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A brief review on phytoconstituents, biological activities and therapeutic uses of *Ocimum basilicum*: king of herbs

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Abstract
Ocimum basilicum commonly known as sweet basil and designated as the King of herbs is widely used as a traditional medicine to cure numerous diseases from ancient times. It is also used in culinary practices and cosmetic industries. It has mythological as well as therapeutic importance that is shown by its wide spectrum of biological activities such as antibacterial, antifungal, antioxidant, anti-inflammatory, anticancer, antiviral, etc. The chemical profile of *Ocimum basilicum* reveals that it is a rich source of linalool, methyl chavicol, eugenol, methyl eugenol and geraniol. This review explores the phytochemical profile, biological activities and therapeutic uses of *Ocimum basilicum* in our life.

Keywords: *Ocimum basilicum*, phytoconstituent, antibacterial, antifungal, linalool

Introduction

In the present era, the world is emphasizing on the use of natural products in every aspect of a human life such as in food, cosmetics, medicines, etc. which results in adopting the aromatic plants, their extracts and essential oils as functional ingredients by various industries [1]. Since 5000 BC, aromatic plants have been used as herbs and spices in food to enhance its flavour and nutritional value, as preservatives and for curing different ailments [2-4]. As per World Health Organization (WHO) report, 80 percent world's population is depending on plants derived medicine for their healthcare and developing countries are leading in it [5, 6]. *Ocimum basilicum* is a well-known herb that has been used since ancient times in food, pharmaceutical, cosmetic and perfumery industries [7]. It is an annual herb that belongs to the Lamiaceae family and commonly known as sweet basil. It is also designated as 'King of herbs' due to its vivid phytoconstituents and significant nutritional value [8]. *Ocimum basilicum* is a branching herb with a height of 0.6-0.9 m. It has green or sometimes purple ovate leaves with several dots that secrete strong-scented volatile oil [9, 10]. It is a widely cultivated essential oil cropped in numerous countries for commercial purposes. The aerial part of the plant is used as antispasmodic, carminative, stomachic and galactogoguein folk medicine [11]. The essential oil of *Ocimum basilicum* shows various chemical compounds such as oxygenated monoterpene, monoterpene hydrocarbons, sesquiterpene, sesquiterpene hydrocarbons, triterpene, oxygenated flavonoids, and some aromatic compounds [12]. *Ocimum basilicum* is a highly nutritious herb. It includes lipids, proteins, minerals like Na, K, Mg, P, Fe, Ca, Mn, and Zn, and vitamins like C, K, A, E, β-carotene, B1 (thiamine), B2 (riboflavin), B3 (niacin), B5 (pantothenic acid), B6, B9, and choline [13]. Synthetic drugs that are used to suppress pathogenic microorganisms are dangerous to the environment and cause acute toxicity. In this regard, the plant's essential oil is found to be the best medication to combat and suppress the pathogenic microorganisms that cause various diseases without harming environment [14]. *Ocimum basilicum* shows numerous activities such as anti-inflammatory, antimicrobial, antioxidant, hypoglycemic, anti-hyperlipidemic, anticancer, hepatoprotective, cardioprotective, cytoprotective, cardiostimulant, antiulcerative, antihypertensive, antiviral, immunomodulatory, sedative, hypnotic, anti-convulsant, anti-nociceptive, chemopreventative, chemomodulatory, mosquito larvicidal, anti-cancer and anti-parasitic activities [15-17].

The present paper overviews the chemical profile, biological activities and therapeutic uses of the essential oil and extracts of *Ocimum basilicum* (*O. basilicum*) that have been researched over the past years.

Chemical profile of *Ocimum basilicum*

Essential oil (E.O) of *O. basilicum* L. consist a variety of phytoconstituents in it. The essential oil of plant has been extracted by hydro-distillation method by using Clevenger apparatus [18-25] and phytochemical composition is determined by GC-FID [21] and GC-MS [18-25] technique.

