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Growth characteristics and meat quality atributes of Clam (*Geloina vexans*) and Oysters *(Crassostrea madrasensis)* harvested from two lagoons of Sri Lanka.

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The present study was focused to evaluate nutritional quality parameters, Ecophysiological and commercial quality indicators of clam (*Geloina vexans*) and oyster (*Crassostrea madrasensis*) at two growth stages (4 months and 6 months) in two different Sri Lankan sites, namely Bolgoda lagoon in Moratuwa area and Pitipana lagoon in Negombo area. According to the results of this study total saturated fatty acids (34.4%) as well as total mono saturated fatty acids are high in clams of Bolgoda lagoon. However, total polyunsaturated fatty acids are high in clams of Negambo lagoon. Results revealed that crude protein level is significantly ($p<0.05$) higher in both species grown in Bolgoda lagoon (CP% 70.8±1.42g/100g and 48.97±2.38g/100g clams in Bolgoda and Negombo respectively while CP% 34.12±1.18 and 45.2±2.23g/100g oysters in Bolgoda and Negambo respectively). However intervalval fluid contents of 6 months age clams and oysters in Negombo are significantly higher than Bolgoda oysters ($P<0.05$) which are 11.39±1.68 g/100g and 9.11± 1.68 g/100g respectively. Water salinity, temperature and pH are some values which are significantly higher in Negombo lagoon than Bolgoda ($P<0.05$) while dissolved oxygen and resistivity are significantly higher in Bolgoda than Negombo.
Results revealed that availability of planktons is high in Bolgoda lagoon. And this may be the possible reason for high CP, ash, DM and meat content in clams and oysters of Bolgoda lagoon. Rich lagoon conditions in Bolgoda lagoon has caused to the high nutritional value and high demand of bivalves in Bolgoda lagoon in Sri Lanka.

Key Words: *Geloina vexans*, *Crassostrea madrasensis*

Introduction

Clams (*Geloina vexans*) and oysters (*Crassostrea madrasensis)* are commercially important edible bivalve species in Lagoons of Sri Lanka. There is a huge demand for sea clam and oyster in the present world market. The market demand of those bivalves in Sri Lanka is fulfilled by wild catch and those two bivalves are highly distributed in Bolgoda lagoon as well as in Negambo lagoon. Both Lagoons are rich in mineral salts, organic matter and planktons. Though sea clam and oysters are highly consumed by Sri Lankans, still there is a lack of scientific information on their meat composition and meat quality parameters. As it is said to be a different consumer preference between Bolgoda and Negambo species there might be a difference in Lagoon conditions of those two lagoons. It is known that water temperature, food availability and reproductive cycle of animals may influence the meat quality and biochemical composition of bivalves [1][2]. However, poor information is available from the literature on eco-physiological and commercial quality parameters of these two species. In the present study, an attempt was made to analyze the eco-physiological parameters and meat quality parameters of bivalves in two lagoons of Sri Lanka.

Materials and Methods

Samples of clams and oysters of the commercial size (4 months in age and 6 months in age) were randomly collected from Negambo and Bolgoda lagoon in Sri Lanka. Samples were cleaned and immediately packed in air tied conditions in polythene bags and transported to the laboratory of the Dept of Animal science, University of Ruhuna. Clams and oysters were rapidly washed and manually shucked by cutting the adductor muscle with a knife. Then the intervalval fluids were collected separately and mean weights of the meat were calculated. Thickness, length, width and height of the shells were measured using a 0.05mm precision caliper as described by Fisher, Schneider and Bauchot [3]. After the biometric measurements, meat and shells of 30 specimens from each species were grouped in pools, weighed and dried at 105 ^{0}C for 24 hrs and Condition Index (CI) was calculated. Crude protein, crude fibre and ash contents of clams and oysters were determined by AOAC[4] method. Total lipids were extracted [5] and the method used in this study was slightly modified [6]. Measured amount of water filtered through plankton net where planktons were concentrated in small chamber in plankton net. Plankton samples are preserved using $MgCO_3$ and few drops are taken above sample and put on to Sedwick Rafter cell (slide) and seen under low power microscope. Counting of organisms in the S-R cell is done by counting horizontal strips along the length of the cell. The plankton counts per strip then determined by multiplying the actual count by factor representing the counted portion of the whole S-R cell volume.

