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Studies on the utilization and nutritive value of whiting (Merluccius bilinearis)

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STUDIES ON THE UTILIZATION AND NUTRITIVE VALUE OF WHITING (MERLUCCIUS BILINEARIS)

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INTRODUCTION

Although the fishing industry dates from biblical times and its operation has never ceased, there is comparatively little written about the use of many of the lesser known fish. Most of the published material deals with the identification and description of fish, the method of catching, the places caught, and the utilization of some of the commoner species of fish. When one looks at library fishery files and notes the number of books and other publications, it is doubtful if such a statement could be true. Yet, a large percentage of the material is written about certain species of fish, or else it pertains to certain scientific aspects which are of no use to those who use fish as a food. The scientific angle of this question is very important, but that is no reason why the practical use of many species of fish should be neglected.

There are still a great number of people in the interior of this and other countries who consider fish as a delicacy and luxury because they are unable to obtain a variety of good quality fresh fishery products at all seasons. This state of affairs is rapidly improving because of the canning industry and other modern methods of preservation of fish. But in most cases, only specif-

ic fish are used for this preservation. Introduction of other species of food fish which will help to provide more varied meals, and which are equally as good as if not better than many of the common market fish, will not only be a boon to the housewife who finds "meals that are different" a problem, but should also be a benefit to the fishing industry.

One of the fish which may readily be used is the Atlantic whiting (Merluccius bilinearis). Comparatively little research has been done with this fish and there is practically no information on its value or use as a food. Whiting is found off the New England coast and as far South as New Jersey. Few are caught farther North or farther South than Massachusetts and New Jersey. The largest percentage of them is caught in this area. The whiting lives near the bottom of the ocean, and during certain seasons it may be found close to the shore. Nets are the chief gear for catching this fish, although floating traps, weirs, and other methods are sometimes used. The fish is really a choice sea food and can be bought very cheaply, yet the number of people who are acquainted with these facts is very limited. The term whiting as used in this thesis is applied to several different species

of fish. Tressler (10) gives the following description of different species, all bearing the common name "whiting". "Whiting (Menticirrhus saxatilis) - This fish is otherwise known as the "kingfish", the"Seamink", and the "sea mullet"; it is abundant from Cape Ann to Pensacola. The sand whiting (M. americanus), also known as the "deep water whiting", is common from Chesapeake Bay to Texas. The surf-whiting (M. littoralis" also called the "silver-whiting", is common from the Carolinas to Texas. The California whiting (M. undulatus) is also known as the "sand-sucker". On the coast of Florida, they are variously known as "kingfish", "barb", "bull-head whiting", and "ground mullet". They attain a length of 10 inches and a weight of one and one-half pounds. They are caught with hook and line and with seines, and are a food fish of considerable importance. The name is also applied to the harvest-fish (Peprilus alepidotus) at Norfolk, Va., and to the silver hake (Merluccius bilinearis) on the New England coast."

In addition, there is apparently another fish referred to by a British investigator (5) as whiting which has the scientific name of Alburnus lucidus.

In this thesis the term "whiting" is used with reference to Merluccius bilinearis, locally known as the silver hake.

OBJECT OF THE INVESTIGATION

The object of this research is to study the nutritive value and chemical composition of the whiting; and to investigate methods of preserving and utilizing the fish for human consumption.

Investigation of the nutritive value of the fish is confined to a biological assay of vitamins A and D. A proximate chemical analysis is made on the flesh of the fish. The preservation of the whiting by means of canning, freezing, and smoking is considered. Various procedures for canning, such as plain, flaked, chowder, tomato sauce, spiced, fish cakes, and smoked are tried.

With the availibility of this data on the whiting, it is hoped that a larger portion of the population will make use of this fish as a source of food. It is also desired that this research will lead others to publish similar information about other lesser known fish. New uses for the whiting or its liver oil may result from these findings.

REVIEW OF LITERATURE

It is evident from a review of the literature that there is a decided dearth of information concerning the true value of whiting as a food fish. Tressler (10) states that some work was done on the utilization of the whiting for food during the World War. When the war broke out, people on the Eastern Coast were forced to eat whiting due to a scarcity of the commoner species of fish to which they were accustomed. Much of the fish was eaten fresh and some of it was canned, but most of it seems to have been salted.

Reference is made in U. S. Bureau of Fisheries Circular (1) to the use of whiting in the following interesting manner.

In East St. Louis there has developed a considerable business in hot fish shops. These shops specialize in hot fish sandwiches consisting of a fish fillet dipped in a batter, fried in deep fat, and put between two pieces of bread. There are now over 400 such shops in the city. Many species of fish were tried, but whiting was introduced and was rapidly accepted by the shop patrons.

