Journal of Tropical Biodiversity and Biotechnology
Volume 09, Issue 02 (2024): jtbb85079
DOI: 10.22146/jtbb.85079

Review Article

A Brief Review of Efficacious Plants in the World: *Tagetes* (Marigold)

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Keywords:
Tagetes
Marigold
Efficacious plant
Submitted:
01 June 2023
Accepted:
17 January 2024
Published:
20 May 2024
Editor:
Furzani Binti Pa'ee

ABSTRACT
Tagetes is a genus consisting of several efficacious plant species known as marigold, which is native to Mexico and has spread worldwide due to its ability to adapt to different soil conditions. This genus is very popular among gardeners because it's easy to cultivate, adaptable, produces flowers all year round, has a free flowering habit, short duration, and the flower has an attractive color and shape. It has many flowers of varying colors such as red, orange, yellow, mixed red-orange or red-yellow, but the yellow and orange color are the most popular. The flowers contain many carotenoids, which act as antioxidants, antibacterial, anti-inflammatory, anti-carcinogen, nematicide, and cosmetics. The carotenoid can also cure fever, epileptic fits, astringent, scabies, liver complaints, stomachache, sore throat, and can be used as a natural moisturizer, and natural mosquito repellent Besides its use as a medicinal plant, *Tagetes* is also used as ornamental plants and edible plants. This manuscript's endeavour is to include some important investigations and studies about the general description, phytochemicals compounds and essential oils, medicinal uses, natural pesticides, and food and beverage uses of the marigolds.

INTRODUCTION
Tagetes is a genus consisting of several species known as marigolds, native to Mexico (Gupta & Vasudeva 2012; Adam 2017). Marigold is applied to several genera in Asteraceae (Compositae) with yellow or golden flowers (Mir et al. 2019). There are 53 species in this genus (Singh et al. 2020), while another publication mentioned that there are 33 species of *Tagetes* and only two species that are commonly known which are *Tagetes patula* L. (*T. patula* L.) known as French marigold and *T. erecta* L. (African marigold) (Ashritha et al. 2022). Besides its use as a medicinal plant, marigold is also a potential ornamental plant used in the culinary arts. The flower can be used as a natural dye and decoration. In the agricultural sector, this genus functions as a biological agent to deter pests and as garden decoration. The flowers contain many carotenoids, which

can act as antioxidants, anti-bacterial, anti-inflammatory, anti-carcinogen, nematicide, as well as can be used in cosmetics. The carotenoid properties also can also alleviate fever, epileptic fits, astringent, scabies, liver complaints, stomachache, sore throat, and can be used as a natural moisturizer, and natural mosquito repellent (Ampai et al. 2013; Priyanka et al. 2013; Munif et al. 2021; Kurniati 2021).

In many parts of the world, *Tagetes* has been used as an ornamental, edible and medicinal plant but has not been massively cultivated, especially in some areas that regularly use it for religious ceremonies and flower boards (Kurniati 2021). The province of Bali is the center of *Tagetes* cultivation in Indonesia, yielding about 100-200 billion IDR annually and meeting the demand of 8 tons per day (Beti 2020). In Indonesia, this plant is known as "bunga tahi ayam", "kenikir", "tahi kotok", "gumitir" and "randa kendana" and belongs to the *Asteraceae* family related to chrysanthemum and sunflower. The color is typically white, orange and yellow (Fauziana & Susandarini 2019; Zanovello et al. 2021; Lenawaty 2022). In Spain and France, *Tagetes erecta* L. (*T. erecta* L.) is mostly used for herbal medicine as an external detersive, resolutive and vesicant (Gras et al. 2017), while in Madagascar this plant is used for its antimalarial properties. The people of Rodrigues Island use this plant as a fever reducer by consuming the flower in liquid form (Joshi & Barbalho 2022).

The World Health Organization (WHO) mentioned that approximately 80% of the world population uses traditional medicine products, especially plant products, to maintain their health (Priyanka et al. 2013). Herbal medicine has been used in Indonesia since ancient times and has even become a part of the culture. Each region or ethnicity has its characteristics of traditional medicine due to natural conditions, especially the availability of some medicinal plants (Son et al. 2019; Az-Zahra et al. 2021). Indonesia has more than 400 ethnicities and sub-ethnics, spreading throughout the territories of Indonesia, such as Sumatra, Java, Kalimantan, and Sulawesi (Adiyasa & Meiyanti 2021). This country is rich in natural resources, and people use plants to cure some diseases because they are easy to grow and find, easy to prepare, contain safe ingredients, natural and have less side effects (Reid et al. 2016; Welz et al. 2018).

