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# Lipid Content and Fatty Acid Composition of 15 Marine Fish Species from the Southeast Coast of Brazil

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**Abstract** Lipid content and fatty acid composition were determined in edible meat of fifteen marine fish species caught on the Southeast Brazilian coast and two from East Antarctic. Most of the fish had lipid amounts lower than 10% of their total weight. Palmitic acid (C16:0) predominated, accounting for 54–63% of the total amount of saturated fatty acids. Oleic acid (C18:1n-9) was the most abundant (49–69%) monounsaturated fatty acid, and docosahexaenoic acid (DHA) was the predominant polyunsaturated fatty acid (PUFA), accounting for 31–84% of n-3 PUFA. n-3 PUFA level were highest in Antarctic fish meat, comprising 45% of the total fatty acid content, which consisted of mainly EPA (16.1 ± 1.5 g/100 g lipids) and DHA (24.8 ± 2.4 g/100 g lipids). The amounts of EPA + DHA in g/100 g of lipids on the Southeast Brazilian coast and Antarctic fish species investigated were found to be similar: 42.0 ± 1.7 for Bonito cachorro, 41.0 ± 2.3 for Atum, and 39.4 ± 1.8 for peixe porco, respectively. All the studied species exhibited an n-3/n-6 ratio higher than 3, which confirms the great importance of Southeast Brazilian coast fish as a significant dietary source of n-3 PUFA.

**Keywords** Lipid content · Marine fish · Fatty acid composition · Southeast Brazil

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## Introduction

The importance of omega-3 fatty acids in human nutrition is widely recognized [1], especially highly unsaturated long chain fatty acids with 20–22 carbons and 5 or 6 double bonds, particularly DHA (docosahexaenoic acid, 22:6n-3) and EPA (eicosapentaenoic acid, 20:5n-3). The potential of these compounds in the prevention of certain cardiovascular conditions [2] and other diseases has been documented [3, 4]. The benefits of n-3 PUFA (polyunsaturated fatty acids), are associated with the synthesis of eicosanoids such as prostaglandins, thromboxanes, and leukotrienes.

EPA and DHA are typically found in marine fish and originate from the phytoplankton and seaweed that are part of their food chain. Cold water fish such as herring, salmon, mackerels, and others are the main sources of n-3 HUFA (highly unsaturated fatty acid). Variations in fatty acid composition occurs due to fluctuations in the quality and amount of food available, especially phytoplankton [5]. The composition of the edible portion of fish is affected by many factors, such as species, sex, sexual maturity, size, place of capture, water temperature, feeding, and season [6, 7].

Little is known about the chemical composition of many Brazilian marine fish at the present [8, 9]. This research primarily focuses on fish fillets consumed as food. This study reports on the investigation of the fatty acid composition and amount of total lipids of fifteen marine fish species of the Southeast coast of Brazil and compares these data to information on two Antarctic marine species.

## Material and Methods

Seventeen marine fish belonging to different species were sampled and identified. Fifteen species of adult fish were caught on the Santos coast (litoral of the São Paulo State) and the other two species were Antarctic sea fish collected near the Comandante Ferraz Antarctic Brazilian Station in Admiralty Bay, King George Island, South Shetlands Archipelago.

Four samplings were done in different periods of the year when six specimens of each species were collected four times in the same area and on the same day. The samples were stored on ice until they reached the laboratory, and then frozen at –20 °C until the completion of the chemical analysis. Sampling was performed irrespective of animal sex and size.

The following dark meat fish species were studied: *Opisthonema oglinum* (Sardinha-da-lage), *Sardinella brasiliensis* (Sardinha brasileira), *Brevoortia aurea* (Savelha), *Scomber colias* (Cavalinha), *Auxis thazard thazard* (Bonito-cachorro), *Trachurus trachurus* (Xixarro), *Pomatomus saltatrix* (Enchova), *Thunnus thynnus* (Atum); light meat fish: *Mycteroperca acutirostris* (Badejo-mira), *Caranx crysus* (Xerelete), *Trichiurus lepturus* (Peixe-espada), *Sarda sarda* (Serra), *Aluterus monoceros* (Peixe-porco), *Mugil liza* (Tainha), *Cynoscion jamaicensis* (Goete), and two endemic Antarctic fish species: *Chaenocephalus aceratus* (Icefish, dark meat) and *Notothenia neglecta* (Rock perch, light meat).

