SHORT COMMUNICATION

NUTRITIONAL COMPOSITION OF THREE COMMERCIALLY IMPORTANT BRACKISH WATER FISH SPECIES RECORDED FROM BATTICALOA LAGOON, SRI LANKA

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ABSTRACT

Fish is a high-quality animal-source food in the nourishment of millions worldwide. The most edible part of the fish is the muscle and which provides a proper balance of proximate and non-proximate nutrition and has a relatively low caloric value than other meats. The present study aimed to fill the gaps in the nutritional profile of three brackish water fishes (*Arius maculatus*, *Mugil cephalus* and *Oreochromis niloticus*) sourced from Batticaloa Lagoon, Sri Lanka. The study was conducted from November 2019 to February 2020 and fish were sampled from Kallady, Kattankudy and Arayampathy fish markets. The nutritional compositions such as moisture content, protein content, fat content and ash content of epaxial muscles of selected fishes were analyzed with standard methods. The moisture content was high among the fish muscles ranging from 56.73 ± 5.96% to 81.48 ± 2.52%. The protein content of A. *maculatus*, M. *cephalus* and O. *niloticus* muscles ranged as 15.36 ± 1.62%, 17.33 ± 1.96% and 13.7 ± 1.55% respectively. Amidst the selected fishes, O. *niloticus* is a lean fish (1.27 ± 0.35%) while A. *maculatus* (3.20 ± 0.59%) and M. *cephalus* (2.43 ± 0.37%) are low-fat fishes based on the muscle lipid content. The ash content of A. *maculatus*, M. *cephalus* and O. *niloticus* ranged from 1.22 ± 0.15% to 1.77 ± 0.45%, respectively. All the measured proximate parameters were significantly different (*P*-value < 0.05%) among the three fish species. The results of this study revealed that the A. *maculatus* contains the highest value of lipid and ash content while O. *niloticus* contains higher amount of moisture content. The M. *cephalus* can considered as a good source of animal protein compared to the other two fish species.

Keywords: *Fish, Lagoon, Nutrition*

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1. INTRODUCTION

Food insecurity is referred to as an inability to access adequate quantity and quality of food to satisfy the minimum nutritional requirements of humans [1]. A healthy diet is a vital key factor to boost our general health and this diet can be obtained by consuming sufficient nutrients at the right proportion [2]. The universal malnutrition crisis involves starvation and undernutrition [3]. The 2019 Global Hunger Index score was 20.0, which indicates that the level of global malnutrition falls on the cusps of the moderate and serious categories [4]. Sri Lanka is affected by the triple burden of malnutrition, which plays a vital role in a significant proportion of child mortality and morbidity in the country [5].

Seafood especially fish owing to superior nutritional quality. Globally, fish and fish products provide an average of about 34 calories per capita per day [6]. The various fish species share different quantity of nutrients and those having unified nutritional features to support a nutrient requirement of the human diet [7]. The nutrient composition of fish muscle, liver and bones are varying extremely. The most edible part of the fish is the muscle and which provides a proper balance of proximate and non-proximate nutrition and has a relatively low caloric value than other meats [8].

The moisture content is an amount or percentage of water within the fish's body or muscle. Water comprises the highest quantity in the fish composition and it has an inverse relationship with the lipid content of the fish. The level of moisture content in the muscles is influenced by numerous parameters such as age, sex, sexual maturity and reproductive period [9].

Fish is a prosperous source of animal protein. Fish protein is declared as high quality and easily digestible, hence it has a balanced amino acid profile hence called "complete protein" and has small amounts of connective tissues respectively [7]. The fish muscle protein can be categorized as sarcoplasmic proteins, myofibrillar proteins and stroma or connective tissue proteins [10]. Protein plays vital functions within the human body including maintaining the body through supporting tissue and muscle; transportation through hemoglobin, myoglobin or transportation proteins in phospholipid cell membranes; regulatory functions such as gene transcription and translation as well as in growth factors; regulating and comprising hormones; comprising enzymes in metabolic

events, intermediary metabolism and osmoregulation [11]. Protein inadequacy guides to some health hurdles such as kwashiorkor, marasmus, impaired mental health, edema, organ failure, wasting and shrinkage of muscle tissues, and weak immune system. Nitrogenous compounds contribute to the food value influencing all the distinctive food attributes, such as colour, flavour, texture, nutrition, safety and the post-harvest deterioration of fish meat [12].

