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Review

Essential Oils and Bioactive Compounds as Natural Preservatives: Focus on Ocimum Basilicum and Momordica Charantia

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	Abstract
Published on: 02.03.2026	Preservatives play a vital role in maintaining the quality, safety, and shelf life of food, cosmetic, and pharmaceutical products by preventing microbial growth and oxidative deterioration. However, the widespread use of synthetic preservatives has raised health and safety concerns among consumers, leading to increased interest in natural alternatives. This review focuses on plant-derived natural preservatives, particularly essential oils and bioactive compounds obtained from <i>Ocimum basilicum</i> (basil) and <i>Momordica charantia</i> (bitter gourd). Essential oils extracted from basil are rich in biologically active constituents such as linalool, eugenol, and estragole, which exhibit strong antimicrobial, antifungal, and antioxidant activities. These properties make basil oil an effective natural preservative for food packaging and processing applications. Similarly, <i>Momordica charantia</i> contains diverse phytochemicals including triterpenes, phenolic compounds, flavonoids, and insulin-like peptides, contributing to its antioxidant, antidiabetic, anticancer, anti-inflammatory, and nutraceutical properties. The review highlights extraction methods, chemical composition, mechanisms of antioxidant action, and the potential applications of these plant-based preservatives. Overall, natural preservatives derived from plants offer a safer, sustainable, and health promoting alternative to synthetic preservatives, supporting their increasing use in food and pharmaceutical industries.
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INTRODUCTION

“Shelf life” simply means the time span between when a product is made and when it reaches its expiration date. It is anticipated that the product will maintain its original features and continue to be

suitable for consumers. Summers in terms of its quality. The product is vulnerable during this time. To physical, biological, and chemical deterioration, which eventually lower the quality of Qualities of the product [1]. As a result, preservatives are widely

used in food, cosmetic, and pharmaceutical products to keep them from spoiling [2, 3]. The product's mean life is determined by a number of factors. Including the proliferation of microorganisms, heating, improper temperature, extended storage, Alteration in moisture content, fermentation, acidification, reaction with light and oxygen, Enzymatic alterations, etc. Which leads the final product to lose its essential characteristics. A wide range of structural components make up pharmaceutical preparation. Chemical reactions can cause the product to break down or deteriorate over time. Occur between the different components of the formulation and the surrounding environment. Longer storage times typically cause a product to deteriorate, impacting its stability, which eventually causes the product's intended natural quality to decline because microbiological contamination and making the product dangerous for the customer. Generally speaking, The product deteriorates through three processes [4]. Chemical disintegration comprises Chemical incompatibilities, including oxidation, photolysis, polymerization, hydrolysis, and high-decarboxylation, dehydration, and duration. [5, 6]. A shift in particle size, temperature, Examples include evaporation, vaporization, efflorescence, hygroscopic, deliquescence, etc. Of

of adding preservatives is to. Extend the shelf life, offer stability and defence against microbial attack, and improve. The product's effectiveness. Prior to being added to various products, preservatives Have been studied for decontamination effectiveness by researchers all over the world. Preservatives sorted according to their sources and modes of action [8].

WHY NATURAL PRESERVATIVES ARE ESSENTIAL

Because they come from natural sources, biopreservatives have recently gained a lot of attention. They're considered safer and more beneficial than synthetic preservatives.

Preservatives in natural foods usually come from microorganisms, animals, and plants. Natural plant-based ingredients—such as herbs, spices, and essential oils—not only act as preservatives but are also commonly used to enhance the aroma of beverages and mask any unpleasant odors from other ingredients (Figure 1) [9]. These natural products have been shown to extend shelf life by slowing down lipid oxidation. Common traditional methods of food preservation include natural or artificial drying, pickling with salt or vinegar, freezing, high-pressure processing, and using edible

