International Journal of Animal Science and Technology
2023; 7(1): 1-4
http://www.sciencepublishinggroup.com/j/ijast
doi: 10.11648/j.ijast.20230701.11
ISSN: 2640-1282 (Print); ISSN: 2640-1312 (Online)

Nutrient Analysis of *Chrysaora fuscescens* (Cnidaria: Scyphozoa)

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To cite this article:
Wang Youkun, Wang Wei. Nutrient Analysis of *Chrysaora fuscescens* (Cnidaria: Scyphozoa). *International Journal of Animal Science and Technology.* Vol. 7, No. 1, 2023, pp. 1-4. doi: 10.11648/j.ijast.20230701.11

Received: December 31, 2022; **Accepted**: February 6, 2023; **Published**: February 16, 2023

Abstract: *Chrysaora fuscescens* is a kind of ornamental jellyfish with high economic value, and become to be a very popular giant medusa in aquarium. In the process of captive breeding, it was found that there are a significant number of deformed individuals In this study, we expected to select more suitable feeding combinations by comparing the differences in nutrient composition, we chose two groups of Chrysaora fuscescens domesticated in aquarium, one is the deformity group, and the other is normal group. We measured the conventional nutrients (water content, protein content, fat content, ash content), fatty acid composition and amino acid composition of the two groups. The results showed that the water content, ash content and protein content of deformity group were higher than those of normal group ($P < 0.05$). The contents of unsaturated fatty acids (C16:1n7, C18:1T, C18:3n3 and C20:4n6) in the deformity group were significantly lower than those in the normal group ($P < 0.05$). Sixteen kinds of amino acids were detected in both groups, among which the contents of Gly and Glu were the highest. The contents of Phe, Ala, Met and other amino acids in malformed group were lower than those in normal group ($P < 0.05$). The results showed that there were some differences in nutrient composition between normal and deformity group. In order to achieve the daily requirements, the supplementation of unsaturated fatty acids and the fortification of Glu should be increased in the selection of bait in the future.

Keywords: *Chrysaora fuscescens*, Nutrient Analysis, Fatty Acid Composition, Amino Acid Composition

1. Introduction

The Northeast Pacific sea nettle, *Chrysaora fuscescens* Brandt, 1835, belongs to the family Pelagiidae, ranges from Mexico to British Columbia [1]. *Chrysaora fuscescens* has yellow-brown or reddish-brown body color within light-colored radial stripes and a bell diameter of up to 30 cm [2], and become to be a very popular giant medusa in aquarium. This medusa is becoming more and more common in aquariums, and adult specimens can fetch up to $100.

In the process of captive breeding, it was found that there are a significant number of deformed individuals with inwards curled edges and non-contracted bells, which will significantly impact typical exhibits. As an ornamental medusa most of the studies on *Chrysaora fuscescens* are focus on its behavior in the wild [3-5]. There have been no studies on the captive individuals. The nutrient analysis experiments focused on other economically important species of medusa, like Stomolophus meleagris, and it revealed that medusa are an organism with high ash content and low fatty acid content, which is somewhat different from the nutrient composition of common aquatic bait organisms. The bait selection of medusa is mostly based on the experience of breeders for rationing. The feeding of medusa is mostly determined by the experience of breeders, and different medusae often use the same recipe, which will impact their growth rates and survival rates [6, 7]. Nutrient composition analysis can be used to evaluate the rationality of the bait by determining the content and composition of fatty acids and amino acids contained in the organisms, and to provide a reference for the rational rationing of the bait.

Therefore, in this experiment, we expected to select more suitable feeding combinations by comparing the differences in nutrient composition between deformed and normal individuals to improve the normal individuals and reduce the deformed ones.