Lipids are small molecules that act as fundamental to biological functions in the human body. Lipids in the body are divided into storage lipids and structural lipids [13]. The crucial tasks of lipids within the human body include energy storage, structural roles in cell membranes, signaling molecules, cell signaling properties, receptors, antigens, sensors, electrical insulators, biological detergents, storage and transportation of lipid-soluble vitamins, and serve as membrane anchors for protein [11]. Based on the fat content in the fish muscle, they are classified into four categories as lean (less than 2% fat), low fat (2–4% fat), medium fat (4–8% fat) and high fat (more than 8% fat) [14].

The analysis of ash content in foods is simply the combusting away of organic content, leaving inorganic minerals. The remaining inorganic minerals can be further classified as major or trace minerals. Minerals are a charge for messaging systems, functioning in osmotic balance and electrical gradients, providing structural roles to other compounds, acting as catalysts, or incorporated in binding events [15].

The actual knowledge on the nutrient composition of fish is vital to comprehend the correlation between nutrient access and intake amount and also support production and value addition. It assists to generate the programs and strategies to optimize food supply that can fulfill nutrient requirements of the population, essential to estimate the quality of the raw material, storage stability, and application of technological processes [14].

The nutrition composition of the fish species and their presence of level are influenced by several factors like genetic factors, water contamination [16], feeding habits, sex, sexual changes connected with spawning, age, maturity stage and seasonal variations [17]. Environmental factors such as geographical location, water temperature, salinity and pH range also extremely determine the nutrition composition of different fish flesh [18]. The objectives of this study were to generate and document comprehensive information on the nutritional status of widely consumed and economically important three species of

brackish water fishes (*Mugil cephalus*, *Oreochromis niloticus*, and *Arius maculatus*) from three local fish markets (Kallady, Kattankudy and Arayampathy) which based on the Batticaloa lagoon fishery in Eastern Province of Sri Lanka.

2. MATERIALS AND METHODOLOGY

2.1 Sample collection and preservation

The fish species analyzed in this study were obtained from three local fish markets located in the Batticaloa district, Sri Lanka. The chosen sampling locations were the Kallady fish market (7.71621N, 81.71054E), Kattankudy fish market (7.67617N, 81.72599E) and Arayampathy fish market (7.67089N, 81.73147E) which are dependent on the Batticaloa lagoon fishery and contribute a steady supply of lagoon fishes for communities. The selected three fish species for this present study were *Arius maculatus*, *Mugil cephalus* and *Oreochromis niloticus*. Each fish species was sampled three times from single fish market during the study period fortnightly. Sampling was done from November 2019 to February 2020 for three months. The number of fishes collected in each sampling was dependent on the average size of each fish species. The fish were identified up to the species level using standard keys [19].

Fishes were transported in an insulated icebox lined with crushed ice and away from direct sunlight, to Fisheries Laboratory, Department of Zoology, Eastern University, Sri Lanka, where they were cleaned and filleted. The fresh fish fillet sample of approximately 10g was sealed in the polythene bag and labelled to store at -18°C until analyzing the nutrition composition of fish flesh. Fish samples were subjected to nutritional analysis by following the standard procedure [20]. The muscle samples of each fish species were analyzed in triplicate.

