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SHORT REPORTS

# Proximate composition and nutritional evaluation of the adductor muscle of pen shell

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**Abstract** The proximate composition of pen shell adductor muscle (PSAM) was determined, and its nutrition value was evaluated. Proximate composition analysis indicated that PSAM contained 91.07% (w/w) protein, 5.77% (w/w) ash, and 2.46% (w/w) fat. Calcium was the predominant mineral followed by zinc and then iron. The amino acid profile was in accordance with the recommended pattern of FAO/WHO except for histidine. At the same time, the first limiting amino acid was histidine. Fatty acid composition showed that docosahexaenoic acid was the major fatty acid, followed by palmitic, stearic, and arachidonic acids. Results indicated that PSAM was rich in nutrition and may be developed as a functional food.

**Keywords** PSAM · Protein · Fat · Essential amino acid · Essential fatty acid

## Introduction

Food demand increases worldwide as a result of world population growth, and especially in developing countries, large groups of the population suffer from malnutrition, hunger, and famine (Embaby and Rayan 2016; Falade et al. 2005). Thus, new food resources must be investigated and developed to meet these nutritional demands and population increase.

Marine products are one of the most important food resources for human, (Anon. 1998; Kadam and Prabhasankar 2010; Nurdiani et al. 2015), and therefore new marine food resources must be investigated and developed. Pen shell *Atrina pectinata*, a well-known bivalve, is harvested in the Yellow Sea. The marketable parts are the edible adductor muscle (Tabata et al. 2013). However, to date, the chemical composition of pen shell has not been determined and its nutrition value has not been evaluated.

Therefore, this study investigated the proximate composition and nutritional value of pen shell adductor muscle (PSAM). The results will provide information on the advisability of this shellfish to be incorporated into human diets.

## Methods and materials

### Materials

Live pen shells with similar properties were purchased from a local farmer's market in Xinpu, China. All chemicals were of reagent grade.

### Moisture, protein, fat, and ash

The pen shells were opened using a sharp stainless steel knife. The PSAM was stripped from the shells. Moisture, protein, fat, and ash contents in PSAM were determined in accordance with the standard methods of the Association of Official Analytical Chemists (AOAC) procedures (2005).

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Moisture content was determined gravimetrically by drying the samples in an oven at 100 °C to a constant weight. The dried PSAM was subjected to other chemical analyses. Crude protein content ($N \times 6.25$) was determined in accordance with the Kjeldahl method (Method No. 978.04) (AOAC 2005). Crude fat was determined in accordance with the Soxhlet extract method using petroleum ether as the extract agent (60–80 °C) (Method No. 930.09) (AOAC 2005). Ash content was assayed by incinerating the samples in a muffle furnace at 550 °C (Method No. 930.05) (AOAC 2005).

### Minerals

The PSAM samples were digested by concentrated nitric acid and perchloric acid (4:1, v/v) at 70–90 °C for 10 min and then cooled for injection. Ferrum (Fe) and zinc (Zn) were determined by using an atomic absorption spectrophotometer (Thermo Electron Corp., S series, AA spectrometer, Type S4 AA system, China). Calcium (Ca) was assayed in accordance with the titration method using a 0.02 M EDTA solution (Chapman and Pratt 1961).

### Amino acid

The composition of amino acids in PSAM samples was determined by a high-performance amino acid analyser (Biochrom 20, Auto sampler version, Amersham Pharmacia Biotech., Sweden). The protein in the samples (100 mg each) was hydrolysed with 5 mL of 6 M hydrochloric acid in a sealed tube in an oven at 110 °C for 24 h and then cooled. The hydrolysed samples were dissolved in Na citrate buffer (pH 2.2), filtered with a 0.2 µm membrane filter, and then injected into the amino acid analyser (Baxter 1996).

### Fatty acid

Fatty acid methyl ester was prepared by the method described by Syad et al. (2013). The column used was HP-5 capillary column, which was equipped with an electron impact ionizer. The initial temperature of the column was maintained at 70 °C, elevated to 250 °C (10 °C/min) and the injection temperature employed was 220 °C. Helium was used as carrier gas at a flow rate of 1 µL/min.

