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Purple basil and the significance of its bioactive compounds

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Abstract
Ocimum basilicum L. usually named "Basil" is a widely recognized plant variety of *Lamiaceae* classification accompanying diverse curative features. Several *Ocimum* class, collectively popular as Tulsi in India, are second hand in Ayurvedic and different traditional cure methods. Purple basil is individual of the cultivars of *Ocimum* with an established sweet basil flavour which holds medicinally valuable metabolites. The main antioxidant compounds of purple basil are Caffeic, Vanillic, Rosmarinic acids, quercetin, rutin, apigenin, chlorogenic and p-hydroxybenzoic. Rosmarinic acid, an ordinary phenolic acid present in basil extracts serves as the main phytochemical due to its allure antioxidant and pharmacological characters. Purple basil has happened to be known for its allure healthy possessions for long time and has existed second hand in usual folk medicine. It has happened second hand in kidney problems, as a haemostyptic in childbirth, earache, menstrual irregularities, arthritis, eating disorder, and sickness. Purple basil has shown definite belongings against viral, fungal, bacterial and several other contaminations. This review focuses on the bioactive components of purple basil and its nutritional and medicinal significance through the pharmacological activities including anti-cancer activity, anti-microbial activity, anti-inflammatory effects, antioxidant activity and the application of products developed from the purple basil.

Keywords: Anthocyanin, bioactive components, biological activities, *Ocimum basilicum*, polyphenolic compounds, pharmacological activities

Introduction

Purple basil (*Ocimum basilicum* L.), a member of the *Lamiaceae* family, is cultivated extensively for using its fresh and dried leaves in the food, beverage and spice industries and for producing its essential oil. Currently, this annual aromatic plant, native to Southeast Asia, is cultivated worldwide and has significant economic value. The plants are ornamental, the leaves are used in cooking and their essential oil is often an ingredient used in the personal care and household cleaning product industry (Varga *et al*, 2017) [1]. Basil has been used in medicinal treatments for headaches, coughs, worms, stomach pains and kidney dysfunction (Ekren *et al*., 2012) [2]. The useful parts of the basil plant are its leaves and seeds, plus both the fresh and dried leaves of the plant are very widely used in the food and spice industries. In addition, it is also considered a source of aromatic compounds and therefore possesses a variety of biological properties such as insect repellent, nematocide, antibacterial, antifungal and antioxidant properties (Akbulut *et al*. 2017). Purple basil, also known as "red rubin," is a cultivar of *Ocimum basilicum* with pink flowers and purple stems and leaves. It has significant commercial potential due to its nutraceutical and pharmacological properties. However, a lot of information is still missing about this strain, ranging from effective growing techniques to sophisticated biotechnological experiments. In the case of the genus *Ocimum*, the production processes for obtaining their essential oils are of great interest, especially for the cosmetics industry. Purple basil is highly prized for its essential oil and widely used in folk medicine, but there are few studies investigating *in vitro* propagation techniques for this basil variety (Da silva *et al*, 2017) [14]. Basil (*Ocimum basilicum* L.) is an edible, medicinal and ornamental plant valued for its antioxidant properties, including purple varieties characterized by the accumulation of anthocyanins in leaves and flowers (Princi *et al*, 2020). *Ocimum basilicum L.* has a wide variety of cultivars grown for different purposes. An old trend of cultivating purple basil for unique marketplace gave rise to a large intraspecies range on biochemical as well as morphological levels (Varga *et al*, 2017) [1].

Purple basil (*Ocimum basilicum, Lamiaceae*) has been marketed for both its culinary and ornamental value, but its instability in which a percentage of the offspring revert to a green ancestor in the same production season, has limited its use as an ornamental plant and also limited its potential applications for other markets. However, they are commonly used for culinary and medicinal purposes (Koroch *et al*, 2017) [6].

Table 1: Phenotypic traits in green and purple basil varieties

Plant Characteristics	Variety		
	Italian Classico	Red Rubin	Dark Opal
Plant height (cm)	18.78	12.58 ± 0.47	17.00 ± 0.39
Leaf fresh weight(g)	0.52	0.37	0.35
Days of flowering	53	59	55
Flower fresh weight (mg)	11.68	9.78	10.00
Corolla fresh weight (mg)	7.94	7.50	7.02

(Source: Silvia Morgutti *et al*, 2019) [5].

Chemical and active constituents in purple basil

Purple basil cultivars varies in their chemical composition and bioactive properties. It is rich in nutrients precisely vitamins, minerals, fat, protein, polysaccharide, fibre, pigments and mucilage (Singh and Chaudhuri, 2018). It possesses minerals like magnesium, potassium and iron in excess quantity. It is rich in plenty of critical nutrients, most significantly vitamin A, vitamin C, calcium and phosphorus (Filip, 2017) [9].

As mentioned in Table 1, dry matter constitutes 16.60-91.35 g/kg of purple basil, while carbohydrate, protein, fat, and fibre constitute 2.3-64.98 g, 22.53-208.8 g, 1.97-64 g, 9.52-12.22 g per kg of purple basil respectively. Similarly, Vitamin E constitutes 80-291.71 mg and Vitamin C constitutes 12.28-25 mg per kg of purple basil. Minerals like Calcium, Iron, Magnesium and Phosphorus constitutes 5.20-177 mg, 15.1-624.51 mg, 0.53-64 mg and 1.10-4.25 mg per g of purple basil respectively.

Purple basil is a rich source of biologically active compounds, specifically antioxidants, phenolic acids and anthocyanins (Nazir *et al*, 2019) [71]. It is rich in monoterpenes, sesquiterpenes, and phenylpropanoids. Phenolics are final products of phenylalanine which is produced through the shikimate pathway whereas terpenoids are produced through the condensation of isopentenyl diphosphate (IPP) and dimethylallyl diphosphate (DMAPP) (Zeljković *et al*, 2020). The leaves additionally contained a huge variety of pharmacologically active substances, including alkaloids, coumarins, tannins, flavonoids, sugars, phenols, terpenoids and saponins (Nguyen *et al*, 2020) [3].

Anthocyanin and phenolic acid composition varies notably amongst cultivars. Total phenolic and anthocyanin tiers correlate with measured antioxidant capacities. Phenolic and anthocyanin composition additionally contributes to antioxidant properties (Flanigan & Niemeyer, 2014) [12]. The LC-ESI-MS/MS evaluation of purple basil sorts allowed quantifying 17 polyphenolic acids and 18 flavonoids, otherwise gathered in leaves and vegetation (Prinsi *et al*, 2019).

Rosmarinic acid was found to be the most significant phenylpropanoid, followed by luteoin, kaempherol, and rutin (Zeljković *et al*, 2020). In addition to rosmarinic acid and others mentioned above, purple basil includes numerous members of the salvianolic acid family, most effective scarcely descripted on this species, as properly as, particularly in vegetation, easy phenolic acids, along with 4-hydroxybenzoic acid and salvianic acid A (Prinsi *et al*, 2019).

