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Article

An Overview of Golden Spice's (Turmeric) Medicinal Properties for Future Development Potential

Zarini Ismail[#] and Nur Ain Nabila Mazuki[*],

[#] *Universiti Sains Islam Malaysia, Jalan Pandan Utama, Pandan Indah, 55100 Kuala Lumpur*
E-mail: zarini@usim.edu.my

[*] *Universiti Sains Islam Malaysia, Jalan Pandan Utama, Pandan Indah, 55100 Kuala Lumpur*
E-mail: ainnabilamazuki@gmail.com

Abstract—**Traditional medicines that are derived mainly from herbaceous plants are widely used for years in many regions of the world. Currently, the world is facing the emergence of resistant microorganisms due to the overuse and misuse of antibiotics and the lack of new drug development. In consequence, the discovery of natural phytochemicals that are safe, cheap, non-toxic, and readily available would be an acceptable alternative source. Turmeric, scientifically known as *Curcuma longa*, in the family of Zingiberaceae (ginger) is well known for its diverse therapeutic properties. The medicinal properties of turmeric include antioxidant, anti-inflammatory, anti-microbial, anti-carcinogenic, cardioprotective, gastroprotective, hepatoprotective, and many more. Numerous studies have shown that curcumin (1,7-bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione), which is the most active compound of turmeric, plays a significant role as a therapeutic agent. The present article provides a brief overview of the plethora of research regarding the medicinal properties of golden spice (turmeric), specifically of curcumin's role in the treatment of various illnesses. Interestingly, turmeric might play a role in protecting COVID-19 patients against the development of lung injury caused by cytokine storms. Hence, this warrants further scientific research to monitor the anti-inflammatory effect of turmeric on SARS-CoV-2.**

Keywords— **Turmeric, *Curcuma longa*, curcumin, curcuminoids, traditional medicine.**

I. INTRODUCTION

Traditional medicines that are derived mainly from herbaceous plants are widely used for years in many regions of the world. This kind of medicine is usually has been handed down from one generation to another. In contrast to modern medicine, traditional medicines are inimitable in terms of exclusive biological activities and costly clinical experiences [1]. Currently, the world is facing the emergence of resistant microorganisms due to the overuse and misuse of antibiotics and the lack of new drug development also [2]. So, the search for an alternative drug continues, and the discovery of natural phytochemicals that are cheap, non-toxic, and readily available would be an acceptable alternative source. Turmeric, which is well known for its characteristic bright yellow colour, has been used extensively in food preparation for its flavour and colour. For example, in India, turmeric is famously used as spice, food preservative, colouring material, and widely used for the treatment of various diseases. In addition, turmeric has been used for years to treat conditions such as toothaches, colic, chest pains, gas, and menstrual difficulties in Chinese and Indian medicines. It is also known to be beneficial to treat liver and stomach problems as well as good in healing wounds and lightening scars.

Turmeric is famed for its anti-aging and skin-lightening properties in the Asian world, which make it useful in cosmetics formulations [3]. Based on new studies that have been conducted, turmeric proved to have many benefits. It includes antidiabetic, antivenom, hepatoprotective, nephroprotective, anticoagulant, and many others [4]. Although the mechanism for traditional medicines is mostly not established properly, it is not wise to ignore them as they play a crucial role in developing new and safer drugs in the future.

The scientific name for turmeric is *Curcuma longa*, in the family of Zingiberaceae (ginger). Turmeric is a leafy plant, with funnel-shaped yellow flowers and rhizome (Figure 1). The rhizome is one of the important parts of turmeric that is usually dried and grounded into yellow spice powder [5]. Generally, the most active compound of turmeric is curcumin (1,7-bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione), typically 60%-70% of crude extract (Figure 2). Curcumin is a product obtained by the solvent extraction of turmeric and purification of the extract by crystallisation. Demethoxycurcumin (1-(4-hydroxyphenyl)-7-(4-hydroxy-3-

methoxyphenyl)-hepta-1,6-diene-3,5-dione, 20-27%) and bisdemethoxycurcumin (1,7-bis-(4-hydroxyphenyl)-hepta-1,6-diene-3,5-dione, 10-15%) are the examples of other curcuminoids that are found in turmeric [6]. Based on studies, curcumin appeared to be safe and non-toxic to humans. Recent evidence highlight that the interaction of curcumin with gut microbiota had gained interest in scientific research. Turmeric extract has been considering for use as therapies targeting the gut microbiota, which is a novel potential therapeutic target [7].

