Volume 24 Number 5 March, 1977

Possible Sources of Marine Protein

R. W. Gerry
D. C. O'Meara
P. C. Harris
T. A. Bryan
D. L. Blamberg

Research in the Life Sciences

UNIVERSITY OF MAINE AT ORONO
Life Sciences and
Agriculture Experiment Station

This work is a result of research sponsored in part by NOAA Office of Sea Grant, Department of Commerce, under Grant # 04-5-158-39, and in part by Hatch funds administered through the Maine Life Sciences and Agriculture Experiment Station. The U.S. Government is authorized to produce and distribute reprints for governmental purposes notwithstanding any copyright notation that may appear hereon.

ACKNOWLEDGMENT

The authors express appreciation to Dr. David Dean, Paul D. Ring and Mark S. Richmond of the University of Maine Marine Laboratory for their assistance in obtaining the scallop viscera and to Dr. T. B. Chawan, formerly with Borden Foods, for supplying the clam viscera. Also, to Malcolm Richards of the Maine Sea and Shore Fisheries Department for testing the scallop viscera for the presence of paralytic seafood poisioning, to Dawes Laboratories, Inc. for some of the vitamins and to Proctor and Gamble Company for the stablized HEF (fat) used in the rations.

POSSIBLE SOURCES OF MARINE PROTEIN

Gerry, R. W.,[1] D. C. O'Meara,[2] P. C. Harris,[2]
T. A. Bryan,[3] D. L. Blamberg[3]

Waste products from the sea may aid in solving the protein shortages of the future. For example, over 50% of the weight of the soft parts of scallops (Figure 1) is discarded at sea and the bellies of surf clams [*Spisula solidisium*] are returned to the sea after the clams have been processed. Either of these procedures is looked upon by some as pollution. Although uneconomical at present, it may at some future time pay to collect such products and process them into animal feed. Experiments have been conducted at the University of Maine at Orono by the Life Sciences and Agriculture Experiment Station to study the nutritional value of such material in broiler rations.

Blamberg and O'Meara (1973) reported on a method of producing dehydrated scallop viscera (Figure 2) which when ground into a meal analyzed 50.01% protein, 18.79% ash and 16.49% ether extract (mostly fat). The amino acid pattern of the protein tended to resemble that of Meat and Bone Meal or Poultry By-Product Meal. Available lysine was apparently not destroyed by the processing temperature used. One of the problems encountered when feeding the dehydrated scallop viscera was the apparent presence of a thiaminase, (Bryan et al., 1975). Neilands (1947) had reported the presence of thiaminase in scallop *muscle*. This enzyme or enzymes, also found in many types of raw fish, will destroy thiamin. This can result in a vitamin deficiency in animals fed such products. Blamberg *et al.* (1973) published a preliminary report concerning the value of dehydrated scallop viscera (DSV) in chicken diets. Their initial four and one half week study with Leghorn chicks fed a commercial starting ration plus 10% DSV resulted in nearly 50% mortality. At the time this was thought possibly due to high dietary intake of certain minerals but upon analysis this did not prove to be true. Also, when a sample of fresh scallop viscera was autoclaved at 15 psi and 108°C and fed similarly no mortality resulted. It appeared that some toxic factor was present in the DSV processed at a relatively low temperature which could be inactivated by proper heat treatment. DSV was subjected to protein quality analysis by the technique of Blamberg (1971). Samples from two different Maine coastal areas did not support weight gain in chicks, mortality was high and some neurologic involvement in the chicks

[1]Professor, [2] Associate Professors, [3]Former Assistant Professors
Department of Animal and Veterinary Sciences

was noted. The possibility of the presence of paralytic shell fish poisoning (Joyner and Spinelli, 1969) was investigated but results were negative.

A lower, more practical level of DSV (5%) was included in formulated diets based on New England College Conference broiler rations and fed to chicks until they were nearly 8 weeks of age. Even at this lower level the mortality ascribed to neurologic involvement was clearly associated with treatment and the birds weighed appreciably less than those fed the control diets or the diets containing autoclaved material. A few of the most severely affected birds (thiamin deficiency symptoms) surviving the latter experiment were injected intramuscularly with 10 mg. of thiamin HCl. The dramatic recovery which occurred was interpreted as meaning that poor growth, excessive mortality and neurological involvement could be explained by the presence of thiaminase in the DSV processed at relatively low temperature, (Blamberg *et al.*, 1973; Bryan *et al.*, 1975). The study was continued with scallop viscera and later with surf clam viscera as described in this paper.