Fatty acid profile were determined by gas chromatography using a 6890 Hewlett Packard gas chromatograph with flame ionization detector, equipped with a SPB TM PUFA fused silica capillary column, 30 m × 0.25 mm inner diameter, 0.20 µm film thickness (Supelco Inc., Bellefonte, PA, USA). Fatty acids were identified by comparison of retention times to authentic standards for area percent normalization. Relative quantities were expressed as weight percent of total fatty acids in each sample.

Water quality parameters were measured Using potable water quality measuring instrument (Cyberscan PCD 650, EUTECH instrument pte Ltd, Thermo Fisher Scientific, Singapore). Data are analyzed by SAS system version 6.12. Comparison of means after the ANOVA test (*P<0.05*) was performed using the Duncan's multiple range test.

Table 1: Percent content of meat, Intervalval fluid content and condition index of clams

	Negombo		Bolgoda	
	4 months	6 month	4 months	6 month
Meat content(g)	4.95± 1.58^{a}	14.52± 1.95^{b}	11.38± 2.12^{c}	15.05± 1.99^{b}
Percent content of meat (g 100 g^{-1})	13.71± 1.23^{a}	22.27± 2.13^{b}	27.06± 1.96^{c}	22.04± 1.39^{b}
Shell weight (g)	3.96±2.24^{a}	50.64± 4.39^{b}	29.05± 1.72^{c}	54.73± 4.77^{d}
Intervalval fluid content(g 100 g^{-1})	11.39± 1.68^{a}	7.65 ±1.03^{b}	6.78± 1.20^{c}	5.59± 0.81^{d}
Condition index	21.11± 1.77^{a}	28.48± 2.21^{b}	67.46± 2.24^{c}	51.01± 1.49^{d}

Results and Discussion

Intervival fluid content and Condition Index of Clam and oysters at two growth stages in two different sites were presented in table 1 and 2. The meat contents are significantly higher (p<0.05) in 6 months old clams and oysters. On the other hand clams and oysters at Bolgoda lagoon are showed significantly higher meat content than in Negambo lagoon. When consider the condition indexes, Bolgoda lagoon indicated significantly higher value (p<0.05) than Negambo lagoon.

Means ± standard deviation. Within a row, values not sharing the same superscript are significantly different (*P<0.05*)

Table 2.

Table 2: Percent content of meat, Intervalval fluid content and condition index of oysters

Means ± standard deviation. Within a row, values not sharing the same superscript are significantly different (*P<0.05*)

Morphological parameters of clams and oysters in both lagoons were shown in table 3 and 4.

Table 3: Biometric parameters of clams in two lagoon sites

Biometric parameters (mm)	Negombo		Bolgoda	
	4 m	6m	4 m	6m
Length	45.2±1.18^a	51.3±1.27^a	43.5±1.52^a	50.2±1.93^a
Width	30.7±0.70^a	44.0±1.06^b	30.0±0.56^a	43.7±1.05^b
Thickness	2.0±0.03^a	2.6±0.05^b	2.1±0.06^a	2.1±0.06^a
Height	31.4± 0.18^a	36.8± 0.10^b	31.8± 0.13^a	36.9± 0.29^b

Means ± standard deviation. Within a row, values not sharing the same superscript are significantly different (P<0.05)

Table 4: Biometric parameters of oysters in two lagoon sites

Biometric parameters (mm)	Negombo		Bolgoda	
	4 m	6m	4 m	6m
Length	69.3±2.90^a	102.0±3.46^b	68.9±2.19^a	100.7±1.11^b
Width	44.8±1.65^a	59.0±1.18^b	43.1±1.89^a	58.9±1.47^b
Thickness	2.9±0.04^a	4.6±0.08^b	3.0±0.04^a	5.3±0.02^c
Height	32.2± 1.16^a	45.0±2.19^b	32.5±1.33^a	45.2± 2.27^b

Means ± standard deviation. Within a row, values not sharing the same superscript are significantly different (P<0.05)

There is no significant difference (p>0.05) between those two different species and both lagoons conditions.

