MFR PAPER 1312

# Charles Woods, Pioneer Scientist on Chemical Composition of Fish

MAURICE E. STANSBY

The first substantial contribution to fishery technology in America was the determination of the proximate chemical composition of most commercially important American species of fish by workers at Wesleyan University, Middletown, Conn., in the laboratory of W. O. Atwater. Today, these results are still the basis for most tabulations in reference works on the protein, fat, and ash content of American food fish. Although the work was conducted nearly a century ago, the analytical work was carried out in a most meticulous way using methods completely compatible with our modern knowledge.

This work has always been attributed to the great American pioneer in agricultural science, W. O. Atwater, under whose sole authorship the results of the work were published. Through the relatively recent availability of correspondence between Atwater and his assistant, Charles Woods[1], it is now apparent that not only the carrying out of most of this work but also much of its planning, as well as the research to adapt analytical methods to analysis of fish, and the writing of the research reports were done by Woods at Wesleyan University during a time when Atwater was on an extended detail to European universities. Much of the credit for this work, therefore, belongs to Woods rather than Atwater. This report documents these facts and includes some of the early background of the then Federal fishery agency which sponsored this research.

In 1871, the first Federal fishery activity began as the U.S. Commission of Fish and Fisheries under the direction of Spencer Fullerton Baird, "In his time perhaps the most representative man of general science in America" (Anonymous, 1920). Baird, without any facilites for carrying out fishery research, set up temporary summer field stations each year at a different locality. In 1878, such a station was established for the year in Gloucester, Mass. (Baird, 1880), and efforts were channeled toward the problems of processing and marketing of fish. For example, Baird interested W. G. Furlow, noted scientist at Harvard University, to look into the causes of red discoloration of salt cod. Within a few weeks, Furlow was able to show that this condition was caused by a microorganism present in the salt, and he prescribed ways for cleaning the salt fish processing plants and then, using uncontaminated salt, to prevent further discoloration (Furlow, 1880).

Noting the complete absence of information on the chemical composition of fish, Baird induced W. O. Atwater, Professor of Chemistry at Wesleyan University, to visit the Gloucester station and interested him in looking into ways that such an investigation might be undertaken. By early 1879, the U.S. Fish Commission had found funding and arranged for Atwater's laboratory to carry out such an investigation. Collection of fish samples took place during 4 years (1879-82) with 80 percent of them being taken in 1881 and 1882. Analyses continued into 1883. Although several progress reports of the work appeared in the Report of the U.S. Commissioner of Fish and Fisheries between 1880 and 1885, the final report was not published until 1892 (Atwater, 1892).

Atwater, in the initial stages of the work, assigned the analyses of the fish samples to seven students, one of whom, Charles D. Woods, began in 1879 while still a senior student at Wesleyan University. Upon his graduation in June 1880, Woods was employed as a full-time assistant to Atwater and thereafter carried out most of the proximate composition analyses of the fish specimens which were completed in 1883. He thus was involved during analyses of nearly 90 percent of such work. During the numerous absences of Atwater from Wesleyan University and especially during Atwater's 15-month stay in Europe, from June 1882 to September 1883, Woods, while acting in charge, conducted a voluminous correspondence with Atwater setting down in considerable detail the activities at Wesleyan University. Thanks to the Cornell University Collection of Regional History and University Archives (footnote 1), this correspondence is available on microfilm. A total of 46 letters from Woods to Atwater and 20 letters from Atwater to Woods are included in these records, and they give an excellent picture in great depth as to the conduct of this early investigation on composition of fish.

## WOODS' EARLY LIFE

Charles D. Woods was born in Brooks, Maine, in 1856. He received his early education at schools in Maine and later, in Massachusetts, after his family had moved to Newton, Mass. In 1876 he entered Wesleyan University. Following his graduation from Wesleyan in June 1880, he was employed

*Maurice E. Stansby is with the Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Boulevard East, Seattle, WA 98112.*

[1]W. O. Atwater Papers, 1876-1892. University Archives, Cornell University, Ithaca, N.Y.

