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Proximate chemical composition and lipid profile of Indian mackerel fish

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Abstract

Fish and fish products of the most available protein sources for human beings. Indian mackerel is the most available and economic fish sold in markets in different countries and is included in many local dishes. Indian mackerel are characterized by dark muscles because of the high contents of myoglobin and lipids. This study aims to investigate the chemical composition, saturated and unsaturated fatty acid contents, and fatty acid fractions in Indian mackerel muscle. Indian mackerel (*R. kanagurta*) were purchased from the central fish market in Jizan, which is caught from the port of Jizan, Saudi Arabia. The samples were analyzed to estimate the proximate chemical composition, Lipid Fractions, and Fatty acid analyses from Indian mackerel. In this study, revealed that moisture, protein, and fat are the main constituents of Indian mackerel. The Indian mackerel contained high and comparable levels of saturated fatty acids and unsaturated fatty acids, and the different samples exhibited somewhat similar fatty acid contents. Among unsaturated fatty acids, the content of polyunsaturated fatty acids was higher than that of monounsaturated fatty acids, and those with the highest levels in Indian mackerel were palmitoleic, palmitic, myristic, oleic, 15-tetracosenoic, linolenic, and stearic acids in addition to docosanoic, eicosanoic, 5,8,11,14,17-eicosapentanoic, and 11-eicosenoic pentadecanoic acids. We conclude Indian mackerel is a rich source of protein and lipids. Polyunsaturated fatty acids are the main constituents of lipids, which exert positive effects on the body by providing the main nutrients and preventing disease in the consumer.

Keywords: Indian mackerel; chemical composition; lipids; fatty acids.

Practical Application: Providing information about the chemical composition, saturated and unsaturated fatty acid contents, and fatty acid fractions in Indian mackerel fish.

1 Introduction

Some of the most available protein sources for human beings of fish and fish products, which represent approximately 80% of animal protein. There is strong evidence that fish are rich sources of vitamins such as B12 and B6 and minerals, especially iodine and fluorine, which are required for the prevention of goiter and promote strong teeth and bones (Håstein et al., 2006).

Indian mackerel (*Rastrelliger kanagurta*) belongs to the family Scombridae and is commonly found in the coastal areas of the Indian Ocean. Mackerel fish are also found in the waters of the Red Sea and the Arabian Gulf and are abundant in summer. Mackerel arrives in India and forms the basis of pelagic fisheries after sardines, representing 7.2% of total marine fish (Sofi et al., 2016). Indian mackerel is the most available and economic fish sold in markets in different countries and is included in many local dishes. Indian mackerel is characterized by a blue-green color on the back, silver flanks and a golden tint. The size of Indian mackerel varies in length, reaching 21.7 cm at 8.6 months old. Additionally, Indian mackerel are characterized by dark muscles because of the high contents of myoglobin and lipids. Mackerel is a fatty fish and a good source of marine lipids; thus, increasing the consumption of this fish is good for human health (Abdussamad et al., 2010; Chaijan et al., 2004). The high levels of amino acids, fatty acids, minerals and vitamins in Indian mackerel play a positive role in human nutrition (Viji et al., 2015; Corapci & Guneri, 2020).

The objective of this study was to investigate the chemical composition, saturated and unsaturated fatty acid contents, and fatty acid fractions in Indian mackerel muscle and to compare the obtained results with previously available data.

2 Materials and methods

2.1 Collection and preparation of Indian mackerel samples

Indian mackerel (*R. kanagurta*), 17 ± 3 cm in length, were purchased from the central fish market in Jizan, which is caught from the port of Jizan, Saudi Arabia. Fish samples were transported to the laboratory in an ice box as soon as possible and were analyzed within 24 hours of catching them.

Fish were prepared by cutting the samples using sterile cutters and homogenizing obtain three samples of Indian mackerel muscle for chemical analysis, Lipid Fractions and Fatty Acids analyses.

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2.2 Chemical analysis

Moisture, ash, protein, and fat were estimated in Indian mackerel by the methods described by the Association of Official Analytical Chemists (2012). All analyzes were performed in three iterations. The carbohydrate content was calculated as follows (Mathew et al., 2014; Equation 1):

$$Total\ carbohydrates = 100 - (moisture + ash + protein + total\ lipids)\ \% \quad (1)$$

2.3 Determination of lipid fractions and fatty acids analysis

Fatty acids were obtained from total lipids by acid-catalyzed transesterification according to (Christie & Han, 2012). amount of 100 mg of the extracted lipid was dissolved in 1.5 mL dichloromethane and 3 mL methanol-sulfuric solution (200:3 at a volume ratio) and shaken vigorously. The reaction mixture was heated at 100 °C for approximately 1 h and then cooled to room temperature. Subsequently, 3 mL hexyl hydride and 1 mL distilled water were added to the mixture. After vortexing and layering, the entire upper phase was collected. One gram of anhydrous sodium sulfate was added to the collected sample and then stewed for overnight stratification. After filtration, the sample was evaporated until its weight turned to be constant under a stream of nitrogen. Heptane was added to the sample to make up a final concentration of 50 mg mL^{-1}. The qualitative analysis of Fatty acids was by column chromatography (CC MSQP5050A System: model 2001, Shimadzu, Japan; autosampler, Shimadzu, Japan; serial number, C111437075). The quantity of each fatty acid was determined by calculating the peak area relative to the total area of the peak. These values are indicated by fatty acid content (%).