Curcumin was first extracted almost two centuries ago and has been using for all kinds of conditions and diseases such as pains, wounds, pulmonary, skin, gastrointestinal system disorders, and many others. Studies showed that curcumin exhibits a wide variety of properties, including anti-inflammatory, antioxidant, antiviral, antibacterial, anti-fungal, and anti-cancer activities [8, 9]. Multitargeted therapy is more desirable for the majority of diseases as compared to monotargeted therapy. Therefore, curcumin that has a high potential in treating many illnesses can be considered as a valuable weapon that demands further indispensable research.

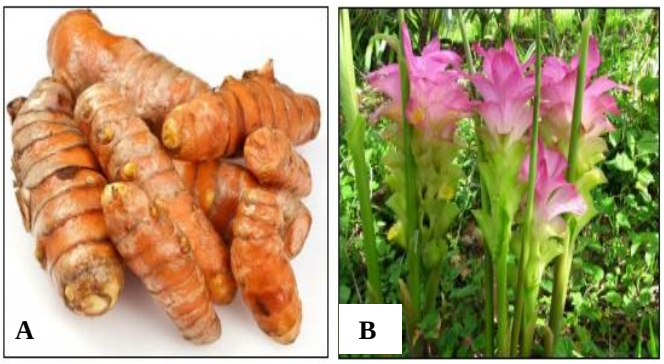

Fig.1 Shows the (A) rhizome and (B) funnel shape flowers of turmeric [5]

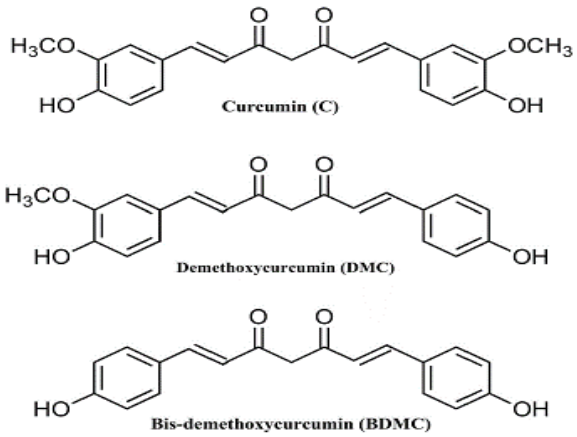

Fig.2 Chemical structures of curcuminoids [10]

This review determines the medicinal significance of turmeric as an anti-inflammatory, antioxidant, antimicrobial, anticarcinogenic, cardioprotective, gastroprotective, and hepatoprotective agent. Published articles were retrieved from the following electronic databases; Google Scholar, Medline, and PUBMED. Several books, journals, and articles were read based on search keywords which comprise turmeric, curcumin, and *Curcuma longa*. All searches were directed towards papers published until the latest 2020. The inclusion criteria included studies related to medicinal turmeric properties mainly as the anti-inflammatory, antioxidant, antimicrobial, anticarcinogenic, cardioprotective, gastroprotective, and hepatoprotective agent. Articles not related to the medicinal properties of turmeric were excluded. Newspaper and magazine articles were also excluded.

II. Phytoconstituents of Turmeric

Turmeric is part of the ginger family that derived from the plant called *Curcuma longa*. The principal compounds of turmeric are called curcuminoids. The main curcuminoids found in turmeric are curcumin, demethoxycurcumin, and bisdemethoxycurcumin [4, 11]. Curcumin, which extracted from the ground rhizome Curcuma plant, is a polyphenolic compound. It has yellow pigment and comprises about 0.3% to 5.4% of raw turmeric. Generally, turmeric is comprise69.4% carbohydrates, 5.1% fat, 6.3% protein, 3.5% minerals and 13.1% moisture [12]. Besides, natural curcumin is hydrophobic and often dissolved in acetone, oils, ethanol, and dimethylsulfoxide. There will be a transition of colour from yellow to red once turmeric is subjected to acidic conditions.