The above report mentions that one-fourth of the entire catch of 17,000,000 pounds is shipped to East St. Louis for hot fish sandwiches. Its importance outside

of East St. Louis may be judged from the following remark:-

"Overshadowed by the more prolific and historical deep-sea fisheries and shellfish industries, the whiting or silver hake of the North Atlantic coast has received but little general public attention."

Most of the fish used in East St. Louis is caught in the vicinity of Cape Cod, Massachusetts, and Monmouth and Ocean Counties, New Jersey. It is frozen and shipped nearly 700 miles to the city where it is made ready for a "deliciously flavored" sandwich. Sometimes the fish are beheaded, eviscerated, skinned and frozen before being shipped, but some are also shipped in the round.

Bull (4) also studied whiting. His studies were on the muscle and oil constants. Clark and Almy (6) gave some of the oil constants for the silver hake (whiting). Fiedler (7) mentioned that some whiting was smoked.

With the exception of these observations, there has been little information published. Vitamin studies of the whiting liver oil, and information on various procedures for canning the whiting have been neglected.

EXPERIMENTAL

Preservation Studies

a. Freezing

This method of preserving is dealt with briefly here, as no actual experimental work was carried on at this laboratory. Fiedler (7) reported that 8 per cent of the total catch of whiting is frozen. The whiting used in this investigation were all frozen. The frozen fish were shipped to Amherst from both Sagamore and Provincetown, Massachusetts. The fish arrived covered with a thin sheet of ice and were in excellent condition.

To verify the quality of the frozen fish, some of them were eaten after they were thawed. Some were fried with a dinner, and others were made up into hot fish sandwiches. The fish proved to be very palatable and had a desirable flavor.

b. Canning

After this introductory examination, several procedures for canning fish were followed to show the advisability of using this method of preservation for the whiting. The cleaning, eviscerating, and filleting processes were the same for all of

the following procedures. The fish were thawed at room temperature when they were brought to the laboratory from cold storage where they were stored at 15° F. The thawing usually took from 5 to 6 hours. The treatment of the fish for canning was similar to that furnished by Jarvis and Griffiths (9), This procedure is outlined below.

1. The fish were washed, scaled, and eviscerated, after which they were filleted, and the fillets washed. Note: On canning, the backbone may be left in as it contains valuable minerals, and after processing it is quite edible.

2. The fillets were then put into a 6 per cent brine and soaked for an hour. This brine was used for only one lot of fish. Fresh solutions were made for each experiment.

3. At the end of the hour, the fish were drained for a few minutes and then cut into container length pieces and packed fairly solidly in pint jars. In packing the pint glass jars, the fish was packed with the skin facing the outside of the jar in order to improve the appearance of the canned product.

4. The glass jars of fish were processed for 110 minutes at 240°F. (10 pounds of pressure). At the end of the process period the jars were removed from the

cooker and cooled in air.

A slight variation in this procedure was followed for the second batch of canned fish. Before being processed, the second lot was heated for 15 minutes while submerged in a 3 per cent brine solution to exhaust some of the air from the cans. After draining, a piece of lemon and a bay leaf were added to each can for flavoring. Processing was for 110 minutes at 240°F.

The next batch of fish followed another slight variation in the original procedure. After brining and draining, these fish were packed cold into one-half pound "c" enamel cans. They were not exhausted and were sealed cold under a vacuum of 15 inches of mercury. They were processed for 90 minutes at 240°F., after which they were cooled under running cold water.

Fish Flakes

Another lot of the whiting was filleted and cooked in boiling water for 15 to 20 minutes, and made into flakes. The usual procedure for flaking is to cook the whole eviscerated fish and then remove the flesh from the bones and skin. However, in this case it was easier to fillet the fish than to pick the fish from the bones. The flakes were cooled and packed dry into one-half-pound cans. They were sealed cold

under a vacuum of 15 inches of mercury and processed for 90 minutes at 240°F.

At the end of a two week incubation period, during which no hydrogen swells appeared, cans from each of the above batches were opened and examined for condition and quality. All of the fish remained firm. One can of whiting was considered a fair product. One of the other cans lacked salt, and the next was too salty. The flaked fish, however, was an improvement. The color was attractive and white. The addition of a little lemon improved the product.

Fish Chowder

A whiting fish chowder was the next product canned. The following chowders were mixed in different proportions, one following the formula offered by Chenoweth and Maclinn (5), and the other being mixed to have a stronger fish flavor. The recipes given in Table I are for condensed chowders and should be mixed with equal amounts of milk before being used. The procedure for making the chowder follows.