2.2 Proximate composition analysis

2.2.1 Determination of moisture content

The day before the analysis the porcelain crucibles were dried in the hot air oven at 100°C for 24 hours. Then they were cooled to room temperature in a desiccator. The fish muscle samples of 5.000g were accurately measured and evenly distributed in the pre-weighed and preheated crucibles. The crucibles with fish muscles were maintained in a hot air oven for 24 hours at temperature 105°C. After complete water loss from samples,

the crucibles were put in the desiccator and allowed to cool down and the loss in weight was calculated as a percentage as follows:

$$\text{Moisture } (\%) = \frac{(W_0+W_1)- W_2}{W_1} \text{ x } 100$$

where W_0, W_1 and W_2 are respectively the weight of the empty crucibles without lid in g, weight of the fresh sample in g and weight of the crucible without lid and dried sample in g [20].

2.2.2 Determination of protein content

Appropriately measured 1g of homogenised fish sample weighed into a Kjeldahl flask, 7g of catalyst (powdered potassium sulfate: copper sulfate (ii) pentahydrate: selenium mixed in the ratio of 96.5:1.5:2 respectively), 12mL of concentrated H_2SO_4, and 10-12 glass beads were added. The contents were then digested until being clear. Contents were cooled and diluted with 80ml of distilled water. Then 30ml of 4% boric acid and five drops and redox indicator (a mixture of methylene blue and phenol blue) were added into the distillation flask. Then distilled water and 100ml of 40% NaOH were added into the distiller. After the digestion flask was accompanied by the distillation, the digested solution was neutralized by adding 10ml of 40% NaOH solution from time to time. The adding phase was stopped after pouring approximately 60-70ml of 40% NaOH solution. The mixture was distilled and the distillate was collected into the boric acid containing 3 drops of indicator. Ammonia was converted to ammonium metaborate and direct titrated with standardized 0.1 M hydrochloric acid. The percentage of protein was calculated using the following formula:

$$\text{Crude protein } (\%) = \frac{(V_2-V_1) \text{ x } N \text{ x } 14.007 \text{ x } 6.25}{M} \text{ x } 100$$

where

V_1 - volume of HCl (ml) solution required for the titration of blank solution,

V_2 - volume of HCl (ml) solution required for the titration of the digested test solution, and

N - normality of the HCl solution,

M - weight of the fresh fish muscle sample in g,

14.007 - atomic mass of nitrogen in g [20].

2.2.3 Determination of fat content

The 250ml round bottom flask was cleaned and dried in the hot air oven at 105°C overnight and its weight was measured. Accurately, 250ml of petroleum ether was filled into a weighed round bottom flask and assembled with a heating mantle. The 3g of dried and powdered fish muscle was placed into a pre-dried porous cellulose extraction thimble and covered with a cotton ball and transferred into the Soxhlet apparatus. The round bottom flask was incubated at 85°C for 14 hours to evaporate the petroleum ether by using a vacuum condenser. Then the bottom flask with extracted fat was dried in an air oven at 100°C until the solvent was completely evaporated and the flask was completely dry. After drying, the flask was allowed to cool and reweighted with its dried fat extract content. The following equation was used to calculate the percentage of crude fat in the fish muscle:

$$\text{Crude fat (\%)} = \frac{W_2\text{-}W_0}{W_1} \text{ x } 100$$

where W_0 W_1 and W_2 are respectively the weight of empty round bottom flask in g, weight of the powdered fish sample in g and weight of round bottom flask and extracted fat g [20].

2.2.4 Determination of ash content

The porcelain crucibles were preheated in the muffle furnace at 550°C for 10 hours and cooled in the desiccator. Then their empty weight was measured. Accurately 5g of fish muscle sample was placed in the preheated porcelain crucible and they were placed in the muffle furnace without a lid for 8 hours at 550°C until obtaining a completely white fluffy ash, without any remaining organic substances. Then the crucibles were cool down in a desiccator. Finally, the weight of crucible plus ash content was accurately measured. The following equation was used to calculate the percentage of crude fat in the fish muscle:

$$\text{Ash content (\%)} = \frac{W_2\text{-}W_0}{W_1} \text{ x } 100$$

where W_0, W_1 and W_3 are respectively the weight of empty crucible in g, weight of fish sample before ashing in g and weight of crucible with ash in g [20].

