

**COMPARATIVE STUDY ON THE PROXIMATE  
COMPOSITION OF FRESH, FROZEN AND  
SUN-DRIED MACKEREL TUNA,**

*Euthynnus affinis*

Dissertation submitted to the University of Kerala  
in partial fulfillment of the  
requirements for the award of the degree of

**BACHELOR OF SCIENCE IN ZOOLOGY (2021-2024)**



**DEPARTMENT OF ZOOLOGY  
TKM COLLEGE OF ARTS AND SCIENCE  
KOLLAM-05**

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## CERTIFICATE

This is to certify that the dissertation entitled COMPARATIVE STUDY ON THE PROXIMATE COMPOSITION OF FRESH, FROZEN AND SUN-DRIED MACKEREL TUNA, *Fuliginis affinis* done by ..AISWARYA..AJIKUMAR.....under my supervision as partial fulfilment of the requirements for the *Degree of Bachelor of Science in Zoology* and this report has not been submitted earlier for the award of any degree or diploma or any other similar titles anywhere.

  
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## DECLARATION

I do hereby declare that this dissertation entitled ~~COMPARATIVE STUDY~~ <sup>THE PROXIMATE COMPOSITION OF FRESH, FROZEN AND SUN-DRIED</sup> ~~ON~~ <sup>MACREL TUNA, *Euthynnus affinis*</sup> is a bonafide work done by me under the supervision of Dr. Rohini Krishna M.V, Assistant Professor, Department of Zoology, TKM College of Arts and Science, Kollam as partial fulfilment of the requirements for the award of *Degree of Bachelor of Science in Zoology*. No part of this has been presented earlier for any degrees or diploma of any university.

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## INTRODUCTION

For many centuries, fish has been one of the main foods for humans and constitutes an important part of diet in many countries. The relevance of fish as an essential source of income and food security, particularly in Asia's heavily populated river regions where a sizable portion of the populace depends on fish for a daily diet. Fishes are usually seen as the most cost-effective, high-quality source of animal protein and have a unique position as a high-protein food commodity for human consumption. It is essential for improving nutritional status, food security, cardiovascular health and other health-related disorders (Bezbaruah and Deka, 2021). Hence it is vital for human nutrition and immunological function since it is high in protein and other vital components. Fish is among the healthiest foods on the planet. It is loaded with important nutrients, such as protein and vitamin D. Fish is also a great source of omega-3 fatty acids, which are incredibly important for your body and brain. It is packed with many nutrients that most people are lacking. This includes high-quality protein, iodine, and various vitamins and minerals. Eating at least one serving of fish per week has been linked to a reduced risk of heart attacks and strokes. Fish is high in omega-3 fatty acids, which is essential for brain and eye development (Joe, 2019).

Fishes are good sources of important nutrients and constitute desirable components of healthy diet. The high nutritional value and easy digestibility are the advantages of fish as food. Eating a diet rich in nutrients is becoming ever more vital in today's world, and fish is becoming more and more popular because of its special nutritional advantages. Because fish have both macronutrients (proteins, fats, and ash) and micronutrients (vitamins and minerals), they are regarded as a nutritionally valuable component of the human diet. These nutrients are essential for human nutrition and have been shown to have a role in a number of metabolic processes. As mentioned earlier, they are rich source of omega-3 (n-3) long chain polyunsaturated fatty acids (PUFAs) which are essential for maintaining the integrity of membrane of all living cells. PUFAs are responsible to produce prostaglandins which regulate inflammation and blood clotting. The fish also contains eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) which serve as important components in the reduction of some risk factors associated with arteriosclerosis and heart disease (Trebble, 2004). The n-3 PUFAs are very important because they play a vital role in the development and functioning of nervous system (brain), photoreception (vision), and reproductive system (Bourre, 2007).

The nutritional content can be used to rank different fish species based on their nutritional and functional benefits, allowing consumers to make better decisions according to their requirements. The study of these components gives us a clear understanding in assessing the energy value of the fishes (Ahmed et al., 2022). The edible portion of fish is mostly composed of four constituents: water, protein, lipid (also known as fat or oil), and ash (minerals). "Proximate analysis" is the term used to describe the examination of these four fundamental components of fish muscle. Reliable data on the proximate composition of the majority of fish species are challenging to come by, despite the fact that these data are essential for many applications and studies along these lines have been conducted since the 1880s. Fish possess distinct biochemical compositions depending on the species, and even within a species, individual differences can be attributed to a variety of factors including size, age, sex, season, and location (Stansby, 1962). Wild and farmed fish vary in nutrients (Nettelton and Exler, 1992) as well as sensorial, chemical and physical properties (Love, 1980).

It is crucial to evaluate the fish's proximate composition in order to determine its nutritional value and to facilitate better processing and preservation (Mridha et al., 2005). For product development, quality control (QC), or regulatory purposes, the food sector may find certain food ingredients useful. Furthermore, proximal profile estimate is frequently required to make sure fish fulfill food standards and commercial demands. The proximate composition generally comprises the estimation of moisture, protein, fat and ash contents of the fresh fish body. The percentage composition of these constituents account for about 96-98% of the total tissue constituents in fish (Nowsad, 2007).

There has long been a discussion concerning whether fresh or frozen fish is preferable. Since fresh typically means higher quality, most people will instinctively think that fresh fish is superior. In Singapore and other wealthy nations, imported food comes from foreign suppliers for more than 90% of the food consumed. Just 9% of the fish consumed worldwide comes from local farms due to a lack of farming area. As a result, frozen seafood is essential to preserving the food supply in such countries. Therefore, when it comes to seafood, each type of fish; fresh or frozen has advantages of its own (Qing, 2021). Drying, the oldest, easiest and excellent way of fish processing has been introduced in our country by the Arabian saints and businessmen who have been believed to be pioneers in the production and marketing of the dried fish products throughout the world since the Egyptian civilization (Kreuzer, 1974). Sun drying is a cheaper method of fish preservation and solar energy is used for the removal of moisture from the fish.

Dried fish is a source of protein and plays a major contribution in providing nutrition for the poor as well as economically disadvantaged people of our country (Reza et al., 2005).

There are several ways to preserve fish, including freezing, icing, smoking, glazing, drying, frying, and salting and canning (wet salting). As a result, all the fishes prepared using different techniques do not have the same quality, which has a different impact on the fish's shelf life. It has been noted that the nutritional contents of fish are affected differently by various processing techniques. All these point out on the general fact that, both fresh and frozen along with dried fishes are commonly consumed by people in various parts of the world. In such scenarios, it is critical to evaluate and contrast the proximate composition of dried, frozen, and fresh fish.