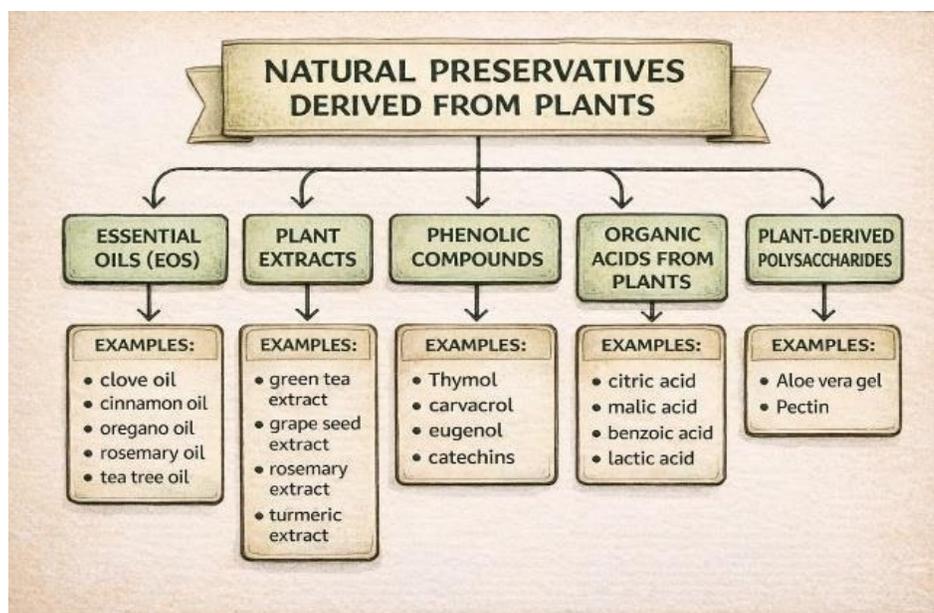


Figure 1 : Natural product derived from plant

deterioration. Microbes that attack the product are present everywhere we look. after it has been opened. The product rapidly begins to lose its microbiological quality [7]. Consequently, the goal

coatings [10].

There are many types of plant phenols, including simple phenols, phenolic acids, flavonoids, anthocyanins, stilbenes, tannins, and lignins.

Phenolic acids, which are aromatic secondary metabolites, are especially common and are found throughout the plant kingdom [11]. Their possible protective function is currently of great scientific interest. Against illnesses brought on by oxidative stress. The primary sources of phenolic acids that are edible are fruits, vegetables, grains, seeds, berries, drinks, olives, and fragrant plants, and they are present in nearly every section of the plant [12]. They can be found as esters, amides and glycosides, but infrequently in their free form [13]. Despite where they came from, these adaptable According to reports, molecules have a broader range of biological activities, including antiviral, antibacterial, antifungal, antioxidant, anticancer, anti-inflammatory, and anti-diabetic keratolytic, estrogenic, and insecticidal properties, among many others [14]. Phenolic Compounds have been widely utilized and are well known for their antioxidant potential. As bio-preservatives, they help extend shelf life while also providing additional proven health benefits. Non-flavonoid polyphenols with carboxy groups are called phenolic acids with a benzene ring connected to one or more hydroxyl groups [15].

PROBLEMS WITH PRESERVATIVES

These days, using artificial or synthetic preservatives has become widespread (as they are affordable and readily accessible), which consumers have not generally embraced because they are aware of the potentially fatal short-term and long-term effects of the preservatives on health, which is what researchers are most concerned about [16]. Consumer health is compromised by the product's hazardous chemicals [17]. The numerous issues are negative. A summary of the consequences of using synthetic preservatives frequently in different formulations. Customer safety and quality control are crucial. Preservatives are consequently, it is important to maintain the normal shelf life of medicines, foods, and cosmetics, but their frequent use has also been linked to certain harmful effects. Unwrapping new and secure products is urgently needed. Natural preservatives for a range of medications, cosmetics, and food items effects because it is clear that using natural preservatives would improve the quality, the product's durability and safety. Cosmetic Preservatives People use cosmetics nearly every day all over the world.

AS NATURAL PRESERVATIVES, ESSENTIAL OILS

A HISTORICAL OVERVIEW

Essential oils are aromatic, volatile extracts obtained from different parts of plants, including flowers, roots, bark, leaves, seeds, peels, fruits, wood, and even whole plants (Hyldgaard et al., 2012). Historically, these substances have attracted considerable attention, and although many traditional applications have faded over time, it is widely acknowledged that humans have been extracting them from aromatic plants since ancient times. Essential oils have a wide range of powerful and versatile applications encompassing culinary applications to improve flavour and nutritional value, as well as roles in the production of perfumes and cosmetics. In ancient Egypt, essential oils were employed in medicinal practices, perfumery, and the embalming and mummification of the deceased. In early Asia, the Vedas documented the liturgical and therapeutic uses of perfumes and aromatic substances. Throughout history, many civilizations— including the Phoenicians, Jews, Greeks, Romans, and cultures of the Mediterranean region, as well as the Mayas and Aztecs in the Americas—developed highly refined traditions involving fragrances for religious rituals, perfume manufacturing, and treatments for infectious diseases (Sonwa 2000)[18]. Following the decline of the Roman Empire, the knowledge and artistry of fragrance were adopted and refined within both Christian and Muslim societies, particularly in the Arab world. During the Middle Ages, Crusaders reintroduced this expertise to Europe, where it was further advanced by alchemists and monastic communities. Alchemists pursued the creation of an "elixir of life".

