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# PROXIMATE COMPOSITION OF SOUTHERN OYSTERS--FACTORS AFFECTING VARIABILITY

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ABSTRACT

Fifty-one pairs of samples of raw shucked oysters were collected from producing plants in Georgia, South Carolina, and the Gulf Coast States in an extension of an earlier study of the proximate composition of oysters. From each plant, unwashed "shell" oysters and washed plant oysters as packed were obtained to compare the effect on composition of differences in plant practices. The dry solids, fat, and carbohydrate contents of all samples conformed to the usual seasonal pattern of variability. Low values observed in summer and fall months increased to a maximum in the late spring just prior to the long spawning period of the Southern oyster.

The ash and salt content of the "shell-oyster" samples are primarily factors of the salinity of the water in which the oysters are grown. In the test period, salinities were high during the late summer. Soluble chlorides, mostly salt, are lost during shucking and washing of the oysters so that the ash and salt content of plant-washed samples are influenced by the amount of exposure to fresh water.

Protein and fat content on a dry basis are increased in the washed oysters, since these components are less soluble and thus constitute a larger proportion of the solids remaining after the soluble salts are lost.

The data on composition emphasize the benefit that would be derived for both producer and consumer if the seasonal demand for oysters in the fall could be met with oysters harvested and frozen in the spring.

## INTRODUCTION

The investigation of the proximate composition of Southern oysters conducted at the Fishery Technological Laboratory, College Park, Md., of the U. S. Bureau of Commercial Fisheries, was continued for a second year. The conclusions reached after the first year (Lee and Pepper 1956) regarding the pattern and extent of seasonal fluctuation have been generally confirmed, so this work is now complete.

The term "Southern" is used here to distinguish the product of the Gulf of Mexico and of the South Atlantic coastal areas. Louisiana has the largest production of fresh shucked oysters, with lesser quantities from Mississippi, Alabama, Western Florida, South Carolina, and Georgia. Southern oysters, Crassostrea virginica, are of the same species as oysters of Chesapeake and Delaware Bays, but the shucked product is handled differently in the South.

The investigation of the composition of Southern oysters had several objectives: (1) Little published information is available on the composition of oysters from that area. Such information is needed by dietitians, processors, and others. (2) The data on unwashed and plant-washed samples provide a means of comparing the effect on composition of different methods of processing. These data are important with re-

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spect to application of the Food and Drug Administration's Standards of Identity to raw shucked oysters. (3) Data on oysters from a number of different states and growing areas are needed to broaden the applicability of results of studies on freezing and utilization of oysters by research groups in Florida and Louisiana.

## ORIGIN OF SAMPLES

The oyster samples were collected at producing plants: 25 sample pairs were obtained from Louisiana, 9 from Alabama, 7 from Florida, 5 from South Carolina, 3 from Georgia, and 2 from Mississippi. Samples of mixed origin were not taken, so each sample represented oysters grown in the state in which it was collected.

Fig. 1 - Oysters are brought to the shucking house in burlap bags in some Southern oyster plants.

Fig. 2 - Three sizes are being sorted into the "pots" at the right.

Two samples were collected from each operating plant visited. One sample, called the "shell" sample, consisted of unwashed shucked oysters representative of the oyster as harvested. Variability in composition of these samples is influenced by environmental factors of temperature and salinity, sampling time with relation to spawning cycle, and other factors such as degree of parasitic infestation that affect the health or "condition" of the oyster. The composition of the shell sample is also affected by the way the shell oyster is handled between the time of harvest and sampling and by the way the sample is taken.

The second sample, called the plant sample, was a randomly-selected pint can of the regular plant product. Variability in the composition of these samples is affected not only by differences in the "shell" oyster but also by shucking, washing, and draining practices of the particular plant from which the sample is obtained.