2.3 Statistical analyses

The final results for the nutrients were calculated according to the equations by using Microsoft Excel 2016. To understand the variation in the composition of nutrients and statistical significance with respect to different selected fish species, One-way ANOVA and Tukey pairwise comparison were done. The statistical analyses were checked at 0.05% significant level by using Minitab version 19.1.

3. RESULTS AND DISCUSSION

The proximate composition results of three brackish water fish species A. *maculatus*, M. *cephalus*, and O. *niloticus* sourced from local markets located in the Batticaloa district were tabulated in table 1 and graphically represented in Figure 1 and Figure 2.

Table 7: Proximate composition of three fish species recorded from Batticaloa Lagoon

Nutrient composition	***Arius maculatus***	***Mugil cephalus***	***Oreochromis niloticus***
Moisture content (%)	56.73 ± 5.96^{a}	75.12 ± 4.37^{b}	81.48 ± 2.52^{c}
Crude protein content (%)	15.36 ± 1.62^{a}	17.33 ± 1.96^{b}	13.70 ± 1.55^{c}
Crude lipid content (%)	3.20 ± 0.59^{a}	2.43 ± 0.37^{b}	1.27 ± 0.35^{c}
Ash content (%)	1.77 ± 0.43^{a}	1.57 ± 0.15^{b}	1.22 ± 0.15^{c}

According to Tukey pairwise comparison means with different superscripts within rows are significantly different from each other.

The mean moisture contents of the analyzed fishes ranged from 56.73 ± 5.96 to 81.48 ± 2.52%. Data obtained from the present study revealed that the moisture content of O. *niloticus* muscle was higher than those of other fishes. Statistically, the moisture content of the fishes differed from species to species significantly (***P***-value = 0.013, ANOVA). Similar finding for moisture content of O. *niloticus* [21] and M. *cephalus* was recorded in some studies [13]. Several factors influence the moisture content of fish species, in which water quality is also one of them. The findings illustrate that the Batticaloa lagoon is highly disturbed by anthropogenic activities such as domestic solid waste, septic pit leakage, sewage and household effluents contamination through the closest living dense human population [22]. On the contrary, environmental hypoxia in brackish water systems and oxidation of meat products are reported issues related to moisture contents [23].

The protein contents of the fishes were greatly varied from 13.7 ± 1.55% to17.33 ± 1.96%. The results for the O. *niloticus* were similar to findings for the same species sourced from Manyame lake [24] and that not agreed with the findings of the same species recorded in the wild and cultured ecosystems [21]. The results for M. *cephalus* were not according to the published literature value in a study [13] which was higher than the values obtained from the current study. Statistically, the mean protein contents of analyzed fishes were significantly varied (***P***-value = 0.000, ANOVA) at a 0.05% confidence level. Findings of some studies indicated that protein composition in the fish flesh is negatively affected by the spawning period of fish [24]. This statement may also be the reason for the variations in the protein content of fish species analyzed in this present study. Other published factors influencing the protein composition are feeding frequency, sex, age category and maturity of the fish species [25]. Research works found that protein compositions of the fish flesh were drastically changed with the pollution level of water bodies [24]. This statement coincides with the condition of the Batticaloa lagoon as reported in the study [22]. The research work concluded that overgrowth of the macrophytes reduced the amount of dissolved oxygen in water [24]. This condition of environmental hypoxia interacts with other factors of fish such as fish size, stocking density, and fish behaviour to affect the fish feeding and reduces the ability to sustain the metabolic process. These factors consonance with the fluctuations in the protein content of analyzed fishes.

