus. 2010; 23 (1): 11–51. (doi: 10.21825/af.v23i1.5037).
4. Kamatou GPP, Vermaak I, Viljoen AM. An updated review of *Adansonia digitate* L: a commercially important African tree. S. Afr. J. Bot. 2011; 77 (4): 908–919. (doi: 10.1016/ j.sajb.2011.08.010).
5. Rashford J. The use of baobab leaves (*Adansonia digitata L* .) for food in Africa: A review. Econ. Bot. 2018; 72: 478–495. (doi: 10.1007/s12231-018-9438-y).
6. Rashford J. The uses of the baobab flower (*Adansonia digitata* L.). Ethnobot. Res. Appl. 2015; 14: 211–225. (doi: 10.17348/ era.14.0.211-229).
7. Rahul J, Manish KJ, Singh PS, Kamal RK, Anuradha A, Naz A, Gupta KA, Mrityunjay KS *Adansonia digitata* L. (baobab): A review of traditional information and taxonomic description. Asian Pac. J. Trop. Biomed. 2015; 5 (1): 79–84. (doi: 10.1016/ S2221-1691(15)30174-X).
8. Nkafamiya II, Osemeahon SA, Dahiru D, Umaru HA. Studies on the chemical composition and physicochemical properties of baobab fruit (*Adansonia digitata* L.). Afr. J. Biotechnol. 2007; 6 (6): 756–759. (doi: 10.4314/ajb.v616.56898).
9. Namratha V, Sahithi, P. Baobab: A review about the tree of life. Int. J. Adv. Herb. Sci. Technol. 2015; 1: 20–26. Available at http://medical.cloud-journals.com/index.pphp/IJAHST/article/ view/Med.254. Accessed on 25th July 2020.
10. Gebauer J, El-Siddig K, Ebert G. Baobab (*Adansonia digitata L* .): A review on a multipurpose tree with promising future in the Sudan. Gartenbauwissenschaf. 2002; 67 (4): 155–160. (doi: 10.1007/s10341-017-0328-8).
11. Kaboré D, Lingani SH, Brehima D, Compaore SC, Dicko HM, Jakobsen M. A review of baobab (*Adansonia digitata*) products: Effects of processing techniques, medicinal properties and uses. Afr. J. Food Sci. 2011; 5 (16): 833–844. doi: 10.5897/AJFSX11.004 .
12. Brady O. The characterization and bioactivity determination of *Adansonia digitata* L. fruit pulp, for commercial product development. Thesis of bachelor of Science in Nutraceuticals for Health and Nutrition Dublin Institute of Technology, Cathal Brugha Street, 2011; 117 p.
13. Chadare FJ, Linnemann AR, Hounhouigan JD, Nout MJR, Van Boekel MAJS. Baobab Food Products: A Review on their Composition and Nutritional Value. Critic. Rev. Food Sci. Nutr. 2009; 49: 254-274.
14. Sibibe M, Williams JT. Baobab – *Adansonia digitata*. Fruits for the future.Int. Centre Underutil. Crops, Southampton,UK,2002; 96p.
15. Shukla YN, Dubey S, Jain SP, Kumar S. Chemistry, biology and uses of *Adansonia digitata* – A review. J. Med. Arom. Plant Sci. 2001; 23: 429-434.
16. Vimalanathan S, Hudson JB (2009). Multiple inflammatory and antiviral activities in *Adansonia digitata* (Baobab) leaves, fruits and seeds. J. Med. Plants Res. 2009; 3: 576-582.
17. Wickens GE, Lowe P. The Baobabs: Pachycauls of Africa, Madagascar and Australia, Springer. 2008.
18. Wickens GE. The baobab – Africa's upside-down tree. Kew Bulletin, 1982; 37: 173-209.
19. Wickens GE. The uses of the baobab (*Adansonia digitata* L.) in Africa. In: Taxonomic aspects of African economic botany, editor, Kunkel, G. 1979.
20. Venter F, Venter J. Baobab In Making the most of indigenous trees. Briza publications, Pretoria, South Africa, pp. 1996; 26-27.
21. Vertuani S, Braccioli E, Buzzoni V, Manfredini S. Antioxidant capacity of *Adansonia digitata* fruit pulp and leaves. Acta Phytotherapeutica. 2002; 86: 2-7.
22. Masola SN, Mosha RD, Wambura PN. Assessment of antimicrobial activity of crude extracts of stem and root barks from *Adansonia digitata* (Bombacaceae) (African baobab). Afr. J. Biotechnol. 2009; 8: 5076-5083.
