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Nutritional Composition of Sea Cucumber *Isostichopus* sp.

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Abstract

The knowledge of the chemical composition of invertebrates as sea cucumber contributes to improving our understanding of these living organisms. This study compared the chemical composition of wild sea cucumber *Isostichopus* sp., between February 2013 and January 2014. Sea cucumbers were captured by hand by artisanal fishermen and transported alive to the laboratory of Aquaculture of the Universidad del Magdalena (Colombia), where they were subsequently killed and taken to freeze until analysis. For proximate analysis 20 g of muscle were used for each sample. The analysis (in triplicate) was performed according to [1]. Significant differences ($p < 0.05$) in the protein content, lipids and ash were found. The chemical composition ranged from 2.74% to 6.63% for protein; about 0.07% to 0.35% for lipids; 3.16% to 3.81% for ash; between 83.74% and 86.92% for moisture. Chemical composition of muscle *Isostichopus* sp. was similar to that reported for fresh sea cucumbers internationally traded, which indicates that it is a species with a competitive commercial value for use in food.

Keywords

Caribbean Sea, Chemical Composition, *Isostichopus*, Protein, Lipids

1. Introduction

Water, inorganic matter and a variety of organic compounds are part of the chemical composition of aquatic organisms [2]-[5]. This composition might be influenced by many factors such as physiological characteristics, habitat and life cycle of organisms, or by the environmental characteristics in where they live [5]-[7].

Proteins, lipids and minerals are the main constituents of living organisms and knowledge about their concen-

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tration provides information related to the physiological and nutritional value of organisms [4] [5].

In living organisms, proteins play an important role in most biological processes, such as transportation, storage, immune protection and the generation and transmission of nerve impulses [5] [8]. Lipids are hydrophobic substances that serve as energy reserves, contribute to the waterline and are structural components of cell membranes and organelles [9]. Minerals are involved in various biological functions with great importance as the formation of skeletal structures in the osmotic processes and muscle contraction [10].

At present there is little information on the chemical composition in many aquatic species. Chemical composition studies comprise mainly organisms with economic importance such as freshwater fish and marine fish, crustaceans and mollusks, leaving away organism like sea cucumbers [11]-[16]. Thus, the information about nutritional composition is subject currently only to organisms of economic importance.

Isostichopus is within genres that are commercially exploited. Their high value is due to its use as food and in traditional Asian medicine. Studies in sea cucumbers include gender distribution, taxonomy, biological activity, aquaculture and nutritional composition besides others [17]-[19]. Analysis on fresh proximal composition has shown that these marine invertebrates have a high nutritional value, which can vary depending on the species, feeding behavior and seasonal variations [20]-[23].

From a nutritional standpoint, sea cucumbers are of great value because of its high protein content, its low fat percentage and vitamin content, among which highlights the vitamins A, B_1 (thiamine), B_2 (riboflavin), B_3 (niacin) and minerals, especially calcium, magnesium, iron and zinc [24] [25].

In Colombia, there are few studies on sea cucumbers [26]-[31]. This group of invertebrates is not well known and only some artisanal fishermen occasionally consume them as food. Although *Isostichopus* is a genus with high ecological impact due to the fact that they remove and oxygenate the natural substrate in which they live, and it's a genus with great commercial interest worldwide, and not yet known aspects related to its proximal composition. Therefore, the objective of this research was to study the proximate composition of fresh *Isostichopus* sp., from the natural environment. The information will be useful to have basic knowledge about the nutritional values (percentages of protein, lipid, ash and moisture in the muscle) and their variations over an annual period of native species of sea cucumber in the Colombian Caribbean.

2. Material & Methods

A total of sixty specimens of *Isostichopus* sp. were collected monthly for one year (February 2013 to January 2014). They were captured from the Bay of Rodadero, Santa Marta (11˚13'22.73"N - 74˚13'32.59"W) and transported alive in plastic containers filled with sea water at 28˚C and 37 Practical Salinity Units (UPS) to the Aquaculture laboratory at the University of Magdalena. Once there, they were killed by hypothermia, internal fluids were drained and body weight (232.39 ± 78.71 g) was recorded with a precision scale (Brand Ohauss). Animals were cut longitudinally from the ventral portion, whereupon the viscera and the muscle bands were extracted from the body wall.