Charles Woods in 1880 when he was beginning his work on proximate composition of fish at Wesleyan University.

by Atwater. As a full-time assistant to Atwater after June 1880, Woods spent much of his time on the fish composition project. Only seven letters from Woods to Atwater covering the period from 1879 to mid-1882 are available to tell us only that he was working on the fish investigation, at first while still a senior as one of several students and later as the only one.

Atwater made a 15-month trip to Europe from 29 June 1882 to about September 1883 (Maynard, 1962). During this trip, he spent several months each in laboratories of noted German investigations in the food science field (such as that of Voit at Munich). During his absence, he left Woods to act in his place. These duties included giving lectures in chemistry, conducting chemical laboratory courses, and continuing research on foods, especially fish composition. The fish investigation at the beginning of this period included determination of the composition of many of the fish samples collected in 1882. When this was completed, the results were tabulated. Where, in some cases, results obtained during earlier stages of the work (often by undergraduate students) appeared not to be in line with those of the majority of similar samples, repeat analyses were made. From the correspondence during this period it was obvious that Woods had not only carried out the regular analyses but had also conducted much corollary research on adapting methods to peculiar problems arising during the fish analysis.

During the period from June 1882 to September 1883, while Atwater was in Europe and Woods was at the critical stage in winding up the work on the fish analysis, he was completely on his own with regard to decisions about which direction the fish project should go. In several instances Atwater did not answer Woods' letters for weeks at a time and when he did, failed to comment on vital issues needing decisions.

Furthermore, Woods failed to receive his salary from Atwater on anything like a regular basis. In his letter to Atwater dated 28 November 1882, Woods writes, "Time moves on and you do not write. It is now some four to five weeks since I have heard from you. I received a letter from Mr. Voorhees in which he said, 'You do not mention Professor Atwater, is he dead?' I do not know how to answer him. I do not suppose an affirmative would be the truth, but my evidence for the negative is slight. But seriously, there are many little matters concerning which I expected answers long ago. I have no instructions from you as regards finance. There are those food and plant bills that I am so weary of . . . As regards the money, my due, I say nothing because you know as well as I do that I have use for it and expected to receive it quarterly and on time. It will very seriously inconvenience me if you do not make an arrangement for paying me at least by January 1."

This matter of recompense for Woods is a key item in the subsequent developments and it is necessary to understand it to see how the completion of the entire project was greatly delayed and how Woods' name never became associated with the research.

Atwater was a member of the faculty at Wesleyan University and as such his salary was paid by the college. He had a budget for his research on foods which he used for many purposes. For the most part, during the period from 1880 when active work on the fish project got fully underway and he hired Woods as an assistant, the salary of Woods came from the grant from the Federal agency sponsoring the work (U.S. Commission of Fish and Fisheries).

When Atwater was away in Europe for the 15-month period, all of the work that Atwater and Woods had previously carried out fell upon Woods. Furthermore, since Woods had no assistant he put in long overtime hours on the fish investigation and he had a verbal agreement with Atwater that he would be paid separately for this overtime on an hourly basis. The quarterly payments for Woods' main salary often did not arrive from the government on time and Atwater kept deferring payment on the overtime for the fish work.

As the end of Atwater's detail to Europe approached during late spring of 1882 the financial picture for Woods became so acute he finally sought other employment. Atwater was unable to give any assurance that Woods' position would extend beyond 30 June 1883, and as it turned out, the support from the U.S. Commission of Fish and Fisheries ceased as of that date. Woods secured an appointment as teacher of science at the Wesleyan Academy at Wilbraham, Mass., in September 1883.

Atwater returned to Wesleyan University at the conclusion of his 15-month sojourn in Germany at the end of September 1883. Upon his return he paid Woods his long overdue regular salary (at a rate of something under $1,000 per year). He had apparently indicated he would pay for the overtime work on the fish project as the work progressed, but later, while still abroad, when pressed by Woods indicated he would settle the matter upon his return from Europe. Yet as late as November 1883, Woods was writing from his new teaching post at Wilbraham requesting payment. The actual amount was only about $100 but at $0.25 per hour as had been agreed, this represented about 400 hours of time. Woods wrote to Atwater from Wilbra-

ham on 5 November 1883: "I have only a minute to remind you that I wrote you a week ago in reference to the money I am due from you. I would like the whole of it ($101.67) or if that is not convenient, I could get along with $50. Hope to hear from you at once as this is of importance to me, for if I cannot have it from you I must raise it elsewhere."

