Chapter 3
Fruits and Vegetables Used in Treating Respiratory and Other Troubles in Africa: Ethnopharmacology and Phytochemistry

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Abstract Respiratory troubles, which encompass conditions such as cough, asthma, tuberculosis, bronchitis, common cold, and chronic obstructive pulmonary disease, pose significant health challenges globally. This chapter explores the diverse array of biologically active agents (BAA) found in vegetables and fruit plants used not only as sources of food but also for treatment of respiratory troubles in Africa. A total of 38 vegetables and fruit plants from 22 families were encountered. The plants are sources of antimicrobials that help the lungs to resist infection as well as boost the immunity of the host; expectorants which stimulate the coughing up of mucus; anti-inflammatory agents and demulcents which soothe irritated membranes, while others are spasmolytic which relax the bronchial muscles. The BAA include allicin from garlic, quercetin from onions, theobromine from cacao, and anethole from fennel. BAA, such as bromelain in pineapple, beta-carotene in carrots, vitamin C in lemon, and glucosinolates in radish, play pivotal roles in mucolytic activities and enhancement of immune function as well as repair of the bronchial membrane. Some of the vegetables/fruits are a source of mineral salts that are vital to the integrity and functioning of lungs. Thus, *Cleome gynandra* contains selenium, a key component that inhibits HIV-associated tuberculosis. The available research evidence

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underscores the importance of integrating the BAA into human daily diets as a prophylactic approach and therapeutic strategy against respiratory troubles.

Keywords Cough · Asthma · Bronchitis · Flavonoids · Acetogenins · Limonoids · Anti-inflammatory · Antimicrobial · Antineoplastic

3.1 Introduction

Respiratory disorders such as bronchitis, pneumonia, asthma, and obstructive pulmonary disease represent a significant global health burden, particularly in low-resource settings such as Africa and Asia (Labaki & Han, 2020). These conditions are exacerbated by environmental factors, especially polluted air or exposure to biomass smoke. Despite these, most indigenous communities still have limited access to health services in developing countries. Thus, such communities rely on traditional medicine as the basic means of managing respiratory ailments (Mutombo et al., 2023). In African ethnopharmacology, vegetables and fruit plants occupy a central role, offering a rich source of remedies with both nutritional and therapeutic benefits.

Africa's vast biodiversity provides a wealth of plant species traditionally used to alleviate respiratory troubles. Many of these plants are not only consumed as part of the diet but are also integral to indigenous healing systems. Ethnobotanical studies have documented a variety of vegetables and fruit plants with antitussive, anti-inflammatory, expectorant, and antimicrobial properties (Parham et al., 2020). These plants are often administered as decoctions, infusions, or poultices and are valued for their efficacy, accessibility, and cultural significance.

The therapeutic potential of the plants can be largely ascribed to their phytochemical constituents. Flavonoids, alkaloids, terpenoids, phenolic derivatives, and saponins have been identified in many species, exhibiting activities that align with the management of respiratory conditions. Moreover, ongoing scientific research has begun to make contributions toward validating the traditional uses of the plants, uncovering relevant phytochemicals, their mechanisms of action, and potential applications for modern drug development (Nasim et al., 2022).

This chapter explored the ethnopharmacological significance and phytochemical profiles of vegetables and fruit plants used in managing respiratory disorders across Africa. It highlights the interplay between traditional knowledge and modern pharmacology, offering insights into how these natural resources can contribute to addressing respiratory health challenges. By bridging traditional practices with scientific evidence, this chapter underscores the potential of African flora in global health contexts while advocating for sustainability in the utilization of medicinal plants and conservation of biodiversity.

3.2 Literature Search Strategy

We retrieved literature on edible vegetables and fruit plants used for treating respiratory troubles from published articles in multidisciplinary databases (Scopus, Science Direct, Web of Science, and Google Scholar) dated until March 13, 2025. Information of interest was limited to use in the treatment of respiratory disorders plus any other ethnopharmacological use in Africa. Data on the plant part (not necessarily the edible part) used in the management of respiratory diseases was also captured. In addition, phytochemical and pharmacological data on the featured plant materials included information sourced from Africa and beyond. Other traditional uses in addition to management of respiratory disorders were also included in the review. Key words/phrases used in the searches included: vegetables and fruits used against cough, asthma, tuberculosis, bronchitis, pneumonia, chest pain, and/or flu; antitussive vegetables and fruits; vegetables and fruits used against influenza; plants used for treating respiratory diseases.

3.3 Fruit Plants and Vegetables Used in Treating Respiratory Problems

The plants were categorized into five sub-sections as those that are normally consumed in forms of (1) fruits, (2) seeds, berries or pods, (3) leafy vegetables, (4) bulbs, and (5) roots.

3.3.1 Fruits

Photos of some fruits commonly consumed are shown in Fig. 3.1.

3.3.1.1 Pineapple (*Ananas comosus* (L.) Merr)

Ananas comosus (Bromeliaceae) (Fig. 3.1A) is commonly called pineapple and is a herbaceous, biennial crop growing up to 1.0–1.5 m high and is widely distributed in Africa and Asia (Spengler, 2019). It has fleshy fruits, edible especially when ripe, with the pulp that is white to yellow in color. The unripe fruit is macerated and prepared as a single-component juice for the treatment of cough associated with respiratory diseases in Nigeria (Lawal et al., 2020). It is effective in clearing bronchial passages in cases of bronchitis, colds, pneumonia, and sinusitis (Abubakar et al., 2022). The fruit is also indicated in cases of indigestion. In addition to respiratory diseases, the fruit/juice is also used to treat hypertension, type II diabetes, overweight, and constipation, in India (Kandasamy & Shanmugapriya, 2015;

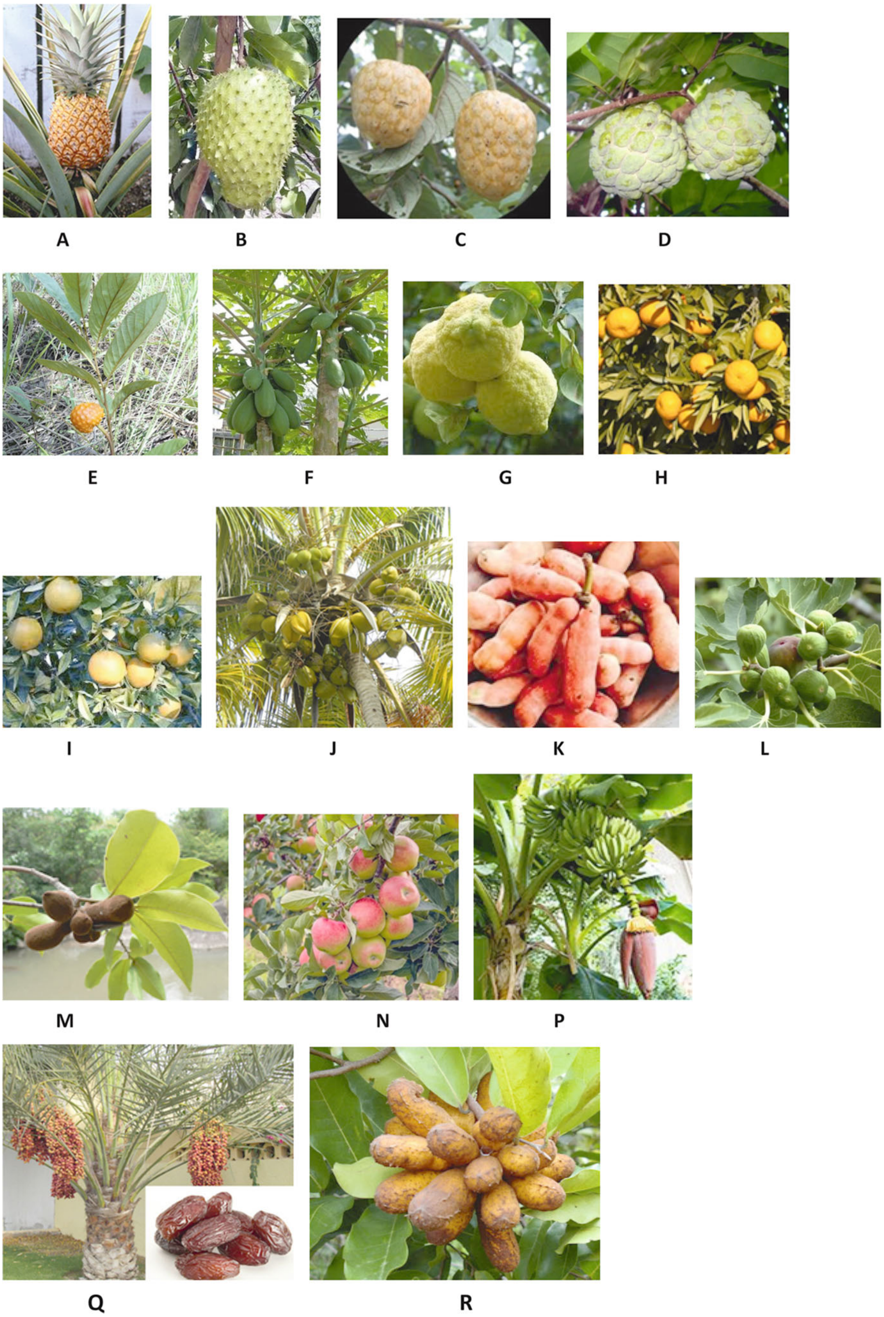


Fig. 3.1 Fruits of (**A**) *Ananas comosus*, (**B**) *Annona muricata* Linn, (**C**) *Annona senegalensis* Pers, (**D**) *Annona squamosa* L, (**E**) *Annona stenophylla* Engl. & Diels, (**F**) *Carica papaya* L, (**G**) *Citrus limon* (L.) Burm, (**H**) *Citrus reticulata*, (**I**) *Citrus sinensis*, L. Osbeck**,** (**J**) *Cocos nucifera*, (**K**) *Dennettia tripetala* Barker (F.), (**L**) *Ficus carica* L., (**M**) *Hexalobus monopetalus* (A. Rich.) Engl. & Diels, (**N**) *Malus domestica* Borkh*,* (**P**) *Musa paradiasiaca* L, (**Q**) *Phoenix dactylifera* L. (**R**) *Uvaria chamae* P. Beauv

Shawarb et al., 2023; Aiyeloja & Bello, 2006; Lawin et al., 2015; Magassouba et al., 2007; Emmanuel & Didier, 2012). Tannins, cardenolides, cardiac glycosides, dienolides, and flavonoids are present in the juice. Among the key constituents of *A. comosus* is bromelain (fruit bromelain, **1**), a proteolytic enzyme responsible for softening the mucus, hence facilitating its expulsion, and it also functions as an immune modulator (Wang, 2016). In a murine model experimentation of acute asthma, it was observed that bromelain caused a decrease in the lung inflammation markers (including infiltration by leucocytes and eosinophils) as well as moderation in the local airway immunity aspects (Secor-Jr et al., 2005, 2008). Bromelain has beneficial effects when used in the treatment of sinusitis (Seltzer, 1967; Braun et al., 2005). Patients with sinusitis experiencing breathing difficulties and with inflammation of the nasal mucosa demonstrated complete resolution in their breathing upon administration of bromelain (Zatuchni & Colombi, 1967; Ahle & Hamlet, 1987). Furthermore, it has been documented that bromelain has inhibitory activities against cancer metastasis (Kleef et al., 1996; Gerard, 1972; Rathnavelu et al., 2016).

