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The Chemical Composition of Giant Clam *(Tridacna gigas)* Tissues

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Abstract - Mantle tissue and adductor muscle from 7.5-year old giant clams, *Tridacna gi-gas*, were analyzed for their water, protein, fat, fiber, cholesterol and ash contents and their amino acid and fatty acid compositions. Water made up 95.2% and 74.4% of the fresh wet weight of mantle tissue and adductor muscle, respectively. The chemical composition of *T. gigas* tissues is generally similar to that of other bivalves. Both mantle tissue and adductor muscle had high protein contents of 44.5% and 57.0%, respectively. Both tissues had low fat and cholesterol contents of 3.57% and 0.05%, respectively, for mantle tissue and 1.95% and 0.032%, respectively, for adductor muscle. On a wet-tissue basis, the fat and cholesterol contents of *T. gigas* were sig-nificantly lower than reported for whole tissues of other bivalves. Both tissues contained high levels of polyunsaturated fatty acids (PUFA) which made up 45.0% of the total fatty acids in mantle tissue and 45.8% in adductor muscle. As a proportion of the total fatty acids, levels of 20:5n-3 and 22:6n-3, which are considered important in human nutrition, are lower in *T. gigas* tissues than reported for some other bivalves.

Recent years have seen major developments in the culture of giant clams (F. Tridacnidae) throughout the Asia-Pacific region. Reliable culture methods have now been developed, and routine commercial-scale production of giant clams now occurs in Palau (Heslinga et al. 1990), the Solomon Islands (Usher and Munro 1988) and Australia (Braley 1988), with smaller scale production in a number of other countries.

A major aim of this culture effort has been to produce giant clam meat for local consumption, and for export to Southeast Asian markets, where giant clam meat (particularly adductor muscle) commands high prices. Surprisingly, there is little information on the chemical composition of the edible parts of giant clams. Although some compositional data are available for the smaller tridacnid clams, *Tridacna maxima* (Ricard and Salvat 1977) and *T. squamosa* (Baria et al. 1987), these are not major culture species. *T. gigas* is the largest of the giant clams and one of the major culture species. Braley et al. (1992) reported the proximate composition of whole 7-month old *T. gigas* juveniles; however, compositional data for market-sized animals have not previously been reported for this species. The major edible parts of giant clams are mantle tissue and adductor muscle. This study was undertaken to determine the chemical composition of mantle tissue and adductor muscle of *T. gigas*.

Clams used for the analyses were cultured according to methods previously described (Crawford et al. 1986;1988). Chemical analyses were con-

ducted on mantle tissue and adductor muscle (Fig. 1) of 7.5-year old clams (40-45 cm shell length) grown intertidally at Orpheus Island, Queensland, Australia (18°35'S, 146°29'E). To determine tissue water content, mantle tissue and adductor muscle were dissected from butchered clams, weighed, freeze-dried and reweighed. Freshly dissected mantle tissue and adductor muscle contained 95.2% ± 0.24 (mean ± SD, n=5) and 74.4% ± 0.49 (mean ± SD, n=5) water, respectively. Because of the high water content of *T. gigas* tissues and rapid water loss once dissected, chemical analyses were conducted on dried tissue samples. Samples used for chemical analysis were composed of an equal dry weight of tissue from five individuals.

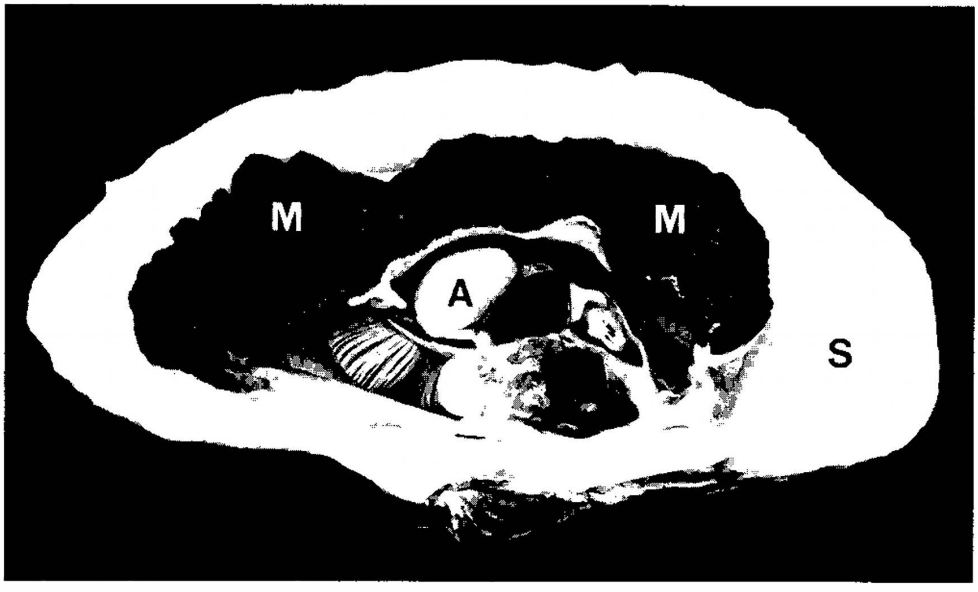

Fig. 1. A mid-longitudinal section through the giant clam, *Tridacna gigas*, showing the position of adductor muscle (A), mantle tissue (M) and shell (S).

