Original article

Seasonal evaluation of nutritional benefits of two fish species in the eastern Mediterranean Sea

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(Received 9 June 2006; Accepted in revised form 9 October 2006)

Summary  Fish are a good nutritional source of proteins, essential fatty acids and minerals. Societies with high fish intake have lower rates of acute myocardial infarctions and atherosclerosis, better cognitive functions, and better neural and visual development in foetuses. In the present work, we evaluated seasonal variation in proximate composition of two commercial fish species, the rabbitfish Siganus rivulatus, an algaevore, and the white sea bream Diplodus sargus, a carnivore from the eastern Mediterranean. Fifteen fish were collected on the second weekend of each of 8 months covering the four seasons. Results show that the nutritive value of a species of fish varies throughout the year. Furthermore, rabbitfish tissue generally contains more lipids than white sea bream, and fillet yield from rabbitfish is greater than from sea bream. As both fish are sold at a similar price in Lebanese markets, results suggest that rabbitfish offers better value for the price than does white sea bream.

Keywords  Mediterranean fish, nutritive value, proximate analysis, seasonal variation, yield.

Introduction

Marine fish are known to be a very healthy food item. They are an excellent protein source that also delivers various minerals and vitamins necessary for good health. Scientists report that societies with high fish intake, such as the Inuit and the Japanese have considerably lower rates of acute myocardial infarctions, other ischemic heart diseases and atherosclerosis (Bang & Dyerberg, 1980; Blanchet et al., 2000). These medical benefits are thought to be due to richness in marine omega-3 polyunsaturated fatty acids (ω-3 PUFA). Furthermore, dietary intake of ω-3 PUFA was inversely related to the risk of impaired cognitive function (Lie, 2004). Last but not the least, ω-3 PUFAs are critical for normal neural and visual development in the human foetus (Innis & Elias, 2003). The two important ω-3 PUFAs, EPA (eicosapentaenoic acid; 20:5 ω3) and DHA (docosahexaenoic acid; 22:6 ω3) are available to consumers mainly through a diet rich in marine fish (Din et al., 2004).

Marine fish should be an integral part of a nutritious human diet. However, fish of various species do not provide the same nutrient profile to their consumers (Soriguer et al., 1997; Takama et al., 1999), and the nutritive value of a fish varies with season (Stansby, 1990a; Varljen et al., 2003). Acquisition and accumulation of ω-3 PUFA is dependent on what a fish eats, how it mobilises essential fatty acids within its system and how much of its stored nutrients it mobilises for egg production during vitellogenesis. Therefore, if natural primary productivity is decreased, as would happen in the cold months, ω-3 PUFA reserves might decrease. Furthermore, if a fish is a herbivore, it might lose more reserves than a carnivore or vice versa.

Siganids (rabbitfish) are a relatively small family of algaevorous fish widely distributed in the Indo-West Pacific Region (Woodland, 1983). The opening of the Suez Canal in 1869 linked the Red Sea to the Mediterranean and resulted in the invasion of two siganid species (Quignard & Tomasini, 2000), one of which is Siganus rivulatus. The species has since established large populations in its new environment (Ben-Tuvi, 1985; Papaconstantinou, 1990) and now has a sizeable and growing market in eastern Mediterranean countries. Although the flesh of rabbitfish is described by local consumers as tasty, white, and with few bones, the nutritive value of wild individuals of the species is not known. Muscle lipid and protein content for aquacultured S. rivulatus were
studied by Abdel Aziz et al. (1992), but seasonal variations were not reported.

The white sea bream Diplodus sargus is a carnivorous fish (Hammoud et al., 2000) found along most of the Mediterranean coast in shallow rocky habitats (Sala & Ballesteros, 1997). The white sea bream is mainly caught by artisan fishermen and constitutes a valuable fishery resource because of its high price on the market (Lloret & Planes, 2003). Although the growth and reproduction of D. sargus have been studied (Micale et al., 1987; Gordoa & Moli, 1997), studies of its body composition and condition (i.e. nutritive value) are scarce.