3.3.1.2 Soursop (*Annona muricata* Linn)

Annona muricata (Annonaceae) (Fig. 3.1B) is distributed throughout the tropics around the world. Its leaf extracts and decoctions from its stem bark and roots are traditionally used in managing colds, flu, asthma, hypertension, epilepsy, fever, headache, cystitis, diabetes, headaches, insomnia, cancer, relaxing nerves, heart pain, hypertension, and mumps (Gavamukulya et al., 2017). The flowers have pectoral and febrifuge properties, and it is used in hot herbal preparations to treat influenza and bronchial catarrh (Emmanuel & Didier, 2012; Suroowan et al., 2019; Konkon et al., 2017; Omara et al., 2020; Moghadamtousi et al., 2015; Kasole et al., 2019; Anywar et al., 2020). The main secondary metabolites in *A. muricata* include acetogenins, terpenoids, alkaloids, saponins, flavonoids, lactones, coumarins, anthraquinones, cardiac glycosides, tannins, phytosterols, and phenols. Some of the isolated compounds include the cytotoxic annonaceous acetogenins muricins J (**2**) and K (**3**), annopentocins A (**4**), muricapentocin (**5**), annomuricin A (**6**), and compounds **7–9**. Argentinine (**9**) displayed significant cytotoxicity against human lung carcinoma A549 cells, human colon cancer HT-29 cells, the murine leukemia P388 cells, and the human KB cells, with ED_{50} values of 33.5, 9.9, 15, and 15.5 μM, respectively (Wu et al., 1993). The annonaceous acetogenin **5** isolated from the leaf extract of the plant exhibited potent cytotoxicity against human lung carcinoma A549 cells with an ED_{50} value of 0.193 μg/ml (Kim et al., 1998).

3.3.1.3 Wild Soursop (*Annona senegalensis* Pers.)

Annona senegalensis (Annonaceae) (Fig. 3.1C) is commonly referred to as wild soursop or African wild custard apple. It is a tree that thrives within the sub-humid and semi-arid parts of Africa (Orwa et al., 2009). Different parts of the tree are, traditionally, used against tuberculosis, inflammations, pain, malaria, convulsions, and trypanosomiasis, and the fruit is used as food/food additive (Okhale et al., 2016; Tabuti et al., 2010; Bunalema et al., 2014). In Ivory Coast pharmacopoeia, the plant is used against asthma and cough (Yeo et al., 2011). The fruit is also used in the treatment of kwashiorkor and marasmus (Okhale et al., 2016). The plant is largely fragrant and a source of essential oils. The ethanol extract from the leaves of the plant collected from Ivory Coast significantly induced reduction in the number of inflammatory cells, which supports the use of the plant in combating respiratory diseases (Yeo et al., 2011). Similarly, the methanol extract from the stem bark of *A. senegalensis* exhibited significant dose and time-dependent analgesic and anti-inflammatory activities in mice at oral doses of 100, 400, and 1000 mg/kg (Suleiman et al., 2014). Some of the compounds identified and isolated from the seeds of *A. senegalensis* include anonaine (**10**), isoboldine (**11**), and epicatechin (**12**). Anonaine and epicatechin are reported to have exhibited strong antioxidant properties, whereas isoboldine is reported to have suppressed the transcription of the pro-inflammatory cytokines IL-1β and IL-6 (Costa et al., 2012; Yilmaz & Toledo, 2004; Chou et al., 2014).

3.3.1.4 Custard Apple (*Annona squamosa* L.)

Annona squamosa (Annonaceae) (Fig. 3.1D) is also native to the tropical regions. It has deciduous leaves and dark brown, quilted fruits. The pulp is reddish yellow, sweet, and very soft, making it a desired ingredient in juices (Tabuti et al., 2010; Syamsuhidayat & Hutapea, 1991; Karou et al., 2011). It is used in treating cough, catarrhal inflammation, dysentery, diabetes, diarrhea, eczema, bladder problems, inflammation rheumatism, and skin eruptions, and is used as an astringent, emetic, tonic, febrifuge, aphrodisiac agent, anti-parasitic, anti-rheumatic, and analgesic and antispasmodic (Anywar et al., 2020; Karou et al., 2011; Nugraha et al., 2019; Dos Santos & Sant'Ana, 2000). In addition to the cytotoxic annonaceous acetogenins as those obtained from other *Annona* species, *A. squamosa* has yielded a wide range of biologically active compounds. Thus, caryophyllene oxide (**13**) and acetoxy-ent-kaur-16-ene (**14**) isolated from the stem bark of the plant showed significant analgesic and anti-inflammatory activities at doses of 12.5 and 25 mg/kg body weight in mice model tests (Chavan et al., 2010, 2011). Furthermore, a cyclic peptide cyclosquamosin D (**15**) isolated from the seeds of *A. squamosa* inhibits the production of pro-inflammatory cytokines (Yang et al., 2008). A number of annonaceous acetogenins have been reported from *A. squamosa* including annosquacin-I (**16**) and uvarigrandin-A (**17**) which exhibited cytotoxicity against human lung carcinoma A-549 cells with IC_{50} values of 0.012 and 0.08 μg/ml, respectively (Chen et al., 2011).

3.3.1.5 Dwarf Custard Apple (*Annona stenophylla* Engl. & Diels)

Annona stenophylla (Fig. 3.1E) is one of the Annonaceae species whose distribution spans from Central Arica, through Eastern Africa, to Southern Africa. The fruits of *A. stenophylla* have pineapple-like flavor and a pleasant taste. The local people eat them in raw form, cooked, or, in some cases, when preserved (Maroyi, 2019). The roots and leaves of the plant and its aerial parts are used as a herbal remedy for cold, bronchitis, asthma, fever, infertility, malaria, skin infections and stomach problems anemia, blood and stomach cleansing, scoliosis abdominal, muscle pains, anemia, malaria, stomach ache and sexually transmitted diseases and to induce (Maroyi, 2019; Dzoyem et al., 2016; Lautenschläger et al., 2018; Maroyi, 2024; Nyagumbo et al., 2022). In Zimbabwe, *A. stenophylla is* used in treating chest pain and pneumonia (Nyagumbo et al., 2022; Maroyi, 2011; Shopo et al., 2022). In Namibia, the roots of *A. stenophylla* are mixed with the roots of *Diospyros chamaethamnus* Mildbr.*, Strychnos pungens* Soler., *Diplorhynchus condylocarpon* (Müll. Arg.) Pichon, and *Bobgunnia madagascariensis* (Desv.), and the concoction is used against malaria and psychological disorders, though the plant parts and proportions are not stated (Maroyi, 2019; Shopo et al., 2022). The plant is generally considered to be non-toxic with $LD_{50} > 2000$ mg/kg in rat models (Nyagumbo et al., 2022). The plant has exhibited the following bioactivities: anti-inflammatory, antifungal, antibacterial hypoglycemic, and antioxidant activities (Maroyi, 2019; Nyagumbo et al., 2022). Phytochemical studies aimed at isolating compounds remain scant.

3.3.1.6 Pawpaw (*Carica papaya* L.)

Pawpaw (*Carica papaya* L.) (Fig. 3.1F) is a herbaceous succulent plant and is commonly found in India and South-East Asia, as well as in the tropical and sub-tropical parts of the world (Tan et al., 2022). The latex from the leaves and the unripe fruit/stem of *C. papaya* is employed in the treatment of whooping cough. In Nigeria, fruit juice from *Citrus aurantifolia* is mixed with the extracts from *Allium sativum* and the powdered seeds of *C. papaya,* and the resultant concoction is used to manage tuberculosis, whereas the dried and cured pawpaw leaves are smoked to treat asthma in Uganda (Adesina et al., 2017). *C. papaya* is used to treat asthma in children and other respiratory diseases in the Democratic Republic of Congo and to manage cough in South Africa (Mhlongo & Van Wyk, 2019). The latex and the leaves are used in individuals lacking digestive juice, pancreatitis, and against intestinal parasites, especially tapeworms, in the Mediterranean region. Consumption of pawpaw is also recommended for colitis, irritable bowel syndrome, and constipation (Muss et al., 2013). The latex contains a protease enzyme called papain, which has properties similar to those of bromelain (**1**), found in pineapples. Thus, papain may be responsible for emulsifying the mucus and facilitating its expulsion from the tracheal system. The fruit is rich in vitamins A (**18**) and C (**19**). The leaves of *C. papaya* contain an alkaloid, carpaine (**20**), with cardiovascular, antimalarial, anti-inflammatory, antioxidant, and antimicrobial properties. The compound is reported to have inhibited *Mycobacterium tuberculosis* with an in vitro minimum inhibitory concentration of 10^{-4} M (Ramasawamy & Sirsi, 1960). Other isolated phytochemicals present include loliolide (**21**), nicotiflorin (**22**), and isorhamnetin-3-*O*-*β*-D-glucopyranoside (**23**) (Hamed et al., 2022).

3.3.1.7 Lemon (*Citrus limon* (L.) Burm.)

Lemon *Citrus limon* (L.) Burm.) (Fig. 3.1G) is one of the tree species in the family Rutaceae, subfamily *Aurantioideae*. It is used in the management of many diseases including common colds, cough, obesity, urinary tract infections, gall bladder, kidney stones (renal lithiasis), acne scars, and pimples (Lawal et al., 2020). The fruits and the peels were part of several recipes that featured in the fight against COVID-19 (Mahmood et al., 2019). It is also used in treating circulatory disorders like anemia, arterial hypertension, coronary disease, angina pectoris, arrhythmia, atherosclerosis, thrombosis, edema, and chronic venous insufficiency (Khan et al., 2010). Lemon is rich in vitamin C (**19**), citric acid (**24**), flavonoids like neohesperidin (**25**), and diosmin (**26**), which are excellent immune-boosters and antioxidants. It also contains minerals like iron, potassium, and calcium, making the fruit a good candidate in cases requiring remineralization such as anemia and osteoporosis. The essence from the fruit peels and leaves contains D-limonene (**27**) which is an excellent detoxifier and with antioxidant, antimicrobial, antiviral, antiseptic, and anti-inflammatory properties (Mahmood et al., 2019; Rafique et al., 2020; Yi et al., 2017; Lv et al., 2015). Other compounds identified from lemon include limonoids such as limonin (**28**), which do have a wide range of pharmacological properties including anti-inflammatory, antioxidant, antiviral, anticancer, antibacterial, liver-protective, and analgesic (Fan et al., 2019; Roy & Saraf, 2006).

3.3.1.8 Tangerine (*Citrus reticulata*)

Tangerine (*Citrus reticulata*) (Fig. 3.1H) belongs to the citrus (Rutaceae) family (Shi et al., 2024). Tangerine is a common choice in the food processing and the pharmaceutical manufacturing industry because of the unique flavor it has. Ethnopharmacologically, *C. reticulata* is recommended in conditions such as sore throat, bronchitis, allergic reactions, sinusitis, gastritis, among others (Shi et al., 2024). Like other citrus fruits, it is reputed for high concentrations of biologically active ingredients and having health-promoting properties (John, 2018), and its major active components can be very effective against respiratory ailments and cardiovascular diseases (Shi et al., 2024). Some of the compounds identified from *C. reticulata* fruit juice include vitamin C (**19**) and quercetin (**30**) as well as limonoids (John, 2018). Quercetin is one of the most valuable constituents in fruits and vegetables because of its potent activities such as antioxidant (particularly radical scavenging), immune stimulation, anti-inflammatory, anti-histamine, antiviral, and cytotoxicity. The compound suppresses the release of pro-inflammatory cytokines from mast cells and it inhibits the release of histamine from basophil cells (Yang et al., 2020; Mlcek et al., 2016). Quercetin, further, exhibited antiviral properties against influenza virus H1N1, dengue virus, and Zika virus with IC_{50} values of 7.75, 28.9, and 2.3 μM, respectively (Johari et al., 2012; Zou et al., 2020).