## EXPERIMENTAL METHODS AND RESULTS

A total of 51 "shell" and plant samples were obtained during the period from October 1955 to October 1956, inclusive. These were analyzed for moisture, crude protein, crude fat, ash, and total chlorides as sodium chloride. The values reported for carbohydrates have been calculated by difference. Because the maximum observed dry-matter content was $2\frac{1}{2}$ times the minimum value (range 7.3 to 18.4 percent), the data are reported in the tables on a dry basis. This method of reporting facilitates comparisons of the effects of external factors on the composition of the oyster. The data are given in tables 1 and 2.

Table 1 - Composition of Shell and Plant Samples of Oysters According to State Origin

| State | Number of Pairs 1/ | On Moisture-Free Basis | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Moisture | | Protein | | Fat | | Ash | | Salt 2/ | | Carbohydrates | |
| | | Shell | Plant | Shell | Plant | Shell | Plant | Shell | Plant | Shell | Plant | Shell | Plant |
| | | (Percent) | | | | | | | | | | | |
| Louisiana | | | | | | | | | | | | | |
| Mean | 25 | 87.8 | 88.8 | 52.0 | 54.0 | 10.8 | 11.2 | 12.4 | 8.5 | 6.4 | 3.4 | 25.0 | 26.3 |
| Maximum | | 91.4 | 92.7 | 63.3 | 66.2 | 16.7 | 17.6 | 20.6 | 17.1 | 12.6 | 7.2 | 34.8 | 36.3 |
| Minimum | | 81.6 | 82.1 | 44.5 | 43.1 | 6.9 | 6.4 | 5.3 | 4.2 | 1.2 | 0.4 | 8.1 | 15.6 |
| Mississippi | | | | | | | | | | | | | |
| Mean | 2 | 87.5 | 86.8 | 48.7 | 50.7 | 13.0 | 14.1 | 11.8 | 7.7 | 5.6 | 2.2 | 26.5 | 27.5 |
| Maximum | | 92.5 | 89.1 | 58.7 | 60.8 | 18.1 | 19.5 | 17.7 | 11.1 | 10.1 | 3.8 | 37.5 | 35.6 |
| Minimum | | 82.5 | 84.3 | 38.6 | 40.7 | 8.0 | 8.8 | 5.8 | 4.3 | 1.0 | 0.6 | 15.6 | 19.3 |
| Alabama | | | | | | | | | | | | | |
| Mean | 9 | 86.2 | 86.1 | 44.3 | 45.0 | 11.8 | 13.9 | 10.3 | 7.1 | 5.6 | 2.7 | 33.6 | 33.9 |
| Maximum | | 88.5 | 90.0 | 55.5 | 55.9 | 14.0 | 18.7 | 14.1 | 12.1 | 9.9 | 6.2 | 45.8 | 40.3 |
| Minimum | | 84.4 | 82.5 | 35.4 | 39.6 | 7.4 | 9.4 | 5.7 | 3.6 | 1.3 | 0.4 | 21.4 | 23.6 |
| Florida | | | | | | | | | | | | | |
| Mean | 7 | 88.3 | 87.3 | 48.3 | 53.2 | 9.4 | 12.1 | 17.8 | 10.7 | 10.0 | 5.0 | 24.5 | 24.0 |
| Maximum | | 91.1 | 88.7 | 52.6 | 56.8 | 11.2 | 16.5 | 26.7 | 16.9 | 19.8 | 9.9 | 35.7 | 33.1 |
| Minimum | | 86.0 | 85.5 | 45.7 | 48.1 | 6.7 | 8.3 | 8.0 | 5.8 | 2.9 | 2.2 | 18.4 | 19.0 |
| Georgia | | | | | | | | | | | | | |
| Mean | 3 | 90.0 | 85.8 | 43.8 | 50.7 | 10.2 | 9.9 | 24.8 | 13.2 | 19.6 | 6.6 | 21.2 | 26.3 |
| Maximum | | 92.0 | 89.7 | 47.1 | 57.3 | 15.2 | 10.8 | 31.1 | 16.4 | 25.4 | 10.0 | 26.3 | 32.6 |
| Minimum | | 87.4 | 82.2 | 40.6 | 45.4 | 7.5 | 8.8 | 22.7 | 7.3 | 15.6 | 2.7 | 13.9 | 16.9 |
| South Carolina | | | | | | | | | | | | | |
| Mean | 5 | 86.1 | 84.2 | 47.7 | 54.1 | 7.7 | 9.3 | 20.8 | 11.9 | 14.4 | 6.7 | 23.8 | 24.7 |
| Maximum | | 88.8 | 85.8 | 49.8 | 55.9 | 9.1 | 10.2 | 24.6 | 15.3 | 19.8 | 10.0 | 31.0 | 27.1 |
| Minimum | | 83.0 | 83.0 | 45.8 | 52.1 | 5.6 | 8.7 | 17.4 | 8.9 | 10.5 | 4.8 | 19.7 | 22.1 |

