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Influence of seasonal variation on the biochemical composition of both sexes of the round sardinella *Sardinella aurita* (Valenciennes, 1847) caught in the marine water of Lattakia Governorate (Syria)

I. Barakat [1]*, A. Saad [2], I. Nisafi [1]*****

[1] *Department of Forestry And Ecology, Faculty Of Agriculture, Tishreen Universiy, Lattakia, Syria.*
[2] *Department Of Basic Sciences, Faculty Of Agriculture, Tishreen University, Lattakia, Syria.*
*Corresponding author, Email address: issabarakat93@gmail.com
**Corresponding author, Email address: Adibsaad52@gmail.com
***Corresponding author, Email address: IbrahimNisafi@gmail.com

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issabarakat93@gmail.com
Adibsaad52@gmail.com
IbrahimNisafi@gmail.com

Abstract138

The effects of seasonal and sexual differences on the biochemical composition of the Round Sardinella fish species *S. aurita* 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 19.88%, fat 11.80%, ash 3.50% of fresh fish muscle), While the Spring season was the lowest (protein 19.53%, fat 7.74%, ash 1.04%). The results also showed the superiority of females in the values of the nutritional components over males, where the values were for females (protein 20.9%, fat 11.2%) and males (protein 20.3%, fat 9.3%), while the results also showed the superiority of males in the values of ash over females of ash (male 1.7%, female 1.2%).

1. Introduction

The Biochemical 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]. 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 biochemical composition of fish tissues and in the fatty acid composition of many marine organisms in response to

different factors. Zlatanos and Laskaridis (2007) [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 Ben Rabah and others (2010) [8] on round sardines *S. aurita*, 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, while no significant changes occurred. In muscle protein content throughout the year, the changes in muscle content of moisture were also opposed to those of fat, which increased in spring and summer and decreased in autumn and winter. This is consistent with a study by Khitouni and others (2014) [9] On the fish species Golden Gray Mullet *Chelon auratus*. The same study also indicated that sex had a relationship with differences in the biochemical 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 (2015) [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 (2018) [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 biochemical 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 biochemical 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.

The importance of research comes from the lack of studies on the biochemical composition of fish and its relationship to the season, sex, and reproductive cycle, and in particular, to the round sardines *S. aurita* which is one of the most desirable commercial species in the Syrian coastal region [13]. Also, linking the chemical composition of the fish with the season and sex helps in achieving the highest benefit from the fish species consumed.

The aim of this study was to estimate the seasonal changes of the biochemical composition throughout the year of round sardines *S. aurita* and to show the possible relationship between the biochemical composition and sex of fish individuals caught from the marine waters of Lattakia Governorate.

2. Methodology

Fish samples

This study was conducted during the four seasons of the year 2021. Samples of round sardines S. aurita were obtained Seasonally from the marine waters of Lattakia Governorate. Fish samples were randomly collected from sites landing along the beach of Lattakia governorate, and approximately individuals were taken for the analysis with three replicates.

The average total length of the individuals was (20.5 cm) and the average total weight (89.7 grams), 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 [14].

The chemical analysis

All chemical analyses were expressed in (g/100g) of fresh fish muscle, according to AOAC [14].

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:

$$\text{Percentage (\%) of moisture} = (\text{Weight loses/Original weight of sample}) \times 100$$

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:

$$\text{Percentage (\%) of fat} = (\text{Weight of extract/Weight of sample}) \times 100$$

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 titrametrically. The percentage of protien in the sample was calculated by the following equation:

$$\text{Percentage (\%) of protein} = (c\text{-}b) \times 14 \times d \times 6.25/a \times 1000 \times 100$$ [14].

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:

$$\text{Percentage (\%) of ash} = (\text{Weight of ash / Weight of Sample}) \times 100$$

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 round sardines *S. aurita* in the current work show that the average values of the chemical composition (fat 9%, protein 20%, ash 1.97%, and moisture 72.1% of fresh fish muscle). In comparison with previous studies, which were conducted in different geographical locations and at different times, where the values of the study carriedout in the Syrian coast [15] are (fat 10.2%, protein 16.33%, ash 1.33, and moisture 72.45%). While the chemical

composition values in the study carried out in Ghana [16] were (fat 9%, protein 20.6%, ash 1.72%, and moisture 68.66). From the foregoing, we note that the chemical composition of round sardines has changed according to the place and date of the study. This confirms that the chemical composition of fish varies according to many factors, especially the 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 [17][18][19]. The round sardines is considered to be a fatty fish [20] where the fat content is > 5% and this fat is stored mainly in the muscles (Bougis, 1952) [21], and this can be attributed to the relatively high activity of this species, which requires a large amount of energy which is in agreement with (Yuan et al) [22]. Table (1) shows the seasonal changes of the round sardines S. aurita, the moisture ranged from 69.26% in Autumn to 75.48% in Summer (Pvalue≤0.05). For protein, there were no significant changes in its value throughout the year, as the values ranged from 19.53% in Spring to 20.36% in Summer (Pvalue≥0.05), While there were significant changes (Pvalue≤0.05) for fat values, which ranged from 6.72% in Summer to 11.80% in Autumn, Ash values showed a significant change (Pvalue≤0.05) also during the seasons of the year, where the values ranged between 1.04% in Spring and 3.50% in Autumn.