23. Ndabikunze BK, Masambu BN, Tiisekwa BPM, Issa-Zacharia A. The production of jam from indigenous fruits using baobab (*Adansonia digitata* L.) powder as a substitute for commercial pectin. Afr. J. Food Sci. 2011; 5: 168-175.
24. Nkafamiya II, Osemeahon SA, Dahiru D, Umaru HA (2007). Studies on the chemical composition and physicochemical properties of the seeds of baobab (*Adansonia digitata*). Afr. J. Biotechnol. 2007; 6: 756-759.
25. Nnam NM, Obiakor PN (2003). Effect of fermentation on the nutrient and antinutrient composition of baobab (*Adansonia digitata*) seeds and rice (*Oryza sativa*) grains. Ecol. Food Nutr. 2003; 42: 265-277.
26. Nour AA, Magboul BI, Kheiri NH (1980). Chemical composition of baobab fruit (*Adansonia digitata* L.). Tropic. Sci. 1980; 22: 383-388.
27. Ramadan A, Harraz FM, El-Mougy SA. Anti-inflammatory, analgesic and antipyretic effects of the fruit pulp of *Adansonia digitata*. Fitoterapia. 1993; 65: 418-422.
28. Al-Qarawi AA, Al-Damegh MA, El-Mougy SA. Hepatoprotective Influence of *Adansonia digitata* Pulp. J. Herbs Spices Med. Plants. 2003; 10:1-6.
29. Mishra RK, Marde R, Joshi B, Srivastava A, Joshi S. Review on *Adansonia digitata* L. (Gorakshi): A historical and endangered tree species in India. International Journal of Unani and Integrative Medicine. 2019; 3(2): 01-04.
30. Indian Express News. Known to live up to 1,000 years, Baobabs are Mumbai's 'green monuments. 2018. Reportee by Benita Chacko , Tabassum Barnagarwala. Mumbai, Maharashtra state, India. August 1, 2018 2:33:43 am
31. Landmark Trees of India: Landmark Trees is an outreach ecology and geography project documenting famous, notable, remarkable, interesting, and heritage trees of India. 2021; (About the Project – Landmark Trees of India (outreachecology.com).
32. Kamatou GPP, Vermaak I, Viljoen AM. An updated review of *Adansonia digitata*: a commercially important African tree. S Afri J Bot. 2011; 77: 908-919.

33. Verma RK. An ethnobotanical study of plants used for the treatment of livestock diseases in Tikamgarh District of Bundelkhand, Central India. Asian Pac J Trop Biomed 2014; **4**(Suppl 1): S460-S467.
34. Jitin R, Singh SP, Naz A. An ethnomedicinal survey of orchha wildlife sanctuary region of Tikamgarh District, Madhya Pradesh, India. J Bot Res. 2013; 4(1): 31-34.
35. Chadare FJ, Linnemann AR, Hounhouigan JD, Nout MJ, Van Boekel MA. Baobab food products: a review on their composition and nutritional value. Crit Rev Food Sci Nutr. 2009; 49: 254-274.
36. Vertuani S, Braccioli E, Buzzoni V, Manfredini S. Antioxidant capacity of *Adansonia digitata* fruit pulp and leaves. Acta Phytotherapeutica. 2002; 5: 2-7.
37. Chadare FJ, Linnemann AR, Hounhouigan JD, Nout MJ, Van Boekel MA. Baobab food products: A review on their composition and nutritional value. Crit Rev Food Sci Nutr.2009; 49: 254-274.
38. El-Rawy EM, Gergis SM, Bazaid S, El-Mougy SA. The immuno stimulant effect of *Adansonia digitata* on the immune response of chicken vaccinated with avian cholera vaccine. J Egypt Vet Med Assoc. 1997; 57: 959-970.
39. Rahul J, Jain MK, Singh SP, Kamal RK, Anuradha, Naz1 A, Gupta AK, Mrityunjay SK. *Adansonia digitata* L. (baobab): a review of traditional information and taxonomic description. 2015; 5(1):79-84.
40. Gimba SN, Anka ZM, Bulakarima HU, Kachallah F (2020) PHARMACOLOGICAL ACTIVITIES OF BAOBAB (*ADANSONIA DIGITATA*). International Journal of Current Medical and Pharmaceutical Research. 2020; 6(1):4906-4910.