Tunas are among the largest, most specialized and commercially important of all fishes. Belonging to the genus *Thunnus* of the family Scombridae, they are found in temperate and tropical oceans around the world and account for a major proportion of the world fishery products (Lee et al., 2005). In the present study, proximate composition (protein, moisture, lipid, ash and carbohydrate contents) of commonly available tuna species of Kerala coast, *Euthynnus affinis* (mackerel tuna or kawakawa) was determined. For this comparative study; fresh, frozen and sun-dried fish meat were analysed.

## AIM & OBJECTIVES OF THE STUDY

The present investigation attempts to evaluate the proximate composition of fresh, frozen and sun-dried tuna (*Euthynnus affinis*). Proximate composition of fish is generally the percentage composition of the four basic constituents viz. water/ moisture, protein, fat, and ash (mainly minerals). Other than the four basic constituents, carbohydrate content was also assessed for the comparative analysis. The current study was initiated with the underlying objectives:

- 1) To ascertain the proximate composition of mackerel tuna, *Euthynnus affinis*.
- 2) To compare and evaluate the biochemical composition of fresh, frozen and sun-dried mackerel tuna.
- 3) To assess the effect of freezing and drying on the proximate composition of mackerel tuna, *Euthynnus affinis*.

## REVIEW OF LITERATURE

Fish is popular all around the world, whether it is eaten raw, boiled, salted, smoked, preserved, or in any other method. The Food and Agriculture Organization (FAO) estimates that about one billion people depend on fish as their main source of animal protein. The consumption of fresh fish is rising at the expense of other fish products, with over 75% of the world's fish production going toward direct human consumption. The leftover fishes serve for the production of non-food items, specifically fish oil and fishmeal (FAO, 2008). Fish comprises wide range of shapes, sizes, habitats and biology, and are thought to account for more than 40% of all vertebrate species worldwide making them one of the essential components of the aquatic ecosystem. These are typically located near the top of the food chain and indicate a healthy aquatic ecosystem (Parveen and Gaikwad, 2018). The proportion of global fish production used for direct human consumption is now over 77%, a significant rise of the last decades, with consumption of fresh fish outstripping other fish products such as canned fish (FAO, 2016). According to Ngasotter et al. (2020), the survey indicated that India is presently ranked third for overall fish production, which made the country one of the top fish producers in the world.

### **Nutritional facts and health benefits of fish**

A fish meal, in addition to providing essential nutrients, contains significant amounts of fatty acids, amino acids and some of the most important vitamins and minerals, which serve as a source of energy for healthy living and are sometimes referred to as 'rich food for poor people' (Balami et al., 2019; Bezbaruah & Deka, 2021). According to Abdullahi et al. (2001), fish is the perfect food for new-borns and adults as it is abundant in key nutrients needed during the early stages of development. Nowadays, fish and its products are considered as an essential component of the human diet due to their high nutritional content, particularly in terms of protein and omega-3 fatty acids, which are thought to aid in the maintenance of good health like prevention and treatment of cardiovascular, inflammatory and neurological diseases (Ahmed et al., 2022; Li et al., 2019). Because of the high content of polyunsaturated fatty acids, shreds of evidence suggest that fish flesh and fish oil are helpful in reducing the serum cholesterol level in humans (Stansby, 1985).

Fish products have a nutrient profile superior compared with other food sources like meats of beef, chicken and many more. Fish tissue possesses high nutritional value and is therefore particularly recommended dietary component. It comprises all ten essential aminoacids in desirable quantity for human consumption. Fish protein is very rich in such aminoacids as methionine, lysine and low in tryptophan compared to mammalian protein (Nowsad, 2007). Fish normally has more polyunsaturated fatty acids (PUFA) than animal fats. An increasing amount of evidence suggests that high content of PUFA in the fish flesh and fish oil are beneficial in reducing the serum cholesterol (Huynh et al., 2009). Moreover, fish is a good source of calcium, phosphorus, sodium, potassium, iron, manganese, zinc, copper, and other vitamins and minerals. They absorb minerals not only from their diets but also from the surrounding water via their gills and skin (Lall, 2002).

A significant portion of the population consumes fish, which is high in protein due to its great palatability, low cholesterol, and soft flesh (Eyo, 2001). It has the optimal amount of each of the ten necessary amino acids for human consumption. Comparing fish protein to mammalian protein, fish protein is low in tryptophan and high in amino acids like lysine and methionine (Nowsad, 2007). In addition, fish is a good source of calcium, phosphorus, sodium, potassium, iron, manganese, zinc, copper, and other vitamins and minerals. Fishes are a great source of vital nutrients needed to complement diets for both infants and adults (Botta et al., 1978). Eating fish and their products helps avoid cardiovascular and other disorders. It is predicted that each person on the planet consumes slightly more than 16 kg of food each year from fisheries in terms of live weight (Adam and Sidahmed, 2012).

Fish oil is currently under intensive scientific research due to its numerous health benefits. This fish oil is receiving a lot of attention because of its health benefits associated with the high levels of the long chain omega-3 polyunsaturated fatty acid (PUFA) especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Wu and Gatlin, 2014). Many studies have shown that fish oil can lower the coronary heart disease, stroke, hypertension, cardiac arrhythmias, diabetes, rheumatoid arthritis, photoreception (vision) and reproductive system, depression, autoimmune disorders (Harris et al., 1990; Russell et al., 2005; Guy et al., 2009) the most important health benefit of taking fish oil is that it is good for the functional development of infant's nervous system (nerve and brain) as well as the retina particularly in premature infants (Alexander et al., 2005; Qi-Yuan et al., 2016). Moreover, many studies have shown that fish oil supplementation increase the DHA content of blood components (Connor, 2000). The nutritional benefits of fish

oil consumption are due to the presence of protein of high biological value, unsaturated essential fatty acid, minerals and vitamins namely vitamin B3 (niacin), vitamin B6 (pyridoxine), vitamin B12 (cobalamin), vitamin E (tocopherol) and vitamin D (cholecalciferol) in fish tissues (Sidhu, 2003).

### **Fish and its proximate composition**

The chemical composition of fish flesh is considered to be a reliable predictor of the fish's quality, nutritional value, physiological state, and habitat (Ravichandan et al., 2011). Fish's primary constituents include 66%–81% water, 16%–21% protein, 1.2%–1.5% mineral, and 0.2%–25% carbohydrate and 0%–0.5% fat (Love, 1970). According to Begum et al. (2012), ash, fat, protein, and moisture make up 96%–98% of a fish's body composition. The assessment of these elements is referred to as the fish's "proximate composition" (Rani et al., 2016). Since they make up a minor portion of the wet mass that is normally assumed, it has been observed that carbohydrates and non-protein molecules are typically ignored during analysis. To be insignificant, roughly less than 0.5% (Ali et al., 2006; Petricorena, 2015). The proximate composition of various fish species may depend on a variety of factors, including dietary composition, feeding and eating habits, feeding rate, age, size, sex, habitats, genetic characteristics, and season/migration (Begum et al., 2016; Daniel, 2015).

