Ghana J. Sci. **31-36** (1991-1996), 37-43

SEASONAL CHANGES IN BIOCHEMICAL COMPOSITION OF THE MANGROVE OYSTER, *CRASSOSTREA TULIPA* (LAMARCK) OCCURRING IN TWO COASTAL WATER BODIES IN GHANA

K. YANKSON, W.A. PLAHAR AND E.A. OBODAI

(K.Y.: Department of Zoology, University of Cape Coast, Ghana; W.A.P.: Food Research Institute, CSIR, Accra, Ghana; E.A.O.: St Augustines College, Cape Coast, Ghana)

Summary

The meat condition and biochemical composition of the mangrove oyster, *Crassostrea tulipa* (Lamarck) were investigated in two water bodies on the coast of Ghana from May 1988 to April 1989. Both the lagoon and estuarine oysters maintained moderate to high condition for at least eight of the 12 months study period, but the lagoon oysters had a higher annual mean condition index. Protein, fat, carbohydrate and ash content of the Ghanaian oyster were comparable with those of other commercial bevalves elsewhere. The results also indicate that the local oyster could serve as a year round rich source of calcium, iron and phosphorus. It is concluded that the nutritional value of the species is high in both populations and that the lagoon could be a favoured site for large-scale cultivation.

Introduction

Wild populations of the mangrove oyster; *Crassostrea tulipa* Lamarck, abound on the coast of West Africa extending from Senegal to Angola (Nicklés, 1950). The species is deemed to have a considerable economic potential, yet its cultivation in the sub-region is still at the experimental level (Afinowi, 1975; Kamara, McNeil & Quaye, 1979; Ajana, 1980; Yankson, 1991). Successful rearing of the species in laboratory cultures has been demonstrated recently (Yankson, 1990; Yankson & Moyse, 1991), but a lot more relevant information is required for its large-scale exploitation.

Ajana (1980) reports briefly on the condition and food value of the species (referred to as *C. gasar)* in Lagos area (Nigeria). However, no records exist on the seasonal variations in the biochemical composition of this oyster. This paper addresses this information gap in an attempt to improve knowledge on the nutritional status of the species. This could facilitate its popularization in the West African sub-region where it is currently known only to small coastal communities as a source of protein. Such a knowledge could also form the basis for a rational harvesting schedule that would ensure optimal utilization of the resource, and also for site selection in any future large-scale controlled production.

Experimental

Samples of oysters were collected monthly from two contrasting water bodies on the coast of Ghana for biochemical analyses between May 1988 and April 1989. The habitats were Benya Lagoon (5^0 05' N, $1^0$20' W) and Pra estuary ($5^0$30' N, 2^0 W). Individual oysters in the size range 40-95 mm shell height were used for the analyses. This is the size range normally harvested for consumption by the locals.

Condition index

The condition indices of 20 oysters from each water body were determined monthly for the equation given by Walne & Mann (1975):

$$\text{Condition index} = \frac{\text{Dry meat weight}}{\text{Inner shell volume}} \times 1000$$

The meat was oven-dried to a constant weight at 100 °C to give the dry weight while the inner shell volume was taken as the numerical difference between the weights of the intact oyster and the two empty valves (Lawrence & Scott, 1982).

Biochemical analyses of the oyster meat

The flesh of 8-10 oysters from each water body was pooled for the monthly analyses. The pooled samples were minced in a Hobart mincer and subsampled for the determination of the proximate composition and mineral content based on AOAC (1970) methods. About 5 g of the minced samples was oven-dried (105 ±1 °C) to a constant weight and the difference between the wet and dry weights gave the moisture content. Protein content was detemined by estimating the total nitrogen using the macro-Kjeldahl method and multiplying the value by 6.25. Fat was extracted by the continuous Soxhlet extraction method while the ash content was determined by igniting 5 g of the dry meat to ash in a muffle furnance at 550 °C. Carbohydrate was obtained by subtraction of the protein, fat and ash values from 100.

The concentration of three major minerals (calcium, iron and phosphorus) in the oyster meat were determined according to the methods outlined by Eyeson & Ankrah (1975) as follows:

Calcium. A sample of ash was dissolved in HCl and the calcium was precipitated as an oxalate which was then dissolved in H_2SO_4. The liberated oxalic acid was titrated against $KMnO_4$ solution to give the calcium content.

