Geographic and Monthly Variation in Composition of Oysters, *Crassostrea virginica*

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ABSTRACT—Cholesterol and glycogen contents of oysters, Crassostrea virginica, *harvested each month for 1 year during 1975-76 from upper Chesapeake Bay (Md.), Mobile Bay (Ala.), and Barataria Bay (La.), were determined. The values varied from 38 to 218 mg with an average of 109.4 mg for cholesterol and from 467 to 6,797 mg with an average of 2,355 mg for glycogen per 100 g of raw oyster meat on a wet-weight basis. Chesapeake Bay and Mobile Bay oysters were further analyzed for protein, fat, ash, moisture, and amino acid content. The protein varied from 5.8 to 10.4 g; fat, 1.4 to 3.0 g; ash, 0.6 to 2.3 g; and moisture, 77.7 to 87.0 g per 100 g of oyster meats on a wet-weight basis. Amino acid profiles of the protein were quite similar in oysters harvested from both locations. The variation in values reported in the literature for the composition of oysters may be associated with time of year and area from which the oyster was harvested. The variation is also due to the physiological status of the organism, which is somewhat influenced by temperature and salinity of growing waters and available food.*

Introduction

A review of the cholesterol content of raw oyster meats reported by certain investigators revealed little apparent consistency. Cholesterol levels reported in the literature ranged from 37 mg (Thompson, 1964) to 470 mg (Okey, 1945) per 100 g of oyster meat. Okey indicated, however, that some of the total digitonin precipitable steroids contained sterols other than cholesterol. Composition of Foods, Agriculture Handbook No. 8 (Watt and Merrill, 1963), lists oysters as containing less than 200 mg of cholesterol per 100 g. For a low-cholesterol diet, the National Heart and Lung Institute, National Institutes of Health, recommends the consumption of not more than 9 ounces of oyster meats a day. This judgment was made on the assumption that oyster meats do not contain over 40 mg per 100 g, in which case the intake would be about 250 g (Frederickson et al., 1973).

The objectives of this study were: 1) To obtain some understanding of the causes for the variation of the cholesterol values reported in the literature for oysters; 2) to observe possible variations in other components—protein, fat, ash, glycogen, and amino acids; and 3) to note the relationships between the aforementioned components in oysters collected regularly over a period of 1 year (1975-76) from Alabama and Maryland.

Materials and Methods

To compare geographical and monthly differences in the composition of the same species, *Crassostrea virginica,* oysters were harvested at the beginning of each month for 1 year (August 1975 to September 1976) from three areas along the coast of the United States—Chesapeake Bay (Md.), Mobile Bay (Ala.), and Barataria Bay (La.).

Maryland samples were 2-year-old, tray-grown, cultchless oysters propagated in the estuaries of the Chesapeake Bay near Shadyside, Md. As soon as they were delivered to the Southeast Fisheries Center (SEFC) College Park Laboratory at College Park, Md., the oysters were shucked, packed in plastic containers, frozen, and stored at -40°F (-40°C). Samples that were to be analyzed for cholesterol and glycogen were packed in dry ice and shipped by air to Louisiana State University, Baton Rouge, La. Samples to be analyzed for proximate composition and amino acids were homogenized and submitted to the analytical group at the College Park Laboratory.

The Alabama oysters were taken to the SEFC Pascagoula Laboratory at Pascagoula, Miss., shucked, packed, and frozen. They were kept in the freezer at -40°F (-40°C) until a shipment was made to the College Park Laboratory or to the Food Science Department, Louisiana

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State University. The College Park samples were homogenized and prepared for analyses in a manner similar to those from Chesapeake Bay.

The Louisiana oysters were taken by the watermen to processors, where they were shucked, packed in pint jars, and transported in refrigerated trucks to Louisiana State University within 6 hours after harvesting. All oyster samples were held at the University at -25°F (-13°C) for subsequent analyses for cholesterol and glycogen, only.