Table (1): Seasonal changes in the chemical composition of *S. aurita*

	Winter	Spring	Summer	Autumn	P-Value
Moisture	70.66±1.37**a***	72.94±2.61**b**	75.48±1.70**b**	69.26±1.30**a**	**≤0.001**
Protein	20.16±1.01**a**	19.53±0.61**a**	20.36±1.26**a**	19.88±0.75**a**	**0.575**
Ash	1.76±0.67**a**	1.04±0.65**a**	1.42±0.99**a**	3.50±1.17**b**	**0.003**
Fat	9.92±2.14**a**	7.74±1.43**b**	6.72±1.93**b**	11.80±2.34**a**	**0.004**

*: 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 (round sardines *S. aurita*), Figure (1) 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 (11.2) were higher than in males (9.3) and in immature individuals (7.5), the differences were significant ((P≤0.05)). the values of protein in females (20.9) were higher than in males (20.3) and in immature individuals (19.2), the differences were significant (P≤0.05). For ash values in immature individuals (2.6) are higher than in males (1.7) and in females (1.2), the differences were not significant (Pvalue≥0.05). while the moisture values in immature individuals (73.3) are higher than in females (73.3) and males (72.2), the differences were not significant (Pvalue≥0.05). It was observed from the results that the highest value of moisture was during the Summer (75.48%) which corresponds to the lowest value of fats (6.72%), And Likewise in the Autumn season in the same period (fat 11.80% and moisture 69.26%) (Table 1). It was also observed that the moisture content was negatively correlated with the fat content :

(R2 = 0.79, P≤0.001, Y = -0.824X + 68.3) as shown in Figure (2).

The results of our current study are in agreement with the results of a study carried out in Tunisia in 2010 on round sardines, which showed a large variation in the content of protein, fat, minerals and moisture during the months of the year.

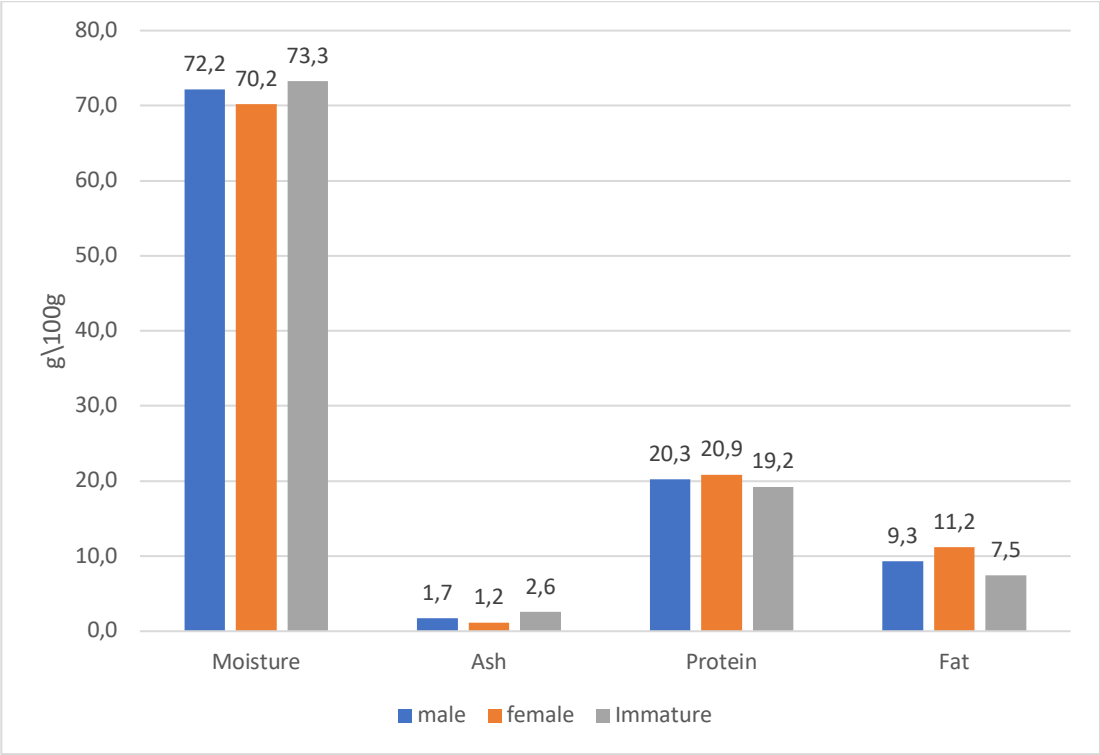

Figure (1) Changes in the chemical composition values according to the sex factor for *S. aurita*

