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EFFECT OF SEX, SEASON, AND SIZE ON THE CHEMICAL COMPOSITION OF RED SEA GOATFISH *Parupeneus forsskali* (Fourmanoir and Guézé, 1976) CAUGHT FROM THE MARINE WATER OF LATTAKIA GOVERNORATE (SYRIA)

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The effects of seasonal and sexual differences and Total Lenght on the chemical composition of the Red Sea goatfish *Parupeneus forsskali* caught from the marine waters of Lattakia Governorate were investigated. Moisture, crude protein, crude fat, and ash were determined as a percentage of the fish muscles. The results revealed that the autumn season was the highest in terms of nutritional components (protein 22.08%, fat 9.78%, ash 2.42% of fresh fish muscle), While the Summer season was the lowest (protein 19.32%, fat 5.46%, ash 1.20%). The results also showed the superiority of females in the values of the nutritional components over males, where the values were for females (protein 22.3%, fat 8.9%) and males (protein 20.7%, fat 6.8%), while The results also showed the superiority of males in the values of ash over females of ash (male 1.5%, female 1.3%). Regarding the body length factor, the results showed a significant positive relationship between an increase in Total length and an increase in protein and fat and a significant inverse relationship with both ash and moisture content.

Keywords: Chemical composition; *Parupeneus forsskali*; Mediterranean sea; Syrian coast.

1. INTRODUCTION

The chemical composition of fish muscles varies greatly depending on (species, reproductive cycle, age, feeding habitat, sexual maturity, sex, environment, season and muscle type) [1,2,3]. It is known that seafood products in general provide large amounts of various beneficial nutrients such as proteins, essential minerals, and fats with high nutritional value unsaturated fatty acids [4].

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In general, different species of fish do not give the same nutritional value throughout the year, but this varies according to the season. Fish is an important source of protein in terms of the ratio, quality of its constituent amino acids, and high digestibility [5]. In addition, fish fats are receiving a great deal of attention for their high content of polyunsaturated fatty acids (ω-3 PUFA), which have a positive effect on the prevention of many diseases such as high blood pressure, infections, psoriasis, depression, and cancer [6].

Several previous studies indicated that there are significant seasonal differences in the chemical composition of fish tissues and in the fatty acid composition of many marine organisms in response to different factors. Zlatanos and Laskaridis [7] indicated that the period of the year that was characterized by the increased nutritional activity of fish was accompanied by an increase in the fat content in the muscles and an increase in the proportion of saturated fatty acids.

In a study conducted by Kalyoncu and Yay [8] on *Mullus surmuletus*, the results showed a change in the fat content of fish muscles throughout the year, increasing in autumn and winter and decreasing in spring and summer, This is consistent with a study by POLAT and others (2007) on the fish species Red Mullet (*Mullus Barbatus*), This is consistent too with a study by Khitouni and others [9] On the fish species Golden Gray Mullet Chelon auratus. The same study also indicated that sex had a relationship with differences in the chemical composition of fish, as females showed a clear superiority in the content of total fats and proteins over males in most months of the year.

The results of the study of Norouzi and Bagheri [10] also showed a decrease in the fat and protein content and an increase in muscle moisture for *C. auratus* species during the breeding period compared to other periods, and it was noted that the decrease was higher in females than in males. Durmus and others [11] also pointed out the importance of sex and fishing season in affecting the chemical and mineral composition and content of heavy metals in the fish species *Mullus barbatus*, where the study showed a variation in the chemical composition of the fish species with both sex and fishing season.

In a study conducted by Kurbah and Bhuyan [12] on the effect of the season on the chemical composition of the fish species *Monopterus cuchia*. The results showed that the protein and fat content was high during the pre-breeding period and decreased during the spawning period. As for the carbohydrate content, there were no significant differences during the seasons.

With regard to the effect of total length on the chemical composition, which indirectly reflects the effect of body size on the chemical composition, studies have varied on the subject. In a study conducted by Hussain and his colleagues in 2016, they found that the effect of size on the chemical composition of fish varies according to the species. The effect was clear for the carnivorous species, while there was no significant effect for the herbivores.In a study conducted by Naeem and Salam in [13] on the fish Species *Aristichthys nobilis* to see the effect of size on the chemical composition of fish, they found an increase in both the fat and protein content with an increase in size accompanied by a decrease in the moisture and mineral content, and this was confirmed by another study on the fish species *Oncorhynchus mykiss* [14].