2.4 Statistical analysis

Data are presented as the mean ± standard deviation (n=3) and were analyzed by one-way analysis of variance (ANOVA) using Minitab 17 software. The significance level was $p < 0.05$.

3 Results

3.1 Proximate chemical composition

The average chemical composition of the tested Indian mackerel samples purchased from different markets in March was investigated and is shown in Table 1. The average moisture, protein, fat, ash and carbohydrate contents were 74.33 ± 0.39, 20.89 ± 0.07, 3.23 ± 0.26, 1.26 ± 0.14, and 0.29 ± 0.14 g/100 g, respectively.

3.2 Composition of lipids

The obtained results in Table 2 and Figure 1 show that the tested Indian mackerel contained high levels of saturated fatty acids, reaching 27.01 ± 0.07 mg/100 g, followed by a similar content of unsaturated fatty acids, which were present at a level of 26.02 ± 0.07 mg/100 g. Unsaturated fatty acids are composed of polyunsaturated fatty acids and monounsaturated fatty acids; the level of polyunsaturated fatty acids was higher (22.01 ± 0.06 mg/100 g) than that of monounsaturated fatty acids (4.01 ± 0.01 mg/100 g). The content of trans fatty acids was 1.001 ± 0.01 mg/100 g in the tested Indian mackerel muscle.

Table 1. Moisture, protein, fat, ash and carbohydrate contents in the muscle of Indian mackerel.

Moisture (g/100 g)	Protein (g/100 g)	Fat (g/100 g)	Ash (g/100 g)	Carbohydrates (g/100 g)
74.33 ± 0.39	20.89 ± 0.07	3.23 ± 0.26	1.26 ± 0.14	0.29 ± 0.14

Values of three independent replicates are expressed as the mean ± SD [Standard deviation].

Table 2. Saturated, unsaturated and trans fatty acid contents of Indian mackerel.

Saturated fatty acids (mg/100 g)	Unsaturated fatty acids (mg/100 g)	Polyunsaturated fatty acids (mg/100 g)	Monounsaturated fatty acids (mg/100 g)	Trans fatty acids (mg/100 g)
27.01 ± 0.07	26.02 ± 0.07	22.01 ± 0.06	4.01 ± 0.01	1.001 ± 0.01

Values of three independent replicates are expressed as the mean ± SD.

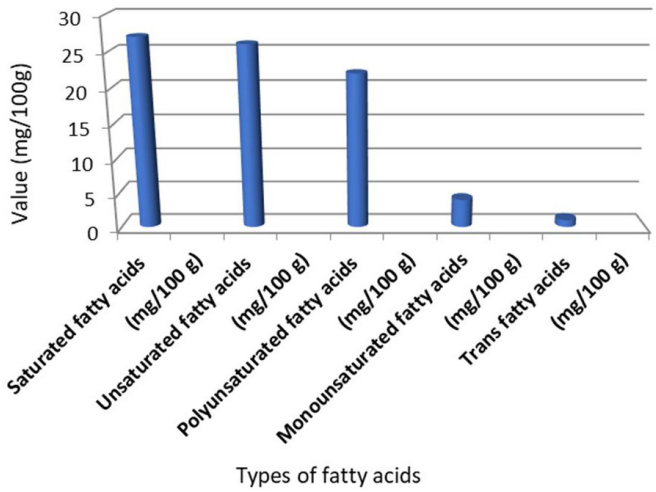

Figure 1. Saturated, unsaturated and trans fatty acids content of Indian mackerel muscle.

3.3 Lipid fractionation

The data in Table 3 and Figure 2 indicate that the fatty acids with the highest contents in Indian mackerel were palmitoleic acid, palmitic acid, myristic acid, oleic acid, 15-tetracosenoic acid, linolenic acid, stearic acid CIS-13,16-docosadioic acid and cis-11,14,17-eicosatrienoic acid, with descending concentrations of 0.270 ± 14.33, 0.235 ± 25.81, 0.234 ± 13.24, 0.144 ± 9.873 0.138 ± 8.84, 0.132 ± 1.04, 0.117 ± 7.42, 0.115 ± 8.41 and 0.10 ± 3.47%, respectively.