The development of traditional medicine has grown significantly in recent years, especially herbal medicine or plant-based medicine. Herbal medicine products have been produced on an industrial scale in some developing countries (Mir et al. 2019). Plant products have been long used for therapeutics, aromatherapy, medicine, food, and beverages, depending on their phytochemical properties and bioactivity (Mir et al. 2019). Herbal medicines, both individually and collectively, may cure some diseases. Consuming natural products either as food or medicine with minimal processing has become the habit of society in the world right now (Roman et al. 2017). The therapeutic value of marigold to treat some human ailments has been known for some time (Singh et al. 2020).

Studies on Marigold have been conducted by many researchers worldwide due to the carotenoid contents (alpha and beta carotene) and xanthophylls (lutein and zeaxanthin) (Buscemi et al. 2018; Manivannan et al. 2021). Other studies revealed that some parts of marigold could also be used as raw materials to make green organic fertilizer (Stroze et al. 2019). Secondary metabolites obtained from *Tagetes* are steroids, alkaloids, triterpenoids, carbon skeletons, derivates of thiophene, derivates of benzofuran, etc. (Verma & Verma 2012; Shetty et al. 2015; Munif et al. 2021). The primary objective of writing a review article on marigold plants is to comprehensively examine and consolidate existing literature,

thereby providing a comprehensive overview of the current knowledge regarding marigold's botanical characteristics, cultivation techniques, medicinal properties, and ecological significance. This review aims to contribute to the academic discourse on marigolds. It offers a valuable resource for researchers, horticulturists, and enthusiasts seeking to expand their understanding of this versatile and culturally significant plant species.

BOTANICAL CHARACTERISTICS

Marigold (Figure 1) belongs to *the Asteraceae* family and consists of 53 different species (Table 1). It originated from Mexico and Central America and can survive and grow even in drought conditions (Gupta & Vasudeva 2012; Khulbe 2015; Adam 2017). This plant is one of the ornamental herbs commonly used as a hedge plant and commercially as cut flowers because of the unique shape and flashy color of the flowers. *Asteraceae*, also called the Daisy family or Compositae is an important flowering plant family with more than 16200 genera and 23600 species. The species includes valuable medicinal plants that are not only used for medicinal purposes but also for ornamental, cosmetics, meditation, and food (Jan et al. 2009; Kashif et al. 2015; Politi et al. 2017), this genus is the second largest member in the Plantae Kingdom.

Tagetes is a genus consisting of annual or perennial species; most are herbaceous plants belonging to the sunflower family Asteraceae. The word *Tagetes* originated from the name of *Etruscan tagetes* (Shetty et al. 2015). This genus is very popular among gardeners due to the ease of which it is cultivated, wide adaptability, it produces the flower all year

Table 1. Accepted species of *Tagetes* (The Plant List 2013).

	Accepted species of *Tagetes*		
1	*Tagetes apetala* Posada-Ar.	28	*Tagetes micrantha* Cav.
2	*Tagetes arenicola* Panero & Villaseñor	29	*Tagetes microglossa* Benth.
3	*Tagetes argentina* Cabrera	30	*Tagetes minima* L.
4	*Tagetes biflora* Cabrera	31	*Tagetes minuta* L.
5	*Tagetes campanulata* Griseb.	32	*Tagetes moorei* H. Rob.
6	*Tagetes caracasana* Humb. ex Willd.	33	*Tagetes mulleri* S.F.Blake
7	*Tagetes congesta* Hook. & Arn.	34	*Tagetes multiflora* Kunth
8	*Tagetes coronopifolia* Willd.	35	*Tagetes nelsonii* Greenm.
9	*Tagetes daucoides* Schrad.	36	*Tagetes oaxacana* B.L.Turner
10	*Tagetes elliptica* Sm.	37	*Tagetes osteni* Hicken
11	*Tagetes elongata* Willd.	38	*Tagetes palmeri* A.Gray
12	*Tagetes epapposa* B.L.Turner	39	*Tagetes parryi* A.Gray
13	*Tagetes erecta* L.	40	*Tagetes perezi* Cabrera
14	*Tagetes filifolia* Lag.	41	*Tagetes praetermissa (Strother)* H.Rob.
15	*Tagetes foeniculacea* Desf.	42	*Tagetes pringlei* S. Watson
16	*Tagetes foetidissima* Hort. ex DC.	43	*Tagetes pusilla* Kunth
17	*Tagetes hartwegii* Greenm.	44	*Tagetes riojana* M.Ferraro
18	*Tagetes iltisiana* H. Rob.	45	*Tagetes rupestris* Cabrera
19	*Tagetes inclusa* Muschl.	46	*Tagetes stenophylla* B.L. Rob.
20	*Tagetes lacera* Brandegee	47	*Tagetes subulata* Cerv.
21	*Tagetes laxa* Cabrera	48	*Tagetes subvillosa* Lag.
22	*Tagetes lemmonii* A. Gray	49	*Tagetes tenuifolia* Cav.
23	*Tagetes linifolia* Seaton	50	*Tagetes terniflora* Kunth
24	*Tagetes lucida* Cav.	51	*Tagetes triradiata* Greenm.
25	*Tagetes lunulata* Ortega	52	*Tagetes verticillata* Lag. & Rodr.
26	*Tagetes mandonii* Sch.Bip. ex Klatt	53	*Tagetes zypaquirensis* Bonpl.
27	*Tagetes mendocina* Phil.		