2. Materials and Methods

2.1. Sample Collection

The *Chrysaora fuscescens* used in this experiment were cultured at the Qingdao Aquarium. All medusae are cultured in a round tank with a flow-through configuration at 14°C in temperature and salinity of 32-33, pH 7.6-8.0, and fed with fresh *Artemia franciscana* and moon jellyfish (*Aurelia aurita*) daily. Six individuals with inrolled edges and non-contracted bodies were selected as the deformed group, with an umbrella diameter of 18.6±0.85 cm and a body weight of 1116.19±107.91 g. The other six individuals with normal morphology and activity were selected as the control group, with an umbrella diameter of 22.2±1.77 cm and a body weight of 1338.78±162.91 g.

2.2. Conventional Biochemical Indexes

The *Chrysaora fuscescens* were dried directly, and the moisture content was determined; ash was determined by the first method of GB 5009.4-2016 "National Standard Determination of Ash in Food"; crude protein was determined by the Kjeldahl method of GB 5009.5-2016 "National Standard Determination of Protein in Food"; fat extraction was determined by GB 5009.6- 2016 "National Standard Determination of Ash in Food"; protein extraction was determined by the first method of GB 5009.6-2016 " National Standard Determination of Protein in Food". The percentages of moisture, ash, protein, and fat were calculated by wet weight.

2.3. Fatty Acid Composition

The fatty acid composition and relative content were determined with reference to GB 5009.168-2016, "National Standard for the Determination of Fatty Acids in Food", and the fatty acids were extracted by hydrolysis, analyzed by gas chromatography, and quantified by an internal standard method.

2.4. Amino Acid Composition

The amino acid composition and relative content were determined with reference to GB 5009.124-2016, "National Standard for the Determination of Amino Acids in Food", proteins were hydrolyzed with hydrochloric acid, and free amino acids were determined by an amino acid analyzer.

2.5. Data Analysis

Using SPSS 19 (SPSS Inc., Chicago, IL) for One-way analysis of variance (One-Way ANOVA). Three replicates (n=3) were set for all samples, and results were expressed as mean±SE. Significant differences were set at P<0.05.

3. Results

3.1. Comparison of Basic Nutrient Contents

The water content of the deformed group accounted for (96.40±0.20) % of the total weight, while the normal group accounted for (95.80±0.10) %; the ash content in the deformed group accounted for (69.63±1.12) % of the dry weight, while the the normal group accounted for (64.92±0.73) %; the fat content of the deformed group accounted for (6.76±0.32) % of the dry weight, while the the normal group was (7.22±0.27) % in the normal group; crude protein in the deformed group was (5.85±0.03) % of the dry weight and (5.52±0.03) % in the normal group; moisture, ash and crude protein of jellyfish in the deformed group were higher than those in the normal group ($p<0.05$).

Table 1. *Comparison of basic nutritional composition between deformed group and control group n=3; $\bar{x}$±SE.*

composition	deformed group	control group
crude ash	69.63±1.12*	64.92±0.73
crude fat	6.76±0.32	7.22±0.27
crude protein	5.85±0.03*	5.52±0.04

Note: * indicates significant differences in different group (P<0.05).

3.2. Fatty Acid Composition

The fatty acid contents were determined separately, and the relative contents of each fatty acid were calculated by dry weight, and the results are shown in Table 2. Seven fatty acids were detected in the deformed group, and 11 fatty acids were detected in the control group.

Table 2. *Comparison of fatty acid between deformed group and control group n=3; $\bar{x}$±SE.*

fatty acid	deformed group	control group
C16:0	30.81±4.41*	22.25±3.25
C16:1n7	——	5.52±0.78
C18:0	10.77±1.62	11.40±0.62
C18:1n9	26.16±1.98*	20.20±1.13
C18:1T	——	2.15±3.72
C18:1n9c	25.12±1.68*	16.29±1.03
C18:2n6	10.38±0.95	8.70±1.52
C18:2n6c	10.23±0.82	8.15±1.18
C18:3n3	——	4.74±0.44
C20:4n6 (ARA)	——	4.74±0.44
C20: 5n3 (EPA)	2.28±3.96*	11.90±1.49
SFA	46.50±2.65*	38.69±3.00
UFA	53.50±2.65*	61.31±3.00
MUFA	32.04±1.45	28.39±0.92
PUFA	21.47±2.00*	32.96±3.40