For a number of reasons, information on the proximate composition of fish is crucial. Two of them are mentioned here. First off, physiology is a necessary component of routine fisheries analysis, and proximate analysis is a good indicator of this. Furthermore, it furnishes data regarding the quality of the raw material, sensory attribute, sexual stage, post-harvest processing, and its impact on the fish's shelf life. Measurements of certain proximate profiles, like protein, lipid, and moisture contents, are frequently required to guarantee that the fish fulfills food regulations and commercial specifications (Ozkano, 2005). Hence, the ability to decode the nutritional quality, physiological condition and health status of any edible portion of the organism requires comprehensive study to understand the proximate makeup of the species. The importance of such studies is to express food value in terms of energy units (Qasim, 1972).

Many preserved fish products held at temperatures over 0° C are susceptible to spoiling due to microbiological activity, autolytic alterations, chemical spoilage, rancidity development, and mold attack (Huss, 2000; Conne, 1995). The preservation of fish is still a difficult issue, despite

the fact that fish production is always rising. Fish's inherent qualities and potential for microbial contamination from a range of sources have been linked to its susceptibility to quick spoiling (Venugopal et al., 1996). Generally, fresh fish contain a considerable amount of minerals, but processed fish such as dried fish have higher values (Kinsella, 1986). The measurement of these micro nutrients in fish will reveal their availability to fish consumers and thus give a room to prevent the resultant effects of their deficiencies (Cabu et al., 2004). Fish generally encompasses all seafood including crustaceans with chitinous exoskeleton such as lobsters, crabs and shrimps such as muscle cockles and oyster (Adams and Moss, 1995). Fish is one of the most highly perishable food products, during handling and storage, quality deterioration of fresh fish rapidly occurs and limits the shelf life of the product (Sallam, 2007).

<i>Constituent</i>	<i>Range</i>
<i>Water/ Moisture</i>	65-90%
<i>Protein</i>	10-22%
<i>Fat</i>	1-20%
<i>Minerals/ Ash</i>	0.5-5%

Table 1: The range of values for proximate composition in the edible portion of common fish species from Indian coastal waters (CIFT, 2021)

### **Moisture content**

One of the first and most basic procedures in estimating the nutrient content of a fish's entire body is to examine its moisture content. The proportion of moisture in food is an excellent indicator of its calorie, protein and fat levels (Barua et al., 2012). Fresh fish primarily consists of water, which makes up over 80% of the weight of a fresh white fish fillet. However, more than half of the water content will be lost when drying fish. Important diluents of the nutrients in food are moisture or water compounds. The percentage of water also acts as a good indicator of its relative amount of protein, energy and lipid (Jolaoso et al., 2016). Aberoumad and Pourshafi (2010) affirmed that moisture content serves as an excellent indicator of relative energy, lipid

and protein content and exhibits an inverse relationship with them, that is, lower the percentage of water, the greater would be the amount of proteins, lipids and higher would be the energy density of the fish.

## **Protein**

Proteins play an important role in the optimum growth of fishes (Wu & Gatlin, 2014) and are considered as the most expensive ingredient in the diet of fishes as well (Deng et al., 2011). Mohanty (2015) stated that fish being a potential source of animal protein can play a vital part in preventing protein-calorie malnutrition. It has been found that inadequate levels of proteins in the diet of fishes lead to the cessation or reduction in their growth (Ahmed & Maqbool, 2017). Still if the proteins are in excess concentration, then the surplus protein through oxidation of amino acids are converted to metabolisable energy and also leads to increased release of nitrogenous wastes (Wu & Gatlin, 2014). Generally, three types of proteins are found in the fish muscle: myofibrillar or contractile proteins (actin, myosin, tropomyosin and actomyosin) which comprises about 60%–65% of the total protein content; sarcoplasmic or enzymatic proteins (albumin, globulin and enzymes) comprising 30%–35% of total protein and stroma or connective tissue proteins (collagen) constituting about 3%–5% of total protein (Nowsad, 2007). Balami et al. (2019) reported that due to the occurrence of the lower levels of connective tissue, fish muscles are normally considered as more digestible compared with other animal proteins. A lot of work has been carried out on the protein content of fish from different parts of the world.

Proteins are considered as the most versatile biomolecules which are made up of amino acids held together by a peptide bond. The amino acid concentration and digestibility of fish proteins are very much high, about 85%–95% (Pal et al., 2018). Fish protein since long has been considered as having a high nutritional value and has immense beneficial health effects in human nutrition (Khalili Tilami & Sampels, 2018). It is mainly accountable for building and repairing muscle tissues, improving blood quality and immunity. The protein immunoglobins act as an effective defence mechanism against viral and bacterial infections and also aids in the maintenance of water balance and electrolyte systems in humans (Balami et al., 2019). Generally, the quantity of protein in fish muscle lies between 15% and 25% (Ryu et al., 2021). The disparity in the protein content of fishes could be affected by their feeding and breeding capabilities (Islam & Joadder, 2005). Borgstrom (1961) reported that the protein and fat content in fish rely on various factors such as sex, age, size, seasonal fluctuations and habitat.

## Lipid content or fat

Fat is regarded as the third main component of fish muscle and is typically found in the subcutaneous tissue, liver, muscle tissue, mesenteric tissue, belly flap, and head regions. Reports of this range from 6% to 20% are common (Moradi et al., 2011). In some fish species (Simpkins et al., 2003), the amount of lipid in the fish's body is thought to be an excellent indicator of future survival. In other fish stocks, it is also a strong signal of reproductive capacity (Mejri et al., 2021). These are regarded as one of the most crucial food reserves and the fat indices are also used as a means of describing the relationship between percent fat and water (Sinclair & Duncun, 1972); such type of relationship has also been extensively used by several researchers in various fishes (Ali et al., 2006; Naeem et al., 2011; Sutton et al., 2000). A number of factors are responsible for bringing variation in the composition of fatty acids in fish such as diet, species and environmental factors, including season, temperature, geographical attributes, salinity, and so forth (Tasbozan & Gokce, 2017).

Lipids and fatty acids also play an important role in membrane-mediated processes such as osmoregulation, nutrient assimilation and transport (Sujatha et al., 2013). However, it is believed that fish skin typically contains higher amounts of lipids than muscle tissue. In case of lean fishes, the fat content generally ranges from 0.2% to 3.9% while fatty fishes had a significantly greater amount of fat about more than 50%. Other organs in fishes also possess appreciable amounts of fat, for example, in cod, the roe possesses about 0.3%–1.5% of lipid and the liver constitutes about 70% of lipid (Ackman, 1994). Studies on the nutritional profiles of different fish species have shown that freshwater fish have a lower fat content than marine fish because they don't have storage mechanisms and use fat right away as a source of energy when they spawn (Tasbozan & Gokce, 2017). Ugoala et al. (2008) investigated the fatty acid composition of certain freshwater and marine species of fish, along with comparing their nutritional properties by looking at the amounts of significant fatty acids present and the study's main relevance determined that marine fishes acted as wider suppliers of omega-3 essential fatty acids. Craig et al. (2017) also discovered that marine fish have a naturally high level of omega-3 highly unsaturated fatty acids and act as good sources of lipids for fish diet production. Lipids from these sources can be accumulated in the muscle of fish. People who eat these fillets could experience the health advantages of omega-3 fatty acid rich meals, for instance, reduced depression symptoms and enhanced cardiovascular fitness.