**Table 1** Amino acid composition and essential amino acid score of pen shell compared to the essential amino acid pattern suggested by FAO/WHO (g/100 g protein)

| Amino acid | Value | FAO/WHO reference | EEA score |
|---|---|---|---|
| Essential | | | |
| Cystine + methionine | 2.99 ± 0.31 | 2.5 | 120 |
| Valine | 4.52 ± 0.27 | 3.5 | 129 |
| Isoleucine | 4.07 ± 0.23 | 2.8 | 145 |
| Leucine | 8.15 ± 0.34 | 6.6 | 123 |
| Tyrosine + phenylalanine | 8.85 ± 0.39 | 6.3 | 140 |
| Histidine | 1.59 ± 0.07 | 1.9 | 84 |
| Lysine | 8.02 ± 0.36 | 5.8 | 138 |
| Threonine | 3.76 ± 0.14 | 3.4 | 111 |
| Nonessential | | | |
| Aspartic acid | 10.12 ± 0.43 | | |
| Proline | 2.80 ± 0.14 | | |
| Serine | 3.37 ± 0.15 | | |
| Glutamic acid | 16.44 ± 0.73 | | |
| Glycine | 6.37 ± 0.29 | | |
| Alanine | 6.94 ± 0.31 | | |
| Arginine | 8.72 ± 0.42 | | |

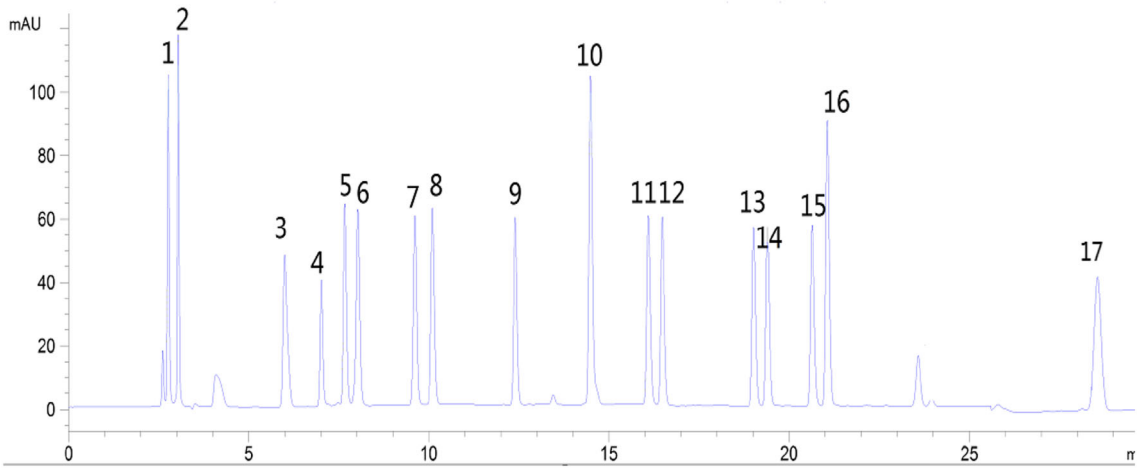


**Fig. 1** High-performance liquid chromatography spectrum of amino acids of pen shell

**Table 2** Fatty acid composition of pen shell fat

| Number | Fatty acids | Ratio (%, w/w) |
|---|---|---|
| 1 | C14: 0 | 1.00 |
| 2 | C15: 0 | 0.79 |
| 3 | C16: 0 | 18.76 |
| 4 | C16: 1 | 1.02 |
| 5 | C17: 0 | 1.54 |
| 6 | C18: 0 | 11.80 |
| 7 | C18: 1 | 1.21 |
| 8 | C18: 1 | 3.17 |
| 9 | C18: 2 | 0.67 |
| 10 | C18: 3 | 1.02 |
| 11 | C20: 1 | 11.42 |
| 12 | C20: 4 | 3.77 |
| 13 | C20: 5 (EPA) | 9.23 |
| 14 | C22: 1 | 9.65 |
| 15 | C22: 3 | 0.70 |
| 16 | C22: 4 | 1.12 |
| 17 | C22: 5 (DPA) | 1.50 |
| 18 | C22: 6 (DHA) | 21.65 |
| SFA | | 33.90 |
| MUFA | | 26.46 |
| PUFA | | 39.65 |
| EPA + DHA | | 30.87 |

### Statistical analysis

All data are presented as mean ± SD. Statistical significance at the 95% probability levels was set at $p < 0.05$. Microsoft Excel (Microsoft Corporation, USA) was used for statistical analysis.