round, free flowering habit, short duration, has attractive flower colors and shapes (Jain & Sing 2021: Awasthi et al. 2022).

Kingdom : Plantae
Division : Magnoliophyta
Class : Magnoliopsida
Subclass : Asteridae
Order : Asterales
Family : Asteraceae
Genus : *Tagetes*
Species : *Tagetes* sp.

This plant grows upright and reaches up to 1.3 m in height; the leaves are dark green pinnate-shaped and have a taproot. The diameter of the flower is between 7 cm to 10 cm, tubular, single, or collected in panicles; the flowers are white, yellow, orange, golden yellow, golden orange, cadmium orange, deep orange and bright orange (Shetty et al. 2009, Kumar et al. 2019; Kurniati 2021). It has a unique color of flower, but the yellow and orange color are more popular, and it could be cultivated any time of the year and in every season (Sheoran et al. 2022). The literature mentions that the leaves of marigolds are arranged in the opposite position, pinnate and complex kinds, oblong, and the edge is dentate. The leaf length reaches less than 2 inches, and the leaves are green. The leaves are curved, with sharp teeth on the edge (Shetty et al. 2009).

Marigolds need a mild climate (14.5 ° C – 28.6 ° C) for better growth to improve the flowering, while higher temperatures will affect the flower production. This plant can be located in a place that is exposed to full sun and some leaves must be pruned to induce the flower. Fertilizer can be applied, either organic or inorganic and needs to be watered twice a day (Chaurasiya 2020). Marigolds will have a better vegetative growth in a sunny location with high temperatures, while a mild climate can profuse the flower (Sheoran et al. 2022).

Figure 1. *Tagetes* sp. that is mostly grown in Indonesia.

Locating a sunny spot with at least six hours of sunlight per day, and well-drained soil are the first steps in growing marigolds. When there is no longer a chance of frost, move the seedlings into the garden. Plant the seeds indoors approximately four to six weeks before the date when they are frost-free. To improve the soil's fertility and consistency,

ensure it dries well and add compost as needed. Plant seeds directly in the garden, spaced one inch apart, or in seed trays if you plan to transfer them. Water the plants regularly, allowing the soil to dry out in between treatments. The process of deadhead to promote more flowers and pinching out tall variety branches to encourage bushier growth offer additional advantages of marigolds (Daycho Khaenamkaew 2021).

Marigolds' various uses contribute to their significant economic value. Their beautiful yellow and gold blossoms are utilized frequently in the food industry due to the essential oils and phytochemicals they contain which have a variety of uses (Mlcek & Rop 2011; Rop et al. 2012; Lee et al. 2013; Padalia & Chanda 2015; Wang et al. 2018; Moczkowska-Wyrwisz et al. 2022). In addition, marigolds are edible flowers whose petals are added to salads and other meals to add colour, increasing their market worth in the food business.

Marigolds are mostly used medicinally to treat skin ailments such as inflammation, bruising, varicose veins, minor cuts, and contusions. Marigold ointment helps sunburns and wounds recover (Salehi et al. 2018; Riaz et al. 2013). Marigold are a natural and efficient pest control alternative that are placed between vegetables in the agricultural sector because they provide an odour that deters insects (Hamaguchi et al. 2019; Fabrick et al. 2020). Because of these characteristics, they are beneficial for sustainable and organic farming practices, which lessen the need for chemical pesticides. As a result, marigolds are a valuable and adaptable plant in many different industries, with applications that include food and agriculture to medicine.

PHYTOCHEMICAL COMPOUNDS

There are two important basic species of *Tagetes*, they are: *T. erecta* L. (American marigold) and *T. patula* L. (French marigold). The flower of *T. erecta* is larger than *T. patula*, and the color is yellow, orange, golden, or bicolored (Shetty et al. 2015). Many studies have been conducted on those plants, especially observing and isolating the components for phytochemical compounds (Table 2) (Tripathi et al. 2012; Shetty et al. 2015).

