Medicinal uses of ginger (*Zingiber officinale* Roscoe) improves growth and enhances immunity in aquaculture

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Abstract

The medicinal plants are of great use in pharmaceutical, cosmetic, agricultural and food industry. The efficacy of some herbal products is beyond doubt, the most recent examples being *Silybum marianum* (Linn.) Gaertn (Silymarin), *Artemisia annua* Linn. (Artemesinin) and *Taxus baccata* Linn. (taxol). Randomized, controlled trials have proved the efficacy of some established remedies, for instance *Zingiber officinale* Roscoe, commonly known as ginger. Ginger contains natural organic materials beneficial to health and enhances resistance to infectious diseases by increasing non-specific and specific immune mechanisms. The rhizome of ginger has shown to be effective in the control of a range of bacterial, viral, fungal and parasitic diseases in humans, poultry and aquaculture owing to its antimicrobial, antioxidant, growth promoter and as immunostimulant properties to health. Hence, this review focuses on the use of ginger as growth promoter, antimicrobial agent, and antioxidant and as immunostimulant in aquaculture.

Keywords: Ginger, *Zingiber officinale*, gingerols, antioxidant, aquaculture.

1. Introduction

The world trend to improve food security and to use natural products will drive the chemically synthesized antibiotics and growth promoters out of use. Aquaculture is therefore an emerging industrial sector which requires continued research with scientific technical development and innovations (Ibrahem et al., 2010) [24]. Extensive use of antibiotics in aquaculture leads to the emergence of antibiotic-resistant bacteria and generation of toxicants, which may cause risks to the environment (Esiobu et al., 2002) [13], and immunosuppression in the host (Panigrahi & Azad, 2007) [38]. There are a large number of feed additives available to improve fish growth performance. Some of these additives used in feed mill are chemical products, especially hormones and antibiotics, which may cause unfavorable side effects. To alleviate these problems, increasing attention is being given to the use of natural alternative feed additives such as ginger for disease-control strategies in aquaculture. Ginger enhances resistance to infectious disease by increasing non-specific and specific immune mechanisms (Harikrishnan et al., 2011) [21]. Ginger contains natural organic materials that facilitate growth, anti-stress, environmentally friendly and antimicrobial properties in fish (Maqsood et al., 2011) [33]. Ginger as a natural antibiotic is the earliest known medicinal plant. It has shown to be effective in treating diseases in humans, poultry and aquaculture owing to its antimicrobial, antioxidant, growth promoter and immunostimulant properties. An optimized dose of ginger is recommended in the diet. Ginger (*Zingiber officinale* (L.) Roscoe) has been used as a spice for over 2000 years (Bartley & Jacobs, 2000) [6]. It is also called “The Great Medicament” in Ayurvedic medicines (Tan & Vanitha, 2004) [44] and is generally considered as a safe herbal medicine (Weidner and Sigwart, 2000) [46].

Ginger (*Zingiber officinale* Roscoe) is a creeping perennial underground rhizome belonging to family Zingiberaceae (Sharma, et al., 2010) [41]. Nepal is the third biggest producer of ginger in the world (FAO, 2012). In the first year, a green, erect reed like stem about 60 cm high grows from this rhizome. The plant has narrow; lanceolate to linear-lanceolate, 15-30 cm long leaves which die of each year. The odour and taste are characteristic, aromatic and pungent. Ginger valued as a spice has been used through ages in almost all systems of medicine against many maladies. The plant is indigenous to Southeast Asia and is cultivated in a number of countries including Nepal. The smell and taste of the drug are typical and aromatic. The medicinal part
of the herb is dried rhizomes. It is now recognized as a drug of choice for nausea and vomiting. It has also been found useful in pregnancy related morning sickness. In rheumatoid arthritis and osteoarthritis it is used as a natural pain reliever and an anti-inflammatory agent. It is also useful in curing ulcer and preventing heart attack and stroke. A number of active constituents and medicinal properties have been reported during the last decade. Thus, the present article provides a comprehensive account of important medicinal properties of this versatile herb.

1.1. Nutrient Composition
Fresh ginger contains 80.9% moisture, 2.3% protein, 0.9% fat, 1.2% minerals, 2.4% fibre and 12.3% carbohydrates. The minerals present in ginger are iron, calcium and phosphorous. It also contains vitamins such as thiamine, riboflavin, niacin and vitamin C. The composition varies with the type, variety, agronomic conditions, curing methods, drying and storage conditions (Govindarajan, 1982; Gugnani & Ezenwanze, 1985) [15, 17].