Iron. A portion of the ash solution was reduced with ascorbic acid and after the addition of dipyridyl solution the intensity of the colour was measured in a Coleman Model 8 Colorimeter. The iron content was read from a standard curve.

Phosphorus. Molybdate-sulphuric acid was added to the ash and the molybdophosphate was reduced with ascorbic acid. The optical density was measured colorimetrically and the phosphorus content calculated by reference to a standard curve.

Results

Condition index

The monthly mean condition indices of adult oysters from the two habitats are shown in Fig.1. In the

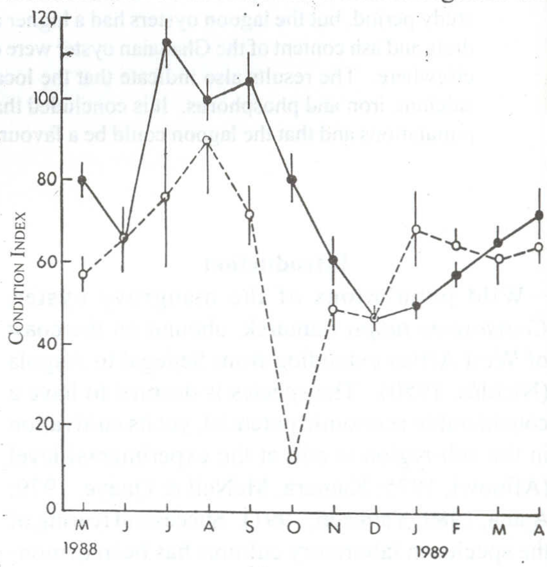

Fig. 1. Monthly changes in condition index of adult oysters from Benya lagoon (solid line) and Pra estuary (broken line). Vertical bars represent standard errors.

Benya lagoon, the index ranged from 47 ± 3 to 114 ± 6 (SE). High values (>80) were recorded from July to October 1988 while low values (<60) were observed between December 1988 and February 1989. In May, June and November 1988, and March and April 1989 the condition of the lagoon oysters was moderate (60-80).

In the Pra estuary, the condition index (CI) of the oysters ranged between 12 ± 1 and 90 ± 13 (SE). The oysters maintained high CI in August 1988 only. In June, July and September 1988 and from January to April 1989, moderate levels were maintained. For the rest of the period, the CI was low. It is apparent from Fig. 1 that the CI was generally higher in the oysters from the Benya lagoon than those from the Pra estuary with the values in the former being statistically higher in six of the eleven sampling months.

Moisture content

The flesh of oysters in both populations maintained high moisture content (>75 per cent) with minimal fluctuations throughout the study period (Fig.2).

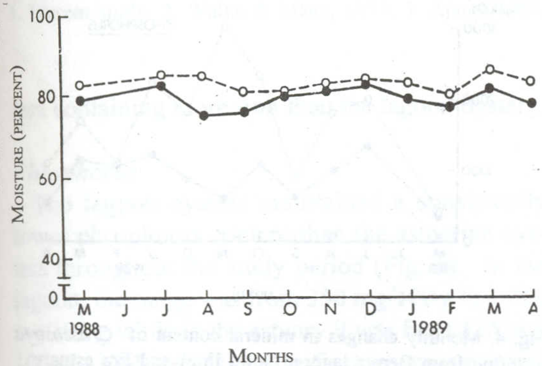

Fig. 2. Monthly changes in moiture content of adult oysters from Benya lagoon (solid line) and Pra estuary (broken line).

The values in the Benya lagoon ranged between 75.5 and 83 per cent while those in the Pra estuary varied from 80 to 85.7 per cent. Comparison of the two populations showed that estuarine oysters had a higher moisture content than those from the lagoon ($t = 2.738$; $P < 0.05$).