Note: * indicates significant differences in different group (P<0.05)

Two saturated fatty acids (SFA), C16:0 and C18:0, were detected in both groups, with the highest percentage of C16:0 in the deformed group (30.81±4.41%) and the normal group (22.25±3.25%), and the percentage of SFA in total fatty acids was higher in the deformed group (46.50±2.65%) than in the normal group (38.69±3.00%) ($p<0.05$).

The content of unsaturated fatty acids (UFA) in the deformed group was significantly lower than that in the normal individuals. Among them, C16:1n7, C18:1T, C18:3n3,

C20:4n6 were not detected in the deformed group, while the contents of C16:1n7 (5.52±0.78) %, C18:1T (2.15±3.72) %, C18:3n3 (4.74±0.44) %, C20:4n6 (4.74±0.44) % and C20:4n6 (4.74±0.44) % in the control group. While the content of the C20:5n3 in the deformed group (2.28±3.96) % was also much lower than that of the control group (11.90±1.49) % ($p<0.05$).

3.3. Amino Acid Composition

The results of 20 common amino acids in the two groups are shown in Table 3. 16 amino acids were detected in both groups. Among the two groups, glycine (Gly) and glutamic acid (Gln) were higher, while methionine (Met) and histidine (His) were lower. The essential amino acids (EAA) accounted for (34.20±0.11) % of the total amino acids in the deformed group, compared with (31.54±0.02) % in the normal group.

Table 3. *Comparison of amino acid between deformed group and control groupn=3;* $\bar{x}$*±SE.*

amino acid	deformed group	control group
Ile#	5.12±0.01*	5.46±0.01
Leu#	6.81±0.02*	7.51±0.03
Val#	5.27±0.01*	5.56±0.01
Lys#	6.53±0.02*	5.92±0.01
Thr#	5.46±0.01*	4.34±0.01
Met#	1.09±0.03*	2.46±0.01
Phe#	3.90±0.09*	4.62±0.01
Ala	6.68±0.01*	6.60±0.04
Pho	4.38±3.25*	5.51±0.02
Gly	16.88±0.04*	17.59±0.03
Gln	13.01±0.01*	15.19±0.03
Arg	5.85±0.01*	3.91±0.01
Tyr	2.57±0.02*	3.29±0.03
Ser	4.47±0.01*	3.59±0.01
Asn	8.61±0.04*	6.84±0.01
His	1.49±0.01*	1.69±0.01
EAA	34.20±0.11*	31.54±0.02

Note: * indicates significant differences in different group ($P<0.05$); # means essential amino acid.

4. Discussion

Nutrient analysis is an important tool to understand the nutritional requirements of cultured animals and an important basis for feeding configuration. Currently, more and more aquariums are exhibiting medusa; however, unlike economic species, aquariums are rearing more species and on a smaller scale [8], and breeding studies of ornamental medusae usually depend on the breeders' experience [2]. In this experiment, the composition of multiple nutrients in *Chrysaora fuscescens* was examined and analyzed for the first time, which will help breeders.

The *Chrysaora fuscescens* had higher ash content, but lower protein and fat content. The ash content in the deformed group accounted for (69.63±1.12) % of the dry weight, while that in the normal group accounted for (64.92±0.73) %, which was slightly lower than that of the sand jellyfish (Stomolophus meleagris) [9]. The crude protein of jellyfish in the deformed group accounted for (5.85±0.03) % of the dry weight, while the normal group was (5.52±0.03) %; the crude fat was (6.76±0.32) % of the dry weight in the deformed group and (7.22±0.27) % in the control group; the difference in crude fat content between deformed jellyfish and normal jellyfish was not significant.

