Asian Fisheries Science **27** (2014): *61-74*

ISSN 0116-6514
E-ISSN: 2073-3720
https://doi.org/10.33997/j.afs.2014.27.1.005

Asian Fisheries Science
The Journal of the Asian Fisheries Society

Meat Yield and Biochemical Composition of Hatchery Reared Spotted Babylon, *Babylonia areolata* (Link 1807)

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Abstract

The meat yield and biochemical composition of hatchery reared spotted babylon, *Babylonia areolata* (Link 1807) was evaluated. The weight of the meat was approximately 30-40% of the total body weight and no significant loss ($p>0.05$) in weight (2-4%) was observed after cooking. Proximate analysis of *B. areolata* showed that they were high in protein (22.4%) and low in fat (2.7%). The main fatty acids detected were C16:0 (15.9%), C18:1n9c (9.85%), C18:3n3 (6.71%) and C18:0 (5.99%). The total saturated fatty acid, mono unsaturated fatty acid and polyunsaturated fatty acid contents of lipids were 30.56%, 23.19% and 23.21%, respectively. Glutamic acid (3.01%) and aspartic acid (2.25%) were the most abundant non-essential amino acids in *B. areolata* while leucine (1.53%) and lysine (1.32%) were the major essential amino acids detected. The main minerals found were potassium, phosphorous, sodium and zinc. Results from this study suggest that hatchery reared *B. areolata* could be considered a healthy food comprising of good sources of protein, amino acids, minerals and low in fat.

Introduction

Babylonia aerolata (Link 1807) is an invertebrate belonging to the phylum Mollusca, class Gastropoda, Family Buccinidae as classified in the World Register of Marine Species (Bouchet 2012). It is commonly known as the spotted babylon, babylon snail, babylon shell, maculated ivory whelk, ivory shell or Thai escargot. In Malaysia it is known as *siput manis* or sweet snail. *Babylonia areolata* is distributed naturally along the South East Asia coastal areas occurring at depths of 10-20 m on sandy bottoms. The flesh is said to be rich in nutrition, has good taste and fetches high export value (Nhuan 2011). In Thailand, the price of *B. areolata* was at US$8.60·kg^{-1} a few years ago (Chaitanawisuti et al. 2009) and in East Malaysia the current price of *B. areolata* is about US$12.00/kg (Mohd Saleh Taha, *pers. comm*.).

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Similar to other marine resources, natural stocks of *B. areolata* have declined sharply from over-exploitation. In order to meet the domestic and export demand, it has been introduced for culture in countries such as Thailand and Vietnam and has become a new source of income for fishermen because of its high profit, shorter culture period (4-6 months to marketable size), relatively simple culture techniques and lower production cost as compared to lobster culture (Nhuan 2011). Since the year 2000, a lot of work has been carried out on the culture of *B. areolata* especially in terms of growth performance or survival (Zhang et al. 2009), culture systems (Kritsanapuntu et al. 2007), diets and feed utilisation (Kritsanapuntu et al. 2007; Li-Li et al. 2009; Sangsawangchote et al. 2010), nursing techniques (Sutthinon et al. 2007), reproductive performance (Sangsawangchote et al. 2010) and economic value (Chaitanawisuti et al. 2009). Beside a study on the biochemical composition of cultured juveniles of *B. areolata* (Chaitanawisuti et al. 2011), there is very limited information on the meat yield and biochemical composition of cultured adult *Babylonia*.

The culture of *B. areolata* has recently been introduced in Malaysia. The information on the *B. areolata* nutritional values would be helpful to promote *B. areolata* which is still considered alien to most local seafood lovers. Hence the objectives of this study are to provide information on the meat yield and biochemical composition of hatchery-reared *B. areolata*.