Table 2: Nutritional composition of Purple Basil

Nutritional Composition	Amount	References
Dry matter	16.60 – 91.35 g/kg	Gadomska *et al*, 2017 [13]: Vlaicu *et al*, 2022 [14]
Carbohydrate	2.3- 64.98 g/kg	Sah *et al*, 2018 [15]: Idris *et al*, 2011 [16]
Crude Protein	22.53- 208.8 g/kg	Shahrajabian *et al*, 2020 [17]: Vlaicu *et al*, 2022 [14]
Crude Fat	1.97- 64 g/kg	Filip, 2017 [9]: Akah *et al*, 2017 [18]
Crude fibre	9.52-12.22 g/kg	Vlaicu *et al*, 2022 [14]
Vitamin E	80- 291.71 mg/kg	Filip, 2017 [9]: Vlaicu *et al*, 2022 [14]
Vitamin C	12.28- 25 mg/kg	Sah *et al*, 2018 [15]: Gadomska *et al*, 2017 [13]
Calcium	5.20- 177 mg/g	Akah *et al*, 2017 [18]: Idris *et al*, 2011 [16]
Iron	15.1-624.51 mg/g	Sah *et al*,2018 [15]: Vlaicu *et al*, 2022 [14]
Magnesium	0.53- 64 mg/g	Akah *et al*, 2017 [18]: Filip *et al*, 2017 [9]
Phosphorus	1.10- 4.25 mg/g	Vidhani *et al*, 2016: Akah *et al*, 2017 [18]

Rosmarinic acid is the most significant basil phenolic compound, however additionally different phenolic acids along with chicoric, vanillic, p-coumaric, benzoic, hydroxybenzoic, syringic, ferulic, protocatechuic, caffeic and gentisic acids are also present in it (Złotek *et al*, 2015) [19]. All these bioactive compounds found in basil leaves including rosmarinic acid, caftaric acid, and chicoric acid are well known for both their intense antioxidant capacities and their chemo preventative potentials (Bajomo *et al*, 2022).

Moreover, Purple leaves particularly include exceptionally acylated anthocyanins, while purple flowers acquire anthocyanins with low level of decoration (Prinsi *et al*, 2019). Specifically, fourteen unique anthocyanins have been recognized in purple basil varities, including Cyanidin and Peonidin glycosides. In 8 exceptional purple basil sorts, anthocyanins ranged from 7.55 to 16.6 mg/g dry weight (Filip, 2017) [9].

The most essential antioxidant compounds of purple basil are caffeic, vanillic, rosmarinic acids, quercetin, rutin, apigenin, chlorogenic and p-hydroxybenzoic. Rosmarinic acid, being the most important phenolic acid in basil extracts, is essential phytochemical, because of its antioxidant and pharmacology properties (Shahrajabian *et al*, 2020) [17]. When phenolic compounds of 100 basil extracts were tested using HPLC it was found that the concentration of chlorogenic, vanillic, cinnamic, p-hydroxybenzoic, caffeic, ferulic, and rosmarinic varied from 0.01 to 79.88 mg/kg of dried extract (DE) while concentration of quercetin, naringenin, rutin ranged from 0.06

to 72.24 mg/kg of DE (Teofilović *et al*, 2021) [20].

Purple basil contains several aromatic chemical compounds like methyl chavicol, methyl eugenol, methyl cinnamate, linalool, etc possessing different chemical structures. The compounds methyl eugenol and chavicol are phenylpropanoids being produced through the shikimic acid pathway (Avetisyan *et al*., 2017) [21]. Linalool is a terpenoid which is synthesized by the mevalonic acid pathway. It possesses antimicrobial and antioxidant activity (Liu *et al*., 2012) [64]. Methyl eugenol is used as a major ingredient of flavouring agents in food industries, perfumeries and in aromatherapy while methyl chavicol is used in aromatic products, as a pain and muscle tension reliever, for cough and cold etc. (Srivastava *et al*, 2018) [22].

Essential oils offer the function aroma notes to basil sorts and are partly liable for basil organic activities. Essential oil of purple basil includes α-Pinene, β-Pinene, Methyl chavicol, 1,8 cineole, Linalool, Ocimene, Borneol, Geraneol, B-Caryphyllone, n-Cinnamate and Eugenol. The most important essential oil of basil is eugenol and chavicolandterpenoids (Shahrajabian *et al*, 2020) [17]. Total seventy-seven volatiles have been observed, with seven of them being in concentrations more than 10% in at the least one accession specifically 1,8-cineole, linalool, linalool acetate, methyl chavicol, eugenol, trans-methyl cinnamate, trans-α-bergamotene. The intraspecific characterization of purple basil consists of 5 chemotypes specifically high-Linalool, Linalool/trans-α-bergamotene, Linalool/methyl chavicol, Linalool/trans-methyl cinnamate and high-methyl chavicol chemotype (Varga *et al*, 2017) [1].

Phenolic acids & flavonol-glycosides are the primary phenolic compounds in purple basil and the primary fatty acid composition consists of Stearic acid, Oleic acid, Palmitic acid, Linoleic acid,

Myristic acid, α-Linolenic acid, Carpic acid, Lauric acid & Arachidonic acid (Shahrajabian *et al*, 2020) [17]. Due to the variety of bioactive compounds found in purple basil, it exhibits several nutritional, medicinal & ayurvedic properties.

Table 3: Proximate composition of fresh and dried purple basil samples (%)

Sample	Moisture	Fat	Protein	Ash	Carbohydrate
Sun dried	9.18±0.00	1.50±0.00	16.40±0.00	14.10±0.00	46.74±0.002
Shade dried	9.35±0.006	1.65±0.00	18.40±2.12	14.50±0.00	45.40±2.00
Solar dried	10.50±0.07	1.60±0.00	17.20±0.00	14.60±0.00	44.79±0.002
Oven dried at 50 degrees	11.21±0.01	1.95±0.03	18.00±0.00	13.50±0.05	44.41±0.12
Oven dried at 60 degrees	11.30±0.00	2.22±0.00	18.15±0.00	13.30±0.01	45.40±0.02
Fresh	85.80±0.42	1.96±0.00	4.75±0.01	1.56±0.03	5.17±0.45

Values are mean of duplicate determination ± standard deviation (Akah *et al*, 2017) [18]

Nutritional, medicinal & ayurvedic significance of purple basil

Purple basil has been recognized for its health care properties for long term and has been utilized in traditional folk medicine (Filip, 2017) [9]. It has been utilized for kidney problems, as a haemostyptic in childbirth, earache, menstrual irregularities, arthritis, anorexia, and malaria. Purple basil has proven tremendous outcomes against viral, fungal, bacterial and a few infections. The leaves were utilized as a remedy for fevers, coughs, asthma, bronchitis, flu, diarrhoea (Shahrajabiana *et al*, 2020) [17]. It helps in the prevention and treatment of many ailments and normal illnesses like headache, colic pain, common cold, sore throat, hepatic diseases, as an antidote for snake bite and scorpion sting, migraine headaches, fatigue, flatulence, wound, insomnia, arthritis, digestive problems, skin diseases and night blindness. The leaves are a great remedy for nerve related issues and to sharpen memory. Chewing of the leaves additionally treats ulcers and infections of mouth (Verma, 2016) [23].