Crude protein (N x 6.25) was determined by the Kjeldahl method using a Tecator Kjeltec Auto Protein Analyzer based on AOAC method 988.05 (AOAC 1990). Crude fat (lipid) and crude fiber were determined according to AOAC methods 922.06 and 962.09, respectively (AOAC 1990). For fatty acid determination, extracted lipid was esterified with boron trifluoride reagent and the resulting fatty acid methyl esters were separated by gas liquid chromatography (GLC) based on AOAC methods 969.33 and 963.22 (AOAC 1990); fatty acids were identified by comparison with known standards. Cholesterol was determined by GLC following saponification with ethanolic potassium hydroxide and derivitization to form TMS ether. Protein amino acids were prepared following hydrolysis with 8N hydrochloric acid at 120°C for 16 h. Samples analyzed for cysteine and methionine were first oxidized with performic acid. Amino acids were analyzed using a Dionex D-300 amino acid analyzer. All chemical analyses were conducted by Rhone-Poulenc Animal Nutrition P/L, Brisbane, Australia. Ash content of tissues was determined by heating to a constant weight at 500°C.

The proximate composition (on a dry-weight basis) of adductor muscle and mantle tissue is shown in Table 1. Both mantle and adductor tissues had a high protein content, which made up 44.5% and 57.0% of tissue dry weight, respectively. Adductor muscle contained only 1.9% fat compared to 3.6% in mantle tissue. Both tissues had low cholesterol content with levels of 0.054% and 0.032% for mantle and adductor muscle, respectively. Ash made up 20.7% of the dry weight of mantle tissue and 12.6% of the dry weight of adductor muscle.

These values are similar to those reported for whole meat of *T. maxima* which contained 78% water and, recalculated on a dry weight basis, 61.5% protein, 6.0% fat and 15.7% ash (Ricard and Salvat 1977). Baria et al. (1987) reported water contents of 74.5-78.9% and 82-84.3% for adductor and mantle tissue, respectively, and ash contents of 8.4% and 16.7%, respectively, for *T. squamosa*. When compared to *T. gigas* and *T. maxima*, the fat content of adductor muscle (13.3%) and mantle tissue (15.0%) from *T. squamosa* are considerably higher (Baria et al. 1987). Baria et al. (1987) also reported that the protein content of *T. squamosa* tissues varied according to reproductive state; the protein content of adductor muscle ranged from 56.3 to 73.1% while that of mantle tissue ranged from 38.3 to 56.3%.

Table 1. Proximate composition of *Tridacna gigas* tissues.

	Composition (g kg^{-1} dry weight)	
Component	Mantle	Adductor
Protein	445.0	570.0
Fat	35.7	19.5
Crude fiber	8.2	8.8
Cholesterol	0.54	0.32
Ash	207.0	126.2

Braley et al. (1992) reported that the protein and lipid content of 7-month old *T. gigas* juveniles varied according to growing conditions and ranged from 26.6-34.5% and 5.1-7.3% of tissue dry weight, respectively. These values differ considerably from those reported for adductor muscle and mantle tissue in the present study; however, this may reflect the age difference of the animals used in the two studies and the fact that Braley et al. (1992) analyzed whole individuals.

The proximate compositions of *T. gigas* tissues are similar to those of other marine bivalves, such as oysters and scallops, which typically have a high protein content, and low levels of fat and cholesterol (Sidwell et al. 1974; Pearson 1977; Paul and Southgate 1978). However, when recalculated on a wet-tissue basis, the fat and cholesterol content of *T. gigas* tissues are considerably lower than those reported for whole tissues of other bivalves. Pearson (1977) found that the fat and cholesterol content of a number of fresh bivalves, including oysters, scallops, mussels and cockles, ranged between 1.3-2.3% and 0.33-0.59%, respectively. The equivalent values for *T. gigas* are 0.17% and

0.0026%, respectively, for mantle tissue and 0.49% and 0.008%, respectively, for adductor muscle. However, the lower values obtained for *T. gigas* tissues may reflect the fact that gonad tissue was not included in the analyses. Bivalve gonad tissue is generally rich in lipid; for example, Baria et al. (1987) reported a significantly higher mean lipid content in gonad tissue (26.3%) than in adductor muscle (13.3%) or mantle tissue (15.0%) of *T. squamosa*.