41. Afolabi OR, Popoola TOS. The effects of baobab pulp powder on the micro flora involved in tempe fermentation. European Food Research and Technology, 2005; 220: 187-190.
42. Assogbadjo AE, Chadare FJ, Kakaï RG, Fandohan B, Baidu-Forson JJ. Variation in biochemical composition of baobab (*Adansonia digitata*) pulp, leaves and seeds in relation to soil types and tree provenances. Agriculture, ecosystems & environment, 2012; 157: 94–99. https://doi.org/doi.org/10.1016/j.agee.2012.01.021
43. Assogbadjo AE, Kyndt T, Sinsin B, Gheysen G, Van Damme P. Patterns of genetic and morphometric diversity in baobab (*Adansonia digitata*) populations across different climatic zones of Benin (West Africa). Annals of Botany. 2006; 97: 819–830. doi.org10.1093/aob/mcl043.
44. Muthai KU, Karori M, Muchugi A, et al. Nutritional variation in baobab (*Adansonia digitata* L.) fruit pulp and seeds based on Africa geographical regions. Food Sci Nutr. 2017;5:1116–1129. https://doi.org/10.1002/fsn3.502.
45. Gebauer J, El-Siddig K, Ebert G. Baobab (*Adansonia digitata* L.): A Review on a Multipurpose Tree with Promising Future in the Sudan. *Gartenbauwissenschaft*, 2002; 67: 155–160.
46. Osman MA. Chemical and nutrient analysis of baobab (*Adansonia digitata*) fruit and seed protein solubility. Plant foods for human nutrition. 2004; 59(1): 29–33. https://doi.org/doi.org/ 10.1007/s11130-004-0034-1
47. Gebauer J, Adam YO, Sanchez AC, Darr D, Eltahir ME, Fadl KE, Hunsche M. Africa's wooden elephant: the baobab tree (*Adansonia digitata* L.) in Sudan and Kenya: A review. Genetic Resources and Crop Evolution. 2016; 63(3): 377–399. https://doi.org/doi.org/10.1007/ s10722-015-0360-1.
48. Sokeng AJT, Sobolev AP, Di Lorenzo A, Xiao J, Mannina L, Capitani, D, Daglia M. Metabolite characterization of powdered fruits and leaves from *Adansonia digitata* L. (Baobab): A multi-methodological approach. Food Chem. 2019; 272: 93–108.
49. Braca A, Sinisgalli C, De Leo M, Muscatello B, Cioni PL, Milella L, Ostuni A, Giani S, Sanogo R. Phytochemical Profile, Antioxidant and Antidiabetic Activities of *Adansonia digitata* L. (Baobab) from Mali, as a Source of Health-Promoting Compounds. 2018; 23: 3104. http://dx.doi.org/10.3390/molecules23123104.
50. Shearer AEH, Knlel KE. Effect of plant-derived proteases on infectivity of Tulane Virus, Murine Norovirus, and Hepatitis A Virus. J. Food Prot. 2021; 84 (3): 418–423. (https://doi.org/10.4315/JFP-20-29).
51. Cotabarren J, Lufrano D, Parisi MG, Obreg´on WD. Biotechnological, biomedical, and agronomical applications of plant protease inhibitors with high stability: A systematic review. Plant Sci. 2019;S0168-9452(19):31571-7.
52. Kim JY, Park SC, Hwang I, Cheong H, Nah JW, Hahm KS et al. Protease inhibitors from plants with antimicrobial activity. Int J Mol Sci. 2009;10:2860-2872.
53. Kim JY, Park SC, Hwang I, Cheong H, Nah JW, Hahm KS et al. Protease inhibitors from plants with antimicrobial activity. Int J Mol Sci. 2009;10:2860-2872.
54. Mishra UN, Reddy MV, Prasad DT. Plant serine protease inhibitor (SPI): A potent player with bactericidal, fungicidal, nematicidal and antiviral properties. Int J Chem Stud. 2020;8:2985-2993.
55. Ryan CA. Protease inhibitors in plants: Genes for improving defenses against insects and pathogens. Annu Rev Phytopathol. 1990;28:425-49.
56. Bianchi E, Pessi A. Inhibiting viral proteases: Challenges and opportunities. Pept. Sci. 2002;66:101-114.
57. Fischmann TO, Weber PC. Peptidic inhibitors of the hepatitis C virus serine protease within non- structural protein 3. Curr Pharm Des. 2002;8:2533-2540.