Additionally, Indian mackerel had relatively low levels of other fatty acids; the contents of the remaining fatty acids are listed in descending order: docosanoic acid, 0.081 ± 0.46%; eicosenoic (arachidic) acid, 0.066 ± 0.92%; 5,8,11,14,17-eicosapentaenoic acid, 0.061 ± 0.51%; 11-eicosenoic acid, 0.049 ± 0.25%; pentadecanoic acid, 0.047 ± 1.25%; heptadecanoic acid, 0.032 ± 1.43%; 8,11,14-eicosapentanoic acid, 0.030 ± 0.29%; and Y-linolenic acid, 0.026 ± 0.44%.

Table 3. Fatty acid composition of lipids in Indian mackerel muscle.

Fatty acid %	Chemical formula	Mean ± SD
Myristic acid	$C_{14}H_{28}O_2$	13.24 ± 0.234
Pentadecanoic acid	$C_{16}H_{32}O_2$	1.25 ± 0.047
Palmitic acid	$C_{16}H_{32}O_2$	25.81 ± 0.235
Palmitoleic acid	$C_{16}H_{30}O_2$	14.33 ± 0.270
Heptadecanoic (margaric) acid	$C_{17}H_{34}O_2$	1.43 ± 0.032
Stearic acid	$C_{18}H_{36}O_2$	7.42 ± 0.117
Oleic acid	$C_{18}H_{34}O_2$	9.873 ± 0.144
Linoleic acid	$C_{18}H_{30}O_2$	2.18 ± 0.011
Eicosenoic (arachidic) acid	$C_{20}H_{40}O_2$	0.92 ± 0.066
Y-Linolenic acid	$C_{18}H_{30}O_2$	0.44 ± 0.026
11-Eicosenoic acid	$C_{20}H_{48}O_2$	0.25 ± 0.049
Linolenic acid	$C_{18}H_{30}O_2$	1.04 ± 0.132
Docosanoic (behenic) acid	$C_{22}H_{44}O_2$	0.46 ± 0.081
8,11,14-Eicosatrienoic acid	$C_{20}H_{34}O_2$	0.29 ± 0.030
Cis-11,14,17-Eicosatrienoic acid	$C_{20}H_{34}O_2$	3.47 ± 0.10
Cis-13,16-Docosadienic acid	$C_{22}H_{40}O_2$	8.41 ± 0.115
5,8,11,14,17-Eicosapentanoic acid	$C_{20}H_{30}O_2$	0.51 ± 0.061
15-Tetracosenoic acid	$C_{24}H_{46}O_2$	8.84 ± 0.138

Values of three independent replicates are expressed as the mean ± SD.

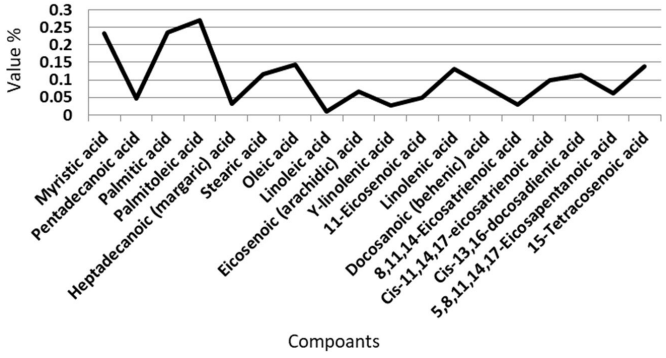

Figure 2. Fatty acid composition of Indian mackerel muscle lipids.

4 Discussion

The obtained proximate analysis results of Indian mackerel are excellent indicators of fish quality. Ahigh moisture content increases fish susceptibility to microbial spoilage and lowers its shelf life (Clucas, 1982; Oliveira et al., 2020). The moisture contents obtained in this study agreed with the results of Nurnadia et al. (2011) and Gokoglu & Yerlikaya (2015), who observed 70-80% moisture in fish muscle. Ali et al. (2013) also reported 72.8-76.6% moisture in Indian mackerel from Oman.

It is known that fish protein is of good quality, containing a good amount of essential amino acids, and is highly digestible and a major source of energy (Pigott & Tucker, 1990). The results of the protein analysis of Indian mackerel were like the results of Bandarra et al. (2001), who reported 18.3 to 19.9% protein in horse mackerel. In agreement with our findings, Nisa & Asadullah (2012), Ali et al. (2013), Kumar et al. (2014) and Bahurmiz et al. (2017) estimated 15.1-22.4% protein in Indian mackerel. Moreover, many researchers have reported that sex, species, age, environment, and season affect the chemical composition of fish (Bandarra et al., 2001; Celik, 2008; Sonavane, 2017; Oliveira et al., 2020b).