## PREPARING FOR PUBLICATION

There is no evidence in subsequent correspondence that this matter was ever resolved. Atwater was unable to prepare the fish work for final publication. He could not do so because much of it was done by Woods while he (Atwater) was in Europe. Yet for reasons unclear from available correspondence, he never paid for the overtime work on this project conducted by Woods.

Atwater tried to get Woods to spend his holiday time at Thanksgiving and Christmas in helping him learn about the fish program. At first Woods had indicated that this might be possible but when it appeared that he was never to be paid for the work that he had done nor was his name to appear as an author on any publication that might result, he put Atwater off with regard to such holiday work. Then on 17 December 1883, he wrote to Atwater: "I have been obliged to change my plans somewhat about Christmas and will not be able to go to Middletown (site of Wesleyan University) as I had expected."

Woods might well have overlooked the failure to pay him for the overtime he spent on the fish composition project if he were to have been promised a junior authorship. On several occasions he wrote suggesting such an arrangement. For example, on 1 October 1883, he wrote to Atwater from Wilbraham saying: "In looking over the notebooks I find that there is a vast amount of material there that I think no one but myself would be able to decipher . . . Now I do not feel like taking the time that is necessary in collecting and arranging this material for the mere pleasure of doing it . . . What I would propose would be we publish it as the work of Professor Atwater and Mr. Woods and everyone would know that you did the brain work and that I did the work in detail, i.e., the analytical work, and it seems to me that that is about the way it was done." Nevertheless, Atwater could not bring himself to agree to such a solution to the problem. Several years passed with nothing being done. Atwater received several critical letters from the U.S. Fish Commission about the long delay in publication of the final research results, research for which they had paid most of the cost.

The deadlock was apparently broken by a letter which Woods wrote on 15 May 1887 from Wilbraham to Atwater which included the following paragraph:

"As regards the old difficulty arising from our investigations, was in hopes that had been finally settled. Wish that you would feel that in that matter, I would be only too glad to help you in any way that you think I can, and that you have but to ask at any time, and I will do all in my power to assist you. If you think that my presence in Middletown would be of the least benefit, I will come if possible. Have been wanting to see you for some time but have not seen it in my way to do so "

Shortly thereafter Woods did go to Middletown and spent a great deal of time in putting together the 189-page final report (Atwater, 1892) which was published in 1892 in the Report of the Commissioner of Fish and Fisheries for 1888.

It is to be noted that Atwater is given as the only author of this report. In consequence, over the intervening years all credit for this work has gone to Atwater, and Woods' connection with it is virtually unknown.

A careful reading of the introduction to the final report, however, comes close to revealing the true situation. Atwater states:

"Although the work has been constantly under my immediate supervision and much of it has been done by myself, the largest part of the details have been skillfully and faithfully performed by my assistants, Messrs. G. P. Merrill, W. H. Jordan, J. H. Long, Miles Beamer, E. B. Vorhees, E. W. Rockwood and especially C. D. Woods. The last-named gentleman has performed the larger portion of the work of the analysis and calculation of the results besides contributing very materially to the elaborating of the methods of analysis and assisting in other ways including the preparation of diagrams and reading of proofs."

Charles Woods at the height of his career as Director of the Maine Agricultural Experiment Station (about 1915).

## EXTENT AND IMPORTANCE OF FISH COMPOSITION REPORT

The final report of the Fish composition studies published in 1892 are the most extensive ever undertaken. The main part of the investigation, carried out primarily by Charles Woods, covered proximate analysis (fat, moisture, protein, and ash content) of 53 species of fish and 11 species of mollusks and crustaceans. The 189-page report contains 87 pages of tabular data. The coverage of various species includes most of the ones which are still of major commercial importance in the New England, middle Atlantic, and Great Lakes fisheries. Coverage of species in the south Atlantic and Gulf of Mexico areas is limited and only two species, one tuna and one salmon, are included for Pacific Coast fishes.