### Preparation of Fish Samples

Fresh fish fillet samples were taken by removing 3-g pieces of meat from the middle portion of the fish. The tissue was cut into small pieces and homogenized. The lipid content was measured in triplicate by gravimetry with chloroform/methanol/water according to the Bligh and Dyer method [10].

### Fatty Acid Determination

The fish fatty acid methyl esters were prepared by esterification with boron trifluoride in methanol [11]. Fatty acids methyl esters (FAME) were analyzed using aChrompack model CP9001 gas chromatograph equipped with a flame ionization detector (FID) and a fused silica capillary column CP Sil-88 (50 × 0.25 mm id., 0.20 μm film thickness, Chrompack) and hydrogen as carrier gas with a flow of 1.0 mL/min, split ratio of 1/100. Injection and detection temperatures were 250 and 280 °C, respectively. The column temperature was maintained at 80 °C for 7 min and programmed from 80 to 180 °C at 10 °C/min and from 180 to 210 °C at 3 °C/min. Retention times and peak areas were computed automatically by a computing integrator. Fatty acids were identified and quantified by comparison with the retention times and peak areas of known standards from Sigma Chemical Co. Data were calculated using the normalized peak area percentages of total fatty acid content and converted into g/100 g lipids with 0.9 as a conversion factor for dark meat fish and 0.7 for light meat fish, according to Holland et al. [12].

## Results and Discussion

Table 1 presents a summary of the data for lipid content and fatty acid composition obtained for marine fish from the Santos coast (São Paulo, Brazil). The lipid concentration of some of the species, such as xerelete and enchova, was much higher (≈19%) than those of all the other species analyzed. Values around 13% were found for sardinha-da-lage, 9.5% for savelha, and 8% for sardinha. The values obtained for all the other species were lower than 7%, particularly for goete, which presented a very low content of 1.4%. The lipid content of the Brazilian marine fish fillets studied ranged from 1.4 (goete) to 18.8 g/100 g (xerelete), whereas the Antarctic marine species, Icefish and Rock perch, contained on average only 3.0 g/100 g of fillet. The total lipid contents of both Antarctic species were also significantly lower than those of northern hemisphere species [13], which is consistent with the findings of Hearn et al. [14].

The data show that the amount of fatty acids varied widely among the species. Palmitic (C16:0) and stearic acid (C18:0) are the predominant saturated acids. Wang et al. [13] show that the level of C16:0 in fish from Lake Superior ranged from 68 to 79%. In the present study, the levels obtained for this acid ranged from 54 to 63% of the total saturated acids, and the Antarctic species presented 73% of C16:0. Palmitoleic (C16:1n-7) and Oleic acid (C18:1n-9) were the major monounsaturated fatty acids.

The n-3 PUFA fatty acid found in the fish comprised of 43.0–45.0% of the total fatty acids, mainly DHA. The percentage of DHA exceeded that of the EPA in the fish species analyzed. High levels of EPA were also found for the Antarctic species (Icefish and Rock perch) when compared to the values obtained for the Brazilian species.

The relative percentage of EPA + DHA (g/100 g total fatty acids) obtained for the Brazilian fish species was found to be similar to that obtained for the Antarctic species: 41.9 ± 0.8% for bonito cachorro, 40.8 ± 0.8% for northern atum and 39.5 ± 0.8% for peixe porco. However, we can observe that the absolute values (g/100 g lipids), that is, considering the total amount of lipids, the Brazilian species were richer in n-3 PUFA than the Antarctic fish, specially frigate tuna. Several authors have reported that cold water fish present higher PUFA concentrations than those of tropical water fish [13], which was not confirmed by this research. DHA and EPA concentrations in the Brazilian fish species studied were generally higher than