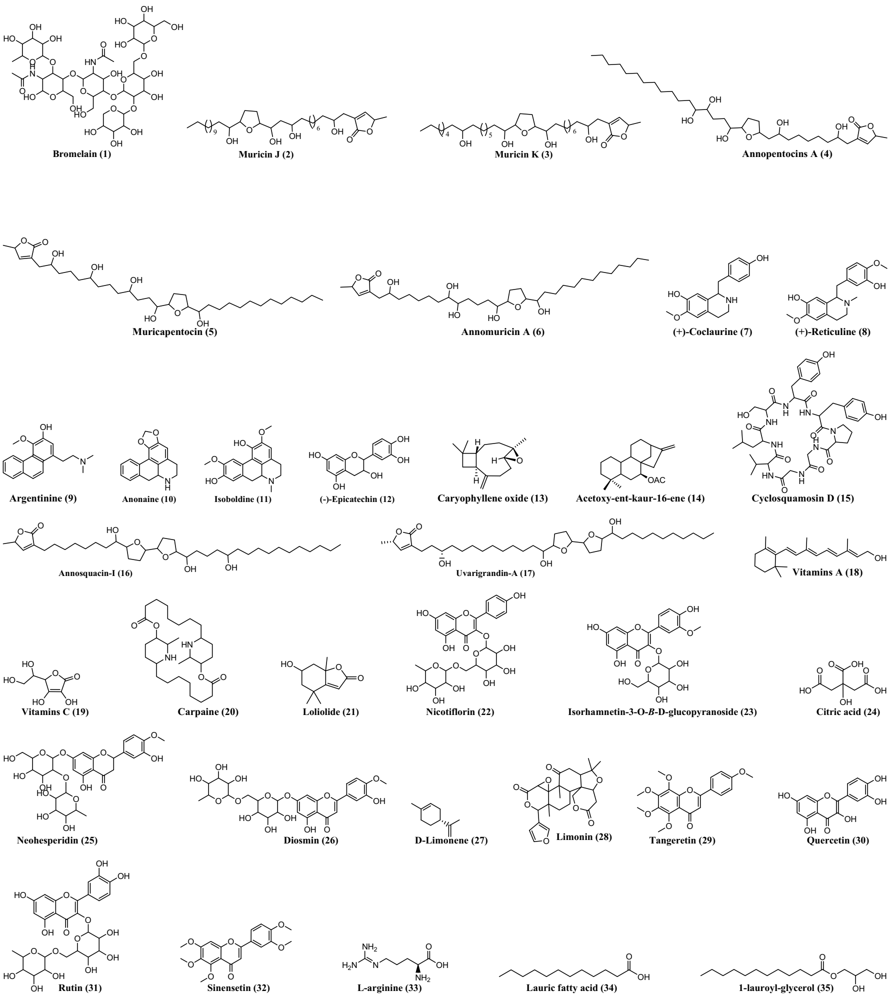
Furthermore, quercetin was among the phytochemicals that exhibited promising activities against COVID-19 with an IC_{50} value of 23.8 μM (Solnier & Fladerer, 2021).

3.3.1.9 Oranges (*Citrus sinensis,* L. Osbeck)

Oranges or sweet orange (*Citrus sinensis,* L. Osbeck) (Fig. 3.1I) belongs to the family *Rutaceae*, subfamily *Aurantioideae.* Its origin is South-East Asia, but it is now grown in all the tropics, subtropic, and temperate regions of the world (Esan et al., 2024). Sweet oranges are important for both fresh markets and processing industries. In addition to their role in food and nutrition, consumption of oranges is associated with health benefits. Having oranges as part of a daily menu is recommended as a preventive measure against allergic reactions like rhinitis, bronchial asthma, flu, colds, and various forms of infections (Turner & Burri, 2013). It is also used, traditionally, in the prevention of risks associated with thrombosis, arteriosclerosis, heart diseases, kidney stones, excess uric acid, osteoporosis, rickets, and cancer (Esan et al., 2024; Dongre et al., 2023). Some of the vital constituents present in oranges include vitamin C (**19**), responsible for the fruit's wide biological activities such as immune-boosting; flavonoids, like rutin (**31**) and sinensetin (**32**), with excellent anti-inflammatory and antioxidant properties; as well as limonoids and glycosides with antitumor effects. Carotenoids are also present in significant amounts as well as minerals like potassium, calcium, magnesium, and phosphorus, hence making the fruit to be suitable in cases of demineralization. The inner peel (white mesocarp) of the fruit is rich in soluble fibers, particularly pectin, that reduce cholesterol levels (Dongre et al., 2023; Miles & Calder, 2021).

3.3.1.10 Coconut (*Cocos nucifera* Linn)

Coconut (*Cocos nucifera* Linn) (Fig. 3.1J)*,* commonly called the "coconut tree," belongs to Arecaceae family. It is adapted to a wide range of habitats. The plant originated from India, dispersed to the East African coast and the interior, then later distributed to Western Africa and to the rest of the tropical regions of the world (Lima et al., 2015). Coconut fruit is consumed for energy from kernel and refreshment from the "coconut water" which provides minerals to compensate for any losses brought about by strenuous exercises (Moreno et al., 2020). Coconut is traditionally used in managing cough, tuberculosis, bronchitis, asthma, sore throat, flu, urinary infections, colitis, bacterial and viral infections, among other diseases (Lima et al., 2015; Nagata et al., 2011). The fruit of *C. nucifera* has mucolytic, demulcent, antiviral, antibiotic, immuno-stimulant, antioxidant, antihelminthic, antifungal, anti-inflammatory, antitumor, and analgesic activities. The edible portion of *C. nucifera* contains a range of nutrients including magnesium (32 mg/100 g), calcium (14 mg/100 g), potassium (356 mg/100 g), iron (2.43 mg/100 g), phosphorus (113 mg/100 g) as well as medium chain triglycerides, tannins, phenolics, anthocyanidins, terpenes, flavonoids, alkaloids, and sterols (Lima et al., 2015; Nagata et al., 2011). The coconut water is also rich in minerals, and with the advantage that it does not contain saturated fats. In addition, the coconut water is rich in *L*-arginine (**33**) (30 mg/dL) and ascorbic acid (**19**) (15 mg/100 mL), both of which possess strong antioxidant properties (Das et al., 2001; Salil & Rajamohan, 2001). Other isolated from the fruit pulp include lauric fatty acid (**34**) which, upon ingestion, is bio-transformed into an effective antimicrobial derivative, 1-lauroyl-glycerol (**35**).



3.3.1.11 Pepper Fruit (*Dennettia tripetala*) Barker (F.)

The leaves and fruits of *Dennettia tripetala* (Fig. 3.1K) (Annonaceae) are edible and are used as appetizers, stimulants, or as a spice in West Africa (Kandasamy & Shanmugapriya, 2015). The leaves and seeds are used by traditional health practitioners in West Africa as remedies for cough, asthma, catarrh, fevers, toothache, nausea, and rheumatism, among other diseases. The phenolic acid and essential oil extracts from the plant have antimicrobial activities against *Staphylococcus aureus*, *Escherichia coli*, and *Salmonella* sp. among other bacterial strains, and the leaves are effective against *Sclerotium rolfsii* fungus (Ejechi & Akpomedaye, 2005; Nwachukwu & Osuji, 2008). The root of *D. tripetala* furnishes vanillin (**36**), dennetine (2, 6-dimethoxychromone) (**37**), and alkaloids such as uvariopsine (**38**). Compound **38** improves the functioning of the liver and facilitates the secretion of bile (López-Martín et al., 2002a). The presence of vanillin (**36**) explains the use of the plant in boosting appetite (Ogawa et al., 2018). The fruit fragrance containing 2-phenylnitroethane (**39**) and linalool (**40**) (72.4 and 18.0%, respectively) as the major components has antimicrobial, anti-inflammatory, muscle relaxant, and antifungal properties (Adesina et al., 2017; López-Martín et al., 2002b).

3.3.1.12 Figs (*Ficus carica* L.)

Ficus carica (Fig. 3.1L), (Moraceae) is native to the Middle East; Mediterranean regions, Northern India, Morocco, Algeria, and Egypt (Mazzeo et al., 2024). It is used for making jellies, jams, and for garnishing baked food products. Dried fig fruits that have been rehydrated or boiled with milk are used to treat cough in North Africa and in Spain. It is, further, utilized in treating fever, chronic bronchitis, respiratory tract infections, inflammation, diabetes, intestinal worms, anemia, constipation, smallpox, paralysis, ringworm, leprosy, herpes, and dysenteric gonorrhea. The fruits possess diaphoretic, aphrodisiac, astringent, laxative, demulcent, and emollient properties. They have a pectoral action that fights infections. They soothe the respiratory tract, relieve cough, and facilitate expectoration (Lazreg-Aref et al., 2011). The figs contain monosaccharides and disaccharides, alkaloids, flavonoids, sterols, coumarins, triterpenes, and anthocyanins; quinine (**41**), rutin (**31**), 4′,5′--dihydropsoralen (**42**), umbelliferone (**43**), and psoralen (**44**) (Badgujar et al., 2014). Umbellifone (**43**) exhibited anti-inflammatory activities by inhibiting the production of nitric oxide, NO (46.10% inhibition at 0.5 mg/ml dosage), and antioxidant activity with radical scavenging properties (IC_{50} = 36.28 μg/ml) against $ONOO^{-}$ radicals (Ali et al., 2019).

3.3.1.13 Baboon's Breakfast (*Hexalobus monopetalus* (A. Rich.) Engl. & Diels)

Hexalobus (Fig. 3.1M) (Annonaceae) is restricted to the tropical savannah of Africa. The genus comprises only six species, which are either small trees or shrubs (Orwa et al., 2009). *Hexalobus monopetalus* is commonly used traditionally by the rural populations of Mwanza, Iringa, Mbeya, Kigoma, Tabora, and Ruvuma sub-regions in Tanzania for the treatment of fevers and stomach troubles (Kasole et al., 2019; Malebo et al., 2014). It is also used against colds, gastric ulcer, sexually transmitted diseases, diarrhea, stomach pains, snakebites, and headaches (Dzoyem et al., 2016; Nyagumbo et al., 2022; Kayode & Kayode, 2008). The stems, roots, bark, leaves, and fruits are utilized in Zimbabwe for the treatment of colds, pulmonary disorders, and bronchitis (Dzoyem et al., 2016). Some of the bioactive compounds isolated from the fruits of *H. monopetalus* include the indoline alkaloids 3,5-hexalobine C (**45**) and 3,5-hexalobine D (**46**), which exhibited mild antifungal properties (zones of inhibition = 5 and 14 mm, respectively) against *Candida albicans* (Malebo et al., 2014).

3.3.1.14 Apples (*Malus domestica* Borkh.)

Apple (*Malus domestica* Borkh.) (Fig. 3.1N) is a domesticated tree from Rosaceae family. It is also used commercially for vinegar, juice, jelly, and apple sauce (Palmatier, 2000). This plant is widely grown globally, and it is prone to drought, which affects its growth, quality, and in some places, yield (Spengler, 2019). Apple fruit/juice is used to treat tuberculosis, dry cough, chronic bronchitis, type II diabetes, neuropsychiatric disorders, obesity, several microbial infections, digestive problems, inflammations and ulcers, coronary heart diseases, cancer, palpitation, and dysentery (Kandasamy & Shanmugapriya, 2015; Hammad & Malik, 2021; Opyd et al., 2017). It is a nutritious fruit having a high dietary fiber content, total soluble solids, vitamins, polysaccharides (pectin), polyphenols, sterols, and triterpenes (Patocka et al., 2020). Some of the compounds present in apples and apple peels include chlorogenic acid (**47**), epicatechin (**12**), *p*-coumaric acid (**48**), and quercetin-3-rhamnoside (**49**) (Opyd et al., 2017; Lu & Foo, 1998; Tsao et al., 2005). Compounds **47** and **48** obtained from other plant materials have exhibited antioxidant, antibacterial, antiviral, and anti-inflammatory properties (Palmatier, 2000). Quercetin-3-rhamnoside (**49**) has exhibited antiviral activities against influenza A (causing a titer reduction of 6 logs ($p < 0.01$) at a concentration of 150 μg/ml) (Mehrbod et al., 2018).