The most significant pharmacological use of purple basil includes anti-cancer activity, anti-microbial activity, radioprotective activity, immunomodulatory activity, anti-diabetic activity, antiinflammatory effects, anti-pyretic activity, anti-arthritic activity, antioxidant activity, anti-strain activity, as a prophylactic agent and in cardiovascular disease (Shahrajabiana *et al*, 2020) [17]. Consumption of purple basil helps with a number of neurocognitive issues along with reduction in stress, anxiety, depression and sexual problems. It also helps in the enhancement of memory and cognitive attention. In diabetic and overweight patients, purple basil helped in reducing postprandial blood glucose, enhancing lipid profiles, and reducing blood pressure. Other useful immune responses covered increased natural killer and T-helper cells in healthy adults and progressed immune reaction to viral infections. It improved critical ability and comfort from asthmatic signs in patients having asthma. It additionally facilitates withinside the treatment-related to the reduction in the populations of numerous oral bacteria, and in enhancing gingival bleeding and purulent discharge (Singletary, 2018) [24]. Magnesium and potassium, as one of the seven important macro minerals, facilitates in enhancing the cardiovascular health, in the transmission of nerve impulses, in imparting protection from numerous chronic diseases. It is digestive stimulant, and is used as diuretic (Filip, 2017) [9].

Apart from giving purple basil its colour, the pigment Anthocyanin exhibits a range of biological activities, including antioxidant, cardioprotective, antidiabetic, anti-inflammation anticancer, antitumor, and eye function properties (Szymanowska *et al*, 2014). It is having both protective and defensive roles to facilitate growth, reproduction and development. The advantage of its intake is related to neuroprotective effects especially reduced chances of Parkinson`s disease. Rosmarinic acid, as a typical phenolic acid in purple basil is a crucial phytochemical, because of its antioxidant and pharmacology properties (Filip, 2017) [9]. Rosmarinic acid is capable of inhibiting LOX and COX activity and therefore can act as an anti-inflammatory factor. Moreover, it possesses antioxidant, antibacterial, astringent, antiviral and antidiabetic, and antimutagenic, properties (Złotek, 2015) [19]. It has been discovered to be an effective active substance in opposition to Human Immunodeficiency Virus kind 1 (Filip, 2017) [9].

Phytochemicals found in purple basil were broadly investigated as bioactive compounds liable for particular organoleptic properties of foods, and protective effects in human cells towards oxidative processes found in the improvement of neurodegenerative and cardiovascular health issues and several cancer types (Złotek, 2015) [19]. Water, ethanol and acetone extracts from leaves and flora of purple basil contained evidently found antioxidant compounds and possessed antioxidant activity which can be attributed to its lipid peroxidation inhibitory, radical scavenging and metal chelating properties (Yesiloglu and Sit, 2012). Purple basil is utilized in Ayurvedic as well as traditional medicine systems for imparting alleviation from stress and anxiety and is a remedy for respiratory, kidney and gastrointestinal ailments, in addition to cardiovascular diseases and skin and eye disorders. It imparts relief from metabolic problems, adds in cognitive enhancement, strengthens the immune system, and improves oral, skin and eye issues (Singletary, 2018) [24]. Phenylpropanoids, especially Eugenol constituted the main share of essential oil in purple basil. The compound Eugenol is mainly responsible for the healing potentials of purple basil whereas methyl eugenol is a highest value aroma chemical present in it (Raina, 2013) [27]. The essential oils and aroma compounds of purple basil are one of the main components of several pharmaceuticals, dental, flavouring and cosmetic products (Singletary, 2018) [24]. The pharmacological properties of purple basil compounds replicate their medicinal significance and facilitates in the standardization of medicinal products (Singh and Chaudhuri, 2018).

Factors affecting the bioactive components of purple basil

Different factors affect bioactive components of purple basil in a range of ways. The factors may include the cultivar, the water level when irrigated, presence of carbon dioxide, temperature range, LED lightning, methods of drying, foliar application, nitrogen starvation, availability of ammonium (Ion *et al*, 2020). According to Flanigan and Niemeyer, cultivar had a considerable impact on the overall anthocyanin range in addition to individual anthocyanin amount. Evaluation of an individual anthocyanin range showed significant variations in the profiles of 4 primary anthocyanins (Anthocyanins A–D) amongst cultivars. Cultivar did not have a great impact on overall phenolic range even though it did have an impact on the amount of a few individual phenolic acids which includes caftaric & chicoric acids (Flanigan and Niemeyer, 2014) [12]. The irrigation treatment influenced the heights of purple basil plants and confirmed statistically sizeable differences. As the quantity of irrigation water reduced, the height of purple basil plants reduced too. The yields of the purple basil improved in parallel to the quantity of irrigation water carried out.

The purple basil is sensitive to the quantity of irrigation water carried out and water pressure in the root area. Yields as a vegetative growth indicator was substantially stricken by irrigation water levels. On the contrary, the essential oil range of purple basil improved and was tormented by water pressure or water deficit in the soil. Water pressure withinside the plant root area has an advantageous impact on essential oil ratio of the purple basil plants (Ekrena *et al*, 2012: Bekhradi *et al*, 2015: Kalamartzis *et al*, 2020) [2, 29]. The overall phenylpropanoid concentrations in purple basil elevated at higher temperatures. The modifications in methyl cinnamate at distinctive temperatures had been close. The amount of linalool turned to be better at low temperature. The highest degree of phenylpropanoid was analysed in control carbon dioxide amounts & confirmed regular decrease till 800 ppm. Additionally, linalool concentrations confirmed ordinary growth till 800 ppm. Purple basil compounds may range relying on temperatures & CO_2 concentrations (Tursun and Telci, 2020: Fallahi *et al*, 2015) [30, 31]. When the plants of purple basil are exposed to LED lights, they display a few extensive changes. Light quality not just impacts the buildup of pigments, but also mediates photo physiological specifications in purple basil leaves. The red-light chroma carried out herein no longer have an effect on the growth of purple basil, however instead triggered active physiological responses.

A ratio of 4:1:1 Red, Blue, Green LEDs own many effective results on development, growth, and look of purple basil plants. The responses of plant growth limitations and Fv/Fm values to a 4:1:1 ratio indicated that this high ratio of red light seemed to be most beneficial for purple basil plants. Light treatment appreciably affected pigments and cultivars differently (Lin *et al*, 2021: Hosseini *et al*, 2019) [33]. According to Yilmazyl and Alibas, colour parameters and the amount of chlorophyll closest to the raw product had been measured in natural drying. The concentration of protein in purple basil leaves was comparable in all drying methods. The amount of potassium and phosphorus closest to the raw samples were measured in natural drying, microwave drying at one thousand W and convective drying at 50 W. Also, the highest concentrations of Ca and Mg had been detected at two hundred and six hundred W. The highest concentrations of Cu, Mn and Fe had been measured at two hundred, six hundred and one thousand W. Besides, the highest concentration of Zb and Na had been evaluated in natural and convective drying methods (Yilmaz1 and Alibas, 2021) [36]. Nitrogen fertilization is required to maintain excessive yields in purple basil, however the delivery of NO_3 ought to lessen the contents of vital phenolic compounds, including rosmarinic acid and anthocyanins.