Some important chemical agents are found in the marigold extract, such as phenylpropanoids, carotenoids, flavonoids, thiophenes, quercetagetin, 6-hydroxykaempferol, quercetin, patuletin, quercetagetin-7-O-glucoside and others (Bhave et al. 2020; Ratananikom et al 2021; Devrnja et al. 2022). The compound produced by plants could vary depending on some factors: part of plant extracted, harvesting seasons, plant development stage, and geographical conditions (Salehi et al. 2018). Other research reported that some chemicals isolated from *Tagetes* species mainly belong to the classes of thiophenes, flavonoids, carotenoids, and phenolic compounds (Gupta & Vasudeva 2012). So far, only 15 species from the *Tagetes* group have been extracted to isolate its chemical compounds, especially the essential oils in the aerial parts, capitula, and leaves (Salehi et al. 2018).

Essential oil is one of the most important phytochemical agents in Marigolds. Gupta and Vasudeva (2012) found that the essential oils in the leaves of *T. erecta* are d-limonene, α-pinene, β-pinene, dipentene, ocimene, β-phellandrene, linalool, geraniol, menthol, tagetone, nonanal and linalyl acetate. While the essential oil in the flower is d-limonene, ocimene, 1-1linalyl acetate, 1-linalool, tagetone and n-nnonyl aldehyde, aromadendrene, phenylethyl alcohol, salicylaldehyde, phenylacetaldehyde, 2-hexen-1-al, eudesmol, tagetone, ocimene, linalyl acetate, etc. Other researchers also concluded the essential oil content from different parts of the plant (Table 3).

Table 2. The phytochemical compound isolated from *Tagetes erecta* Linn.

No	Phytochemicals compound	Part of plant
1	Quinic acid (Tripathi et al. 2012; Llorent-Martínez et al. 2015)	Leaves
2	Dihexoside (Tripathi et al. 2012; Burlec et al. 2021)	Flower
3	Shikimic acid hexoside (Tripathi et al. 2012; Burlec et al. 2021)	Flower
4	Theogallin (Dou et al. 2007; Tripathi et al. 2012)	Flower
5	Phenylalanine (Tripathi et al. 2012)	Flower
6	Methyl-gallic acid (Tripathi et al. 2012; Burlec et al. 2021)	Flower
7	Tryptophan (Tripathi et al. 2012; Garcia et al. 2016).	Flower
8	Syringic acid-hexoside II (Parejo et al. 2004; Tripathi et al. 2012)	Flower
9	Syringic acid (Parejo et al. 2004; Tripathi et al. 2012; Burlec et al. 2021)	Leaves
10	Trigalloyl-hexoside (Meyers et al. 2006; Tripathi et al. 2012;	Flower
11	Ellagic acid-hexoside II (Tripathi et al. 2012; Fracassetti et al. 2013)	Flower
12	Quercetagitrin (Parejo et al. 2004; Tripathi et al. 2012)	Flower
14	Di-syringic acid hexoside I (Parejo et al. 2004; Tripathi et al. 2012)	Leaves
15	Di-syringic acid hexoside II (Parejo et al. 2004; Tripathi et al. 2012)	Leaves
16	Patulitrin (Parejo et al. 2004; Tripathi et al. 2012)	Leaves
17	8-Hydroxyquercetagetin (Parejo et al. 2004; Tripathi et al. 2012)	Leaves

The essential oil, also known as aromatic oil or volatile oil, is produced by the plant from metabolic processes, which are formed due to the reaction between various chemical compounds and air. This oil is synthesized in the gland cell of the tissue, and some are formed in resin vessels. It can also be produced from the degradation of triglycerides by enzymes, triglycerides indirectly contribute to volatile oil production in plants by releasing fatty acids upon enzymatic hydrolysis, and these fatty acids can serve as precursors for the synthesis of some volatile compounds. This oil has been used for many purposes for a long time and serves as a source of natural antimicrobials today (Herman et al. 2019).

T. patula L. that has been investigated by some researchers has shown some presence of secondary metabolites such as alkaloids, tannins, phenolic compounds and steroids, fatty acids and resins (Munhoz 2014; Kafaltiya et al. 2019). The concentration of essential oils in marigold depends on the species and environmental conditions. Some researchers found different essential oil concentrations in different countries where marigold is cultivated, such as five species collected in Venezuela which are *T. caracasana*, *T. filifolia*, *T. subulata*, *T. patula*, and *T. erecta* and show different concentrations with *T. erecta* L. In Indonesia and *T. erecta* L in India (Armas et al. 2012).