Preparation of Fish and Broth

1. The fish were eviscerated and beheaded before they were placed in a steam jacketed kettle. When fresh fish is used, the entire eviscerated fish is used for the broth, but as these were frozen, the heads were

discarded. The fish were covered with water and the mixture boiled until the fish were partially cooked. The flesh was removed from the skin and bones, and the water was discarded. Fresh water was poured over the skin, bones, fins, and tails and boiled for 1½ hours in the covered kettle. The liquid was strained and used as the broth for the chowder.

2. The pork was diced in ½ inch cubes and browned in a frying pan until it was yellow in color. The chopped onions were added and cooked until they were light brown in color.

3. The potatoes were diced and put in a weak brine solution (3 oz. salt per gallon of water) to prevent discoloration. It is necessary to use old potatoes for chowder to prevent the potatoes from being dark in the final product.

4. All of the ingredients were thoroughly mixed and filled into one-half pound cans. They were sealed cold under a vacuum of 15 inches of mercury, and processed for 90 minutes at 240°F. They were cooled in running cold water. If the cans are not sealed under a vacuum, they should be filled hot and immediately sealed and processed.

At the end of the incubation period the chowder

was opened and sampled. The potatoes were only slightly darkened as was the broth, and the chowder had an attractive appearance. The special formula gave a chowder in which one could taste the fish and onions present; both chowders were appetizing and palatable.

Tomato Sauce

Whiting canned in tomato sauce may be considered one of the best fish products studied in this investigation. The recipe for the tomato sauce used for this experiment follows.

1 gallon of tomato puree
6 tablespoons spiced vinegar sauce
½ oz. ground horseradish
2 tablespoons minced onions
1 oz. salt

The ingredients were mixed and concentrated to one-half the original volume. If more of the spiced vinegar flavor is desired, the vinegar may be added after the concentration.

The only variation in the canning of the whiting in tomato sauce wasin the temperature of the process. After exhausting and draining for three minutes, hot tomato sauce was filled into the jars to within ¼ inch of the top. Hot sauce was also poured into the

No. 1 cans that were used. Some half pound cans, however, were packed and sealed cold under a vacuum of 15 inches of mercury.

The first batch was processed in pint jars for 100 minutes at 240°F. One half of the next batch, also pint jars, was processed at 240°F. for 100 minutes and the other half at 212°F. for 100 minutes. The last batch was canned in No. 1 and half pound cans. One half of each group was processed for 90 minutes at 220°F., and the other half for 90 minutes at 212°F.

At the end of the incubation period, sample lots processed by each method were opened and examined. The fish processed at 240°F. was scorched and dark. The color of the tomato sauce was also very dark, and a pronounced scorched flavor was evident. Of the jars processed at 212°F. some were poor due to very solid packing which prevented the penetration of the tomato sauce around and into the fish, whereas the other lot was delicious. The color of the sauce was a deep red, and the flavor of the sauce had penetrated the fish leaving a moist product with a distinctive flavor. The same results were recorded on the fish canned in the No. 1 (12 ounce) and half pound cans. These results indicate that a temperature of 240°F. is too

Table I

Materials for Whiting Fish Chowder

Ingredients	Chenoweth and Maclinn	Special
Diced potatoes	6 pounds	4 pounds
Prepared fish	3 "	3¼ "
Onions	1¼ "	1¼ "
Salt pork	1¼ "	1¼ "
Salt	2½ tablespoons	3½ tablespoons
Pepper	½ teaspoon	2 teaspoons
Broth	3 quarts	3 quarts

high for a process for this product. Although the pH of the tomato sauce was 5.9 in all cases, there were no spoiled cans at the end of the incubation period. To further test the advisability of using a lower temperature, bacterial plates were made of the sauces of these cans processed at 212°F. At the end of 72 hours there was no growth in any of the Petri dishes or cultures made from the canned whiting.

Spiced Whiting(Marinated)

This product would be more apt to appeal to certain races and individuals, due to the decided vinegar flavor. These fish were exhausted for 20 minutes while submerged in a weak vinegar solution. They were drained and lemon and bay leaves were added for flavoring. A hot, fresh vinegar sauce was poured over the fish, and the jars were sealed and processed 90 minutes at 240°F. They were air cooled and stored. The formulas for the spiced vinegar sauce follows.