The presence of *P. forsskali* in Syrian marine waters was recorded for the first time in 2014 [15] and after that date the numbers of individuals belonging to this species began to appear in increasing quantities within the catches with gills nets and cages at depths ranging between 5 and 30 meters on the Syrian coast, so that the catches of *P. forsskali* rival the catch of any of the other four species of the Mullidae family (*Mullus barbatus, Mullus surmelutus*, *Upeneus moluccensis, Penus pori*). In addition, *P. forsskali* enjoys great acceptance and palatability among the consumer, which supports the implementation of a study on the chemical composition of this species in its new environment.

Fig. 1. A sample of *P. forskalis* fish that used 45 individuals in this research (scale bar 20 mm)

The aim of this research was to estimate the seasonal changes of the chemical composition throughout the year of Red Sea goatfish *P. forsskali* (Fig, 1) and to show the possible relationship between the chemical composition and sex and the total length of fish individuals caught from the marine waters of Lattakia Governorate.

2. MATERIALS AND METHODS

2.1 Fish Samples

This study was conducted during the four seasons of the year 2021. Samples of Red Sea goatfish *P. forsskali* were obtained seasonally from the marine waters of Lattakia Governorate. Fish samples were randomly collected from sites landing along the beach of Lattakia governorate (Fig. 2), and approximately 12 individuals were taken for the analysis with three replicates.

The average total length of the individuals was (18.9±3.6 cm) and the average body weight (83.8±50.1 grams/fish), while the standard length of the individuals was used in addition to the gonad examination in order to determine the sex of the individuals and the stage of sexual maturity. The muscles behind the pectoral fin were used for the subsequent chemical analyses. The samples of male, female and undifferentiated individuals (immature gonads) were analyzed separately for accuracy and ease of analysis of the results [15].

2.2 The Chemical Analysis

All chemical analyses were expressed in (g/100g) of fresh fish muscle, according to [16].

Moisture: At first, the initial weight of the samples was taken. Then samples were dried in an oven at about 105^0 C for about 8 to 10 hours until a constant weight was reached and cooled in a desiccator and weight again .Then the samples were minced in an electric grinder. The percentage of moisture content was calculated by the following equation:

Percentage (%) of moisture = (Weight loses/Original weight of sample) × 100

Fat: For the estimation of fat content, the dried samples left after moisture determination were finely grinded and the fat was extracted with a nonpolar solvent, ethyl ether. After extraction, the solvent was evaporated and the extracted materials were weighed. The percentage of fat content was calculated as:

Percentage (%) of fat = (Weight of extract/Weight of sample) × 100

Fig. 2. Fish sample collection sites (within the rectangle) along the coast of Lattakia Governorate

Protein: The protein content of the fish was determined by micro-kjeldahl method. It involves conversion of organic nitrogen to ammonium sulphate by digestion with concentrated sulphuric acid in a microkjeldahl flask. The digest was diluted, made alkaline with sodium hydroxide and distilled. The liberated ammonia was collected in a boric acid solution and was determined by titration method. The percentage of protein in the sample was calculated by the following equation:

Percentage (%) of protein = (c-b) × 14 × d × 6.25/a × 1000 × 100

Where:

a = sample weight (g)
b = volume of NaOH required for back titration and neutralize 25ml of 0.1N H_2SO_4 (for sample)
c = volume of NaOH required for back titration and neutralize 25 ml of 0.1N H_2SO_4 (for blank)
d =normality of NaOH used for titration
6.25= conversion factor of N to protein

14 = atomic weight of N

Ash: The ash content of a sample is the residue left after ashing in a muffle furnace (Gerhardt) at about 550-600 C till the residue become white. The percent of ash was calculated as follows:

Percentage (%) of ash = (Weight of ash / Weight of Sample) × 100

2.3 Statistical Analysis

The experiments were carried out according to a randomized complete block design, and the results were analyzed by applying the ANOVA ONE WAY test, and the results were compared using the least significant difference (LSD) method at the significance level of 0.05 using the programs: Microsoft Excel 2016 and SPSS 2011.