The delivery of NH_4^+ to purple basil plants in hydroponic cultivation may have low effect than NO_3 on the concentration of those compounds. This approach may be beneficial in increasing the technical and nutritional costs of purple basil (Prinsi *et al*, 2020) [5]. Drought pressure and distinctive concentrations of the foliar spray of chitosan improved the phenolic compounds, and the antioxidant activity of the extracts and the essential oil yield in purple basil. Foliar application of chitosan and low irrigation, as a probable technique, may be used to boom the phenolic compounds and antioxidant activity in cultivation process of purple basil. This additionally indicates the significance of biotic and abiotic elicitors for improvement of the phenolic compounds and the antioxidant activity of purple basil extracts, which is probably an opportunity and powerful approach as opposed to genetic modification (Pirbalouti *et al*, 2017: Moghadam *et al*, 2015) [35].

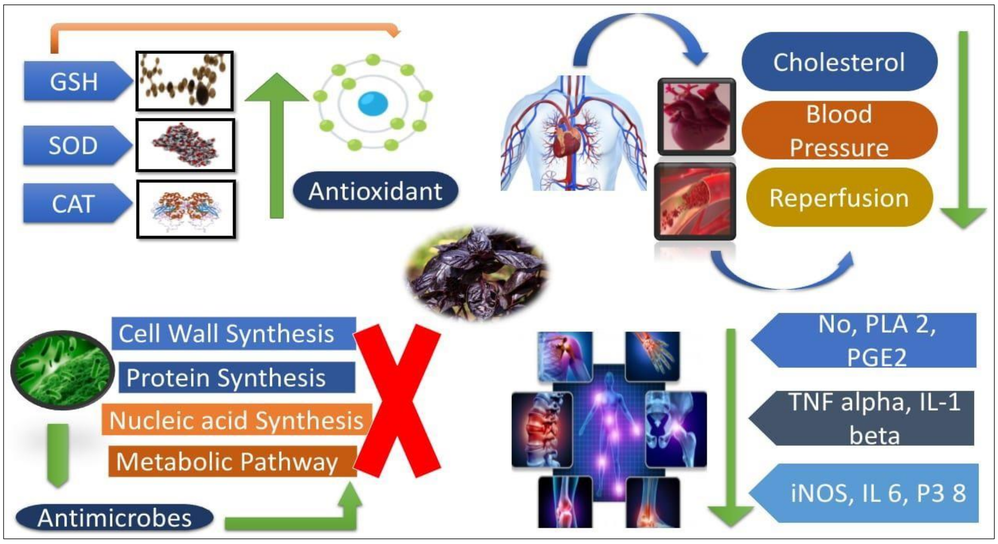

Fig 1: Mechanism of action of purple basil

Pharmacological activities

Purple basil is used in pharmaceutical and cosmetic preparations (Kwee and Niemeyer 2017) [37]. Due to its high level of phenolic compounds, which are well-known phytochemical substances found in all plants, these compounds act as antioxidants, lowering the risk of heart disease, inflammation, cancer, and diabetes, as well as reducing the rate of mutagenesis in human cells (Mastaneh *et al*. 2014) [38]. The redox properties of phenolic compounds are primarily responsible for their antioxidant activity, it can act as reducing agents, hydrogen donors, and singlet oxygen quenchers over this (Hakkim *et al*. 2007) [39]. One of the most abundant caffeic acid esters present in *Ocimum spp* is rosmarinic acid and it have some important biological properties including antioxidant, anti-inflammatory, antibacterial and antiviral activities (Pereira 2015) [40].

Teofilovic, (2017) has showed that ferulic acid may have potential as a preventative agent against colon tumor development. The main phenolic components in basil are Phenolic acids and flavanol glycosides. The main fatty acid composition of basil species is Stearic acid, Oleic acid, Palmitic acid, Linoleic acid, Myristic acid, α-Linolenic acid, Carpic acid, Lauric acid and Arachidonic acid and the antioxidant compounds of basil are., vanillic, rosmarinic acids, caffeic, quercetin, rutin, apigenin, chlorogenic and p-hydroxybenzoic. Increases in temperature and light conditions have influence on antioxidant capacity (Vidovic *et al*. 2016).

Essential oils of basil are α-Pinene, β-Pinene, Methyl chavicol, 1,8 cineole, linalool, Ocimene, Borneol, Geraneol, B-Caryphyllone, n-Cinnamate and Eugenol. The most important essential oil of basil is eugenol, chavicol and terpenoids (Castronuovo 2019) [42].

Antimicrobial activity

Ocimum basilicum contains linalool, eugenol, methyl chavicol, methyl cinnamate, ferulate, methyl eugenol, triterpenoids, and steroidal glycoside known to exhibit antimicrobial, bactericidal activities. Basil's antimicrobial activity is shown in its antibacterial, antifungal, antiviral, and anti-parasitic properties, which are attributed to the presence of various bioactive chemicals. The major constituents were methyl eugenol (39.3%) and methyl chavicol (38.3%). Other minor constituents were terpinolene (7.7%), eugenol (4.5%), and cubenol (1.9%) was examined by Joshi (2014) [43].

Rubab. (2017) identified that the essential oil of purple basil showed antimicrobial activity against strains of *S. aureus*, *E. faecalis*, *L. monocytogenesm*, *E. aerogenes*, *E. coli*, *S. enteric*, and *S. typhimurium*. Bassolé *et al*. (2010) showed that *O. basilicum* had as its main bioactive compounds: linalool (57%) and eugenol (19.2%).

Avetisyan *et al*. (2017) [21] observed that cultivars of *O. basilicum var. purpureum* has proven effective against S. aureus and B. subtilis, respectively. They showed differences in the main chemical composition, such as 57.3% methyl-chavicol (estragole) for var. purpureum.

Adamu *et al*. (2016) [46] showed that the antimicrobial activity of *O. basilicum* seeds extracted in petroleum ether was tested against nine clinical infections. The zone of inhibition formed after the incubation period was used to determine antimicrobial activity. All pathogens were inhibited by a zone of inhibition created by a petroleum ether extract of *O. basilicum* seeds. The highest zone of inhibition was observed against Pseudomonas aeruginosa at a concentration of 100 mg/ml. Antimicrobial activity was found in a petroleum ether extract of *O. basilicum* seeds against Grampositive and Gram-negative bacteria.

Joshi (2014) [43] has examined the constituents of basil were determined based on retention index (RI). Without using the correction factor, the relative amounts of different components were evaluated based on GC peak area (FID response). The antimicrobial assay done by the tube-dilution method to determine the minimum inhibitory concentration (MIC) of the essential oil of *O. basilicum* against the microorganisms under study. The oil was dissolved in 10% DMSO with Tween 80 (1% v/v for easy diffusion). The oil's final concentration was 5.00 mg/mL. By using the stock solution, serial two-fold dilutions of the essential oil for bacteria and fungi were made and its yielding concentrations ranging from 5.00 to 0.009 mg/mL. For the determination of the minimal bactericidal concentration (MBC), 0.1 mL of the culture in each tube of MIC without apparent growth was distributed on nutrient agar plate and incubated at 37°C for 24 and 48 hours, respectively, for bacteria and fungi. The MBC was determined by the maximum dilution at which 99.9% of the bacterial and fungal inoculum were destroyed.

According to Baldim *et al*. (2018) [47], Antimicrobial activity of basil essential oil against Gram-positive bacteria like *Bacillus cereus, Staphylococcus aureus*, and *Listeria monocytogenes*, as well as Gramnegative bacteria like *Salmonella sp*. and *Pseudomonas aeruginosa*. It does, however, show that the primary component (linalool) is not the only one responsible for this biological activity, since other components in smaller proportions are also involved (synergistic effect). Linalool has a higher cell membrane fluidity and alters cell permeability; therefore, this synergistic impact is feasible. This makes things simpler to get smaller amounts of the components into the system.

