Mar. Sci. Tech. Bull. (2021) 10(1): 71-84
e–ISSN: 2147–9666
info@masteb.com

dergipark.org.tr/en/pub/masteb
www.masteb.com
DOI: 10.33714/masteb.771756

Marine Science and Technology Bulletin

REVIEW

A review on turmeric (*Curcuma longa* L.) and usage in seafood

Nilgün Güneri[1*]

[1] *University of Sinop, Fisheries Faculty, Department of Fish Processing Technology, Sinop, Turkey*

ARTICLE INFO

Article History:
Received: 20.07.2020
Received in revised form: 12.10.2020
Accepted: 12.10.2020
Available online: 03.12.2020

Keywords:
Turmeric (Curcuma longa)
Curcumin
Antioxidant
Natural colorants
Human health
Seafood

ABSTRACT

Seafood stands out as an important protein source for human nutrition. Providing food safety, increasing food production and processing, preventing nutrient losses, preserving the quality of food, and extending shelf life have gained importance. Thus, the use of food additives has been a technological must. Turmeric (*Curcuma longa* L., Zingiberaceae) is obtained from the root of the *Curcuma longa* plant, a fiber plant from the ginger family. It is a plant with polyphenolic effects. Curcumin (diferuloylmethane) is the most active ingredient of turmeric. It has an antioxidant effect. Turmeric has been found to have anti-inflammatory, anti-carcinogenic, and antiatherogenic effects. Turmeric is used in smoked meats, pickles and some cakes, seafood, fish soup and other soups, rice, cold cuts, and various vegetable dishes. Turmeric has a very important role in maintaining the nutritional quality of seafood products, extending the shelf life with its antioxidant and antimicrobial effect, increasing the attractiveness of seafood by adding color and flavor and obtaining healthy products.

Please cite this paper as follows:

Güneri, N. (2021). A review on turmeric (*Curcuma longa* L.) and usage in seafood. *Marine Science and Technology Bulletin*, 10(1): 71-84.

Introduction

Today, one of the most important problems of our world, which is in a rapid change in social, cultural and economic terms, is nutrition with adequate, balanced and healthy foods. It is stated that seafood is the only dietary food that contains protein, fat, carbohydrates, vitamins and minerals in a balanced and proportionate form for healthy nutrition, growth, development and survival (Koral, 2006).

Seafood is one of the most valuable food substances in terms of the nutrient components it contains. In addition to the fact that its diabetic characteristics, especially due to its low energy value, containing high amount of unsaturated fatty acid, very high protein rate and being easy to digest, it contains almost most of the amino acids in nature, is rich in minerals and vitamins and has high biological value. These factors include seafood among the valuable and quality foods and make it an important raw material in catering technology. Fish is preferred by consumers due to its low fat, cholesterol and calories. Since it is abundant and cheap, and also can be replaced with the decreasing natural stocks by aquaculture, it has become more

* Corresponding author
E-mail address: nilguneri1@hotmail.com (N. Güneri)

and more important in the world day by day (İnal, 1988; Gülyavuz and Ünlüsayın, 1999).

Seafood is an important source of protein for human nutrition. They contain about 11-25% protein. The total muscle protein has consisted of 30% sarcoplasmic protein, 60-40% myofibrillar protein and 10% stroma (connective tissue) protein (Çaklı, 2007).

It is stated that seafood meat contains less common essential amino acids in other foods such as valine, leucine, isoleucine, lysine, threonine, methionine, phenylalanine, tryptophan, arginine, histidine in the most convenient amounts in addition to amino acids commonly found in other foods such as aspartic acid, serine, proline, alanine, taurine, glycine, tyrosine (Gülyavuz and Ünlüsayın, 1999).

Apart from protein, fish meat also contains non-protein nitrogenous substances. These substances are responsible for both flavor and spoilage. Fish meat is a food rich in fat-soluble vitamins (A, D, E, K), especially vitamins A and D (Göğüş and Kolsarıcı 1992; Gülyavuz and Ünlüsayın, 1999).

Fish meat is easy to digest and is excellent food in terms of the high protein (rich in lysine and isoleucine) and fat (due to ω3 and ω6 unsaturated fatty acids, EPA and DHA in fish oils, especially in oily fish such as salmon, mackerel, tuna, pike, garfish, trout, anchovy) (Altun et al., 2004).

Fish and seafood are shown as healthy food by health institutions in many parts of the world. It is stated that especially omega-3 and omega-6 fatty acids protect against some important diseases such as coronary heart diseases and cancer (Atar and Alçiçek, 2009).

The food industry, with its changing consumption habits, is turning onto methods to produce healthier and safer foods (Barazi and Erkmen, 2010).

Compared to other meat products, seafood can spoil faster due to its high water content and weak connective tissue. Many seafood processing techniques have been applied to slow this deterioration. These processing technologies are increasingly diversified through advancing knowledge and experience. However, while this increase is being realized, traditional methods are not abandoned completely, but are evaluated and developed (Varlık et al., 2004; Alçiçek and Bekcan, 2009).

In addition to the fresh consumption of seafood today, it has an important place in the processing sector due to being processed with various processing technologies. Technologies such as drying, salting, smoking, cold preservation, freezing and marinating are some of the processing methods used for preserving seafood. It is known that the demand for processed products has increased due to reasons such as developing technology, rapidly increasing human population and the increasing number of working women. Moreover, Turkish people are more selective in terms of healthy nutrition. They show a tendency to both processed and healthy products. While extending shelf life is an important criterion, it is equally important to preserve the nutritional content of the product, to add flavor to the product and also to obtain a healthy product.

General Information

Since the existence of mankind, food preservation has been necessary for the continuity of life. Due to the changing eating habits over time and the increase in the number of employees, the development of ready-to-eat foods has become mandatory. Along with the developments in food processing methods and the acquisition of new products, it is aimed to extend the shelf life of the products obtained and to maintain their quality. In this way, seafood that is hunted abundantly in certain periods can be offered to human consumption when they are less (Gram et al., 2002).