CONCEPT AND DEFINITION

Essential oils are sweet-smelling, highly volatile plant extracts obtained mainly by steam distillation or mechanical methods. They carry the natural fragrance and flavour of the plant from which they are derived, but in a much more concentrated form. Each essential oil is named after its source plant and reflects the aroma of the specific plant part used [19]. According to Schilcher, Hegnauer, and Cohn Riechter, essential oils are volatile, aromatic substances formed in plant cells and present as tiny droplets. The International Organization for Standardization (ISO) defines essential oils as products obtained from natural plant materials through steam distillation, dry distillation, or mechanical extraction, without significant chemical

alteration. Essential oils are complex mixtures of aromatic compounds, usually liquid, colourless to pale yellow, and fast-evaporating. They are insoluble in water but soluble in organic solvents and blend well with fats and waxes. Their density, refractive index, and optical rotation are important quality indicators. Various international organizations regulate their safe use and composition[20].

NAMED ESSENTIAL OILS

1. BASIL (OCIMUM BASILICUM L.) OIL INTRODUCTION

The genus *Ocimum* is classified within the Lamiaceae family and comprises approximately 150 species[21]. Several *Ocimum* species have been used since ancient times to treat a wide range of ailments, with *Ocimum basilicum* (Figure 2) being especially prominent notable[22]. Commonly known as sweet basil, this herbaceous perennial is cultivated worldwide. It is a flavourful culinary herb widely used in Italian cooking and in Southeast Asian cuisines such as those of Thailand and Vietnam. Its rich profile of potent metabolites contributes to a range of biological activities, making it valuable in traditional medicine while also enhancing its appeal as an ornamental plant [23]. *Ocimum basilicum* essential oil slips into food as a natural flavour spark, cherished not only as a kitchen herb but also as a vibrant culinary touch and a graceful ornamental plant in the home. Additionally, it is applied in commercial fragrances and flavours, and to extend the shelf life of food items[24]. *Ocimum basilicum* has been extensively documented in agricultural, food, and pharmacological research. Therefore, this review aims to provide further insight into various aspects of *O. basilicum* for researchers. Concurrently, the decline of *O. basilicum* in certain regions is escalating, underscoring the importance of raising awareness about its medicinal value to avert its extinction. These considerations have motivated the preparation of this review, which primarily focuses on the pharmaceutical potential of *Ocimum basilicum*[25]



Figure 2: *Ocimum basilicum*

EXTRACTION PROCESS

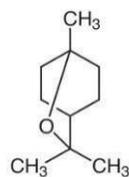
Essential oils are extracted from plants through techniques such as hydrodistillation and steam distillation. However, these traditional methods have certain drawbacks, including the risk of thermal degradation of sensitive components, high energy consumption, and long processing durations. To overcome these challenges, environmentally friendly alternatives—such as supercritical and pressurized fluid extraction, along with microwave- and ultrasound-assisted methods—are being increasingly explored. Commercially, basil oil is typically obtained by distilling the leaves, stems, or other parts of the basil plant. At the laboratory scale, the Clevenger hydro-distillation technique is commonly used. Hydro-distillation continues to serve as the officially recognized standard method for essential oil extraction in quality control[26].