The cholesterol and glycogen determinations were made according to the method described by Grodner and Lane (In press). The analyses for crude protein and fat were conducted according to the methods described in Horwitz (1970): protein 2.051; ether soluble fat 7.048. Moisture analyses were performed by placing weighed samples in moisture tins and drying them for 16 hours in a forced air oven maintained at 100°C. The ash was determined by placing the weighed samples in a muffle furnace at 550°C for 16 hours. Amino acids were determined with an automatic amino acid analyzer by the method described by Moore et al. (1958).

Results and Discussion

Table 1 lists the amounts of cholesterol determined in the samples of raw oysters harvested each month throughout the year from the three areas. The January and February Maryland samples were lost in transit to Louisiana. Maryland oysters were highest in cholesterol during December 1975 and May 1976 and lowest in July 1976. The average for the nine samples was 92 mg, with a range of 37-124 mg, per 100 g of raw whole oysters. The Alabama oysters contained the most cholesterol during January, March, and April 1976. The February value does not fall in line with the aforementioned months. The apparent anomaly cannot be explained. The lowest cholesterol levels occurred from July through September 1976. For the year, the average was 107 mg with a range of 57-159 mg per 100 g of oyster meat. In general, the Louisiana oysters contained the most cholesterol—125 mg, with a range of 97-218 mg per 100 g for the year. The overall average for the samples analyzed in this study was 109.4 mg, with a range of 37-218 mg per 100 g. Statistically, there is no significant difference among the cholesterol values from the three areas.

A limited number of values have been reported in the literature for the cholesterol content of *C. virginica*. Thompson (1964) reported 58 mg of cholesterol in oysters harvested in November from the upper Chesapeake Bay, as compared to 77 mg per 100 g reported in this study. For the same species harvested in January near Biloxi, Miss., a value of 37 mg was obtained, compared to 157 mg for oysters harvested in nearby Alabama Bay. Although the times of the year that the oysters were harvested were not recorded by Achard et al. (1934), Koga (1970 a, b), Shimma and Taguchi (1964), Kritchevsky and Tepper (1961), and Kritchevsky et al. (1967), the values they reported fall within the limits of the values obtained in this study. The physiological status of animals harvested at different times from the same area clearly can be one of the causes for the variation in cholesterol content. In addition, some of the variation between areas may be associated with salinity and temperature of the water.

Table 2 records the amount of glycogen found in raw oysters from three areas throughout the year. The yearly average was lowest for the Louisiana oysters, 1,326 mg (range 467-2,960 mg); Alabama was second, 2,495 mg (range 603-4,155 mg); and Maryland third, 3,539 mg (1,919-6,920 mg) per 100 g of raw oyster meat. The data from each area are correlated with each other, indicating they form the same shape curve. When the data were fitted to a sine curve to test for annual cyclic trends, they conformed significantly with the peak in the same area of the curve.

The Maryland and Alabama oysters appear to be fattest during March, April, May, and June. This concurs with the results reported by Lee et al. (1960). In the Lee et al. (1960) investigations of gulf oysters, glycogen content was obtained by the difference between the sum of protein, fat, ash, and moisture content and 100 percent.

When the data for the three areas were pooled to determine if a correlation exists between the cholesterol and glycogen content of oysters, it was determined that there was no significant relationship (r=0.15). Therefore, a high cholesterol value does not necessarily imply a large amount of glycogen.

Table 3 shows the average and range of the values for the proximate composition of the same lots of monthly samples from the coastal waters of Alabama and Maryland used in the cholesterol and glycogen determinations. Maryland samples were collected from August 1975 to August 1976; therefore, there are 13 lots in this phase of the study. Alabama samples were collected from September 1975 to September 1976, but there are 12 lots since the July 1976 lot was not analyzed. To facilitate the direct comparison of the oysters from the two areas, the values on both a dry-weight and wet-weight basis are recorded. Also,

Table 1.—Cholesterol values of oysters, *Crassostrea virginica*, harvested monthly for 1 year (1975-76) from three areas.