Fatty acid profile of clams

Table 5: Fatty acid profile of clams in two lagoon sites . Within a row, values not sharing the same superscript are significantly different (*P<0.05*)

Fatty Acid	Negombo clam	Bolgoda clam
	g per 100g of fish oil	g per 100g of fish oil
C 12:0	0.2	0.1
C 14:0	1.4^a	2.8^b
C 15:0	0.4	0.3
C 16:0	18.4^a	20.5^b
C 17:0	3.1	2.5
C 18:0	10.8	10.6
Total saturated	34.4	36.8
C 20:1	7.9	6.6
C 22:1	1.5	1.2
C 16:1	2.2	3.7
C 18:1	7.6	8.8
Total monounsaturated	19.2	20.3
C20:2n-6	2.2^a	3.6^b
C20:3n-6	0.4^a	0.8^b
C20:3n-3	0.1	0.1
C20:4n-3	0.3	0.3
C 20:5n-3	5.5^a	7.9^b
C 18:2n-6	0.6^a	1.0^b
C18:4n-3	0.4	0.3
C 18:3n-3	0.5	0.4
C 22:4n-6	2.0	1.6
C 22:5n-3	2.4	2.3
C 22:6n-3	9.6^a	6.0^b
Total polyunsaturated	24	24.3
Total n-3 polyunsaturated	18.8	17.3
Total n-6 polyunsaturated	5.2	7.0
Ratio n-3/n-6	3.62	3.15
Total Composition of all the unknown peaks	22.5	18.6

The fatty acid profile of total lipids extracted from clams in two different lagoons is listed in table 5.

	Negombo		Bolgoda	
	4 months	6 month	4 months	6 month
Meat content(g)	7.24 ±0.81^a	20.72± 2.07^b	13.18± 1.73^c	23.83± 1.52^d
Percent content of meat (g 100 g^{-1})	10.55± 0.95^a	13.34± 1.23^b	16.35± 1.54^c	13.34± 2.15^b
Shell weight (g)	61.32± 5.66^a	133.54± 8.88^b	63.01± 5.27^a	145.65± 2.48^c
Intervalval fluid content (g 100 g^{-1})	9.11± 1.68^a	4.79± 1.06^b	7.47± 1.23^c	3.84± 0.52^b
Condition index	8.84± 1.85^a	15.69± 1.17^b	20.21± 2.67^c	23.03± 1.10^d

According to the results of this study total saturated fatty acids (34.4%) as well as total mono saturated fatty acids are high in clams of Bolgoda lagoon. However, total polyunsaturated fatty acids are high in clams of Negambo lagoon. The relevance between the fatty acid profile of aquatic filter- feeders and that of their diet is a known fact [7]. It is generally considered that besides reproductive influences, the availability of planktons during the year may affect the lipid profile of bivalves, relying on plankton as the main food source [8].

Total n-3 PUFA (18.8 %) is high in clams in Negombo and total n-6 PUFA (5.5%) is high in Bolgoda clams. That means n-3 PUFA (5.2 %) is low in Negombo clams. Therefore, n-6/n-6 ratio (3.62) is high in Negombo and clams in Negombo lagoon are more nutritious than clams in Bolgoda lagoon.

High levels of n 3 PUFA, is important in the human diet for their platelet anti aggregating and blood pressure-reducing properties. Seafood products are, in fact, the only significant source in the human diet of n 3 PUFA, a class of nutrients fundamental in the prevention of human chronic inflammatory and cardiovascular diseases. In consideration of the increased consumption of food rich in n 6 PUFA in industrialized countries and of the important re-establishment of a healthy balance between n 3 and n 6 PUFA, an increment of the consumption of seafood is recommended by the current dietary guidelines [9]. Present study show that the fatty acid profile of the clams of Bolgoda was distinct from Negombo. The main reason behind this may be the differences in naturally available foods sources in both lagoons.

