TECHNOLOGICAL STUDIES OF THE STARFISH

PART V-STARFISH AS FERTILIZER

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INTRODUCTION

The four previous papers of this series of technological studies of the starfish (Asterias forbesi) have reported data in the literature, as well as those obtained in these investigations on the chemical composition of starfish, use of starfish meal as a protein feedstuff, and on the presence of thiaminase in raw starfish and starfish meal. The present paper gives the results of an investigation on a small local scale directed towards the better utilization of starfish as fertilizer.

Most of the reports on the utilization of starfish prior to 1942 have been concerned with its value as fertilizer (Kole, 1919 and Vachon, 1920). Since 1942, the dried starfish meal has been found to have sufficient value as a protein supplement for poultry feeds so that any meal which could be produced could be used for this purpose. The only recent reports of its use as fertilizer have been limited to the use of whole raw starfish. The starfish landed at Providence during the period when the State of Rhode Island was paying bounty on the pests were disposed of in this way (Gibbs, 1941 and 1946). There have been other unpublished reports of similar use of small quantities on private gardens and small farms.

In general, reports of the use of starfish for fertilizer have been quite favorable. So far as is known, however, none of the trials have been adequately planned, with control and competitive plots, to permit comparison of starfish with balanced commercial fertilizers.

Starfish, on the basis of chemical analysis, is a source of organically bound nitrogen, containing negligible amounts of phosphorus and potassium, the latter two elements being of primary importance in balanced fertilizers. The ash content, largely calcium carbonate, may amount to 60 percent by weight of the meal and dilutes the nitrogen to a fairly low value, less than 5 percent on a dry matter basis. As a fertilizer, this calcium carbonate is a desirable addition for acid or "heavy" soils. Starfish were not being used in any way and since they have some fertilizer value, an investigation was made to determine a practical way to use raw starfish as fertilizer. Most starfish are taken in the spring and summer, and piles of raw, untreated starfish decompose rapidly at the temperatures prevailing during these seasons. The odors thus developed would condemn handling

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NOTE: Part I of this series, "Starfish Control--Its Economic Necessity and Methods Used," appeared in the January 1948 issue of Commercial Fisheries Review, pp. 1-6. Also available as Sep. No. 193.

Part II, "Chemical Composition," appeared in the February 1948 issue, pp. 11-18. Also available as Sep. No. 196.

Part III, "Value of Starfish Meal--Protein Supplement for Growth of Rats and Chicks and for Egg Production," appeared in the March 1948 issue, pp. 8-19. Also available as Sep. No. 199.

Part IV, "Thiaminase in Starfish," appeared in the May 1948 issue, pp. 12-19. Also available as Sep. No. 204.

in this manner, inasmuch as most of the starfish are landed in sizable cities, such as New Haven and Milford, Conn., and Providence, R. I.

Because of the rapidity with which starfish decompose, it is the general practice for those taken in control operations to be shoveled overboard before reaching port. The suggestion was made that if these starfish could be treated so as to delay decomposition, sufficient quantities might be accumulated to justify hauling the material some distance to farms where it could be used as fertilizer. In this way, small and scattered amounts of starfish could be utilized when and where landed, largely eliminating adverse factors of cost of transportation and irregularity of supply which practically prohibit the use of starfish as raw material in fish meal drying plants.