1/Each pair of samples consists of unwashed oysters ("shell") and washed oysters as packed (plant).
2/Total chlorides are reported as salt.

PREPARATION OF THE SAMPLE FOR ANALYSIS: The entire contents of the sample can, from 250 to 450 grams of oysters and body fluids, were ground in a laboratory blender. Any large pieces of shell were removed, but careful inspection was not needed, since most of the shell and grit settled out of the ground oysters.

Fig. 3 - Care is used to avoid cutting up the oysters as the muscle is freed from the shell.

MOISTURE: The method of the Association of Official Agricultural Chemists (AOAC) for total solids in raw oysters was used (8th edition, section 18.6) except that a Petri dish was substituted for the metal one. Metal dishes were found hard to clean. Glass dishes gave consistent tare weights.

Comparison of the average values for moisture content in tables 1 and 2 indicates that, in most instances, there is little difference between the values for plant and "shell" samples. The data in table 2 indicate an irregular correlation of moisture content of both plant and "shell" oysters to season of harvesting. Lower moisture values and correspondingly higher solids contents were observed from March through June just prior to the spawning season, this being the period of most rapid growth. The dry solids content declined rapidly to a low point in August and did not show definite recovery until December after cooler waters had stopped oyster spawning and growth was resumed.

Table 2 - Composition of Shell and Plant Samples of Oysters According to Month Samples Were Collected