58. Moulin MM, Rodrigues R, Ribeiro SFF, Goncalves LSA, Bento CS, Sudre CP. Trypsin inhibitors from Capsicum baccatum var. pendulum leaves involved in Pepper yellow mosaic virus resistance. Genet Mol Res. 2014;13:9229-9243.
59. Fang EF, Wong JH, Ng TB. Thermostable Kunitz trypsin inhibitor with cytokine inducing, antitumor and HIV-1 reverse transcriptase in hibitory activities from Korean large black soybeans. J Biosci Bioeng. 2010;109:211–217.
60. Lin P, Ng TB. A stable trypsin inhibitor from Chinese dull black soybeans with potentially exploitable activities. Process Biochem. 2008;43:992–998.
61. Domagala JM, Hagen SE, Lunney E, Arbor A, Tait BD. Coumarin derivatives as protease inhibitors and antiviral agents. US Patent. 1996;5,510,375.
62. Ye XY, Ng TB. A new peptidic protease inhibitor from *Vicia faba* seeds exhibits antifungal, HIV-1 reverse transcriptase inhibiting and mitogenic activities. J Pept Sci. 2002;8:656–662.
63. Shamsi TN, Parveen R, Amir M, Baig MA, Qureshi MI, Ali S. *Allium sativum* protease inhibitor: A Novel Kunitz trypsin inhibitor from garlic is a new comrade of the serpin family. PLoS one. 2016;11:e0165572.
64. Bhat AV, Pattabiraman PN. Protease inhibitors from jackfruit seeds. J Biosci. 1989;14:351–365.
65. Babu SR, Subrahmanyam B. Bio-potency of serine proteinase inhibitors from Acacia senegal seeds on digestive proteinases, larval growth and development of Helicoverpa armigera (Hu¨bner). Pesticide Biochem Physiol. 2010;98:349–358.
66. Lam SK, Ng TB. A dimeric high-molecular-weight chymotrypsin inhibitor with antitumor and HIV-1 reverse transcriptase in hibitory activities from seeds of *Acacia confusa*. Phytomed Int J Phytother Phytopharmacol. 2010;17:621–625.
67. Gupta S, Kanwar S. Plant protease inhibitors and their antiviral activities - Potent therapeutics for SARS CoV-2y. J Med Discov. 2021; 6(1):jmd20068; DOI:10.24262/jmd.6.1.20068.
68. Chakravarti R, Singh R, Ghosh A, Dey D, Sharma P, Velayutham R, Roy S Ghosh D. A review on potential of natural products in the management of COVID-19. RSC Adv. 2021; 11: 1671.

69. Guijarro-Real C, Plazas M, Rodríguez-Burruezo A, Prohens J, Fita A. Potential in vitro inhibition of selected plant extracts against SARS-CoV-2 Chymotripsin-Like Protease (3CLPro) Activity. Foods. 2021; 10: 1503. (https://doi.org/10.3390/ foods10071503).
70. Darr D, Chopi-Msadala C, Namakhwa CD, Meinhold K, Munthali C. Processed Baobab (*Adansonia digitata* L.) Food Products in Malawi: From Poor Men's to Premium-Priced Specialty Food?. Forests. 2020; 11: 698. http://dx.doi.org/10.3390/f11060698.
71. Gyebi GA, Ogunro OB, Adegunloye AP, Ogunyemi OM, Afolabi SO, Gyebi GA. et al. Potential inhibitors of coronavirus 3-chymotrypsin like protease (3CLpro): An in silico screening of alkaloids and terpenoids from African medicinal plants. J. Biomol. Struct. Dyn. 2020; 1–13. doi:10.1080/ 07391102.2020.1764868.
72. Mandal A, Jha AK, Hazra B. Plant products as inhibitors of Coronavirus 3CL Protease. Front. Pharmacol. 2021; 12:583387. doi: 10.3389/fphar.2021.583387.
73. Vougogiannopoulou K, Corona A, Tramontano E, Alexis MN, Skaltsounis AL. Natural and nature-derived products targeting Human Coronaviruses. Molecules. 2021; 26: 448. https://doi.org/ 10.3390/molecules26020448.
74. Zahra'u B, Mohammed AS, Ghazali HM, Karim R. Baobab Tree (Adansonia digitata L) Parts: Nutrition, Applications in Food and Uses in Ethno-medicine – A Review. *Ann Nutr Disord & Ther*. 2014;1(3): 1011.