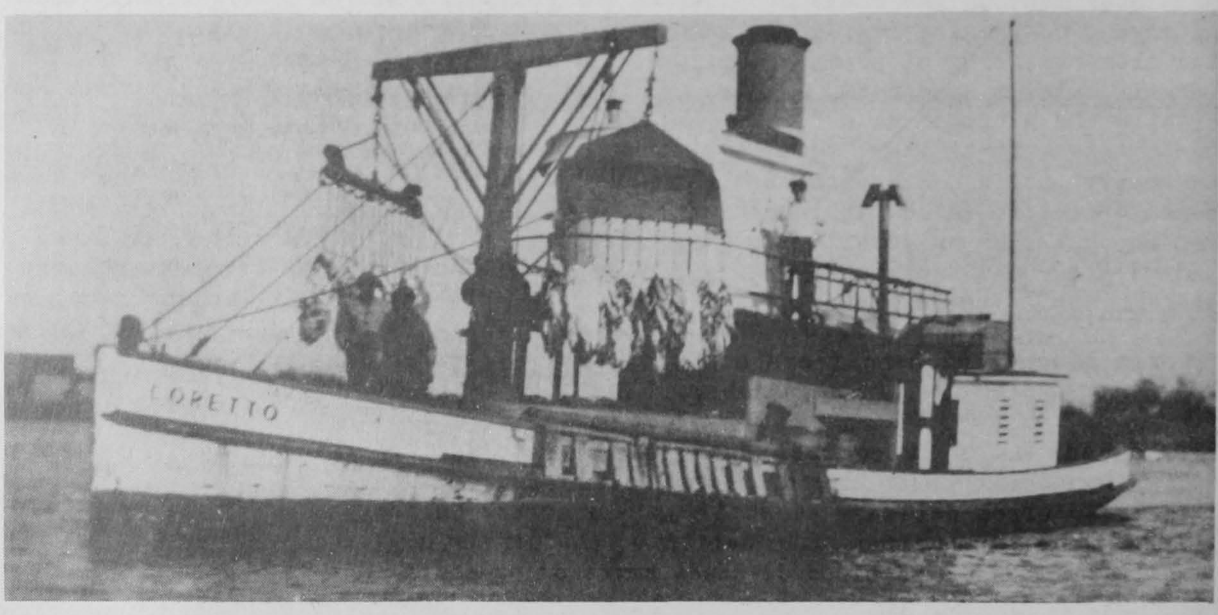
EXPERIMENTAL

In the early days of the menhaden oil industry, sulfuric acid was often used to delay decomposition of the presscake until enough had accumulated to operate the driers. For this purpose, 3 to 5 percent sulfuric acid by weight gave the desired result. The suggestion was made that a similar small amount of acid might be equally effective on starfish.

Therefore, a field trial was planned, using freshly caught starfish handled in a manner similar to that necessary in any practical adaptation of the process. Various quantities and concentrations of sulfuric acid were used to determine the optimum conditions for the desired effect.

Preliminary tests in the laboratory had shown that the starfish could withstand fairly concentrated acid without rapid structural breakdown. For greater safety in handling, the first tests were carried out with dilute acid.

Concentrated sulfuric acid was siphoned into a quart measure and added to an amount of water in a stoneware crock, which would give the desired dilution. This



TYPICAL STARFISH BOAT, OPERATING IN LONG ISLAND SOUND, EQUIPPED WITH MOPS

STARFISH CAUGHT IN FOUR HOURS BY A CRAB DREDGE BOAT (CRABBING) IN CHESAPEAKE BAY

technical grade acid, 56 Baume acid, cost at that time about 3 cents a pound in 5-gallon carboy lots. Great care is needed in the mixing operation. The concentrated acid is rapidly, and the dilute acid more slowly, corrosive to both skin and clothing, and the dilute acid rapidly attacks any metallic equipment unless lead lined. Rubber gloves and rubber equipment are desirable as protective clothing, and a stoneware crock is the best mixing container usually available. In the use of stoneware, care is also necessary to prevent cracking from the heat generated by too rapid addition of acid to water. The above properties should be considered because of the danger which would be involved if the acid were to be handled by oystermen or farmers without special equipment and knowledge of the precautions necessary for safety.

The starfish used in the present investigation had been picked from mops by the starfishing crews of a New Haven, Conn., company, and the acid treatment was carried out in the grounds of the plant. Two lots were collected, on October 28 and 30. Approximately 200 pounds of starfish in the first lot were divided into three piles. No facilities were available for weighing the material so all quantities were estimated. The 3 batches of starfish were then treated with 3 dilutions of acid, 1 to 9, 4 and 2, parts of water by volume, respectively, An equal quantity, 6 quarts, of each dilution was used, and this amount was sprinkled slowly over the piles during the course of about one-half hour. The starfish were turned and mixed with a fork several times during the process.

There was a rapid initial action of the acid with exposed carbonate in the ambulacral spines, etc., but this soon slowed down, and a considerable amount of the acid thereafter ran off to the ground and was lost. The calcareous, exoskeleton makes the starfish very non-absorbent and difficult to treat by ad-mixture of any liquid in this manner. The fact that the calcium sulfate formed by the acid action is only slightly soluble in either acid or water further tended to hinder the reaction going rapidly to equilibrium.