Due to many requirements such as increasing need for long-term preservation of seafood without spoiling in accordance with hygiene and sanitation rules, processing product when it is abundant and consuming in other seasons, processing it with suitable methods and making use of the wastes in terms of economy, making it ready to use the product and providing convenience for consumer and diversity for products, it has become important to utilize seafood by processing in recent years (Anonymous, 2001).

Today, increase in consumption and processing of food based on the relationship between the development of the industry and consumption and production of food has made the use of food additives a technological must. Increase in the number of people working outside the home, changing eating habits, having less time for preparing food or the desire to spend little time for preparing have encouraged the production of semi-ready or commercially completely ready food and this situation has made the use of food additives inevitable (Toprak et al., 2002; Angiş and Oğuzhan, 2008).

Providing food safety and security is one of the most important issues of today. In providing food security, increasing food production and preventing nutrient losses, preserving their quality during the period between when the food is abundant and less and extending their shelf life have gained importance. The use of food additives has become inevitable in this case, too (Yurttagül and Ayaz, 2008).

One of the Food Additives: Colorants

The definition of food additive included in the Turkish Food Codex regulation published in the Official Gazette dated 16 November 1997 is as follows: They are substances which cannot be consumed as food alone or used as a food raw material and either has nutritional value alone or not; their residue or derivatives can be found in the product during the process or manufacturing used by the technology chosen; they are allowed to be used to preserve the taste, smell, look, structure and other qualifications of the food during the period of production, classification, processing, preparation of the food or to prevent the unwanted changes in the given qualifications and stages (TGKY, 2010).

When historical developments regarding the use of chemicals in foods are examined, it is understood that salt and wood smoke is the oldest known additive use methods. It is seen that the use of food dyes dates back to the Egyptians in 3500 BC, around 3000 BC salt was used to store meat and seafood, and around 900 BC both salt and wood smoke were used as food storage methods. In addition to salt and wood smoke in the middle ages, nitrate is added to the meats to prevent botulism and it has been noticed it changes the color of the meat in a positive way and makes it look healthier. 50 BC spices have been used as flavors and in parallel with the rapid urbanization in Istanbul during the 19th century, the use of additives has become widespread, especially to protect food against spoilage. Today, these substances have formed an indispensable part of developing food technology (Altuğ, 2009).

Ensuring nutritional quality, achieving a reduction in residual rate, and helping processing by performing quality and endurance are the characteristics sought in food additives used in foods. A food additive should not hide processing and production errors, deceive the consumer, and reduce the nutritional value of a food. The categories of food additives according to their intended use are indicated on the packages of convenience foods with their special names and "E (European)" numbers according to the category. To indicate that a food additive is allowed to be used in the European Union (EU) countries, it is assigned the number "E". "E" numbers are introduced by European Union countries as a practical coding method for food additives. "E" at the beginning of the number symbolizes the EU (European Union). "E" numbers and special names allow food to be easily recognized during export and import. In the classification of food additives according to the basic functions with the "E" number system, Colorants are numbered with E 100180 (Sağlam, 2000).

Codex Alimantarius Comission (CAC) has been founded with the cooperation of World Health Organization (WHO) and Food and Agriculture Organization (FAO). Every year in the meetings they hold about food additives, after the approval by international organizations such as Joint Expert Committee on Food Additives, Scientific Committee on Food of European Commission and Food and Drug Administration of USA, Joint Expert Committee on Food Additives decides which foods can be added to which food and to what extent. They prepare suggestive standards for all countries (Çalışır et al., 2003; Yurttagül and Ayaz, 2008).

Colorants and sweeteners are defined by the Turkish Food Codex in the "Declaration of Communicators Used in Foods (2002)". According to this declaration, colorants are defined as substances that are not consumed as food alone or used as the main ingredient in foods and are added to the food as color enhancers or color regulators (Anonymous, 2002).

Colorants, dyes and pigments are used to gain consumer admiration, strengthen natural color, to regain color lost during processing of food or to color a product that is colorless. Some of the colorants have been found to be toxic and carcinogenic and their use is prohibited. Health problems associated with coloring agents that are allowed for use are hypersensitivity reactions (Yurttagül and Ayaz, 2008).

Use of plants by mankind as paint dates back centuries. Therefore, dye plants have become the main dyestuff of industrial products such as textiles, food, leather, etc. Our country is one of the richest countries in Europe and the Middle East in terms of vegetation with its nearly 10,000 plant species. Parallel to this rich flora, the number of plants used in natural dyeing is quite high. There are nearly 150 plant species used in natural dye production in our country. Some of these plants are turmeric, elecampane, licorice, common juniper, and sage (Mert et al., 1992).

Food dyes, which constitute an important group in food additives, are used in the industry for various purposes such as preserving, increasing, or modifying the existing and typical color available, controlling color change and deterioration, standardizing the appearance, adding decorative features or creating new products. Food dyes should not be used to raise low quality and mislead the consumer and should not be harmful to health. Use for these and similar purposes have been brought under control through legal regulations (Newsome, 1990; Karaali and Özçelik, 1993; Yentür et al., 1996).

Food dyes are additives used in confectionery, food eaten between meals, soft drinks, pastries, and many foods such as gelatin desserts (Furia, 1980; Yentür et al., 1996).

Color is one of the first characteristics of food that attract people. A conventional color is desired in foods to be consumed. There is more or less loss of color when processing raw materials. Colorants are substances added in food production to correct changes in a color loss that occur during processing or at the end of the process, that is, to correct the color of food or to color food. Color substances are also important for creating a standard color in the product technologically (Anonymous, 2002; Batu and Molla, 2008).

Color is the first sensory parameter about food quality and taste. In this sense, synthetic dyes constitute an important class of food additives. It has been known for years that the use of dyes as food additives makes food ingredients more aesthetically and psychologically attractive. Besides, dyes are widely used to provide the desired color in foodstuffs that lose their natural color during production and storage (Altınöz and Toptan, 2003; Tripathi et al., 2007; Yentür et al., 2009).