| Month | | Number of Pairs[1] | Moisture | | On Moisture-Free Basis: Protein | | Fat | | Ash | | Salt[2] | | Carbohydrates | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Shell | Plant | Shell | Plant | Shell | Plant | Shell | Plant | Shell | Plant | Shell | Plant |
| | | | (Percent) | | | | | | | | | | | |
| Oct. 1955 | Mean | 5 | 90.5 | 88.5 | 54.5 | 58.1 | 9.0 | 9.1 | 19.8 | 13.4 | 13.5 | 6.2 | 16.8 | 19.5 |
| | Max. | | 92.5 | 92.7 | 60.2 | 66.2 | 16.7 | 10.3 | 26.7 | 17.1 | 19.8 | 9.9 | 21.3 | 23.9 |
| | Min. | | 88.7 | 83.8 | 48.1 | 51.1 | 5.8 | 8.3 | 14.9 | 8.0 | 8.7 | 3.8 | 8.1 | 15.6 |
| Nov. 1955 | Mean | 5 | 87.9 | 89.5 | 52.5 | 56.5 | 9.0 | 9.2 | 16.6 | 11.9 | 9.4 | 5.8 | 22.0 | 22.3 |
| | Max. | | 89.8 | 92.3 | 58.4 | 60.5 | 11.2 | 11.2 | 24.3 | 16.9 | 14.1 | 9.9 | 29.0 | 24.5 |
| | Min. | | 86.1 | 86.4 | 47.2 | 53.8 | 6.9 | 8.3 | 11.0 | 9.4 | 5.5 | 4.1 | 16.3 | 19.9 |
| Dec. 1955 | Mean | 3 | 86.3 | 86.1 | 50.3 | 55.5 | 7.9 | 9.4 | 16.1 | 10.6 | 10.1 | 5.7 | 25.7 | 24.4 |
| | Max. | | 89.8 | 91.7 | 54.9 | 61.5 | 8.7 | 9.6 | 19.6 | 12.1 | 10.5 | 6.2 | 31.1 | 29.2 |
| | Min. | | 84.4 | 82.5 | 46.1 | 49.2 | 6.9 | 9.2 | 14.1 | 9.7 | 9.8 | 5.2 | 22.4 | 18.9 |
| Jan. 1956 | Mean | 6 | 87.7 | 86.8 | 48.1 | 47.5 | 9.7 | 12.8 | 15.4 | 7.7 | 8.6 | 3.8 | 26.8 | 32.0 |
| | Max. | | 91.3 | 91.5 | 50.4 | 54.8 | 12.7 | 17.9 | 21.3 | 9.2 | 12.6 | 5.5 | 31.8 | 36.9 |
| | Min. | | 83.8 | 83.5 | 41.5 | 39.6 | 7.2 | 9.2 | 8.6 | 5.6 | 4.7 | 1.5 | 20.8 | 27.1 |
| Feb. 1956 | Mean | 7 | 88.1 | 87.1 | 43.1 | 46.5 | 11.7 | 12.9 | 14.0 | 8.3 | 9.4 | 3.3 | 31.2 | 32.3 |
| | Max. | | 92.0 | 89.9 | 46.1 | 52.2 | 16.8 | 18.7 | 22.7 | 16.4 | 17.8 | 7.0 | 35.7 | 35.7 |
| | Min. | | 85.3 | 82.2 | 35.4 | 40.0 | 5.6 | 8.8 | 5.3 | 4.2 | 1.2 | 0.7 | 23.5 | 26.8 |
| Mar. 1956 | Mean | 6 | 84.8 | 85.6 | 44.0 | 46.0 | 13.5 | 15.8 | 8.1 | 6.1 | 2.9 | 1.6 | 34.4 | 32.2 |
| | Max. | | 87.7 | 88.9 | 51.4 | 54.6 | 18.1 | 19.5 | 11.9 | 10.5 | 5.4 | 3.6 | 45.8 | 40.3 |
| | Min. | | 81.6 | 82.1 | 38.6 | 40.7 | 7.4 | 12.4 | 5.7 | 3.6 | 1.0 | 0.4 | 22.7 | 21.6 |