In the fatty acid composition of deformed *Chrysaora fuscescens*, 11 fatty acids were detected in the normal group, while only 7 fatty acids were detected in the deformed group. The content of unsaturated fatty acids in the deformed group was significantly lower than that in the control group. Among them, four UFAs, C16:1n7, C18:1T, C18:3n3 and C20:4n6, were not detected in the deformed group, and the content of C20:5n3 was also much lower than that in the control group.

In the study of sand jellyfish, 20 fatty acids were detected in the gonads, 13 in the umbrella body, and 14 in the oral arms [9], while Yan Yuxia et al. [10] detected a richer fatty acid composition in the sand jellyfish. The main reason for the difference in fatty acid composition between species may be that the gonads of the *Chrysaora fuscescens* in this experiment were not fully developed, so some fatty acids with high content in the gonads, such as DHA, were not detected in this experiment. The *Chrysaora fuscescens* in this experiment were fed with fresh *Artemia franciscana* larvae and sea moon jellyfish blocks on a daily basis, and the fatty acids of *Artemia franciscana* from different production areas varied greatly [11], while Peng Ruibing [12] tested five food organisms including *Artemia franciscana* and found that the polyunsaturated fatty acid content of *Artemia franciscana* was lower than the proportion of normal *Chrysaora fuscescens* in this experiment, while *Acanthomysis brevirostis, Calanus sinicus* and *Ampithoe valida* were rich in EPA and could be considered in combination with *Artemia franciscana* to make them compatible with the nutritional requirements of *Chrysaora fuscescens*. Jeckel's study on shrimp [13] shows the EPA and ARA are very important for aquatic animals, and deficiency of EPA may lead to higher mortality of aquatic animal larvae. Therefore, it is important to supplement C16:1n7, C18:1T, C18:3n3, C20:4n6, and C20:5n3 in *Chrysaora fuscescens* culturing.

A total of 16 amino acids were detected in *Chrysaora fuscescens*. Among them, Gly, Glu had the highest content, which was similar to the results of Li Yan-Yen [14] in sand jellyfish, but the umbrella of sand jellyfish had higher Phe content, while the *Chrysaora fuscescens* had lower Phe content and higher Asp content. Asp, Glu and Gly are flavored amino acids, and Gly is an important amino acid for collagen synthesis, while Glu is involved in the synthesis of many physiologically active substances [15]. Gly, Pro, and Hyp are important amino acids for collagen synthesis [16], and the total essential amino acids were (35.46±0.67) %, respectively, in the normal group, while the contents of Phe, Ala, Met, Pho, Gly, Glu, Tyr, Leu, and Val were significantly higher in the control group than in the deformed group. In contrast, the content of Gly was higher and the content of Glu was very low in *Artemia franciscana*, and the Glu in *Acanthomysis brevirostis, Calanus sinicus,* and *Ampithoe valida* were lower than that of *Chrysaora fuscescens*, while Daphnia magna was abundant in Glu [17], which could be used with *Artemia franciscana*. Therefore, the Glu fortification should be enhanced to meet the requirements of jellyfish when using *Artemia franciscana* as a daily recipe.

5. Conclusion

In this study, we measured and analyzed the moisture, ash, crude fat, crude protein, fatty acid and amino acid content and composition of normal and deformed *Chrysaora fuscescens*. We discovered that the ash content was higher and the protein and fat content were lower in *Chrysaora fuscescens*. Less varieties of fatty acids and unsaturated fatty acids, as well as fewer various amino acids concentrations were present in the deformed group than in the normal group. The regular *Chrysaora fuscescens* have higher levels of unsaturated fatty acids and Glu than *Artemia franciscana* larvae when compared to the makeup of the commonly utilized bait species. In order to achieve the daily requirements, the supplementation of unsaturated fatty acids and the fortification of Glu should be increased in the selection of bait in the future. Future study can be validated by altering the bait ratios for growth tests since the current experiment only assessed the makeup of *Chrysaora fuscescens*.

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