Fat is a valuable reservoir for life as it offers almost double energy of the carbohydrates. The mean fat contents of selected brackish water fishes ranged from 1.27 ± 0.35% to 3.20 ± 0.59%. The fat composition of A. *maculatus* reveals that this may be a good source of fat given the fact that the fat content of A. *maculatus* is the highest among all documented samples and followed by M. *cephalus* and O. *niloticus* containing the fat content values of 2.43 ± 0.37% and 1.27 ± 0.35% respectively. The results for M. *cephalus* are near to the findings of the same species in marine water [26], and lower than some published literature value [13]. The recorded fat content of the O. *niloticus* was lower than the recorded literature value of the same species sourced from three different lakes [24] and higher than the findings for the same cultured and wild fish species [21]. The lipid content of the analyzed brackish water fishes varies much more widely than other analyzed proximate compositions. Statistically, there was a significant difference

(***P***-value = 0.024, ANOVA) between the fat content of three fish species at a 0.05% confidence level.

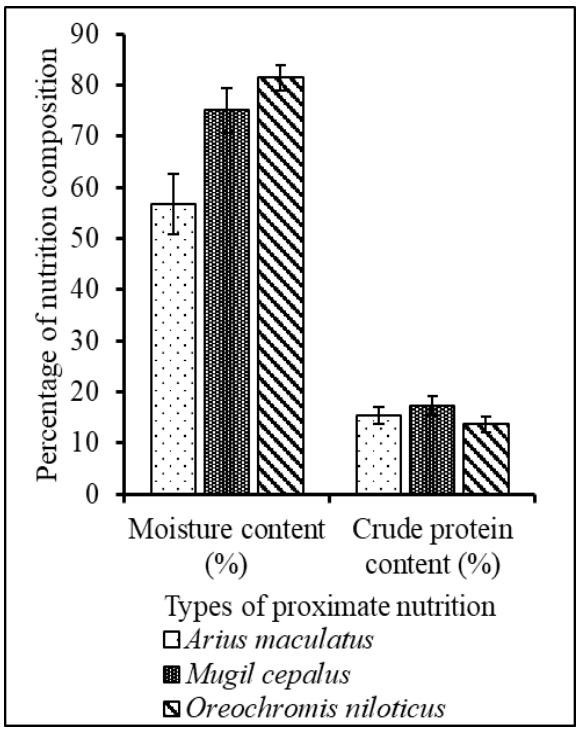

Figure 1: Distribution of mean moisture content and crude protein content in selected

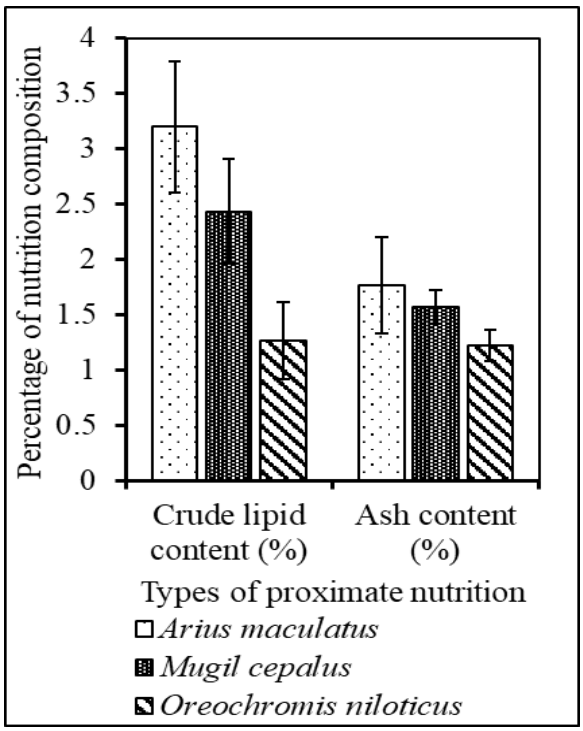

Figure 2: Distribution of mean crude lipid content and ash content in selected fish