Curcumin is regarded as the most active constituent in turmeric. Besides curcumin, various volatile oils specifically atlantone, turmerone, and zingiberone are found to be the other active constituents of turmeric. Proteins, sugars, and resins are also known to be the contents of the *Curcuma longa* plant. Due to its diverse therapeutic functions, curcumin has had sufficient roles in Ayuverdic medicines for centuries as it is non-toxic to humans and can act as antioxidant, analgesic, anti-inflammatory, antiseptic and anticarcinogenic [8].

Apart from that, curcumin has a low absorption rate, whereby about 40% to 85 % of an oral dose of curcumin passes down the gastrointestinal tract unchanged. Most of the flavonoid is absorbed and metabolized in the liver and intestinal mucosa. To increase the absorption and to intensify the anti-inflammatory effect, curcumin is commonly formulating with bromelain [8].

When curcumin is pass through oral administration, it is broken down into curcumin sulfonate and curcumin glucuronide. On the other hand, if it is administered intraperitoneally or systemically, it is broken down into hexahydrocurcuminol, tetrahydrocurcumin, and hexahydrocurcumin. There are two tautomeric forms in which curcumin can exist, that are keto and enol. However, in the solution and solid phase, enol appears to be more energetic [11].

III. Benefits of Turmeric and Its Mechanism of Actions

There is a wide range of medicinal properties of turmeric/ curcumin that have been reported before. Scientific research

has confirmed the numerous therapeutic effects of curcumin and its ability to act as a potential therapeutic agent to treat various illnesses.

A. Antioxidant Effects

Free radicals that are produced by our body play a crucial role in the development of many chronic diseases, such as cancer, cardiovascular diseases, diabetes, aging, and others. Excessive free radicals can lead to oxidative stress that may cause harm to our bodies. These cause, many people to take dietary antioxidants to reduce the effect of oxidative stress. Studies have reported that turmeric has a strong antioxidant activity. Isolation of turmeric antioxidant protein (TAP) from the aqueous extract of turmeric showed that the antioxidant protein appeared to be a heat-stable protein. The protein exhibits concentration dependant inhibitory effect on the promoter induced lipid peroxidase [13, 14]. Therefore, this study observed the potential efficacy of turmeric anti-oxidant protein in protecting tissues from peroxidative damage.

Curcumin protects against free radicals, and studies showed that it helps in enhancing cellular resistance to oxidative damage. Being undoubtedly a strong scavenger of oxygen free radicals, curcumin helps to protect hemoglobin or lipids from oxidation. Curcumin can also inhibit the production of reactive oxygen species (ROS), for example, superoxide anions, nitrite radical generation, and H2O2 by the activated macrophages.

B. Anti-Inflammatory Effects

Curcumin and volatile oils play essential roles as a potent anti-inflammatory agent. For acute inflammation, oral administration of curcumin immediately after an inflammation seemed to be as effective as cortisone or phenylbutazone. Meanwhile, it is half as effective in cases of chronic inflammation [8]. Studies done on mice demonstrated that curcumin capable of inhibiting edema at doses between 50 and 200 mg/kg. Consequently, when a dose of 48 mg/kg body weight was introduced, there was a 50% decrement in edema and demonstrated an effect as effective as phenylbutazone and cortisone at similar doses [12]. There was a remarkable reduction of inflammatory swelling in experimental rats with Freund's adjuvant-induced arthritis after oral administration of *Curcuma longa* as compared to control groups.

Turmeric also helps to decrease inflammation by reducing the level of histamine and perhaps by elevating the production of natural cortisone by the adrenal glands [15]. Inflammatory conditions such as arthritis, bursitis, and back pain can be relieved with the usage of turmeric. Its anti-inflammatory action is possibly contributed by the amalgamation of three different properties. First, it helps to reduce the development of histamine, which is induced by the inflammatory process. Next, turmeric prolongs and elevates the action of cortisol and adrenal hormones, which are parts of natural anti-inflammatory secreted by the body. Lastly, turmeric improves circulation and leads to the excretion of toxins from the small joints that usually trap cellular wastes and inflammatory compounds [11].