Although fish is purchased on a weight basis, the edible portion is generally only the fillet. Accordingly, edible portion yield of fish is important when comparing price of fish purchased on the market. The present study compares the nutritive value and yield of a locally available algaevorous marine fish to that of a locally available carnivorous marine fish at different times of the year. The species of fish were chosen because of their abundance, ease of recognition by fishermen, availability year-round, and public acceptance as food items and because of their respective trophic level.

Materials and methods

Fish analysed in the present research were collected live from a fisherman and transported to the marine laboratory of the American University of Beirut (AUB) for proximate analysis. All fish were caught in traps deployed in the same location off the beach of Antelias, north of Beirut. Fish were sampled during the first week of June, August, October and December, 2004, and February, March, April and May 2005. Fifteen rabbitfish S. rivulatus and 15 white sea bream D. sargus were taken at random from the fisherman’s traps during each sampling period. At AUB, fish were individually weighed and their length measured. The fillets of each fish were then removed, weighed, dried at 98 °C to a constant weight and then reweighed. Dry fillet tissue was then ground and stored at ~20 °C for further analysis.

All samples were then analysed for protein content using a nitrogen analyser (Thermo Finnigan/EA1112 elemental analyser, Thermo Electron Corporation, Madison, WI, USA) with aspartic acid as a calibration standard. Samples were weighed in tin containers and inserted into the machine. Every tenth sample was duplicated for quality control and the machine was recalibrated after each thirty samples were analysed. Nitrogen values were multiplied by 6.25 to estimate protein content of samples (Alavane & Orto, 1963). Total lipids were extracted using a Soxhlet apparatus with diethyl ether as solvent (AOAC Method 948.22a). A known sample weight was combusted in a furnace at 550 °C for 12 h to estimate ash content. All proximate analysis results were then reported on a wet weight basis.

Statistical analyses were performed using spss statistical software (v.12 for Windows; SPSS Inc., Chicago, IL, USA). Yield was calculated as wet weight of fillet in proportion to total weight of fish. Variables were compared among seasons using one-way ANOVA and Student–Newman–Keuls multiple range test ($P < 0.05$). Yield, protein and lipid contents during each of the sampling periods were compared using Student’s $t$-test ($P < 0.05$).

Results

The composition of rabbitfish muscle tissue varied among seasons (Table 1). The average weight of fish caught in December was smaller than fish caught in other months. Fillet yield in rabbitfish also varied from 33.6% in October to 38.9% in May. Protein as a percentage of fillet weight was the lowest between February and May and the highest between June and August, while tissue lipids were the lowest between December and March and the highest in August. Percent lipid dropped from 2.14% to 1.68% between May and June, but then rose again from 1.68% to 3.81% between June and August.

White sea bream muscle composition also varied with season (Table 2). Again, fish caught in December were significantly smaller than fish caught during the rest of the year; however, the condition index (CI) did not vary with season or size of fish. Fillet yield was the highest in October and the lowest in March, while percent protein of fillet was high between June and February and low between March and May. Lipid proportion of the fillet was the highest in October, March and June and the lowest in April and May. Percent lipid dropped from 2.05% in March to 0.35% in April and then again from 2.27% in October to 0.79% in December.

| Table 1 Weight (g), length (cm),% moisture of muscle tissue,% yield (wet weight of fillet in proportion to weight of fish),% protein in wet muscle tissue and% ash in wet muscle tissue of the rabbitfish Siganus rivulatus, caught in traps off the coast of Lebanon in the Eastern Mediterranean sea |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                  | Weight Length % Moisture YIELD % Protein % Lipid % Ash |
| February         | 106.8±h 19.4±a 78.54±a 36.28±b 19.27±b 1.15±b 3.13±b    |
| March            | 89.4±a 19.4±a 79.11±a 36.28±b 18.45±b 1.29±b 3.10±b    |
| April            | 70.3±a 16.9±a 75.91±c 36.37±h 19.34±b 2.58±b 3.13±b    |
| May              | 99.2±b 19.3±a 78.75±a 38.85±h 17.82±d 2.14±b 1.08±b    |
| June             | 110.1±a 19.6±a 74.26±d 37.77±b 22.44±b 1.68±b 3.17±b    |
| August           | 102.4±b 19.4±a 73.58±d 35.70±h 21.13±b 3.81±b 2.27±c    |
| October          | 57.5±a 16.1±b 76.95±b 33.63±c 19.09±a 1.76±b 3.12±b    |
| December         | 32.2±d 14.1±c 76.87±b 35.25±b 20.14±b 1.23±b 1.49±b    |

PSE, pooled standard error.