3. RESULTS AND DISCUSSION

The results of the chemical composition analysis of Red Sea goatfish *P. forsskali* in the current work show that the average values of the chemical composition (fat 7.5±2.5%, protein 21±2.08%, ash 1.8±0.73%, and moisture 72.7±2.4% of fresh fish muscle). Compared with the chemical composition of other species belonging to the same family that was carried out in different geographical locations and at different times, where the values of the study conducted on the species *Upeneus moluccensis* were (fat 4.35 %, ash 1.1 %, moisture 79.4%), and for the species *Mullus surmuletus* are (fat 10.3%, ash 1.6% , Humidity 73.1%) [17]. And the values of the study conducted on the species *Mullus barbatus* were (fat 4.9 %, Protein 19.09% ash 1.1%, moisture 74.3%) [18].

From the foregoing, we note that the chemical composition of fish varies according to many factors, especially the species, fishing season, sex, and the period of sexual maturity. This is confirmed by several studies, where it was found that the chemical composition of fish changes and is related to many different factors such as temperature, location, reproductive cycle, diet, age, size, sex, and other factors [19,20,21].

The Red Sea goat is a fatty fish (Boyer *et al*., 1995) with a fat content of >5% this fat is mainly stored in the muscle [22] and this can be attributed to the relatively high activity of this species, which requires A large amount of energy, It is also a species of demersal fish that accumulates fat to withstand the low temperatures in the deep sea [23].

Table (1) shows the seasonal changes of the Red Sea goatfish *P. forsskali*, the moisture ranged from 70% in Autumn to 75.38% in Summer (*pvalue*≤0.05). For protein, there were no significant changes in its value throughout the year, as the values ranged from 19.32% in Summer to 22.08% in Autumn (*pvalue*≥0.05), While there were significant changes (*pvalue*≤0.05) for fat values, which ranged from 5.46% in Summer to 9.78% in Autumn, Ash values showed a significant change (*pvalue*≤0.05) also during the seasons of the year, where the values ranged between 1.20% in Summer and 2.42% in Autumn.

Table 1. Seasonal changes in the chemical composition of *P. forsskali*

	Winter	Spring	Summer	Autumn	*p*-Value
Moisture	71.40±1.10**a**	74.19±1.19**b**	75.38±0.72**b**	70.00±1.35**a**	**<0.001**
Protein	21.06±2.04**a**	21.06±2.34**a**	19.32±2.08**a**	22.08±0.88**b**	**0.211**
Ash	1.96±0.51**a**	1.63±0.34**a**	1.20±0.73**a**	2.42±0.66**b**	**0.039**
Fat	7.67±3.11**a**	6.52±1.22**a**	5.46±1.26**b**	9.78±2.19**c**	**0.028**

**: The different letters (a-c) within one line indicate the presence of significant differences at (P≤0.05)*

With regard to the effect of the sex factor on the chemical composition of fish (Red Sea goatfish *P. forsskali*), Table (2) shows the changes in the chemical composition values of the studied fish species with the change of sex. Where the values of fats in females (8.9) were higher than in males (6.8) and in immature individuals (6.3), the differences were significant ($p \leq 0.05$). The values of protein in females (22.3) were higher than in males (20.7) and in immature individuals (19.8), the differences were significant ($p \leq 0.05$). For ash values in immature individuals (2.4) are higher than in males (1.5) and in females (1.3), the differences were significant ($p \leq 0.05$). While the moisture values in males (73.9) are higher than in females (72.1) and immature individuals (72.6), the differences were significant ($p \leq 0.05$).

It was noted from the results that the highest value of moisture was during the summer (75.38%), which corresponds to the lowest value of fat (5.46%), and vice versa in the autumn season in the same period (fat 9.78% and moisture 70%) (Table 1). It was also observed that moisture content was negatively correlated with fat content ($R^2 = 0.70$, $P \leq 0.001$, $Y = -0.865X + 70.32$) as shown in Fig. (3).

The results of our current study are also in agreement with the results of a study conducted in Turkey in 2018 on *M. barbatus*, where this study indicated the importance of sex and fishing season in influencing the chemical and mineral composition and heavy metal content in fish. Where the chemical and mineral composition of the muscles differed significantly according to sex and season [12].