3.3.1.15 Bananas (*Musa paradiasiaca* L.)

Bananas (*Musa paradiasiaca* L.) (Fig. 3.1P) are cultivated in Asia, South America, and Africa (Ahmed et al., 2021; Galani, 2019). The fruits are majorly consumed fresh, but some varieties are eaten after cooking. Bananas are industrially processed jellies, syrup, and banana vinegar (Galani, 2019; Tugume et al., 2016; Begashaw et al., 2023). In Nigeria, the leaves and fruits from the crop are utilized in treating cough (Lawal et al., 2020). In Pakistan, it is used to treat whooping cough (Lawal et al., 2020). The people from Eastern Uganda use the ash from the petiole of *M. paradiasiaca* var *paradiasiaca* and a decoction of the inflorescence from *M. paradiasiaca* var. *sapientum* against cough (Tabuti et al., 2003). It has been revealed that the *M. paradiasiaca* has numerous pharmacological activities such as anti-diarrheal, diuretic, antiulcer, anti-dysentery, antimalarial, vermifuge, and antimicrobial activities (Begashaw et al., 2023). Phytochemicals obtained from the leaves of *M. paradisiaca* include phenolics, cardiac glycosides, flavonoids, tannins, terpenoids, saponins, anthraquinones, and alkaloids, viz, rutin (**31**) and naringenin

(**50**) (Behiry et al., 2019). Rutin has anti-inflammatory and neuroprotective properties (Aruna et al., 2014; Park et al., 2014). Naringenin has shown activity against Chikungunya virus and Zika virus ($IC_{50} = 6.18$ and 58.79 μM, respectively) (Zou et al., 2020; Ahmadi et al., 2016).

3.3.1.16 Dates (*Phoenix dactylifera* L.)

Dates (*Phoenix dactylifera* L.) (Fig. 3.1Q), scientifically known as *Phoenix dactylifera* (Arecaceae, photo 16), were first domesticated in the Gulf of Persia and then later introduced to Northern Africa (Najafiniya & Rahkhodaei, 2024).

Dates do contain high concentrations of total polyphenols and significant amounts of antioxidants, and this has been attributed to the intense heat from the sun that the dates are exposed to (Al-Karmadi & Okoh, 2024). Traditionally, it is used in the treatment of the respiratory system, hypertension, and skin and skin-related diseases (Cámara-Leret et al., 2014). The phytochemical compounds isolated from the leaves of *P. dactylifera* include rutin (**31**), quercetin-3-*O*-glucoside (**51**), vanillyl alcohol (**52**), and oleanolic acid (**53**) (Suleiman et al., 2021).

3.3.1.17 Bush Banana or Finger Root *(Uvaria chamae* P. Beauv)

Uvaria chamae (Fig. 3.1R)*,* (Annonaceae) is a small tree and sometimes a climbing shrub distributed across West Africa, through Central Africa up to the Eastern Africa region (Guisan et al., 2013). The fruit of *U. chamae* is edible and widely eaten. The plant is used in treating asthma, fevers, wounds, sores, and yellow fever in Nigeria (Abu et al., 2018), and it has antibiotic properties (Adesina et al., 2017). The methanol extract from the stem bark of the plant exhibited antibacterial activity against *Escherichia coli*, methicillin-resistant *Staphylococcus aureus*, *Proteus* spp., *Klebsiella* spp., *Staphylococcus aureus* ATCC25923, *Escherichia coli* ATCC25922, and *Pseudomonas aeruginosa* ATCC27853 with MIC of 5.62, 200, 12.59, 35.48, 5.62, 28.18, and 19.95 mg/ml, respectively (Oluremi et al., 2010). It is also reported to have exhibited anticancer activity against human nasopharyngeal carcinoma (in vitro) and mouse P-388 lymphocytic leukemia (in vivo). The extract further yielded the cytotoxic C-benzylated flavonoids including chamanetin (**54**), dichamanetin (**55**), and uvaretin (**56**), among others (Lasswell & Hufford, 1977). The crude root extract of *U. chamae* exhibited significant antiplasmodial activity in mice when orally administered at 300–900 mg/kg/day (Okokon et al., 2006).

3.3.2 Fruits Consumed as Pods, Berries, and/or Seeds

Photos of vegetables consumed as pods, berries, and/or seeds were shown in Fig. 3.2.

3.3.2.1 Okra (*Abelmoschus esculentus* L. Moench)

Okra (*Abelmoschus esculentus* L. Moench) (Fig. 3.2A), belonging to Malvaceae family, is sometimes called lady's finger. It is grown in many parts of Africa, Asia, America, and Southern Europe (Islam, 2019). Okra pods, which are approximately 15–20 cm in length, are valued for their edibility.

The pods, fruits, together with the seeds as well as the leaves of the plant have various applications due to their composition and properties especially in treating bronchitis, tuberculosis, and heart diseases in Zimbabwe (Nyagumbo et al., 2022; Chimponda & Mukanganyama, 2010), as well as pneumonia, diabetes, syphilis, anemia, catarrhal infections, dysuria, gonorrhea, ulcer, antispasmodic in the rest of Africa (Omara et al., 2020; Uwimbabazi et al., 2023; Obakiro et al., 2020). The extract from the seed and peel (100 mg/Kg) caused significant ($P < 0.05$) reduction in blood glucose level (96.84 ± 9.09 mg/dL) compared to that of the standard drug (metformin, 182.70 ± 34.81 mg/dL) 15 days after alloxan-induction (80 mg/Kg) of diabetes in Winstar rats (Abi et al., 2017). Since one of the symptoms of diabetes is an irritant cough (Wang et al., 2008), it is most likely that *A. esculentus* alleviates respiratory tract disorders through the regulation of blood sugar levels. The plant is generally considered safe with $LD_{50} > 2000$ mg/kg, and phytochemically, *A. esculentus* has been found to contain high amounts of flavonoids and moderate concentrations of sterols, terpenes, and phenolic compounds (Taiwo et al., 2021; Roy et al., 2014). These phytochemicals possess pharmacological properties; antioxidant, antidiabetic, hypolipidemic, antiulcer, neuroprotective activities; and are very effective in the healing of wounds. They also modulate the immune system, inhibit cancer and microbial growth, and protect the liver, the cardiovascular system,

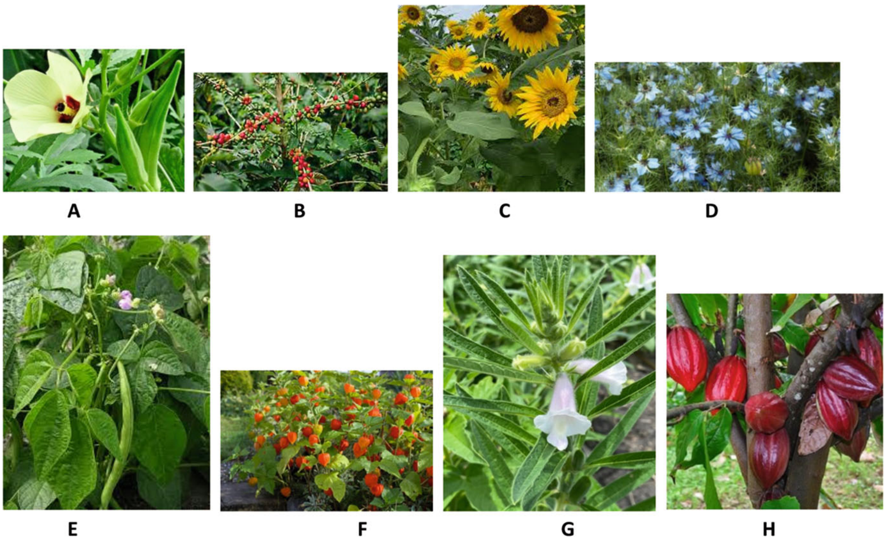


Fig. 3.2 Aerial parts of (**A**) *Abelmoschus esculentus* L. Moench, (**B**) *Coffea canephora* Pierra ex A. Froehner, (**C**) *Helianthus annuus* L, (**D**) *Nigella sativa*, (**E**) *Phaseolus vulgaris* L, (**F**) *Physalis alkenkengi* L, (**G**) *Sesamum indicum* L, (**H**) *Theobroma cacoa* L.

and the gastro-intestinal tract (Prabhune et al., 2017; Chowdhury et al., 2019). Some of the isolated compounds from the plant include isoquercitrin (**57**) and quercetrin diglucoside (**58**) (Taiwo et al., 2021; Lin et al., 2014). The two compounds **57** and **58** showed strong antioxidant properties against intracellular reactive oxygen species (ROS), in a 2′,7′-dichlorofluorescein diacetate assay, with IC_{50} values of 2.7 ± 0.5 and 1.9 ± 0.2 μg/ml, respectively (3 hours after treatment) and 2.0 ± 0.8 and 1.5 ± 0,4 μg/ml, respectively (24 hours after treatment) (Taiwo et al., 2021).

3.3.2.2 Coffee (*Coffea canephora* Pierra ex A. Froehner)

Coffee (*Coffea canephora* Pierra ex A. Froehner) (Fig. 3.2B) is a shrubby plant, in the Rubiaceae family, distributed from tropical West Africa to Ethiopia and northern Angola, as well as in countries along the equator. In various countries like Ethiopia, Sudan, Indonesia, and Jamaica, coffee is used as a source of ethnomedicines, especially as a leaf-based beverage (Mewaba et al., 2022). In different parts of Africa, the seeds of *C. canephora* are used against asthmatic attacks (Moyo et al., 2015). In countries like Cuba, Peru, Nicaragua, and Mexico, coffee leaves are used as an emollient when managing flu, fever, and cough (Chen et al., 2018), as well as intestinal troubles and diarrhea in Africa (Mewaba et al., 2022). In addition to being a stimulant, the beverage obtained from coffee beans is believed to alleviate several disorders, like fever, anemia, and intestinal pain (Campa & Petivallet, 2018). The extract from the beans is reported to have caused a reduction in fasting glucose, insulin resistance, serum leptin, inflammatory tendencies in adipose tissues, among other effects, in atherogenic-diet fed ApoE−/− mice at 220 mg/kg intra-gastric dosage, thrice a week for 14 weeks (de Almeida et al., 2019; Caro-Gómez et al., 2019). A diversity of classes of secondary metabolites have been identified from *C. canephora*, namely, alkaloids, flavonoids, and phenolic compounds. Most of these compounds have anti-inflammatory, antioxidant, lipid-lowering, and immunomodulatory activities. Thus, caffeic acid (**59**), chlorogenic acid (**47**), mangiferin (**60**), and caffeine (**61**) are among the secondary metabolites identified from different parts the crop. Consumption of foods (and beverages) containing compounds **47** and **59** is associated with health-promoting attributes such as antioxidant and anti-inflammatory properties of the compounds (Liang & Kitts, 2015). Compound **47** is reported to have significantly reduced pulmonary eosinophilia and expression of interleukin 4 (IL-4), interleukin 5 (IL-5), and the tumor necrosis factor (TNF-α) in the lungs of mice with ovalbumin-induced allergic asthma upon intraperitoneal administration of the compound at a concentration range of 0.5–25 mg/Kg body weight (Kim et al., 2010). However, the roasting process during the production of brewed coffee beans tends to reduce the concentration of compound **47** (Mondolot et al., 2006). Relatedly, compound **60**, which was first isolated from the leaves, stem bark, and the peel of *Mangifera indica*, is reputed for a wide range of pharmacological properties including anti-inflammatory, antihyperlipidemic, antidiabetic, neuroprotective, antioxidant, and antimicrobial activities (Du et al., 2018). The xanthine alkaloids, including caffeine, present in various species of coffee have bronchodilatory properties and, thus, help in relieving pain in the respiratory tract (Zhang et al., 2024; Shi et al., 2016); however, high concentrations of caffeine are associated with insomnia, palpitations (tachycardia), tremors, headache and anxiety in some sensitive individuals. So it is advisable that coffee be consumed but in moderation (O'Keefe et al., 2018).

3.3.2.3 Sunflower (*Helianthus annuus* L.)

Helianthus annuus (Fig. 3.2C) (Asteraceae) is considered to be the most important oilseed in the world, producing dietary fiber in addition to premium oil (Adeleke & Babalola, 2020). Traditionally, in some communities, different parts of sunflower are used to treat asthma, chronic obstructive disease, bronchitis and laryngitis, migraine, and seasonal allergic fever, and also used as an expectorant (Sharif et al., 2022). The seeds contain flavonoids, steroids, polyphenols, monounsaturated and polyunsaturated fatty acids, amino acids, especially L-arginine (**33**) with antidiabetic and antihypertensive properties, as well as minerals like potassium which contribute to the well-being of the consumers. The phenolic compounds in *H. annuus* have exhibited very good antioxidant properties (Gai et al., 2020). Some of the compounds identified from the aerial parts and the non-oil fractions of the seeds of the plant include 1,5-Di-*O*-caffeoylquinic acid (**61**) and 4,5-Di-*O*-caffeoylquinic acid (**62**). The caffeoylquinic acid derivatives isolated from other plant materials exhibited significant anti-inflammatory, expectorant, and antitussive properties in a three-day oral administration experiment, with doses of 10 and 20 mg/kg per day, in a mouse model (Ye et al., 2015). The bioactivity of the caffeoylquinic acid derivatives, in this regard, may be associated with the catechol moiety similar to what is found in β_2-agonists, with smooth muscle relaxant and bronchodilation properties (Marques & Vale, 2022).