## Ash content and carbohydrate

Ash content, which offers a measure of the total amount of minerals without a food source, is the inorganic residue left over after the water and organic materials have been removed by heating in the presence of oxidizing agents. According to Julian (2003), there are three primary methods for determining the ash content of food: dry-ashing, wet-ashing, and low temperature plasma dry ashing. It is an inorganic residue obtained after the whole organic matter has been burnt off (Adewumi et al., 2014). In terms of quantity, it comes at fourth place and varies from 0.5% to 5% of the total body weight of fish. Ndome et al. (2010) reported that ash generally acts as a significant source of nutrients in case of fishes. Bano (1977) reported that various conditions of fish possess a significant relation with the amount of ash content in their body. Since ash is associated with the detection of minerals in fishes, therefore, it is considered as the most reliable way of detecting the mineral composition of fish as it represents the total inorganic content or mineral content of the fish sample. It has been reported that the total mineral content in wet fish muscle generally ranges from 0.6% to 1.5% of total fish body weight.

Fish muscle and bones behave as an excellent source of dispensable minerals and about 65% of minerals are stocked in the skeleton, particularly vertebra (Njinkoue et al., 2016). Minerals perform a significant part in maintaining bodily functions such as acid–base balance and the formation of haemoglobin (Duran et al., 2010). They are also involved in osmoregulation, bone and teeth formation and act as catalysts in different enzyme-catalysed or metabolic reactions either as activators or inhibitors (Njinkoue et al., 2016). Besides the above-mentioned nutritional and physiological functions, minerals also add to food flavour and influence the food texture (Ersoy & Celik, 2010).

Fish products are a great way to get high-quality animal protein and are appropriate for diets that include additional carbohydrates. Starch, a polymer of glucose, is the type of carbohydrate that is most frequently present in fish. Among carbohydrates, glucose primarily functions as an energy-producing substance, the body's principal fuel, and the structural component of the organism. It contributes to the metabolism of fatty acids and amino acids. As stated by Mohd (2010), disaccharides are primarily responsible for digestion and serve as the main source of energy in the diet, but monosaccharides are crucial for the formation of nucleotides and nucleic acids.

### Importance of tuna and its body composition

Tuna fish, a member of the Scombridae family, encompasses several species known for their remarkable size, speed, and culinary appeal. Found in oceans worldwide, tuna is a staple in many cuisines, prized for its mild flavour, firm texture, and nutritional value. Tuna comprises several species, each with its unique characteristics and habitat preferences. Among the most commonly consumed species are skipjack, yellowfin, albacore, bigeye, and bluefin tuna. Bluefin tuna, renowned for its large size and exquisite flavour, is particularly prized in culinary circles, though concerns over its sustainability have led to increased attention on other species. The tuna species selected for the present work, *Euthynnus affinis* is popularly known as 'little tunny' or 'kawakawa', and belongs to the family scombridae, fetch high value in the global market (Poisson, 2006). This fish fetches a high price in the raw seafood market, representing a very interesting species from both nutritional and economic point of view. Along the Indian coast, *E. affinis* is exploited throughout the coastal states and islands and forms the bulk of the tuna landings of the country (Silas and Pillai, 1982; Khan and Saffar, 2004).

Wild tuna's body composition, at least in terms of lipid content and fatty acid composition, may provide some insight into potential dietary needs. It is obvious that carcass fat levels can vary greatly, reflecting condition parameters that are almost definitely related to the season. On the other hand, it was found that the protein composition was less varied. The fish get energy for their migrations from muscle lipid reserves, according to the very strong inverse relationship between body fat and water as found in Atlantic northern bluefin tuna (*Thunnus thynnus*) (Clay, 1988). The fact that the lipid content of flesh can vary so much has significant farming implications. The amount of fat in the meat will vary depending on seasonal factors that affect metabolism as well as the amount of fat in the diet. High fat diets may have advantages like faster growth, but they may also have disadvantages like lower product quality and lower market acceptance.

The majority of marine fish have polyunsaturated fatty acid (PUFA) compositions that are dominated by the *n*-3 *lc*-PUFA acids docosahexaenoic (DHA; 22:6*n*-3) and eicosapentaenoic (EPA; 20:5*n*-3) (Sargent et al., 2002). Nonetheless, tuna species' fatty acid compositions seem unusual since they are marked by very high DHA levels and, more significantly, a very high DHA:EPA ratio (Sawada et al., 1993). In the lipids of marine fish in the northern hemisphere, this ratio seldom rises over 2, but in the southern hemisphere, the lipids of marine fish often

exhibit higher EPA levels and, as a result, even lower DHA:EPA ratios (Ackman, 1980). On the other hand, the stomach contents revealed a DHA:EPA ratio of slightly over 3 (Ishihara and Saito, 1996), and the muscle phospholipids of *Thunnus orientalis* displayed DHA levels of between 25% and 36% with DHA:EPA ratios of up to 6 (Medina et al., 1995). The lipid and fatty acid content of albacore (*Thunnus alalunga*) was examined by Murase and Saito (1996) in a number of organs, including the liver, heart, pyloric caeca, stomach content, ventral muscle, dark muscle, liver, and heart. They discovered that DHA:EPA ratios ranged from 3.0 in the liver to 6.6 in the heart, and that DHA levels were always greater than 25% of total fatty acids in weight percentage. Thus, it would be necessary to duplicate the tuna species' comparatively high DHA and high DHA:EPA ratio in farmed fish in order to maintain the desired attributes for the consumer.

### **Factors influencing the proximate composition in fishes**

Fish proximate composition can be influenced by both endogenous and external influences. Endogenous variables, which are mostly genetically controlled, are primarily linked to the life cycle of fish, including life stage, size, age, sex, and anatomical location (Huss, 1995). Fish composition is mostly determined by a majority of principles that are governed by these elements. However, as noted by Olsson et al. (2003), the external influences often consist of temperature and salinity variations, as well as a range of environmental oscillations and shifts in the availability and content of feed within fish dwelling zones (Khalili Tilami & Sampels, 2018). It has been discovered that, of all these exogenous variables, the diet has the greatest impact on the fishes' proximate composition, whereas the effects of other variables, such as variations in temperature, pH, light, oxygen concentration, and salinity, are less pronounced. According to Oyelese (2006), feed consumption has a significant impact on the proximate composition of fish since these animals often eat a wide range of foods and use them to gain the nutrients needed for healthy growth and development. The availability of food varies with the seasons of the year, which leads to variations in the body's constituent parts (Habshy, 1973).