The anti-inflammatory effects of turmeric could be due to its potential to inhibit both neutrophil function and biosynthesis of inflammatory prostaglandins from the arachidonic acid during the inflammation process. Curcumin also modulates the inflammatory response by regulating the activity of cyclooxygenase-2 (COX-2), lipoxygenase, and inducible nitric oxide synthase (iNOS) enzymes [9].

Chronic kidney disease (CKD) is a kind of progressive disease and involves a contrary relation between kidney function with inflammation level and oxidative stress. Reports have concluded that *Boswellia serrata* and curcumin show anti-inflammatory effects on the lipoxygenase and cyclooxygenase pathways. Therefore, the study was done to assess the effects of supplements that comprise curcumin and *B. serrata* on eicosanoid derivatives in a patient with early-stage CKD who is not on hemodialysis. The result of the studies revealed a significant effect of the supplements towards PGE2 in the case of early-stage CKD. However, further studies are required to prove the effectiveness of supplements in terms of decreasing the inflammatory process in patients diagnosed with CKD [16].

C. Antimicrobial Effects

Bacteria, pathogenic fungi, and parasites growth can be inhibited by the essential oils of *Curcuma longa* and turmeric extract. Mohammed et al. evaluated the inhibition effect of curcumin on oral Gram-positive bacteria, *Streptococcus mutans*, and *Streptococcus pyogenes* by using diffusion assay [17]. Based on his study, it is reported that curcumin significantly inhibits the activity of both bacteria;hence, it has the potential to control dental biofilms and subsequently control dental cavity formation. Curcumin extracts also exhibit potent growth inhibitory effect against various bacteria such as Gram-positive bacteria (*S. aureus* and *S. mutans*), Gram-negative bacteria (*E.coli* and *P.aeruginosa*), and pathogenic yeast, *C. albicans* [18]. A previous study also showed that curcumin prevented the growth of other bacteria such as *Lactobacillus* and *Helicobacter pylori* CagA+ strains in vitro [19, 20].

The antibacterial activity displayed by turmeric could cause by the changes in the microorganism's membrane, which was described in a previous study. Turmeric can pass through the bacterial membrane easily and leads to leakage and derangement of the membrane. It is due to its lipophilic and amphipathic properties [11]. Mazumber et al. demonstrated that curcumin also has an antiviral activity by inhibiting the human immunodeficiency virus-1 (HIV-1) integrase enzyme needed for viral replication [21]. Moreover, curcumin and its derivative may have the potential for novel drug development against HIV [19]. It also was shown to inhibit other viruses, such as influenza virus, hepatitis B, hepatitis C, zika, chikungunya, and dengue [22].

D. Anticarcinogenic Effects

A few published showed the growth of some different types of malignant cells that can be inhibited by turmeric. Curcumin

acted as a potent anti-carcinogenic compound and had demonstrated in animal studies by using mice and rats along with in vitro studies by using human cell lines. Curcumin exhibited three mechanisms of inhibition, namely tumour promotion, angiogenesis, and tumour growth. The activity of some common mutagens and carcinogens in many distinct cell types can be suppressed by curcumin and turmeric. Generally, the anti-carcinogenic properties of turmeric together with curcumin are secondary to their antioxidant effect and free-radical scavenging effect. Furthermore, its effect is further enhanced by its potential to indirectly raise glutathione levels which aid in detoxification of both carcinogens and mutagens by the liver and retards the genesis of nitrosamine [11]. Among various mechanisms, the induction of apoptosis plays a significant role in its anti-carcinogenic effects [19].

Apart from that, curcumin also disturbs cancer cell proliferation, decreases the invasion, as well as prevents resistance, including further improves survival.

E. Cardiovascular Effects

Cardio-protective effects offered by turmeric are attributed to its antioxidant properties. Several studies demonstrated that turmeric reduced lipid peroxidation and inhibited platelet aggregation, and thus protected the cardiovascular system. Turmeric is believed to inhibit thromboxane synthesis and potentiate prostacyclins synthesis that enable it to inhibit platelet aggregation [23].

Early studies suggested that turmeric might help to prevent atherosclerosis. Mirzabeigi et al. investigated the curcumin efficacy on lipid profile, blood glucose level, and inflammatory markers in patients with coronary artery disease. A total of 33 patients were randomly assigned to receive either curcumin four times daily for eight weeks or receive a placebo.