COMPOSITION OF CHEMICAL CONSTITUENTS

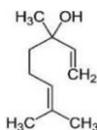
The essential oil of *Ocimum basilicum* L. contains over 20 key chemical constituents, with linalool, methyl eugenol, and estragole being the predominant components [27]. Variations in essential oil composition across different basil varieties contribute to their unique aromatic profiles observed worldwide (Figure 3) [28]. The essential oil of basil consists of eucalyptol (1.79%), linalool (12.63%), α -terpineol (0.95%), eugenol (19.22%), β elemene (2.68%), α bergamotene (3.96%), α guaiene (2.33%), germacrene D (8.55%), cubenol (1.78%), tau-cadinol (15.13%), camphor (0.70%), bornyl acetate (1.97%), β -caryophyllene (0.61%), α caryophyllene (1.67%), elixen (2.59%), β cadinene (0.80%), α -copaene (0.33%), methyl eugenol (0.76%), β farnesene (0.58%),

epibicyclosesquiphellandrene (0.76%), taumurolol (0.96%), α -bisabolol (0.35%), δ - gurssjunene

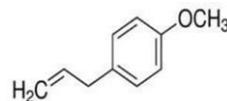
an essential step toward the successful integration of essential oils in food preservation[30].



Linalool



Estragole



Eucalyptol

Figure 3: chemical structure of the major components present in Basil (*Ocimum basilicum* L.), essential (5.49%), and δ -cadinene (5.04%) [29]. oils

USAGES OF BASIL OIL AS PRESERVATIVES IN FOOD PACKAGING AND PROCESSING

While numerous studies have highlighted the potential of essential oils and their components as preservatives in laboratory settings, several constraints limit their practical application in food preservation. One major limitation is the high cost and the elevated concentrations frequently needed to achieve adequate effectiveness. A second issue involves changes in organoleptic properties, such as browning and strong odours observed in treated lettuce. The antimicrobial activity of essential oil components can be affected by the food matrix, such as the presence of fats and starches, as well as external conditions like pH and temperature. Additionally, the effectiveness of the decontamination solution decreases quickly when it is used repeatedly on multiple samples.

Several strategies have been explored to overcome these limitations. One approach involves encapsulating basil oil within polymers used in edible and biodegradable packaging, enabling its gradual release onto the food surface. Another method is the encapsulation of essential oils into nano emulsions, This helps protect volatile compounds, preventing unwanted interactions with the food matrix, while also enhancing their antimicrobial effectiveness by improving passive cellular uptake. Additionally, combining essential oils with other antimicrobial agents can produce a synergistic effect, allowing for reduced concentrations without sacrificing antimicrobial performance. Such synergistic interactions are well documented among essential oil combinations. Consequently, this area presents opportunities to develop potent antimicrobial blends at lower concentrations, preserving efficacy while potentially avoiding undesirable sensory changes—

FOOD PRESERVATIVES AND FOOD SAFETY

Food spoilage results from physical, chemical, enzymatic, and microbial processes. While certain spoiled foods remain safe for consumption, others can be hazardous. The adverse health effects caused by ingesting spoiled or contaminated food are known as food-borne illnesses. This issue is becoming a major public health concern around the world. The CDC (2011) reports that about 9.4 million food-borne illness cases occur each year in the United States alone, caused by 31 different pathogens. The most common culprits behind these domestically acquired infections are Norovirus, nontyphoidal *Salmonella*, *Clostridium perfringens*, *Campylobacter* species, and *Staphylococcus aureus*. The primary pathogens leading to hospitalizations are nontyphoidal

Salmonella, Norovirus, *Campylobacter* species, *Toxoplasma gondii*, and *Escherichia coli* O157 (CDC, 2011). There is growing consumer demand for fresh and minimally processed foods that are free from synthetic preservatives. As a result, natural and effective food preservatives are essential for successfully controlling food-borne pathogens and inhibiting mycotoxin production in food. Basil oil and its natural compounds help prolong the shelf life of many foods, thanks to their strong antimicrobial and antioxidant effects.

The United States Food and Drug Administration and the European Commission have approved and categorized components of basil oil as generally recognized as safe (GRAS), indicating no health risk to consumers. However, regulatory restrictions remain on the acceptable daily intake of three primary components— linalool, estragole, and eugenol—due to significant variations in the chemical composition of basil essential oil and

extracts. Samples labelled as basil oil may originate from different subspecies of *Ocimum basilicum* or other species, despite sharing a common name. Additionally, test microorganisms, methodologies, and evaluation standards differ across studies. Consequently, a preliminary compatibility test between the essential oil and the food product should be conducted before incorporating it as a preservative [31].