3.3.2.4 Black Seeds (*Nigella sativa*)

Black seed (*Nigella sativa*) (Fig. 3.2D) is from Ranunculaceae plant family, and considered to be a miracle herb with an enriched ritualistic and historical background (Yimer et al., 2019; Javed et al., 2010). The seed oil is used in Unani and Ayurveda medicine practices. According to Prophet Muhammad, "black seed" was considered to cure almost all ailments (Hosseinzadeh et al., 2007). The seeds are commonly prescribed in cases of asthma, cough, digestive diseases, bacterial infections, diabetes, and viral infections, among others (Javed et al., 2010; Ferizi et al., 2023). *N. sativa* has a wide range of biological activities including bronchodilation, diuretic, antihypertensive, anti-inflammatory, analgesic, antidiabetic, antioxidant, antimicrobial, contraceptive, and antifertility, among others. The ethanol extract of *N. sativa* exhibited was active against the methicillin-resistant *Staphylococcus aureus* isolates with MIC values of 0.2–05 mg/ml (Forouzanfar et al., 2014). Some of the isolated compounds from black seeds include nigellicine (**63**), nigellidine (**64**), thymohydroquinone (**65**), and thymoquinone (**66**) (Ferizi et al., 2023; Mehta et al., 2009). Thymoquinone induced a significant reduction in the levels of pro-inflammatory mediators (TNF-γ, IL-6, IL-1γ, PGE-2, IFN-γ) and raised the level of IL-10 in collagen-induced arthritic Wistar rats (Umar et al., 2012).

3.3.2.5 Kidney Beans (*Phaseolus vulgaris* L.)

Phaseolus vulgaris (Fig. 3.2E) (Fabaceae) is an herbaceous annual plant. In Africa and parts of Asia, the green leaves and the young pods are consumed as vegetables and sometimes as salads, and the dry beans, mainly in cooked form, are a good source of protein (Ganesan & Xu, 2017). The beans are recognized for their special health attributes such as their high concentration of proteins and dietary fiber, low levels of saturated fats, presence of minerals and vitamins, as well as phytochemicals, making them to be suitable options in diet replacement formulations. In Uganda, bean pods/husks are also used to treat respiratory disorders, in particular tuberculosis (Bunalema et al., 2014), and in Zimbabwe, they are used to manage bilharzia and postpartum conditions (Maroyi, 2023). Beans contain nonheme iron, potassium, flavonoids such as 3,5,7,4′-tetrahydroxyflavone (**67**), 5,7,4′-trihydroxyflavone (**68**), europinidin (**69**), and aurantinidin (**70**), as well as amino acids including *L*-arginine (**32**), which is associated with the antidiabetic properties of the bean pods (Olowookere & Malomo, 2024).

3.3.2.6 Winter Cherry (*Physalis alkenkengi* L)

The red ripened berries of Winter cherry (*Physalis alkenkengi* L) (Fig. 3.2F) are edible. In Uganda, where it is known as "Entuntunu" (Luganda), the berries are used for the management of colds and flu as well as for improvement of female fertility (Orwa et al., 2009; Namukobe et al., 2011). The berries also have diuretic, depurative, and uricosuric properties. They are, further, used in cases of urinary lithiasis, gout, and uric arthritis. Winter cherry berries are rich in vitamin C (**19**) (its concentration is higher than in lemon), malic acid (**71**), citric acid (**24**), and carotene/provitamin A (**72**) and traces of alkaloids (Pamploma-Roger, 2006).

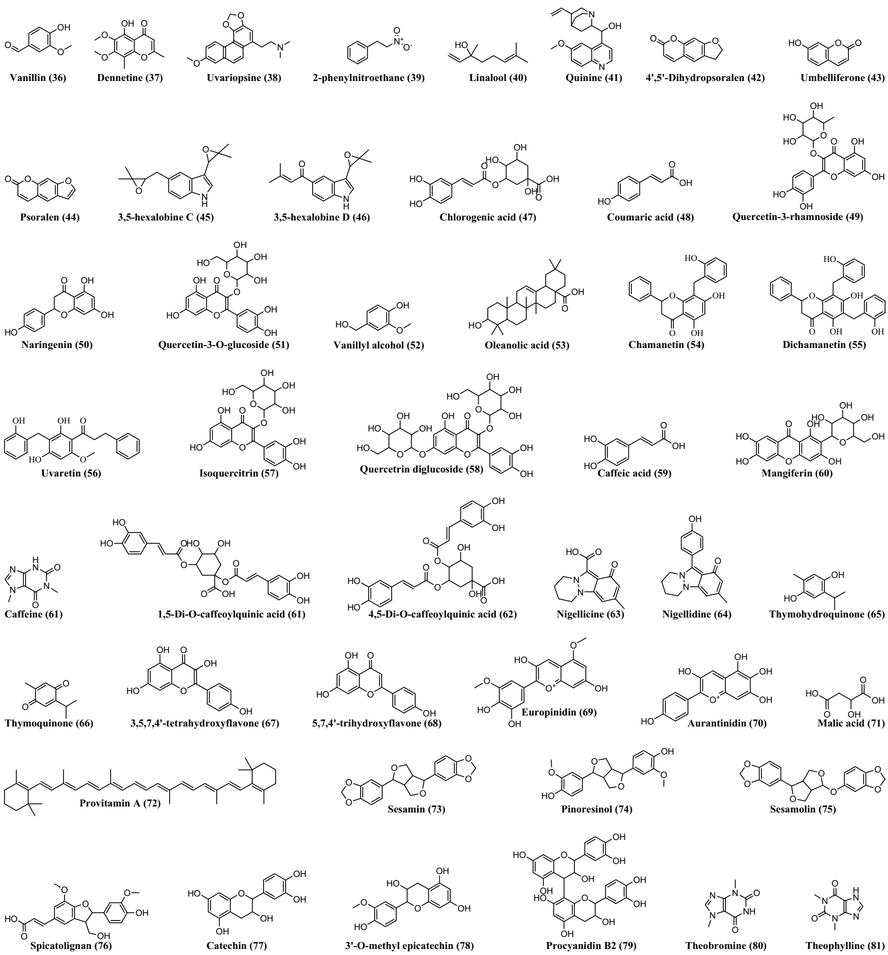
3.3.2.7 Sesame (*Sesamum indicum* L.)

Sesame (*Sesamum indicum* L.) (Fig. 3.2G) is an herbaceous plant from Pedaliaceae family, whose seeds are edible and a source of vegetable oil. It originated in Pakistan from where it was distributed to the Indo-China region, Malaysia, and Myanmar, and it is currently cultivated in several countries worldwide (Hou & Meng, 2022). Ethnomedicinally, sesame has been used as food, medicine, and in cultural rituals in Egypt, the Middle East, and India. Sesame oil was used to prepare perfumes and medicines in the Babylonian empire, and for the purification ceremony in ancient Egypt (Mili et al., 2021). The fruits are used against cough and constipation (Dzoyem et al., 2014). The oil is traditionally used in cases of tuberculosis and cough, and it has demulcent and antitussive properties. Other medicinal uses of the oil include treatment of eye diseases, ulcers, migraines, hair loss, constipation, and induction of breast-milk production as well as promotion of menstruation (Peter, 2012; Ross, 2007). The leaves are used in treating catarrh, inflammations in the mouth cavity, dysenteric diarrhea, cystitis, type II diabetes, rabies, skin dandruff, and urinary tract diseases (Peter, 2012; Anis & Iqbal, 1994). The roots are also used to treat asthma and cough, promote hair growth, and prevent premature growth of gray hair (Peter, 2012). It was reported that application of the seed oil into the nasal cavity could inhibit the proliferation of SARS coronavirus in humans (Allam et al., 2021). Sesame seeds are rich in terpenoids, phenols, anthraquinones, lignans, steroids, naphthoquinones, and glycosides, having many nutritive and health benefits. The crop has important pharmacological properties like anti-inflammatory, antihypertensive, antioxidant, anticancer, antipyretic, and hepatoprotective activities (Hou & Meng, 2022; Mili et al., 2021). The following are some of the isolated compounds from sesame leaves: sesamin (**73**), pinoresinol (**74**), sesamolin (**75**), and spicatolignan (**76**) (Allam et al., 2021). Sesamin has exhibited immunomodulatory and anti-inflammatory properties. Thus, 30-minute pre-treatment of murine BV-2 microglial cells with sesamin (10–100 μg/ml) followed by co-treatment with lipopolysaccharide and sesamin (10–100 μg/ml) for 24 hours caused inhibition in the production of the pro-inflammatory cytokines, IL-6, and TNF-γ in a concentration-dependent manner (Jeng et al., 2005). Structure activity studies show that the catechol moiety is responsible for the anti-inflammatory activities of sesamin (Abe-Kanoh et al., 2019).

3.3.2.8 Cocoa (*Theobroma cacoa* L.)

Cocoa/Cacao (*Theobroma cacoa* L.) (Fig. 3.2H) (family Malvaceae) is a tree that originated from Central America, particularly in the Guyana Plateau and the Amazon basin (Zhang et al., 2011). It is one of the major economic crops in Western Africa with the highest producer of the beans being Ivory Coast. A concoction from the leaves of *T. cacao* is used to treat cough associated with respiratory diseases in Nigeria (Lawal et al., 2020). A decoction from the pod rinds is used against cough and as a stimulant in Mexico (Zhang et al., 2024). The cocoa beans are used in the preparation of "teas" and help to fight high blood pressure. It is also believed to protect nerves from injury and inflammation, as well as the skin against oxidative damage caused by UV radiation from the sun. Furthermore, it is believed to improve on mood and cognitive abilities. The beverage and extract from the beans protect against heart disease, reduce the viscosity of blood, and exhibit anticancer properties (Zhang et al., 2011; Rojo-Poveda et al., 2020). It has diuretic, sedative, emollient, and wound-healing properties. The health benefits gained from the consumption of chocolate and cocoa may be due to the presence of polyphenolic compounds, flavonoids, and procyanidins. *T. cacao* contains catechin (**77**), 3′-*O*-methyl epicatechin (**78**), and procyanidin B_2 (**79**) (Erlejman et al., 2008), as well as xanthine alkaloids such as theobromine (**80**) and theophylline (**81**). Compound **79** is reported to have suppressed lipopolysaccharide-induced inflammation and apoptosis in human alveolar epithelial cells and lung fibroblasts by inhibiting nuclear factor kappa B (NF-kB) and NOD-like receptor family, pyrin domain containing

3 (NLRP3) inflammasomes (Jiang et al., 2020). Catechin exhibited strong antioxidant properties with a strong ferric reducing antioxidant power (FRAP) of 0.793 ± 0.004 mol trolox equivalents per mol (Grzesik et al., 2018). The xanthine alkaloids have bronchodilation properties and hence help in relieving cough, but they are also associated with the risk of insomnia, anxiety, and tachycardia in some individuals. *T. cacao* is commonly applied in the following cases: lip sores, nipple sores, burns, skin rashes, hemorrhoids and vaginitis, and for hair growth.



3.3.3 Leafy Vegetables

Photos of leafy vegetables were shown in Fig. 3.3.

