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A NARRATIVE REVIEW ON EFFECTIVE USE OF MEDICINAL PLANTS FOR THE TREATMENT OF PARASITIC FOODBORNE DISEASES

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ABSTRACT

Parasitic foodborne illnesses continue to pose a worldwide health problem, particularly in areas where people have limited access to medical services. The drawbacks of traditional pharmaceutical treatments, such as the development of drug resistance and negative health effects, require the investigation into alternative remedies. Medicinal plants, which have a long tradition in healing methods, are being seen as potentially valuable for addressing this problem. These plants contain a wide range of biologically active substances such as alkaloids, flavonoids and terpenoids, which possess strong anti-parasitic properties. Though, there are obstacles to be faced in the process of incorporating medicinal plants into modern medicine. To guarantee the safety and effectiveness of these natural remedies, it is crucial to have standardization, quality control and regulatory measures in place. We highlight the value of medicinal plants in addressing foodborne diseases caused by parasites and emphasize the importance of ongoing research and partnership between traditional and modern medicine. This article explores the potential use of medicinal plants to treat parasitic foodborne diseases. It examines their historical usage, how they work and their proven effectiveness. It ensures that diverse populations can access effective treatments, thus promoting global health equity. In order to address the obstacles associated with medicinal plant-based therapies, it is imperative to expand research efforts and integrate traditional knowledge into modern healthcare practices to facilitate advancements in the field. Through this process, we can effectively harness the capabilities of medicinal plants, promoting overall health and well-being on a global scale in the continuous battle against parasitic infections.

***Keywords*:** Foodborne diseases; Medicinal plants; Treatment of parasitic; Parasitic infections; Natural remedies

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1. INTRODUCTION

Parasitic diseases are commonly endorsed to the ingestion of tainted food and water, resulting in infections caused by a variety of parasites such as protozoa and helminthes. Throughout history, medicinal plants have been deployed in traditional medicine as a means because of their inherent antiparasitic properties. An evaluative article has discussed the use of botanical remedies for the management of parasitic foodborne ailments (Abuseir 2023). This review will be helpful as a highly beneficial tool for healthcare practitioners, researchers and those with a keen interest in exploring natural therapeutic options for such afflictions. Foodborne diseases caused by certain parasites are a big problem around the world, especially in places with poor sanitation and not enough clean water. These diseases are mainly spread through eating and drinking contaminated food and water. This can cause various types of parasitic infections with different symptoms (Narayan et al. 2023).

Medicines are being used for parasites infections, but they have some drawbacks. It is important to understand these restrictions to avail possible advantages of trying out alternative treatments like herbal or plant based medicines. A big problem in treating these infections by medicines or antibiotics is that these parasites become resistant to drugs. Over time, the microorganisms become immune to the medicines that are normally used to treat. This resistance can decrease the effectiveness of the treatment (Akram et al. 2021). Some medicines that are used to treat foodborne infections also have toxic effects on the body. When taking regular medications to fight parasites,

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they also affect the normal gut flora and have negative effects on their overall health. In some areas with limited resources, it is difficult to find and get medicine for foodborne diseases caused by parasites (Kumar et al. 2023). Most regular drugs that kill parasites usually have only one specific target within the parasite's body. This one-target method can put pressure on the parasites, which might cause them to become resistant. Furthermore, focusing on one specific pathway may not be enough to completely eliminate the parasite. Each type of infection typically requires specific drugs for treatment. Sometimes, regular medicines don't fully understand the immune system and parasites interact (Bubela et al. 2008).

1.1. Potential of Medicinal Plants as Remedies

Traditional medicines are not always effective in treating foodborne diseases caused by parasites; scientists are looking into other options like using plants as medicine. This could be a hopeful solution. Plants that are used for medicine have been used for a long time and now they are being more recognized for their possible use in treating parasitic infection (Luanda et al. 2023). There are a number of possible benefits of using medicinal plants in different ways to treat health problems. For many years, different cultures have used plants with healing properties in their traditional medicine. Indigenous people have discovered and used many plants that can kill parasites (Falaro and Tekle 2020). Plants with healing properties have a lot of helpful substances that can fight against parasitic infections. This discourse examines illustrative instances of these compounds and their efficacy in combating parasites (Kumar et al. 2023). In contrast to conventional pharmaceuticals, botanical resources frequently present a heightened level of patient safety and a diminished incidence of adverse effects. The present inquiry discusses the potential of medicinal plants as a facilitative means to alleviate adverse reactions in patients, thereby contributing to the enhanced ease in the administration of various medical treatments (Ullah et al. 2020). Certain botanical specimens possess the potential to combat various types of parasites. This strategy helps to avoid resistance and improves the chance of successful treatment (Awotedu et al. 2020). Using natural plants in healthcare can be combined with traditional and modern medicine. The possibility of using plants that have healing properties alongside current treatments to improve the care provided to patients, these plants can be found nearby and are a good option in areas where medicine is not easily accessible (Chithra et al. 2023).