The colorants are used to regain the natural color lost during processing and storage, to strengthen the weak color, to color the actually colorless food, and to gain consumer appreciation by hiding low quality (Topsoy et al., 1991).

As the additives are chemicals, their excess is harmful to health. Adding these colorants more than the allowed amounts may increase health risks (Batu and Molla, 2008).

According to the way they are obtained, the colorants are divided into two as natural and artificial colorants. Natural colorants are obtained from microbial, vegetable, animal, and mineral sources. The color stability of natural colorants is very low against physical and chemical effects. The majority of natural colorants are low in water solubility. Anatto, anthocyanin, canthaxanthin, plain caramel, carotenes and chlorophylls are examples of natural colorants. The substances that are not found in nature due to their chemical structure and obtained by chemical synthesis are artificial colorants. Artificial colorants are more preferred in the food industry in terms of their physicochemical properties. Artificial colorants are easily soluble in water and oil (Altuğ, 2009).

In recent years, synthetic and natural colorants are used in some foods to eliminate the discoloration applied to food processing techniques and related color disorders. Moreover, color materials are used to provide homogeneous color distribution in the product, to make its appearance attractive and to color the food with new formulations (Saldamlı and Uygun, 2004).

Turmeric (Curcuma longa L.), One of the Spices Used in Foods

People have used spices and aromatic herbs not only to add flavor and smell to food, but also to mask the impaired taste and smell of spoiled meat, to obtain body odors, to treat wounds, to have a clear mind. In addition to using spices for color (turmeric, saffron, paprika, red pepper), fragrance (clove, cinnamon, cumin, black pepper, rosemary, sage), they are also used in some cases to extend the shelf life of foods with their antioxidant and antimicrobial effects (Wilson, 1993).

International Organization for Standardization (ISO) defines spices and condiments as natural herbal products or mixtures used to add color and fragrance to foods (Abbas and Halkman, 2003).

It is known that most of the spices used in foods are contaminated with varying degrees of bacteria, yeast and mold. Since the plants from which spices are obtained are in contact with the soil and water, which are the source of many bacteria and fungi, they are naturally contaminated with these microorganisms (İnal, 1969).

Another reason for contamination is that many spices are grown and harvested in regions where hygiene conditions are not sufficient. Spices are usually laid and let to in areas such as fields and stream beds that are exposed to high levels of contamination and dried. Additionally, growing spices in hot and humid areas also increase the risk of mold and bacteria contamination (Tainter, 1992).

If contamination in the contaminated spice is not eliminated, the deterioration caused by the lack of sanitation in processed foods causes food poisoning and foodborne diseases (Hayashi et al., 1994).

Spices are usually cooked with food, but microorganisms in the form of spores remain alive during the cooking process, causing a proliferation in products stored in improper conditions during storage and distribution. The microflora in the spice shortens the shelf life of the products, moreover, it causes spoilage and foodborne diseases. These bacteria generally cause spoilage in products such as pickles, salami, sausage and canned food (Abbas and Halkman, 2003).

The place of turmeric (*Curcuma longa L.*) in the systematic is shown in Table 1 (Aggarwal et al., 2005).

Table 1. The place of Turmeric (*Curcuma longa* L.) in the systematic

Systematic Classification	Nomenclature
Kingdom	Plantae
Division	Magnoliophyta
Class	Liliopsida
Order	Zingiberales
Family	Zingiberaccae
Genus	*Curcuma*
Species	*Curcuma longa* L.

Turmeric (*Curcuma longa* L., Zingiberaceae) is obtained from the root of the Curcuma longa plant, a fiber plant from the ginger family. It is a plant with polyphenolic properties. Curcumin (diferuloyl methane; 1,7-bis- (4-hydroxy-3-methoxyphenyl) -1,6-heptadiene-3,5-dione) is generally known in the literature as turmeric (*Curcuma longa*) (Aggarwal et al., 2005).

The Latin name of turmeric is *Curcuma longa*, in English, Indian Saffron (turmeric) and in Persian “zerd-çubi”. Other names are saffron root, yellow dye, curcuama domestica and

Indian saffron. Turmeric is a fragrant, perennial herbaceous plant with fleshy rhizomes, large and pointed leaves, yellow flowers (Mert et al., 1992). The plant can grow up to 1-2 meters in height. It has long dotted leaves and funnel-shaped flowers. The main rhizomes of the plant under the ground (finger-shaped roots) are egg-or pear-shaped. Its side rhizomes are finger-shaped. The upper side of the rhizomes is yellowish and the inner side is yellow. It has a bitter taste. Turmeric is often used as a coloring agent in foods. It also contains tetrahydrokurcumin, an odorless and heat-resistant antioxidant compound. It has a mild aroma and a sharp taste similar to ginger (Craig, 1999).

It is available on the market in the form of fingers (rhizome) and powder. The rhizomes (root tubers) of the plant are used. The active ingredients of these rhizomes are: Curcumin, eugenol, cinnamic acid, limonene, linalool, turmerone, vanillic acid, calcium, iron, manganese, potassium, phosphorus, zinc, vitamins B, B2, B3 and C. Curcumin (diferuloylmethane) is the most active ingredient of turmeric (Aggarwal et al., 2003).

It contains essential oil, resin, and curcumin. But its active ingredient is curcumin (contains 36%) and its color is bright yellow. Curcumin is isolated from turmeric, which has been used as a spice that gives yellow color in dishes for a long time, and is produced from the yellow powder of *Curcuma longa* which is a tropical plant. It is a polyphenolic herbal compound consisting mainly of small molecules. It has an antioxidant effect and no toxic effects (Ammon et al., 1991).