75. Sisakht M, Mahmoodzadeh A, Darabian M. Plant-derived chemicals as potential inhibitors of SARS-CoV-2 main protease (6LU7), a virtual screening study. Phytotherapy Research. 2021;35:3262–3274. https://doi.org/ 10.1002/ptr.7041.
76. Verma D, Mitra D, Paul M, Chaudhary P. Kamboj A, Thatoi H, Janmeda P, Jain D, Panneerselvam P, Shrivastav R, Pant K, Mohapatra PKD. Potential inhibitors of SARS-CoV-2 (COVID 19) proteases PLpro and Mpro/ 3CLpro: Molecular docking and simulation studies of three pertinent medicinal plant natural components. Current Research in Pharmacology and Drug Discovery. 2021; 2: 100038. https://doi.org/10.1016/ j.crphar.2021.100038.
77. Venter SM, Glennon KL, Witkowski ETF, Baum D, Cron GV, Tivakudze R, Karimi N. Baobabs (*Adansonia digitata* L.) are self-incompatible and 'male' trees can produce fruit if hand-pollinated. South African Journal of Botany. 2017; 109:263-268.
78. Te Velthuis AJ, van den Worm SH, Sims AC, Baric RS, Snijder EJ, van Hemert MJ. Zn(2+) inhibits coronavirus and arterivirus RNA polymerase activity in vitro and zinc ionophores block the replication of these viruses in cell culture. PLoS Pathog. 2010; 6: e1001176.
79. Fernández-Quintela A, Milton-Laskibar I, Trepiana J et al., Key aspects in nutritional management of COVID-19 patients. J Clin Med. 2020; 9(8): 2589.
80. Naja F, Hamadeh R. Nutrition amid the COVID-19 pandemic: A multi-level framework for action. European Journal of Clinical Nutrition. 2020; 74:1117–1121 (https://doi.org/ 10.1038/ s41430-020-0634-3).
81. Chand V. Nutrition as a key weapon in strengthening immune system relative to pandemic novel Coronavirus disease (COVID-19): A review. International Journal of Health Sciences and Research. 2020; 10 (8): 96-104.
82. Malabadi RB, Meti NT, Chalannavar RK. Role of herbal medicine for controlling coronavirus (SARS-CoV-2) disease (COVID-19). International Journal of Research and Scientific Innovations. 2021a; 8(2): 135-165.
83. Malabadi RB, Meti NT, Chalannavar RK. Applications of nanotechnology in vaccine development for coronavirus (SARS-CoV-2) disease (Covid-19). International Journal of Research and Scientific Innovations. 2021b; 8(2): 191-198.
84. Malabadi RB, Kolkar KP, Meti NT, Chalannavar RK. Melatonin: One molecule one- medicine for many diseases, coronavirus (SARS-CoV-2) disease (Covid-19); Function in plants. International Journal of Research and Scientific Innovations. 2021c; 8(3): 155-181.
85. Malabadi RB, Kolkar KP, Meti NT, Chalannavar RK. Vaccine development for coronavirus (SARS-CoV-2) disease (Covid-19): Lipid nanoparticles. International Journal of Research and Scientific Innovations. 2021d; 8(3): 189-195.
86. Malabadi RB, Kolkar KP, Meti NT, Chalannavar RK. Role of botanical essential oils as a therapy for controlling coronavirus (SARS-CoV-2) disease (Covid-19). International Journal of Research and Scientific Innovations.2021e; 8(4): 105-118.
87. Malabadi RB, Kolkar KP, Meti NT, Chalannavar RK. Role of plant based hand sanitizers during the recent outbreak of coronavirus (SARS-CoV-2) disease (Covid-19). Significances of Bioengineering & Biosciences. 2021f; 5(1): 458-468.
88. Malabadi RB, Kolkar KP, Meti NT, Chalannavar RK. Outbreak of Coronavirus (SARS-CoV-2) Delta variant (B.1.617.2) and Delta Plus (AY.1) with fungal infections, Mucormycosis: Herbal medicine treatment. International Journal of Research and Scientific Innovations. 2021g; 8(6): 59-70.
89. Malabadi RB, Kolkar KP, Meti NT, Chalannavar RK. Camphor tree**,** *Cinnamomum camphora* (L.); Ethnobotany, and pharmacological updates. Biomedicine. 2021h; 41 (2): 181-184.