Materials and Methods

Samples

The spotted babylon (*B. areolata*) (initial mean size of 0.3 cm) were reared in circular tanks (1.0 m in diameter) at a density of 200 pieces $\cdot$tank^{-1} in the hatchery at the Fisheries Research Institute Pulau Sayak, Kota Kuala Muda, Kedah, Malaysia from July 2011 to February 2012. The water temperature in the tanks ranged from 25.3-31.4˚C during the experiment and the salinity range was at 29-30 ppt. The tanks were fitted with a flow-through water system and provided with aeration throughout the growth period. The gastropods were fed with trash fish at 5% bodyweight daily. Feed samples were analysed for basic proximate composition. In March 2012, commercial sized (mean length; 5.13 ± 0.39 cm and mean weight; 8.14 ± 0.93 g), sexually matured *B. areolata* (about 8-9 months old) were harvested and transported in an ice cooled insulated box to the Fisheries Research Institute, Batu Maung, Penang, Malaysia for meat yield and biochemical composition analysis.

Meat yield

For meat yield determination, 30 specimens of the spotted Babylon collected from several tanks were weighed and measured individually to get the mean weights and lengths. The shells were broken to separate the flesh from the shell. In this context, the term flesh includes the foot, visceral mass (esophagus, stomach and rectum) and the head. The flesh was then weighed. This experiment was carried out for fresh and cooked samples.

Biochemical composition

Proximate analysis was done on fresh uncooked samples in triplicate for crude protein, fat, carbohydrate, ash and moisture content using the method of the Association of Official Analytical Chemist (AOAC), 1998. Meat was removed from the shell, viscera were discarded and large central muscle was minced and employed as samples. The crude protein was determined by the Kjeldahl method (N X 6.25) using an automatic Kjeldhal system (Gerhard, Vap50 – Germany). Fat was extracted from the tissue by acid hydrolysis first and followed by extraction with chloroform/methanol (2:1, v/v). The moisture content was determined by oven drying at 105°C to a constant weight. Ash was determined gravimetrically in a muffle furnace by heating at 550°C to constant weight. Carbohydrate was determined by the difference.

Fatty acid analysis of the samples was determined as fatty acid methyl ester (FAME) (Majid et al. 2003). The fatty acid methyl ester was separated by gas liquid chromatography on a HP 5890 (USA) equipped with a flame ionisation detector and fitted with capillary column (DB23; 30 m x 0.25 mm x 0.25 mm, Agilent, USA). Hydrogen was used as the carrier gas with a flow rate of 1.3 $ml \cdot min^{-1}$. Injector and detector temperatures were programmed to be at 240 and 250°C, respectively. The total run was 30 min. The FAME was identified by the comparison of retention times with reference of known standard (Supelco 37, component FAME mix). The fatty acids were calculated by the percentage of total lipid.

A total of 0.1-0.2 g of *B. areolata* meat samples were hydrolysed in 5 mL of 6 N HCl at 110°C for 24 h. Hydrolysate was filtered through a 0.45 mm membrane filter prior to analysis. Amino acid profiles of samples were determined using HPLC (Waters 2475, Waters Co., Milford, MA, USA) with fluorescence detector (Waters 2475), Waters AccQ. Tag Amino Acid Analysis Column (internal diameter 3.9 x 150 mm) and mobile phase (AccQ. Eluent A and AccQ. Eluent B or 60% acetonitrile). All determinations were carried out in triplicate.

Minerals (calcium, iron, potassium, magnesium, manganese, copper, zinc and sodium) were determined using the atomic adsorption spectrophotometer (GBC 906 Elite, Hampshire, USA) and phosphorous and selenium using the Inductively Coupled Plasma Mass Spectrometry, ICPMS (ELAN 9000, Perkin Elmer, USA).