2. PARASITIC FOODBORNE DISEASES

Parasitic foodborne diseases encompass a collection of infectious ailments induced by different parasites, predominantly protozoa and helminthes (Aschale et al. 2022). These parasites are transmitted via the ingestion of contaminated food and water. These diseases pose a considerable public health concern on a global scale, given their extensive prevalence, diverse etiological agents and the potential for grave health outcomes. This section will present a thorough introduction to prevalent parasitic foodborne illnesses (Chithra et al. 2023). It will elucidate the responsible parasites, their modes of transmission and the resulting clinical manifestations (Ranasinghe et al. 2023).

2.1. Giardiasis

Giardiasis is primarily attributed to the parasitic protozoan, *Giardia duodenalis*. It is also referred to as *Giardia lamblia*. This particular waterborne parasitic infection ranks among the most frequently encountered instances. The consumption of *Giardia cysts* via water or food contaminated by this pathogen can result in gastrointestinal manifestations such as diarrhea, abdominal cramps, and nausea. Giardiasis has the potential to manifest as a chronic condition and give rise to considerable challenges in nutrient uptake, consequently resulting in weight reduction and heightened fatigue (Khattak et al. 2023). The typical manifestations are diarrhea, abdominal cramps, bloating, and flatulence. Stool odor and appearance can become unpleasant and oily as a result of fats being inadequately absorbed in the body. Instances of giardiasis can progress to become a chronic condition, causing sustained diarrhea, loss of body mass, and deficiencies in essential nutrients. Infections contracted by children can impede proper growth and hinder overall development (Naz et al. 2018).

2.2. Amebiasis

Entamoeba histolytica serves as the etiological agent of amebiasis, a disease that primarily impacts the anatomical region of the large intestine. The ingestion of this parasite can occur through the consumption of food or water that has been contaminated. Amebiasis may present with a spectrum of symptoms, encompassing mild episodes of diarrhea to severe cases, which have the potential to result in life-threatening dysentery (Hajare et al. 2022). Amebiasis can give rise to a diverse range of clinical manifestations. Mild instances can encompass a condition of loose stools and abdominal discomfort, whereas more severe infections may give rise to bloody diarrhea and abdominal pain. The parasitic organism possesses the ability to infiltrate various organs, predominantly the liver, which subsequently results in the development of amebic liver abscesses. The

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symptomatology may manifest as right upper quadrant pain accompanied by elevated body temperature. Systemic symptoms may encompass manifestations such as unintended weight loss, sensations of exhaustion, and a decline in physical strength (Gilchrist 2014).

2.3. Cryptosporidiosis

Cryptosporidium refers to a group of protozoan parasites that induce the infection known as cryptosporidiosis. Water source contamination is a prevalent modality of transmission (Kumar et al. 2018). Cryptosporidiosis, elicited by members of the Cryptosporidium genus, can give rise to diverse clinical manifestations Infection has the potential to induce the manifestation of profuse watery diarrhea, abdominal discomfort, and the deleterious state of dehydration. Cryptosporidiosis poses a significant risk to individuals with compromised immune systems. Diarrhea can result in dehydration, particularly among susceptible demographic groups. In individuals with compromised immune systems, the infection may manifest as a severe and prolonged condition (Gerace et al. 2019).

2.4. Ascariasis

Ascaris lumbricoides is a pathogenic helminth that is the primary causative agent of the parasitic infection known as ascariasis. The consumption of food or water that has been tainted with Ascaris eggs can result in the acquisition of intestinal worms. The presence of infection may persist without showing any visible symptoms, however, in cases characterized by extreme severity, it can give rise to obstructions in the gastrointestinal tract and deficiencies in the intake of essential nutrients. The medical condition known as ascariasis, which is primarily attributable to the parasitic roundworm (Aschale et al. 2022). Infection may give rise to the ensuing array of clinical manifestations. In instances of elevated severity, the aggregation of worms can result in the occlusion of the intestine, thereby giving rise to manifestations such as abdominal discomfort, emesis and pronounced fecal impaction. Persistent infection can potentially cause malabsorption of essential nutrients, consequently leading to the depletion of body weight and the occurrence of deficiencies in vital nutrients (Kumar et al. 2014).

