Thyme: A natural preservative for seafood

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Abstract

Nowadays, food preservation for a long time without any change in quality is a global issue. Currently, 25 categories of food additives have been defined. These compounds are used to extend the shelf life of foods by protecting them against microorganisms as well as chemical reactions. Medicinal plants, having proven antimicrobial and antioxidant properties are suitable candidates for this purpose. Among them, thyme with a wide range of bioactive compounds has been extensively studied. This plant belongs to the family *Lamiaceae* and has a particular situation in traditional medicine. Nowadays, thyme and its derivate present a wide range of functional possibilities in the pharmacy and food industry. This article discusses thyme's application as a food preservative in the seafood industry.

Introduction

In ancient history, medicinal plants were extensively used for different purposes. They were used as spices as well as the therapeutic agents used in wound healing, gastrointestinal disorders, and infectious diseases.[1] Moreover, several ancient civilizations have used various herbs, including Indians, Egyptians, Romans, and Arabs, due to their culture and traditions.[2] In consequence, it gave rise to the theocratic viewpoint detected in all ancient civilizations, such as Greece, which was before the advent of the Hippocratic School based on observation and performing experiments.[3] Thyme, which has been used as a supportive therapeutic agent for thousands of years, belongs to the family *Lamiaceae*. Scientists have identified over 900 species belonging to the genus Thymus – such as *T. serpyllum* (wild thyme) and *T. vulgaris* (common thyme) as the representative species – in several regions, including Europe, Northern Africa, Asia, Southern America, and Australia. The interest in these aromatic medical plants has been increased through the years.[4,5] In an investigation conducted by De Martino *et al.*,[6] several other species are noted as the species that are spread widely in the Mediterranean area, such as *T. satureioides* (Morocco), *T. willkomii*, *T. carnosus* (Iberian), *T. moroderi* (Spain), *T. grandulosus* (Spain and North Africa), *T. villosus*, *T. capitellatus*, *T. camphoratus* (Portugal), *T. longicaulis*, *T. poulegioides* (Italy), *T. lotocephalus*, and *T. herba-barona*. According to their analysis, up to 30 monoterpenes were found in the *T. vulgaris* essential oil, which led to varied chemical compositions of the derivative oils (the species plants) and resulted in the advent of various chemotypes. A study performed by Alu'datt *et al.*[7] illustrates the main active chemicals in thyme oil are hydrocarbon and phenolic compounds, such as borneol, carvacrol, cymol, linalool, thymol, tannin, apigenin, luteolin, saponins, and triterpenic acid. Asllani and Toska[8] indicated that *T. vulgaris* principally contains *p*-cymene (7.76%-43.75%), γ-terpinene (4.20%-27.62%), thymol (21.38%-60.15%), carvacrol (1.15%-3.04%), and b-caryophyllene (1.30%-3.07%). They also reported that ortho-cymene (7.76%–43.75% of entire phenolic content) and γ-terpinene (4.20%–27.62%) are amongst the main phenolic compounds in thyme oil. On the other hand, the significant hydrocarbon with alcohol group in thyme oil is comprised of linalool (1.48%–3.00%), borneol (0.50%–1.84%), terpinen-4-ol (0.48%–1.22%) and α-terpineol (0.17%–0.70%).

It was indicated that several constituents had antibacterial effects, including thymol, carvacrol, *p*-cymene, and terpinene. For instance, Tohidpour *et al.*[9] have proved *T. vulgaris* responsible for antibacterial effects against 14 clinical isolates of Methicillin-resistant *Staphylococcus aureus* (MRSA), which could be due to the impacts of thymol. Beyond its typical culinary and therapeutic applications, it has been recommended as a preservative in food based on antimicrobial and antioxidant activities.

Food contamination is considered a vital challenge toward the consumers' health. Several bacterial species could result in the spoilage of the food product as well as causing a food-borne disease in humans. In this regard, several pathogenic bacteria have been reported in seafood.[10,11]

A great deal of effort has been devoted to developing methods that can decrease contaminations and increase the shelf life of food products. Adding food additives enhances or adjusts the product's durability or features. This may include its appearance or organoleptic properties; however, it must not modify the current

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structure's nutritional values. It is believed that only limited amounts of the materials are added to food throughout production since they do not contain a considerable nutritional value, either natural or synthetic. Considering the strict regulations to use chemical preservatives, using natural compounds that can increase shelf life has been a matter of interest by researchers. It is proven that some synthetic (chemical) preservatives may have side effects, specifically if antibiotics are being used during production, which results in the development of resistant microorganisms.[12] Many safer approaches have been announced to prevent food spoilage, such as utilizing herbal, animal, and microbial products. Several studies suggest using ginger,[13] cumin and mint leaf,[14] red grape pomace,[15] thyme, clove, and rosemary extracts,[16] and oregano or thyme essential oil[17] as herbal preservatives. Also, as an animal product, chitosan can preserve food products because it contains some antimicrobial and antioxidant components.[18] They stated that the antimicrobial activity of chitosan is related to the amino and carboxyl groups located on the cell wall of bacteria or fungi. In addition, some bacteria, such as lactic acid bacteria, can produce antimicrobial by-products, including organic acids, which lead to preservative effects.[18]

Different spoilage rates have been identified in foods due to the various constituents. For instance, a higher spoilage rate is detected if more lipids are in the structure of the food. However, the previously mentioned literature review shows that thyme can extend the preservation period, depending on several factors, including the dosage and the conditions. Many reports indicate the effects of thyme on the microbial count and shelf life of seafood.[19-21] In this article, these effects will be discussed.