Another research study mentioned that marigold is also a natural source of xanthophyll which can be used as a natural food additive to lighten egg yolks and poultry skin. Marigold also can be used as a fabric dye because it contains ethanol (Saputri et al. 2021). Carotenoids are the most important chemical agent found in the marigold. Carotenoids and polyphenols are mostly found in the flower petals of marigold, where the major components are esters that account for more than 75% of the total carotenoids (Manzoor et al. 2017).

THE USE of *Tagetes* as HERBAL MEDICINE

Tagetes sp is well-known as traditional medicine, and some people use it to cure some diseases, including respiratory infections, as an anti-inflammatory, cough, wound healing, stomachache, anemia, and irregular menstruation (Aziz et al. 2020). These genera have cultural significance in traditional medicine systems and are integrated into various remedies, showcasing their broad relevance in herbal medicine practices across different regions worldwide, some species that commonly uses for herbal

Table 3. Essential oil components from *Tagetes erecta* Linn in various part of plant.

No	Essential oil components	Part of plant
1	d-limonene (Maciel et al. 2002; Marotti et al. 2004; Tripathi et al. 2012; Gupta & Vasudeva 2012)	Aerial, Capitula/flower, leaves
2	(E)-β-farnesene (Tripathi et al. 2012; Gupta & Vasudeva 2012)	Leaves, flower
3	(E)-β-ocimene (Tripathi et al. 2012; Gupta & Vasudeva 2012; Sharifi-Rad et al. 2018a)	Aerial, Capitula/flower and leaves
4	(Z)-myroxide (Salehi et al. 2018)	Capitula/flower
5	(Z)-β-ocimene (Tripathi et al. 2012; Gupta & Vasudeva 2012; Sing et al. 2015)	Aerial, Capitula/flower, leaves
6	1,8-cineole (Gupta & Vasudeva 2012; Sing et al. 2015; Salehi et al. 2018)	Aerial
7	2-hexen-1-al (Gupta & Vasudeva 2012; Sing et al. 2015; Salehi et al. 2018)	Capitula/flower
8	Aromadendrene (Gupta & Vasudeva 2012; Sing et al. 2015; Salehi et al. 2018)	Capitula/flower
9	Camphene (Gupta & Vasudeva 2012; Sing et al. 2015; Salehi et al. 2018)	Leaves
10	Carvacrol (Gupta & Vasudeva 2012; Sing et al. 2015; Salehi et al. 2018)	Aerial, Leaves
11	Cyperene (Gupta & Vasudeva 2012; Sing et al. 2015; Salehi et al. 2018)	Leaves
12	d-carvone (Gupta & Vasudeva 2012; Sing et al. 2015; Salehi et al. 2018)	Capitula/flower
13	dihydrotagetone (Sharifi-Rad et al. 2017)	Aerial
14	Dipentene (Gupta & Vasudeva 2012; Sing et al. 2015; Salehi et al. 2018)	Aerial, Leaves
15	Eudesmol (Gillij et al. 2008)	Capitula/flower
16	eugenol (Marotti et al. 2004; Sharifi-Rad et al. 2018b)	Capitula/flower

medicine are *T. erecta*, *T patula*, and *T. Minuta*, (Riaz et al. 2013; Salehi et al. 2018).

Various parts of the plant's components are used as herbal medicine (Table 4). The leaves are usually used to cure stomachache, especially in newborns, babies and toddlers in Indonesia. The leaves can also cure kidney problems, wounds, muscular soreness, ulcers, and boils (Shetty et al. 2009). The flower of *Tagetes* is usually used to reduce fever, epileptic fits, stomachache, liver and eye diseases, and scabies. The flower could be used to purify the blood, and the flower juice is used to treat bleeding, rheumatism, fever and bronchitis (Rhama & Mardhavan 2011). Furthermore, the flower juice has some functions in different countries. Indians use it as a blood purifier and to treat piles. Brazilians use leaf infusions as a vermifuge, while Mexicans use them to cure diuretics and carminatives (Chaudhary et al. 2022).

As mentioned previously, Marigolds contain yellow carotenoid pigments, such as carotene (alpha and beta carotene) and xanthophyll (luten and zeaxanthin). The yellow flower is caused by the carotenoid and flavonoid content. Some publications mentioned that flavonoids are the secondary metabolites of polyphenols, found widely in plants with various bioactive effects, including anti-viral, anti-inflammatory, anti-aging, antioxidant, cardioprotective, antidiabetic, and anti-cancer properties (Qinghu et al. 2016). The utilization of the marigold plant as herbal medicine is concluded in Table 4. In a tropical country like Indonesia, many species of marigold are found in nature without any special treatment as it is easy to grow.