2.5. Trichuriasis

Trichuriasis is an infectious disease primarily attributed to *Trichuris trichiura*, a species of intestinal helminth. This parasitic infection ensues when eggs are consumed via contaminated food or water sources. Trichuriasis is known to induce various clinical manifestations such as chronic diarrhea, abdominal pain, and anemia due to blood loss. Chronic infection has the capability to elicit prolonged and ongoing episodes of watery diarrhea. The occurrence of abdominal discomfort is widespread. A protracted infection can lead to anemia as a consequence of hemorrhaging occurring from the gastrointestinal tract (Idris et al. 2019).

2.6. Hookworm Infections

Hookworm infections are typically attributed to the parasitic species *Necator americanus* and *Ancylostoma duodenale*. These parasites are able to infiltrate the body by penetrating the skin, particularly in the area of the feet, and advance towards the intestinal tract. The larvae's initial dermal penetration can elicit pruritus and give rise to a distinctive serpiginous dermatosis referred to as cutaneous larva migrans. Potential symptoms that individuals may experience comprise of abdominal pain, anemia, and protein malabsorption. Infections commonly known as hookworms, are characterized by a range of presenting symptoms. The manifestation of symptoms encompasses abdominal pain, diarrhea, as well as anemia resulting from gastrointestinal blood loss (Ramlal et al. 2023).

2.7. Taeniasis Cysticercosis

Taeniasis occurs due to the presence of tapeworms, specifically *Taenia saginata* and *Taenia solium*. *Taenia saginata* comes from beef or pork, causes infection by eating beef that is not fully cooked or has been contaminated. The cysticerci of Taenia saginata can be distinguished by their appearance. Possible symptoms may involve slight pain in the abdomen, diarrhea and a decrease in body weight. Consuming the larval stage of *Taenia solium* has the potential to cause cysticercosis, a condition that can impact different tissues and organs in the body, including the brain. The presence of solium can result in an infection caused by tapeworms in the intestines. Neurocysticercosis can lead to the occurrence of seizures, neurological manifestations and detrimental health effects (Cao 2023).

2.8. Toxoplasmosis

Toxoplasmosis is a pathological condition precipitated by the parasitic microorganism known as *Toxoplasma gondii*. This infection can be acquired through the consumption of inadequately cooked or contaminated meat, particularly pork and lamb, predominantly (Rostami et al. 2021). Toxoplasmosis infection caused by the substantial hazard to individuals with compromised immune systems and pregnant women, despite often resulting in mild or asymptomatic manifestations among generally healthy individuals (Picone et al. 2020).The infection's

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clinical outcomes encompass the ensuing consequences. A significant proportion of individuals in good health may exhibit no symptoms. Minor infections can elicit flu-like manifestations, such as elevated body temperature and exhaustion. During gestation, the occurrence of an infection may give rise to a condition known as congenital toxoplasmosis, potentially causing anatomical abnormalities and impairing the developmental trajectory of the neonate (Kamus et al. 2023).

2.9. Cryptosporidiosis

Cryptosporidiosis is caused by Cryptosporidium spp. which is the source of the diarrheal illness known as cryptosporidiosis. The term "Crypto" is used to refer to both the parasite and the illness. Numerous Cryptosporidium spp. may infect animals and some of them can even infect people. The parasite is shielded by an outer shell that enables it to endure prolonged periods of time outside the body and increases its resistance to chlorine treatment. Although there are several ways in which this parasite can spread, the most popular one is through water both drinking and recreational water. In the US, Cryptosporidium is a major contributor to waterborne illnesses in people. In immunocompetent people, *Cryptosporidium* spp. infections typically resolve on their own, but in people with compromised immune systems, they can be fatal. Symptoms of HIV infection might include life-threatening diarrhea that lasts for a long time. Extraintestinal symptoms may appear in these people and progress to other organs such as the pancreas, biliary tract, gall bladder and pulmonary system (Villanueva 2017; Hassan et al. 2021; Hernández-Castro et al. 2023).