**Table 1** Lipid content and fatty acid profile in muscle tissue of different marine fish species from Santos cost (São Paulo State, Brazil)

| Fish species | Lipids (g/100 g) | 14:0 | 15:0 | 16:0 | 16:1 n-7 | 18:0 | 18:1 n-9 | 18:2 n-6 | 18:3 n-3 | 20:1 n-9 | 22:1 n-9 | 20:4 n-6 | 20:5 n-3 | 24:0 | 22:4 n-6 | 22:5 n-3 | 22:6 n-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fatty acids (g/100 g lipids)[a] | | | | | | | | | | | | | | | | |
| *Badejo-mira* | 4.97 ± 0.16 | 3.5 ± 0.2 | 1.9 ± 0.2 | 18.1 ± 1.0 | 5.8 ± 0.3 | 5.4 ± 0.3 | 9.6 ± 0.7 | 1.1 ± 0.0 | 1.5 ± 0.2 | ND | 5.2 ± 0.4 | 1.2 ± 0.1 | 8.9 ± 0.6 | 2.4 ± 0.2 | 2.4 ± 0.2 | 3.5 ± 0.2 | 25.1 ± 1.4 |
| *Xerelete* | 18.8 ± 0.21 | 3.7 ± 0.2 | 1.2 ± 0.1 | 22.8 ± 1.1 | 5.9 ± 0.3 | 7.2 ± 0.4 | 15.6 ± 1.1 | 1.7 ± 0.1 | 1.6 ± 0.2 | 1.0 ± 0.0 | 1.8 ± 0.2 | 1.2 ± 0.0 | 6.5 ± 0.4 | 1.1 ± 0.0 | 2.5 ± 0.3 | 3.6 ± 0.3 | 19.7 ± 1.1 |
| *Sardinha da lage* | 13.3 ± 0.03 | 7.7 ± 0.5 | 2.3 ± 0.2 | 23.4 ± 1.2 | 6.1 ± 0.4 | 6.2 ± 0.3 | 9.3 ± 0.6 | 1.7 ± 0.1 | 2.4 ± 0.2 | 1.3 ± 0.1 | 3.5 ± 0.2 | ND | 6.8 ± 0.5 | ND | 1.6 ± 0.2 | 2.1 ± 0.1 | 19.0 ± 0.9 |
| *Sardinha Brasileira* | 8.19 ± 0.18 | 7.5 ± 0.6 | 1.7 ± 0.1 | 22.4 ± 1.2 | 7.7 ± 0.4 | 5.2 ± 0.3 | 8.5 ± 0.6 | 2.2 ± 0.2 | 2.1 ± 0.1 | 1.6 ± 0.1 | 2.5 ± 0.2 | ND | 8.5 ± 0.6 | ND | 1.5 ± 0.1 | 1.4 ± 0.1 | 22.5 ± 1.3 |
| *Peixe espada* | 2.75 ± 0.18 | 4.2 ± 0.2 | 3.2 ± 0.2 | 15.1 ± 0.9 | 4.5 ± 0.2 | 4.3 ± 0.2 | 10.7 ± 0.7 | 1.2 ± 0.0 | 1.6 ± 0.1 | ND | 5.7 ± 0.3 | 2.3 ± 0.2 | 7.7 ± 0.6 | ND | 7.1 ± 0.5 | 5.9 ± 0.3 | 20.9 ± 1.0 |
| *Serra* | 2.44 ± 0.15 | 5.3 ± 0.3 | 1.3 ± 0.0 | 13.0 ± 0.8 | 11.2 ± 0.9 | 3.2 ± 0.2 | 29.6 ± 1.6 | 4.1 ± 0.3 | 2.4 ± 0.2 | 2.0 ± 0.2 | 1.7 ± 0.1 | 0.8 ± 0.1 | 11.2 ± 0.9 | ND | 1.2 ± 0.0 | 1.4 ± 0.0 | 8.0 ± 0.5 |
| *Peixe porco* | 3.59 ± 0.02 | ND | 1.7 ± 0.1 | 11.9 ± 0.8 | 2.1 ± 0.1 | 5.1 ± 0.3 | 7.9 ± 0.6 | 0.8 ± 0.0 | 1.3 ± 0.0 | ND | 11.5 ± 0.6 | ND | 9.0 ± 0.7 | 3.0 ± 0.3 | 3.2 ± 0.4 | 4.2 ± 0.3 | 30.4 ± 1.7 |
| *Tainha* | 2.58 ± 0.28 | 2.0 ± 0.0 | 2.6 ± 0.2 | 18.2 ± 1.0 | 2.3 ± 0.1 | 10.0 ± 0.8 | 8.0 ± 0.6 | 2.0 ± 0.2 | 1.2 ± 0.0 | 0.7 ± 0.1 | 7.3 ± 0.3 | 0.7 ± 0.0 | 9.4 ± 0.7 | 0.9 ± 0.1 | 1.8 ± 0.2 | 5.6 ± 0.4 | 24.6 ± 1.5 |