The part of the turmeric used is its powdered root (Figure 1). Turmeric powder contains curcumin in the ratio of approximately 1:30 to 1:100. The use of 1 dessert spoon of turmeric, with its top wiped, (an average of 3 grams) contains an average of 30-90 mg of curcumin. Turmeric has been found to have anti-inflammatory, anti-carcinogenic and antiatherogenic effects at 200 mg/day doses (about 2-4 dessert spoon of powder with its top wiped) (Ammon and Wahl, 1991; Aggarwal et al., 2003).

Figure 1. Plant and powder form of turmeric (*Curcuma longa*)

It is known that turmeric has been used worldwide for 4000 years. Its miraculous features have not been reflected in past literature, including Ottoman records. While tea, tincture and extract of almost all plants in nature can be made, this process has not been possible in turmeric. After a European scientist discovered curcumin, the active ingredient of turmeric in the early 1900s, it has been noticed in the last 20 years as a result of technological researches even though it was late and intensive clinical researches have been started (Aggarwal, 2013).

Although turmeric, which is one of the basic elements of curry powder, is used as a spice in the west, it has been used as a natural remedy in Asia for a long time. Turmeric has also been used to treat stomach and liver problems in Asia. Turmeric, which entered Turkish cuisine in the 16th century, was used as a natural dye to give yellow color to the saffron rice dessert called *zerde*, a name similar to turmeric in Turkish. Even though the first purpose in history was dyestuff for fabrics and yarns, its use for health purposes has largely surpassed its use for spice today (Karaman and Köseler, 2017).

It is also called “Indian saffron” since dyed substance resembling saffron is obtained from the stems of this plant. Turmeric is generally used in making *zerde* instead of saffron due to its high price. Dried turmeric is used as a spice and in making curry, it gives the curry yellow color. With its bright yellow color, turmeric has been used as paint, medicine and spice since the 600s BC. Marko Polo has described turmeric as “a vegetable that replaces saffron, but is not saffron”. Its homeland is South Asia. It grows in the tropical regions of Asia, primarily Pakistan, India, China, Bangladesh and Indonesia. Indonesians used to use this spice to paint parts of their bodies during wedding ceremonies. It is cultured in tropical countries. Turmeric is also grown in Turkey. Although it is mostly used as a spice in the West, it has been used as a natural medicine for a long time in Asia. Turmeric, which we know as a household remedy and spice, actually plays an important role in the prevention and even treatment of many diseases. Its healing properties have been proven in the Indian and Chinese medical systems. It is widely used in the treatment of many diseases (Ammon and Wahl, 1991).

Turmeric is applied locally in skin diseases, insect bites and chickenpox in India (Nadkarni, 1976). It has been used as a supplement to alternative medicine in wound healing for many years (Sidhu et al., 2002). Apart from the purpose of coloring in food and clothing products, it was recommended because it shows bactericidal activity against *Escherichia coli* and *Staphylococcus aureus*, and this activity has been proven microbiologically (Shinyoung, 2005). It is still used in India as an antimicrobial agent (Negi et al., 1999).

The benefits of turmeric can be listed as follows:

It has an antioxidant effect. The antioxidant effect of curcumin is stronger than vitamins E and C. It has anti-inflammatory properties. Turmeric is beneficial for the liver. It strengthens the liver and helps remove toxins from the liver. It is used in the treatment of respiratory infections. Curcumin protects against cancer and has an anti-proliferative feature. Studies have shown that it can be beneficial for skin, colon, esophagus and breast cancer. Another of the benefits of turmeric is its effect against the functional diseases of the gallbladder and biliary tract. Experimental studies have shown that turmeric has a cholesterol-lowering effect. In the study, it was also seen that it can prevent heart diseases. Using turmeric facilitates digestion and helps flatulence. It has been seen in a study that it can significantly reduce the harm caused by smoking. It has been used in the treatment of conditions such as calcification and dementia. It is externally useful for skin conditions (Aggarwal, 2013).

Turmeric is used in smoked foods, pickles, and some cakes. It is used in some dishes, the mixture of curry, mustard, sauces for chicken meat, in some desserts, especially *zerde*, a dessert served at weddings in Anatolia, and gives it its yellow color. It is also used in seafood, fish soup, egg dishes, soups, rice, cold cuts, and various vegetable dishes. It is used especially in Indian and South Asian cuisine. On the other hand, turmeric is used for dyeing silk fabrics and thin leathers and as a colorant in henna. Moreover, turmeric paper was used instead of litmus paper in the past. The parts of turmeric used are their fruits. To use it as a spice, the turmeric plant must be boiled in water after being cleaned, or dried after steaming, and the dark yellow root stems must be ground. After powderize the dried fruits, it can be used as a spice or turmeric tea, which can be prepared by boiling in water. It should be stored in cool, dry, and dark places (Özer, 2010).

The Effects of Turmeric on Health

Turmeric has been shown to have strong antioxidant and anti-inflammatory effects. However, the use of doses of turmeric to provide the same therapeutic effect for this effect should be accurate daily, it is not advisable to use a high dose in once. Turmeric is generally a reliable food material as long as there is not much consumption in healthy individuals and there are no side effects (Karaman and Köseler, 2017).

Even if all the nutrients and substances in nature are beneficial for human health, they can turn into a harmful substance when consumed too much. There is an amount that each substance affects and this amount should not be exceeded. Studies have shown that the tolerability and safety of polyphenol is not toxic even at doses up to 8 grams per day, but a clear dose and active ingredient to illuminate this subject have not been determined. Nutritional Content of Turmeric is shown in Table 2. (Karaman and Köseler, 2017).

Oxygen Radical Absorption Capacity (ORAC) value, which shows the antioxidant capacity of foods, is 44.776 in turmeric. With this value, turmeric ranks first in the list of spices with the highest antioxidant capacity. ORAC is a scale that is called free radicals in our body that indicates the absorption of substances that cause many diseases, especially cancer, that is, it is used for nutrients that indicates the absorption value. A high ORAC value indicates that food is more antioxidant, protects against cancer and delays aging. ORAC is a scale that indicates the absorption value of the substances called free radicals in our body that cause many diseases, especially cancer, and is used for foods. A high ORAC value indicates that food is more antioxidant, protects against cancer and delays aging (Karaman and Köseler, 2017).