Results

Meat yield determination

The length and weight of *B. areolata* in this study ranged from 4.82-5.94 cm (mean length; 5.13±0.39 cm) and 7.33-10.26 g (mean weight; 8.14±0.93 g), respectively. The average weight of the flesh before cooking was 2.97±0.44 g or about 30-40% of the total body weight. The average weight of the flesh after cooking was 2.75±0.16 g. There was no significant loss in weight (2-4%) upon cooking based on the t test carried out ($p = 0.133$ $t = 1.7$ and $df = 8$).

Biochemical composition

Table 1 shows the proximate composition of the edible parts of hatchery reared *B. areolata* and feed used in the study. The protein, carbohydrate and fat contents in the feed used were 20.65, 1.06 and 1.74 $g \cdot 100g^{-1}$ respectively. Moisture was a major component in the raw *B. areolata* flesh (average 67.1%). Protein content (22.4% of wet weight, 68.1% of dry weight) is the second highest component in hatchery reared *B. areolata*. Carbohydrate (2.40%), ash (5.4%) and fat (2.70%) constitute a minor percentage of total proximate composition.

The mean value of fatty acid in percentage for hatchery reared *B. areolata* is presented in Table 2. The saturated fatty acids (SFA) were the most important groups of fatty acids (about 31%) detected in hatchery reared *B. areolata* in the present study compared to monounsaturated fatty acids (MUFA) (23%) and polyunsaturated fatty acids (PUFA) (23%). Palmitic acid (C16:0) (15.85%) was found to be the highest level among the SFA followed by stearic acid (C18:0) (5.99%).The contents of monounsaturated fatty acids (MUFA) of *B. areolata* were around 23% with oleic acid C18:1*cis*9 (9.85%) as the major MUFA found in *B. areolata*. The main n-3 PUFA in cultured *B. areolata* in the present study were ALA (α-linolenic acid), C18:3n3 (6.71%) and EPA 20:5n-3 (2.56%). DHA was not detected in *B. areolata* in the present study. On the other hand, the levels of n-6 PUFA were about 9.0% with arachidonic acid C20:4n6 (3.74%) representing the main fatty acid of this group. The ratio of n-3: n-6 of *B. areolata* obtained in this study was 1.17:1 while the ratio of saturated: unsaturated fat was 0.66:1.

Table 3 indicates the amino acid composition of the edible portion of *B. areolata*. In general, *B. areolata* comprise almost all essential amino acids (EAA). The highest contents of EAA areleucine (1.53%) and lysine (1.32%). The lowest contents among the essential amino acids were methionine (0.56 ± 0.05%) and histidine (0.61 ± 0.20%).

The results of mineral analysis both macro (calcium, potassium, sodium, magnesium and phosphorous) and micro (copper, iron and zinc, manganese and selenium) are presented in Table 4. The most abundant macro minerals in *B. areolata* are potassium (225.5 $mg \cdot 100g^{-1}$), phosphorous (132.9 $mg \cdot 100g^{-1}$) and sodium (107.5 $mg \cdot 100g^{-1}$). Although not as concentrated as in oysters, zinc is the most plentiful (3.35 $mg \cdot 100g^{-1}$) micro mineral in *B. areolata* followed by iron (2.82 $mg \cdot 100g^{-1}$) and copper (0.95 $mg \cdot 100g^{-1}$). In addition, *B. areolata* also contain trace amounts of selenium (0.78 $mg \cdot 100g^{-1}$) and manganese (0.06 $mg \cdot 100g^{-1}$).

Table 1. Proximate composition (g·100g^{-1} wet weight) of hatchery-reared *B. areolata* from this study as compared to juvenile *B. areolata*, other marine gastropods and commercial shellfish in Malaysia.