MATERIALS AND METHODS

In three tests, sexed, day-old broiler type chicks were reared in electrically heated battery brooders with raised wire floors. The birds received feed and water *ad libitum*. Duplicate groups of 10 males and 10 females were weighed, banded and randomly assigned to each treatment and battery location. Slightly modified New England College Conference broiler starter and finisher rations were used as control diets, (Table 1). The levels of scallop or clam viscera were added in place of soybean meal and yellow corn meal on a protein basis. The DSV contained about 10% NaCl so the salt normally added to the rations was omitted when DSV was used. The starting diets were fed to five weeks and the finishing diets to the end of the tests at seven weeks and four or five days of age. The body weight and feed efficiency data were subjected to an analysis of variance and the individual means then compared by Duncan's multiple range test (Steel and Torrie, 1960). Birds which died were autopsied and the problems diagnosed. Frequently the symptoms of a typical thiamin deficiency complicated by slipped tendon or synovitis were present.

The first test involved a sample of dehydrated scallop viscera (Figure 2) from one coastal area (Jonesport) and two samples from a second area (Stonington I and Stonington II). The difference between the two Stonington samples was that "I" was collected with accompanying water while in collecting "II" an attempt was made to strain out some of the water. The Stonington II sample was fed both as dehydrated and as autoclaved-dried. The scallop viscera were placed in pails for autoclaving at 15 psi which developed a temperature of 108° $\pm$2C on the gauge. The temperature in the center of the mass in the pails was not measured but

apparently it was sufficient to markedly deactivate the thiaminase in the raw material. All samples were fed at a 5% level. Preliminary results of this test were included by Blamberg *et al.* (1973).

In the second test the "Stonington I" sample was fed at a 4% level and the "Stonington II" sample at a 5% level with and without added thiamin, (2.56 mg/kg). "Stonington II" was also fed at a 2.5% level dehydrated and at a 5% level autoclaved-dried. Dried clam viscera (French machine oil dried) were fed at 2 and 5% levels.

The third test involved a new supply of scallop viscera. Samples of this were autoclaved for various lengths of time (12, 8 or 4 minutes) and then dried at either 48.9° or 54.4°C and fed at 5% levels. Two treatments involved the free liquid which was produced during autoclaving. This free

Table 1. Basal starting and growing diets fed.[1]

Ingredient	Starter %	Finisher %
Ground yellow corn	54.03	60.40
Soybean meal (dehulled)	28.10	18.80
Corn gluten meal (60%)	2.50	3.75
Fish meal (Herring - 65%)	2.50	2.50
Meat & bone meal (47%)	2.50	2.50
Alfalfa meal (17%)	-	1.25
DL-Methionine	.04	-
Fat (Hyd. an. and veg.)	5.70	6.30
Dicalcium phos.	0.50	0.45
Ground limestone (35% Ca)	0.80	0.70
Iodized salt [2]	0.40	0.35
Trace minerals [3]	0.15	0.15
Premix [4]	2.55	2.55
Choline Chloride (25%)	0.23	0.30

1. When the scallop or clam viscera were added, the protein was maintained by adjusting the soybean meal and corn.
2. Added salt was omitted when scallop viscera were used.
3. Provides per kg. of diet: manganese, 90 mg; zinc, 30 mg; iron, 30 mg; copper, 3 mg; iodine, 1.8 mg; cobalt, 0.3 mg; and calcium, 435 mg.
4. Provides per kg. of diet: vitamin A, 4,450 I.U.; vitamin D_3, 1,100 I.C.U.; riboflavin, 3.7 mg; pantothenic acid, 5.9 mg; niacin, 25.1 mg; menadione, 1.2 mg; vitamin B_{12}, 13.3 mcg; ethoxyquin, 125 mg; procain penicillin, 6.6 mg; Amprolium, 125 mg and soybean meal carrier.

liquid was mixed with control feed and the mixture was then dried. The amount added was equal to that produced in autoclaving sufficient viscera to provide a 5% level of dried material in the ration. This procedure was undertaken in an attempt to determine whether the thiaminase was in the autoclaved solid material or in the free liquid which could be poured off. In one final treatment, some remaining "Stonington II" was fed at a 5% level and thiamin HCl was added at a rate of 3.68 mg/kg of feed, double the thiamin requirement for chickens under normal conditions, (National Research Council, 1971.).