Through the results, we were observed that water is the main component of the various parts of the muscles, where the highest values of moisture content were in Summer (>75%), And as stated in the study [24], the water content in fish tissues varies widely according to the seasons of sampling, and in inverse proportion to the fat content.

Also, the protein content was maintained at relatively high and stable levels throughout the year and this is in agreement with several previous studies [25,26]. The maturation period of the gonads of the studied fish extends between Spring and Summer [27], Which is associated with lower values of muscle chemical components (protein 19.32%, fat 5.46%, and ash 1.2%), For the period from Autumn to Winter (i.e, the period of gonad immaturity), the fish samples showed relatively medium and high nutritional values (protein 21.06% to 22.08%, fat 7.67% to 9.78%, and ash 1.96% to 2.42%).

Table 2. Changes in the chemical composition values according to the sex factor for *P. forsskali*

	Moisture	Protein	Ash	Fat
Male	73.9±2.4	20.7±2.07	1.5±0.78	6.8±2.43
Female	72.1±2.6	22.3±1.63	1.3±0.48	8.9±2.71
Immature	72.6±2.4	19.8±1.84	2.4±0.4	6.3±1.89
p-value	**0.015**	**0.033**	**0.024**	**0.012**

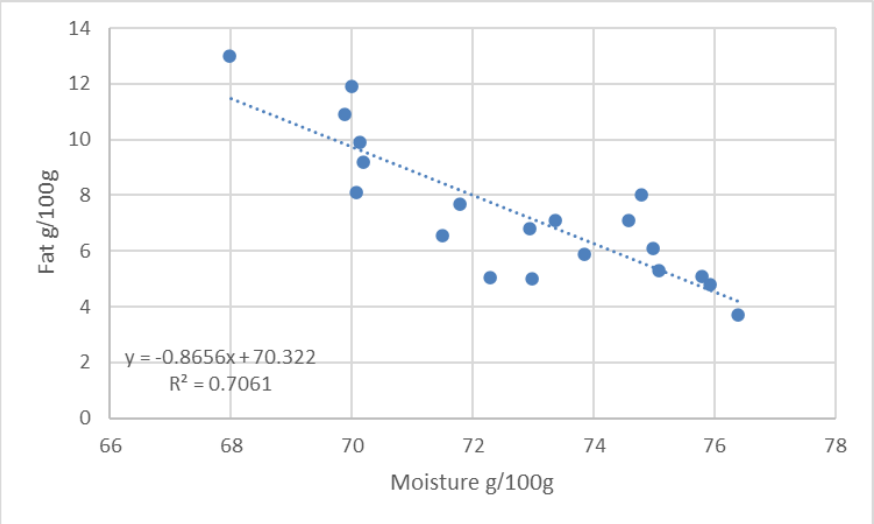

Fig. 3. The relationship between moisture content and fat content of *P. forsskali*

The high content of fat, protein, and ash during the gonad maturation period can be explained by the fact that fish need these nutrients as an energy source for use during the spawning stage [28]. Also, the high content of nutrients in the muscles of females compared to males, which was shown by the results, may be attributed to the high energy that females need in the reproductive process and the preparation of the appropriate environmental nest for laying eggs compared to males and immature individuals, where there were significant differences (P≤0.05) between the nutritional compounds (protein, fat, Ash) in females, males and immature individuals during most seasons of the year.

Regarding the relationship of total length (cm) with the chemical components of muscle, both fats and proteins showed a good positive relationship (P≤0.05) with total length, while the inverse relationship was good (P≤0.05) with both moisture and ash content as shown in Fig. (4).

By comparing the results of the current work with a study conducted by Ashraf and others in [29] on the relationship between the total length of a fish and its chemical composition in a group of fish, we note that it agrees with his results regarding proteins that increased with the increase in total length significantly, while it contradicts the results of his study with regard to fats, whose values decreased with the increase in total length in carnivorous species, while the opposite occurred in herbivorous species.

In comparison with another study conducted by researchers Naeem and Salam in 2010 on the fish species *Aristichthys nobilis* to see the effect of volume on the chemical composition of the fish, they found an increase in both the fat and protein content with the increase in the volume accompanied by a decrease in the moisture and mineral content and this is consistent with The results of our current work. This was confirmed by another study on the fish species *Oncorhynchus mykiss* [14].