Month	Year	Mg/100 g of oyster tissue		
		Alabama	Louisiana	Maryland
October	1975	[1]108	[1]103	[1]106
November	1975	109	142	77
December	1975	116	109	124
January	1976	157	129	—[2]
February	1976	76	164	—[2]
March	1976	140	117	105
April	1976	148	107	94
May	1976	124	106	123
June	1976	109	98	91
July	1976	77	218	37
August	1976	57	97	69
September	1976	65	108	—
Average		107	125	92

[1]Average of two determinations
[2]Sample missing

Table 2.—Glycogen values of oysters, *Crassostrea virginica*, harvested monthly for 1 year (1975-76) from three areas.

Month	Year	Mg/100 g of oyster tissue		
		Alabama	Louisiana	Maryland
October	1975	[1]603	[1]876	[1]2,510
November	1975	1,322	467	1,929
December	1975	1,925	1,374	1,919
January	1976	2 211	1,827	—[2]
February	1976	2,117	2,349	—[2]
March	1976	4,069	1,597	3,346
April	1976	4 155	1,333	4,973
May	1976	6,797	2 960	6,920
June	1976	3,731	968	4,098
July	1976	953	836	3,135
August	1976	916	606	3,017
September	1976	1,143	715	—
Average		2,495	1,326	3,539

[1]Average of two determinations
[2]Sample missing

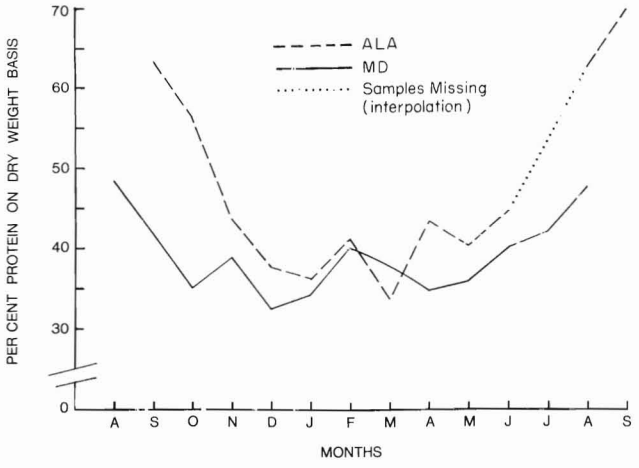

Figure 1.—Comparison of protein content in the monthly samples of freshly harvested oysters from Alabama and Maryland during 1975-76.

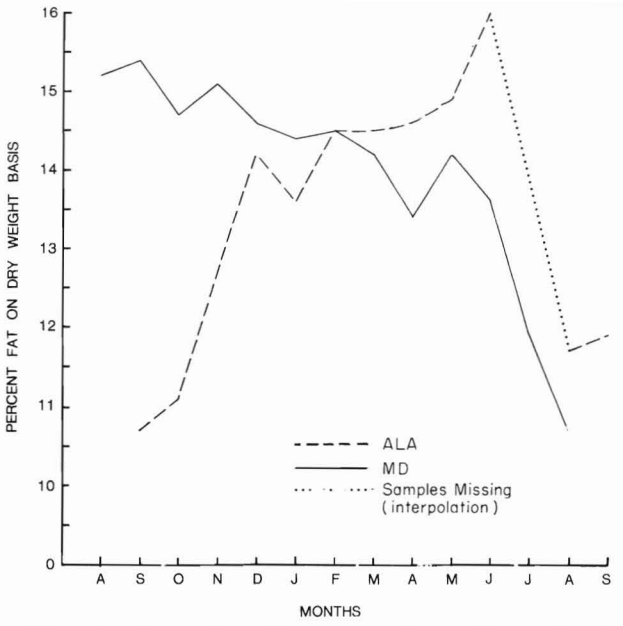

Figure 2.—Comparison of fat content in the monthly samples of freshly harvested oysters from Alabama and Maryland during 1975-76.