3. MEDICINAL PLANTS AS ANTI-PARASITIC AGENTS

Throughout history, medicinal plants have served as critical components in traditional healing methods utilized within various cultural contexts. Several of these plant species have been employed in the treatment of parasitic infections and recent scientific investigations have progressively confirmed their efficacy as antiparasitic agents. This section will discuss selected botanical specimens renowned for their efficacy in alleviating parasitic foodborne disorders, as well as the bioactive chemical constituents accountable for their antiparasitic properties (Sunita et al. 2017).

3.1. *Artemisia annua* (Sweet wormwood)

Sweet wormwood *(Artemisia annua),* a medicinal plant, has a long history of use in Traditional Chinese Medicine (Chebbac et al. 2023). Its therapeutic properties have been relied upon for countless centuries in this ancient healing system. Historically, this remedy was employed for the treatment of fevers, particularly those linked to malaria. Artemisinin is the principal bioactive constituent accountable for the antimalarial efficacy exhibited by Artemisia annua (Biswas and Mandal 2023). Artemisinin-based combination therapies have become an essential component in the management of malaria. This intervention has demonstrated notable efficacy against various Plasmodium species (Lu et al. 2023). These therapeutic interventions involve the strategic combination of artemisinin or its derivatives with additional antimalarial medications, with the aim of enhancing overall effectiveness and mitigating the potential development of resistance (Weathers 2023).

3.2. *Allium sativum* (Garlic)

Garlic has been extensively employed for its therapeutic attributes in diverse societies, encompassing its utilization as an antiparasitic agent. Allicin and ajoene, as significant bioactive constituents found in garlic, possess considerable potential in manifesting antiparasitic properties. Evidence from previous studies suggests that garlic extracts and their bioactive constituents possess notable anti-parasitic capacities, specifically when combatting protozoan parasites such as Giardia and Entamoeba (AlGabbani et al. 2023; Okoro et al. 2023).

3.3. *Azadirachta indica* (Neem)

Neem, an integral component in traditional Ayurvedic medicine, possesses a venerable lineage of employment in addressing diverse health ailments, which encompasses parasitic infections. The neem plant possesses a diverse range of bioactive compounds, including azadirachtin, which manifests notable antiparasitic characteristics. In laboratory studies, it has been observed that neem extracts demonstrate effectiveness in combatting parasitic organisms such as Giardia and Entamoeba. The mechanisms of action encompass impeding the growth and metabolism of the parasites(Abu et al. 2023; Eg et al. 2023).

3.4. *Berberis vulgaris* (Barberry)

Barberry has been utilized in traditional medicine due to its remarkable antimicrobial and antiparasitic attributes. Berberine, a prominent bioactive compound found in barberry, has gained considerable attention for its potential as an antiparasitic agent. Berberine has exhibited significant efficacy against diverse parasites,

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encompassing *Entamoeba histolytica*, *Giardia lamblia* and *Plasmodium* species. The substance exhibits disruptive effects on the cell membranes and metabolic pathways of parasites (Boakye et al. 2023;Crista and Butnariu 2023).

3.5. *Artemisia afra* (African wormwood)

African wormwood has been traditionally employed in traditional African medicine to address a range of health concerns, such as parasitic infections (Molokoane et al. 2023). Sesquiterpene lactones and other compounds found in this plant have been identified as potential contributors to its antiparasitic properties (Taljaard et al. 2023). Several scientific investigations have focused on evaluating the potential effectiveness of African wormwood in combating various types of protozoan parasites (Shinyuy et al. 2023).

3.6. *Carica papaya* (Papaya)

Papaya seeds have historically been employed as a natural therapeutic intervention for the eradication of intestinal helminths. Papain and carpaine are bioactive constituents discovered within papaya seeds, which are reportedly attributed with anthelmintic properties. Research findings have demonstrated the potential efficacy of papaya seeds in facilitating the expulsion of intestinal worms, with a particular emphasis on roundworms. Additionally, these seeds have exhibited a broad-spectrum antiparasitic effect (Garg et al. 2023; Malviya et al. 2023; Soromou et al. 2023).

3.7. *Curcuma longa* (Turmeric)

Turmeric has been extensively utilized in Ayurvedic medicine as well as other traditional healing systems for addressing a wide range of health-related issues throughout its extensive historical usage. Curcumin, the predominant bioactive constituent found in turmeric, demonstrates promising antiparasitic properties. Curcumin exhibits a potential in vitro effect against parasitic protozoans and helminths, as evidenced by laboratory studies. This phenomenon has the potential to interfere with the metabolic pathways and membranes of the parasite (Ezzatkhah et al. 2023).