Protein

The protein content ranged between 45.28 and 67.88 per cent of the dry flesh in the oysters from the Benya lagoon. With the exception of September 1988, the protein content remained above 50 per cent of the proximate composition of the oysters in this lagoon (Fig. 3). In the Pra estuary samples, the protein content remained above 50 per cent through-

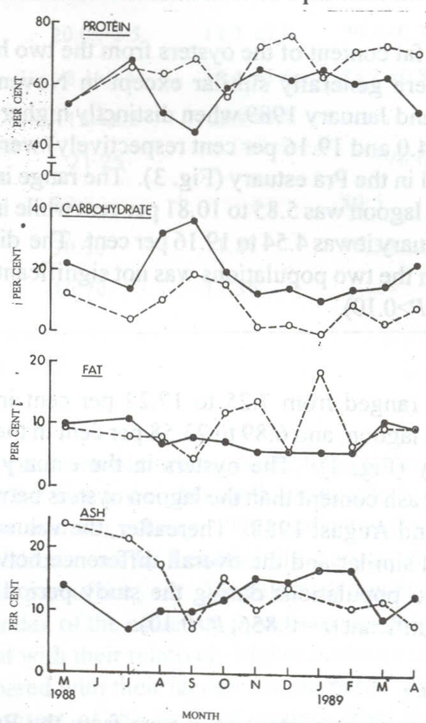

Fig. 3. Monthly changes in the approximate composition of the dry flesh of *Crassostrea tulipa* from the Benya lagoon (solid line) and Pra estuary (broken line).

out the study period, ranging between 54.44 and 77.46 per cent. The difference between the two populations was significant ($t = 3.251$; $P < 0.01$).

Carbohydrate

The two populations showed maximum carbohydrate values in September and minimum values between November and January (Fig. 3). In the Benya lagoon population, the carbohydrate content ranged between 11.32 and 36.65 per cent, while in the Pra estuary, the range was from 0.30 to 19.11 per cent. The difference between the two populations was highly significant ($t = 7.879$; $P<0.001$).

Fat

The fat content of the oysters from the two habitats were generally similar except in November 1988 and January 1989 when distinctly higher values (14.0 and 19.16 per cent respectively) were recorded in the Pra estuary (Fig. 3). The range in the Benya lagoon was 5.85 to 10.81 per cent while in the Pra estuary it was 4.54 to 19.16 per cent. The difference in the two populations was not significant ($t = 1.287$; $P>0.10$).

Ash

Ash ranged from 7.25 to 17.22 per cent in the Benya lagoon, and 6.89 to 23.58 per cent in the Pra estuary (Fig. 3). The oysters in the estuary had higher ash content than the lagoon oysters between May and August 1988. Thereafter, the values appeared similar and the overall difference between the two populations during the study period was not significant ($t = 0.856$; $P>0.10$).

Calcium

The calcium content of oysters from the Benya lagoon attained a peak of 3444 mg/100 g of dry tissue in February 1989 (Fig. 4). For the rest of the period, the values were below 2000 mg/100 g. In the Pra estuary, the calcium content exhibited a more drastic fluctuation with a major peak of 5,864 mg/100 g in July 1988, and two minor peaks of 3050 mg/100 g and 3400 mg/100 g in October and December 1988 respectively. In general, the estuarine oysters contained more calcium than their lagoon counterparts ($t = 2.808$; $P<0.05$).

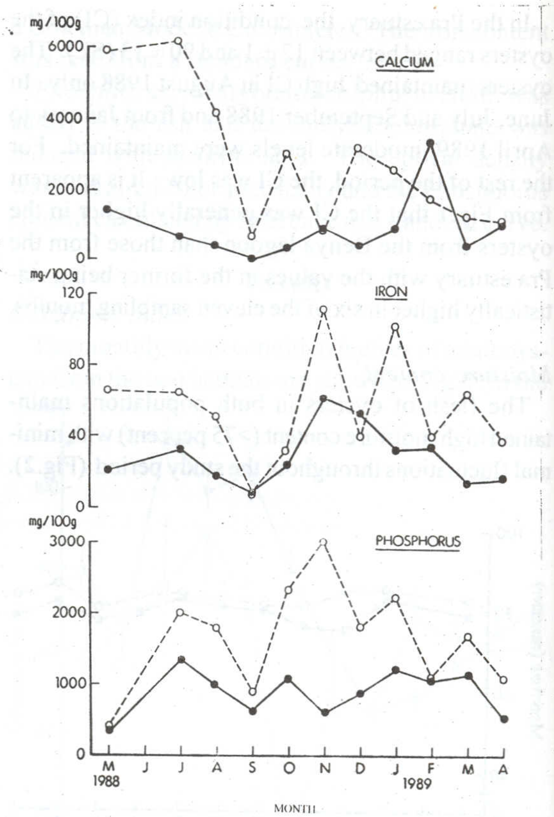

Fig. 4. Monthly changes in mineral content of *Crassostrea tulipa* from Benya lagoon (solid line) and Pra estuary (broken line).