3.3.3.1 Spiny Amaranth or Spiny Pigweed (*Amaranthus spinosus* L.)

Amaranthus spinosus (Fig. 3.3A) (Amaranthaceae) is an annual herb found throughout Africa. A decoction of the aqueous extract from the leaves is used against respiratory diseases in Nigeria (Lawal et al., 2020; Dele & Ojone, 2023). It is also used against bronchitis in Pakistan (Mahmood et al., 2011). In addition, the plant is used traditionally against anemia, hepatitis B, hemorrhoids, venereal diseases, eczemas, abdominal troubles, intestinal pain and bladder inflammation, vomiting and as a laxative, an emollient poultice, and it might have antimalarial, antioxidant, antimicrobial, anti-inflammatory, antidiuretic and abortifacient properties (Suroowan et al., 2019; Peter & Gandhi, 2017; Soladoye et al., 2010; Asiimwe et al., 2014). Isolated compounds from the different parts of *A. spinosus* include amaranthoside (**82**), trigonelline (**83**) (Bulbul et al., 2011; Chaudhary et al., 2012), and spinoside (**84**) (Sarker & Oba, 2019; Tanmoy et al., 2014).

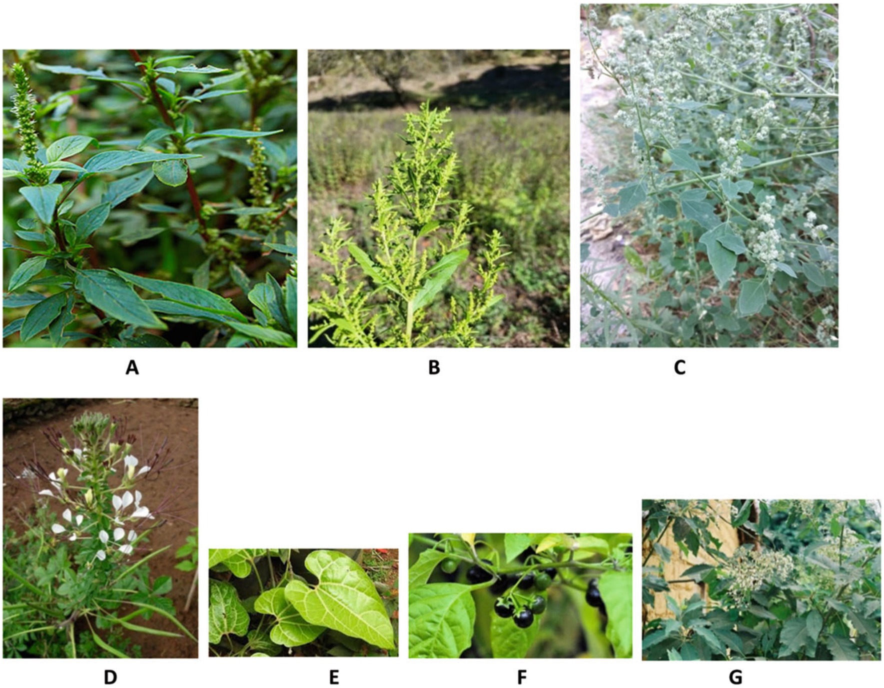


Fig. 3.3 Aerial parts of leafy vegetables, (**A**) *Amaranthus spinosus* L, (**B**) *Chenopodium ambrosioides* L, (**C**) *Chenopodium opulifolium*, (**D**) *Cleome gynandra* L, (**E**) *Gongronema latifolium* Benth et Hook, (**F**) *Solanum nigrum* L, (**G**) *Vernonia amygdalina* (Delile)

3.3.3.2 Mexican Tea or Wormseed (*Chenopodium ambrosioides* L.)

Chenopodium ambrosioides (Fig. 3.3B) belongs to the family Chenopodiaceae and is spread worldwide. It is used for managing several diseases in both humans and livestock (Kasali et al., 2021). In Nigeria, where it is used as a condiment, the herb is traditionally prescribed against bronchitis, pneumonia, catarrh, asthma, and tuberculosis, among other ailments (Kasali et al., 2021). In Ghana, water extracts from the leaves of *C. ambrosioides* are used against tuberculosis (Nguta et al., 2015). The whole plant is said to possess anti-asthmatic, analgesic, carminative, vermifuge, and stomachic properties (Kokanova-Nedialkova et al., 2009). The essential oil is effective against a number of parasites, such as dysenteric amoeba, but is not effective against tapeworms. Similarly, across the Pacific Ocean, in Southern America, the essential oil treats insect bites and athlete's foot (plants, P.f.a.F.D.o.e.a.u, 2024). Small quantities of the leaves are added to cooked bean dishes as a flavoring because of their carminative activity and, thus, the ability to reduce flatulence (plants, P.f.a.F.D.o.e.a.u, 2024). In Brazil, this plant is commonly used as an antiprotozoal agent against *Trypanosoma, Leishmania*, and *Trichomonas* species (Monzote-Fidalgo et al., 2004; Okuyama et al., 1993). The plant is also used for the treatment of enteroparasites, including *Trichuris trichiura, Ascaris lumbricoides*, and *Ancylostoma duodenale* (Nakazawa, 1996). The wide range of traditional uses not only in Africa but also in other continents is an indication that medicinal products can be developed from the herb. Some of the chemical constituents identified from *C. ambrosioides* include 1-piperoylpiperidine (**85**), 1,2-benzopyrone (**86**), patuletin (**87**), and afzelin (**88**) (Kasali et al., 2021; Ghareeb et al., 2016; Hammoda et al., 2015). The essence from the plant is rich in monoterpenes such as ascaridoles (Kokanova-Nedialkova et al., 2009). Ascaridole **88a** is reported to show an hypothermic effect and an analgesic effect after oral administration at a dose of 100 mg/Kg to acetic acid-induced writhing mice (Okuyama et al., 1993). The methanol extract of the dried leaves of *C. ambrosioides* exhibited anti-inflammatory activity by producing a dose-dependent inhibition (300–700 mg/Kg) of cotton pellet-induced granuloma and carrageenan-induced paw edema in rats (Ibironke & Ajiboye, 2007). Herbal teas made from the water extract of the plant showed moderate antioxidant activity in the trolox equivalent antioxidant capacity (TEAC) test (Speisky et al., 2006), whereas the essential oil from the plant exhibited potent antioxidant activity when tested using the 2,2′-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid) ABTS method (Kumar et al., 2007). The essential oil from the leaves of *C. ambrosioides* exhibited an in vitro antifungal activities by inhibiting the mycelial growth of *Aspergillus flavus* at a concentration of 100 μg/ml and broad fungitoxicity against *Aspergillus niger*, *A. fumigatus*, *Botryodiplodia theobromae*, *Cladosporium cladosporioides*, *Helminthosporium oryzae*, and *Pythium debaryanum* at the same concentration (Kumar et al., 2007). Ascaridole **88a** is also reported to have exhibited in vitro antineoplastic activity against a range of tumor cell lines including human acute lymphoblastic leukemia CCRF-CEM cells, human promyelocytic leukemia HL60 cells, and human breast cancer MDA-MB-231 cells (Efferth et al., 2002). The compound has also shown strong antiplasmodial activity against *Plasmodium falciparum*. It exhibited, further, potent inhibition of *P. falciparum* by arresting the growth of the microorganism at a concentration of 0.05 μM and caused total elimination of the parasite from the culture at 0.1 μM (Pollack et al., 1990). The antimicrobial, antioxidant, and anti-inflammatory properties, as well as antineoplastic activities of the extracts and the constituent compounds, may be major contributory factors to the efficacy of the plant against respiratory diseases.

3.3.3.3 Grey Goosefoot (*Chenopodium opulifolium*)

Chenopodium opulifolium (Fig. 3.3C), (Chenopodiaceae) is commonly used as a vegetable in African local cuisines and for treating cough (Esezah et al., 2015) and sore throat in Uganda (Tugume et al., 2016). A decoction from the plant relieves pain during menstruation and quickens childbirth (Ajayi et al., 2016). Some of the constituents identified from *C. opulifolium* include flavone derivatives, phenolics, saponins, and triterpenoids with a wide range of properties: antiviral, antimicrobial, pain-relieving, anti-inflammatory and immunomodulatory activities (Ajayi et al., 2016). Some of the isolated bioactive compounds include allantoin (**89**) and decan-2-one (**90**). Allantoin exhibited promising antiplasmodial activity against *Plasmodium falciparum* clinical field isolates KOM_234 and KDH_204, with IC_{50} values of 2.29 ± 0.98 and 10.94 ± 1.51 μg/ml, respectively (Juma, 2022). Allantoin is also reported to boost wound-healing properties through a mechanism of regulating inflammatory response and stimulus to fibroblastic proliferation as well as extracellular matrix synthesis (Araújo et al., 2010). This could be one of the major contributory factors to the effectiveness of *C. opulifolium* in the healing of the pulmonary system. The compound has antioxidant properties and biological properties similar to those of ascorbic acid, which has been attributed to the closeness in the thermodynamic properties of the two compounds (Gus Kov et al., 2004; Shestopalov et al., 2006). Compound **89**, furthermore, plays the role of being a barrier in the placenta for primates, thus protecting the embryo from sources of free radicals, and it is considered to be a dominant embryonic antioxidant. It is also assumed to be a non-specific immune stimulant (Gus Kov et al., 2004).

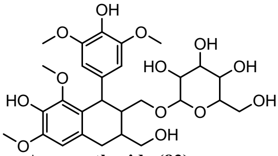
3.3.3.4 Spiderwisp (*Cleome gynandra* L.)

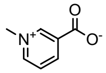
Cleome gynandra (Fig. 3.3D) (Capparaceae) is an upright herbaceous vegetable distributed in sub-Saharan and in some South-East Asian countries. It is also known as African spider flower, traditionally used as a leafy vegetable throughout Africa

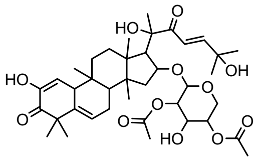
(Chataika et al., 2020; Mashamaite et al., 2022). *C. gynandra* is used in the management of HIV-associated tuberculosis (Otieno et al., 2016), due to the presence of selenium which boosts the defense mechanism of cells against infections and oxidative stress (Hussain et al., 2019; Gupta et al., 2017). The leaves of *C. gynandra* are used as a source of livelihood for vendors in Southern Africa (Thovhogi et al., 2021). The whole plant has been used by the local communities in Africa and Asia in treating a range of medical conditions including chest pains, anemia, scurvy, arthritis, hepatic disorders, stomach ache, irritable bowel syndrome, piles, diabetes, malaria, cardiovascular diseases, constipation, epilepsy, tumors, rheumatism, earaches, and cancer. The root decoction is drunk to facilitate childbirth and is against stomach ache, diarrhea, severe infestation of threadworms, and constipation (Omara et al., 2020; Obakiro et al., 2020; Chand et al., 2022). The plant is rich in vitamins, minerals, and proteins. A number of studies have led to the identification of several health-promoting compounds from *C. gynandra* including alkaloids, flavonoids, proanthocyanidins, glucosinolates, carbonyls, phenolics, saponins, tannins, terpenes, and sterols (Chand et al., 2022). Fractionation of an extract from the aerial part of the plant led to the isolation and identification of cleogynones A (**91**), B (**92**) and (hexadecahydro-17-(tetrahydro-5-(2-hydroxypropan-2-yl)-2-methylfuran-2-yl)-4,4,8,14-tetramethyl-3-oxo-1H-cyclopenta[a] phenanthren-10-yl)methyl acetate (**93**). Compound **92** was moderately active against human lung cancer A549 cells, and all the three compounds were moderately cytotoxic against human breast cancer MDA-MB-468 cells, whereas compounds **92** and **93** were moderately active against colorectal cancer (HCT-116 and HCT-15) cells (Mzondo et al., 2021). This information further supports and validates the use of *C. gynandra* in treating respiratory diseases and other ailments.