4. MEDICINAL PLANTS USE IN TRADITIONAL MEDICINE

The utilization of botanical resources in traditional medicine holds a time-honored legacy spanning numerous millennia and serves as a fundamental component of healthcare systems observed across diverse global cultures (Kayser et al. 2002). Traditional medicine systems, namely Ayurveda, Traditional Chinese Medicine and indigenous healing practices, have historically resorted to the extensive understanding of local botanical resources for the purpose of addressing a diverse range of medical conditions, encompassing parasitic infections among others. Within this section, an examination will be undertaken to delve into the historical and cultural import of medicinal plants concerning traditional medicine (Zothantluanga et al. 2022). These advantages underscore the potential of natural remedies, specifically those derived from medicinal plants, in effectively addressing the challenges associated with parasitic infections. Although not a complete substitute for traditional pharmaceutical treatments, alternative and complementary approaches can be beneficial, especially in areas where the prevalence of parasitic diseases poses a significant public health issue (Zothantluanga et al. 2022).

The aforementioned benefits underscore the prospective efficacy of natural remedies, comprising medicinal plants, in surpassing certain constraints linked to traditional pharmaceutical interventions for parasitic infections (Ranasinghe et al. 2023). Although medicinal plants present certain challenges and necessitate further investigation and affirmation, their diverse mechanisms and specificity hold potential for enhanced treatment effectiveness and mitigation of drug resistance an issue of escalating importance in global health (Chebbac et al. 2023). Table 1 shows the medicinal plants used for the treatment of foodborne diseases.

5. BIOACTIVE COMPOUNDS IN MEDICINAL PLANTS

For many years, medicinal plants have been employed as remedies for various health issues, which also include treating parasitic infections. The therapeutic properties of these plants can be attributed to the bioactive substances they contain. These compounds possess diverse biological properties, including abilities to combat parasites, reduce inflammation, provide antioxidant benefits, and act against microorganisms (Shang et al. 2022).

5.1. Alkaloids

Alkaloids are a wide range of compounds containing nitrogen. Quinine and berberine are widely recognized alkaloids that exhibit anti-parasitic effects. Quinine is derived from the Cinchona bark and is employed to combat malaria, while berberine, found in plants such as barberry and goldenseal, is utilized to treat different infections.

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Table 1: Medicinal plants used for the treatment of foodborne diseases

S. No.	Foodborne Disease	Medicinal Plant	Bioactive Constituents	Action Against Signs/Symptoms	References
1	Salmonellosis	*Aloe vera*	Aloin, Aloesin	Anti-diarrheal, Healing	Naz et al. (2022)
2	Campylobacteriosis	*Berberis vulgaris* (Barberry)	Berberine	Antimicrobial, Diarrhea	Tarekegn and Balkachew (2023), El-Zahar et al. (2022), Qassadi et al. (2023)
3	Listeriosis	*Psidium guajava* (Guava)	Quercetin, Tannins	Immune Support, Diarrhea	Jadimurthy et al. (2023), Todorov et al. (2023), Mohamad et al. (2022)
4	Norovirus Infection	*Zingiber officinale* (Ginger)	Gingerol, Shogaol	Antiemetic, Nausea	Silva Figueiredo et al. (2023)
5	Botulism	*Cinnamomum verum* (Cinnamon)	Cinnamaldehyde	Antimicrobial, Nerve Function	Sulieman et al. (2023)
6	Shigellosis	*Artemisia annua*	Artemisinin	Antidiarrheal, Antibacterial	Alzahrani et al. (2022)
7	Staphylococcal Food Poisoning	*Thymus vulgaris* (Thyme)	Thymol	Antimicrobial, Gastrointestinal	Ekiert et al. (2022), Yassin et al. (2022)
8	Hepatitis A	*Silybum marianum* (Milk Thistle)	Silymarin	Liver Protection, Jaundice	Qureshi et al. (2022), Samee et al. (2023)
9	Trichinosis	*Carica papaya* (Papaya)	Papain	Digestive Aid, Muscle Pain	Dogan et al. (2022), Kumar et al. (2023)
10	Cyclosporiasis	*Cuminum cyminum* (Cumin)	Cuminaldehyde	Antiparasitic, Gastrointestinal	Kamaraj et al. (2014), Sahoo et al. (2014)
11	Toxoplasmosis	*Artemisia afra* (African Wormwood)	Sesquiterpene Lactones	Antiparasitic, Flu-like Symptoms	(Kasanah et al. (2022), Kumar et al. (2023)
12	Vibrio Infection	*Capsicum annuum* (Chili Pepper)	Capsaicin	Analgesic, Anti-inflammatory	Waghulde and Kharche (2023), Moghadam et al. (2023), Grojja et al. (2023)
13	Cholera	*Psidium guajava* (Guava)	Quercetin, Tannins	Antidiarrheal, Dehydration	Yadav and Manikandan (2022), Gholkar et al. (2022)
14	Cryptosporidiosis	*Azadirachta indica* (Neem)	Azadirachtin	Antiparasitic, Diarrhea	Kayser et al. (2002) (Ranasinghe et al. (2023)
15	*Clostridium perfringens*	*Curcuma longa* (Turmeric)	Curcumin	Anti-inflammatory, Abdominal Pain	Nwachukwu (2023), Mousa et al. (2019)
16	Cyclospora Infection	*Citrus limon* (Lemon)	Limonene	Antimicrobial, Diarrhea	Teneva and Denev (2023), Petretto et al. (2023), Thapa et al. (2022)
17	*Yersinia enterocolitica*	*Allium cepa (Onion)*	Quercetin, Allicin	Antimicrobial, Gastrointestinal	Piamsomboon and Han (2022), Bozinou et al. (2023)
18	*Vibrio parahaemolyticus*	*Alpinia galanga* (Galangal)	Galangin, Alpinin	Antibacterial, Gastrointestinal	Basha et al. (2023), Fu et al. (2022)
19	Giardiasis	*Foeniculum vulgare* (Fennel)	Anethole	Antigiardial, Digestive Upset	Kumar et al. (2023), Dominguez-Vigil et al. (2022)