Iron

In the Benya lagoon, iron content of the oysters ranged from 9.81 mg/100g to 62.03 mg/100 g (Fig. 4). With the exception of November and December 1988, the iron content of oysters in the lagoon remained below 40 mg/100 g. In the Pra estuary, the iron content remained above 40 mg/100 g for most of the period except September 1988. The difference between the oysters from the two habitats was signficant ($t = 3.866$; $P<0.01$) with the estuarine oys-

TABLE 1

Major nutritional components (percent of dry tissue) and moisture content (per cent of fresh tissue) of Crassostrea tulipa *compared with other bivalves*

Species	*Protein*	*Fat*	*Carbohydrate*	*Ash*	*Moisture*
C. tulipa[1]					
(Benya Lagoon)	59.3 ±2.2	8.0±0.6	20.0± 2.5	12.7 ±1.0	79.4±0.3
(Pra Estuary)	67.7±2.2	9.8±1.3	8.1±0.4	14.4 ±1.6	83.2 ±0.5
C. gigas[2]	55±3.3	-	11.0±2.2	20.9 ±1.7	-
C. gasar[3]	40.13	9.71	21.25	-	76.0
C. virginica[3]	50.25	10.7	28.7	-	80.5
Anadara granosa[3]	51.89	5.90	30.30	11.81	76.30
Perna picta[4]	64.01	7.93	10.70	17.36	-

1. Present study; 2. Walne & Mann, 1975; 3. Ajana, 1980; 4. Shafee, 1989.

ters containing more iron than the lagoon oysters.

Phosphorus

The lagoon oysters maintained a consistently lower phosphorus content than the estuarine oysters throughout the study period (Fig. 4). In the lagoon, the range was from 350 mg/100 g to 1,350 mg/100 g while in the estuary it was from 426 mg/100 g to 3068 mg/100 g. The fluctuations were more drastic in the estuarine population in which the values were also significantly higher ($t = 4.309$; $P < 0.01$).

Discussion

The condition index of bivalves which is a measure of the plumpness of their meat (Quayle, 1971) is of considerable importance in their fishery (Hancock & Franklin, 1972). The two oyster populations investigated in this study showed a generally similar pattern of relatively high condition index during the rainy season (from May to September) and low indices during the dry season. This pattern was not related to any one of the three main food nutrients. The oysters maintained moderate to high meat condition for nine and eight months respectively, in the lagoon and the estuary. This indicates that both populations can be beneficially harvested for a greater part of the year. The relatively lower condition index of the estuarine oysters seems to be consistent with their relatively higher moisture content compared with their lagoon counterparts. The water content of the flesh of oysters from the two populations were high and fall within the range recorded for other commercial bivalves elsewhere (Table 1).

The protein, fat, carbohydrate and ash levels in the Ghanaian oysters compare favourably with those in other commercial bivalves. With the exception of carbohydrates, all the other nutrients (including the minerals) in the oysters from the estuary were higher than the lagoon oysters. This should, however, be interpreted with caution since the estuarine oysters had a significantly higher moisture content ($P < 0.05$) and the fact that the nutrient contents were computed on dry matter basis. It is possible, therefore, that on 'as - is' basis, a larger number of oysters may be needed from the estuary to supply the same amount of nutrient than from the lagoon. The significantly lower carbohydrate content of the estuarine oysters would seem to suggest a higher metabolic rate in their unstable habitat where the characteristic fluctuating salinities (Barnes, 1974; McLusky, 1981) could pose persistent osmotic problems.

TABLE 2

Some mineral content (mg per 100 g) of the local mangrove oyster (Crassostrea tulipa) *compared with those of some good food sources (values in parenthesis are standard errors)*

Food source	*Calcium (mg/100 g)*	*Iron (mg/100 g)*	*Phosphorus (mg/100 g)*
Dried skim milk[1]	1277	-	-
Black pudding[1]			
(Blood sausage)	-	20.0	-
Calf's brain[1]	-	-	355
Crassostrea tulipa[2]			
Pra estuary	2810 (±583)	58.7 (±8.9)	1693 (±226)
Benya lagoon	964 (±274)	29.7 (±4.9)	923 (±95)