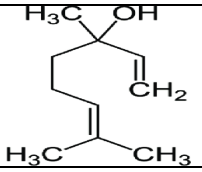
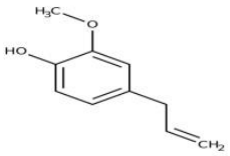
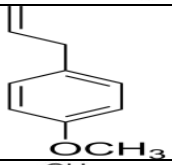
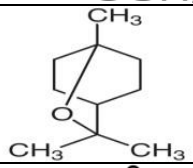
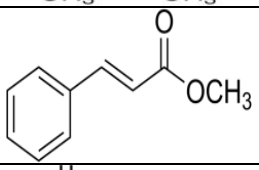
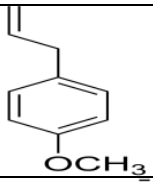
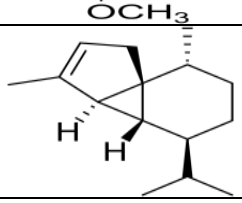
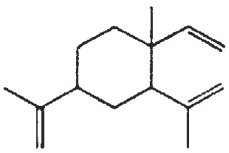
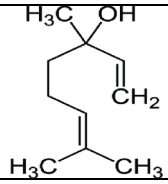
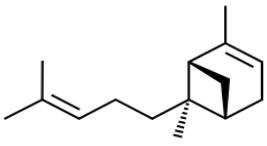
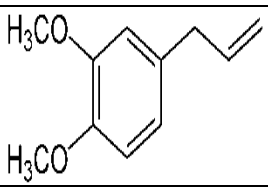
Table 1

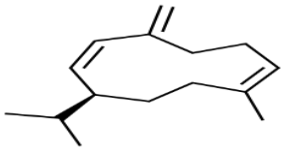
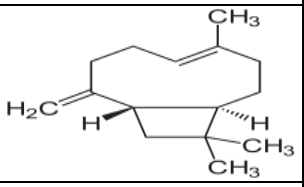
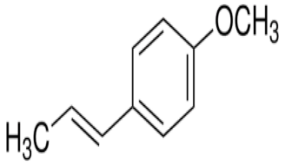
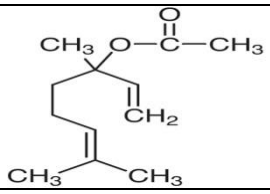
Class of chemical compound	Chemical compound	Molecular formula	Part of plant taken for E.O extraction	References
Monoterpene Hydrocarbons	Mycrene	$C_{10}H_{16}$	Aerial[18,21]	18, 21
	α- Pinene	$C_{10}H_{16}$	Aerial[19,21], Fresh leaves[22], Dried leaves[25]	19, 21, 22, 25
	β- Pinene	$C_{10}H_{16}$	Aerial[19,21], Dried leaves[25]	19, 21, 25
	Camphene	$C_{10}H_{16}$	Aerial[19,21]	19,21
	β- Mycrene	$C_{10}H_{16}$	Aerial[19], Fresh leaves[22], Dried leaves[25]	19, 22, 25
	Trans-β-Ocimene	$C_{10}H_{16}$	Aerial[19,21], Dried leaves[25]	19,21, 25
	Cis-β-Ocimene	$C_{10}H_{16}$	Aerial[21], Dried leaves[25]	21. 25
	γ- Terpinene	$C_{10}H_{16}$	Aerial[19,21], Dried leaves[25]	19, 21, 25