Alkaloids possess the ability to impede the metabolism of parasites, hinder the function of enzymes and interfere with the growth and reproduction of parasites (Chithra et al. 2023). Quinine, a compound derived from the bark of the Cinchona tree, serves as an example of such alkaloids. Quinine is a widely recognized alkaloid known for its effectiveness against malaria. It focuses on the Plasmodium parasite, impeding its development and ability to reproduce. It stands as one of the earliest successful remedies for treating malaria (Barati and Chahardehi 2023). Berberine can be discovered in plant varieties such as barberry, goldenseal, and Oregon grape. Berberine demonstrates effective antiparasitic effects on different parasites, such as Giardia lamblia and Entamoeba histolytica. It has the ability to disturb the membranes of parasites' cells and impede their growth (Mitropoulou et al. 2023).

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5.2. Terpenoids

Terpenoids are a considerable group of substances present in essential oils. Two compounds, artemisinin derived from *Artemisia annua* and thymol sourced from thyme, exhibit antiparasitic characteristics. Terpenoids frequently demonstrate strong abilities to combat parasites through disruption of cellular membranes, inhibition of enzyme function, or interference with vital processes. Artemisinin, found in Artemisia annua (also known as sweet wormwood), is the crucial bioactive component. Artemisinin and its derivatives demonstrate strong efficacy against malaria. They aim at the Plasmodium parasite, disturbing its development and resulting in its demise. Thymol can be discovered within the essential oils of various plants, including thyme. Thymol's antiparasitic properties extend to a range of parasites, such as Giardia lamblia. It has the ability to disturb the cell membranes of parasites and hinder their development (Cheesman et al. 2023; Jiang et al. 2023; Kamdem et al. 2023; Praseetha et al. 2023).

5.3. Flavonoids

Flavonoids are natural compounds present in numerous fruits, vegetables, and herbs that serve as pigments. The compounds quercetin and artemetin, which can be found in different plants and *Artemisia annua* respectively, possess antiparasitic properties. Flavonoids possess the ability to hinder the growth of parasites, interfere with their protective barriers and regulate the immune responses of their hosts. Quercetin can be found in a range of plants, such as onions, apples and capers. The potential of quercetin in fighting parasitic infections, such as those caused by *Leishmania* species, has been studied. It has the ability to regulate the immune responses of the host and decrease inflammation linked to parasitic infections (Ramlal et al. 2023). Artemetin is a type of flavonoid that can be found in the *Artemisia annua* plant, also known as sweet wormwood. Artemetin has demonstrated effective antiparasitic properties against a range of parasitic agents, with a notable effectiveness against Plasmodium species. It specifically aims to hinder the metabolic processes and development of the parasites (Dardona et al. 2023).