Behbahani (2013) [48] has proven that the eugenol obtained from the methanolic extract of *O. basilicum* expressed anti-viral properties against human immunodeficiency virus 1 (HIV-1). Eugenol increases the proliferation of peripheral blood mononuclear cells and reduces viral replication in a dosedependent manner. Several phytoconstituents isolated from *O. basilicum* had a potent anti-viral activity. The apigenin, linalool, and ursolic acid are the most important components; ursolic acid has antiviral action against various viral agents, including HSV-1, ADV-8, CVB1, and EV71. The antiviral action of ursolic acid against EV71 and CVB1 occurred in both the initial infection phase and replication phase. The apigenin and linalool also exhibited potent anti-viral activity.

Anti-inflammatory activity

Saponins, taninis, terepenoids, flavonoids, steroids and alkanoids have anti-inflammation effects. Anti-inflammatory action of the basil is attributed to the compounds such as estragole, methyl cinnamate, methyl eugenol, α- bergamotene, α-cadinol, and linoleic acid was identified by Saleh (2017) [49].

Aye *et al*. (2019) [50] examined the bioactive component of basil has been shown to have potential health benefits in terms of reducing and preventing pathological inflammations. To enhance the anthocyanin content of *O. basilicum*, elicitor compounds such as jasmonic acid, arachidonic acid, and -aminobutyric acid can be utilised. Elicitor treatment has been shown to improve anthocyanin anti-inflammatory properties, as seen by enhanced inhibition of lipoxygenase and cyclooxygenase enzymes. Eliciting jasmonic acid, an endogenous phytohormone that plays a critical role in plant growth and development, improves the composition of essential oil produced from *O. basilicum*. Increased quantities of linalool, eugenol, and limonene in essential oils may be associated with enhanced anti-inflammatory action, which was beneficial in the treatment of both acute and chronic inflammation.

Gnoula (2014) [51] has proven that the essential oil of *O. basilicum* also exhibited the anti-inflammatory activity by inhibition of lipoxygenase enzyme (98.2%) at 8 mg/mL concentration. The crude methanolic extract of basil has anti-inflammatory effect due to the inhibitory action on key proinflammatory cytokines (TNF-α, IL-2, IL-β) and other mediators of inflammation. In a turpentine oil-induced acute inflammatory model in rats, the tincture of *O. basilicum* showed better antiinflammatory activity, as indicated by a significant reduction in monocyte percentage, total leukocyte count, and circulating phagocyte activation. The anti-inflammatory effect of O. *basilicum* tincture was shown to be inferior to that of the drug diclofenac.

Rodrigues *et al*. (2016) [52] conducted a study comparing steroidal and non-steroidal anti-inflammatory drugs. When compared to steroidal anti-inflammatories, the conjugated complex of β-cyclodextrin and essential oil of this plant enhanced the anti-inflammatory effect, and the estragole in *Ocimum basilicum* caused a reduction in acute and chronic inflammation in the paws of rats (dexamethasone and indomethacin). This action is achieved through inhibiting the inflammatory process' receptor mechanisms and chemical mediators. The therapeutic potential of *O. basilicum* essential oil and its crucial component, estragole has also been demonstrated by Rodrigues *et al*. The essential oil of basil leaf extract has a lot of potential for advances in the field of anti-inflammatory drug development.

Złotek (2015) [19] has evaluated the statistical analysis of purple basil, that indicated the antiinflammatory activities were correlated significantly and positively with the phenolic contents. The ability to inhibit liquid oxygen was found to be positively and significantly correlated with benzoic acid levels, as well as positively but not significantly with rosmarinic acid content. It should be also noted that cyclooxygenase (COX) inhibition level was positively and significantly correlated with the benzoic acid, rosmarinic acid and o-coumaric acid contents. The activities of the two main enzymes of the phenylpropanoid pathway (PAL and TAL) were determined to identify the mechanism involved in enhancing the phenolic content in the stimulated basil leaves. All the studied elicitors caused an increase in the activities of PAL. The highest activity of this enzyme was determined in the JA-elicited basil (0.62 mM trans cinnamic acid mg protein min). In the AA- and BABA-treated plants, the PAL activity was higher about 10% and 21% in comparison with the control plants, respectively.

Antifungal activity

The species *O. basilicum var.* contains the main compounds of antifungal activities such as: linalool-44% and 1,8-cineole-15.5% did not inhibit any Candida, which is probably due to the presence of the monoterpene alcohols as main constituents. Vieira *et al*. (2014) who examined antifungal activity actions of different Ocimum species. The species *O. basilicum var. purpurascens* (main compounds: linalool - 41.5% and α-muurulol - 11.8%) showed antifungal activity only for *C. parapsilosis* and *C. albicans*.

Majid (2012). have been observed that the fungus like *Aspergillus fumigatus, Aspergillus flavus, Candida albicans, Cryptococcus neoformans, Botrytis fabae, Uromyces fabae, Aureobasidium pullulans, Trichophyton rubrum, Microsporum gypseum,* and *Trichoderma viride* have been found to have significant antifungal activity. The methanolic, ethanolic, and aqueous extracts of *O. basilicum* stem bark have significant antifungal activity *in vitro* against *Candida albicans*, indicating that it could be used as an antifungal agent. The essential oil of O. basilicum was found to have antimicrobial activities against *Aspergillus fumigatus, Aspergillus niger, and Penicillium chrysogenum*. The *O. basilicum* extracts such as ethyl acetate and methanol exhibited antifungal efficacy against Bipolaris and Cochliobolus species, respectively.

Ahmad *et al*. (2016) [53] found that the methanolic extract of *O. basilicum* exhibits considerable antifungal and phytotoxic properties. The pathogenic fungus *Aspergillus flavus, Aspergillus niger, Aspergillus fumigates, Penicillium, Rhizopus solani*, and *Alterneria alternata* were all significantly inhibited by the methanolic extract of this plant, whereas *Candida albicans* and *Curvularia lunata* were the least affected. Anti-fungal action on *Sclerotium rolfsii*, basil aqueous extract has been observed. Essential oil of *O. basilicum* has been shown to inhibit the growth of Aspergillus flavus and the generation of aflatoxin.

El-Soud (2015) [57] has conducted the research on the *Ocimum basilicum* oil was tested against pathogenic fungi such as: *Aspergillus niger, Aspergillus fumigatus, Penicillium italicum* and using the disc diffusion method and determining the minimal inhibitory concentration in *Rhizopus stolonifera*. Surprisingly, high antifungal effect was found highlighting the potential of *Ocimum* species as a preservative in food and medical industries.

Gucwa (2018) [58] reported the essential oil of *O. basilicum* has been prevent the growth of *Aspergillus flavus* and the *aflatoxin* production. The fungal growth was completely inhibited at 1,000 mg/L oil concentration, whereas aflatoxin B1 generation was significantly reduced from 500 to 1,000 mg/L concentration. The essential oil of *O. basilicum* showed potent fungistatic and fungicidal activity against *Candida albicans* and *C. glabrata* isolates. The inhibition of the transformation of yeast to mycelial form has been done in the mechanism of action.