	α- Terpinene	$C_{10}H_{16}$	Aerial[21]	21
	Limonene	$C_{10}H_{16}$	Aerial[21]	21
	Sabinene	$C_{10}H_{16}$	Aerial[21], Dried leaves[25]	21, 25
Oxygenated Monoterpene	1,8-Cineole	$C_{10}H_{18}O$	Aerial[18,19,21]	18, 19, 21
	Linalool	$C_{10}H_{18}O$	Aerial[18,19,21], Fresh leaves[20], Stem[23], Dried leaves[25]	18, 19, 20, 21,23, 25
	Linalyl acetate	$C_{12}H_{22}O_2$	Aerial[18], Dried leaves[25]	18, 25
	Camphor	$C_{10}H_{16}O$	Aerial[18,19,21], Fresh leaves[20]	18, 19, 20, 21
	Eugenol	$C_{10}H_{12}O_2$	Aerial[18,19,21], Fresh Leaves[22], Stem[23]	18, 19, 21, 22, 23
	Estragole	$C_{10}H_{12}O$	Aerial[18], Fresh leaves[22]	18, 22
	Terpineole- α	$C_{10}H_{18}O$	Aerial[18,21], Dried leaves[25]	18, 21, 25
	Bornyl acetate	$C_{15}H_{24}$	Aerial[18,21]	18, 21
	Myrtenol	$C_{10}H_{16}O$	Aerial[19]	19
	Menthone	$C_{10}H_{18}O$	Aerial[21], Fresh Leaves[22]	21, 22
	Iso-menthone	$C_{10}H_{18}O$	Aerial[21]	21
	Menthol	$C_{10}H_{20}O$	Aerial[21]	21
	Methyl chavicol	$C_{10}H_{12}O$	Aerial[21,24]	21, 24
	Geraniol	$C_{10}H_{18}O$	Aerial[21]	21
	Geranial	$C_{10}H_{16}O$	Aerial[21]	21
	1,6-Octadien-3-ol, 3,7-dimethyl	$C_{10}H_{18}O$	Fresh leaves[22]	22
	Eucalyptol	$C_{10}H_{18}O$	Fresh leaves[22], Aerial[24], Dried leaves[25]	22, 24, 25
	Citral<Z>	$C_{10}H_{16}O$	Fresh leaves[22], Stem[23]	22, 23
	Citral<E>	$C_{10}H_{16}O$	Stem[23]	23
	Neral	$C_{10}H_{16}O$	Dried leaves[25]	25
	Terpinyl acetate	$C_{12}H_{20}O_2$	Dried leaves[25]	25
	Geranyl acetate	$C_{12}H_{20}O_2$	Dried leaves[25]	25
	Neryl acetate	$C_{12}H_{20}O_2$	Dried leaves[25]	25
Sesquiterpene Hydrocarbons	Guaiediene	$C_{15}H_{24}$	Aerial[18]	18
	Elemeneα	$C_{15}H_{24}$	Aerial[18]	18
	Germacrene-D	$C_{15}H_{24}$	Aerial[18,19], Stem[23], Dried leaves[25]	18, 19, 23, 25
	Elemeneβ	$C_{15}H_{24}$	Aerial[18,21], Fresh leaves[20], Dried leaves[25]	18, 20, 21, 25
	α- Guaiene	$C_{15}H_{24}$	Aerial[18,21]	18, 21
	Caryophyllene	$C_{15}H_{24}$	Aerial[18], Stem[23]	18, 21,23
	Iso-caryophyllene	$C_{15}H_{24}$	Aerial[19]	19
	α-caryophyllene	$C_{15}H_{24}$	Aerial[19]	19
	Elemeneδ	$C_{15}H_{24}$	Leaves[21]	21
	α-farnesene	$C_{15}H_{24}$	Aerial[19]	19
	Germacrene-B	$C_{15}H_{24}$	Aerial[19]	19
	α- Cubebene	$C_{15}H_{24}$	Aerial[19,21]	19,21
	τ- Muurolene	$C_{15}H_{24}$	Fresh leaves[20]	20
	α-bulnesene	$C_{15}H_{24}$	Fresh leaves[20], Aerial[21]	20, 21
	Aciphyllene	$C_{15}H_{24}$	Aerial[21]	21
	γ- Cadinene	$C_{15}H_{24}$	Aerial[21]	21
	δ- Cadinene	$C_{15}H_{24}$	Aerial[21]	21
	α- Cadinene	$C_{15}H_{24}$	Aerial[21]	21
	α- trans-bergamotene	$C_{15}H_{24}$	Aerial[21], Fresh leaves[22]	21, 22
	α-Copaene	$C_{15}H_{24}$	Aerial[21],Stem[23]	21,23
	Gurjunene	$C_{15}H_{24}$	Aerial[21], Stem[23]	21, 23
	α- humulene	$C_{15}H_{24}$	Aerial[21], Dried leaves[25]	21, 25
	Cis-α-bisabolene	$C_{15}H_{24}$	Fresh leaves[22]	22
	β- bourbonene	$C_{15}H_{24}$	Stem[23]	23
	β- Selinene	$C_{15}H_{24}$	Stem[23]	23
Oxygenated Sesquiterpene	Tau- Cadinol	$C_{15}H_{26}O$	Fresh leaves[20]	20
	Epi-α-cadinol	$C_{15}H_{26}O$	Aerial[21]	21
Aromatic Compound	Methyl cinnamate	$C_{10}H_{10}O_2$	Aerial[19], Fresh leaves[20]	19,20
	Azulene	$C_{10}H_8$	Aerial[19,24]	19, 24
	Methyl eugenol	$C_{11}H_{14}O_2$	Aerial[21], Stem[23]	21,23
	Trans- Anethole	$C_{10}H_{12}O$	Aerial[24]	24
	Cis- Anethole	$C_{10}H_{12}O$	Aerial[24]	24