| April 1956 | Mean | 5 | 86.5 | 85.6 | 46.6 | 48.3 | 12.5 | 14.8 | 11.7 | 6.9 | 6.1 | 2.3 | 29.2 | 29.9 |
| | Max. | | 91.1 | 87.9 | 52.6 | 56.8 | 13.3 | 16.5 | 16.4 | 9.1 | 10.5 | 2.8 | 37.3 | 40.0 |
| | Min. | | 82.5 | 83.7 | 42.2 | 39.8 | 10.8 | 13.1 | 6.4 | 4.7 | 1.9 | 1.0 | 20.5 | 22.3 |
| May 1956 | Mean | 2 | 84.9 | 86.5 | 49.6 | 51.2 | 12.1 | 12.3 | 7.9 | 5.8 | 3.9 | 2.0 | 30.5 | 30.7 |
| | Max. | | 86.5 | 89.9 | 52.0 | 52.5 | 13.5 | 13.5 | 8.1 | 5.9 | 3.9 | 2.2 | 34.5 | 30.7 |
| | Min. | | 83.2 | 83.0 | 47.1 | 50.0 | 10.9 | 11.0 | 7.6 | 5.8 | 3.8 | 1.8 | 26.4 | 30.6 |
| June 1956 | Mean | 2 | 83.8 | 86.1 | 47.5 | 50.2 | 10.3 | 12.0 | 11.7 | 6.6 | 6.2 | 3.0 | 30.6 | 31.2 |
| | Max. | | 85.0 | 89.7 | 48.3 | 53.1 | 10.3 | 12.3 | 12.8 | 7.0 | 6.7 | 3.6 | 32.6 | 33.5 |
| | Min. | | 82.7 | 82.5 | 46.6 | 47.3 | 10.2 | 11.7 | 10.6 | 6.2 | 5.6 | 2.4 | 28.6 | 29.0 |
| July 1956 | Mean | 2 | 87.9 | 90.1 | 59.5 | 61.1 | 8.8 | 7.5 | 10.4 | 8.0 | 4.5 | 2.9 | 21.3 | 23.4 |
| | Max. | | 88.6 | 91.5 | 63.3 | 61.8 | 9.8 | 8.6 | 10.9 | 9.3 | 4.8 | 3.6 | 24.5 | 25.1 |
| | Min. | | 87.1 | 88.7 | 55.8 | 60.4 | 7.8 | 6.4 | 9.9 | 6.7 | 4.2 | 2.3 | 18.1 | 21.7 |
| Aug. 1956 | Mean | 2 | 90.0 | 90.4 | 56.6 | 58.7 | 9.9 | 9.5 | 10.4 | 8.7 | 3.1 | 2.7 | 23.1 | 23.1 |
| | Max. | | 90.6 | 91.2 | 57.3 | 59.4 | 10.8 | 10.7 | 11.9 | 9.9 | 5.0 | 4.2 | 26.2 | 23.8 |
| | Min. | | 89.4 | 89.5 | 55.9 | 58.0 | 9.0 | 8.3 | 9.0 | 7.5 | 1.2 | 1.1 | 20.0 | 22.4 |
| Sept. 1956 | Mean | 2 | 88.4 | 88.6 | 53.8 | 58.3 | 9.6 | 8.6 | 14.5 | 9.6 | 10.6 | 5.0 | 22.0 | 23.5 |
| | Max. | | 88.6 | 90.2 | 54.8 | 58.9 | 11.6 | 9.5 | 18.3 | 9.8 | 11.2 | 5.8 | 26.8 | 24.0 |
| | Min. | | 88.2 | 86.9 | 52.8 | 57.8 | 7.6 | 7.7 | 10.8 | 9.4 | 9.9 | 4.3 | 17.3 | 23.0 |
| Oct. 1956 | Mean | 4 | 89.5 | 87.7 | 49.2 | 54.6 | 9.7 | 10.3 | 23.1 | 13.6 | 14.2 | 6.9 | 19.0 | 21.5 |
| | Max. | | 90.7 | 91.9 | 53.0 | 57.3 | 10.8 | 10.9 | 31.1 | 15.9 | 25.4 | 10.0 | 25.7 | 25.9 |
| | Min. | | 88.0 | 84.3 | 45.8 | 52.1 | 7.9 | 10.0 | 17.2 | 8.4 | 1.3 | 0.4 | 13.9 | 16.9 |