RESULTS AND DISCUSSION

The results of the first test are shown in Table 2. Any of the three samples of dehydrated scallop viscera (DSV) fed at a 5% level resulted in significantly reduced weight gains, poorer feed efficiency and increased mortality. Mortality in all groups was excessive due to leg problems, but the addition of DSV to the ration produced a paralytic condition in an additional number of birds. This was especially true with the sample of scallop viscera (Stonington II) from which part of the water had been strained when the viscera were collected, (treatment 4). There would seem to be no satisfactory explanation for the very heavy occurrence of the paralytic condition in the birds fed this sample as compared with the other two samples.

Table 2. Effect of feeding various samples of dehydrated scallop viscera (DSV) at 5% levels in broiler rations, sexes combined.

Treatment	7 wk., 5 day Av. wt. (gms.)	Feed/Gain[1] 0 to 6 wks.	Mortality (%)[2] 0 to 7 wk. 5 days
1. Control	1770[a]	1.71[a]	27.5
2. Jonesport S.V.	1645[b]	1.80[a]	40.0
3. Stonington S.V.I.	1644[b]	1.80[a]	35.0
4. Stonington S.V.II	1605[b]	1.79[a]	87.5
5. As 4 autoclaved	1800[a]	1.72[a]	17.5

1. Too few birds left in some groups at 7 wks. plus 5 days of age to obtain representative feed efficiency data.
2. Includes all dead birds and all birds with leg problems and thiamin deficiency symptoms. Only birds on treatment 4 had thiamin deficiency symptoms.

Means within columns 1 & 2 *without* a common superscript are significantly different ($P<.05$).

In the second test (Table 3) the addition of thiamin at 25% above the requirement level, to rations containing DSV prevented the symptoms of thiamin deficiency (treatments 3 and 6). It also improved growth and feed efficiency but not to equal those of the control birds (treatment 1). A 4% level of "Stonington I" DSV (treatment 2) or a 2.5% level of "Stonington II" DSV (treatment 4), were apparently too low to produce any thiamin deficiency symptoms but these levels of DSV did produce significantly poorer growth and feed efficiency than did the control ration.

Table 3. Effect of feeding various levels of dehyrdrated scallop viscera, added thiamin and dried clam viscera in broiler rations.

Treatment	7 wk., 5 day Av. wt. (gms.)	Feed/Grain 0 to 7 w. 5d.	Mortality (%)[3] 0 to 7w. 5d.
1. Control	1941[a]	1.84[ab]	10.0
2. Stonington I, 4%	1791[bc]	1.91[cde]	15.0
3. As 2 + thiamin[1]	1809[bc]	1.89[bcd]	7.5
4. Stonington II, 2.5%	1738[cd]	1.96[e]	17.5
5. Stonington II, 5%	——[2]	——[2]	100.0
6. As 5 + thiamin[1]	1663[d]	1.94[de]	17.5
7. As 5 autoclaved	1886[ab]	1.82[a]	27.5
8. Clam viscera 2%	1890[ab]	1.85[abc]	22.5
9. Clam viscera 5%	1890[ab]	1.85[abc]	15.0

1. Thiamin added at 25% above requirement level.
2. No birds living at 7 weeks and 5 days of age.
3. Includes all dead birds and all birds with leg problems and thiamin deficiency symptoms. Only birds on treatment 5 had thiamin deficiency symptoms.

Means within columns 1 & 2 *without* a common superscript are significantly different ($P<.05$).

Growth and feed efficiency with "Stonington II" scallop viscera autoclaved-dried and fed at a 5% level (treatment 7) were not significantly different from those of the control birds as was true in the first test. This was further indication that the toxic factor in the scallop viscera was inactivated by proper heat treatment. The dried clam viscera fed at 2 or 5% levels (treatments 8 and 9) also supported growth and feed efficiency which were not significantly different from those of the control birds. Mortality in this test was again relatively high due to leg problems but only treatment 5, the "Stonington II" DSV at a 5% level, resulted in thiamin

deficiency symptoms.