These outcomes agree with the conclusions of Tzikas et al. (2007) and Sone et al. (2019), who recorded that the moisture, protein, fat and ash contents of mackerel were 76.8 ± 1.39%, 20.3 ± 0.68%, 1.3 ± 1.08% and 1.5 ± 0.08%, respectively, throughout the year. The fat content of the muscle increased by 2.5%, 2.8% and 2.1% in March, April, and May, respectively, compared with that in February, with a decrease in moisture content to below 75.9%. In contrast, in September and October, a low-fat content (0.4% and 0.6%, respectively) and high moisture content, reaching 78.2% and 77.6%, respectively, were observed.

It has been reported that fish lipids are mainly composed of polyunsaturated fatty acids, especially docosahexaenoic and eicosapentaenoic acids, which can prevent and treat rheumatoid arthritis, coronary heart disease, diabetes, and cancers. Fatty acids play a positive role in osmoregulation, nutrient assimilation, and transport via the cell membrane (Ackman, 1982; Osman et al., 2001). The lipid content results from this study agreed with the results of Johnston et al. (1994), as the lipid content was low in lean, starved fatty fish (0.5%) and increased to above 20% in well-fed, fatty fish. Additionally, Wickramanayake et al. (1989), Nisa & Asadullah (2012), Kumar et al. (2014) and Bahurmiz et al. (2017) recorded that lipids accounted for 0.7% to 12.0% of the muscle content of mackerel caught in the Arabian Sea.

Our results showed that the ash content in mackerel muscles was 1.26 ± 0.14%, which was within the ranges of 0.5% and 1.8%, as recorded by Sidwel (1981), and 0.9-1.4%, as reported by Nisa & Asadullah (2012) and Ali et al. (2013).

The obtained composition results of Indian mackerel showed predominantly saturated fatty acids followed by unsaturated fatty acids, both of which were present in a similar range. Unsaturated fatty acids are composed mainly of polyunsaturated fatty acids, which agrees with many studies, including those of Marichamy et al. (2009), Ganga et al. (2010) and Azim et al. (2018). Additionally, in a study on Atlantic mackerel, the fat content increased with an expected increase in food consumption and varied among years, seasons and geographic areas (catching grounds) in addition to individual variations in weight gain, as a higher total fat content is related to the feeding period and the size of the mackerel (Romotowska et al., 2016, 2017; Calixto et al., 2020).

The obtained fatty acid fractionation results of Indian mackerel contradict those of previous studies of different species, seasons, diets, and environmental conditions (Bahurmiz & Ng, 2007; Hong et al., 2015; O'Neill et al., 2015; Wijekoon et al., 2014; Costa et al., 2020). It is well documented that docosahexaenoic acid and palmitic acid are the main fatty acids in aquatic fish (Sahena et al., 2009). Palmitic acid is needed for biosynthesis processes in fish and may play a role as a structural component of phospholipids in cell membranes (Pérez et al., 1999; Nascimento et al., 2020; Marques et al., 2020).

It has also been suggested that fish are rich in polyunsaturated fatty acids, such as eicosapentaenoic acid and docosahexaenoic acid, and have desirable components of a nutritious diet. Polyunsaturated fatty acids affect prostaglandin synthesis and hence encourage wound healing. ω-3 and ω-6 polyunsaturated fatty acids protect

against cardiovascular diseases and cancer. Additionally, these fatty acids play a vital role in nervous, vision and reproductive system development and functions (Agusa et al., 2007; Luzia et al., 2003). Therefore, Indian mackerel is a rich source of protein and lipids. The Indian mackerel contained high and comparable levels of saturated fatty acids and unsaturated fatty acids, and the different samples exhibited somewhat similar fatty acid contents.

5 Conclusion

The present study revealed that Indian mackerel is a rich source of protein and lipids. Polyunsaturated fatty acids are the main constituents of lipids. The lipid profile of Indian mackerel showed high levels of palmitoleic acid, palmitic acid, myristic acid, oleic acid, 15-tetracosenoic acid, linolenic acid, and stearic acid, which exert positive effects on the body by providing the main nutrients and preventing disease in the consumer.

5.1 Recommendations

The obtained results showed favorable dietary components, mainly protein and lipids, in Indian mackerel and highlighted the importance of the lipid profile on the health of consumers and the application of different technological processes to avoid rancidity in fish. Further studies should be conducted on the amino acid, vitamin, and mineral contents of Indian mackerel in different seasons and catching areas.

5.2 Significance statement

This study estimates the proximate chemical composition, mainly those of protein and lipids of Indian mackerel and highlights the importance of the lipid profile to the health of consumers. This study will help researchers determine other nutrients, such as amino acids, vitamins, and minerals, in Indian mackerel and their differences between different seasons and catching areas, which many researchers have not been able to explore thus far. Thus, new theories on micronutrient combinations in Indian mackerel may be developed.

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