| *Cavalinha* | 6.94 ± 0.25 | 5.1 ± 0.3 | 0.9 ± 0.0 | 11.4 ± 0.8 | 12.0 ± 1.0 | 2.9 ± 0.2 | 33.6 ± 1.7 | 4.0 ± 0.3 | 2.4 ± 0.2 | 1.8 ± 0.1 | 1.6 ± 0.1 | 0.9 ± 0.1 | 9.1 ± 0.6 | 0.8 ± 0.1 | 1.9 ± 0.2 | 2.5 ± 0.2 | 6.5 ± 0.3 |
| *Savelha* | 9.64 ± 0.08 | 3.8 ± 0.1 | 1.4 ± 0.1 | 14.7 ± 0.9 | 5.6 ± 0.3 | 5.8 ± 0.3 | 12.2 ± 0.7 | 3.0 ± 0.2 | 1.7 ± 0.1 | 1.7 ± 0.2 | 4.4 ± 0.3 | 0.9 ± 0.1 | 11.6 ± 0.9 | ND | 1.4 ± 0.1 | 1.9 ± 0.1 | 24.7 ± 1.4 |
| *Bonito cachorro* | 6.05 ± 0.43 | 2.7 ± 0.1 | 1.1 ± 0.1 | 18.2 ± 1.1 | 3.3 ± 0.2 | 8.6 ± 0.4 | 7.5 ± 0.5 | 1.6 ± 0.1 | 1.8 ± 0.1 | 1.0 ± 0.0 | 3.6 ± 0.2 | ND | 8.8 ± 0.6 | 0.8 ± 0.1 | 1.4 ± 0.0 | 1.6 ± 0.1 | 33.2 ± 1.6 |
| *Xixarro* | 6.57 ± 0.01 | 3.1 ± 0.1 | 1.2 ± 0.1 | 18.4 ± 1.0 | 4.4 ± 0.2 | 7.3 ± 0.4 | 9.2 ± 0.6 | 1.3 ± 0.0 | 1.7 ± 0.1 | 1.0 ± 0.0 | 3.5 ± 0.2 | 1.3 ± 0.1 | 8.4 ± 0.7 | 2.4 ± 0.3 | 2.1 ± 0.2 | 3.7 ± 0.3 | 28.1 ± 1.6 |
| *Goete* | 1.40 ± 0.30 | 7.2 ± 0.3 | 1.4 ± 0.0 | 19.0 ± 1.1 | 8.7 ± 0.4 | 4.2 ± 0.3 | 11.8 ± 0.7 | 3.2 ± 0.2 | 2.3 ± 0.2 | 2.4 ± 0.1 | 2.2 ± 0.1 | 0.8 ± 0.1 | 12.8 ± 1.0 | ND | 1.5 ± 0.1 | 1.8 ± 0.1 | 16.6 ± 0.8 |
| *Enchova* | 18.7 ± 0.07 | 4.3 ± 0.1 | 1.1 ± 0.0 | 20.4 ± 1.2 | 7.7 ± 0.4 | 6.2 ± 0.3 | 25.2 ± 1.5 | 1.6 ± 0.1 | 3.2 ± 0.3 | 1.0 ± 0.0 | 2.6 ± 0.2 | 1.1 ± 0.1 | 4.0 ± 0.3 | 1.3 ± 0.1 | 2.2 ± 0.2 | 2.4 ± 0.2 | 13.4 ± 0.7 |
| *Atum* | 4.71 ± 0.02 | 2.0 ± 0.0 | 1.8 ± 0.2 | 14.7 ± 0.9 | 1.9 ± 0.1 | 8.3 ± 0.4 | 10.1 ± 0.7 | 1.5 ± 0.1 | 1.1 ± 0.0 | ND | 6.3 ± 0.4 | 0.6 ± 0.0 | 4.7 ± 0.3 | 1.1 ± 0.0 | 1.7 ± 0.2 | 1.3 ± 0.0 | 36.3 ± 2.1 |
| *Icefish*[b] | 3.06 ± 0.06 | 2.8 ± 0.1 | ND | 16.6 ± 1.0 | 11.2 ± 1.1 | 2.9 ± 0.2 | 12.8 ± 0.8 | 1.4 ± 0.1 | 1.6 ± 0.1 | 0.8 ± 0.1 | 3.0 ± 0.3 | 0.7 ± 0.0 | 16.0 ± 1.1 | ND | 1.1 ± 0.1 | 1.5 ± 0.1 | 24.6 ± 1.6 |
| *Rock perch*[b] | 3.19 ± 0.11 | 2.1 ± 0.0 | ND | 16.4 ± 1.1 | 8.7 ± 0.8 | 2.9 ± 0.2 | 12.9 ± 0.8 | 1.6 ± 0.1 | 1.5 ± 0.1 | 1.1 ± 0.1 | 2.7 ± 0.2 | 1.6 ± 0.2 | 16.2 ± 1.0 | 0.8 ± 0.1 | 1.6 ± 0.1 | 1.8 ± 0.2 | 24.9 ± 1.8 |