ANTIMICROBIAL ACTIVITIES

Numerous studies examined the antioxidant, antifungal, and antibacterial properties of essential oils from *Ocimum* species, including delicious basil. Foodborne fungi may produce mycotoxins and cause food and grain spoilage. Of the assessments that have been run on a variety of natural chemicals, but one of the best is basil oil. Of the seven fungi that were separated from *Alternaria* sp., *Aspergillus flavus*, *Botrytis cinerea*, *Cladosporium herbarium*, *Eurotium amstelodami*, and *Eurotium Chevalier*, *A. flavus* was the most resistant to basil oil, while *E. chevalieri* was the most sensitive (Jakowienko et al., 2011). The fungi *Penicillium aurantiogriseum*, *Penicillium glabrum*, and *Penicillium chrys* - were effectively combated by sweet basil oil. *Penicillium brevicompactum* and *ogenum* (Kocić-Tanackov et al., 2012). *P. chrysogenum* had the highest sensitivity, with 1.5% basil extract completely inhibits growth. Mycelium growth was completely inhibited by basil oil at 0.6% v/v. 50% inhibition of *Fusarium* proliferate and 50% inhibition of the rice pathogenic fungi *Fusarium moniliform* and *Pyricularia arisea*. However, it was ineffective against *Rhizoctonia solani*. *F. moniliform* spore germination may be inhibited by 0.8% v/v basil oil (91%) and *Alternaria brassicicola* (100%) (Piyo et al., 2009) [32]. At 3000 ppm, basil oil completely inhibited the *Aspergillus ochraceus*, *Aspergillus parasiticus*, *A. flavus*, and *F. moniliform* are toxic fungi (Soliman and Badaea, 2002). *Aspergillus Niger*, *Aspergillus nidulans*, *Absida glauca*, *Colletotri Rhizopus nadssus*, *Pestlotiapsidi*, *F. moniliform*, and *chum capsici* (Soković et al., 2013) *Anethole* and *linalool* showed Microdilution tests showed good antifungal activity at 0.03– 0.3 mg/mL and 1.3–2.8 µL/mL, respectively (Soković et al., 2013). Sweet basil oil had minimal inhibitory concentrations of 145–160, 40–45, and 80–95 µg/mL against the Gram negatives, Gram positive bacteria *S. aureus* and *Bacillus subtilis*, fungi *A. niger* and *Candida*, and bacteria *Salmonella typhi* and *E. coli albicans*, in turn (Shirazi et al., 2014). Strong anti-*Streptococcus pneumoniae* activity was demonstrated by sweet basil oil. *Pseudomonas*

putida and *Pseudomonas aeruginosa*, but not *Hemophilus influenzae*, *Candida albicans*, or *A. niger* (Srivastava 2014 et al). The Gram positive bacterium *Brochotrix thermoplastic* was not affected by basil oil. *Lactobacillus delbrueckii*, *Lactobacillus lactis*, *Enterococcus faecalis*, and *Lactobacillus plantarum*. *Vibrio* species, including *The sensitivity of Vibrio parahaemolyticus* to basil oil was very high [33].

PHARMACOLOGICAL ACTION

This substance is primarily employed in the management of anxiety, colds, fevers, migraines, diabetes, menstrual cramps, sinusitis, cardiovascular conditions, neuralgia, insect bites, and headaches. Additionally, it exhibits anticonvulsant, antihyperlipidemic, anti-inflammatory, antioxidant, antiplatelet, antithrombotic, antimicrobial, insecticidal, immunomodulatory, and cytotoxic properties. It is also effective against neurodegenerative and digestive disorders, and serves as a cardiogenic and abdominal analgesic. Furthermore, it demonstrates activity against coccidial infections in broiler chicks. The substance possesses spasmolytic, carminative, hepatoprotective, diuretic, and stimulant characteristics, This has led to its use in creating a wide range of pharmaceutical products derived from *Ocimum* [34].

IMMUNOMODULATORY ACTIVITY

Wistar albino rats received different doses of basil extract, ranging from low to high concentrations. Antibody titers were determined using the SRBC titer method. The results indicated elevated levels of red blood cells, white blood cells, hemoglobin, and antibody titers. Basil also contributed to an increase in body weight relative to control animals in the evaluation of immunomodulatory effects [35]. Extracts from the *Ocimum basilicum* L. plant demonstrate immunomodulatory properties at the cellular level, This includes its ability to prevent platelet aggregation and inhibit HIV-1 reverse transcriptase activity [36,37].