2 quarts vinegar

1 quart water

2 oz. sugar

1/4 oz. whole white pepper

1/4 oz. mustard seed

1/4 oz. whole cloves

1/8 oz. cracked cardamon seed

1/8 oz. cracked whole ginger

1/8 oz. bay leaves

The sugar and water were added to the vinegar. The spices were tied in a cloth and allowed to simmer but not boil in the vinegar for one hour. The solution was strained and ready for use.

This product was processed too long. The color was black and the pH of the solution was 5.0. The fish was too spicy for the taste of most people.

Whiting Fish Cakes

Some fish cakes were made from the thawed whiting which proved to be one of the best products made from this fish. Fish cakes are usually made from salt fish which had been freshened, but in this experiment they were made from the frozen fish.

Procedure

1. The fish were filleted, skinned and then

flaked. The fish was then cooled and ground in a meat chopper.

2. The potatoes were cooked and then riced and mixed with the ground fish.

3. The onions were ground and added to the potatoes and fish. The combination was not heated. The mixture was thoroughly mixed and salt and pepper added. Enough water was added to give the proper uniformity and consistency to the product.

4. The fish cakes were then packed in one-half pound cans and sealed cold under a 15 inch vacuum. They were then processed for 70 minutes at 240°F.

The formula for these fish cakes follows.

3/4 pound onions

4 pounds prepared fish

5 pounds potatoes

The product proved to be very good. It compared very favorably with commercial brands. The color was exceptionally white, and the consistency of the product appeared very good.

Smoking

The next method of preservation of the whiting to be considered was by means of smoking. Fiedler (7)

states that 50,000 pounds of whiting were smoked in 1933. Publications of how this product was received are apparently lacking. Smoking is an old art that remains essentially the same as it was when men started smoking their products over fire in the early days of civilization. Opinions vary as to what constitutes a perfectly smoked fish and there are numerous small variations in the treatment of fish for this reason.

The general procedure for smoking these whiting was taken from Griffiths and Lemon (6) who described the general methods.

1. The whiting were cleaned and filleted in the usual manner and then rewashed thoroughly to make sure that no blood spots were on the fillets. The 32 fillets were then placed in a 10% salt solution (38.5° salometer) and left to soak for an hour and a half in order that the salt might evenly penetrate the fillets.

2. The fillets were then hung up and left to drain and partially dry overnight at room temperature. If the fillets are not allowed to partially dry, the smoke may not be evenly absorbed and brown streaks may prevail throughout the flesh.

3. The fillets were then taken to the college smoke house and smoked for the desired number of hours.

Corn cobs were used as a source of smoke, and the first two batches were smoked for six and eight hours respectively. The corn cobs were replenished as often as necessary to keep a fairly dense smoke surrounding the fish. The approximate temperature in the smoke house was 100°F.

A third lot of fish was smoked there for four and one-half hours. Corn cobs were also used for the source of smoke for these fillets. The temperature was also within a few degrees of 100°F.

Results of Smoking Whiting

The difference in the color of the three batches of fish was noticeable. The eight hour smoke gave a dark brown color to the fillets; the six hour smoke gave a golden brown color; and the four and one-half smoke gave a nice light golden brown color. The odor of the three lots varied slightly, but all had a pleasant smoky odor and flavor. When the fish were prepared for eating by some appropiate method, they proved to be very tasty.

Moisture determinations on the fillets smoked for six to eight hours showed that the fillets contained 54 percent. Most smoked fishery products have a moisture content of approximately 60 per cent. The last lot was smoked about the correct length of time.

These smoked fish were kept at 34°F. and were eaten as late as two weeks after they were smoked. They appeared and tasted as good as they did shortly after the smoking. The bacteria count probably increased, but after being boiled in water for 20 minutes they were still very tasty.

For experimental purposes some of this smoked fish was canned in half pound "c" enamel cans. Some of the fish was packed as whole fillets and others were cut up in container length pieces and then packed. In both cases the whiting was packed tightly. Cottonseed oil was poured over and around the fish. The cans were sealed cold under a vacuum of 15 inches of mercury and then processed for 70 minutes at 240°F. This product proved very tasty and retained its smoky flavor very well. Apparently, canning the smoked fish is a means of preserving the smoked whiting indefinitely.

CHEMICAL COMPOSITION

Analytical Methods

a. Oil

The whiting liver oil was extracted from the ground livers by cold ether extractions on a commer-

cial basis and on a laboratory scale. The ether was distilled from the oil-ether mixture, and the oil was used for the later vitamin studies. The livers contained 42 per cent oil, but only 31 per cent was obtained by the rough extraction.