Table 2: Major Compounds Found in Essential Oil of *O. basilicum*

Chemical compound	Percentage in E.O	Molecular structure	References

Linalool	39.28[18], 44.18[19], 17.50[20], 31.60[21], 22.52[25]		18,19,20,21, 25
Eugenol	5.42[18],8.59[19]		18,19
Estragole	31.48[18], 41.40[22]		18,22
1,8- Cineole	13.65[19]		19
Methyl cinnamate	4.26[19], 70.10[20]		19, 20
Methyl Chavicol (syn. Estragole)	23.80[21], 86.40[24]		21, 24
α-Cubebene	4.97[19]		19
β-elemene	6.90[21]		21
1,6-Octadien-3-ol, 3,7-dimethyl (syn. Linalool)	29.49[22]		22
Trans-α- Bergamotene	5.32[22]		22
Methyl Eugenol	52.60[23]		23

Germacrene-D	9.19[23]		23
Caryophyllene	18.75[23]		23
Trans- anethol	8.31[24]		24
Linalyl acetate	53.89[25]		25

Biological activities of *Ocimum basilicum* L.

Antimicrobial activity

Both gram-positive and gram-negative bacteria are susceptible to the antibacterial effects of *Ocimum basilicum* essential oil. One of the studies showed a strong antibacterial activity against gram positive bacteria: *Staphylococcus aureus (S. aureus), Bacillus subtilis (B. subtilis)* and Gram-negative bacteria: *Escherichia coli (E. coli)* and *Pasteurella multocida (P. multocida)*. However, the study revealed its strong impact on *S. aureus* and *B. subtilis* bacterias with a lowest MIC value 0.9 mg/ml and 0.8 mg/ml respectively as compared to gram negative bacterias. It also showed a good antifungal activity against pathogenic fungi: *Aspergillus niger (A. niger), Mucor mucedo (M. mucedo), Fusarium solani (F. solani), Botryodiplodia theobromae (B.theobromae)* and *Rhizopus solani (R. solani)*. Out of these fungi, it shows the best activity against *A. niger* and the least against *M. mucedo.* [26]. According to Ljiljana P. Stanojevic *et al.* [21], *O. basilicum* essential oil shows strong antimicrobial activity against *Providencia stuartii, Salmonella enterica*, Coagulase-positive *Staphylococcus*, *Streptococcus* group D in contrast to commercially available antimicrobial agent Ciprofloxacin and the pathogenic fungi *Candida Albicans* exhibited better antimicrobial effect than commercial antimicrobial agent Metronidazol. *O. basilicum* essential oil is also sensitive against *Listeria monocytogenes* and *Proteus mirabilis*. It has been found that the antimicrobial activity of *O. basilicum* essential oil is greater than its aqueous extract [24]. Adiguzel *et al* [27]. conducted a study in which methanol, ethanol and hexane extracts of *O. basilicum* were tested against 146 bacterial strains. The hexane extract showed the best antimicrobial activity among them followed by methanol and ethanol extract. According to Al abassy *et al* [28]. study, the essential oil extracted from the aerial part of *O. basilicum* showed resistance against the growth of *Staphylococcus aureus, Salmonella typhimurium, Bacillus cereus* and *Escherichia coli* but didn't show any activity against *Staphylococcus epidermidis, Pseudomonas aeruginosa* and *Klebsiella pneumonia*. Ahmad *et al* [29]. revealed that the methanolic extract of *O. basilicum* exhibited a significant impact on pathogenic fungi *Aspergillus flavus, A. fumigates, A. niger, Rhizopus solani, Penicillium* and *Alterneria alternate* whereas least impact on *Curvularialunata* and *Candida albicans.*