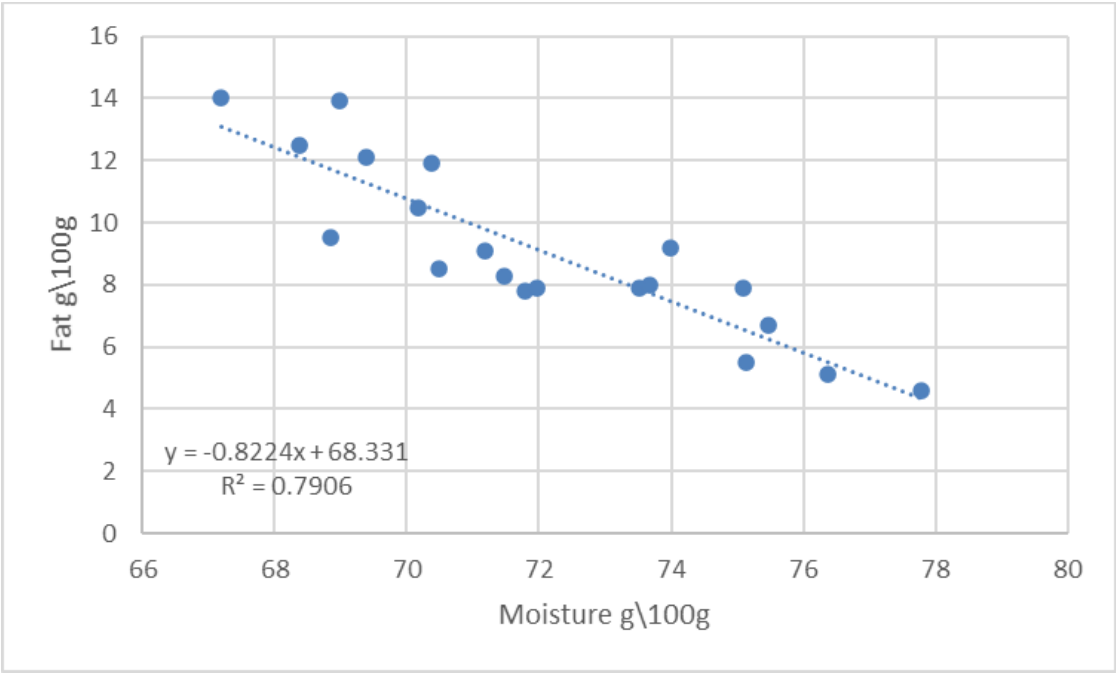

Figure (2): The relationship between moisture content and fat content of *S. aurita*

The content of both fats and minerals increased during the fall months compared to the rest of the year, while the moisture decreased during the fall, and the protein had slight changes throughout the year. The same study also indicated that there was a significant relationship between the sex factor and 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 [8]. The results of our current study also agreed with the results of a study conducted in Turkey in 2018 on the *Mullus barbatus*, where this study indicated the importance of sex and fishing season in influencing the chemical and mineral

composition and content of heavy elements in the fish species studied. Where the chemical and mineral composition of the muscles varied with both 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%), As stated in the study [23], 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 [24][25]. The maturation period of the gonads of the studied fish extends between April and June [26], Which is associated with lower values of muscle chemical components (protein 19.9%, fat 7.2%, and ash 1.2%), For the period from July to March (i.e, the period of gonad immaturity), the fish samples showed relatively medium and high nutritional values (protein 19.88% to 20.16%, fat 9.92% to 11.80%, and ash 1.76% to 3.50%).

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 [27], 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 ($P \leq 0.05$) between the nutritional compounds (protein, fat, Ash) in females, males and immature individuals during most seasons of the year. Similar results were obtained on Sardina (Trachurus trachurus) [28] at the Moroccan Mediterranean. The parameters of the length-weight relationship were determined and analyzed by length and sex. It appears that this species has better growth in length than in weight, therefore having a negative or lower allometry. It varies according to sex, length, and season. Such findings are in good agreement with Literature [29-31].

Conclusion

The chemical composition of round sardines 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 round sardines 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 research recommends conducting more studies on the relationship between the chemical composition of round sardines 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. And Similar studies should be conducted on all economic and ecological fish species.

Disclosure statement: *Conflict of Interest:* The authors declare that there are no conflicts of interest. *Compliance with Ethical Standards:* This article does not contain any studies involving human or animal subjects.

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