Proximate composition	*B. areolata*	Juveniles *B. areolata*[2]	Marine snails [3]	Abalone (mixed species)[3]	Whelk [3]	Mussels[4]	Oyster[3]	*Turbo brunneus*[5]	*Trash fish*
Calories, Kcal·100g^{-1}	94	n.r	90	105	137	86	64	n.r.	n.d
Fat, g·100g^{-1}	2.70	0.12	1.4	0.76	0.40	2.24	2.0	1.28-1.36	1.74
Protein, g·100g^{-1}	22.4	18.11	15	17.10	23.84	11.90	9.0	54.69	20.65
[1]Carbohydrate, g·100g^{-1}	2.4	5.47	2	6.01	7.76	3.69	2.4	7.41-7.61	1.06
Ash, g·100g^{-1}	5.4	2.91	1.30	n.r	n.r.	0.0	1.4	n.r.	3.20
Moisture, g·100g^{-1}	67.1	73.37	79.20	74.56	66.0	80.58	85.2	n.r.	73.35

n.r. – not reported

n.d - not done

[1] % Total carbohydrate = 100-(% ash + % moisture + % protein + % fat)

[2]Chaitanawisuti et al. (2011)

[3] National Nutrient Database for Standard Reference (2012)

[4] Tee et al. (1997)

[5]Ramesh and Ravichandran (2008)

Table 2. Fatty acid contents (expressed as % of total fatty acid) of *B. areolata* edible portion.

Fatty acids[1]	*B. areolata*
Saturated fatty acid (SFA)	
C10:0	0.15±0.05
C11:0	0.24±0.24
C12:0	0.74±0.51
C13:0	0.35±0.18
C14:0	1.73±0.28
C16:0	15.85±1.28
C17:0	1.41±0.82
C18:0	5.99±1.01
C20:0	0.04±0.01
C22:0	0.68±0.58
C24.0	3.38±0.91
∑ SFA	30.56
Monounsaturated fatty acids (MUFA)	
C15:1	1.18±0.35
C16:1	2.15±1.09
C17:1	0.43±0.24
C18:1n9c	9.85±2.06
C18:1n9t	2.01±1.16
C20:1n9	2.13±0.52
C22:1n9	2.03±0.66
C24:1	3.41±1.85
∑ MUFA	23.19
Polyunsaturated fatty acids (PUFA)	
C18:2n6t	1.39±0.09
C18:2n6c	2.13±0.46
C18:3n3	6.71±0.89
C18:3n6	1.67±1.23
C20:2	1.15±0.21
C20:3n3	1.94±0.49
C20:3n6	0.66±0.13
C20:4n6 (Arachidonic acid)	3.74±0.54
C20:5n3 (Eicosapentaenoic acid-EPA)	2.56±1.00
C22:2	1.26±0.73
C22:6n3 (Docosahexaenoic acid-DHA)	Not detected
Total PUFA	23.21
Total unsaturated fatty acid (TUFA)	46.40
∑ n-3	11.21
∑ n-6	9.59
n-6/n-3	0.86
n-3/n-6	1.17
TUFA/SFA	1.52

[1] Values are Mean ± S.D. of triplicate determinations

Table 3. Amino acid composition (% w/w) of *B. areolata* edible portion.

Amino acids	% w/w
Essential amino acids	
Leucine	1.53±0.25
Lysine	1.32±0.30
Valine	0.91±0.16
Threonine	0.85±0.13
Phenylalanine	0.78±0.11
Isoleucine	0.75±0.14
Histidin	0.61±0.21
Methionine	0.56±0.05
Non-essential amino acids	
Glutamic acid	3.01±0.72
Aspartic acid	2.25±0.54
Glycine	2.28±0.61
Arginine	1.96±0.36
Proline	1.19±0.25
Alanine	1.70±0.39
Serine	1.01±0.19
Thyrosine	0.68±0.11
Cysteine	Not determined
Tryptophan	Not determined

Discussion

The wet weight of the meat yield when compared to the that of the total weight of *B. areolata* has important implication for its cultivation. The meat yield of cultured *B. areolata* in this study is about 30-40% of total weight. The weight of the shell made up the bigger percentage (60.48-70.12%) of total body weight. There is a potential for the shell to be exploited for other uses such as jewellery, handbag, craft or source of calcium carbonate. Our observation is in accordance with Gifari (2011) who reported about 31-39% of flesh and 61-67% of shells in related Babylon species (*Babyloni aspirata*) (Linnaeus, 1758).