5.4. Polyphenols

The collective term "polyphenols" refers to a broad class of chemicals with pharmacological activity against bacterial, oxidative stress, cardiovascular, and inflammatory disorders. These secondary metabolites play a crucial part in protecting the organism against harmful infections, parasites, and UV radiation as part of its defense system (Pandey and Rizvi 2009). Polyphenols can be found in various plants, such as grapes, green tea and turmeric, with resveratrol, epigallocatechin gallate and curcumin being their respective components. Polyphenols can produce an antiparasitic impact by affecting different cellular processes, including mitochondrial function and signal transduction pathways (Gade and Kumar 2023).

5.5. Saponins

Saponins, a class of glycosides, are abundantly present in various botanical sources such as soapwort (*Saponaria officinalis*) and licorice (*Glycyrrhiza*) additionally, they are commonly found in certain traditional antiparasitic remedies. Saponins have the potential to induce disruptions in parasite cell membranes, rendering them susceptible to the permeation of external substances (Mohammed et al. 2022; Edo et al. 2023) .

5.6. Tannins

Tannins are present in botanical specimens including oak bark and black tea. Ellagic acid, a polyphenolic compound, exemplifies antiparasitic potential. Tannins exhibit the capability to impede the proliferation and maturation of parasites, indicating possible antiparasitic properties (Almuzaini 2023).

5.7. Coumarins

Coumarins are classified as aromatic compounds detected in botanical sources, such as tonka beans and sweet woodruff. Moreover, they have been subjected to scrutiny due to their potential efficacy against parasites. The biological activities of coumarins encompass their potential to significantly affect parasite enzymes and metabolic pathways (Ecevit et al. 2022; Kopel et al. 2022).

5.8. Lignans

Lignans are ubiquitously present within various plant sources, such as flaxseed and sesame seeds. Certain lignans have demonstrated antiparasitic properties. Lignans may potentially exert an influence on parasite metabolism and various cellular processes (Kopel et al. 2022; Drissi et al. 2022).

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6. MECHANISMS OF ACTION AGAINST PARASITIC AGENTS

Medicinal plants contain bioactive compounds that display their antiparasitic properties through diverse mechanisms. These mechanisms selectively aim at crucial processes and formations within parasitic agents, disturbing their development, reproduction and ability to survive. Having a deep comprehension of these mechanisms is vital in order to effectively utilize the medicinal properties of plants for combating parasitic infections (Liu et al. 2020; Shang et al. 2022).

6.1. Disruption of Parasite Membranes

Numerous pharmacologically active constituents present in botanicals, including saponins and certain terpenoids, possess the capability to disrupt the structural integrity of parasitic cell membranes. This phenomenon entails augmented permeability, disrupted ion equilibrium and ensuing cellular demise. Disruption of the structural integrity of the parasite's cell membrane can impede its capacity to assimilate vital nutrients, thereby critically compromising its growth and survival (Wink 2008).

6.2. Inhibition of Enzyme Function

Certain bioactive compounds have the ability to suppress crucial enzymes that participate in the metabolic pathways of parasites. This perturbation has the potential to result in the diminishment of crucial intracellular constituents and, consequently, the ultimate demise of the parasite (Haddad et al. 2011). One potential strategy for combating parasites involves the use of compounds that inhibit reproductive enzymes. By targeting these enzymes, crucial for the parasites' reproduction, their capacity to proliferate within the host can be significantly diminished (Wink 2012).

6.3. Alteration of Cellular Processes

Bioactive compounds have the potential to hinder DNA replication and transcription inside the parasite, thereby interfering with the process. This phenomenon has the potential to impede the synthesis of indispensable proteins vital for sustaining the life cycle of the parasite (Wink 2012). The interruption of mitochondrial functionality has been observed in various compounds that specifically target the mitochondria of parasitic agents, resulting in significant impairment of their energy production processes. As a consequence, this leads to a decreased production of ATP and an impaired homeostasis of cellular energy (Haddad et al. 2011).

6.4. Modulation of Immune Responses

The immune response of the host can be modulated through immunomodulation of specific bioactive compounds, thereby augmenting the host's capacity to identify and combat parasitic agents. One potential aspect involves the modulation and control of cytokines and other immune signaling molecules (Tiwari et al. 2018). Bioactive compounds have demonstrated potential in diminishing excessive inflammation caused by parasitic infections, thereby aiding the host in mitigating tissue damage without compromising their ability to effectively combat the presence of parasites (Shang et al. 2022).