Scallop viscera were autoclaved (15psi; 108°C) and dried for five of the nine treatments in a third test (Table 4). Autoclaving for twelve, eight or four minutes and drying at 48.9° or 54.4°C produced no significant differences in weights or feed efficiencies from those of the control birds. Neither did the adding to the feed of the liquid from the 8 minute autoclaved viscera. However, when the liquid from the four minute autoclaved material was added to the feed, body weights were significantly less and mortality was higher than with the control birds. Some evidence of thiamin deficiency was noted in the birds on this treatment. This suggests that the thaminase was poured off in the liquid from autoclaving and that four minutes was not enough autoclaving time to destroy the enzyme. Treatment 9, the "Stonington II" scallop viscera with about twice the thiamin requirement added to the feed produced growth and feed efficiency equal to those produced by the control diet. This indicated that the detrimental effect of adding DSV containing thiaminase at a 5% level could be overcome by the addition of sufficient thiamin.

Table 4. Effects of including in broiler rations 5% levels of scallop viscera (SV) treated in various ways.

Treatment	7 w. 4. d. Av.wt. (gms.)	Feed/Gain 0 to 7w. 4d.	Mortality(%) 0 to 7w. 4d.
1. Control	1784[a]	1.96[a]	2.5
2. 12 min. - 130°F[1]	1824[a]	1.99[a]	7.5
3. 12 min. - 120°F[1]	1794[a]	1.99[a]	10.0
4. 8 min. - 130°F[1]	1848[a]	1.96[a]	5.0
5. 8 min. - 120°F[1]	1813[a]	1.97[a]	10.0
6. 4 min. - 120°F[1]	1806[a]	1.97[a]	7.5
7. As 1+ liquid from 5[2]	1764[a]	1.93[a]	5.0
8. As 1+ liquid from 6[2]	1605[b]	2.00[a]	22.5[4]
9. Stonington II + Thiamin[3]	1812[a]	1.96[a]	15.0

1. Minutes autoclaved and drying temperature.
2. Free liquid equivalent to that produced in autoclaving sufficient viscera to provide a 5% level of dry material in the ration.
3. Dehydrated viscera plus thiamin added at double the requirement level.
4. Thiamin deficiency symptoms in over half of these.

Means within columns 1 & 2 *without* a common superscript are significantly different.

SUMMARY

Certain waste products from the sea such as scallop and clam viscera were found to be relatively high in good quality protein. A quantity of scallop viscera was obtained and dehydrated at a relatively low temperature (38± 1°C) or autoclaved for 12, 8 or 4 minutes. French machine oil dried clam viscera were also obtained for use in one test. Broiler rations containing either 2 or 5% of the dried clam viscera in place of soybean meal and corn on a protein basis were found to be equal to the control rations as promoters of growth and feed efficiency. This was also true of scallop viscera prepared for use by autoclaving for 12 or 8 minutes, pouring off the free liquid, drying, and feeding the resulting solids at levels of up to 5%. However, the scallop viscera dehydrated at 38 ± 1°C and fed at 2.5, 4 or 5% levels did not produce results equal to those of the control rations. At the 5% level of feeding, thiamin deficiency symptoms in the chicks were much in evidence. Also, these symptoms occurred in chicks fed rations containing the free liquid from 4 minutes autoclaving of the scallop viscera. Apparently a thiaminase was present in the scallop viscera which was not destroyed by the 4 minute autoclaving or the dehydrating at 38± 1°C. In these instances, thiamin deficiency symptoms were eliminated by injecting thiamin hydrochloride intramuscularly or by adding thiamin hydrocholride to the feed. When sufficient thiamin hydrochloride was added to the feed, about double the normal chick requirement, growth and feed efficiency were equal to those of the control chicks. Therefore, it is possible to process scallop viscera or clam viscera into valuable animal protein feed ingredients. The need for animal protein feed ingredients may someday be great enough to make it economically feasible to salvage such products.

LITERATURE CITED

Blamberg, D. L., 1971. A chick bioassay for evaluating the protein quality of dry breakfast cereals. Poultry Science 50:300-302.

Blamberg, D. L. and D. C. O'Meara, 1973. Dehydrated scallop viscera, a potential component of poultry rations. Poultry Science 52:1203-1205.