As indicated in Table 1, generally the proximate composition of *B. areolata* was within the range reported in other marine gastropods. The moisture content in *B. areolata*is comparable to whelk and abalone but lower compared to other marine bivalves such as oysters and mussels (National Nutrient Database for Standard Reference 2012; Tee et al 1997). This is anticipated as *B. areolata* is a gastropod and they do not have valves trap fluid as in the case of bivalves such as mussels and oysters thus making their flesh drier.

Protein content (22.4% of weight wet, 68.1% of dry weight) is the second highest component in *B. areolata.* As we are unable to obtain wild *B. areolata*, comparison is made with wild species of Babylonia obtained from literature. Periyasamy et al. (2011) reported a lower level of protein content (53.86% of dry weight) in *B. spirata* harvested from the Southeast coast of India while Gifari (2011) reported much higher protein (80.6% of dry weight) content in *B. spirata* harvested from Indonesian waters. The slight variation observed here is expected, as proximate composition of shellfish is known to vary with many intrinsic (genetic, food intakes, age, metabolism rate, reproductive cycles) and extrinsic (water temperature, nutrient availability, habitat, seasons) factors. It is noted that the fat content in *B. areolata* meat was higher than the fat content of the trash fish given. This probably suggests that the *B. areolata* samples taken at that time were not at spawning stage. Protein content recorded in *B. areolata* in the present study is within the range reported for *B. areolata* juveniles (18.11%) and the marine gastropod, whelk (23.84%) but slightly higher than marine snails (15.0%) and abalone (17.1%). Protein content in *B. areolata* observed in this study is also much higher than bivalve species, green mussels, *Pernaviridis* (Linnaeus 1758) (11.90%) and oysters (*Ostrea* spp.) (9.0%) commercially available in Malaysia. Carbohydrates (2.40%) and fat (2.70%) constitute a minor percentage of total proximate composition.

Many studies have similarly indicated that protein is the most prominent component of marine foods (Ackman and Eaton 1966) and most types of marine organisms are characterised by fat levels lower than 3% (Martino and Maria da Cruz 2004). The low fat content is a good attribute because it qualifies *B. areolata* to be a low-fat food and preventing them from easily becoming rancid during storage. Based on FDA guidelines on food labelling (21 CFR 101.62(b)) (FDA, 1997), hatchery reared *B. areolata* could be considered as low-fat (less than $3g \cdot 100g^{-1}$) food and may be included in a low-fat diet as recommended by the FDA in addition to being a good source of protein.

SFA were the most important groups of fatty acids (about 31%) identified in hatchery reared *B. areolata* in the present study compared to MUFA (23%) and PUFA (23%). This could be due to the warm temperatures throughout the cultivation period. According to previous report, saturation of fatty acids in marine organisms increases with high temperatures. Our finding is in accordance with Phleger and Nelson (2001) who claimed that fatty acids profiles of mollusc usually contain about 30-40% of saturated fatty acid. On the other hand, PUFA is the major fatty acids detected in other gastropods such as Australian farmed abalone, *Haliotis laevigata* (Donovan 1808) and *Haliotis rubra* Leach, 1814 (Su et al. 2006); marine snails (*Hexaplex trunculus*) (Linnaeus 1758) from Tunisian Mediterranean coasts (Zarai et al. 2011), wild sea snail *Tonna dolium* (Linnaeus 1758) from southeast coast of India (Babu et al. 2011) and *Turbo coronatus* (Gmelin 1791) from Iran (Nooshin and Peyman 2011).

Table 4. Mineral contents of *B. areolata* edible portion from this study as compared to other commercial shellfish in Malaysia and marine gastropods.