During the time of heavy or normal feeding, it has been observed that the protein content rises a little in the muscles at first and then the fat content shows a speedy increase. Contrary to this, during starvation (spawning, migration) or non-availability of food, a considerable decline in fat and protein content may also be observed (Huss, 1988, 1995). In addition, it has been studied that in case of intensive culture circumstances, the composition of the feed and feeding regime

has a foremost influence on the nutritional profile of the fishes (Lie, 2001). In addition to the raising system and feeding regimen, feed composition has been discovered to have a significant impact on the amount of lipids and the composition of fatty acids (Khalili Tilami & Sampels, 2018). On the other hand, regardless of the amount in the diet or feeding regimen, the amount of protein in the fish seems to be predetermined for each species of fish as soon as they are fed diets that contain all necessary elements in sufficient quantity (Morris, 2001). The ash level and mineral composition of fish are predetermined, just as that of proteins. However, there are certain additional micronutrients that can change and may have an effect on the quality of fish flesh (Baker, 2001).

### **Freezing and Drying**

Freezing storage is an important postmortem method for preservation of fish and it is considered as the best way of preserving the quality of fish if proper care at each step of freezing is done (Foucat et al., 2001). Fish quality also deteriorates to some extent during freezing storage and the extent of deterioration is usually determined by measuring the sensory, chemical, and physical changes (Liu et al., 2009; Obemeata et al., 2011). Fish is a highly nutritious food that is packed with vitamins and minerals. In the process of defrosting frozen fish, some of the natural water content may be lost, resulting in flesh that is not as moist as fresh fish after cooking. It is possible for water-soluble vitamins in the fish, such as vitamin B12, to be dissolved and lost through thawing, though fat-soluble vitamins will remain. Hence, fresh fish generally retain more nutrients than their frozen counterparts and result in more tender flesh after cooking (Qing, 2021).

Drying, the oldest, easiest and excellent way of fish processing has been introduced in our country by the Arabian saints and businessmen who have been believed to be pioneers in the production and marketing of the dried fish products throughout the world since the Egyptian civilization (Kreuzer, 1974). Sun drying is a cheaper method of fish preservation and solar energy is used for the removal of moisture from the fish. Dried fish is a source of protein and plays a major contribution in providing nutrition for the poor as well as economically disadvantaged people of our country (Reza et al., 2005). The product of dried fish is easily transportable, marketable and storable. Although dried fishes do not give similar flavor, taste or texture of fresh fish, it is liked and consumed by a large number of people in the world due to its characteristic taste and flavor. It is an important source of animal protein in providing nutrition of the poor and economically disadvantaged people (Alam, 2007).

Sun drying is the traditional method of drying fish, and it has been proven to be able to reduce the moisture level. Despite this, the contamination by flies and insects during open drying has become a safety concern, as some people have used organochlorine chemicals as insecticide (Dhuiyan, 2009). One of the solutions requires the usage of a thick mesh of nylon or a mosquito net while the fish were drying in the sun to protect them from contamination from the outside, bird attack, and fly infestation (Farid et al., 2014). Fish can be dried using a smoking kiln, which is also widely used in fish drying (Praveenkumar, 2017). In terms of moisture content, this technique can lower the level, as low as 15.30% in dried tilapia, at a lower temperature compared to ovens. Even so, the drying time needed is typically in the range of 10–24 h, longer than higher temperature drying methods (Foline, 2011).

In general, it has been suggested that the proximate composition of each fish species varies and is primarily influenced by both exogenous and endogenous variables (Love, 1957; Weatherley & Gill, 1983), which includes the effect of water temperature (Touhata et al., 1998), feeding habit, age and seasonal variations (Silva & Chamul, 2000), species to species variation (Huss, 1988, 1995; Islam & Joadder, 2005), condition factor (Naeem et al., 2011), size (Naeem & Ishtiaq, 2011), sex (Yousaf et al., 2011). Besides this, various other factors such as season, intensive feeding or starvation, migration, spawning, feed, maturity stage, muscle location, and so forth have also been found to have a pronounced impact on the proximate composition of different fish species (Boran & Karacam, 2011; Karki et al., 2019).

## MATERIALS AND METHODS

### Sampling and preparation

Sample for the proximate analysis, Mackerel tuna (*Euthynnus affinis*) were procured from the landing centre of Vizhinjam, Thiruvananthapuram. The samples were placed in sterile polythene bags, kept in ice and brought to the laboratory within 30 minutes. In the laboratory, the fish was washed and Total length (TL in cm) and body weight (kg) data were recorded. The fish weighed 0.32 kg with a TL 46.7 cm. The sample was thoroughly washed, dissected, eviscerated and filleted using a sharp and sterile stainless-steel knife. Flesh from the consumable portion was taken for homogenization and further analysis was carried out. For this, the fish meat was equally divided into three samples and were taken as fresh (S1), frozen at -24°C for 4 days (S2) and dried under direct sunlight (S3) for 4 days and was later analysed for the proximate composition.

### Analysis of samples

Fish samples were subjected for proximate analysis as described by the Association of Official Analytical Chemists (AOAC). The standard protocols for the analysis of proximate compositions are given below.

#### Moisture Content

**Materials used:** Metal Moisture Dish, Oven, Desiccator, silica gel

**Principle:** The difference in weight after heating the finely minced meat or a ground fish at a particular temperature for a defined duration gives the water content present in the sample. It is presented as g per 100g meat (AOAC, 2000).

**Procedure:** Pooled minced meat was taken in a clean dry petridish and kept in an oven at 105°C for 2 hrs, cooled in a desiccator and weighed (W1). About 10-20g portion of meat (W2) was taken in the pre-weighed petri dish, kept in an oven maintained at 105°C overnight. The petri dish was cooled in a desiccator and weighed again (W3). The petri dish was again kept in an oven for half an hour, cooled as above and weighed again to get reproducible weights.

**Calculations:**

$$\text{Moisture content (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

$$\text{Moisture content (\%)} = \frac{\text{Weight of moisture in the sample}}{\text{Weight of wet sample}} \times 100$$

**2. Protein content****Reagents used:**

- a) Kjeldahl catalyst - 15gm Pot. Sulphate + 0.5gm Copper sulphate
- b) Sulphuric Acid - Concentrated
- c) NaOH solution - 50% (1+1). Let stand until clear
- d) Standard NaOH solution-0.1 N =0.1 M (4.00gm/litre)
- e) Standard acid solution- Prepared HCl solution (HCl sol-0.1 N = 0.1 M (3.646gm/litre)
- f) H<sub>2</sub>SO<sub>4</sub> sol - 0.1N =0.05 M (4.9gm/litre)
- g) Methyl Red Indicator - 0.5gm in 100ml ethanol

**Principle:** The nitrogenous compounds in the sample are converted in ammonium sulfate by boiling with concentrated sulfuric acid. Upon distillation with excess alkali, the ammonia is liberated which is estimated by titration with standardized sulfuric acid.