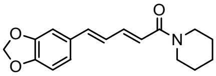
3.3.3.5 Amaranth Globe (*Gongronema latifolium* Benth et Hook)

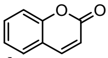
Gongronema latifolium (Fig. 3.3E) (Asclepiadaceae), with a common name of "arokeke" or "utazi" in Nigeria, grows in tropical rainforests. It is used as a vegetable and a spice (Ugochukwu et al., 2003; Ugochukwu & Babady, 2002). It is, further, used as an anti-asthmatic and antitussive in herbal medicine and for the treatment of viral hepatitis, cough, diarrhea, among other infections. The vegetable also finds use in the management of cough in poultry (Essien et al., 2007). Extracts from *G. latifolium* have exhibited antibacterial activities (Edim et al., 2012). From the ethanolic leaf extract, pregnane derivatives such as iloneoside(**94**), marsectohexol (**95**), 3-*O*-[6-deoxy-3-*O*-methyl-*β*-D-allopyranosyl-(1→4)-*β*-D-oleandropyranosyl-17*β*-marsdenin (**96**), 3-O-[6-deoxy-3-O-methyl-*β*-D-allopyranosyl-(1→4)-*β*-D-canaropyranosyl]-17*β*-marsdenin(**97**), as well as ajugoside (**98**) were isolated.

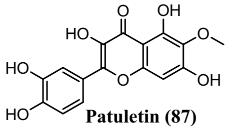

Amaranthoside (82)

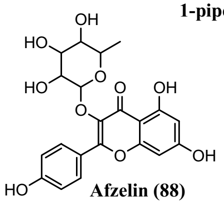

Trigonelline (83)

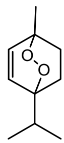

Spinoside (84)

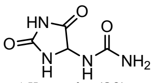

1-piperoylpiperidine (85)

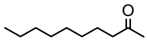

1,2-benzopyrone (86)

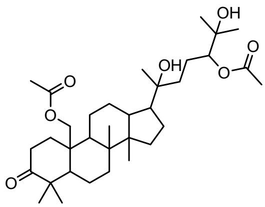

Patuletin (87)

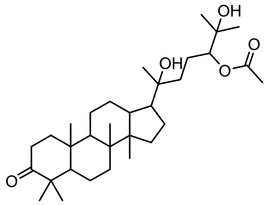

Afzelin (88)

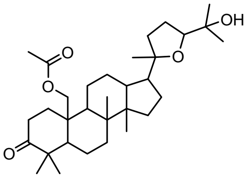

Ascaridole 88a

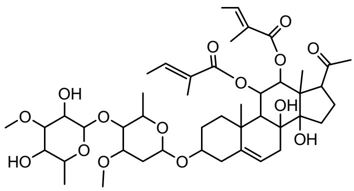

Allantoin (89)

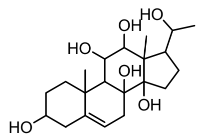

Decan-2-one (90)

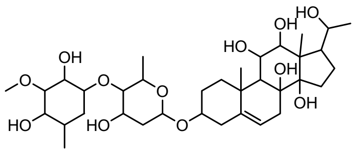

Cleogynone A (91)

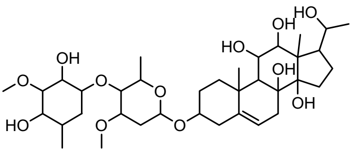

Cleogynone B (92)

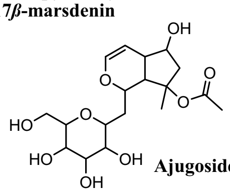

(hexadecahydro-7-(tetrahydro-5-(2-hydroxypan-2-yl)-2-methyfuran-2-yl)-4,4,8,14-tetramethyl-3-oxo-1H-cyclopenta[a]phenanthren-10-yl) methyl acetate (93)


Iloneoside (94)


Marsectohexol (95)


3-O-[6-deoxy-3-O-methyl-*β*-D-allopyranosyl-(1›4)-*β*-D-canaropyranosyl]-17*β*-marsdenin (97)


3-O-[6-deoxy-3-O-methyl-*β*-Dallopyranosyl-(1›4)-*β*-D-oleandropyranosyl]-17*β*-marsdenin (96)


Ajugoside (98)

The compounds exhibited antiproliferative activities (at a concentration of 50 μM) against human leukemia KL-60 cells with inhibitions of 4.7 ± 0.3, 22.3 ± 1.2, 23.6 ± 3.7, 27.6 ± 1.0, and 18.4 ± 0.4%, respectively (Gyebi et al., 2018).

3.3.3.6 Black Nightshade (*Solanum nigrum* Linn)

Solanum nigrum L. (Fig. 3.3F), (Solanaceae) is an herb native to tropical Africa as well as India, the Mediterranean region, and Southern America. Its leaves are edible as vegetables (after cooking) in addition to being used in alleviating chronic bronchitis and sore throat (Maroyi, 2024; Tugume et al., 2016; Wang et al., 2017; Younis et al., 2018). In South Africa, it is used against asthma, fever, and tuberculosis (Thinyane & Maroyi, 2019). Juice extracted from the roots is used against asthma and whooping cough in India (Sikdar & Dutta, 2008).

The fresh leaves are applied (externally) as lotions, compresses or poultices to alleviate pruritus (itching) on the vagina or the anus and relieve skin itching caused by scabies, herpes, ringworm, warts, or any other form of rashes and burns (https://safelizwellness.com/en/product-view/enciclopedia-de-las-plantas-medicinales/; Moshi et al., 2009; Boulos, 1983). A diluted infusion of the berries is used against eye diseases: blindness, conjunctivitis, glaucoma, trachoma, and cataract (Boulos, 1983). The leaf paste is applied to dog-bite wounds to cause healing and to treat rabies in India (Hills, 2010; Muthu et al., 2006). The roots are boiled with sugar to increase fertility in women (Upadhyay et al., 2007). Different studies have revealed that the plant is antimicrobial, anticancer, anti-inflammatory, radical scavenging, anti-epileptic (anticonvulsant), and anti-neurodegenerative, both in vivo and in vitro (Chen et al., 2022). Both the crude extracts and individual components from *S. nigrum* have exhibited antiproliferative properties against several cancer cell lines. A phytoglycoprotein (with molecular mass of 150 kDa) isolated from the plant is reported to possess antiproliferative activities against human cervical cancer HeLa cells, human breast cancer MCF-7 cells, human colon cancer HCT-116 cells, human female colorectal adenocarcinoma HT29 cells, and liver cancer Hep3B cells (Son et al., 2003; Lee & Lim, 2008; Lim, 2005). Compounds identified from the plant include flavonoids, steroidal compounds, alkaloids, propanoids, and glycosides (Chen et al., 2022). One of the major constituents of the plant is a glycoalkaloid solanine (**99**), which is so powerful on the nervous system, causing muscular relaxation, analgesia, and narcosis. It has antispasmodic, antiproliferative, analgesic, and sudorific properties but is toxic (https://safelizwellness.com/en/product-view/enciclopedia-de-las-plantas-medicinales/).

3.3.3.7 Bitter Leaf (*Vernonia amygdalina* (Delile))

Vernonia amygdalina (Fig. 3.3G), Asteraceae) is a perennial herbaceous shrub indigenous to sub-Saharan Africa (Kamatenesi et al., 2013). The leaves of the shrub are eaten in Nigeria (Nwosu et al., 2013). Different plant parts of *V. amygdalina* are used against tuberculosis, asthma, and cough in Nigeria (Mann et al., 2007; Ofukwu et al., 2008), diabetes mellitus, intestinal worms, tonsillitis, hepatitis, snake bites, urine retention, ulcers, and malaria among many other ailments in much of Africa (Aiyeloja & Bello, 2006; Tugume et al., 2016; Uwimbabazi et al., 2023; Namukobe et al., 2011; Tabuti, 2008; Betti, 2004; Cos et al., 2002). In Uganda, it is used against respiratory infections, cough, and tuberculosis in addition to malaria (Anywar et al., 2020; Bunalema et al., 2014; Mugisha et al., 2014). It has antioxidant, antimicrobial, and antiviral properties (Cos et al., 2002). The ethanol and methanol crude extracts demonstrated a 4-day parasitemia suppression of 67% against *Plasmodium berghia* at doses of 500 mg/Kg and 1000 mg/Kg, respectively, whereas the aqueous extract reduced the parasitemia by 63% at 125 mg/Kg in a mice model test (Abosi & Raseroka, 2003; Iwalokun, 2008; Challand & Willcox, 2009). Toxicological studies have revealed that the plant is safe (Tijjani et al., 2017). Chemical analyses have indicated the presence of alkaloidal compounds, saponins, flavones, tannin derivatives, terpenes, lactones, steroids, as well as phenols. Isolated phytochemicals from different parts of *V. amygdalina* include vernolide (**100**), vernodalol (**101**), vernodalin (**102**), and vernomygdin (**103**) (Erasto et al., 2007), Vernolide and vernodalin exhibited in vitro antiplasmodial activities with IC_{50} values of 1.87 and 0.52 μg/ml, respectively, against blood stage *P. falciparum* (Chukwujekwu et al., 2009). Vernodalol (**101**) has exhibited antitumor properties and studies demonstrated that the compound suppresses acute promyelocytic leukemia APL cell proliferation and induces cell cycle arrest in the G2/M phase through the upregulation of p21 and cell division cycle 25. The compound also induced cellular apoptosis via the mitochondrial pathway (Wu et al., 2018). Furthermore, vernomygdin (**103**), vernodalin (**102**), and vernolide (**100**) isolated from the chloroform extract of *V. amygdalina* exhibited significant in vitro cytotoxicity against human nasopharyngeal (KB) carcinoma cells (ED_{50} = 1.5, 1.8, and 2.0 μg/ml, respectively) (Kupchan et al., 1969), thus validating the usage of the plant against respiratory ailments.

3.3.4 Vegetables in Form of Bulbs

Figure 3.4 shows vegetables in form of bulbs.

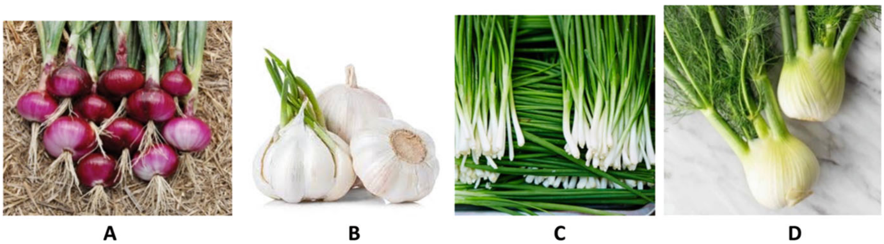
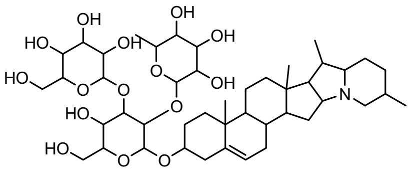


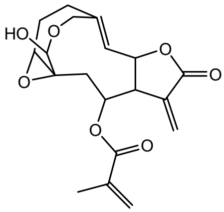
Fig. 3.4 Vegetables consumed as bulbs: (**A**) *Allium cepa* L, (**B**) *Allium sativum* L, (**C**) *Allium tuberosum* Rottl. ex Spreng, and (**D**) *Foeniculum vulgare* Mill

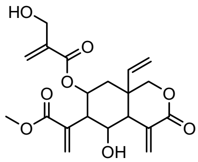
3.3.4.1 Onions (*Allium cepa* L.)

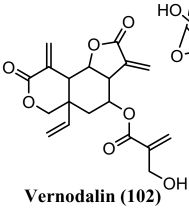
Onion (*Allium cepa* L.) (Fig. 3.4A), scientifically known as *Allium cepa* (Amaryllidaceae), is envisaged to have originated from Afghanistan, Iran, and Russia, then spread to more than 175 countries around the world.

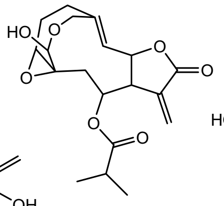
It is rich in dietary nutrients, and it is reputed for its numerous health benefits. Some of the indications are in ailments including cough, respiratory catarrh, sinusitis, pharyngitis, bronchial asthma, lung emphysema, tuberculosis, sore throat, cholera, hypertension, blood thinning, hepatic disorders (hepatitis, fatty liver degeneration, and cirrhosis), among others. It has mucolytic, antibiotic, diuretic, depurative, vermifuge, hypoglycemic, hypotensive, anti-inflammatory, and invigorating properties (Shawarb et al., 2023; Mahmood et al., 2011; Teshika et al., 2019; Chakraborty et al., 2022; Marwat & Rehman, 2011; Ganesan & Kumaresan, 2017). Phytochemicals isolated from *A. cepa* include the antioxidant, anti-inflammatory, and antiviral quercetin (**30**) and its derivatives: quercetin 4′-glucoside (**104**), 3-Hydroxyquinine (**105**) (Fossen et al., 1998).