Minerals (mg·100g^{-1})	*B. areolata*	Oysters[1]	Marine snails[1]	Mussels[1]	Oysters[2]	Mussels[2]	Abalone (mixed species) [1]	Whelk [1]
Calcium	26.70	59	10	26	140	64	31	57
Potassium	225.5	156	382	320	15	126	250	347
Magnesium	27.50	18	250	34	n.r.	n.r	48	86
Sodium	107.5	85	70	286	19	479	301	206
Phosphorus	132.9	97	272	197	111	254	190	141
Iron	2.82	4.61	3.50	3.95	6.1	3.8	3.19	5.03
Copper	0.95	1.58	0.4	0.09	n.r.	n.r.	n.r.	n.r.
Zinc	3.35	39.30	1.00	1.60	n.r.	n.r.	0.82	1.63
Selenium	0.78	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Manganese	0.06	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.

n.r. – not reported

[1] National Nutrient Database for Standard Reference (2012)

[2] Tee et al. (1997)

Palmitic acid (C16:0) was found to be the highest level among the SFA in *B. areolata* as is commonly found in other marine species (Ackman and Eaton 1966; Martino and Maria da Cruz 2004). Palmitic acid (C16:0) was also the prominent saturated fatty acid found in farmed abalone (Su et al. 2006), *H. trunculus* (Zarai et al. 2011), *T. dolium* (Babu et al 2011) and *T. coronatus* (Nooshin and Peyman 2011). This fatty acid is considered as the key for many metabolic processes in fish and in many other aquatic animals and the level is not influenced by the diet (Ackman and Eaton 1966). Oleic acid C18:1 *cis* 9 (9.85%) was the main MUFA detected in *B. areolata.* Generally the double bonds in unsaturated fatty acid are usually of the *cis* type i.e the hydrogen atoms attached to the carbon atoms in the fatty acid chain point in the same direction compared to the trans type where carbon atoms in the fatty acid chain point in different direction. Oleic acid was also one of the dominant MUFA found in other marine gastropods (Su et al. 2006; Zarai et al. 2011; Babu et al. 2011; Nooshin and Peyman 2011).

The valuable fatty acids in marine organisms are PUFA, especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) which belong to the n-3 series or omega-3 oils (Chen et al. 1995).The main n-3 PUFA in cultured *B. areolata* in the present study were ALA (α-linolenic acid), C18:3n3 (6.71%) and EPA 20:5n-3 (2.56%) while DHA was not detected.

On the other hand, Gifari (2011) reported slightly lower EPA (0.65%) and DHA of 2.91% in related species, *B. spirata*. Likewise, Nooshin and Peyman (2011) found only 20:5n-3 (EPA) of n-3PUFA in in *T. coronatus* ranging from 0.48-6.12%. Su et al. (2006) also noted abundance of EPA and lower DHA in farmed abalone at all seasons.

The PUFA/SFA value of *B. areolata* in the present study was 0.76. The level is above the value for PUFA supplement of 0.58 as recommended by the Food and Drug Association (FDA) (FDA 1997). It also exceeds the minimum level of PUFA/SFA value of 0.45 as recommended by Her Majesty Stationary's Office, UK (HMSO 1994). In addition, value of more than 0.50 has also been shown to lower blood cholesterol level (Gurr 1984). Meanwhile, the n-3: n-6 ratio has been proposed as a useful indicator for comparing relative nutritional values of food. It has been suggested that n-3: n-6 of 1:1 or 1: 5 would constitute a healthy human diet (FDA 1997). Based on the FDA recommendation, hatchery reared *B. areolata* could be included in a healthy diet intake as it contains a balanced lipid composition.