Valencia, Castro, Pascual, & Magdalita, (2011) [59] has conducted the research on the antifungal activities of *Ocimum basilicum* leaves extracts, that were evaluated against mycelia and sclerotial body of *S. rolfsii* by using agar dilution technique. For each type of inoculum, the experiment was set up in a completely randomized with six treatments and three replications. The treatments were distilled water as negative (-) control, *Ocimum bacilicum* extracts with the concentrations of 25%, 50%, 75%, 100% and fungicide (active ingredient Benomyl) with the concentration of 300 ppm as positive (+) control. Standard stock solutions of plants leave extract concentrations were prepared separately by adding the required quantity of plants extract to the molten PDA medium. One set was made without plant extract and kept as negative control. All these were poured into sterilized Petri plates. Before the medium solidified, petri plates with plant extract were gently combined. The mycelial disc of *S. rolfsii* at 5 mm diameter was taken from 3 – 4 days old mycelial cultures and centrally inoculated onto PDA medium in each of the petri plates containing different leaves extracts concentrations and control under aseptic conditions. At room temperature, all these petri plates were incubated. The colony's diameter was measured in two directions and the average was noted. At 60 hours after inoculation, the negative control plates were examined until mycelia had fully grown.

Anticancer activity

Linalool, eugenol, terpenoids, flavonoids and phytochemicals (such as Rosmarinus acid, isoeugenol) are the main bioactive components of *O. basilicum* that contributed to the anticarcinogenic effects. Ocimum species of plants have been traditionally utilized in cancer treatment was determined by Rodenak-Kladniew *et al*. (2014) [60].

Alagawany (2017) [61] has proven that the *Ocimum basilicum* contains an active compound known as eugenol, The level of expression of p53 mRNA increases when breast cancer cells are treated with this compound, while the expression of the bcl-2 gene decreases. Eugenol induces p53 to get into the apoptosis. It's also important to note that when cells are subjected to eugenol, the amount of bax protein expression increases.

Mahgoub (2019) [62] has identified that, In the basil, the crucial phytochemicals that are potentially effective against cancer include caffeic, rosmarinic acid and isoeugenol apart from eugenol. All these along with linalool show potent anticancer activity against SKOV3 cells (cancer cell line of human ovary origin). Eugenol and isoeugenol cause inhibition of synthesis of DNA and possess potent cytotoxic activity against tumour cell line of salivary gland. *O. basilicum* contains alkenyl benzenes, which are carcinogens; however, the existence of nevadensin-like compounds counteracts this side effect, making *O. basilicum* containing pharmaceuticals are considered as safe formulations. Gajendran *et al*. (2016) has evaluated the *O. basilicum* seeds extracts for cytotoxic activity on human osteosarcoma cell lines (MG63). MG63 human osteosarcoma cell lines have been used to perform an *in vitro* measure of anticancer activity of *O. basilicum* seeds using the MTT cell growth inhibition assay. The cell viability percentage showed maximum activity at the lower concentration 12.5 g/ml. There was more death of cell line or cell deterioration with increase of concentration of *O. basilicum* seeds. At high concentrations of basil seeds, the cells shrunk with membrane blebbing and showed indications of separation from the well surface, indicating cell death.

According to Pereira *et al*. (2018) [40] linalool causes human prostate cancer cells to stop reproducing.

Zhang *et al*. (2015) [64] also reported this substance triggered apoptosis in the myeloid leukaemia cells. Linalool exhibits pro-apoptotic effects on a human melanoma cell line, according to Cerchiara *et al.* (2015). Besides these, other studies describe the anticancer activity of linalool in different cell types, such as hepatocellular carcinoma cells (HepG2) human-alveolar-adenocarcinoma cells. Torres (2018) [65]. Basil leaf extract can induce drug detoxification enzymes such as glutathione S-transferase and DT-diaphorase, making it a potent cancer chemo preventive agent. Abd El-Azim *et al*. (2015) [66] also proved that *O. basilicum* methanol extract exhibited a strong cytotoxic effect against the colon carcinoma and liver cell lines owing to the presence of active phenolic compounds.

Hepatoprotective activity

Hepatoprotective role of the basil leaves extract is attributed to its antioxidant nature; thereby protecting hepatic tissue from oxidant damage, which ultimately aids in preventing hepatic fibrosis. Compounds with hepatoprotective activity combined with antioxidant activity have a synergistic effect in preventing the initiation and progression of hepatocellular diseases has proven by Karaali (2019) [67].

Abatan (2016) [68] has conducted the research on the leaf extract of *O. basilicum.* It can ameliorate the acetaminophen-induced acute hepato-renal toxicity in mice. The hepatoprotective and antioxidant activities of *O. basilicum* were investigated in rats using an acetaminophen liver damage model. Significant reductions in the levels of liver enzymes such as serum-like alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase were observed (ALP). Total bilirubin and blood urea nitrogen (BUN) levels in the blood were also significantly reduced. It was noted that the reduction was significantly higher with the use of methanolic whole plant extracts of *O. basilicum* when compared to that of chloroform, diethyl ether, and ethyl acetate extract.

Saeed (2015) has conducted the research on the hepatoprotective effect of basil extract against liver fibrosis-induced by carbon tetrachloride (CCl) was studied in rats. Rats were allocated into five groups. Basil treatment decreased the amount of hydroxyproline in the liver and increased the activity of hyaluronidase (HAase). The effect of basil extract on hepatic superoxide dismutase (SOD) activity was stimulated, whereas lipid peroxidation was significantly reduced. Treatment with CCl significantly increased the activities of transaminases (AST), alanine aminotransferase (ALT)], and alkaline phosphatase (ALP). The basil extract decreases these activities. The protection of basil significantly reduced the higher levels of serum urea and creatinine in the CCl_4 group. Basil extract reduces the blood AST and ALT activities by increasing antioxidant enzyme levels, which may protect the liver from adverse effects and inhibit LPO. Basil is rich in flavonoids, and the antioxidant activity of its flavonoids may indicate how *O. basilicum* has a hepatoprotective effect. As a result, the livers of rats were treated with aqueous basil extract showed normal livers.

Branislava Teofilović (2021) [20]. has examined the hepatoprotective effects were apparent though the increase in the activity of antioxidant enzymes, decreased lipid peroxidation and serum activity of liver transferase enzymes as well as in animals pre-treated with basil extract, the excretory liver function was preserved. The ameliorative effect of aqueous basil extract in acetaminophen-induced liver injury was confirmed by changes in tissue morphology and morphometric analysis of the surface density of liver tissue damage.

Bahmani (2015) [70] has proven that the hepatoprotective efficacy of methanolic whole plant extracts of *O. basilicum* was found to be superior to that of Silymarin is a standardized extract of milk thistle seeds containing a mixture of flavonolignans. Silymarin shows the hepatoprotective (antihepatotoxic) properties that protect liver cells from toxins in both *in vitro* and animal studies. Moreover, the production of reactive oxygen species (ROS) by certain drugs, such as acetaminophen, induces nephrotoxicity and hepatotoxicity.

Antioxidant activity

Purple basil extract has an abundant antioxidant activity such as polyphenols, flavonoids and compounds such as rosmarinic acid. The two main biologically active compounds – anthocyanins and phenolic acids, as well as estragole, methyl cinnamate, methyl eugenol, α-cadinol, linoleic acid, and αbergamotene also contribute to the antioxidant activities of *O. basilicum* was identified by Nazir (2019) [71].