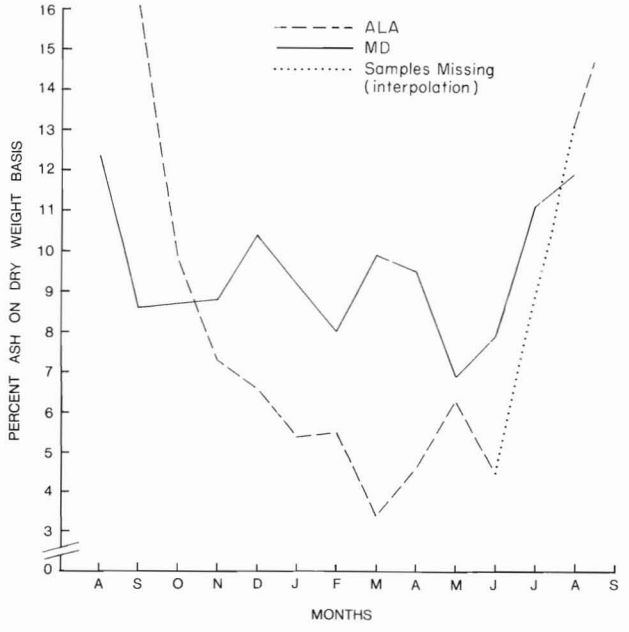

Figure 3.—Comparison of ash content in the monthly samples of freshly harvested oysters from Alabama and Maryland during 1975-76.

the data on dry-weight basis are graphically reported in Figures 1, 2, and 3.

Figure 1 shows the fluctuation in protein content of the oysters harvested monthly over a 1-year period from Alabama and Maryland waters. Between December and April, the protein content of the oysters is low in both harvest areas compared to the other months of the year. The protein ranged from 32.5 to 34.8 g during these months for the Maryland oysters and from 35.6 to 41.1 g for the Alabama oysters per 100 g of dried meat. Protein content was higher during the summer and early fall, before harvest season. Protein content of the Alabama oysters is significantly (p=0.01) higher than that of the Maryland oysters. The sine curves formed by the data from both sites are the same, except the values for Alabama oysters were higher than for Maryland oysters. These curves had a significant fit to sine curves with peaks in August to indicate an annual cycle.

The 11 values for protein reported in the literature for this species ranged from 5.2 to 10.0 g (Sidwell, in press). The range of the protein content in the oysters used in this study was very similar (5.6-10.3 g per 100 g) on a wet-weight basis. Venkataraman and Chari (1951) reported a similar seasonal variation in this species of oysters harvested from Indian waters.

Table 4 presents the amino acid profile of the protein found in oysters. As expected, the profiles for oysters harvested monthly from Alabama and Maryland waters are similar, because the amino acid pattern of the protein is species oriented. In contrast, the amount of protein in the oyster is influenced by

Table 3.—Proximate composition of oysters, *Crassostrea virginica*, harvested monthly for 1 year (1975-76) from two areas.

Area	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Glycogen (%)
Alabama					
Dry weight		[1]47.0	[1]12 9	[1]8.1	[1]14.4
		[2]33.9-70.1	[2]10.8-14.6	[2]3.1-16.2	[2]4.4-30.4
		[3]12	[3]12	[3]12	[3]11
Wet weight	83.4	7 6	2 2	1.3	2.5
	77.7-87 0	6.1-10 4	1.4-3 0	0.6-2 3	0.6-6.8
	12	12	12	12	12
Maryland					
Dry weight		39.2	14 0	9.5	20.0
		32 5-48 4	10 7-15 4	6.9-12.3	10 6-39.2
		13	13	13	9
Wet weight	82.7	6.7	2 4	1 6	3 5
	80.6-85.0	5 8-7.9	1 7-2.9	1.2-2.0	1.9-6.9
	13	13	13	13	9

[1]Average.
[2]Range of values.
[3]Number of values used to calculate the two statistics.

Table 4.—Amino acid profile of the protein in oysters, *Crassostrea virginica*, harvested monthly for 1 year (1975-76) from two areas.