According to the classification of fishes based on their fat content [14], the fishes analyzed in this study can be classified into lean or low-fat fish. The low-fat fishes (fat content 2 - 4%) are A. *maculatus* and M. *cephalus* while O. *niloticus* is classified under the lean fishes with fat content lower than 2%. The variations in the results may also be affected by several factors. This supports the concept that the lipid content of fish changes due to species, diet, geographical origin, season [27], life cycle variation and competition for food [14] during the sampling period. The findings of a study stated that the value for lipid content of fish muscle has an inverse relationship with moisture content in the muscle [28]. This statement is in agreement with the findings of selected all three fish species in the present study. The variations in the lipid content of the different fish species agreed with the published statement [29], where Lipoxygenases and enzymatic hydrolysis of lipids were a major problem for fluctuation in the lipid content of post-mortem fish species. The study pointed out that fish species store fat in the liver, muscle, and perivisceral and subcutaneous tissues and the distribution of lipids in fish decreased from head to tail [30]. Based on this argument, a higher proportion of lipid

content in the analyzed fish species may store in other organs rather than stored in muscle tissue.

The ash contents from fish muscles are an indicator of mineral contents. A. *maculatus* was found to be at the top with the highest ash contents (1.77 ± 0.43%) among selected fishes and followed by M. *cephalus* (1.57 ± 0.15%) and O. *niloticus* (1.22 ± 0.15%). This behaviour for O. *niloticus* was like that observed in the study [21]. The published literature ash value [13] recorded in a study for M. *cephalus* was substantially lower than the recorded value in this present study. The mean ash contents of selected fish species were not the same throughout the study period. Statistically, there was a significant difference (***P***-value = 0.020, ANOVA) between the ash content of selected three fish species at 0.05% confidence level.

According to the previous studies, the ash content varies with the capacity of the fish to absorb and assimilate the minerals from the water where they live or availability of food [24]. Other published findings denoted that the brackish water contains some major solutes such as sodium, calcium, and bicarbonate ions, which typically originate from water reactions with minerals [31]. The results from studies recorded salinity variation in the Batticaloa lagoon, and which may lead to the variation in major mineral concentration and their ratios in the lagoon water [32 and 33].

The higher level of ash content in the A. *maculatus* may be due to its feeding habitat. This is the only fish species having a carnivore diet, which gives more and important mineral compositions for fish muscle. The findings of a study stated that the bottom layer of Batticaloa lagoon water found with more salt content than the surface of the lagoon water, where salt settled at the bottom without strong mixing with the surface layer [33]. The O. *niloticus* prefers shallow water while feeding and tend them to feed item at the periphery of water bodies [34]. This factor allows O. *niloticus* to habitat in less saline water and results in a low level of ash composition in their muscle.

Other factors that come into play in the ash composition are feeding frequency, seasonal and biological differences (species, size, dark/white muscle, age, sex, and sexual maturity), area of catch, processing method, food source, and environmental conditions such as water chemistry, temperature, and contaminants [25]. The environmental condition was not stable throughout the study period, the fluctuation in the season may

be influenced by the variations of the salinity and mineral content of lagoon water. The high content of several important minerals in fish species may be naturally attributed to the inclusion and exclusion of various fish parts such as bones, skin, head, viscera, etc. [14]. The low ash content results in the present study coincide with this statement.

CONCLUSION

The present study was carried out to study the nutritional status of three widely consuming brackish water fish species of the Batticaloa lagoon, Sri Lanka. Findings illustrated that selected fishes are a source of moisture, high-quality protein, lipid and ash. The highest constituent in the fish muscles of all species was moisture compared to other nutrients while all the species were recorded with the lowest value of ash content. A. *maculatus* and M. *cephalus* can be considered as good sources of nutrient composition than O. *niloticus* to fulfill the nutrient requirement and all the chosen fishes can support beating the food insecurity in the country. With reference to all of these findings, consumption of A. *maculatus*, M. *cephalus* and O. *niloticus* are highly recommended and assist to generate nutrient balance and affordable diets for humans. The nutritional composition data can be used to fill the gaps of the nutrient composition of brackish water fish species in Sri Lanka and further it is essential for comparisons to fish nutritional quality, formulating fish feed for animals, processing and preservation of fish and other important means for human food, medicine and for industries.

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