1/Each pair of samples consists of unwashed oysters ("shell") and washed oysters as packed (plant).
2/Total chlorides are reported as salt.

CRUDE PROTEIN: Total nitrogen was determined by the Kjeldahl method, mercury being used as the catalyst. The ammonia was collected in 20 milliliters of 4-percent boric acid and was titrated directly with 0.2 normal sulfuric acid.

Shucking and washing the oysters do not significantly affect protein content on a dry basis. Plant samples are higher in protein, but this finding can be accounted for by the fact that as the soluble salts present in the body fluids are lost during shucking and washing, the more insoluble constituents--that is, protein and fat--make up a greater proportion of the remaining solids. The protein content of oysters follows a fairly definite seasonal cycle opposite in phase from the glycogen content cycle; that is, protein content is high during July through September, when glycogen is low, and low in February and March, when glycogen is high. The explanation is that protein constitutes a much larger proportion of the solids remaining after glycogen is used during the spawning cycle.

CRUDE FAT: The method of the AOAC for crude fat in fish and shellfish by acid hydrolysis (8th edition, section 18.12) was used.

"Fat" oysters is a trade expression that refers to the plump, creamy condition associated with the seasonal build-up of glycogen. Oysters are usually classified as a nonfat seafood. Actually, on a dry basis, the solvent-soluble lipids constitute an average of 10.5 percent of "shell" oysters and 11.7 percent of the washed oysters. Some oysters contain 18 to 20 percent fat on a dry basis. Experiments have shown that in frozen storage, oysters develop a rancid flavor instead of the usual sour flavor that develops in spoiled raw iced oysters (Schwartz and Watts 1957; Fieger, Novak, and Bailey 1959). It is interesting to note that the fat content follows the same type of seasonal cycle as do dry solids and glycogen contents; that is, the fat content varies from a high of 13 percent in March and April to a low of 8.8 percent in July. The fluctuations are less extreme--with the fat content remaining fairly constant, between 9 and 10 percent--from August through December.

ASH: Fifteen to 20 grams of ground oysters was weighed into a tared porcelain dish and ashed at 550° C. until white. (Ash occasionally may be pale blue, or may fuse and remain black, but extra heating should be avoided as it may cause loss of chlorides.)

Chlorides and other soluble salts make up most of the ash of unwashed oysters which may amount to 25 percent of the dry weight for oysters grown in waters of high salinity. The ash content of the washed plant samples is decreased to a degree dependent on the amount of washing with fresh water, and approaches a minimum of roughly 4 percent of the dry weight.

TOTAL CHLORIDES: The method of the AOAC for salt (chlorine as sodium chloride, 8th edition, section 18.9) was used.

The soluble salts in oysters are readily removed during the usual washing operations. Thus a comparison of the total chlorides of the washed and unwashed samples gives an indication of the amount of exposure to fresh water to which the oysters were subjected. The salt content of "shell" oysters varies greatly, depending on the salinity of the waters where the oysters grew. Since *Crassostrea virginica* is an estuarine species, salinity of water over oyster beds is largely a matter of rainfall on the river system draining into the growing area and may range from extremes in excess of 40 parts per thousand in almost closed bays in Texas or North Carolina to less than 4 parts per thousand in some growing areas in Louisiana or in the upper Chesapeake Bay during flood periods. In fact, fresh water has frequently caused heavy mortality in some oyster-growing areas. In the accompanying data, the extreme range for the salt content on the dry basis of individual samples of shell oysters was 1.0 to 25.4 percent.

The salt content of the washed oysters (the plant sample) is only secondarily influenced by the original salt content. Even unwashed oysters lose one-half or more of their salt content in body fluids released during the time on the shucking bench. Then, the usually limited exposure to fresh water during the washing operations used in South-

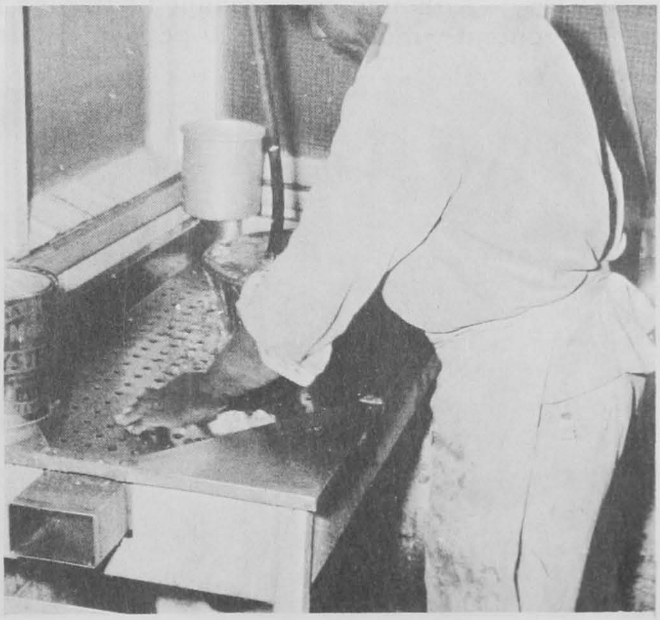

Fig. 4 - In the South, oysters usually receive a brief washing in a pan before packing. Blowers are never used.

ern plants further reduces the salt content of the plant samples, though never to the degree of freshness reached by "blowing" as practiced in the Middle Atlantic States.