**Procedure:** Digestion: 0.1-0.2g of wet sample was weighed in to a Kjeldahl flask. A pinch of digestion mixture (copper sulphate and potassium sulphate were mixed in the ratio 1:8 and finely powdered) and 10 ml of concentrated sulfuric acid was added. It was then digested over a sand bath by heating slowly till the solution starts boiling and then vigorously until the solution becomes colorless. The sample was then cooled and made up to the desired volume (100ml) according to the protein content of the sample. A blank was kept with distilled water.

**Distillation:** A conical flask containing 10 ml of boric acid with few drops of Thashiro's indicator (pink in color) was placed at the receiving end of the distillation apparatus in such a

way that the tip of the condenser is slightly immersed in boric acid. 5ml or any convenient volume of the made-up sample was pipette out in to the distillation apparatus. 10ml or known volume of 40% NaOH as shown excess by phenolphthlene indicator was added in to the distillation unit followed by rinsing with little distilled water. The unit was made air tight. The content was steam distilled till the boric acid solution in the flask doubles or for 5minutes. The color of the solution turns green. The flask was lowered and the condenser tip was washed with little water.

**Titration:** The solution in the receiving flask is green at this stage. The content was titrated against N/100 sulfuric acid until the original pink color is restored. The volume of acid used for titration was noted. The distillation and titration process were repeated to get concordant value (AOAC, 2000).

**Calculation:**

1000ml 1N H<sub>2</sub>SO<sub>4</sub> =14g N<sub>2</sub>

1ml 1 N H<sub>2</sub>SO<sub>4</sub> = 0.014g N<sub>2</sub>

1ml 0.01 N N/100 H<sub>2</sub>SO<sub>4</sub>= 0.00014g nitrogen or (0.14/1000)

If the titer value of the sample after subtracting blank is "X", then,

$$\text{Protein content (\%)} = \frac{X \times 0.14 \times V \times 6.25^* \times 100}{1000 \times V_1 \times W}$$

Where,

V = Total volume of digest,

V<sub>1</sub> = Volume of the digest for distillation &

W =Weight of sample for digestion

\*Nitrogen content of most fish/meat protein is 16%. Hence 1 g nitrogen equivalent of protein is 100/16 or 6.25.

### 3. Fat/ Lipid (Soxhelet method)

**Principle:** Fat soluble in organic solvents can be extracted from moisture free samples by using solvents like petroleum ether, ethyl ether etc. The solvent is evaporated and fat is estimated gravimetrically (AOAC, 1990).

**Procedure:** 5-10g of sample was weighed accurately in to a thimble and cotton plugged. The thimble was then placed in a soxhlet apparatus and 1 and half volume of ether (approximately 200ml) was added and distilled for 16 hrs. The apparatus was cooled and the solvent was filtered in to a pre-weighed conical flask (W2). The flask of the apparatus was rinsed with small quantities of ether and the washings were added to the above flask. The ether was removed by evaporation and the flask with fat was dried at 80-100 °C, cooled in a dessicator and weighed (W3).

**Calculation:**

$$\text{Fat content (g/100g)} = \frac{W3-W2}{W1} \times 100$$

$$\text{Moisture content (\%)} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

Where,

W1 = weight of dry matter taken for extraction;

W2 = weight of conical flask &

W3 = weight of flask with fat

#### 4. Ash

**Materials used:** Nickel crucible, Muffle furnace, desiccator

**Principle:** Ash is the residue obtained after incineration of the dry material at high temperature and appears as grey-white colored powder.

**Procedure:** Nickel crucible was heated to 600 °C in a muffle furnace for one hour, cooled in a dessicator and weighed (W1). 2g of dried sample was weighed accurately in to a crucible and heated at low flame by keeping on a clay triangle to char the organic matter (W2). The charred

material was then placed inside the previously set (600 °C) muffle furnace and heated for 6-8 hrs which gave a white or grayish white ash. The crucible was cooled in a desiccator and weighed (W3). The crucible was heated again for further 30mins to confirm completion of ashing; cooled and weighed again.

#### Calculation:

$$\text{Ash content (g/100g)} = \frac{W3-W1}{W2-W1} \times 100$$

Where,

W1 – Weight of crucible,

W2 – Weight of dry matter and crucible &

W3 – Weight of crucible after ashing

$$\text{Ash content (g/100g)} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

### 5. Carbohydrate (Anthrone method)

#### Principle

Carbohydrates are dehydrated with concentrated sulphuric acid (H<sub>2</sub>SO<sub>4</sub>) to form furfural. Furfural forms a green colored complex by condensation with anthrone and its absorbance can be measured colorimetrically at 620 nm. Anthrone reacts with dextrans, monosaccharides, disaccharides, polysaccharides, starch, gums and glycosides (Loewus, 1952).

#### Procedure

0.2 to 1ml of working standard solution was taken in five different test tubes S1-S5. Added water and brought the volume to 1ml in each test tube. A blank with 1ml of distilled water was prepared. Pipetted out 0.3 and 0.7 ml of standards in tubes marked Test-T1 and T2. Added 4 ml of anthrone reagent to all tubes. Mixed the contents well and keep the test tubes in water bath at 100°C for 10 minutes. Cooled the test tubes in room temperature and measure the absorbance in a photoelectric colorimeter at 620nm. Constructed a calibration curve on the graph paper by

Plotting the glucose amount on X-axis and absorbance at 620 nm on the Y-axis. Computed the amount of the sugar in the sample from the calibration curve. While calculating the sugar amount in the unknown sample, the dilution factor was taken into account.

**Calculation:**

$$\text{Amount of test (mg/ml)} = \frac{\text{Absorbance of test}}{\text{Absorbance of Standard}} \times \text{Amount of Standard}$$



Fig. 1: Mackerel tuna (*Euthynnus affinis*)



Fig. 2: Filletted tuna mackerel



Fig. 3: Samples after water bath



Fig. 4: Muffle furnace



Fig. 5: Ash content obtained for S3



Fig. 6: Samples arranged for protein estimation

## RESULTS

Proximate composition involves water content/moisture, lipids, proteins, ash and carbohydrates of the fresh, frozen and dried fish. By comparing proximate composition between fish meat under different parameters, the changes in nutrient composition of the fish can be observed clearly. For the present study, the proximate analysis of the three samples [fresh (S1), frozen (S2) and sun-dried (S3)] from the fish, *Euthynnus affinis* showed significant variation in the total protein. The ash content and carbohydrate content also showed variation while moisture and lipid content comparatively showed slight difference. The detailed proximate estimation results, of fresh, frozen and sun-dried samples are given below in Table 2.