1.2. Chemical composition
Ginger is an antiplatelet, antibacterial, antifungal, antiviral, antivorm, anti-inflammatory and has anti-oxidative activity. It effects gastrointestinal and cardiovascular systems, antilipidemic and antihyperglycemic, anti-tumour properties and are known to be effective as an immuno-modulatory agent in human and animals, including fish (Nya and Austin, 2009; Apines-Amar et al., 2012 and Talpute et al., 2013) [15, 16, 43]. Gingerols and shogaols are the major active components in the fresh rhizome (Hoffman, 2007). The volatile oil components consist mainly of sesquiterpene hydrocarbons, predominantly zingerberene (35%), curcumene (18%) and farnesene (10%) (Govindarajan, 1982) [15]. Non-volatile pungent compounds include gingerols, shogaols, paradoisol and zingerone. Paradoisol is similar to gingerol and is formed from hydrogenation of shogoal (phenylalkanones).

Ginger contains fats, waxes, carbohydrates, vitamins and minerals. Ginger rhizomes also contain a potent proteolytic enzyme called zingibain. The pungent taste of ginger is due to nonvolatile phenylpropanoid-derived compounds, particularly gingerol and shogaol. Supplementing ginger in fish diets may enhance disease resistance by reinforcing host innate immune functions that are necessary for protection against infectious diseases. Ginger may play diverse biological roles in anti-oxidative, anti-inflammatory, hypolipidemic, anti-carcinogenic, anti-nausea, antithrombotic, cardiovascular, and antibacterial processes (Kikuzaki & Nakate, 1993; Grzannar et al., 2005; Kadnur & Goyal, 2005; Stoilova et al., 2007; Nicoll & Henein 2009) [30, 16, 26, 42, 35].

1.3. Ginger as growth promoter
Ginger extracts have been reported to enhance the growth of teleosts. For instance, rainbow trouts (Oncorhynhus mykiss) that were fed ginger had significant increases in growth, feed conversion, and protein efficiency. Supplementing diets with acetone extract from ginger was reported to enhance the growth of tilapia (Oreochromis mossambicus) (Immanuel et al., 2009) [25]. The administration of ginger can produce significantly higher weight gain and specific growth rates in Penaeusmonodon post larvae (Venkataramalingam et al., 2007) [45]. The efficiency of feed proportionately increased with the increased percentage of ginger. Moreover, digestive enzyme activity significantly increased with ginger enrichment (Venkataramalingam et al., 2007) [45].

1.4. Ginger as antioxidant agent
Ginger is a strong antioxidant substance and may either mitigate or prevent generation of free radicals (Haksar et al., 2006; Kim et al., 2007) [20, 31]. It is considered to be a safe herbal medicine with only a few insignificant side effects (Ali et al., 2007) [2]. All major active ingredients of Ginger, such as zingerone, gingerdiol, zingibrene, gingerol and shogaols, are known to possess anti-oxidant activities (Chrubasik et al., 2005) [9]. This antioxidant activity in ginger is due to the presence of polyphenol compounds (6-gingerol and its derivatives) (Chen, et al., 1986; Herrmann, 1994) [8]. The total phenolic content in the alcoholic extract of the dried rhizome of ginger is 870.1 mg/g dry extract (Stoilova et al., 2007) [42]. Antioxidant property of ginger is extremely significant as it can be used as a preventive agent against a number of diseases in aquaculture.

1.5. Ginger as antimicrobial agent
Ginger has some antifungal properties as well (Nielsen & Rios; 2000) [36]. Ginger inhibits Aspergillus sp, a fungus known for the production of aflatoxin, a carcinogen (Nielse & Rios, 2000) [36]. Fresh ginger juice showed inhibitory action against Aspergillus niger, Saccharomyces cerevisiae, Mycoderma sp. And Lactobacillus acidophilus (Kapoor, 1999) [27]. It provides protection against invading microorganisms, including bacteria such as E. coli and Staphylococcus aureus (a common cause of skin infections) and fungi, including Candida albicans. The benzene extract of Zingiber officinale rhizome showed highest antibacterial activity against drug resistant P. aeruginosa isolated from wound and pus samples. Melvin et al., 2009 also reported that the ginger extract exhibited maximum antimicrobial activity against P. aeruginosa. Ginger was also found to be protective against DNA damage induced by H2O2 and enhanced health (Khaki, et al., 2009; Robertsen, 1999) [28, 29]. The rhizome of ginger (Zingiber officinale) has been reported to possess a broad-spectrum of prophylactic and therapeutic activities (Ernst and Pittler, 2000) [12]. Ginger is effective in the control of a range of bacterial, viral, fungal and parasitic diseases (Agrawal et al., 2001; Martins et al., 2001; Endo et al., 1990) [11, 34, 12]. Cultured fish suffer from a wide variety of bacterial, viral, parasitic and fungal diseases (Austin & Austin, 2007) [4]. The application of ginger in aquaculture is an innovative approach to enhance health of fish and to prevent diseases. Numerous evidences suggest that many dietary factors may be used alone or in combination with traditional chemo- therapeutic agents to prevent or treat diseases. Ginger has an excellent antimicrobial activity against various gram positive and gram negative bacteria and fungi. In vitro studies have shown that active constituents of ginger inhibit multiplication of colon bacteria. These bacteria ferment undigested carbohydrates causing flatulence. This can be counteracted with ginger (Gupta & Ravishankar, 2005) [18]. The extract of ginger inhibits the growth of Escherichia coli, Proteus vulgaris, Staphylococcus aureus, Streptococcus pyogenes and Salmonella (Ernst and Pittler, 2000; White, 2007) [12, 47]. This plant can to be used as one of the best medicinal plants is controlling pathogenic bacteria.