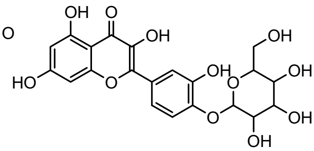

Solanine (99)

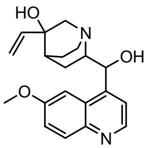

Vernolide (100)


Vernodalol (101)


Vernodalin (102)


Vernomygdin (103)


Quercetin 4'-glucoside (104)


3-Hydroxyquinine (105)

3.3.4.2 Garlic (*Allium sativum* L.)

Garlic (*Allium sativum* L.) (Fig. 3.4B) (Amaryllidaceae) originated from Asia. All the parts of *A. sativum* are utilized in the preparation of decoction mixtures to treat several ailments such as respiratory disorders (Tudu et al., 2022). The garlic cloves are a common spice and a food additive in various dishes around the world. Ethnopharmacologically, garlic is used against acute and chronic bronchitis, whooping cough, tuberculosis, asthma, lung cancer, blood pressure, high cholesterol, COVID-19. It is an expectorant, antibiotic and antiseptic, antiviral, hypoglycemic, anti-carcinogenic, immune-stimulant, hypotensive, hypolipidemic, antidiabetic, blood thinner, and vermifuge (Shawarb et al., 2023; Omara et al., 2020; Anywar et al., 2020; Obakiro et al., 2020; Mailu et al., 2020; Cock & Van-Vuuren, 2020; Villena-Tejada et al., 2021). Garlic contains bioactive compounds including allicin (**106**), *trans*-1-propenyl-thiosulfinate (**107**), E/Z-ajoene (**108**), alliin (**109**), quercetin (**30**) (Shang et al., 2019), diosgenin (**110**), and gitogenin (**111**) (Diretto et al., 2017).

3.3.4.3 Leek (*Allium tuberosum* Rottl. ex Spreng)

Allium tuberosum (Fig. 3.4C), (Amaryllidaceae) is a perennial herb quite popular within the genus *Allium* originating from Southeast and East Asia (Liu et al., 2015). It also grows in several parts of Africa. The crop is reputed for good medicinal and nutritional values. The main edible part of leek are the leaves and the bulb is edible only after processing (Wang et al., 2023). The roots are effective in reducing on blood stasis and improving blood circulation. It is recommended as a remedy for bronchitis, sinusitis, inflammation, constipation, uratic arthritis, gout, kidney disorders, ulcers, and cerebrovascular and cardiovascular diseases (Liu et al., 2015). It has mucolytic properties and, thus, it enhances fluidization of mucus. Phytochemical studies of leek have yielded flavonoids, lignans, phenols, saponins, and sulfur-containing compounds. Studies by Ma et al. (2012) as well as Liu et al. (2015) resulted in the isolation of pharmacologically active compounds which exhibited expectorant, antibacterial, vascular, antioxidant, and endothelial protection activities (Liu et al., 2015; Ma, 2012). These compounds include buddlenol (**112**), daucosterol (**113**), 3,4-dihydroxyacetophenone (**114**), alliin (**109**), and (*E*)-1-allyl-2-(3-(allylsulfonyl)prop-1-en-1-yl) disulfane (**115**) (Wang et al., 2023).

3.3.4.4 Fennel (*Foeniculum vulgare* Mill.)

Fennel, scientifically called *Foeniculum vulgare* (Fig. 3.4D) (Apiaceae or Umbelliferae), is ethnobotanically used to treat respiratory tract diseases, hormonal disorders, gastrointestinal tract pain, and reproductive and cardiovascular-related diseases (Jadid et al., 2023). Fennel has anti-inflammatory, gastro-protective, antiviral, antimicrobial, antioxidant, anti-anxiety, estrogenic, antidiabetic, anti-mutagenic, anticancer activity, hepato-protective, and neuro-protective properties (Jadid et al., 2023).

Isolated compounds include furano-coumarins like bergapten (**116**) and xanthotoxin (**117**) as well as antiviral flavonols like quercetin (**30**) (Nassar et al., 2010; Riska, 2002). Compounds **116** and **117** exhibited antibacterial activity against the gram-positive bacterial strain of *Staphylococcus aureus* (MIC = 1.87 and 3.75 mg/ml, respectively) (Golfakhrabadi et al., 2016). Xanthotoxin has exhibited antifungal activities against the plant pathogens *Rhizoctonia solani*, *Fusarium graminearum*, and *Magnaporthe oryzae* (88, 68, and 83% inhibition, respectively) at a 30 μg/ml dose and an EC_{50} of 14.6 μg/ml against *Coletotrichum capsica* (Song et al., 2017). It is, therefore, possible that such compounds could inhibit pathogenic microbes within the human pulmonary tract. Bergapten also exhibited anti-carcinogenic activity (IC_{50} of 40.05 μM) against osteosarcoma (Saos 2) cell lines, whereas xanthotoxin inhibited neuroblastoma (SK-N-AS) and metastatic colon cancer (SW640) cells (IC_{50} = 56.3 and 88.5 μM, respectively) (Bartnik et al., 2017; Bartnik et al., 2023).

3.3.5 Underground Vegetables (Roots)

Photos of underground vegetables (roots) are shown in Fig. 3.5.

3.3.5.1 Carrot (*Daucus carota* subsp. *sativus* L.)

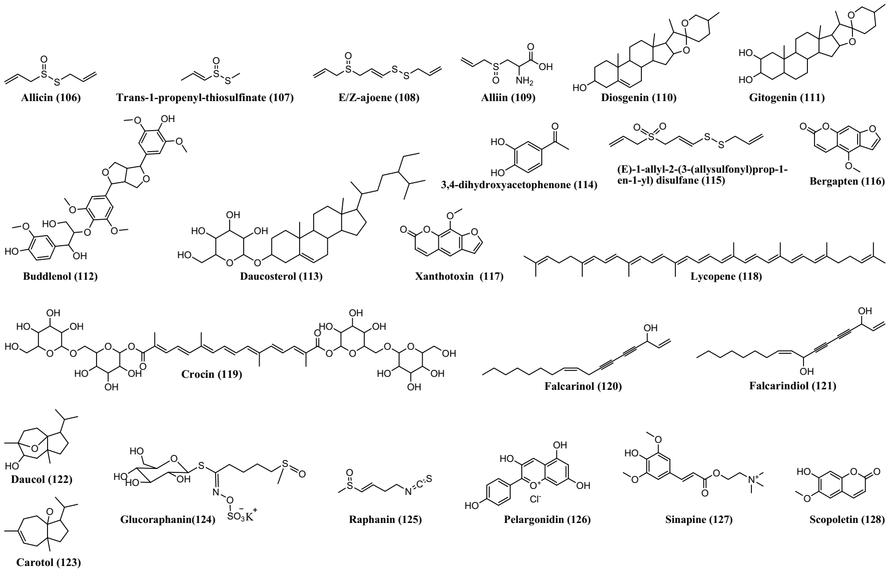
Daucus carota subsp. *sativus* (Fig. 3.5A), (Apiaceae) is used in South Africa to treat tuberculosis (Que et al., 2019). Juice made from a mixture of carrot, fennel bulbs, onions, and honey (or molasses) is used to treat cough within the Mediterranean region (Pamploma-Roger, 2006). Carrot is also used in treating arteriosclerosis, liver inflammation, heartburn, liquid retention, diseases of the retina, and in attempts to quit smoking (Pamploma-Roger, 2006). The characteristic orange color is attributed to the presence of carotenoids, and thus carrots are considered to be rich in lycopene (**118**), crocin (**119**), falcarinol (**120**), falcarindiol (**121**), daucol (**122**), and carotol (**123**) (Horbowicz et al., 2008; Kumarasamy et al., 2005). These compounds are beneficial in fighting against lung cancer, emphysema, asthma, fibrosis, acute lung

A B

Fig. 3.5 Vegetables consumed in the form of roots, (**A**) *Daucus carota* subsp. *sativus* L and (**B**) *Raphanus sativus* L injury, and COPD. The carotenoids do activate the NRF2/HO-1 pathway and inhibit the MAPK, NFK-JAK/STAT-3, and PI3K/AKT pathways. Epidemiological investigations have revealed that when carotenoids are included in the diet, the risk of lung complications is lowered (Manochkumar et al., 2022).

3.3.5.2 Radish (*Raphanus sativus* L.)

The root part of *Raphanus sativus* (Fig. 3.5B), (Brassicaceae) is the main edible organ. The root tuber of *R. sativus* may appear in many color shades like white, purple, or red, due to anthocyanin accumulation (Gamba et al., 2021). Radishes, traditionally, find use in the treatment of bronchial catarrh, bronchitis, laryngitis, sinusitis, tobacco addiction, and hepatic and biliary diseases. It has mucolytic, expectorant, antibiotic, anticancer, cell-protecting, choleretic, cholagogue, liver regeneration, and mood-stabilization properties (Manivannan et al., 2019). Radish is reputed for the presence of sulfur-containing glucosinolates, particularly glucoraphanin (**124**), which is responsible for the sharp pungent taste. Upon enzyme action, glucoraphanin is hydrolyzed to raphanin (**125**), which has mucolytic properties, hence softening the mucus/phlegm and facilitating its expulsion from the pulmonary airways. Compound **125** is also active against a wide range of microorganisms, including *Corynebacterium diphtheria, Mycobacterium* sp., *Staphylococcus aureus*, *Streptococcus pyogenes*, *Bordetella pertussis*, and some pathogenic fungi (Ivànovics & Horvath, 1947). Other compounds present include pelargonidin (**126**), sinapine (**127**), and scopoletin (**128**) (Noreen et al., 2023; Gutiérrez & Perez, 2004).



3.4 Future Prospects

In the future, with the general public moving toward maximizing utilization of resources plus tendencies toward circular economy, it can be forecasted that farmers will be growing vegetables and fruits not only for food, but also as sources of nutraceuticals such as those against respiratory troubles. Several vegetables and fruits will be used as supplements to the available conventional drugs in treating health conditions. Various parts of the food crops, other than the edible parts, will be considered valuable, not to be discarded but to be processed for utilization in medicine and other applications. Given the vast scientific knowledge, individuals will be making informed choices of what to consume depending on their health status and motivation, which will greatly contribute to longevity and increased lifespan. With the sensitization on the importance of particular plants, there will be an increase in the demand for vegetables and fruits which will translate into domestication of what are currently considered to be wild plants and commercialization of the vegetables and fruits. Furthermore, it is expected that, with time, the fruits and vegetables will be subjected to targeted processing in order to extract the active ingredients, standardize the biomass and where possible the ingredients will be synthesized chemically or by use of biotechnological tools.

3.5 Conclusions

This chapter concludes by highlighting the vital role that a variety of naturally occurring dietary fruits, vegetables, and plants play in promoting respiratory health. Based on both traditional and modern ethnopharmacological research, this chapter highlights the unique bioactive compounds present in these medicinal plants that have shown promise in easing symptoms and providing therapeutic aid for respiratory illnesses. Compounds like flavonoids, alkaloids, terpenoids, phenolics, saponins, vitamins, and amino acids have the potential to exhibit antimicrobial, anti-inflammatory, and immune-boosting properties. As a result, they are helpful allies in the treatment of respiratory conditions, from bronchitis and asthma to flu, colds, and coughs. The findings demonstrate the importance of including naturally occurring foods with therapeutic properties into regular meals as a preventative strategy and as an adjunct to existing treatments for respiratory conditions. It is crucial to recognize that more clinical studies are required to validate the safety and efficacy of these plants in a variety of settings and individuals.

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