It found that serum levels of triglycerides, LDL, and VLDL cholesterol significantly decreased in the curcumin group compared to the baseline measurement that had taken before the study started. However, there was no significant difference detected between the curcumin and the placebo group [24].

In another study performed on experimental diabetic rats, turmeric was showed to decrease blood glucose levels and reduced diabetic complications. On the other hand, to determine the side effects and optimal dosages of turmeric for cardiovascular protection as well as glucose or lipid-lowering activities, further studies recommended with more clinical trials that are required [25].

F. Gastrointestinal Effects

Tumeric has shown to have several protective effects on the gastrointestinal tract. Many studies reported that turmeric inhibits ulcer formation. An example of ulcer effectors is stress, cigarette, alcohol consumption, usage of non-steroidal anti-inflammatory drugs, *H. pylori* infection, pyloric ligation, and others [12]. Ulcer disease can occur in any part of the gastrointestinal tract as such in the esophagus, stomach, and duodenum. Curcumin has been showing to have a significant function in preventing gastrointestinal-induced ulcers [26]. Nasri et al. described a study conducted on 25 patients diagnosed with gastric ulcers by endoscopic examination. After being given 600 mg of powdered turmeric five times daily, the ulcers showed improvement and healed completely in 48% of the patients [12]. Moreover, over time the success rate rose, and after treatment with turmeric for 12 weeks, 76% claimed to be ulcer free with no significant side effect of any blood abnormalities noted [8].

Furthermore, curcumin raises the bicarbonate, secretin, gastrin, and pancreatic enzyme secretion, and also displays inhibition to intestinal spasm.

Studies done on mice with experimentally-induced colitis showed that curcumin managed to decrease mucosal injury. Meanwhile, inflammation was able to be reduced by curcumin in the rat models with experimentally-induced pancreatitis. Another example is a study performed on ethanol-induced pancreatitis. As a result, curcumin was able to make the disease better as measured by its histology, neutrophil infiltration, pancreatic trypsin, and serum amylase. It was due to the effect of curcumin in inhibiting inflammatory mediators [12].

G. Hepatoprotective Effects

Several studies have demonstrated the hepatoprotective effect of turmeric. In short, experimental studies with various hepatotoxic insults such as galactosamine, carbon tetrachloride (CCl4), Aspergillus aflatoxin, acetaminophen, diethylnitrosamine, alcohol, lindane, and heavy metal-induced hepatotoxicity were done. Curcumin is demonstrated to have hepatoprotective and renoprotective effects [27-30]. Both effects are generally due to its antioxidant properties and its capability to reduce the development of pro-inflammatory cytokines [9]. Besides, salt of curcumin, namely sodium curcuminate, shows choleretic effects by elevating biliary excretion of bile salts, bilirubin, cholesterol and helps raise bile solubility, thus making it possible to treat and prevent cholelithiasis [31].

H. Future Trend

Currently, the new coronavirus infection (COVID-19) has caused a critical worldwide health problem due to a higher infection rate and death. It is caused by a newly discovered strain of coronavirus, which is SARS-CoV-2. Concerning this current pandemic, Gupta et al. suggested that well-defined randomised studies should be performed to evaluate the efficacy of turmeric against SARS-CoV-2 and assess its possible value for the treatment of COVID-19 [22].

A previous study had demonstrated that curcumin is a natural ligand of peroxisome proliferator-activated receptor-γ, which can repress the inflammatory process by reducing cytokine production, the tumour necrosis factor-α (TNF-α) [32]. Therefore, it might play a similar role with the synthetic drug in protecting the COVID-19 patients against the development of lung injury caused by cytokine storm due to SARS-CoV-2 infection [33]. Therefore, curcumin could be a novel therapeutic drug soon to treat coronavirus infection.

IV. CONCLUSIONS

In summary, turmeric is one of the unique traditional herbs that has been recognising and attributed to numerous medicinal properties in traditional medicines. Furthermore, turmeric is a non-toxic, safe, cheap, and readily available source of effective alternative treatment for many diseases due to its unique and diverse therapeutic properties. To date, there are numerous studies done for turmeric because it has sparked the interest of researchers due to many beneficial properties.

However, research on drug development from turmeric is still lacking. More studies are needed to target drug development from curcumin, which is the most promising curcuminoids from turmeric.

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