1.6. Ginger as an immunostimulant
In aquaculture, the application of dietary medicinal herbs as immunostimulants can elevate the innate defense mechanisms of fish against pathogens during periods of stress, such as, intensive farming practices, grading, sea transfer, vaccination and reproduction. The excess use of antibiotics in the
management of disease in aquaculture has resulted in serious health and environmental problems. Consequently, the need of safe and effective alternatives to antibiotics is required. In this context, immunostimulants have attracted significant attention. Ginger as a natural antibiotic is one of the most effective natural immunostimulants. The powdered ginger rhizome is able to enhance non-specific immune response in rainbow trouts (Haghhighi and Rohan, 2013) [19]. Non-specific immunity plays an especially important role in the defense of fish and is the sole immunological mechanism by which invertebrates protect themselves from diseases (Secombes and Olivier, 1997) [40]. Non-specific defense mechanism plays an important role in all stages of fish infection. Fish particularly depend mostly on these non-specific mechanisms than mammals do (Avtalion, 1981) [21]. Ginger essential oil showed improvement in humoral and cell mediated immune response in immune-suppressed mice (Carrasco, et al., 2009) [7]. However, future studies might look into the dose-response, determination of optimal dose, treatment duration, and its use in large scales in fish farms. In general, this study suggests that ginger can be applied as an alternative diet and a supplement to boost immune system for rainbow trout.

Ginger is effective as an immunomodulatory agent in animals and fish and helps to reduce the losses caused by diseases in aquaculture (Nya and Austin, 2009; Ali et al., 2008; Zhou et al., 2006; Tan and Vanitha, 2004) [17, 48, 64]. Rainbow trout on powdered ginger rhizome diet for 12 weeks showed increased haematocrit, haemoglobin, erythrocyte, MCH, MCHC, WBC values and neutrophils percentage in comparison to the control group (p<0.05). De Pedro et al., (2005) [10] indicated that total and differential leucocyte counts are important indices of non-specific defense activities in fish. Also, they are centrally involved in phagocytic and immune responses to bacterial, viral and parasitic challenges (Houston, 1990) [23].

1.7. Traditional use
Ginger is known as Sunthi in Ayurveda and description of the plant appears in the old text like Charaka, Sushruta, Vagbhata and Chakra-dutta (Malhotra & Singh, 2003) [32]. The use of drug is mentioned in form of Trikatu, a famous Ayurvedic remedy for the treatment of digestive disorders. In Ashhtagha Hridaya, the plant has been used in Rasna Saptak Quath (a decoction based on seven medicinal herbs), and a traditional remedy of arthrosis. Pharmacologically, the drug in Ayurveda has been described as appetizer. It is also indicated in ointment form for local application in pains.

1.8. Phytochemistry
Ginger is a rich source of volatile oil. Zingiberol, zingiberene, phellandrene and linalool are important constituents of the oil. They account for the aroma of the drug. The pungency of the ginger is due to gingerols and shogaols. Investigations have shown gingerol and shogaols to be mutagenic.3 In addition, ginger contains a special group of compounds called diarylheptanoids including gingeronene (Kikuzaki et al., 1991) [28]. The standardization of the drug is based on presence of pungent principles of the plant.

2. Conclusion
Medicinal herbs are rich source of synthetic and herbal drugs. They contain a wide range of chemical compounds commonly referred to as phytochemicals. Ginger is a hot herb today and number of studies has shown it to be a useful medicinal agent. Its potential as an effective anti-inflammatory and anti-emetic agent cannot be ruled out. Zingiber officinale, ginger, is an important plant with several medicinal, ethno-medicinal and nutritional values used in traditional medicine. Ginger is consumed worldwide as a spice and flavoring agent and is attributed to have many medicinal properties such as cardio-protective, anti-inflammatory, anti-microbial, anti-oxidant, anti-cancer properties, etc. The ginger is used as growth promoter, antimicrobial agent, antioxidant and as immunostimulant in aquaculture. Gingerol, the active constituent of ginger has been isolated and studied for pharmacological and toxic effects. Large-scale clinical studies are required to justify ginger as suitable phytopharmaceutical drug although initial data seems to be promising.

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4. References
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