The values are means ± SD in triplicate

[a] These values were calculated using conversion factors of 0.9 and 0.7 for dark meat and light meat fish, respectively, according to McCance and Widdowson (1994)

[b] Antarctic marine fish species

**Table 2** Sum of the groups and ratios between fatty acid groups of the muscle tissue of different marine fish species from Santos cost (São Paulo State, Brazil)

| Fish species | SFA[a] | MUFA[b] | HUFA[c] n-3 | HUFA[c] n-6 | PUFA[d] n-3 | PUFA[d] n-6 | n-3/n-6[e] |
|---|---|---|---|---|---|---|---|
| *Badejo-mira* | 31.3 ± 1.1 | 20.6 ± 0.9 | 37.5 ± 1.5 | 3.6 ± 0.2 | 39.0 ± 1.5 | 4.8 ± 0.2 | 8.1 ± 0.6 |
| *Xerelete* | 36.0 ± 1.3 | 24.3 ± 1.2 | 29.8 ± 1.2 | 3.7 ± 0.3 | 31.4 ± 1.2 | 5.4 ± 0.3 | 5.8 ± 0.4 |
| *Sardinha da lage* | 39.6 ± 1.3 | 20.2 ± 0.8 | 27.9 ± 1.0 | 1.6 ± 0.2 | 30.3 ± 1.1 | 3.4 ± 0.2 | 8.9 ± 0.7 |
| *Sardinha Brasileira* | 36.8 ± 1.4 | 20.3 ± 0.8 | 32.4 ± 1.4 | 1.5 ± 0.1 | 34.5 ± 1.4 | 3.7 ± 0.2 | 9.3 ± 0.7 |
| *Peixe espada* | 29.1 ± 1.0 | 20.9 ± 1.0 | 34.5 ± 1.5 | 9.4 ± 0.5 | 36.1 ± 0.8 | 10.7 ± 0.2 | 3.4 ± 0.1 |
| *Serra* | 22.8 ± 0.9 | 44.5 ± 1.8 | 20.6 ± 1.0 | 2,0 ± 0.1 | 23.1 ± 1.2 | 6.1 ± 0.3 | 3.8 ± 0.3 |
| *Peixe porco* | 21.7 ± 0.9 | 21.5 ± 0.8 | 43.6 ± 1.9 | 3.2 ± 0.4 | 44.9 ± 1.9 | 4,0 ± 0.4 | 11.2 ± 1.9 |
| *Tainha* | 33.7 ± 1.3 | 18.3 ± 0.7 | 39.6 ± 1.7 | 2.5 ± 0.2 | 40.7 ± 1.7 | 4.5 ± 0.3 | 9.0 ± 0.7 |
| *Cavalinha* | 21.1 ± 0.9 | 49.0 ± 2.0 | 18.1 ± 0.7 | 2.8 ± 0.1 | 20.5 ± 0.7 | 6.9 ± 0.4 | 3.0 ± 0.2 |
| *Savelha* | 25.7 ± 1.0 | 23.9 ± 0.8 | 38.2 ± 1.7 | 2.3 ± 0.0 | 39.8 ± 1.9 | 5.3 ± 0.2 | 7.5 ± 0.5 |
| *Bonito cachorro* | 31.4 ± 1.2 | 15.4 ± 0.8 | 43.6 ± 1.8 | 1.4 ± 0.2 | 45.3 ± 1.7 | 3.1 ± 0.1 | 14.6 ± 0.7 |
| *Xixarro* | 32.4 ± 1.1 | 18.1 ± 0.7 | 40.2 ± 1.8 | 3.4 ± 0.1 | 41.9 ± 1.8 | 4.7 ± 0.1 | 8.9 ± 0.6 |
| *Goete* | 31.8 ± 1.2 | 25.1 ± 0.8 | 31.2 ± 1.3 | 2.3 ± 0.2 | 33.4 ± 1.2 | 5.4 ± 0.2 | 6.2 ± 0.4 |
| *Enchova* | 33.3 ± 1.2 | 36.5 ± 1.6 | 19.8 ± 0.8 | 3.3 ± 0.2 | 22.9 ± 0.8 | 4.9 ± 0.2 | 4.7 ± 0.2 |
| *Atum* | 27.9 ± 1.0 | 18.3 ± 0.8 | 42.3 ± 2.1 | 2.3 ± 0.2 | 43.4 ± 2.1 | 3.8 ± 0.2 | 11.4 ± 0.8 |
| *Icefish* | 22.3 ± 1.0 | 27.8 ± 1.4 | 42.1 ± 1.9 | 1.8 ± 0.1 | 43.6 ± 1.9 | 3.2 ± 0.1 | 13.6 ± 0.7 |
| *Rock perch* | 22.2 ± 1.1 | 25.4 ± 1.1 | 42.9 ± 2.1 | 3.2 ± 0.2 | 44.4 ± 2.1 | 4.8 ± 0.2 | 9.3 ± 0.6 |