6.5. Disruption of Reproductive Processes

The reduction of population levels of parasitic agents within the host can be achieved by targeting their reproductive processes through the inhibition of specific compounds. In the context of helminths, the inhibition of egg development by specific bioactive compounds is crucial in impeding the perpetuation of the parasite's life cycle (Nowak-Perlak et al. 2023).

6.6. Antioxidant and Antifungal Properties

The antioxidant properties of specific compounds derived from medicinal plants exhibit the capability to function as antioxidants, thereby mitigating oxidative stress within parasitic entities and causing a noteworthy deterioration in their cellular frameworks (Luanda et al. 2023). The antifungal properties displayed by certain bioactive compounds can potentially be advantageous in addressing parasitic agents that exhibit fungal components or associations (Bano et al. 2023).

6.7. Mitigation of Drug Resistance

The presence of numerous bioactive compounds in medicinal plants contributes to a multifaceted approach that poses challenges for parasites' development of resistance. The implementation of this multifaceted approach is imperative in order to effectively address and mitigate the various challenges associated with drug resistance (Rudrapal et al. 2022).

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7. SAFETY AND SIDE EFFECTS

7.1. Safety Profile of Medicinal Plants

The safety profile of botanical substances employed in the management of parasitic foodborne illnesses constitutes a multifaceted and intricate matter in academic discussions. Although numerous plants have a longstanding track record of being safely utilized, it is imperative to approach their application in contemporary healthcare with caution and thorough research to ascertain both their safety and efficacy (Sanyal et al. 2022). The integration of traditional knowledge, scientific research, and regulatory oversight plays a crucial role in effectively exploiting the potential therapeutic benefits of medicinal plants, while also placing paramount importance on ensuring patient safety. Collaboration between patients and healthcare practitioners is imperative for well-informed decision making concerning the incorporation of herbal remedies within a holistic healthcare approach (Kamaraj et al. 2022).

7.2. Potential Side Effects and Contraindications

Understanding the potential adverse effects and contraindications linked to the utilization of herbal remedies is essential in promoting a secure and efficacious therapeutic approach. The utilization of these plants presents noteworthy alternatives for combating parasitic foodborne diseases, however, it is imperative to exercise informed and responsible practices in their application (Ullah et al. 2020). It is advisable for patients to seek guidance from healthcare professionals or herbal specialists when contemplating the inclusion of therapeutic plant species in their healthcare routine, in order to optimize advantages and mitigate potential hazards (Falaro and Tekle 2020).

7.3. Proper Dosage and Administration Importance

The appropriate dose and administration play a crucial role in ensuring the safe and efficacious utilization of medicinal plants for the treatment of parasitic foodborne illnesses. Attaining an optimal equilibrium between the desired therapeutic effects and possible adversities is contingent upon the precise administration of dosages (Ranasinghe et al. 2023). The integration of conventional wisdom, professional guidance and individualized attention has the potential to yield ideal treatment results while mitigating deleterious consequences. Collaboration between patients and healthcare professionals is imperative in order to guarantee the judicious dosing and meticulous administration of herbal remedies as a fundamental component of a comprehensive healthcare approach (Ranasinghe et al. 2023).

8. CONCLUSION

Medicinal plants offer hope in treating foodborne diseases caused by parasites. Unlocking full potential requires research, standardization, and regulatory advancements. We can globally prevent and treat parasitic infections by integrating medicinal plants into healthcare and overcoming challenges. Emphasizing the need, it is crucial to highlight the significance of medicinal plants as symbols of hope in the ongoing fight against foodborne diseases from parasites. The historical use, bioactive substances and proven effectiveness support the development of readily available and effective treatments. Despite challenges in standardization, quality control and regulation, medicinal plant-based therapies offer notable advantages. In the future, collaboration is crucial for scientists, healthcare professionals and regulators to conduct further research and ensure the safety, quality and effectiveness of natural remedies. By pursuing this approach, we maximize medicinal plants' capabilities to prevent and treat parasitic foodborne illnesses, promoting global health and welfare. The partnership of conventional and contemporary medicine is crucial for advancing treatment of foodborne diseases caused by parasites. The combination of these approaches preserves cultural heritage while fostering new discoveries, comprehensive healthcare, and better patient outcomes. By working together, we can fully utilize medicinal plants to provide secure and efficient remedies for parasitic infections. Ultimately, we will promote global health and enhance wellbeing.

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