In typical estuarine growing areas, seasonal wet and dry spells change water salinities to produce a seasonal pattern of fluctuation in the salt and ash content of the oysters. In the 1955/56 season, as in the preceding year, lack of rainfall during fall and winter months kept oyster salinities high, whereas heavy precipitation during the spring and summer reduced salinities. In September and October 1956, oyster salinities again increased.

CARBOHYDRATES: In these studies glycogen was not determined directly. The difference between 100 and the sum of moisture, protein, fat, and ash has been reported as carbohydrates (by difference). This would include glycogen, its breakdown products, and the accumulative error from the other analyses. Although much less specific, the results obtained by this procedure have shown good correlation to the variation in glycogen that would be expected to result from the spawning and growth patterns of Southern oysters.

The average carbohydrate content of the plant samples is only slightly greater than that of the shell samples. Carbohydrate content evidently does not show the same proportional increase that was observed for the protein and fat content of the plant samples, which resulted from the loss in salt. This observation might indicate that significant amounts of soluble glycogens also are lost in the body fluids. The data for carbohydrates follow the well-known seasonal pattern related to spawning habits. Glycogen is stored during the late fall and early winter and holds over, with little loss, until May or June. Spawning continues during the hot summer period, so there is little recovery of "fatness"--that is, glycogen content--until the cool weather of late fall.

## DISCUSSION

The weighted average of 12.6 percent dry solids content for the plant-washed samples of Southern oysters compares favorably with the solids content of oysters from Chesapeake Bay. Unpublished data from the Food and Drug Administration, the senior author, and recent studies of a government-industry research team are in general agreement in the values found for dry solids content of oysters in Chesapeake Bay. Although some washed samples from Chesapeake Bay have a high dry solids content--more than 14.0 percent--this is exceptional. In the early fall, samples with dry solids ranging from about 12.0 to less than 9.0 percent are observed for both the unwashed and plant-washed oysters.

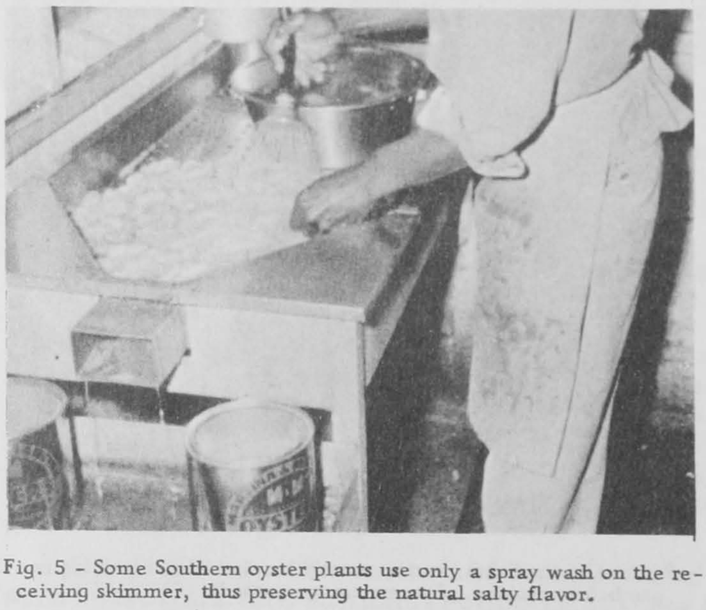

Fig. 5 - Some Southern oyster plants use only a spray wash on the receiving skimmer, thus preserving the natural salty flavor.

The relatively high solids content of Southern oysters is a result of the more limited exposure to fresh water during the washing methods customarily used in the South; that is, spraying the oysters on the delivery skimmer. This treatment is sometimes followed by stirring the oysters gently in a pan or bucket of fresh water. In preparation of samples for analysis the liquor that bled out of the meats after packing was included. Thus values for dry solids content of drained oysters would have been higher. It is a characteristic of Southern oysters, and occasionally of oysters from certain beds in the Chesapeake Bay area, to form excessive amounts of free liquor within a short time after packing, even when exposure to water has been quite limited. This has greatly complicated enforcement of Section 36.10 of the present U. S. Food and Drug Administration Standards of Identity for raw oysters which defines this product, in part, by its free liquor content.