## Results and discussion

### Proximate composition

The analysis results show that PSAM possessed very high protein content (91.07%, w/w), which was higher than that (75.66%, w/w) of rock scallop *Crassadoma gigantean* (Cao et al. 2016). This result further indicated that PSAM can be developed as source of food protein. At the same time, the fat content in PSAM was relatively low (2.46%, w/w), which was lower than that (4.32%, w/w) of rock scallop *C. gigantean* (Cao et al. 2016).Therefore, PSAM can be included in food formulations as food with "high protein, low fat". The ash content of PSAM was 5.77% (w/w), which was also lower than that (8.30%, w/w) of rock scallop *C. gigantean* (Cao et al. 2016).

### Mineral composition

Ca was the predominant element followed by Zn and Fe, and its content in PSAM was 200 mg/kg. This condition indicated that PSAM can be included in food formulations as Ca resource. Zn content in PSAM was also high (29 mg/kg); Zn is closely related to human reproduction (Uriu-Adams and Keen 2010).

### Amino acid composition

The amino acid profile showed that PSAM contains all the essential amino acids except for tryptophan, which was destroyed during hydrolysis with hydrochloric acid (Fig. 1; Table 1). The essential amino acid scores (EEA) of

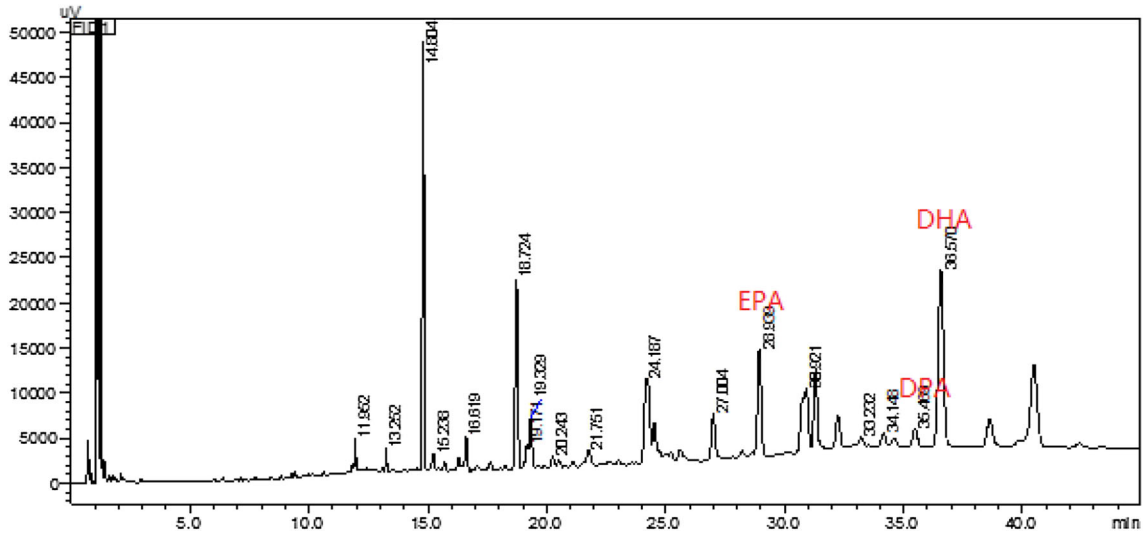


**Fig. 2** Gas chromatogram spectrum of fatty acids of pen shell

cystine + methionine, valine, isoleucine, leucine, tyrosine + phenylalanine, lysine, and threonine were 100–140, and were in accordance with the recommended pattern of FAO/WHO. However, the EEA of histidine was 84, and should be supplemented.

### Fatty acid composition

Fatty acids are one of the human major nutrients. The fatty acid composition of PSAM is shown in Table 2 and Fig. 2. Unsaturated fatty acids accounted for 66.11% (w/w) of the total fatty acids. Among the unsaturated fatty acids, docosahexaenoic acid (DHA) was the predominant unsaturated fatty acid followed by eicosaenoic, and eicosapentaenoic acids (EPA). EPA and DHA show favorable effects on platelet, endothelial, and vascular function (Cottin et al. 2016). The ratio of EPA + DHA to total fatty acids reached 30.87% (w/w), indicating that the fat of PSAM can be considered as healthy oil. These reports indicate that PSAM could be a source of unsaturated fatty acids.

## Conclusions

The PSAM examined in this study possessed a good amount of proteins, fats, and minerals. The amino acid profile was in accordance with the recommended pattern by FAO/WHO. The PSAM contained a good amount of EPA, DHA, and Zn. Results indicated that PSAM can be one of the sources of nutrients for humans.

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**Compliance with ethical standards**

**Conflict of interest** The authors have declared that no competing interests exist.

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