Leucine and lysine were the major amino acids detected in juveniles of *B. areolata* (Chaitanawisuti et al. 2011) and one of the top three amino acids detected in wild *B. spirata* (Periyasamy et al. 2011). Lysine and leucine also constitute the highest EAA concentration in marine snail *Helix trunculus* (Linnaeus 1758) (Zarai et al. 2011) and land snail, *Helix aspersa* Muller 1774 (Çağiltay et al. 2011). Meanwhile, glutamic acid, aspartic acid and glycine are the major non-essential amino acids (NEAA) in *B. areolata* as in marine snail *(H. trunculus)* (Zarai et al. 2011). This could probably explain the unique sweetness of *B. areolata* flesh.

Glycine and alanine are commonly known to give sweet taste (Sikorski et al. 1990) while arginine, though a bitter amino acid, brings out a seafood-like flavour (Sarower et al. 2012). In addition, glutamic acid and aspartic acid induce umami like taste that is peculiar to seafood (Sarower et al. 2012). Umami is a term referred to the taste of amino acids (glutamates and nucleotides) which is generally described as pleasant, "brothy" or "meaty taste". The amino acids profiling results suggest that glutamic acid, aspartic acid and glycine could be responsible for the taste of *B. areolata* as suggested by Ozden (2005) who claimed that glutamic acid, aspartame and glycine were the amino acids responsible for the product specific taste. The ratios of EAA to NEAA of *B. areolata* in this study was 0.75 which is in agreement with findings of Iwasaki and Harada (1985) in other marine species.

Minerals are necessary for a healthy diet as they play important roles in biological systems. The data is expressed as $mg \cdot 100g^{-1}$ wet samples, to be consistent with consumer needs which may assist them to estimate their mineral intake from common serving size of shellfish. The most abundant macro minerals in *B. areolata* are potassium (225.5 $mg \cdot 100g^{-1}$), phosphorous (132.9 $mg \cdot 100g^{-1}$) and sodium (107.5 $mg \cdot 100g^{-1}$). These minerals have also been reported in other gastropods and marine food. Phosphorous, potassium and sodium as among the most predominant minerals in marine snails, abalone and whelk (National Nutrient Database for Standard Reference 2012), land snails, *Helix pomatia* Linnaeus 1758 (Ozogul et al. 2005) and *H. aspersa* (Çağiltay et al. 2011).

Potassium, phosphorous and sodium are also the key minerals in Malaysian mussels and oysters (Tee et al. 1997). Micro minerals which are considered as essential minerals are also available in *B. areolata*. Among others, zinc is known to control levels of progesterone, which has a positive effect on the libido (Prasad et al. 1996). Iron which is required in the red blood cell formation is the second most concentrated (2.82±0.30 $mg \cdot 100g^{-1}$) micro minerals in *B. areolata*.

Zinc and iron were also two main micro minerals reported in Malaysian bivalve molluscs (Tee et al. 1997) and marine gastropods (National Nutrient Database for Standard Reference 2012). Copper is essential in a diet because it helps to form haemoglobin and collagen and also helps to regulate neurotransmitters and part of several enzyme systems (Bryd-Bredbenner et al. 2009). A 100g serving of *B. areolata* has enough copper in it to meet the Dietary Reference Intake (0.9 $mg \cdot day^{-1}$) for males and females aged 19 to >70 years (Food and Nutrition Board, 2004). In addition, *B. areolata* also contain trace amounts of selenium (0.78 $mg \cdot 100g^{-1}$) and manganese (0.06 $mg \cdot 100g^{-1}$). Similar to biochemical composition, mineral composition of marine foods could also vary with seasonal and biological differences (species, size, age, sex and sexual maturity), area of catch, food source and environmental conditions (water chemistry, salinity, temperature and contaminant) (Rodrigo et al. 1998).

Conclusion

The results from this study suggest that hatchery reared *B. areolata* are good sources of protein, amino acids, and minerals and are low in fat. Future work should be carried out at different season and maturation cycles to investigate the variability of biochemical content so as to optimise nutritional properties at harvest time.

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Received: 23/12/2013; Accepted: 19/03/2014 (MS13-98)