1. Pyke, 1989; 2. Present study.

Calcium, iron and phosphorus are among the major mineral elements which contribute to the proper functioning of the human body and are accordingly considered as important dietary elements (Pyke, 1986). The concentrations of these minerals in the Ghanaian mangrove oyster are compared with those in foods deemed to be good sources in Table 2. It is evident that the annual mean levels of the three minerals in *C. tulipa* were higher than those in the recommended good sources. It is interesting to note that the oysters maintained high mineral levels throughout the year (Fig. 4). This species can, therefore, be regarded as a reliable source of such mineral irrespective of the season. It is also worthy to note that the monthly fluctuations in the mineral content in the estuarine oysters were more drastic compared with the gradual variations in those originating from the lagoon. This could also reflect the relative instability in the estuarine habitat compared with the open lagoon in which conditions could be buffered by the sea.

In view of their high protein and mineral content, and moderate carbohydrate and fat composition, it may be concluded that the local mangrove oyster has a high nutritional status. The comparatively higher meat condition, lower moisture content and less variation in the nutrients of the lagoon oysters seem to indicate that the lagoon could be a favoured site for cultural purposes. However, information on growth, survival and other aspects of productivity are needed to support this assertion.

Acknowledgement

The authors are grateful to the University of Cape Coast and Food Research Institute (CSIR), Accra, Ghana, for supporting this research.

References

AFINOWI, M. A. (1975) The biology of *Anadara senilis and Gryphaea (Crassostrea) gasar* in West African waters. In *FAO/CIFA Symposium on Aquaculture in Africa*. 386-406, Rome: FAO.

AJANA, A. M. (1980) Fishery of the mangrove oyster, *Crassostrea gasar,* Adanson (1757), in the Lagos area, Nigeria. *Aquaculture* **21**, 129-137.

AOAC (1970) *Official Methods of Analysis,* 11th ed. Washington D.C.: Association of Official Analytical Chemists.

BARNES, R. S. K. (1974) *Estuarine Biology*. London: Edward Arnold Ltd.

EYESON, K. K. & ANKRAH, E. K. (1975) *Composition of foods commonly used in Ghana.* Accra, Food Research Institute, Council for Scientific and Industrial Research.

HANCOCK, D. A. & FRANKLIN, A. (1972) Seasonal changes in the condition of the edible cockle *(Cardium edule* L.*). J. appl. Ecol.* **9**, 567-579.

KAMARA, A. B., MCNEIL, K. B. & QUAYLE, D. B. (1979) Tropical mangrove oyster culture: Problems and prospects. In *Advances in Aquaculture. FAO Technical Conference on Aquaculture, Kyoto, Japan* (ed. T. V. R. Pillay and W. A. Dill), pp. 344-348. Rome: FAO.

LAWRENCE, D. R. & SCOTT, G. I. (1982) The determination and use of condition index of oysters. *Estuaries* **5**, 23-27.

MCLUSKY, D. S. (1981) *The Estuarine Ecosystem*. Glasgow and London: Blackie & Son Ltd.

NICKLÈS, M. (1950) Mollusques testaces marins de la côte occidentale d'Afrique. Paris: Manuels Ouest-Africains.

PYE, M. (1986) *Success in Nutrition*. London: John Murray (Publishers) Ltd.

QUAYLE, D. B. (1971) Pacific oyster raft culture in British Columbia. *Bull. Fish. Res. Bd. Can.* **178**, 1-34.

SHAFEE, M. S. (1989) Reproduction of *Perna picta* (Molusca: Bivalvia) from the Atlantic coast of Morocco. *Mar. Ecol. Prog. Ser.* **53**, 235-245.

WALNE, P. R. & MANN, R. (1975) Growth and biochemical composition in *Ostrea edulis* and *Crassostrea gigas.* In *Proceedings of the 9th European Marine Biology Symposium* (ed. H. Barnes). Aberdeen, Arbedeen University Press.

YANKSON, K. (1990) Preliminary studies on the rearing of the West African mangrove oyster, *Crassostrea tulipa*, in the laboratory. *Discovery and Innovation* **2**, 45-51.

YANKSON, K. (1991) Certain aspects of the culture of the local mangrove oyster *(Crassostrea)*. *Ghana Ocean.* **3**, 9-14.

YANKSON, K. & MOYSE, J. (1991) Cryopreservation of the spermatozoa of *Crassostrea tulipa* and three other oysters. *Aquaculture* **97**, 259-267.

Received 19 Apr 94; revised 23 Jan 94.