Amino acids	% of total protein					
	Alabama			Maryland		
		[2]6.6			[2]5.6	
Lysine	[1]8 4	11.0	[3]12	[1]7 6	9.6	[3]13
		1 7			2.0	
Histidine	2.1	2.4	12	2.4	3.0	13
		5.4			5.0	
Arginine	6.4	7.1	12	6.3	8.8	13
		8.8			9.0	
Aspartic acid	9.8	11.2	12	10.4	12.2	13
		3.6			3.6	
Threonine	4.1	5.0	12	4.2	4.7	13
		4.2			4 2	
Serine	4.8	5 2	12	4 9	5.6	13
		11.4			11.2	
Glutamic acid	14.0	15.0	12	12.8	14.4	13
		3.8			3 6	
Proline	4 4	5.2	11	4.1	4.6	10
		4.5			4.5	
Glycine	5.1	5.8	12	5 2	5.7	13
		4.9			4.6	
Alanine	5 5	6.0	12	5.1	5.7	13
		3.6			3.7	
Valine	4 6	4.8	12	4.2	4.6	13
		1.6			1.1	
Methionine	2.0	2.4	12	2 0	2.3	8
		3 2			3.4	
Isoleucine	3.7	4.4	12	3.8	4.2	13
		5.6			5.4	
Leucine	6.6	7 4	12	6 3	7 2	13
		2.6			2 4	
Tyrosine	3.3	3 8	12	3.2	3.8	12
		2 5			2 4	
Phenylalanine	3.4	4.0	12	3.4	3 8	13

[1]Average.
[2]Range of values.
[3]Number of analyses.

Table 5.—Fat and ash content on a dry-weight basis in oysters, *Crassostrea virginica*, harvested in 1975-76 from the coastal waters of Alabama and Maryland.

Month	Alabama		Maryland	
	Fat (%)	Ash (%)	Fat (%)	Ash (%)
1975				
September	10.7	16.1	15.4	8.6
October	11.1	9.8	14.7	8.7
November	12.7	7.3	13 1	8 8
December	14.2	6.6	14.6	10.4
1976				
January	13.6	5.4	14 4	9.1
February	14 5	5.5	14 5	8.0
March	14.5	3 4	14.2	9 9
April	14.6	4.6	13.4	9.5
May	14.9	6.3	14.2	6.9
June	16.0	4.5	13.6	7.9
July	—	—	11.9	11.1
August	11.7	13.1	10.7	11.9

external factors, such as the availability of the food from the surrounding environment.

Figure 2 illustrates the monthly variation in the fat content of the Alabama and Maryland oysters. On a dry-weight basis, the fat content of Maryland oysters averaged 14.0 g, with a range of 10.7-15.4 g per 100 g; Alabama oysters averaged 12.9 g, with a range of 10.8-14.6 g per 100 g. The seasonal trend of the fat content in the Alabama oysters was quite clearly defined. It was low in September for both 1975 and 1976, peaking in June with a decline in August. Lee et al. (1960) observed the low point to occur in July for southern oysters collected at various points along the Gulf of Mexico coast. This trend was not noted for the Maryland oysters. Fat content on a dry-weight basis was 15.2 g in August 1975 and 10.7 g in August 1976. There was a steady decline throughout the year in the fat content of Maryland oysters.

There was no significant difference between the data on the fat content of oysters from the two areas. The Alabama data fit significantly to a sine curve with a peak in March, April, and May. This was not so for the Maryland data.

There is no significant correlation (r=0.32) between the fat and cholesterol content in oysters harvested from the Chesapeake and Mobile bays when the data are pooled. Separately, there is a significant correlation between fat and cholesterol content (r=0.80) of the Maryland oysters, but not so of the Alabama oysters (r=0.47).

In this study, no effort was made to study the character of the fat in oyster muscle. Bonnet et al. (1974) reported that 28.1 percent of the fat was saturated; 10.6 percent contained one bond; 61.3 percent contained more than one bond.