Marigold attracted the attention of researchers due to the presence of some bioactive compounds and its therapeutic potential especially in

Table 4. The use of *Tagetes* as herbal medicine in various part of the plant.

No	Species	Uses	Part of plant	Preparation	References
1	*T. erecta L*, *T. filifolia L.*, *T. lucida L.*	Stomachache, dysentry, diarrhea	Leaves and flowers	crushed the leaves or flowers and applied on the stomach	Gupta & Vasudeva 2012; Ali et al. 2013; Joshi & Barbalho 2022
2	*T. erecta L*	cough, sore throat	Flowers	boils the flower and drink the water	Blanco & Thiagarajan 2017
3	*T. erecta L.*, *T. lucida L.*	Dental problem	Flowers	boils the flower and gargle the water	Joshi & Barbalho 2022
4	*T. erecta L.*, *T. minuta*	Wound healing	Leaves	boils the leaves to wash affected area	Jayavant 2018; Sharma & Kumari 2021; Chaudary et al. 2022
5	*T. erecta L.*,	Skin problems	Leaves	boils the leaves to relieve the rash and ichiness on the skin	Gupta & Vasudeva 2012; Kafaltiya et al. 2019
6	*T. erecta L.*,	Fever	Flowers	boils the flower and drink the water	Gupta & Vasudeva 2012; Kafaltiya et al. 2019
7	*T. erecta L.*	Diuretic problems	Leaves and flowers	boil the flowers or leaves and drink the water	Ali et al. 2013; Singh et al. 2015

reducing macular degeneration (Manzoor et al. 2022). The presence of some phytochemical agents and nutraceuticals in marigold can be used to cure eye-related diseases such as cataracts and age-related macular degeneration (AMD), and cardiovascular diseases. Lutein is one type of carotenoid and is very important for the health of the human eye (Nam et al. 2021). This chemical is the major pigment in the macular region of the retina, and it has been found to prevent damage to the retina cells due to an antioxidant effect which can remove free radicals, lutein also was able to block blue light and positively affects the immune response and inflammation (Kijlstra et al. 2012)

NATURAL PESTICIDE

The use of marigold in controlling pests has been researched by some researchers (Table 5). This plant produces a lot of bioactive compounds that can be used as natural pesticides, such as α-therthienyl which is known as one the most toxic chemical agents against pests. The chemical α-therthienyl is found in abundance in *Tagetes* especially in the roots and it is toxic for some number of insects (Hamaguchi et al. 2019; Fabrick et al. 2020). Other researchers also mentioned that this chemical is also used as a fish poison (Cunha et al. 2016). The chemicalα-therthienyl generates oxygen radical species and has the capacity to inhibit some activities of the important enzymes in insects (Nivsarkar et al. 2001).

In some tropical countries where a number of infectious diseases are carried through a vector, are to be increasing due to climate change. The flowers of Marigold have many functions due to their attractive colors. It has a strong smell, which is important as an insect repellent (Ponkiya et al. 2018). This flower contains a lot of chemical agents, such as eugenol compounds, flavonoids, alkaloids, saponins, tannins, and triterpenoids which provide a repellent effect against *Aedes aegypti* (Shinta 2020). The essential oils containing eugenol can repel mosquitos by interfering with their sense of the smell (Mossa 2016).

The chemical α-terthienyl is an allelochemical agent which is used to suppress plant parasitic nematodes such as the model organism *Caenorhabditis elegans* and the root-knot nematode, *Meloidogyne incognita* (Ponkiya et al. 2018; Hamaguchi et al. 2019). The essential oils that are available in *Tagetes minuta* L. shows some antimicrobial activities against

Table 5. The benefits of Marigolds as natural pesticides.

No	Species	Benefits	References
1	*T. erecta* L.	Mosquitoes' repellent	Ponkiya et al. 2018
2	*T. minuta* L	Against *Rhipicephalus microplus*, *Rhipicephalus sanguineus*, *Amblyomma cajennense* and *Argas miniatus*	Notes et al. 2013; Wanzala & Ogama 2013; Amaral et al. 2015; Cunha et al. 2016; Zulfikar et al. 2019
		Againts *Anopheles gambiae*	Kyarimpa et al. 2014
3	*T. patula* L	Against *Lygus hesperus* and *Bemisia tabaci*	Fabrick et al. 2020
4	*T. filifolia L.*	Againts *Tribolium castaneum*	Olmedo et al. 2015
5	*T. lucida* L.	Bio-nemacides	Omer et al. 2014