Güez (2017) [72] examined that the anthocyanin, lutein, zeaxanthin, beta-carotene, linalool-eugenol, and beta-cryptoxanthin are some of the key antioxidants present in purple basil. These antioxidants, as well as basil's essential oils, are responsible for many of basil's health benefits. Free radical sequestration, hydrogen donation, and metal ion chelation are some of the ways by which antioxidants work.

Bayala (2014) [51] investigated the essential oil from *O. basilicum* gave the highest antioxidant activity by using DPPH (1,1-diphenyl-2-picrylhydrazyl radical) and ABTS (2,2′-azinobis-3-ethylbenzothiazoline- 6-sulfonic acid) methods. The effect of ethanol extract of basil leaves on the oxidative stability of soybean oil has been observed in recent years. The amount of polyunsaturated fatty acids (PUFA) and tocopherols has also decreased significantly. As a result of this experiment, it was discovered that basil, which is high in different chemicals and has antioxidant characteristics, may be employed as a flavouring agent in vegetable oils in the form of an extract as a replacement for the synthetic antioxidants. The basil plant's leaves contain a wide range of antioxidants, including hydrophilic (such glutathione and vitamin C) and lipophilic components (carotenoids and vitamin E). Furthermore, the presence of higher levels of linalool and eugenol, the antioxidant activity of basil essential oil is also increased. The antioxidant activity of essential oils varies based on the chemical ingredients.

The methylation behaviour was reported by Koroch *et al*. (2017) [6], who stated that essential oils with the highest concentrations of linalool and methyl chavicol have the highest antioxidant activity, with a predominance of the highest eugenol content; on the other hand, essential oils with the highest concentrations of linalool and methyl chavicol have the lowest reducing activity. This behaviour was observed and correlated to the presence of a hydroxyl group (OH) in some substances, such as methyl eugenol, which is prevented by methylation, reducing antioxidant action. Additional methoxy groups significantly improve antioxidant activity, according to the authors, which explains eugenol's high antioxidant activity (presence of the methoxy group in the molecule).

According to Złotek *et al*. (2016) [25] When compared to the control jasmonic acid significantly boosted antioxidant activities, and this biological activity is attributed to higher amounts of linalool and eugenol. Furthermore, the finding suggests on a possible link between the proportion of eugenol and antioxidant capacity, indicating that an increase in eugenol concentration influences an increase in bioactivity.

Dorman (2014) explained that the total anthocyanin content in *O. basilicum* was determined using the pH differential method (Giusti & Worlstad, 2015). The purple basil leaf extracts have a significant antioxidant impact, according to their findings, which indicate that methanolic extracts of purple basil have concentration-dependent antioxidant activity, and that phenolic compounds are responsible for this effect.

Table 4: Total Phenolic compound, anthocyanin contents and antioxidant activity in Leaves, flower and corolla of green and purple basil varieties

Organ	Variety	` Total Phenols	Anthocyanin	Antioxidant
Leaf	Italian	5.40±0.27	0.01±0.01	62.48±1.09
Flower	Classico Red Rubin	7.10±0.13	3.94±0.05	67.98±2.10
	Dark Opal	6.06±0.20	3.48±0.20	61.44±2.10
	Italian	3.48±0.05	0.02±0.01	140.18±2.51
Lorolla	Classico Red Rubin	4.20±0.10	0.80±0.11	133.40±7.80
	Dark Opal	4.50±0.32	0.70±0.12	106.44±4.47
	Italian	2.28±0.15	0.03±0.02	147.58±1.22
	Classico Red Rubin	3.30±0.02	1.28±0.26	134.41±2.44
	Dark Opal	3.68±0.24	1.00±0.14	99.26±3.00

GAE: Gallic acid equivalents, CGE: Cyanidin-3-glycoside equivalents, AAE: Ascorbic acid equivalents, Values are means±SE n(n=3) (Source: Negrini *et al*, 2019, Akah *et al*, 2017) [18].

Utilization and application of products formulated from purple basil

Purple basil is an important medicinal plant and having many medicinal properties. It is rich source of carbohydrates, fibers, vitamins, and calcium. Purple basil used as dried leaves in food, beverage, and spice industries to produce essential oil. It is developed as functional food products (Turkey *et al*, 2017)

Purple basil sirkencubin syrup

Sirkencubin syrup is a nutritious drink consisting of fusion of purple basil, honey, vinegar and water. Because of its high bioactive properties, pine honey was selected. For mixture honey (14g) + vinegar (6ml) + sterile water (0.2L) was homogenized in the homogeniser for about 2 minutes. Mostly purple basil tea was used to make the sirkencubin syrup. Then add about (0.2l (7.5g purple basil/l)) in the mixture and the mixture was coded as PBSS and the sample was stored at -18 degree Celsius until analysis. Sirkencubin syrup has controlled the hypertension (chronic disease) though it has negative effects on heart, kidney, brain, and eyes. In healthy young people, it is critical to maintain heart health and maintain blood pressure within normal ranges. (YIKIMIS *et al*. 2020).

Purple basil sherbet

Sherbet, a frozen dessert usually flavoured with fruit, made from sugar-sweetened water with flavouring. This study specifies that there is no production of sherbet in industrial scale, but people make this product at their home for refreshing themselves (Yigitvar, 2020).

Purple basil yogurt

Yogurt is a dairy product obtained by fermenting milk of two species including *Streptococcus thermophiles* and *Lactobacillus bulgaricus*. In the purple basil yogurt, purple basil extracts were used in powdered form or water extract form for possible contribution in its taste desired flavour (Gurkan *et al*, 2017) [75].

Purple basil pesto

Pesto, or pesto alla Genovese, is a sauce originated in Genoa, the capital city of Liguria, Italy. It traditionally consists of crushed garlic, European pine nuts, coarse salt, basil leaves, and hard cheese such as Parmigiano-Reggiano or Pecorino Sardo, all blended with olive oil. “Crushing” basil, garlic, pine nuts, olive oil and some hard cheese in a food processor or blender make the most popular variety of pesto now (Ciriello *et al*, 2021).

Purple basil kombucha beverage

Kombucha, is also known as tea fungus. It is made from fermented traditionally flavoured black or green tea with symbiotic culture of bacteria and yeast. In this research, the changes in the bioactive components, physiochemical activity, sensory properties of black tea and different proportion of purple basil kombucha after the fermentation was judge. It was found that the total amount of phenolic and flavonoids in purple basil is higher than other samples. In this study it was found that antioxidant on the 30^{th} day determine the highest DPPH value (61.19%) and CUPCAC (41.48%), there no change in its smell, taste, and general acceptance. As a result, 30 days was found to be successful and favourable for 100% purple basil kombucha tea (Tuggum *et al*, 2019)

Purple basil infusion can be used successfully in kombucha fermentation, which creates a beverage with significant amounts of phenolic, flavonoid and antioxidant compounds. In addition, in terms of taste and sensory characteristics, consumers liked it more than kombucha tea produced by the traditional method. In terms of health, of kombucha teas appear to be positive because of their phenolic substances, flavonoids, antioxidant levels and sensory properties, although more *in vivo* research is needed to prove their health effects (Chu and Chen, 2006).