Antimicrobial effects

Many species of bacteria have been indicated to be responsible for food spoilage at refrigerator temperature, such as *Pseudomonas*, *Aeromonas*, and *Flavobacterium* genus Altunatmaz *et al.*[22] The antimicrobial effects of thyme have been reported several times.[23] Several compounds have been used against food microbial spoilage.[12] This property has been attributed to the active ingredients of this plant, such as thymol and carvacrol. Thymol and carvacrol express antimicrobial activity against essential microorganisms such as Escherichia coli O157:H7, *Staphylococcus aureus*, and *Listeria innocua*.[24] Thymol can be extracted from several plants such as *Thymus hyemalis, Thymus glandulosus, Thymus zygis, Thymus vulgaris, Origanum dictamnus, Monarda fistulosa, Origanum vulgare, Origanum onites* and *Origanum compactum*.[25] In vitro and In vivo antimicrobial effects of thyme and other plants containing thymol in the forms of raw material, extract, and essential oil has been frequently proven.[26-29] Magi *et al.*[30] elucidated the effectiveness of utilizing oregano or thyme's essential oils –retaining high contents of carvacrol and thymol – which could particularly inhibit Gram-positive bacteria's growth in comparison to Gram-negative bacteria. Additionally, it is informed of a reduction in campylobacter counts (0.5%) after carvacrol and thymol merged.[31] Some studies indicate TEO's antimicrobial activities, which may be used against several pathogenic organisms, including Aspergillus, Pseudomonas, Streptococci, Salmonella, Bacillus, Listeria and Fusarium.[32,33] In a recent study, Moumeni Shahraki *et al.*[29] reported that *T. caramanicus* was able to prevent in vitro growth of Aeromonas hydrophila. This bacterial species is an important pathogenic agent causing septicemia in many cultured and wild species.

The antimicrobial effects of thyme on rainbow trout fillets during cold storage were studied by Erkan *et al.*[20] The total microbial count reached 5.10 cfu/g in the fillets treated with thyme, according to the results. This value was lower than it in the fillets refrigerated without essential oil. Effects of thyme on fish fillets are presented in Table 1.[19,20,34-38]

Table 1. Preservative effects of thyme on fish fillet.

Medicinal plant	Sample	Effects	Reference
1. Thyme's essential oil 5% w/w	Mullet	Decrease microbial count Increase physicochemical composition No difference in sensory acceptance	[19]
2. Powder 1% w/w	Sea bream	Increase ice storage Increase physiochemical composition	[34]
3. Thyme's essential oil 1% w/w	Smoked rainbow trout	Decrease microbial count Increase physicochemical composition Decrease sensory acceptance	[20]
4. Thyme's essential oil 1% v/v	Channa argus	Increase refrigerated storage Decrease microbial count Increase physicochemical composition Decrease sensory acceptance	[22]
5. Combined oil nanoemulsion	Rainbow trout	Increase refrigerated storage Increase physicochemical composition Decrease microbial count	[35]
6. Thyme's essential oil	Rainbow trout	Increase refrigerated storage Decrease microbial count Increase physicochemical composition Increase sensory acceptance	[36]
7. Thyme's essential oil nanoemulsion	Rainbow trout	Decrease microbial count	[37]
8. Thyme's essential oil with guar gum	Tilapia	Increase physicochemical composition Increase sensory acceptance	[38]

Antioxidant effects

Lamiaceae plants are well known to contain a high level of antioxidant constituents. It is stated that based on the antioxidant components found in the thyme extract, scientists identified radical scavenging effects in various in vitro and in vivo conditions. Previously, using an unsaturated lipid system, it was hypothesized that 1% of oregano impacted the regulation of mackerel oil's oxidation similar to 200 ppm Butylated Hydroxyanisole (BHA). Many studies have indicated the thyme's protective effects on food.[36-38]

According to a previous report, adding thyme powder (1% w/w) to fish fillets during ice storage resulted in preservative impacts from witnessing exceptional lower levels of TVB-N, TMA-N, free amino acids (NPS), TBA, and LHC. Also, the antioxidant features of various thyme species have been illustrated based on a modified Thiobarbituric Acid (TBA) reactive substances assay (TBARS).[39] They reported that the species expressing high antioxidant properties were carvacrol-, thymol- or p-cymene-rich oils. According to an experiment reported by Ozogul *et al.,*[35] a considerable difference was identified when the fillets were treated with thyme compared to the control group. Thyme had also resulted in a pH decrease in fillets compared to other plant extracts such as rosemary. It shows the antioxidant activity of thyme in preventing ammonia production after a prolonged storage period. Equivalently, in research treating fillets with thyme, it was announced that the TVB-N level of rainbow trout's flesh was less than 20 mg/kg, which was tolerable.

Conclusions

Different forms of thyme have been investigated as natural antimicrobial agents and antioxidants for food preservation. Based on the literature review, this plant can increase shelf life – which varies from 3-15 days – and decrease the microbial count of fish fillets. The most common dosage of thyme was 1%, and higher dosages may affect the sensory properties of the food, as reported in some studies.

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