Turmeric can be used in the form of capsules, liquid essence and tincture, containing powder for adults. The cut root of turmeric can be used 1.5-3 g daily, dried powdered turmeric root 1-3 g daily can be used. Also, a standard powder (curcumin), 400-600 mg, can be taken 3 times a day. Liquid extract (1:1) is recommended to consume 30 to 90 drops per day, 1 dose in the morning and 1 dose in the evening (1 part is 5ml). Fresh turmeric can be stored for several weeks in a cool dry place. When olive oil is consumed together with black pepper and chili pepper, its absorption is much higher. It can be preferred in Indian dishes as a sauce, stews, Turkish dishes, and in all cuisines such as noodles and pasta. It can be used especially in salads, rice and meat dishes to increase the flavor of the food and the consistency of the sauce, to give the food a yellow color. It can be added to the dishes by mixing with honey. It is also added to fish soup, cold cuts and various vegetable dishes as a seasoning. It is used in the famous "paella" dish of the Spanish, and in the "curry" sauce of the Indians. Turmeric can also be used as tea. Its use as tea is popular in Asian countries, especially in Japan (Aggarwal, 2013).

Curcuma, the active ingredient of turmeric, prevents cancer and Alzheimer's, protects from heavy metals, heals the liver, and is also a powerful antioxidant. But for this effect of turmeric, the doses that will provide the same therapeutic effect in daily times should be correct. Curcuma is great when it is pure and in small quantities, but its taste is bitter and less enjoyable when taken in larger doses. It is not recommended to use high doses at once (Änderung, 2017).

Curcumin is absorbed very little in the human body when taken alone and is rapidly excreted from the intestines. For this reason, many studies have been conducted on the substances that will increase the bioavailability of curcumin, and it has been suggested that the piperine contained in black pepper can increase the absorption of curcumin by 2000% (20 times). Due to the rapid metabolism of turmeric in the liver and intestinal walls, its bioavailability is tried to be improved through piperine, which increases the absorption of all nutrients. Very

Table 2. Nutritional content of turmeric

Nutritional Ingredient	Spice Powder (100gr)	Vitamins	Content	Minerals	Content
Water	12.85gr	Vitamin C, total ascorbic acid	0.70 mg	Calcium, Ca	168 mg
Energy	312.00 kcal	B^1, thiamine	0.058 mg	Iron, Fe	55.00 mg
Protein	9.68 gr	B^2, riboflavin	0.150 mg	Magnesium, Mg	208 mg
Total fat	3.25 gr	B^3, niacin	1.360 mg	Phosphor, P	299 mg
Carbohydrate	67.14 gr	B^6, pyridoxine	0.107 mg	Potassium, K	2080 mg
Total fiber	3.25 gr	B^9, folic acid	0.00	Sodium, Na	27 mg
Total sugar	3.21 gr	Folate (total)	20 qg	Zinc, Zn	4.5 mg
Sucrose	2.38 gr	B^{12}	0.00	Copper, Cu	1.300 mg
Dextrose	0.38 gr	Vitamin D	0.00	Manganese, Mn	19.800 mg
Fructose	0.45 gr	Vitamin A, IU	0.00	Selenium, Se	6.2ug
FATS		Vitamin E, (α tocopherol)	4.43 mg		
Total fatty acid saturated	1.838 gr	Vitamin K	13.40 qg		
Total fatty acid monounsaturated	0.449 gr	Others			
Total fatty acid polyunsaturated	0.756 gr	Caffeine	0.00		
Total fatty acid trans fatty	0.58 gr				
Cholesterol	0.00				

little of curcumin is absorbed if such an improvement is not used, and even doses up to 4,000 mg can be completely inactive. Scientific researches show that the active ingredient of turmeric, curcumin, is a difficult substance to absorb, and accordingly, it has poor bioavailability as well. Scientific researches also show that piper, the active ingredient of black pepper, increases the absorption of substances that are difficult to absorb. Taking these two substances together with an oil rich in unsaturated fatty acids further strengthens this benefit (Rajinder et al., 2002).

With the widespread use of natural additives in the food industry, the interest in natural antioxidants in plants around the world is increasing day by day. Our country has an important potential in terms of production and export of some herbs and spices. With the widespread use of natural additives in the food industry, the interest in natural antioxidants in plants around the world is increasing day by day. Our country has an important potential in terms of production and export of some herbs and spices. Knowing the antioxidant and antimicrobial properties of these herbs and spices will make an important contribution in extending the shelf life of food products (Çoban and Patır, 2010).

Lipid oxidation is an important problem that limits the shelf life of foods and causes quality loss. Synthetic antioxidants have been used for many years to control lipid oxidation. However, many studies have found that the use of these substances has negative effects on human health. Hence, consumer preferences have shifted to natural products, and the use of herbs and spices as antioxidants has come to the fore. Foods rich in polyunsaturated fatty acids are exposed to oxidative deterioration. Oxidative deterioration is one of the important factors that limit the shelf life of food products and cause quality loss. In industrial processes, synthetic antioxidants are mainly used to prolong the preservation of nutrients. However, many researchers point out that some synthetic antioxidants used in food processing for a long time have carcinogenic and teratogenic effects in the living organism. Consumers generally prefer natural antioxidants over synthetic ones. Thus, spices and natural aromatic herbs that are used as additives to increase the properties of nutrients such as smell and taste have become increasingly important. The antioxidant effect of phenolic compounds found in the structures of these plants derives from their properties such as cleaning free radicals, compounding with metal ions and preventing the formation of single oxygen. Some of these herbs and spices have been proven to have more antioxidant capacities than synthetic antioxidants. Because of the flavors and aromas peculiar to them and antimicrobial and antioxidant properties, herbs and spices that have a wider bioactivity profile are natural antioxidant substances that can be used as an alternative in the food industry. Prevention of lipid oxidation in foods with such natural substances is very important for the producer and consumer. In this context, turmeric has a very important place among natural antioxidants with its strong antioxidant effect (Altun et al., 2004).