In treating the second lot of starfish, a single concentration of strong acid, 1 part of acid to 1 of water by volume, was used in an effort to lessen the loss by run off, and the volume of acid was varied. The lot was divided into 4 batches which were treated with 2, 3, 4, and 7 quarts, respectively, of the 1 to 1 acid in the same manner as the first lot. The weights of the individual batches were estimated to be about the same as for lot 1, or approximately 70 to 80 pounds each.

After treatment, the starfish were allowed to remain in a pile for a time in order to allow absorption of as much of the acid as possible. They were then raked out into a thin layer on the ground to dry. Threatening rain on October 29 made it necessary to take the first 3 lots into the shelter of a shed. October 30, the weather cleared and all 7 lots were spread outside to dry. Unfortunately, during the night, the whole area was flooded by an exceptionally high tide, so that all piles were under water the morning of October 31. Some starfish floated off but the bulk of each lot was forked out of the water and moved to high ground. The next day, rain again made it necessary to move the starfish inside so that on the following day the material was packed into barrels and shipped to College Park.

RESULTS

At the time of shipping, decomposition had already begun in the batches treated with 6 quarts of 1 to 9 acid and 2 quarts of 1 to 1 acid and only small amounts of these batches were shipped (batches 1 and 4, Table 1). Some spoilage was also

Table 1 - Results of Treating Starfish with Sulphuric Acid

Batch number	Concentrated acid used	Approximate part of acid used to 100 parts starfish	Nitrogen, dry basis	Calcium carbonate, dry basis	Approximate efficiency of acid action
	Pounds		Percent	Percent	Percent
Lot 1:					
1	2.30	3.5	4.72	46.4	96
2	4.60	6.5	4.23	38.8	77
3	7.95	11.0	4.47	32.4	59
Lot 2:					
4	3.85	5.5	4.79	43.0	73
5	5.75	8.5	4.70	35.8	71
6	7.65	11.0	4.52	32.1	62
7	13.40	19.0	4.43	22.9	47

evident in the batches which had been treated with 6 quarts of 1 to 4 acid and 3 quarts of 1 to 1 acid (batches 2 and 5, Table 1). The condition of the other 3 batches indicated fair preservation, evident by the comparative stiffness of the starfish, which normally mat together quite cohesively. This matting makes it difficult to sun-dry fresh starfish, and consequently, the acid treated samples would dry relatively easily and rapidly, given suitable weather.

On arrival November 5, at College Park, 6 and 8 days after treatment, inspection confirmed previous conclusions as to the effectiveness of the various treatments. Only the batches treated with 6 quarts of 1 to 2 acid, and 4 and 7 quarts of the 1 to 1 acid solutions were fairly well preserved (batches 3, 6, and 7, Table 1).

In Table 1, the amount of concentrated acid used in each treatment and the approximate proportion of acid to starfish (column 3) has been calculated. Samples of each batch were ground and analyzed for nitrogen and carbonate. On the basis of previous analytical data, it was estimated that the initial nitrogen content was 4.90 percent and the calcium content was 58 percent of the dry matter.

These data (Table 1 and Figure 1) indicate that the nitrogen content is not greatly affected by the acid treatment, but that the variation which does occur is opposite to that which would be expected. In general, the lots which received the most acid have the lower nitrogen content. Since the condition of the samples did not indicate that this result could have been due to post-treatment decomposition of protein, which should have led to the exactly opposite effect, it would appear that the nitrogen was lost at the time of acid treatment, presumably by hydrolysis of part of the starfish protein to a soluble form which was then leached out.