ANTIFUNGAL ACTIVITY

A wide range of infections affecting the skin, hair, nails, and subcutaneous tissues in humans and animals are caused by various fungi (Amer et al., 2006). Dermatophytes are the organisms responsible for these infections, which are collectively known as dermatophytoses [37]. The use of synthetic antifungal drugs in both humans and animals is limited because they can cause considerable toxicity. In several countries, plant-

derived antifungal agents and natural products are permitted for therapeutic use in both humans and animals. Most plant-based antifungal treatments are considered safe for consumption by humans and animals [38]. Research findings indicated that the minimum inhibitory concentration (MIC) of solvent extracts from aerial parts and roots, basil oil, and isolated phytochemical compounds was substantially higher compared to standard antiseptics. This implies that greater concentrations are necessary to suppress the growth of various test organisms, as supported by experimental data [39]. Research shows that phytochemicals obtained from the leaves—and especially their ethanol extracts—have stronger antifungal activity compared to extracts from the roots. This suggests that the active antifungal compounds are likely polar in nature[40]. Additionally, essential oils have also demonstrated significant antifungal properties against various plant-pathogenic fungi [41].

ANTITOXIC ACTIVITY

Exposure to deltamethrin induced several histopathological alterations in the kidneys of albino rats, such as degeneration of epithelial lining cells, dilation and constriction of renal blood vessels, infiltration of inflammatory leukocytes into intertubular spaces, and elevated levels of urea and serum creatinine. Malondialdehyde (MDA) concentrations increased significantly, The activities of superoxide dismutase (SOD) and catalase (CAT) in the kidney tissue dropped significantly. However, when basil aqueous extract was given together with deltamethrin, the histopathological damage improved. Creatinine and urea levels returned to normal, MDA levels decreased, and the activities of CAT and SOD were restored [42].

2. BITTER GOURD (MOMORDICA CHARANTIA) OILS

INTRODUCTION

In recent years, herbal medicine has grown rapidly in popularity across both developing and developed countries, largely because these remedies come from natural sources and tend to have fewer side effects. *Momordica charantia* (Figure 4), a plant from the Cucurbitaceae family, is widely known as bitter melon, bitter gourd, balsam pear, karela, or pare. It flourishes in tropical regions such as the Amazon, East Africa, Asia, India, South America, and the Caribbean. This perennial climbing vine bears long, cucumber-like fruits with a characteristic warty surface. When unripe, the fruit appears white

or green and has a distinctly bitter taste, which becomes even more pronounced as it ripens.

Momordica charantia contains a variety of biologically active phytochemicals such as triterpenes, proteins, steroids, alkaloids, saponins, flavonoids, and acids, which contribute to its antifungal, anti-bacterial, anti-parasitic, anti-viral, antifertility, anti-tumorous, hypoglycaemic, and anticarcinogenic properties. The fruit is traditionally used to treat conditions such as rheumatism, gout, parasitic worms, colic, and liver and spleen ailments. It is also recognized for its efficacy in managing cancer and diabetes. Its potent hypoglycaemic effect is attributed to alkaloids, insulinlike peptides, and a blend of steroidal sapogenins known as charantin. Diabetes mellitus ranks among the top five causes of death worldwide. It represents a significant global health challenge, with projected prevalence increasing from 171 million in the year 2000 to 366 million by 2030, while many cases continue to go unrecognized. This syndrome involves disordered metabolism, typically resulting from a combination of hereditary and environmental factors, leading to abnormally elevated blood glucose levels. Etiologically, it arises from a relative or absolute deficiency of insulin, insulin insensitivity, or both. *Momordica charantia* is the most widely used plant in alternative medicine for its anti-diabetic properties[43 – 50].



Figure 4 : *Momordica charantia* plant

EXTRACTION PROCESS

M. charantia specimens were obtained from the Mueang Mai markets in Chiang Mai. The bitter melons were separated into flesh and inner tissue (pericarp with seeds), cut into small pieces and then dried at 45 °C in a hot-air oven [52]. The dried material was ground into a powder and sieved to produce fine particles. Macerations were prepared using a 1:10 ratio (powder to solvent), with ethanol concentrations ranging from 20% to 100% or water serving as the solvent [52]. The suspensions were

stirred twice daily throughout the maceration process. After three days, the bitter melon powder was separate ,released by the solvent. The resulting supernatant was concentrated using a rotary evaporator for alcoholic extractions or a freeze

lipids. Among its specific constituents are alkaloids, momordicin, charine, momorchanins, momordicilin, charantin, momordicius, momordenol, momordin, momordolol, cryptoxanthin, cucurbitacins, cucurbitins, cycloartenols, cucuritanes, erythrodiol,