The refractive index of the oil was 1.471 and the specific gravity was 0.920. The refractive index was taken at room temperature. The specific gravity was determined by weighing a very small tube filled with water and reweighing the same dry tube filled with the whiting oil.

b. Flesh

A moisture determination was made on the fish flesh using the method given by Bean (3). There was 81.3 per cent moisture on a wet basis. A soxhlet ether extraction of this sample showed the flesh to contain 2 per cent fat. A proximate analysis was made on a dry basis. The sample was prepared by eviscerating and beheading and cleaning the fish. The fish was then ground in a meat chopper and spread out in an oven at 100°F. to dry. When it was thoroughly dried, the fish was passed through a mill, after which it was ready for analysis.

The moisture, fat, nitrogen, ash, calcium, phosphorus, and potassium were determined by the official

Table II

Chemical Composition of Whiting Fish Meal

Moisture	5.55 per cent
Fat (Ether Extract)	9.73 " "
Protein	81.48 " "
Ash	5.29 " "
C_a O	0.32 " "
P_2 O_5	2.03 " "
K_2 O	1.76 " "

	Wet Basis	Dry Basis
Moisture	81.3 per cent	
Fat	1.99 " "	10.3
Protein	16.65 " "	86.27
Ash	1.07 " "	5.60
C_a O	.065 " "	.34
P_2 O_5	.416 " "	2.16
K_2 O	.36 " "	1.86

methods of the A. O. A. C. (2). The protein was determined by nitrogen times the factor 6.25.

Results of Chemical Study

The amount of oil present in the livers of the whiting warrant its extraction, even though it would be impossible to obtain 40 per cent oil from the livers. The physical constants of the oil that were determined compare favorably with those shown by Tressler (10).

The calcium and phosphorus contents of the fish meal were low but the amount of potassium salt present was exceptionally high. The protein content was also very high. By reference to Table II, it is noted that the total adds up to more than 100 per cent. This may be accounted for by a high protein due to variations from the factor 6.25. This may vary with different species of fish.

NUTRITIVE VALUE OF WHITING

Biological Assay of Vitamin A

The U. S. P. method of assay for vitamin A was used. Young albino rats not exceeding twenty-eight days of age and weighing between 40 and 50 grams are placed in individual cages and fed on a vitamin A

deficient diet and distilled water for the period of time necessary for them to manifest symptoms characteristic of vitamin A deficiency, namely xeropthalmia and loss of weight. This is known as the depletion period.

At the end of the depletion period, the diet of the rat is supplemented with the assay oil or other substance. The supplement is not to exceed 0.1 cc. if it is an oil. The rats are weighed three times per week during the assay period. The daily dose means six days out of a week. The potency of the assay material is judged by the gain in weight over a period of twenty-eight days - the assay period. The basal diet and salt mixture used may be found in Tables III and IV.

Determination of Vitamin A

During the canning experiments, the livers were removed from the viscera and saved for the vitamin assays. The whiting liver oil was obtained by cold ether extractions of the livers. For the remaining assays, flesh from the frozen whiting was used. The flesh had been set aside in a hardening room at approximately 0°F., and it was stored there between feedings. All rats used showed signs of xerophthal-

Table III

Basal Diet for Vitamin A Rats

Casein	18 per cent
Salt mixture	4 per cent
Yeast (Irradiated)	8 per cent
Starch	65 per cent
Vegetable oil (Crisco)	5 per cent

Vitamin D - not less than 3 U. S. P. units derived from irradiated yeast.

Table IV

Osborne and Mendel (11) Salt Mixture

$Ca\ CO_3$	134.8 grams
$Mg\ CO_3$	24.2 "
$Na_2\ CO_3$	34.2 "
$K_2\ CO_3$	141.3 "
$H_2\ PO_4$ (100 per cent)	119.3 "
H Cl (100 per cent)	166.9 "
$H_2\ SO_4$ (100 per cent)	9.8 "
Citric Acid (1 H_2O)	111.1 "
Ferric Citrate (1-½ H_2O)	5.7 "
KI	0.020 "
$Mn\ SO_4$	0.079 "
Na F	0.248 "
$K_2\ Al_2\ (SO_4)_4$	0.0245 "

"The available form of each chemical substance is taken in sufficient quantity to furnish the stipulated equivalent quantity of each chemical. The mixed carbonates and ferric citrate are added to the mixed acids. The specified quantities of KI, $Mn\ SO_4$, Na F, and $K_2\ Al_2\ (SO_4)_4$ are added as solutions of known concentrations and the resulting mixture is evaporated to dryness in a current of air at from 90° to 100° C and ground to a fine powder."

mia and loss of weight.