In January 1959, studies were started by the Government-Industry-Cooperative Oyster Research Program team of the physical and chemical characteristics and changes occurring during processing of oysters in the Chesapeake Bay and other nearby oyster-growing areas. This research has the primary objective of obtaining information useful in revision of current Standards of Identity. The data on composition of Southern oysters obtained in the studies herein reported confirms the necessity for extending the Government-Industry-Cooperative Oyster Research Program investigations to include oysters from the Gulf Coast at the earliest opportunity.

Although the number of samples from most of the Southern States was not sufficient to give a complete pattern of season variation, the data indicate that this pattern is similar in all areas. Unfortunately, the product is at its best when the demand for it is lowest--that is, in the late spring months. The industry would therefore have an advantage if it could operate in such a manner that no oysters would be shucked during September, October, and November. At this time, Southern oysters are still thin, the yield is poor, prices for oysters in the shell are high, and plants often operate at a loss, but the market demands oysters and the plants operate to supply this market. The data illustrate the magnitude of these differences and the need for developing methods, such as freezing, of holding raw shucked oysters from the spring when they are in optimum condition, until the fall increase in market demand. At present, oyster canneries use these spring oysters, but this processed product cannot compete for the same market as the fresh or frozen raw shucked oysters.

## CONCLUSIONS

1. The total solids, carbohydrate, and fat contents of the oyster show a seasonal pattern of fluctuation, from high values in the late spring just prior to spawning to low values during the fall just before cooler waters stimulate new growth.

2. The salt and ash contents are related primarily to water salinity, which is influenced by rainfall and other environmental factors that vary for each oyster bed. In the 2 years from October 1954 to October 1956, oysters taken in the fall had higher salinity than those taken in the spring or the summer.

3. As a result of loss of salt during shucking and washing, insoluble constituents of the plant samples--that is, protein and fat--constitute a higher proportion of the remaining solids. The carbohydrate content of washed plant samples increases less than the proportional amount of solubles solids lost, indicating some loss of soluble glycogens during washing. The proportion of the original salt content that remains in the washed oysters depends on the amount of exposure to fresh water during the washing process.

4. Solids content of Southern oysters varies over a wide range, but the average of 12.6 percent for all washed oysters is comparable with that of oysters from Chesapeake Bay.

5. Oysters from all Southern States have a similar pattern of seasonal variability. Benefit to the industry would result through increased production and utilization of oysters during March through May, perhaps by use of freezing if the technical problems were solved.

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## LONG SALMON MIGRATIONS

As a part of the International North Pacific Fisheries Commission program, the Fisheries Research Institute has been tagging salmon in the North Pacific Ocean under a contract from the U. S. Bureau of Commercial Fisheries. The objective of the tagging study is to determine the qualitative and quantitative distribution of salmon at sea with respect to continent of origin.

Some amazingly long migrations of salmon and steelhead trout have been recorded from this work. One of the most interesting cases concerns a steelhead which was tagged on September 5, 1958, in the Gulf of Alaska, near Kodiak Island, and recovered February 5, 1960, at a fish cultural station on the Alsea River, Oregon. Personnel at the station state that the fish had been fin-clipped and released in the Alsea River in April 1958. At that time it was approximately 5 or 6 inches in length. At tagging it measured 14 inches and at recovery, 22 inches. Fin clips were not noticed during tagging since time is not taken to watch for missing fins. However, at final recovery, fin clips were still unmistakeable. Thus, data on this steelhead (positively identified at three points) revealed its origin, a minimum migration of 2,400 miles round trip, and true homing at maturity.

The longest migrations have been reported from steelhead trout and king salmon. Some of these fish have really traveled. For example, a steelhead tagged south of Adak on July 19, 1957, was recaptured by rod and reel in the Chehalis River, Washington State, on March 13, 1958. The distance traveled was approximately 2,000 miles in 8 months. A king salmon tagged in approximately the same area in 1956 was recovered in the Salmon River, Idaho, the following year. The fish was at liberty 11 months and traveled a minimum of 2,400 miles.