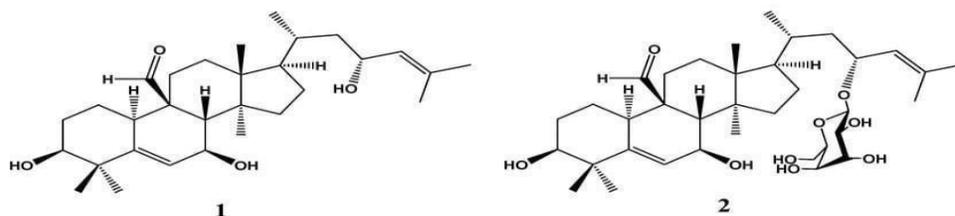


Figure 5 : Chemical structure of momordicin I (1) and momordicin II (2).

dryer for aqueous extractions.

CHEMICAL COMPOSITION

The main chemical components found in *Momordica charantia* (bitter melon) include (Figure 6) triterpenes, proteins, steroids, alkaloids, inorganic substances, phenolic compounds, and

elaeostearic acids, galacturonic acid, gentisic acid, goyaglycosides, goyasaponins, multiflorenol, cucurbitacins, cucurbitanes, diosgenin, guanylate cyclase inhibitors, gypsogenin, lauric acid, karounidiols, hydroxytryptamines, lanosterol, linoleic acid, linolenic acid, momordicinin, and momordicosides [53].

MECHANISM OF ANTIOXIDANTS ACTION IN FOOD

- Oxidative stress plays a major role in food spoilage, leading to things like fat breakdown and changes in colour. Bitter gourd helps counter this damage through several different protective mechanisms.
- Phenolic compounds like gallic acid, catechin, and chlorogenic acid, along with flavonoids and vitamins A, C, and E, act as powerful freeradical fighters. They donate electrons to stabilize reactive molecules such as DPPH and hydroxyl radicals, stopping the chain reactions that lead to food spoilage.
- Enzyme Regulation: Extracts from bitter gourd can increase the function of intrinsic antioxidant enzymes—such as superoxide dismutase (SOD) and catalase (CAT)—within food matrices or biological systems, It helps control and balance the body's oxidative processes.
- Metal Ion Binding: These extracts also exhibit metal-chelating properties, binding metal ions that might otherwise accelerate oxidation in food products.
- Collectively, these antimicrobial and antioxidant properties position bitter gourd as a promising

natural preservative for the food sector, providing a viable substitute for artificial additives[54].

NUTRACEUTICAL PROPERTIES OF M. CHARANTIA

Many studies have shown that bitter gourd has strong nutraceutical benefits. As illustrated in (Figure 6) several significant characteristics are detailed in the subsequent section :

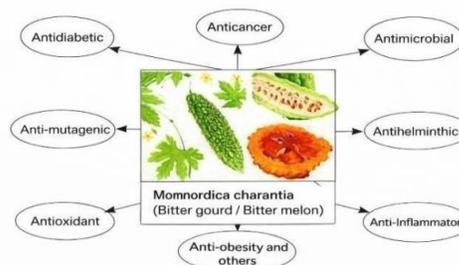


Figure 6: Nutraceutical Properties of M.Charantia

ANTICANCER ACTIVITY

Grover et al.[55] It has been reported that extracts and individual compounds from *Momordica charantia* (bitter gourd) show strong anticancer effects against several types of tumors, including lymphoma, leukemia, choriocarcinoma,