2.1. Proximal Composition Analysis

To chemical analysis composition 20 g of fresh muscle were used. The samples were processed at the Laboratory of Food Science (Universidad del Magdalena). Determining analysis (in triplicate) was performed according to [1]. The content of crude protein (N × 6.25) was determined by the Kjeldahl method [1]. In the process a digester system with neutralizing gases, integrated recirculation pump and distiller (UDK 132, Velp Scrubber® SMS, Italy), titration with hydrochloric acid a digital burette (50 ml) was used (Brand was used ®, Germany). Total lipids were extracted with diethyl ether extraction in a Fosstech analyzer after HCl hydrolysis and evaluated gravimetrically in an analytical balance (Adventurer-OHAUS™, China) [1]. The inorganic content (ash weight) was obtained by incinerating the samples in a muffle furnace at 550˚C (Vulcan 3-550™, USA). Pure dry ashes were calculated from the difference between the dry weight and wet weight. Moisture were determined using a moisture extractor digital balance (Ohaus MB45™, USA), and values were expressed as percentages.

In Colombia, two climate period are identified: a rainy season, from April to October, when fresh and brackish waters from the Magdalena River and Ciénaga Grande de Santa Marta mangrove-estuarine system, reach the shelf in the central region and a dry season, from November to March, in which Northeastern Trades Winds induce upwelling. For the Caribbean coast the maximum annual precipitation values do not exceed 2500 mm. The average temperature is below 27˚C [32]-[36].

2.2. Statistical Analysis

To know the effect of time (a period of twelve months) on the proximal composition of *Isostichopus* sp., a one way analysis of variance was applied, after verification of compliance with the assumptions of normality (Kolmogorov-Smirnov) and homoscedasticity (Levene's test). Since the ANOVA yielded a significant result ($p < 0.05$), the Multiple Tukey test, was also applied to determine statistically difference between months. For all these tests the statistical program Statgraphics Centurion vs. XVI (2010) was used.

3. Results

The chemical composition of *Isostichopus* sp. is presented in **Table 1**. The protein content varied significantly ($p < 0.05$), and their values were in the range of 2.74% and 6.63%, with the highest percentage found in July, while that minors were recorded between February and May (2013) and between November (2013) to January (2014).

Significant variations in lipids and ash between the months sampled ($p < 0.05$) (**Table 1**) were found. The lipid content ranged from 0.07% ± 0.10% to 0.35% ± 0.44%; lipid percentages presented a variation from February to May and from June to December, being May when the highest percentage of lipid was observed. On the other hand, the ash content showed variations between the sampled months in this way, the highest percentage (3.81% ± 0.11%) was observed in August, and the lowest percentage (3.16% ± 0.55%), was presented in April.

The moisture content presented fluctuations during the sampled months, however it was in July where it reached its maximum value (86.92% ± 1.54%), while in January the minimum percentage of water was detected (83.74% ± 1.07%). Nevertheless, the statistical analysis showed that significant differences did not exist between the months sampled ($p < 0.05$).

4. Discussion

Knowledge of the chemical composition of species with potential for food human consumption is of great importance for nutritional characterization, however this content, may be influenced by animals feeding, physiological characteristics, life cycle and habitat of the species, besides the environmental features [5] [37].

There are few studies related to proximal muscle composition of sea cucumbers worldwide. The results found in muscle composition of individuals of *Isostichopus* sp. are within the ranges reported for other species such as *Stichopus japonicus*, *Apostichopus japonicus*, *Parastichopus californicus*, *Holothuria tremula*, *Holothuria scabra* and *Cucumaria frondosa* [21] [38]-[41].

In this study the protein content for *Isostichopus* sp. was between 2.74% and 6.63%, being within the ranges

Table 1. Chemical composition of muscle of sea cucumber *Isostichopus* sp., in terms of percentage (g/100g) of crude protein, lipid, ash and moisture during the months of sampling and represent the mean of tree replicates ± Standard Deviation (Fresh samples, n = 60).