Flesh Assay

The first three groups to be considered are the assays made using varying amounts of the flesh from the frozen whiting.

The first group consisted of seven rats which at the end of their depletion period were given three grams of whiting flesh as a supplement to their vitamin A deficient diet. They were given this amount six times a week for 28 days and careful record was kept of their weight three times a week. One rat died shortly after the beginning of the experiment. The other six rats gained steadily. The average gain in weight for this group for the assay period was 39.3 grams.

The second group consisted of seven rats which were given one gram of flesh as a daily dose. Before the twenty-eight days had passed, two of these rats had died and the others had either remained at constant weight or else had lost weight. The average gain in weight for this group was 18.4 grams over the assay period.

The third group of rats was depleted and then given 0.5 gram of the whiting flesh as a supplement

to their basal diet. This daily dose of 0.5 gram was given to seven rats for twenty-eight days. All of these rats lived, but their average gain in weight amounted to only 14.4 grams. As in the previous case these rats also began to lose some of the weight they had gained. The rats all gained in weight steadily until the last ten days of the assay period when the weights began to decline.

These results indicate that there is very little vitamin A present in the flesh of the whiting. The little that is present is traced to the fat present in the tissues of the flesh. The oil equivalents of the flesh samples is given below:

3 gram flesh = .06 gram oil
1 " " = .02 " "
0.5 " " = .01 " "

It may be concluded that the flesh contains 2 U.S.P. units of vitamin A.

Vitamin A Present in Liver Oil

At the same time assays for vitamin A were completed, using the liver oil for the daily dose. Either salad or olive oil was used when a diluent was necessary.

The first group of seven rats was depleted and then given 0.1 gram of the whiting liver oil as a supplement. From the very beginning of the supplemented

diet, the rats started gaining weight rapidly. At the completion of the assay, the average weight of these rats amounted to 84.4 grams. Evidently the dosage was too high as the U. S. P. (11) places the average gain of the albino rats for the assay to be a minimum of 12 grams and a maximum of 60 grams. A comparison with the gain in weight of the reference assay oil also points to the over dosage of the whiting liver oil.

The next group of seven rats was placed on a supplemented diet of 0.01 gram of the oil. Practically the same situation was found in this instance as the average gain in weight of this group was 73.1 grams.

A third group of seven rats was given 0.002 gram of the whiting liver oil, and they also rapidly and steadily gained weight until at the end of the assay period, the average gain in weight was 77.7 grams.

To rectify this error, the next group of rats was given a daily dosage of only 0.005 gram of the oil, and the gain in weight in this instance was grams.

By studying Table V, it is noticed that the average gain in weight for the different levels was

Table V

Record of Vitamin A Results

Daily Dose	No. of Rats	Ave. Gain in Weight per sample	U.S.P. Units
Liver Oil			
0.1 gram	7	77.7	
0.01 gram	7	73.1	
0.002 gram	7	84.4	
0.0005 gram	7	16.0	2,772.
Flesh			
0.5 gram	7	14.4	
1.0 gram	7	18.4	2.0
3.0 gram	6	39.3	
Reference Oil			
1 U.S.P. Unit	7	23.0	

very nearly the same. This may be accounted for by the fact that if the rats are given a certain dosage of oil they will gain weight in proportion to the dosage up to a certain limit. Beyond this limit, a larger dose would fail to increase the rats' weight proportionately. A certain amount of the oil does the rat so much good and that is all it can handle regardless of added portions submitted in its feed.

The Table also discloses the potency of the whiting liver oil in comparison with the reference cod liver oil. It may be concluded safely that this assayed oil contains 2,772 Int. U. S. P. X. units per gram of vitamin A and is an excellent source of vitamin A.

NUTRITIVE VALUE

Biological Assay of Vitamin D

The U. S. P. (11) method of assay for vitamin D was used. Young albino rats at an age of twenty-one to twenty-eight days were provided with the rachitogenic diet and distilled water only, for what is called the depletion period. The diet used for these rats consisted of:

Yellow Corn	76 per cent
Wheat Gluten	20 " "
$Ca\ CO_3$	3 " "
$N_a\ Cl$	1 " "

No other dietary supplement was fed to the animals until they had developed severe rickets. The rickets were manifested by enlarged joints and a peculiar wabbly gait. This condition is usually noticed in from eighteen to twenty-four days.