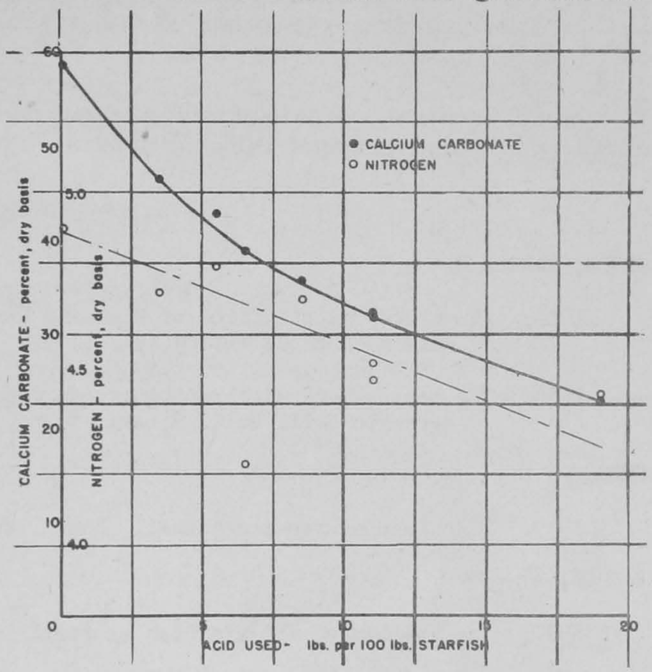


FIGURE 1 - RELATIONSHIP OF THE CALCIUM CARBONATE AND NITROGEN CONTENTS OF RAW STARFISH (DRY BASIS) TO THE AMOUNT OF CONCENTRATED SULFURIC ACID USED IN THEIR TREATMENT FOR FERTILIZER.

The calcium carbonate remaining is a measure of the extent of the action of acid with this component. A greater proportion of acid reacted with carbonate at the lowest levels of acid used. As the amount of acid was increased, the amount of unchanged calcium carbonate decreased as shown in Figure 1. The proportion of acid which reacted decreased also, until when the most acid was used only about one-half of the acid was found to have reacted with carbonate.

A portion of the excess acid must have reacted with or have been absorbed by the protein, as some preservative effect was obtained. However, most of the acid which did not form sulfate was most probably lost on the ground as run off. Even when the acid used amounted to nearly one-fifth of the weight of the wet starfish, it did not neutralize much more than 60 percent of the calcium. The excess alkaline ash must soon have restored the mixture to a nearly neutral reaction; whereas, with the menhaden type of fish meal, small amounts of acid are sufficient to maintain an acid reaction.

CONCLUSIONS

Raw starfish, on the basis of chemical analysis, is rated as a fair source of nitrogen for fertilizer and as a poor or unimportant source of phosphorus and potassium. The calcium carbonate it contains would be beneficial when used on acid or heavy clay soils.

Treatment with sulfuric acid is not a very effective means of preventing decomposition of raw starfish to facilitate its use as fertilizer because of the large quantities of acid required. To delay decomposition, concentrated acid amounting to 15 percent of the weight of the raw starfish is required.

The cost of acid, estimated to be $35.00 per ton of dry meal, is excessive considering the relatively low value of the starfish as fertilizer. Acid treatment further decreases the fertilizer value in two ways: by loss of nitrogen, presumably by leaching of a soluble protein hydrolysate; and by replacement of part of the alkaline acting calcium carbonate by the neutral, relatively insoluble calcium sulfate.

Acid treatment of starfish involves danger to person and property in the hands of inexperienced persons lacking special equipment and protective clothing.

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GUANO ISLANDS, UNION OF SOUTH AFRICA

Guano is deposited by malagas (or gannets), penguins, and duikers in the latter half of the year on the Guano Islands, Union of South Africa. The collection is undertaken during the ensuing six months. The extraordinary wealth of fish in the waters surrounding the Guano Islands is indicated by the fact that 20,000,000 birds, each requiring a minimum of one pound of fish per day, are to be found at the same time on the one Island of Ichabo. The astonishing quantity of guano on a given area is further demonstrated by the fact that Seal Island, in False Bay, with an area of one acre, yields from 30 to 80 short tons each year.

Guano is sold as a fertilizer in pulverized form and is used principally in the cultivation of cereals and vegetables. It is no longer available for orchards and vineyards on account of the big demand in other respects. Its principal chemical constituents are nitrogen, potash, phosphoric oxide, and lime, and as the composition of the deposits obtained from the different islands varies materially in certain essentials all collections are systematically mixed so as to obtain an approximately uniform grade of article.

--Fishery Leaflet 305