Turmeric is used for dyeing silk fabrics and thin leathers and as a colorant in henna. Besides, turmeric paper used to be used instead of litmus paper in the past. It is added as a seasoning to fish soup, rice, sauces, chicken bouillon, pickled cheese, cold cuts and various vegetable dishes. It is used in the famous "paella" dish of the Spanish, and the "curry" sauce of the Indians. It is reported that turmeric, which has great importance in Indian medicine, is used in the treatment of cold, cough, liver disorders, rheumatism, sinusitis, and anorexia. It is also used in Ayurveda for blood purifiers, tonic, and skin diseases (Çoban and Patır, 2010).

Turmeric, which is generally used as a coloring agent in foods, contains tetrahydro-curcumin as an active ingredient, which is an odorless, heat-resistant, antioxidant compound. The molecular formula of curcumin, which melts at 184 degrees, is $C_2H_2O_6$ and makes up 3-5% of turmeric. It is soluble in acetone and ethanol, but insoluble in water. The chemical structure of the curcuminoids is shown in Figure 2. (Çoban and Patır, 2010).

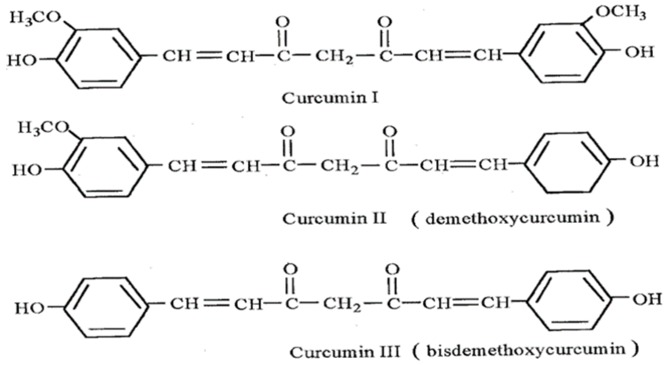

Figure 2. The chemical structure of the curcuminoids (Jayaprakasha et al., 2005)

Studies on Turmeric

In study, hot smoked needlefish (*Belone belone euxini*, Günther 1866) marinated in brine which was added turmeric (*Curcuma longa* L.) and sunset yellow FCF, storage in the refrigerator conditions. The determination of these product shelf lives was aimed at using freshness control methods like chemical, microbiological and sensorial. The amount of Total volatile basic nitrogen (TVB-N) and Thiobarbituric Acid (TBA), the number of Total mesophilic aerobic bacteria, Total psychrophilic bacteria, Total yeasts and molds increased during the cold storage. Effects of turmeric and sunset yellow FCF uses on the sensory freshness control methods like appearance, smell, taste, texture, and saltiness scores were significantly ($p<0.05$). According to the sensory freshness control methods, the shelf life of hot smoked Needlefish kept in the refrigerator has been determined as 17 days. It has been observed that the use of turmeric instead of Sunset yellow FCF can provide positive changes in the appearance, taste, and texture of the product that may appeal to the consumer. It has also been found to have a positive effect on the increase in the consumption of smoked garfish. Thus, the use of turmeric, which is a natural colorant where more positive results are obtained, instead of artificial colorants that may be harmful to human health, has been suggested in terms of both making the color that is impulsive to the consumer in the product attractive and increasing the consumption of the smoked product (Özer, 2010).

In a study conducted in Scotland, the content of mold and yeast in the ground spice mixture was analyzed and no mold was found only in cloves. It has been found that the least mold in the spice examined was turmeric with 50 cfu/g and the highest was black pepper with $6.4x10^5$ cfu/g (Flannigan and Hui, 1976).

In another study conducted in India, it has been observed that the dominant microflora in turmeric, red pepper, and ginger samples consist especially of Bacillus species such as *B. cereus, B. subtilis, B. polymyxa* and *B. coagulans* (Seenappa and Kempton, 1981).

Researchers have done microbiological analyzes in commonly used spices such as packaged and unpackaged turmeric, red pepper, black pepper and coriander. While the total number of bacteria in the packaged samples is 1.3×10^5 cfu/g on average, they have not detected a significant change in the total number of bacteria in the packaged and unpackaged samples. In the vast majority of the samples analyzed, they have found coliforms in numbers ranging from 0>1100/g. *Aspergillus niger* and *Aspergillus flavus* were identified as the dominant molds isolated from both groups of samples and no yeast has been found in any sample (Shamshad et al., 1985).

Researchers have investigated the development of *Aspergillus parasiticus* in black pepper, turmeric, red pepper, dried ginger and cardamom, which are autoclaved whole, ground, surface sterilized, and forming aflatoxin. They have found that black pepper and turmeric is an insufficient substrate for fungal growth and aflatoxin production (Madhyastha and Bhat, 1985).

In another study, the researchers have investigated the distribution of microorganisms in 15 samples of selected spices. They have reported that the total number of bacteria in turmeric, black pepper, white pepper, rosemary and basil is between 3×10^3-5×10^7 cfu/g. They have also stated that coliforms are determined between 2×10^2-2×10^6 cfu/g in 8 samples and *Bacillus pumilus* and *Bacillus subtilis* are the aerobic spore-forming bacteria (Muhamad et al., 1986).

Turmeric, red pepper, "Garammasala", ground black pepper, "Tandori masala", coriander, ginger, mustard, garlic, paprika and curry have been checked for the presence of bacteria that cause food poisoning. The results have shown that the total bacterial load in all spices, except garlic and mustard, is more than 5×10^6 cfu/g at 37°C. The dominant microflora *Bacillus spp.* consists of *B. subtilis* and *B. lichenif ormis*.