Sample	PROXIMATE COMPOSITION (% wet weight)				
	Moisture	Protein	Lipid	Ash	Carbohydrate
S1	73.75	23.18	2.32	1.59	0.44
S2	73.32	18.67	2.02	1.32	0.21
S3	18.23	31.4	1.1	3.26	0.1

Table 2: Proximate composition of *Euthynnus affinis* (NB: S1: Fresh, S2: Frozen, S3: Sun-dried)

The moisture content showed only slight variation between S1 and S2 while it was comparatively low for sun-dried fish as the water content was drained out during the drying process. The water content was 73.75% for S1, 73.32% for S2 and 18.23% for S3. The protein content showed significant variation between the three samples with a higher value of 31.4% for S3 followed by S1 with 23.18% and only 18.23% for S2. The lipid content showed only slight variation among the samples with comparatively highest % of 2.32 for S1 while it was 2.02% for S2 and 1.1% for S3. The ash content obtained for the three samples were 3.26%, 1.59% and 1.32% for S3, S1 and S2 respectively. The difference between carbohydrate content of the three samples were not so sounding compared to other proximate compositions. Even though it was 0.1% for S3, 0.21% for

52 and 0.44% for S1 which showed superficial variation. The graphical representation of the proximate composition of three different samples of *Euthynnus affinis* is demonstrated below in figure 7.

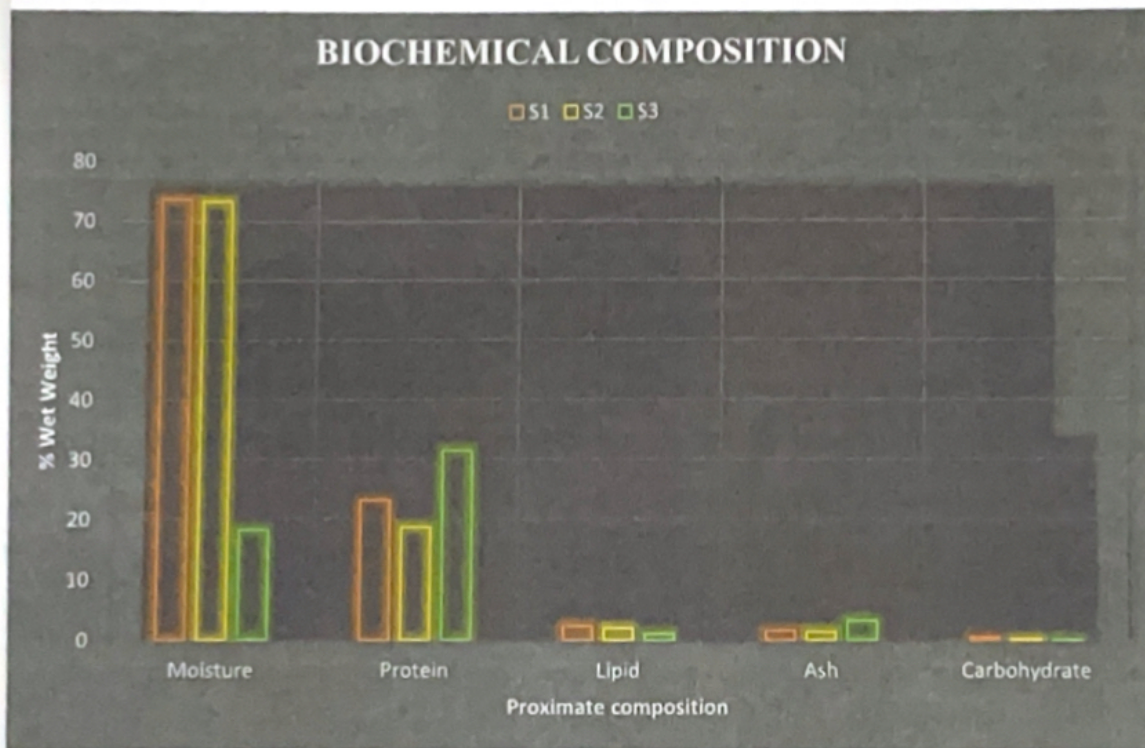


Figure 7: Comparative proximate composition of *E. affinis* (NB: S1- Fresh, S2- Frozen; S3- Sun-dried)

## DISCUSSION

Proximate composition is generally a good indicator of the physiological condition of the fish. Tuna is considered as an excellent source of high-quality protein. Fish products are considered a good source of many micronutrients of significance. Fish is also a cheaper and preferred source of animal protein (Ashitey and Flake 2010); Gordon et al. (2011). The levels of most of the minerals are found in high amounts in fish bones. However, apart from eating small-sized fish species whole (with the bones inclusive), consumption of fish bones of larger fish is rarely practiced. An increased use of seafood, including bones, could contribute significantly to reducing the level of micronutrients and protein malnutrition (Toppe, 2014). Many vulnerable groups cannot afford to buy seafood products, especially in areas where seafood is not available. A solution to the economic and logistic challenges in increasing fish consumption among the poor will be essential in order to make seafood accessible and affordable in micronutrient deficient areas. High-quality fish products from underutilized small pelagic fishes and edible fish processing by-products that can easily be stored and transported should be considered as supplement to diets in such areas. The product should have a potential of being easily introduced into local diets and acceptable by the indigenous population.

Nowadays, appropriate knowledge about the proximate composition of fish is increasingly finding application in various profound areas and knowing the chemical composition of fish helps nutritionists to determine readily available sources of high-protein low-fat food sources for human food (Foran et al., 2005; Mozaffarian et al., 2003) and to food scientists in establishing high-protein foods with high nutritive value (Mohamed et al., 2010). Pertinent information on the proximate composition of a species helps in determining its nutritional and edible values in terms of energy units in comparison with other species. It would also aid the processing technologists to characterise the optimum processing and storage conditions so that the quality of fish could be preserved up to the maximum possible extent.

Even though there has been a great deal of research on the biochemical makeup of fish conducted throughout the world, with the majority of the research published in the 1970s and 1980s, the knowledge that is currently available is dispersed and has not been methodically assembled in one location. Since mackerel tuna, *Euthynnus affinis*, is a large source of protein and has great economic importance, an attempt has been made in this work to highlight the significant variance in its proximate composition. The comparative research conducted in this investigation revealed

a significant difference in the total protein content among sun-dried, fresh and frozen tuna, which is important for human consumption and feed formulation. There were variations in other factors as well, such as moisture, fat, ash content, and carbohydrate. Sun drying is a cheaper method of fish preservation and solar energy is used for the removal of moisture from the fish. Dried fish is a source of protein and plays a major contribution in providing nutrition for the poor as well as economically disadvantaged people of our country (Reza et al., 2005). The product of dried fish is easily transportable, marketable and storable (Alam, 2007). Although dried fishes do not give similar flavor, taste or texture of fresh fish, it is liked and consumed by a large number of people in the world due to its characteristic taste and flavour. It is an important source of animal protein in providing nutrition of the poor and economically disadvantaged people.