Antioxidant activity

Certain phytoconstituents such as estragole, methyl cinnamate, linalool, eugenol, methyl eugenol, linoleic acid, α-cadinol and α-bergamotene contribute to accelerating the antioxidative potency of *O. basilicum* [30, 31]. One of the studies revealed that on applying the DPPH assay method, the essential oil of *O. basilicum* showed strong antioxidant property after an incubation period of 90 minutes with half-maximal inhibitory concentration, EC_{50} or IC_{50} value of 2.38 mg/ml [21]. Qasim *et al.* [24] studies the antioxidant effect of *O. basilicum* essential oil and its aqueous extract by three different methods namely, DPPH assay, ABTS assay and FRAP assay method. One of the studies revealed that the aqueous extract of *O. basilicum* showed a stronger antioxidant effect with an IC_{50} value of 4.12 $\pm$0.08 mg TEs/g (DPPH assay), 21.00 $\pm$0.06 mg TEs/g (ABTS assay) and 33.13$\pm$0.17 mg TEs/g (FRAP assay) in comparison to *O. basilicum* essential oil with IC_{50} values of 6.41$\pm$0.02, 32.58$\pm$0.53 and 74.66$\pm$0.65 mg TEs/g by DPPH assay, ABTS assay and FRAP assay respectively. In another study, the results revealed that DPPH radical scavenging assay, metal chelating activity, superoxide anion radical scavenging assay and H_2O_2 radical scavenging assay showed that the antioxidative potency of methanolic extract of *O. basilicum* is superior in comparison to its aqueous extract [32]. The season variability also affects the antioxidant activity of essential oil. Hussain *et al* [26]. in their study showed that the *O. basilicum* essential oil extracted in the winter and spring seasons exhibited greater antioxidant potential than those extracted in the autumn and summer seasons using DPPH assay method. Aside from this, Linalool, a key component of *O. basilicum* essential oil, was

likewise shown to have a lower antioxidant capacity than the total essential oil,

Anti-inflammatory activity

The essential oil of *O. basilicum* contains specific chemicals that demonstrate its anti-inflammatory characteristics, including methyl cinnamate, estragole, methyl eugenol, α-cadinol, linoleic acid, and α-bergamotene [30]. Lipoxygenase is one of the prime enzymes that significantly show chronic inflammation. An investigation revealed that both the essential oil and aqueous extract of *O. basilicum* show a remarkable inhibitory effect against this enzyme. However, the essential oil exhibited higher anti-inflammatory potency in comparison to its aqueous extract [24]. Akoto *et al* [33]. in their study showed that ethanol and hexane extracts of *O. basilicum* thermally inhibit the denaturation of protein (egg albumin) which indicate its anti-inflammation property. The results revealed that hexane extract of *O. basilicum* has greater anti-inflammatory potency than its ethanol extract and both have higher inhibition potential than asprin (a standard drug). In turpentine oil-induced acute inflammatory paradigm in rats, *O. basilicum* tincture demonstrated superior anti-inflammatory activity as measured by a considerable decrease in the percentage of monocytes, total leukocyte count, and activation of circulating phagocytes but weaker than diclofenac drug [34]. The anti-inflammatory action of *O. basilicum* essential oil was improved in mice when it was combined with β-cyclodextrin and making it useful for managing both acute and chronic inflammation. Rodrigues *et al* [35]. found that the essential oil of *O. basilicum* and estragole, one of its prime compounds, both show higher potency against acute and chronic inflammation however the potency of essential oil is somewhat greater than estragole.

Anticancer activity

The epoxide form of eugenol, an active compound found in the essential oil of *O. basilicum* helps in inhibiting the growth of cancer cells. This chemical compound causes breast cancer cells to express more p53 mRNA while expressing less of the Bcl-2 gene, which prevents apoptosis [36]. Apart from eugenol, Caffeic, rosmarinic acid, isoeugenol along with linalool show strong anticancer activity against SKOV3 cells (cancer cell line of human ovary origin). Eugenol and isoeugenol impede DNA synthesis and have strong cytotoxic effects on salivary gland tumor cell lines. The cytotoxic impact of isoeugenol is attributed to the existence of lipophilic radicals and their interaction with cell membranes [37]. It has been shown that *O. basilicum* methanolic extract fractions cause leukaemia cells to undergo apoptosis via activating the JNK pathway. These fractions produced a good outcome, which may have been caused by the presence of derivatives of cinnamic acid and epicatechin as the main components [38]. The human breast cancer cell line (MCF-7) was shown to be less likely to proliferate when exposed to aqueous leaf extracts of *O. basilicum*. Even after the course of therapy was stopped, the extract continued to show cytotoxic effects, suggesting that it may have a therapeutic effect on human breast cancer [39].