The amino acid compositions of mantle tissue and adductor muscle are shown in Table 2. Glutamic acid, glycine, aspartic acid, arginine and leucine were the most abundant amino acids in mantle tissue, and glutamic acid, aspartic acid, arginine, lysine and leucine were the most abundant amino acids in adductor muscle. The amino acid compositions of *T. gigas* tissues are similar to those reported for other marine bivalves. For example, glutamic acid, aspartic acid, lysine, leucine and arginine are the most abundant amino acids in whole tissues of oysters and mussels (Paul et al. 1980). Baria et al. (1987) reported that glycine, alanine, glutamic acid, aspartic acid and serine were the five most abundant amino acids in protein isolated from the gonad of *T. squamosa*.

Table 2. Amino acid composition of *Tridacna gigas* tissues.

	Composition (g kg^{-1} dry weight)	
Amino acid	Mantle	Adductor
Cystine	3.6	4.4
Taurine	7.3	15.2
Aspartic acid	49.1	62.2
Threonine	18.8	24.2
Serine	20.4	24.7
Glutamic acid	63.4	86.2
Glycine	53.2	28.0
Alanine	21.4	29.5
Valine	17.6	24.2
Methionine	8.5	12.0
Isoleucine	16.0	24.7
Leucine	27.6	41.4
Tyrosine	13.6	19.0
Phenylalanine	14.2	18.3
Histidine	4.4	9.3
Lysine	22.8	42.6
Arginine	33.6	48.0

The fatty acid compositions of mantle tissue and adductor muscle are shown in Table 3. Saturated fatty acids made up 32.6% of the total fatty acids in mantle tissue and 33.7% in adductor muscle. Monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) made up 22.4% and 45.0% of the total fatty acids, respectively, in mantle tissue and 20.5% and 45.8%, respectively, in adductor muscle. The proportion of saturated fatty acids, MUFA and PUFA in *T. gigas* tissues are similar to those reported for other bivalves. For example, Pearson (1977) showed that in whole tissues of oysters, mussels, scallops and cockles, saturated fatty acids composed 37.7-53.9% of the total fatty acids, while MUFA and PUFA made up 17.1-24.7% and 29.0-43.2% of the total, respectively. The high levels of PUFA found in *T. gigas* tissues agree with the findings of similar studies; typically, marine bivalves contain high levels of PUFA (Pearson 1977; Paul et al. 1980).

Of current interest in human nutrition are the n-3 highly unsaturated fatty acids (HUFA), in particular, eicosapentaenoic acid (20:5n-3; EPA) and docosahexaenoic acid (22:6n-3; DHA). n-3 HUFA have been shown to be beneficial in reducing plasma cholesterol and triglyceride levels, and in reducing

the risk of cardiovascular disease (Shrapnel et al. 1992; Tucker 1992). Bivalve tissues generally contain relatively high levels of these HUFA (Pearson 1977; Paul et al. 1980) and both were present in *T. gigas* tissues (Table 3). EPA and DHA made up 2.7% and 8.4%, respectively, of the total fatty acids in mantle tissue, and 2.4% and 7.3%, respectively, in adductor muscle. Pearson (1977) reported that the EPA and DHA content of whole bivalves varied greatly between species; for example, in the four species examined, EPA content ranged from 6.0% of total fatty acids in cockles to 21.8% in mussels. Similarly, DHA contents ranged from 6.9% in mussels to 17.4% in cockles. The levels of EPA and DHA found in *T. gigas* tissues are low by comparison.

Table 3. The major fatty acids of *Tridacna gigas* tissues.

	Composition (% total fatty acids)	
Fatty acid	Mantle	Adductor
14:0	2.3	0.3
16:0	21.1	20.1
16:1(n-7)	5.7	3.0
18:0	5.6	8.9
18:1(n-9)	6.5	11.0
18:2(n-6)	2.0	1.9
18:3(n-3)	0.1	Tr
18:4(n-3)	7.5	2.9
20:0	2.0	1.8
20:1	2.7	3.1
20:4(n-6)	3.9	10.4
20:5(n-3)	2.7	2.4
22:0	0.4	0.2
22:1(n-9)	1.9	1.3
22:5(n-3)	0.4	1.0
22:6(n-3)	8.4	7.3
24:0	0.2	0.2
Total[1] saturated	32.6	33.7
Total[1] monounsaturated	22.4	20.5
Total[1] polyunsaturated	45.0	45.8

[1]Total includes other minor fatty acids not listed. Tr, trace amount.

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