bacteria such as *Staphylococcus aureus* and *Enterococcus faecium*, those chemicals presented acaricidal activities against ticks *Rhipicephalus microplus*, *Rhipicephalus sanguineus*, *Amblyomma cajennense* and *Argas miniatus*, larvicidal activity against *Aedes aegypti* (Notes et al. 2013; Wanzala & Ogama 2013; Amaral et al. 2015; Cunha et al. 2016; Zulfikar et al. 2019). The extract of *Tagetes erecta* L. also has antimicrobial activities against *Enterococcus faecalis*, *Escherichia coli and Lactobacillus acidophilus bacteria and Candida albicans* (Tuna et al. 2021). The effects of the marigold against mosquitos have also been investigated, and the ethanolic extracts of *Tagetes erecta's* flower together with its solvent fraction have been shown to repel different instars of *Culex quinquefasciatus* (Nikkon et al. 2011). The use of 8 ml marigold leaf extract could kill the larvae of *Aedes aegypti* by 50% (Zulfikar et al. 2019).

Tagetes patula L. (French marigold) is an aromatic plant species that consists of many secondary metabolites and has the potential for pesticidal activities (Devrnja et al. 2022). The use of extracted leaf from *Tagetes patula* L. using water as a solvent has also been effectively used as bio-controlling agent against various diseases in tomato plants. Besides reducing the percentages of disease levels, the leaf extract has also been shown to increase the growth and yield of tomato plants (Nahak & Sahu 2017), due to the fact that it contains saponin and polyphenols (Andresen & Cedergreen 2010).

Tagetes erecta L. has been shown to have properties against arthropods and certain species of predatory insects (Silveira et al. 2009). Some research conducted by planting marigold plants in between rows of onion crops showed that marigold reduced the numbers of aphid, nematode, and whitefly populations and viruses in diseased plants (Silveira et al. 2009). However, the use of marigold flower as refugia in rice cultivation was also found to significantly affect the populations of pests (Wardani & Leksono 2013; Wardana et al. 2017; Erdiansyah et al. 2019).

Some species from the *Tagetes* genera are well-known as a natural pesticide because they contain some chemical agents with pesticidal properties. Many studies that have been conducted have shown insecticidal activity of *Tagetes erecta* L. or African marigold (Nikkon et al. 2009; Salinas-sanchez 2012; E Santos et al. 2022) against mosquitos (Nikkon et al. 2011), T*agetes minuta* L. (Mexican marigold) or *Tagetes patula* L. against mosquitos (Notes et al. 2013; Marini et al. 2017), sand flies (Kimutai et al. 2017), termites, activity as ascarides (Andreotti et al. 2013; Politi et al. 2013). Some chemical agents that are contained in *Tagetes* which are important for insecticides are; monoterpenoids, carotenoids, and flavonoids which are the major biocidal constituents, but unfortunately many of those chemicals have limited practical uses due to volatile and poor persistence under field conditions (Marahatta et al. 2012; Palacios-Landín et al. 2015; Fabrick et al. 2020)

FOOD AND BEVERAGE

Edible plants are innocuous and non-toxic plants that could be consumed with health benefits for humans (Chitrakar et al. 2019; Santos & Reis 2021). People usually eat flowers either as a fresh salad or used as food ingredients since ancient times. These flowers have also been used as a material for making jam, cakes, etc. (Mlcek & Rop 2011; Rop et al. 2012). For many years, humans have been using plants as sources of food and nutrients, and many of them are beneficial for human health (Lee et al. 2013; Padalia & Chanda 2015; Wang et al. 2018; Moczkowska-Wyrwisz et al. 2022). The use of marigold as a natural coloring for food and beverages has already been known worldwide, and there has been some researcher conducted in this area already (Navarro-González et al. 2015; Alim-un-Nisa et al. 2018; Yanti et al. 2019; Casella et al. 2021).

These plants are a rich source of lutein which is very important for the human eyes and immunity, thus its already commercially used and produced as a nutritional supplement in capsule or tablet form (Cannavale et al. 2019; Wu et al. 2023). Since the human body cannot synthesize those chemicals, it must be obtained from the diet, however, it is known lutein is also contained naturally in fruits, cereals and some vegetables (Gupta et al. 2022; Chauhan et al. 2022). High levels of lutein (oxygenated carotenoid xanthophyll) are contained in the petals of marigold and can be used for food coloring agents as well as for antioxidants (Ingkasupart et al. 2015; Cezare-Gomes et al. 2019; Casella et al. 2021; Gupta et al. 2022).