When the rats developed severe rickets, their diet was supplemented by 0.1 cc. of the oil being assayed. This oil may be diluted by any edible vegetable oil which contains neither vitamins A nor D. Each rat was fed a daily dose of the assay oil for eight days. On the ninth and tenth days, the rats were fed only their basal diet. On the eleventh day, the rats were killed, and their tibias removed. These were placed in formaldehyde until ready for examination. At this time the bones were cleared of adhering tissues, and a cross section of the joint was exposed by cutting with a razor. These bones were then cleansed in distilled water and placed in acetone for three minutes and then dipped in silver nitrate for one minute. The bones were then exposed to a strong light until the calcified areas had developed a

clearly defined line. After developing, the bones may be placed in some sodium thiosulphate to wash off the excess silver nitrate. Examination for calcification and recording of results was the last step of the procedure.

The degree of calcification of the rachitic metaphysis of the bones by the line test is usually recorded in one of the following degrees:

Negative = no calcification

Traces = bones showing only traces of calcification

1 - = bones showing a broken line of calcification

2 - = bones showing a narrow continuous line of calcification

3 - = bones showing a broad continuous line of calcification

4 - = bones showing no uncalcified areas - healing

The liver oil used for the vitamin D assay was the same as that used for the vitamin A assays. The body oil was extracted from the flesh in the same manner as that extracted from the livers. All the oils were diluted with salad oil in the correct proportions to satisfy the required amounts of feeding.

The first two assays were on the whiting body oil. Six rats were used for each of these assays. One-tenth of a gram of the diluted oils was fed to the rats as a supplement for the first eight days. The first six rats were each fed 0.5 gram of the whiting body oil in the eight days. The 0.1 gram fed to them daily contained 0.0625 grams of the oil being assayed. The second group of rats were fed a total of 0.05 gram in the eight days. Their daily dose actually amounted to only 0.00625 gram of the whiting body oil.

The results of these assays showed that all of the rats in the first group showed a four plus calcification. Of the six rats recorded in the second group, three of them showed a three plus calcification, and three of them showed a two plus calcification. The results and weights of the rats on this assay for vitamin D are found in Tables VI and VII.

One reference group was used for both body and liver oils. Six rats were in this group, one dying on the eighth day of the assay period. They were fed a total of 1 gram or 95 International Units during the assay period.

When the tibias of these rats were developed,

three of the rats showed three plus calcification and three of them showed two plus calcification. It will be noticed that the results of the lower level of the body oil compares favorably with the results of the reference oil just given. The weights of the rats and the results of the calcification may be found in Table VIII.

Liver Oil

The next assay for vitamin D was on the whiting liver oil. Three groups of six rats each and one group of seven rats were used for this assay.

The first of these groups was fed a total of 0.5 gram of the whiting liver oil in eight days. The rats were fed 0.1 gram of the diluted oil daily but were actually receiving only 0.0625 gram of the liver oil daily. All six rats of this group showed four plus calcification of radii and ulnae.

The second group of rats was fed a total of 0.1 gram of the whiting liver oil during the assay. The 0.1 gram of diluted oil fed daily to these rats contained only 0.0125 gram of the oil being assayed. One of the rats died on the fifth day.

The results recorded were: four of these rats showed four plus calcification, and one rat showed

three plus calcification of radii and ulnae.

The third group of rats on the liver oil was fed 0.01 gram in the eight days. Although 0.1 gram of diluted oil was fed daily, only 0.00125 gram of the whiting liver oil was included in this daily dose. One of these rats died on the fifth day.

Of the five rats in this group, four of them showed four plus calcification and one showed three plus calcification.

The fourth group of rats on this vitamin D assay also was on whiting liver oil. The seven rats were each fed 0.1 gram of diluted oil daily. This included 0.000625 gram of the whiting liver oil.

The total dose of liver oil per rat amounted to 0.005 gram during the assay. All of the rats on this assay showed four plus calcification.

The weights of the rats and the results of these vitamin D assays on the whiting liver oil may be found in Tables VIII, IX, X, XI.

Summary of Vitamin D Assays

A careful study of Tables VI, VII, XII shows that the body oil of the whiting contains approximately the same amount of vitamin D as the reference cod liver oil.