Values within the same column with different superscripts are significantly different from each other ($P < 0.05$).
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Table 2 Weight (g), length (cm), % moisture of muscle tissue, % yield (weight of fillet in proportion to weight of fish), % protein in wet muscle tissue, % lipid in wet muscle tissue and % ash in wet muscle tissue of the white sea bream Diplodus sargus, caught in traps off the coast of Lebanon in the eastern Mediterranean Sea.

<table>
<thead>
<tr>
<th></th>
<th>Weight</th>
<th>Length</th>
<th>Moisture</th>
<th>% Yield</th>
<th>Protein</th>
<th>Lipid</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>February</td>
<td>169.1a</td>
<td>21.5a</td>
<td>76.24c</td>
<td>28.29a</td>
<td>20.38a</td>
<td>1.41bc</td>
<td>1.65a</td>
</tr>
<tr>
<td>March</td>
<td>162.5a</td>
<td>21.4a</td>
<td>76.51bc</td>
<td>23.37c</td>
<td>18.11c</td>
<td>2.05ab</td>
<td>1.60a</td>
</tr>
<tr>
<td>April</td>
<td>119.5bc</td>
<td>19.6bc</td>
<td>79.29a</td>
<td>30.50a</td>
<td>18.71bc</td>
<td>0.35d</td>
<td>1.62a</td>
</tr>
<tr>
<td>May</td>
<td>148.7ab</td>
<td>20.8bc</td>
<td>79.39a</td>
<td>29.73a</td>
<td>18.59bc</td>
<td>0.23d</td>
<td>1.64a</td>
</tr>
<tr>
<td>June</td>
<td>147.7ab</td>
<td>20.5bc</td>
<td>76.65bc</td>
<td>29.39a</td>
<td>19.38bc</td>
<td>1.85ab</td>
<td>2.37b</td>
</tr>
<tr>
<td>August</td>
<td>121.9bc</td>
<td>19.6bc</td>
<td>77.66b</td>
<td>30.95a</td>
<td>20.18a</td>
<td>0.73bc</td>
<td>2.33b</td>
</tr>
<tr>
<td>October</td>
<td>108.2c</td>
<td>18.5c</td>
<td>76.44bc</td>
<td>31.30a</td>
<td>19.27bc</td>
<td>2.27a</td>
<td>1.54a</td>
</tr>
<tr>
<td>December</td>
<td>70.8d</td>
<td>16.2d</td>
<td>77.33bc</td>
<td>30.88a</td>
<td>19.83bc</td>
<td>0.79bc</td>
<td>1.63a</td>
</tr>
</tbody>
</table>

PSE, pooled standard error.

Fillet yield of rabbitfish was higher than white sea bream in all samples except in October where they were equal (data not shown). The protein proportion of the fillet varied among samples. Percent protein in the tissue of both fish was similar between October and March (P = 0.923, 0.379, 0.099 and 0.349, respectively) and different from each other between April and August (P = 0.000). White sea bream had a higher percent protein in its tissue only in May (P = 0.000). Lipid proportion of the fillet followed a similar trend to protein proportion in that lipid content was similar between October and March. Percent lipid in the fillet of the two species of fish was significantly higher in the rabbitfish in April, May and August (P = 0.000). When proximate analysis results were averaged for the whole year (Table 3), rabbitfish had a significantly higher fillet yield than white sea bream (36.8 vs. 28.8), slightly lower moisture content (76.7% vs. 77.8%), similar protein proportion of fillet (20.0% vs. 19.7%), significantly higher lipid proportion of fillet (1.95% vs. 1.14%) but a significantly lower proportion of ash (1.40% vs. 1.88%).