Month	% Protein	% Lipid	% Ash	% Moisture
Feb-13	3.12 ± 0.72^{ab}	0.09 ± 0.05^{ab}	3.77 ± 0.35^{bc}	84.83 ± 1.20^{a}
Mar-13	2.96 ± 0.81^{ab}	0.13 ± 0.15^{ab}	3.37 ± 0.12^{ab}	85.78 ± 2.02^{a}
Apr-13	2.74 ± 0.79^{a}	0.07 ± 0.10^{a}	3.16 ± 0.55^{a}	86.56 ± 2.45^{a}
May-13	3.21 ± 0.67^{ab}	0.35 ± 0.44^{bc}	3.36 ± 0.16^{ab}	84.10 ± 2.10^{a}
Jun-13	6.17 ± 1.30^{d}	0.08 ± 0.06^{a}	3.44 ± 0.34^{abc}	85.66 ± 1.64^{a}
Jul-13	6.63 ± 0.59^{d}	0.16 ± 0.07^{ab}	3.26 ± 0.59^{a}	86.92 ± 1.54^{a}
Aug-13	5.43 ± 0.77^{c}	0.24 ± 0.35^{ab}	3.81 ± 0.11^{c}	83.96 ± 1.52^{a}
Sep-13	5.34 ± 0.71^{c}	0.10 ± 0.06^{ab}	3.45 ± 0.20^{abc}	85.11 ± 1.85^{a}
Oct-13	4.64 ± 0.46^{c}	0.13 ± 0.09^{ab}	3.51 ± 0.13^{abc}	84.44 ± 1.34^{a}
Nov-13	3.70 ± 0.93^{b}	0.14 ± 0.07^{ab}	3.57 ± 0.67^{abc}	86.44 ± 1.37^{a}
Dec-13	3.34 ± 0.81^{ab}	0.07 ± 0.06^{a}	3.57 ± 0.13^{abc}	86.28 ± 2.01^{a}
Jan-14	3.15 ± 0.78^{ab}	0.07 ± 0.05^{a}	3.22 ± 0.26^{a}	83.74 ± 1.07^{a}

* ^{abcd}Values in the same column with the different superscripts are significantly different ($p < 0.05$).

reported by [42] in *Stichopus japonicus* (3.31% and 6.78%) and [21], to *Parastichopus spp.* (2.5% and 13.8%); in turn, they are in the average range reported by [43] for *Apostichopus japonicus* (1.13% and 3.99%), although in this case the inferior value of this is very lower compared to that found in the species in this study. Moreover, *Isostichopus* sp. records are below those obtained by [24], for *Thelenota pineapple* (16.64%) and *Acaudina molpadioides* (12.94%), or are relatively lower when compared to those reported by [23], in *H. polii*, *H. tubulosa* and *H. mammata* (7.88 and 8.829%).

According to [20]-[23]), seasonal variations affect bromatological content of sea cucumbers. Throughout this study, the percentage of protein presented dramatically fluctuations with the highest values from June to October at its maximum increase in July. This case is contrary to what was reported by [42] who reported that *Stichopus japonicus* showed variations in the protein content from January to August, while [40] reported values of protein of 9.53% and 5.78% of *H. scabra* in the spring and summer, indicating that these fluctuations may be related to the physiological characteristics, seasonal variations, the life cycle of the species and the and the study region [5].

Moreover, the period where the highest values of protein were found coincides with the breeding season of the species recorded by [30]. It is possible that increased protein content has an influence on the mobilization of nutrients during the breeding season and subsequent release of sea cucumbers. It is well known that good nutrition on organisms in general is critical to optimizing reproductive processes and normal development of embryos. An optimal level of nutrients will determine the success in the morphology of eggs and hatching rates. However studies related to nutritional composition, diet, breeding seasons and reproductive success in sea cucumbers, are scarce, so this would be a preliminary reference on what happens inside the native sea cucumbers of the region against the reproductive processes vs. the composition and nutritional requirements thereof. Then, deep future studies should address in this regard.

Moreover, total lipid content found in this study presented variations during all the sampled months: the lowest percentage was observed in April and the largest increase in May. Despite belonging to the same family, the fat content of *Isostichopus* sp. (0.07 than 0.35%,) was much lower than that reported by Tanikawa *et al*. [42], for *Stichopus japonicus* (0.56% to 2.3%), by [44] to *Apostichopus japonicus* (0.28% to 0.33%) and the findings by [38], to *Parastichopus californicus* (0.57% and 0.44%). While [24], reported values below related in this study, with a percentage of 0.27% to 0.03% for *Thelenota ananas* and *Acaudina molpadioides*. Finally, the results recorded for *Isostichopus* sp. in this work contrast with those found by [23] to *H. tubulosa*, *H. polii* and *H. mammata* who report lipid content between 0.09%, 0.15% and 0.18% respectively.