The increase in the nutritional components of fish with the increase in the total length and consequently with age can be attributed to the fact that the fish with age sexually mature and its activity increases, which increases its need for food components as savings to obtain the energy needed for the processes of searching for food and reproduction, preparing the appropriate environmental nest for laying eggs and caring for newly hatched individuals.

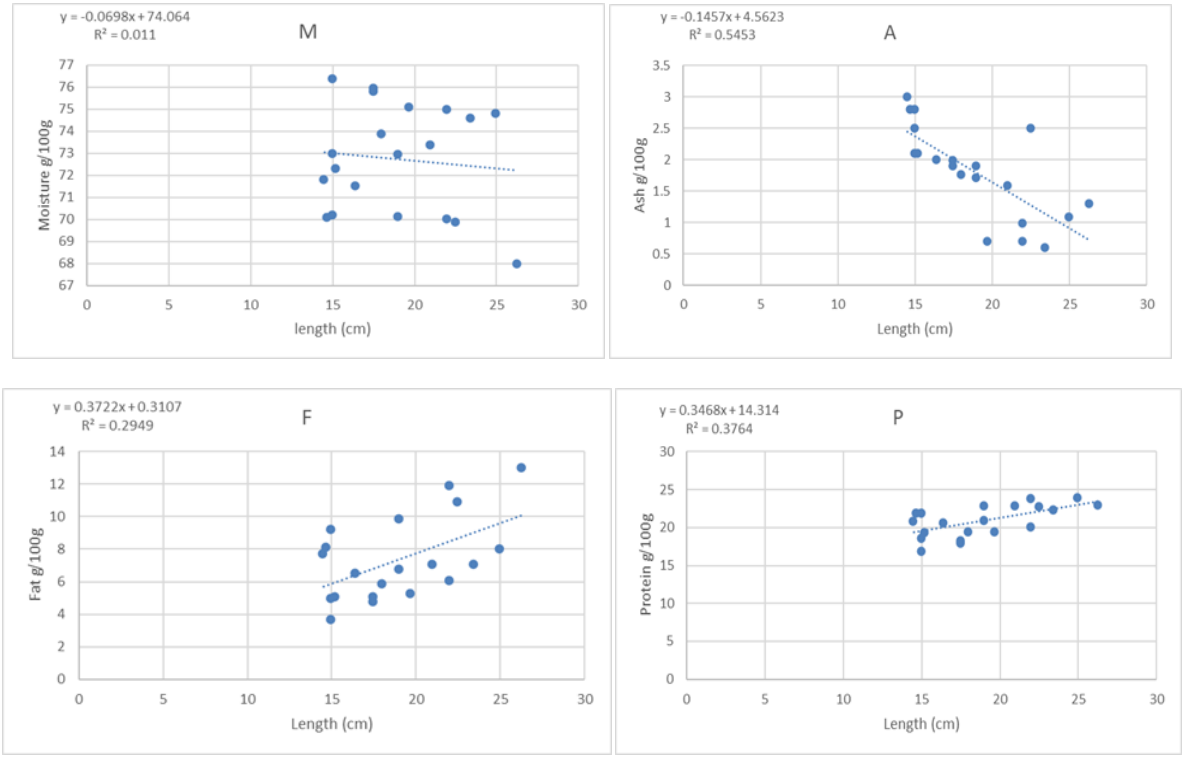

Fig. 4. Relationship between the total length (cm) and chemical composition (P) protein, (F) fat, (M) moisture, (A) ash for *P. forsskali*

4. CONCLUSION

The chemical composition of *P. forsskali* changes according to the fishing season, with the exception of the proteins whose values remain similar throughout the year. There is an inverse relationship between the moisture content of muscle and its fat content. The muscle content (protein, fat, and ash) of *P. forsskali* varies according to gender, being higher in females compared to males. The muscle content of (protein, fat, and ash) is lower during the gonad maturation period (the reproductive period) compared to the rest of the year (the resting period). The chemical composition of the muscles also changes with the change in the total length, as both fats and proteins increase with the increase in the total length, while the moisture and mineral content decreases with this increase.

The research recommends conducting more studies on the relationship between the chemical composition of Red Sea goatfish *P. forsskali* fish with the surrounding environmental factors in order to understand the extent to which this species is affected by its environment and thus the ability to benefit from it as much as possible.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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