Escherichia coli, *Salmonella spp*., *Clostridium perfringens*, *Bacillus cereus* and *Staphylococcus aureus* could not be isolated (Chattopadhyay et al., 1986; Abbas and Halkman, 2003).

It has been observed that the ground and prepackaged turmeric, black pepper, red pepper and coriander spices are heavily contaminated with bacteria and molds, and the total number of bacteria is 10^5-10^7 cfu/g, the total number of molds is 10^2-10^6 cfu/g (Munasiri et al.,1987).

Irradiated (10 kGy) and non-irradiated, pre-packaged whole and ground black pepper, red pepper and turmeric have been analyzed in 6 different laboratories in India to determine their microbiological quality. In 3 of 6 laboratories, it has been stated that no colony development detected while in the other 3 laboratories at a level of 0-90 cfu/g counting has been noted in irradiated samples. All of the laboratories have specified that no *E. coli* and *B. cereus* found in irradiated spice (Sharma et al., 1989).

In the study, in which the effect of irradiation at 0.5 and 10 kGy dose on the color value of dry turmeric and 3 red pepper samples are investigated, it has been observed that gamma radiation does not cause any change in the color values of turmeric and red pepper when stored for up to 1 year in room conditions (Chatterjee et al., 1998).

The researchers state that about curcumin, which is the main component of turmeric, has therapeutic properties in many chronic diseases in which inflammation plays a major role, as well as its preventive and curative effects in various types of cancer. In addition to neurodegenerative diseases such as multiple sclerosis, Alzheimer's disease, Parkinson's diseases, they have stated that curcumin has a protective effect in Crohn's Disease, Helicobacter pylori infection, after kidney transplantation from a cadaver, gallbladder function and cognitive disorders such as cognitive performance, learning and verbal memory. It is noted that curcumin has a wide range of anti-inflammatory and anticancer properties, and extensive controlled studies are needed to better understand the health effects of curcumin. They have reported that turmeric has become a promising natural remedy in diseases with its reliability, low cost and proven efficacy (Delikanlı Akbay and Pekcan, 2016).

In the study, the combined effect of turmeric powder and salt (dry) along with sun-drying process on physico-chemical (physical characteristics, proximate and chemical analysis), mineral and bacteriological quality of three freshwater fish products (shol, taki and tengra) has been identified. Sensory characteristics, moisture, protein, fat, ash, salt, TVB-N, FFA, pH, some mineral contents (Ca, Mg, Fe, Cu, Zn, Mn) and bacterial load (SPC and HBC) were analyzed of freshly processed turmeric and salt-treated sun-dried fishes using standard methods of analyses. The lowest moisture content of these three dried fish-products indicated that it was more resistant to enzymatic and microbial activities (Farzana et al., 2016).

The study was carried out on raw meat samples derived from pigs fed with a control diet and a diet supplemented with daily 4.5 g of turmeric powder per pig. After slaughter raw meat was stored for 7 days at 4°C. At day 0 and day 7 samples were cooked in a preheated oven at 163°C to the internal temperature of 71°C. Color parameters, Warner Bratzler shear force, TBARS and antioxidant capacity (ABTS, DPPH and FRAP) were determined at day 0 and day 7. Dietary turmeric powder induced an increase in cooked meat of L* value ($P<0.001$) and reductions in a*, b* indexes and in C* value ($P<0.01$, $P<0.001$ and $P<0.001$, respectively). Color modifications in cooked meat were correlated with color parameters of raw samples. The *Curcuma longa* powder dietary supplementation did not affect lipid oxidation, Warner Bratzler shear force and antioxidant capacity of cooked meat ($P>0.05$) (Mancini et al., 2017).

In this study was to evaluate the effects of turmeric powder and ascorbic acid on lipid oxidation and antioxidant capacity in cooked rabbit burgers. The burgers were derived from 3 different formulations (C, control, with no additives; Tu with 3.5% of turmeric powder and AA with 0.1% of ascorbic acid) and were stored at 4°C for 0 and 7 d and cooked. The lipid oxidation (thiobarbituric acid reactive substances [TBARS]) and antioxidant capacity (2,2-azinobis-[3 ethylbenzothiazoline-6-sulfonic acid] {ABTS}, 1,1-diphenyl-2-pircydrazyl [DPPH] and ferric reducing ability [FRAP]) were evaluated. A significant interaction between storage time and formulation ($P<0.001$) was observed for DPPH, FRAP and TBARS in cooked burgers. At day 0 and day 7, the DPPH value was higher in Tu and AA compared to C burgers. At day 0, C showed a lower level of FRAP than the Tu and AA burgers. At day 7, the FRAP values tended to decrease but remained significantly higher in Tu and AA compared to C burgers. Lipid oxidation at day 0 in Tu and AA showed lower TBARS values compared to C burgers. The addition of 3.5% turmeric powder in rabbit burgers exerts an antioxidant effect during storage and it seems more effective in controlling lipid oxidation than ascorbic acid after cooking (Mancini et al., 2016).

In the study, 180 Nile tilapia fish were used in 3 months growth trial to study the effect of turmeric on growing tilapia. Fish were divided into three treatment groups. The first group T1 was given the basal diet without any supplementation of turmeric and served as the control group. The second group T2 was given a diet supplemented by 0.25% turmeric powder. The third groupT3 was given a diet supplemented by 0.50% turmeric powder. At the end of the growth trial, fish were challenged with pathogenic *Pseudomonas fluorescence*. Turmeric supplementation non-significantly improved growth performance. There was a trend of higher values with increasing the turmeric supplementation level, and significant improvement in feed consumption in T3 compared to T1 and T2. Fish body composition was affected by turmeric supplementation. Crude protein content was significantly increased in T3 compared to T1. Ether extract content was significantly decreased with increasing the turmeric supplementation level as T1 was the highest in ether extract content and T3 was the lowest, this was significantly reflected on the gross energy (GE) content of the fish. The clinical signs in the challenged fishes were observed on the second-day post-injection. Fish showed loss of balance, excessive mucus secretions on skin and gills, ascites with slightly protruded reddish vent and hemorrhages all over the body surface, frayed and torn tail and fins, with no mortalities in the 0.50% turmeric supplemented group. We concluded that 0.50% turmeric supplementation may improve growth performance and significantly protect fish against *P. fluorescens* (Manal et al., 2014).