Blamberg, D. L., D. C. O'Meara, R. W. Gerry, P. C. Harris and T. A. Bryan, 1973. Preliminary observations concerning the nutritive value of dehydrated scallop viscera as a component of poultry rations. Life Sciences and Agriculture Experiment Station, University of Maine, Miscellaneous Report No. 129, p. 14.

Bryan, T. A., D. L. Blamberg, R. W. Gerry, P. C. Harris and D. C. O'Meara, 1975. Observations of possible thiaminase activity in scallop viscera fed in broiler diets. Case report. Poultry Science 54:1299-1301.

Joyner, T. and V. Spinelli, 1969. Mussels: a potential source of high quality protein. Comm. Fish. Rev. 31:31-35.

National Research Council, 1971. Nutrient requirements of poultry.

Neilands, J. B., 1947. Thiaminase in aquatic animals of Nova Scotia. J. Fish. Res. Bd. Can. 7(2): 94-99.

Steele, R. G. D. and J. H. Torrie, 1960. Principles and procedures of statistics with special reference to the biological sciences. McGraw-Hill Book Co., Inc., New York.

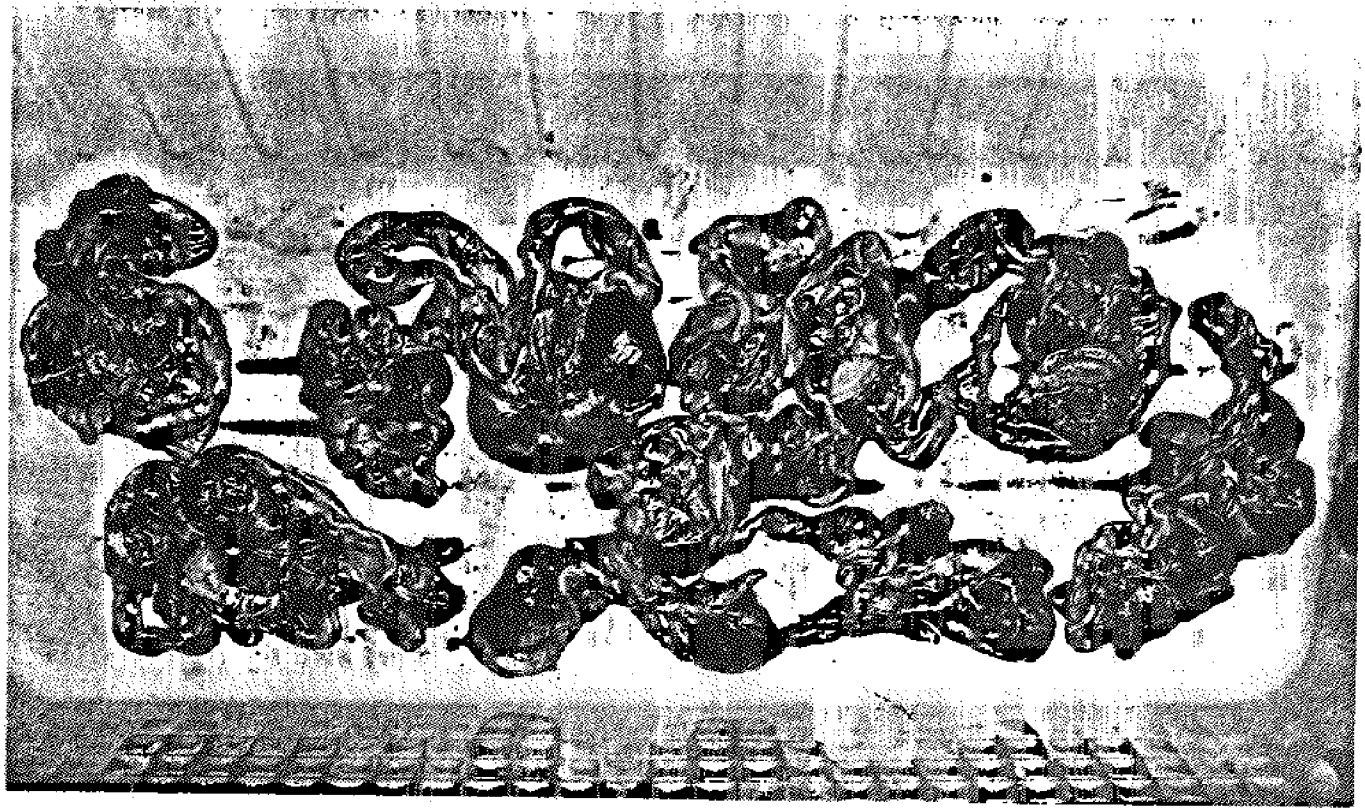

Figure 1. Scallop viscera which are normally discarded at sea.