Figure 3 shows that the ash content of oysters varies with season. It appears to be high during the late summer and lower in the winter and spring months. Again, this phenomenon is more clearly defined in the Alabama oysters. The ash data for the Alabama oysters significantly fits the sine curve with a peak in September. This is not true for the Maryland data.

Table 5 shows that the ash content appears to be inversely related to the fat content of the oyster muscle. This accumulation of mineral salts (ash) may be a physiological effort by the animal to maintain cellular osmotic pressure. On the other hand, there may be a greater accumulation of sandy materials in the gut during certain times of the year. There is a significant correlation between fat and ash content of Alabama oysters but not Maryland oysters.

Figure 4 shows graphically the relationship between the three components, protein, cholesterol, and glycogen, in the whole Alabama oyster during the various months of the year. There is a tendency for cholesterol and glycogen to be high at about the same time the protein is low. The Maryland oysters (Fig. 5) show a similar trend but it is not as clearly defined as in the Alabama oysters.

The apparent variation in values for the cholesterol and glycogen content of oysters, *C. virginica*, reported in the literature is associated with the time of the year, and possibly with the area from which the oysters are harvested. It is

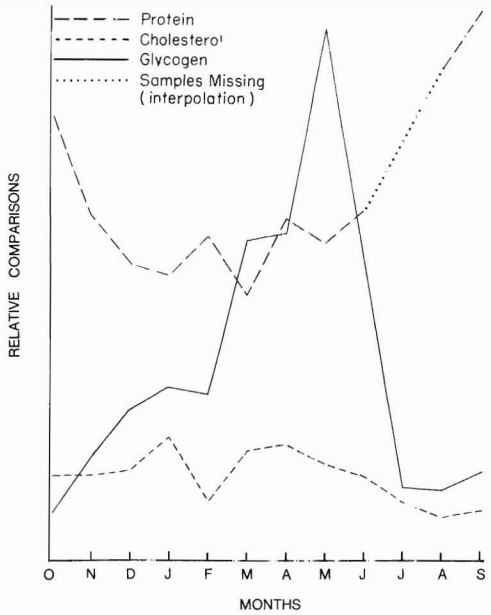

Figure 4.—Comparison of amounts of protein, cholesterol, and glycogen present in the monthly samples of freshly harvested oysters from Alabama during 1975-76.

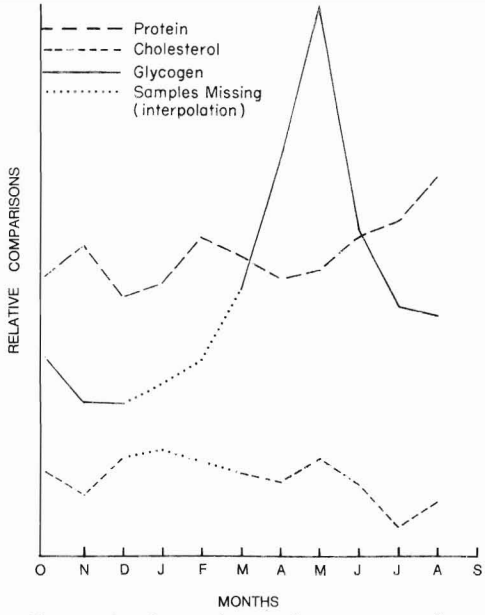

Figure 5.—Comparison of amounts of protein, cholesterol, and glycogen present in the monthly samples of freshly harvested oysters from Maryland during 1975-76.

logical to conclude that variation is due to the physiological status of the organism, which is associated with environmental conditions like temperature and salinity of the water, as well as to the available food. The amount of other food components, e.g., protein, fat, and ash, in the whole oyster is probably influenced by the same factors.

In this study the results were often not statistically significant because of the small sample. To obtain data that will characterize the cyclic nature of the composition of the oyster, it will be necessary to collect data over a period of at least 2 years. Each monthly lot of oysters should be subsampled to obtain some information on the variability within each sample. Also, a description of the physiological status of the animals used in the analysis should be observed to help explain some of the variation.

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