Proximate composition of clams

Table 6: Chemical composition (* g 100 g^{-1} dry weight) of clams from the two lagoon sites

	Negombo		Bolgoda	
	4 m	6 m	4 m	6 m
Crude protein *	45.20±0.89^a	48.97±2.38^b	62.68±1.84^c	70.8±1.42^d
Total lipid*	4.5±0.70^a	5.0±0.1^b	4.5±0.70^a	6.5±0.70^b
Crude fibre*	ND	ND	ND	ND
Ash*	6.5±0.70^a	11.5±2.12^b	12.0±0.1^c	18.5±2.12^d
Meat pH	6.25±0.34	6.48±0.08	6.40±0.07	6.26±0.17
Flesh dry matter (g 100 g^{-1})	12.56±0.38^b	9.02±0.31^a	15.95±1.69^c	16.92±1.34^c

Means ± standard deviation. Within a row, values not sharing the same superscript are significantly different (*P<0.05*). ND = not detected

Crude protein (CP), total lipid, ash, dry matter (DM) and meat pH differences of clams at two growth stages in two different lagoons are shown in table 6. When consider the CP content of clams, it is significantly affected by both lagoon conditions (*P<0.0001*). Thus the highest CP amount is recorded in 6 months clams in Bolgoda and the lowest value was observed clams in Negombo. When consider about ash content, it is significantly affected by lagoon (*P<0.01*) conditions and the highest value is recorded in 6 months clams in Bolgoda lagoon (18.5 %).

The pH content of the meat is not affected by lagoon conditions. However the dry matter content is significantly higher in clams and oysters in Bolgoda lagoon. Possible reason for those results may be the different lagoon conditions in both lagoons. It is known that water temperature and food availability of animals may influence the meat yield and biochemical composition of bivalves [1].

Table 7: Chemical composition (* g 100 g^{-1} dry weight) of oysters from the two lagoon sites

	Negombo		Bolgoda	
	4 m	6 m	4 m	6 m
Crude protein *	34.12±1.18^a	36.18±1.41^a	43.1±1.58^b	45.24±2.23^b
Total lipid*	5.5±0.70^a	7.5±0.70^b	8.0±1.41^b	9.5±0.70^c
Crude fibre*	ND	ND	ND	ND
Ash*	10.0±0.1^a	14.0±1.14^b	12.5±2.12^a	15.5±2.12^b
Meat pH	6.28±0.06^a	6.39±0.21^a	6.42±0.12^a	6.37±0.16^a
Flesh				

dry matter (g 100 g^{-1})	6.92±0.54 [b]	9.32±1.11 [a]	7.66±1.21 [b]	12.19±0.91 [c]

Means ± standard deviation. Within a row, values not sharing the same superscript are significantly different (*P<0.05*). ND = not detected

The plankton density in Bolgoda lagoon (1800 organisms/ml) is significantly higher (p<0.05) than plankton density in Negombo (160 org/ml) (table 7) and therefore food availability for bivalves is high in Bolgoda than Negambo. That might be the reason for high condition index, dry matter and proximate composition of bivalves in Bolgoda. Condition Index and meat content of bivalves are affected by a variety of extrinsic and intrinsic factors, such as water temperature and salinity, food availability and gametogenic cycle of animals [2]. Larval growth of bivalves was generally found to increase as the algal density increased, indicating the important role of food availability in larval growth [10].

The present investigation shows that the water quality parameters of Bolgoda lagoon were distinct from Negombo lagoon. Temperature, pH, oxidation reduction potential (ORP), conductivity, total dissolved solids (TDS) and salinity values are higher in Negombo lagoon (table 7). It is known that the quality requisites of bivalve molluscs are primarily dependent on the water quality, assuring a healthy product and a safe consumption, and by a variety of factors, such as food availability, water temperature and salinity. [11]. Larval survival rate of bivalves was significantly lower at the higher temperature, despite larvae having the greatest shell growth. Similar results have been found for larvae of other bivalve species and this has been explained by increased microbial activity at higher temperatures [12]. The difference of fatty acid profile and differences of other meat quality parameters of the bivalves of two water bodies in the present study might be due to the variations in available food sources (planktons) and water quality parameters.

Conclusions

The present study indicated that the nutrient quality and meat quality are higher in bivalves of Bolgoda lagoon. Reason behind might be the differences in naturally available food sources in the lagoon. Results revealed that availability of planktons is high in Bolgoda lagoon. Furthermore, the present study suggested the further investigations have to be carried out to determine effect of physiochemical parameters on fatty acid profile and other nutrient qualities of the bivalves in Sri Lankan lagoons.

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