Discussion

Rabbitfish S. rivulatus and white sea bream D. sargus are both popular food fish varieties in Lebanon and along the eastern Mediterranean coast. However, their dress-out characteristics are different from each other. Rabbitfish had the highest yield in the winter and spring and lower yields in the summer and fall. These results were not correlated with moisture content of the muscle. The proportion of protein in rabbitfish muscle was the highest in June at 22.4%, rising from a low of 17.8% in May. This rise was concomitant with a muscle lipid drop from 2.14% to 1.68% between May and June. The decrease in moisture and lipid content of the tissue are probably associated with spawning. Siganus rivulatus on the Lebanese coast spawns mainly in June (Bariche et al., 2003). Amin (1984) observed that S. rivulatus from the Red Sea had maximum tissue moisture in the spring and summer and maximum lipid in late fall and early winter. Differences between the earlier studies and those of the present work are attributed to differences in climate, water temperature and diet between the Red Sea and the eastern Mediterranean. Such environmental factors are well known to affect proximate analysis and condition of white sea bream and other fish, especially fat content (George & Bhopal, 1995; Iverson et al., 2002). A rise in the lipid proportion of tissue in August and a subsequent drop in October reflect a possible second spawn in September as reported by Hussein (1986). Low lipid values between October and March reflect a decrease in feeding probably associated with low water temperatures and a change in the species of algae available for food (Lundberg & Golani, 1995). Temperatures off the Lebanese coast start rising above 20 °C in April (Bariche et al., 2003) and tissue lipids to start increase.

Proximate analysis of white sea bream muscle tissue also varied with season. The low yield in March (23.37%) is probably because of improper fillet removal by the laboratory technician. All other reasons were reviewed and rejected. Spawning season for white sea bream in the Mediterranean is in April and March (Lloret & Planes, 2003) and as with rabbitfish, percent lipid in the tissue decreased during spawning. Lipid proportion of muscle also showed a marked reduction between June and August and between October and December. A speculative reason might be an extended reproductive season because of warmer waters in the eastern Mediterranean when compared with the north-western Mediterranean. Nevertheless, muscle lipids of white sea bream observed in the present study fall within ranges reported by Soriguer et al. (1997) and Lloret & Planes (2003).

When rabbitfish and white sea bream were compared on a monthly basis, the former tended to be a better fish to purchase most of the time. Rabbitfish generally had less moisture, better fillet yield, slightly higher protein proportion and frequently more lipid than white sea bream. Both fish are similarly priced on the Lebanese coast.
market and have regular demand. Consequently, rabbitfish with 8% more yield on average is better value for money. Moreover, the health benefits of consuming fish are in the lipids not the protein (Stansby, 1990b; Steffens, 1997). Essential proteins and amino acids can be found in poultry and livestock meat, but these are poor in marine lipids rich in ω-3 fatty acids (Bourre, 2005). Results of the present study suggest that rabbitfish in the eastern Mediterranean are healthier than or as healthy to eat as white sea bream, depending on the month. When averaged over the year, rabbitfish consumers acquire more marine-origin fatty acids than white sea bream consumers. Nevertheless, it should be stated that both fish are not as good a source of marine-origin fatty acids as blue fish, mackerel and herring (Holub, 2002). Ultimately, people consume what they find to be tasty and can afford to purchase. In addition, many prefer less oily fish than sardines, herring or mackerel. However, if the choice is between rabbitfish and white sea bream, the present study suggests a health benefit to those choosing the rabbitfish. Moreover, as both fish have the same price on the Lebanese market (circa US$ 7 kg$^{-1}$) and rabbitfish yields more flesh per unit body weight, the present study clearly identifies rabbitfish as the better species to purchase.

**Acknowledgments**

The authors thank the Lebanese National Science Council for their funding and support of the present project. We also thank Dr Issam Bashour, Ms Amal Malek, Ms Sandra Yanni, Ms Carol Sukhn and Dr Amer Sakr for their assistance, advice and for allowing us to use their laboratory equipment.

**References**