90. Malabadi RB, Kolkar KP, Meti NT, Chalannavar RK. Traditional herbal folk medicine used for controlling coronavirus (SARS-CoV-2) disease (Covid-19). International Journal of Innovation Scientific Research and Review. 2021i; 3 (7): 1507-1517.
91. Malabadi RB, Kolkar KP, Meti NT, Chalannavar RK. An age old botanical weapon for herbal therapy: Camphor tree, *Cinnamomum camphora* (L.). Journal of Innovation Scientific Research and Review. 2021J; 3(7):1518-1523.
92. Zagga AI, AbdulJabbar IA, Garko MBA, Tsoho B, Gbande S. Phytochemical composition of *Adansonia digitata* L. leaf extracts. Proceedings of 6th NSCB Biodiversity Conference; Uniuyo. 2018; 300 - 304.
93. Sundarambal M, Muthusamy P, Radha R, Suresh J. A review on *Adansonia digitate* Linn. Phytojournal of Asia. 2013;1:6 234240.
94. Adesanya SA, Idowu TB, Elujoba AA. Anti-sickling activity of *Adansonia digitata.* Planta Medica. 1998; 54: 374-380.
95. Bengalore, Karnataka, India**.** India gives emergency approval for world's first COVID-19 DNA vaccine, 20th August 2021 (www.yahoo.com).https://ca.yahoo.com/news/india-approves-zydus-cadilas-covid-135614592.html**;** ZyCoV-D, Zydus Cadila's needle-free COVID-19 vaccine gets DCGI nod; Zydus Cadila's COVID-19 Vaccine Approved in India; Was Tested on Children Above 12.
96. Singh S, Rai S, Khan S. *In vitro* seed germination of *Adansonia digitata* L.: An endangered medicinal tree. Nanobiotech Univer. 2010; 1: 107–112.
97. N'Doye AL, Sambe MAN, Sy MO. Propagation of African Baobab (Adansonia digitata L., Bombacoideae, Malvaceae) Germplasm through in vitro cloning. Adv Env Biol. 2012; 6: 2749–2757.
98. Rolli E, Brunoni F, Bruni R. An optimized method for in vitro propagation of African baobab (Adansonia digitata L.) using two-node segments, Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology: Official Journal of the Societa Botanica Italiana. 2014; DOI: 10.1080/11263504.2014.991362.
99. Ishii K, Kambou S. *In vitro* culture of an African multipurpose species *Adansonia digitata* L. Propag Ornam Plants. 2007; 7: 62–67.

100. Rolli E, Bigliardi MV, Ricci A. Micropropagation of *Adansonia digitata* L. Acta Italus Hortus. 2012; 6: 68–72.
101. Assogbadjo AE, Gle`le` Kakaı¨R, Chadare FJ, Thomson L, Kyndt T, Sinsin B, et al. Folk classification, perception and preferences of baobab products in West Africa: Consequences for species conservation and improvement. Econ Bot. 2008; 62: 74–84.
102. Assogbadjo AE, Gle`le` Kakaı¨ R, Edon S, Kyndt T, Sinsin B. Natural variation in fruit characteristics, seed germination and seedling growth of Adansonia digitata L. in Benin. New Forests. 2011; 41: 113–125.
103. Assogbadjo AE, Gle`le` Kakaı¨ R, Kyndt T, Sinsin B. Conservation genetics of baobab (*Adansonia digitata* L.) in the parklands agro forestry system of Benin (West Africa). Not Bot Hortic Agrobot Cluj. 2010; 38(2): 136–140.
104. Jensen JS, Bayala J, Sanou H, Korbo A, Ræbild A, Kambou S, et al. A research approach supporting domestication of Baobab (*Adansonia digitata* L.) in West Africa. New Forests. 2011; 41: 317–335.
105. Besco E, Braccioli E, Vertuani S, Ziosi P, Brazzo F, Bruni R, et al. The use of photochemiluminescence for the measurement of the integral antioxidant capacity of baobab products. Food Chem. 2007; 102: 1352–1356.
106. Cuni Sanchez A, De Smedt S, Haq N, Samson R. Variation in baobab seedling morphology and its implications for selecting superior planting material. Sci Hortic. 2011; 130: 109–117.
107. Cuni Sanchez A, Haq N, Assogbadjo AE. Variation in baobab (*Adansonia digitata* L.) leaf morphology and its relation to drought tolerance. Genet Resour Crop Evol. 2010; 57: 17–25.

****