[a] Sum of Saturated fatty acids (SFA)

[b] Sum of Monounsaturated fatty acids (MUFA)

[c] Sum of Highly unsaturated fatty acids (HUFA, C ≥ 20:4n-)

[d] Sum of Polyunsaturated fatty acids (PUFA, C ≥ 18:2n-)

[e] Ratio of Σn-3 to Σn-6. The standard deviations are calculated by propagation of indeterminate errors

those reported for notothenioid fish from East Antarctica [15], Australian fish [7], and marine fish from Brazil in a previous investigation [8]. The difference probably can be explained due to the small sampling of the previous studies.

Table 2 presents a summary the fatty acid groups and the ratio of fatty acids. Saturated fatty acids (SFA) ranged from 20.9 to 39.6 g/100 g lipids, and between 27.4 and 49.2 g/100 g lipids was obtained for polyunsaturated fatty acids (PUFA). PUFA n-3 ranged from 53.1 (peixe espada) to 91.8 (peixe porco)g/100 g lipids, whereas the Antarctic fish presented levels around 75%. The levels obtained for high unsaturated fatty acid (HUFA, C ≥ 20:4n-) and PUFA in peixe porco, bonito cachorro, xixarro, tainha, and northern atum were similar to those of Antarctic species. The mean n-3/n-6 ratio for all the studied fish was 3.0–14.9, which was higher than the 0.22–4.19 ratio calculated for freshwater fish from southern Brazil [16]. The value of n-3/n-6 obtained for tainha (11.4) was similar to the one obtained by Andrade et al. [7]. The n-3/n-6 ratios obtained were higher than those calculated by Osman et al. [17] for marine fish from Malaysian waters and similar to Mediterranean marine fish species [18]. The importance of ingesting products rich in n-3 PUFA and poor in n-6 PUFA [19, 20] as well as the benefits provided by a high n-3/n-6 ratio [18] have been reported in the literature.

The present study showed that the fatty acid composition of the studied species of Brazilian fish (from Santos cost) are a good source of EPA and DHA. In addition, the information presented in this study may be valuable for the pharmaceutical and food industries in the selection of marine fish and fish oils for chemical studies.

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