According to what observed by [45], "lipids are greater metabolic energy source in reproduction processes of fish, which can be mobilized from a tissue storage until oocytes developing food purchased directly or synthesized *de novo* in the ovarian follicle". In sea cucumbers is little the knowledge in this regard. According [42] variations in the fat content may be related to gonadal growth. This study showed an increase in lipid values in May, when as [30], found *Isostichopus* sp. show gonads in vitellogenic stage and previtellogenic oocytes stage. Thus, the lipid concentration is likely to affect the reproductive potential of the species, which previously mobilize its lipid reserves for reproduction and development of gamete. As mentioned by [46] and [47], who report that holothurians may have wide variations in lipid concentrations (and polyunsaturated fatty acids), depending on the reproductive pattern and the type of development of each specie, biochemical composition being listed as a factor species specific. Future studies should address in this regard, in order to know the class of lipid and the role they have on the reproductive function of the species.

Many factors are linked with changes in chemical composition in living organism [16]. Environmental changes has been reported as one of a key factor which could influences proximal composition in marine invertebrates [16] [48]-[50]. Furthermore sea cucumber physiology, seasonal variations in feeding behavior, feeding regimes and food supply from sea environment are factors which may help explained variations on nutritional or chemical composition [23] [51]-[53]. In addition, as state [54], sea cucumbers may have different chemical composition including those sampled from the same environmental conditions. In Colombia there are two climatic periods: dry season and rainy season [36]. In this sense, lower protein and lipid levels were found during the dry season and the highest percentages were registered in rainy season which is also consistent with lower water temperature (27˚C) in the dry season and with a higher water temperature (28˚C) in the rainy season. Authors as [55] argue that changes in the lipid content in the sea cucumber are linked to the season and habitat. Similar trends have been found by [56] and [50].

Ash content ranged from 3.16% to 3.81%; these variations are above the values reported by [42] for *S. japo-*

nicus and [24] to *T. ananas* and *A. molpadioide*s. Native values of sea cucumbers are lower than those reported by Aydin *et al*. [23], for *H. polii*, *H. tubulosa* and *H. mammata* with a range between 5.13% and 7.85%. Fluctuations found in this study may be due as [42] and [57] recorded for sea cucumbers, who reported that the mineral content can be linked to the high content of spicules have sea cucumbers in their body. It should be noted that the ash content in this work was obtained from muscle integument without any procedure to extract the spicules (decalcification), so it is believed that this might affected the percentages of ash obtained for *Isostichopus* sp.

In the other hand, marine invertebrates' humidity may vary between 65% and 95% with exceptions in some taxa [58]-[60]. During this study the moisture content was between 83.74% and 86.92%, which values are within the ranges established previously by [21] for sea cucumber, and within those reported by [23] (81.24% to 85.24%), for three Holothuria species (*H. tubulosa*, *H. polii* and *H. mammata*) and [42], (84, 89% and 91.30%) in *Stichopus japonicus*. Humidity values in this study are above those reported by [54] (67.82% and 69.45%), in two species of sea cucumber Persian Gulf: *H. arenicola and H. parva*. These were recorded below that reported by [21] and [38], (88.8% and 90.1%), in *Parastichopus californicus* and those exposed by [41] in *Cucumaria frondosa* (87.4% and 90.1%). Moisture percentages found in this study may be linked to the time of year, environmental factors, geographical variations or feeding behavior [21] [22] [40].

The results obtained in this study are consistent with those made in other species of sea cucumber, which allows us to set up that sea cucumbers, native of Santa Marta Caribbean Sea (Colombia), have a chemical composition with valuable nutritional properties, which could be used for consumption and pharmaceutical applications.

5. Conclusion

As a conclusion, the compositional analysis showed that *Isostichopus* sp. possesses valuable nutritional properties, including high percentage of protein (6.63%) and low percentage of lipids (0.35%). In addition, the highest values of protein and lipid content in muscle are related to the reproductive season which is probably linked to patterns of reproductive biology of the species. The nutritional composition of *Isostichopus* sp. fluctuates in line with environment changes, where in the dry season, values are low and in the rainy season these are higher. Native sea cucumber *Isostichopus* sp might be a potential candidate to be commercialized in worldwide markets with the highest consumption of *bêche de mer* or *trepang*. *Isostichopus* sp. could be used for human consumption because of its high nutritional value.

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