In general, fresh fishes are used in culinary. However, drying of fish is also a common practice among various ethnic groups. Drying of fish is an age long practice for preserving fish for a fairly long time to prevent deterioration and spoilage in the quality of the product. It is also to reduce post-harvest losses and make available the product in times of shortage, thereby ensuring cheap protein availability to people. Drying increases the shelf life, enhance the quality, provide ease of handling, further processing and sanitation (Mujumdar, 2007). Drying involves the application of heat to vaporize moisture or remove water vapour from a product (Visavale, 2012).

When considering the texture and quality of fish meat, the protein content of fish is considered of great significance and is regarded as the best source of protein in developing countries (Palani et al., 2014). The high protein content obtained for sun-dried sample in the present investigation underlines the following facts regarding protein content in dried fish. The removal of water will stop or slow down the growth of microbes, oxidation of fat and autolytic activities in the fish with resultant reduction in weight and volume. Normally the sun-dried fishes contain 60 to 80% protein (Haque, 2004). Mansur et al. (2013) found the protein content ranged from 49.23 to 62.85% in three selected dried fish species. Azam et al. (2003) found that the protein content varied between 40.69 to 66.52% in fourteen selected dried fish species. Higher percentage of protein is desirable, it being an important factor for quality assessment. According to Haque (2004), the sun-dried fish normally contain an average of 10-20% moisture. Mansur et al. (2013) found that the moisture content had ranged from 19.17 to 23.12 in three selected dried fish species.

The proximate composition of most fish and shellfish is primarily water, proteins and lipids and these constituents make up about 98% of the total mass. According to the observations of the present study, moisture content showed very feeble difference between fresh (73.5%) and frozen fish (73.32%), while it was lower for dried fish (18.23%) due to its drying process. According to Qing, (2021) during the process of defrosting frozen fish, some of the natural water content may be lost, resulting in flesh that is not as moist as fresh fish after cooking. It is possible for water-soluble vitamins in the fish, such as vitamin B12, to be dissolved and lost through thawing, though fat-soluble vitamins will remain. Hence, fresh fish generally retain more nutrients than their frozen counterparts and result in more tender flesh after cooking. Generally, bound water molecules are trapped in the organised structure of myofibril, whereas free water molecules are located between the space between the protein. Therefore, free water molecules have higher mobility than bound water. This implies that free water is more easily lost during evaporation whilst fish drying; hence, it contributes to the decrease in moisture content (Andersen, 2002).

The lipid content showed only slight variation among the samples with comparatively highest % of 2.32 for fresh sample while it was 2.02% for frozen sample and 1.1% for sun-dried sample. The amount of lipid in the body of fish is considered a good index of future survival in a few species (Simpkins et al., 2003) and also a strong indicator of reproductive potential in some fish stocks (Mejri et al., 2021). These are regarded as one of the most crucial food reserves and the fat indices are also used as a means of describing the relationship between percent fat and water (Sinclair & Duncun, 1972); such type of relationship has also been extensively used by several researchers in various fishes (Ali et al., 2006; Naeem et al., 2011; Sutton et al., 2000). The values obtained in the current experiment closely agrees with the range of ash values (1.35 - 1.66%) obtained for rainbow trout by Gokoglu et al. (2004). It is also within the values (0.95 - 2.50%) reported for silver catfish by Weber et al. (2008), but is lower than 2.5 - 6.25% obtained in raw mince of five different Indian fish species (Muraleedharan et al., 1993). The variation noticed could have been due to variations in age, sex, and environment (Huss, 1995).

The ash content obtained for the three samples were 3.26%, 1.59% and 1.32% for sun-dried, fresh and frozen respectively. Substantial loss of moisture was responsible for the higher ash content in the fish species. In skipjack tuna (*Katsuwonus pelamis*), moisture content, lipid and ash content were higher in dark muscle (Liu et al., 2014). In general, marine fish has long been identified as an important source of high-quality protein with high biological value, vital minerals, vitamins and a reliable source of essential fatty acids in the human diet, all of which

are critical to human nutrition and disease control (Kumaran, 2013; Mohanty & Nayak, 2018; Mohanty et al., 2015; Rasul et al., 2021). Numerous marine fish proteins safeguard against the development of insulin resistance caused by a poor diet (Kaur et al., 2014; Kim et al., 2016; Liaset et al., 2019). However, when it comes to daily fish consumption, freshwater fishes are considered somewhat better than marine fishes in terms of protein supplied, although at the same time marine fish do provide better daily fish fat, minerals and trace metals (Zn, Mn and Cu) compared with freshwater (Rahman et al., 2020).

It has been observed that different processing methods have different effects on the nutritional compositions of fish (Holma and Maalekuu, 2013). According to Hanna (1985), the moisture content was noted lower in investigated freshwater fishes compared with marine and brackish water species. This could be attributed to the fact that most freshwater species osmotically expel water, whereas marine species osmotically take in water (Hanna, 1985; Ndome et al., 2010). Analogous inferences were studied by Soumiya (2015) and concluded that marine fish comprised high amount of calcium, iron and fat, than freshwater fish species where high protein and vitamin contents were observed. Herring, *Clupea harengus* as a marine fish has a higher fat content in higher salinities than brackish environments (National Food Agency of Sweden, 2017). It has also been reported that freshwater fish have lower proportions of omega-3 polyunsaturated fatty acids than marine fish (Dhaneesh et al., 2012; Memon et al., 2010; Mohsen, 1985; Rahnan et al., 1995; Shoba et al., 2020; Stansby & Hall, 1967; Vlieg & Body, 1988). Differences in fatty acids between marine and freshwater fishes should be evaluated not just in terms of environment, but also in terms of natural diet, particularly if a species is herbivorous, carnivorous or omnivorous (Dhaneesh et al., 2012; Sargent et al., 1995).

## SUMMARY

Fish quality, physiological state, and nutritional status can all be evaluated by using knowledge of their proximate composition, which is crucial for understanding the fish's nutritive profile. It also provides the most reliable information about the nutrient content of different fish species to those exports who primarily deal with fish and fishery-related products. The present study, which provides a substantial nutritional data and emphasizes the availability of healthful elements found in the edible portion of fish, is a significant step toward understanding the relevance of future research on the nutrient composition of consumable and affordable fish species. There has long been debate concerning whether fresh or frozen fish is preferable. Since fresh typically means higher quality, most people will instinctively think that fresh fish is superior. Our nation's underprivileged and economically challenged citizens rely heavily on dried fish as a source of protein and nutrition. Hence, the present study has made an attempt to estimate the proximate composition of mackerel tuna, *Euthynnus affinis* in fresh, frozen and sun-dried condition. The results indicated that the protein content was more prominent in dried fish compared to fresh and frozen fish samples which can be attributed to the nutrient quality provided by the same.

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