Purple basil ice cream

In a study by Javidi *et al*. (2016), it was determined that basil seed gum is used as a surface-active polysaccharide to improve the rheological properties in low-fat ice cream production used as both an emulsifier and a stabilizer. At the same time, the use of basil seeds in ice cream gave positive results in the sensory evaluations made by the panelists.

Kumar *et al*. (2013) found that, because of sensory evaluation of ice creams to which purple basil added at 2 and 3% was more liked by the panellists. The addition of medicinal and aromatic substances to ice creams is not only to improve their functional, physical, sensory, and antimicrobial properties but also natural colorants are preferred instead of synthetic colorants used in production.

Table 5: Products formulated from purple basil

Product	Optimization	Findings and results	Reference
Purple basil Sirkencubin Syrup	Soluble solids were measured by refractometer, Proximate test has been done for estimating ash moisture and fibre.	The pH value was determined (3.18±5.10), total phenolic content of sample is 17.64%, ascorbic acid contents of the samples decreased during storage.	Seydi *et al*,2020:
Purple basil Kombucha Syrup	Its physical appearance was evaluated, ph and total solid, gravity and viscosity has been done.	The radical scavenging activity is 64.19% and cupric reducing antioxidant capacity is 40.45%, it shows differences in colour during the storage process. Calorie content per 100 ml is 3.17g	Yikkims *et al*, 2019; Adhilari *et al*, 2020
Basil yogurt	Sensory evaluation, microscopic examination; titratable acidity and pH measures	0.5%BSG (basil seed gum) added to reduced-fat yogurt, its colour and experience is about (6.87±0.95), flavour about (7.17±0.59), Ph is about ranging from (4.87±0.06) to (5.47±0.06) against the control (5.80±0.00).	Tasnim *et al*, 2020; [82] Phyrim lee *et al*, 2020
Purple basil ice cream	Castor sugar in a food processor for making coarse powder, uses rheometer to characterize its consistency, testing for temperature and yield stress.	Homogenization, hydration phenomena during aging, freezing and frozen storage conditions,	Trivedi *et al*, 2014
Purple basil Pesto	Its consistency test, pH value, proximate analysis, shelf life.	Ph value of pesto is very close to 7, its 172% to 413%, 2.4% eugenol, to improve its quality extending its shelf life and reducing oxidation during storage.	Pietro *et al*, 2006; Luigi *et al*,2021

Toxicology and recommendation

The essential oil and extracts recovered from *Ocimum basilicum* L. have least toxic effect as compared to the other species of Ocimum. The variability in toxicological data for *O. basilicum* L. extracts is dependent on a variety of factors, including the type of extract, the heterogeneity of the biochemical profile of plant material, the age and height of the plant, the part of the plant tested, the cultivar, and the chemotype.

According to the European Food Safety Authority (EFSA), The food constituent, *Ocimum basilicum* L., has been appropriately defined with the following conditions of usage: 2-4 g dried leaves, 2-3 times per day, and corresponding amount in extract". The study by Fandohan *et al.* (2008) [83] is the only one who determine no observed adverse effect levels for *O. basilicum* essential oil: 71.4 mg/kg/day during a subacute feeding period, and an extrapolated safe level for humans of 0.7 mg/kg/day (estimated at 1/100 of the NOAEL). In a study on the toxicity of plant hydroalcoholic extracts the *Ocimum basilicum* extract had a medium lethal dose (LD50) of 956.5 mg/kg in mice. (Parra *et al*., 2011) [84]. *In vivo* intraperitoneal application of Aqueous, methanolic, and petroleum ether extracts have been further tested for medium lethal dose estimation, which yielding 470 mg/kg, 3,800 mg/kg, and 3,800 mg/kg respectively. (Umar *et al*.,2013)

Like other essential oils, *Ocimum basilicum* essential oils used in cosmetics at concentrations more than 5% can cause skin irritation. Human subjects were found to be safe after 72 hours of single exposure to microemulsions contained 3% *O. basilicum* essential oils with no visible indications of irritation, erythema, or edema. (Pansang *et al*., 2010) [86].

The major source of concern about *O. basilicum* safety is the fairly high amounts of methyl eugenol and estragole plant derived and its products, particularly *Ocimum basilicum* essential oils may contain. Indeed, both p-allylalkoxybenzene derivatives were shown to be carcinogenic and genotoxic. (Restani *et al*.,2011)

Future perspective

New culinary trends favour fresh herb over traditional dried leaves and the demand for locally grown products is increasing. Expanding market for raw culinary purple basil shifts focus from field production to year-round cultivation in enclosed controlled environments such as the vertical farms and greenhouses (CBI, 2020). Vertical farms, plant factories deliver the maximum level of manipulation for basil cultivation (Butturini *et al*., 2019). The cultivation area is completely isolated from outdoor environment and LED light replaces solar irradiation In-store farms grow and directly sell fresh herbs including basil in food retail stores (Butturini *et al*., 2015, Cointet *et al*., 2019). Shelf life and tolerance in the direction of environmental factors is certainly improved by the means of green: red (1:4) light treatment (Jensen *et al*., 2018). Nevertheless, the existence of selenium, a trace element without light treatment is also helpful in order to extend shelf-life of basil (Puccinelli *et al*., 2020). Optimization of basil production depends on several factors: production goals, environmental parameters like light, temperature, water supply, soil nutrient content, CO2 concentration, relative humidity, air velocity variety, and production system (Sipos *et al*., 2021). In the recent years, due to increasingly negative consumer perceptions of synthetic preservatives, interest in essential oils and their application in food preservation has been and so there is a huge scope of basil based essential oil in the market (Chouhan *et al*.,2017).

Conclusion

Parts of basil plants, particularly the leaves, and extracts have been shown to have health advantages in a range of therapeutic situations. Several basils have commercial potential to produce industrial products. Camphor-rich or eugenol-rich basil chemotypes, for example, could be a potential industrial source of natural compounds such as camphor and eugenol. (Simon *et al*.) concluded that purple basil contains very high concentration of total anthocyanins and are valuable sources of these components, which may serve as potential new source of red pigments for the food industry. Although polyphenolic chemicals are prevalent in basilicum, it acts as a natural antioxidant. Rosmarinic acid, the principle active compound observed in basil, has been established to have medicinal value, and its advanced antioxidant activity with vitamin E. Although there is encouragement to include basil in the diet to improve management of diabetes and the metabolic syndrome, several issues need to be more thoroughly addressed when assessing all these purported health benefits. Basil extracts had a higher DPPH radical scavenging capacity than essential oils and included a significant amount of total phenolic content. High correlation among antioxidant activity and overall phenolic contents of basil extracts were observed. Essential oils have a wide range of free radical scavenging activities. Because of their significant antioxidant activities and abundance in the plant kingdom, phenolic compounds may be advantageous in food processing. They are particularly interesting for application in functional foods and nutraceuticals because they act as preservatives, protecting the human body from degenerative diseases caused by oxidative stress. Among the aromatic and medicinal plants available to the food industry, basil (*Ocimum basilicum* L.) has promising beneficial properties. This review summarizes our knowledge of available phytonutrients from purple basil, antioxidant activity and their health-benefits in prevention of some modern diseases.

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