Noodles prepared using marigold powder contained a high content of lutein (Nam et al. 2021). In some countries, the fresh flowers of marigold added to the food such as salads or as an edible garnish, the taste is found to be bitter and balances out an overly sweet dish (Singh et al. 2015). The orange-yellow carotenoid lutein compound found in marigold's flowers had been identified, isolated, and approved by the European Union (EU) as a food coloring and nutrient supplement (food additive). It is widely used for baked foods and baking mixes, beverages and beverage bases, cereals for breakfast, and as an additional compound in chewing gum, egg products, fats and oil, desserts, gravies and sauces, candy, toddler foods, milk products, fruit juices, soup mixes, biscuits, etc. (Navarro-González et al. 2015; Tiwari et al. 2016; Rajvanshi & Dwivedi 2017; Alim-un-Nisa et al. 2018; Sathyanarayana et al. 2018; Toliba et al. 2018).

One study found that the partial replacement of flour with marigold extract to make a sponge cake was a suitable alternative. Marigold could be seen as more desirable to customers when compared to other alternatives in terms of its taste, smell, porosity and color (Moczkowska-Wyrwisz et al. 2022). In Chile and Argentina, marigold is a well-known ingredient in traditional foods such as in stews, due to its flavor, and in some other countries its flowers are used as a soup condiment (Cornelius & Wycliffe 2016; Paniagua-Zambrana et al. 2020). While in other parts of the world, *Tagetes* are commonly used for making hot tea and also cold beverages, as well as herbal teas (Kusuma et al. 2020).

Tagetes erecta L. is one of the most popular edible flowers in the world and is commonly used as an ingredient in salads and as a natural coloring agent for food (Table 6) (Navarro-González et al. 2015). Its flowers are rich in lutein and are grown many parts of the world such as in Mexico, Peru, Ecuador, Spain, India and China. The essential oil of *Tagetes minuta* L. is also used for food production and beverage preparation such as alcoholic drinks and cola, as well as for dairy desserts, some sweet things, jellies and spices (Vazquez et al. 2011). *Tagetes minuta* L. is

Table 6. The benefits of Marigolds for consumption.

No	Species	Part of plant	Consumed as	References
1	*T. erecta* L.	Flowers	Fresh salad	Mlcek & Rop 2011; Rop et al. 2012
			Food ingredients	Mlcek & Rop 2011; Rop et al. 2012
			Food coloring	Navarro-González et al. 2015; Alim-un-Nisa et al. 2018; Yanti et al. 2019; Casella et al. 2021
			Beverage (tea)	Kusuma et al. 2020
2	*T. minuta* L	Leaves and flower	Food production	Vazquez et al. 2011
			Beverage	Vazquez et al. 2011
3	*T. patula L.*	Flowers	Food additives	Szarka et al. 2007
			Marigold powder for bread, noodle and sponge cake	Nam et al. 2021

one of the more important species forms *Tagetes* genera that has been used for a long time as food, perfumes, medicines, ornamentals and for religious ceremonies (Gakuubi et al. 2016; Cornelius & Wycliffe 2016; Kumar et al. 2020).

CONCLUSION

Marigold is an important plant in the world and has been used as an ornamental, medicinal, and also as an edible plant. This genus is belonging to the *Asteraceae* family, and is easy to grow but is still not cultivated massively in some countries. Some important chemical agents are found in the marigold extract, such as phenylpropanoids, carotenoids, flavonoids, thiophenes, quercetagetin, 6-hydroxykaempferol, quercetin, patuletin, quercetagetin-7-O-glucoside and others. The essential oils of marigold leaves are d-limonene, α-pinene, β-pinene, dipentene, ocimene, β-phellandrene, linalool, geraniol, menthol, tagetone, nonanal and linalyl acetate. While the essential oils in the flower are d-limonene, ocimene, 1-1linalyl acetate, 1-linalool, tagetone and n-nnonyl aldehyde, aromadendrene, phenylethyl alcohol, salicylaldehyde, phenylacetaldehyde, 2-hexen-1-al, eudesmol, tagetone, ocimene, linalyl acetate, etc. The chemical agents in all parts of the plant can be used as medicine, such as to cure Stomachache, dysentery, diarrhea, wound healing, and fever. Some species from *Tagetes* genera are widely used as natural pesticides because they contain some chemical agents with pesticidal properties. As edible plants, they are used in many forms of food preparation and beverages can also be made from the marigold. Considering all the benefits of this plant, the cultivation of Marigold should be more widely practiced.

AUTHOR CONTRIBUTION

M.Z. designed the research and wrote the manuscript. V.N.A & S.F.H search for the informations and the literatures.

ACKNOWLEDGEMENTS

The authors would like to thank Muhammadiyah Aceh University for providing the literature review, materials, and financial support.

CONFLICT of INTEREST

The authors stated that there is no conflict of interest regarding to this manuscript.

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