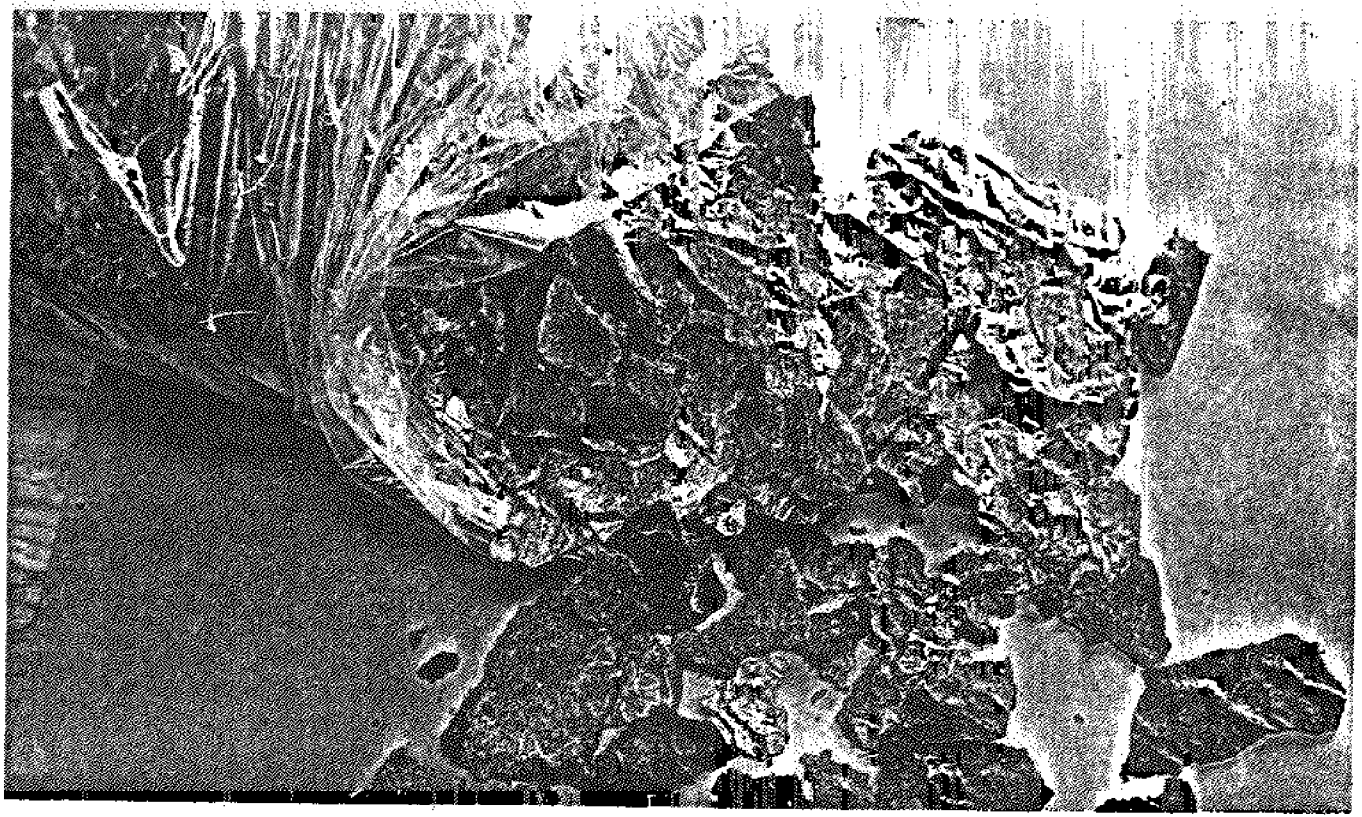

Figure 2. Scallop viscera dehydrated at 38±1°C produced these flakes which were ground into meal.