Turmeric increases the duration of storage by preventing peroxide formation in foods. Turmeric has been reported to be more effective than vitamin E in preventing lipid oxidation. It is determined that the components isolated from *Curcuma longa* have a strong antioxidant effect and are very important on lipid oxidation (Jayaprakasha et al., 2005).

In a study, 400 ppm turmeric extract is added to chicken mince and its antioxidant properties are investigated. The results of the research have revealed that turmeric extract is significantly effective when compared with the control group. It is stated that turmeric is caused by the phenolic components contained in its antioxidant properties (Sharma, 1976).

In another study, antioxidant properties of curcuminoids have been investigated and it is determined that the antioxidant capacity of these extracts is equivalent to ascorbic acid. It is noted that compared to 100 ppm BHT, curcumin has higher antioxidant activity. Turmeric roots have been reported to have aromatic and antiseptic properties (Khana, 1999).

The antioxidant properties of curcumin, which is a large proportion of turmeric and is a phenolic component, have been investigated and it has been determined that curcumin is an antioxidant that can be used safely in the food industry (Ak and Gülçin, 2008).

In this study is to evaluate the effects of turmeric powder (*Curcuma longa*) as a dietary supplement for the ornamental fish Green Terror (*Andinocara rivulatus*) on growth and feed performance, survival rate, and hematologic parameters. In this regard, 144 specimens with an average weight of 1.53±0.22 (g) were obtained and the hypotheses were studied with four iso-caloric and iso-nitrogenous diets containing 0.1, 0.2 and 0.3 percent of turmeric powder, formulated with Win feed 2.8 software. Along the period of 100 days, the fish were biometry every 20 days, and at the end of the trial, a blood examination test was performed. Results showed that the fish fed with diet contains 0.3% turmeric powder (T3) had better growth performance, FCR, condition factor and survival rate specification, but no significant differences observed between the treated and control groups (p>0.05). RBC, PCV, hemoglobin, MCHC were increased not significantly (p>0.05), whereas WBC increased significantly in T3 compared to the other groups (p<0.05). MCH and MCV were decreased non-significant in groups fed by supplemented diets compared to the control group (p>0.05). Applying turmeric powder at the level of 0.3 percent of the basal diet could not alter the growth indices significantly but could alter the hematological parameters with emphasis on WBC (Mooraki et al., 2019).

The effect of Turmeric has been evaluated on the Immune stimulatory response of fish *Labeo rohita* as an effective compound (Behera et al., 2011). In another study reported that curcumin had a protective effect on Bloch tissue and increase the growth performance (Manju et al., 2011). In this regard, the consumption of turmeric by fantail guppy (*Poecilia reticulate*) caused the reduction of FCR and improvement of growth performance (Mukherjee et al., 2009). Sand Goby (*Oxyeleotris marmoratus*) also showed a positive reaction to the consumption of turmeric powder by an increment in amylase, lipase, trypsin and chemotrypsin secretions (Rojtinnakon et al., 2012). The effectiveness of turmeric powder on Immunity response of *Labeo rohita* to *Aeromonas hydrophila* and white shrimp (*Litopenaeus vannamei boone)* has been evaluated by Sahu et al. (2008), Vanichkul et al. (2010) and Lawhavinit et al. (2011), respectively. Moreover, it has been evaluated the effect of turmeric on hematological and immunological parameters of *Mugil cephalus* vaccinated with *Aeromans hydrophila* bacterin (El-Bahr and Saad, 2008). This synergistic effect was also investigated on Japanese flounder (Ji et al., 2007) and Nile Tilapia fingerlings (El-Maksoud et al., 2002) fed by a diet supplemented with turmeric.

In another study, the effect of turmeric Curcuma longa on *Cyprinus carpio* was studied. Fish were divided into four groups being fed for 45 days with 0.3, 0.6 and 0.9gm with add-on commercial diet as the control. After the Groups fed with copepods mediate treated with *C. carpio* using by the different concentration at 0.3gm, 0.6gm and 0.9gm when compare to the high dose, were differential leukocyte counts in *C. carpio* Neutrophils, Lymphocytes, Monocyctes, Esnophils and basnophils analysis was showed a highly significant difference compared to controls (Palanisamy et al., 2016).

Conclusion

Seafood is among the most valuable nutrients in terms of the nutritional components it contains. Preserving food is a necessity for the continuity of life. Along with the developing technology, it should be aimed to extend the shelf life of new products obtained with the developments in food processing methods and to preserve the nutritional content of the product, to add flavor to the product and most importantly, to obtain a healthy product besides preserving their quality. At the stage of obtaining healthy products, consumers started to prefer natural products and the use of natural additives in the food industry has become widespread. Turmeric is a plant with polyphenolic properties, Curcumin is the most active ingredient. Turmeric has been determined to have antioxidant, anti-inflammatory, anticancer and antiatherogenic effects. Turmeric is used in fish soup, rice, sauces, pickles, pastas, salads, cold cuts and various vegetable dishes. When it is consumed with olive oil, black pepper and chili pepper, its absorption is much higher. In addition to being the most valuable nutrient with the nutritional components it contains, seafood can deteriorate much faster. In this context, turmeric has a very important role in extending the shelf life of seafood products by preserving the nutritional value with its powerful antioxidant and antimicrobial effect, and also in obtaining healthy products with its natural coloring and flavoring aspect.

Compliance with Ethical Standards

Conflict of Interest

The author declares that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

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