Antiviral activity

The human immunodeficiency virus type 1 (HIV-1) was not able to infect the eugenol derived from the methanolic extract of *O.basilicum*. Eugenol inhibits viral replication while producing a dose-dependent increase in peripheral blood mononuclear cell proliferation [40]. *O. basilicum* had a number of phytoconstituents with strong antiviral properties. Linalool, apigenin, and ursolic acid are the three most significant ingredients; of these, ursolic acid has shown antiviral efficacy against multiple viral agents, such as HSV-1, ADV-8, CVB1, and EV71. Strong antiviral action was also shown by apigenin and linalool [41]. According to a recent *in vitro* study, the highly diluted ethanolic extract of *O. basilicum* leaves effectively prevented the Zika virus from replicating in Vero E6 cells. This was achieved by blocking the virus's ability to attach to the cell and enter the host cell, with an IC_{50} value of 1:134, all without harming the cell line. By inhibiting the attachment of the virus and hence blocking its entry into the host cell, the extract exhibited inhibitory action [42].

Therapeutic uses of *Ocimum basilicum* L.

Sweet basil has long been used as an herbal remedy for kidney problems, warts, worms, diarrhoea, constipation, migraines, and coughs. It is a popular culinary herb that is widely used in food industry to enrich the flavor of food and make it healthy too [43]. It cures the dental problems and is also used in perfumes. It helps in treating lung disorders, asthma, cough, bronchitis and sore throat. *O. basilicum* has been found effective in the treatment of cardiovascular disease, neurocognitive disorders and gastrointestinal disorders [44]. Diseases including anxiety, pyrexia, infections, arthropod stings, stomach problems, and more have all been treated with it. Along with having anti-spasmodic and anti-diabetic qualities, it helps to regulate and lower blood sugar. Due to its remarkable resistance to freeze-thaw treatment and its increased textural qualities upon freezing, basil seed gum can be used as a textural and rheological modifier when preparing foods that will be exposed to both heat and freezing temperatures [45]. The treatment of urogenital disorders, such as gonorrhoea, involves the use of *O. basilicum* seeds. Both otitis and syphilis can be effectively treated with the seed oil. Additionally, it is applied as first aid for cases of snakebite and wasp stings. The dry leaf extract of *O. basilicum*, which contains rosmarinic acid, has also been demonstrated to increase the number of sex hormones in rabbits, prompting them to engage in sexual behaviour. The perfume, soap, shampoo, detergent, and other cosmetic product industries use the essential oil extracted from the aerial portions of *O. basilicum* consisting the high linalool concentration [46].

Conclusion

Today the world is seeking herbal medicines over allopathic medicines due to its harmless side effects and powerful therapeutic effects. *Ocimum basilicum* commonly known as Tulsi or sweet basil is an herb for a reason. It has mythological as well as medicinal importance. *O. basilicum*'s essential oil is a hub of phytoconstituents. It contains numerous phytoconstituents that shows a wide range of biological activities. Linalool, methyl eugenol, methyl chavicol, methyl cinnamate are some major compounds that can be extracted from *O. basilicum*'s essential oil. The essential oil and different extracts of *O. basilicum* show a wide range of activity spectrum such as antimicrobial, anticancer, antioxidant, antidiabetic, antiviral, anti-inflammatory, anti-ulcerative, anti-convulsant and many more. A few of them are discussed in this review. Due

to these pharmacological activities, it is used to treat many ailments. It is widely used in food, cosmetic, perfumery and pharmaceutical industries. The irregular work mode, unhealthy eating habits, competitive stress, disturbed sleeping patterns, etc are increasing the health risks in today's era. Covid is the recent pandemic that the world has come across and has taken many lives. In future, we need to explore various aspects of basil to make new products that increase the health benefits and lead the world a healthier and peaceful place to live.

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