Table VI

Vitamin D in Whiting Body Oil
.05 grams

Initial Weight of Rats grams	Final Weight grams
66	71
54	59
59	69
56	57
58	62
60	65

Results: 3 rats showed a 2+ calcification
3 rats showed a 3+ calcification

Table VII

Vitamin D in Whiting Body Oil
0.5 gram (level)

Initial Weight of Rats grams	Final Weight grams
59	65
68	65
60	65
67	74
56	56
62	64

Results: All rats showed a 4+ calcification

Table VIII

Vitamin D in Whiting Liver Oil
.01 gram daily dose

Initial Weight of Rats grams	Final Weight grams
46	49
60	73
55	64
54	(44) died on 5th day
57	67
48	53

Results: 1 rat showed a 3+ calcification

4 rats showed a 4+ calcification

Table XII

Vitamin D Reference Cod Liver Oil
95 units per gram

Initial Weight of Rats grams	Final Weight grams
48	52
63	69
52	58
58	63
55	Died on 8th day
60	67

Results: 2 rats showed a 2+ calcification

3 rats showed a 3+ calcification

Table IX

Vitamin D in Whiting Liver Oil
0.1 gram level

Initial Weight of Rats grams	Final Weight grams
57	61
60	56
59	68
58	62
53	58
61	Died on 5th day

Results: 1 rat showed a 3+ calcification

4 rats showed a 4+ calcification

Table X

Vitamin D in Whiting Liver Oil
0.5 gram daily dose

Initial Weight of Rats grams	Final Weight grams
54	54
50	53
56	66
54	67
59	61
54	62

Results: All rats showed a 4+ calcification

Table XI

Vitamin D in Whiting Liver Oil
0.005 gram level

Initial Weight of Rats grams	Final Weight grams
74	76
86	96
89	101
90	106
82	93
82	90
84	98

Results: All rats showed a 4+ calcification

The whiting liver oil apparently is a much better source of vitamin D than is the body oil. With the results of the lowest level of the whiting liver oil still poorer than those of the Reference oil, it is safe to assume that the liver oil is even more potent than the amount recorded. It may be concluded that the whiting body oil contains approximately 100 U. S. P. units per gram, and that the whiting liver oil contains more than 200 U. S. P. units per gram.

Discussion

After this investigation relative to the use and nutritive value of the whiting, it is obvious that the use of the frozen whiting for manufactured products is practical. All these experiments were made with the frozen fish which indicates that the same products made with strictly fresh fish would give fully as satisfactory results.

The methods of canning used illustrate possibilities for commercial whiting products. The chowder was average in quality but probably would be better if made from fresh fish.

The whiting canned in tomato sauce and processed at 212°F. was very good. The tomato sauce was not scorched, and added moistness and pleasant flavor to the canned product. Incubation and bacterial tests indicate that the thermal treatment is adequate.

The spiced fish did not show the same promise but possessed distinct commercial possibilities. It can be made into a product resembling "roll mops". The fish cakes made during this investigation were attractive and white, and should meet readily with the public's approval.

Smoking fish is an old business, and other whiting

have been smoked, but the satisfactory use of this method of preservation can not be overemphasized. Undoubtedly many people would purchase such a product, were it commercially available. The development of smoked fishery products has merely begun. The fresh smoked whiting fillets or flakes canned in cottonseed oil is also a very palatable product which should become poplular. The smoked whiting of this investigation were attractively colored, and when they were prepared by one of the many recipes offered in cook books or elsewhere, they were made into tasty and very good dishes. The canned smoked product retains its smoky flavor and firmness, and due to its being canned for future use, it should have much promise as a merchandising product.

The vitamin studies of the whiting indicate the value of whiting liver oil as a valuable source of vitamins A and D. A comparison of these values with those of other fish oils point very favorably to the use of this oil. The small size of the fish is a practical obstacle to be overcome.

Although the proximate analysis showed that the flesh of the whiting was low in two important minerals, calcium and phosphorus, the flesh is an excellent source of potassium and of protein, and together with the amount

of oil present in the flesh make a combination of high nutritive value. While the biological value of the protein of whiting has not been determined, it probably compares favorably with that of haddock.

SUMMARY

1. Review of the literature shows that there is very little published information on the composition and utilization of the Atlantic whiting.

2. The preservation of whiting by means of freezing, canning and smoking is considered and the various processes which were investigated are described.

3. Smoking was found to be the most satisfactory method of processing the whiting from the standpoint of palatability. Of the canned products tested, smoked whiting canned in oil, fish chowder, fish cakes, and whiting in tomato sauce, were outstanding.

4. A proximate chemical analysis of the edible whiting flesh (moist basis) showed it to contain 81.3 per cent moisture, 1.99 per cent fat, (ether extract), 16.65 per cent crude protein and 1.07 per cent ash. Compared with white fish meals (those made from haddock and cod) the whiting is much higher in protein and fat, but is lower in ash. The ash is low in calcium

and phosphorous content but is high in potassium.

5. The livers contain between 30 and 42 per cent oil. Biological assays show this oil to contain over 200 U. S. P. units of vitamin D per gram. The liver oil is also rich in vitamin A.

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