carcinoma, melanoma, and prostate denocarcinoma. One such component is momordin, a protein extracted from bitter gourd, has been identified as possessing ribosome-inactivating properties; when conjugated with anti-CD5 monoclonal antibodies, it demonstrated superior efficacy compared to other anti-CD5 immunoconjugates containing ricin-A chain in experiments involving human T-lymphocyte leukemia Jurkat cells [56]. Bitter gourd seeds have shown strong tumor-inhibiting effects in living organisms. Researchers have found that eleostearic acid—one of the major compounds in these seeds—and its dihydroxy form obtained through ethanol extraction are especially powerful in fighting tumors [57]. These compounds can slow down the growth of several cancer and fibroblast cells, including HL60 leukemia cells and HT29 colon cancer cells, as shown in research by Grossmann et al. [58]. indicated that eleostearic acid inhibits the proliferation of both estrogen receptor (ER) negative and ER α -positive breast cancer cell lines, and can induce G2-M cell cycle arrest and apoptosis. *M. charantia* extract modulates signal transduction pathways to inhibit carcinoma cell growth and may serve as a dietary supplement for cancer prevention [59]. Asiamah et al. reviewed the chemopreventive properties of *M. charantia* in azoxymethane-induced cancer in male rats and assessed its impact on selective hepatic detoxification and antioxidant enzymes [60]. The green leaves, fruits, seeds, and stems of the plant contain numerous chemically active proteins and steroids. These include alpha- and beta-momocharins, which possess anticancer and anti-HIV properties [61].

ANTIDIABETIC ACTIVITY

Diabetes mellitus, a rapidly increasing global health issue, It refers to a group of metabolic disorders that occur when the body has problems with insulin either not making enough of it or not using it properly [62]. Many studies show that *M. charantia* extract is used as a natural treatment to help manage diabetes. Different cultures have relied on it as an antidiabetic remedy for thousands of years

[63]. According to Mishra et al. [64], aqueous extract of bitter gourd fruit significantly reduced blood glucose levels in streptozotocin (STZ)-induced diabetic rats when administered orally. The aqueous extract of bitter gourd fruit can stimulate insulin production by pancreatic β -cells isolated from obese-hyperglycemic mice [65]. Additionally, bitter gourd extract can reduce glucose concentrations independently and decrease intestinal glucose absorption [66].

M. charantia contains compounds such as charantin, vicine, arabinosides, glycosides, and polypeptide-p

plant insulin. These phytochemicals enhance blood glucose regulation by reducing intestinal glucose absorption, increasing glucose uptake from the blood, helping the liver and muscles store more glycogen, and adipose tissue, and inducing hypoglycemic effects. Reports suggest these compounds may enhance insulin secretion from pancreatic beta-cells and support the proliferation of insulin-secreting beta-cells. *M. charantia* also has a bioactive lectin that acts similarly to insulin. It can bind to insulin receptors, helping lower blood sugar levels after consumption. Lectin acts on peripheral tissues, leading to reduced blood glucose concentrations. Charantin, a potent hypoglycemic agent composed of mixed steroids extracted from *M. charantia* using alcohol, is sometimes employed in diabetes treatment to lower blood sugar levels [67].

DISCUSSIONS

This review highlights the significance of plant-based natural preservatives as safer alternatives to synthetic preservatives. Essential oils and bioactive compounds from *Ocimum basilicum* and *Momordica charantia* exhibit strong antimicrobial and antioxidant activities that help prevent microbial growth and oxidative spoilage. Basil essential oil, rich in linalool and eugenol, effectively inhibits foodborne pathogens, while bitter gourd phytochemicals scavenge free radicals and enhance antioxidant defense mechanisms. Although challenges such as volatility and sensory effects exist, modern techniques like encapsulation and nano-formulations improve their applicability. Overall, these plant-derived preservatives show promising potential for enhancing food safety and shelf life.

CONCLUSION

The growing awareness of health risks associated with synthetic preservatives has increased interest in natural, plant-based alternatives. Essential oils and bioactive compounds derived from plants offer a safer and more sustainable approach to preservation. This review emphasizes the preservative potential of *Ocimum basilicum* (basil) and *Momordica charantia* (bitter gourd), which are rich in phytochemicals possessing strong antimicrobial and antioxidant activities. Basil essential oil, containing constituents such as linalool, eugenol, and estragole, demonstrates effective inhibition of microbial growth and oxidative deterioration, making it suitable for food packaging and processing applications. Similarly, bitter gourd contains phenolic compounds, flavonoids, triterpenes, and insulin-like peptides that contribute to its

antioxidant, antidiabetic, anticancer, and nutraceutical properties. These bioactive components help extend shelf life and improve product safety. Overall, basil and bitter melon represent promising natural preservatives that can reduce reliance on synthetic additives. However, further research is needed to optimize extraction methods, standardize formulations, and ensure regulatory compliance for large-scale industrial use.

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