It might appear that the analytical chemical methods used in the 1880's would be inadequate and that the results thereby might be of little value today. This is definitely not the case. The method used for determination of ash content was identical to that used today. The methods for fat and moisture were equivalent to present-day practice. These components were determined by drying in an atmosphere of hydrogen (probably superior to modern-day practice of vacuum drying where the vacuum is not always as high as desirable) with fat extraction being carried out with ethyl ether, as is done in modern-day methodology. Protein was determined by multiplying nitrogen content by 6.25 (exactly as is done today) but the nitrogen content was determined for most of the samples by heating with soda ash to release the nitrogen rather than by the modern-day Kjeldahl method. The Kjeldahl method for nitrogen determination was published first in 1883, the year that the analyses of the last of the fish composition samples was completed. However, spot check analyses of many of the samples were later made in Atwater's laboratory by the Kjeldahl method and essentially identical results obtained. By 1889, the Kjeldahl method had replaced the older soda lime method for nitrogen in Atwater's laboratory.

The one serious limitation on the results reported in this paper was the fact that the investigators apparently failed to recognize the fact that there is a very wide variation from one season of the year to another in fat content of the high oil content species. The number of individual fish of each species used in the analyses, ordinarily collected together at one time for this work, usually were not more than five. Accordingly, in the case of the fat types of fish—about eight species (12 percent of the total species analyzed)—the fat content reported would have little meaning.

The values for proximate composition as reported by Atwater in 1892 have been widely quoted and still are to be found in numerous food charts and tables in reference works on the proximate composition of fish.

In addition to the results on fat, moisture, protein, and ash (the work which was carried out largely by Charles Woods), the report contains analyses of both the sulphur and phosphorous content of many of the species. Also, there is a short section of the report dealing with digestibility and calorific value of fish. Although these latter data are limited, they still constitute a large part of what is known on this subject. The work involving determination of digestibility and calorific value was the part of the report in which W. O. Atwater himself was the one actually involved. Some of the work was done in Europe at the time (1882-83) when he visited food laboratories in which such work was underway. Especially the energy value reported was work carried out at Middletown, Conn., after Atwater's return. This work involved use of special calorimeter equipment devised by Atwater.

## LATER CAREER OF CHARLES WOODS

Although Charles Woods never received proper credit for his work on the fish composition research, Atwater was instrumental in securing for him the post of Vice Director of the Storrs Connecticut Agricultural Experiment Station in 1888. The Connecticut Agricultural Experiment Station was the first such station established in this country. Woods remained in this position until 1896 and was in close touch with Atwater during this period. The Atwater correspondence shows that their reconciliation was complete. At one time Woods and Atwater spent some time together visiting several European laboratories.

In 1896, Woods was appointed Director of the Maine Agriculture Experiment Station, a position which he held until 1920. He was also Professor of Agriculture at the University of Maine and in 1905 received a Doctor of Science degree from that university. During his long tenure in Maine, he built up the Agriculture Station into a vast empire having research in fields well beyond the limits ordinarily covered in such an activity

During his tenure at Maine, Woods' personality evidently changed markedly from the retiring, diffident attitude he displayed at Wesleyan University under Atwater to a forceful individual apparently somewhat resembling Atwater. Although he left the Maine Agriculture Experiment Station Directorship post in 1920, he is still remembered today as the "Bull of the Woods," as he had been called. He had the reputation of being a "very good" man yet one who was willing, if necessary, to push aside all opposition to his plans in order to attain his objectives.

After leaving Maine he returned in 1920 to Newton, Mass., where his parents still resided and was employed as a Food Information Director at the Massachusetts Agriculture Department. He died in Newton in March 1925.

## LITERATURE CITED


Anonymous. 1920. Baird, Spencer Fullerton. Encycl. Br.

Atwater, W. O. 1892. The chemical composition of nutritive values of food-fishes and aquatic invertebrates. U.S. Comm. Fish Fish., Rep. Comm. 1888, p. 679-868.

Baird, S. F. 1880. Inquiry into the history and statistics of food-fishes. U.S. Comm. Fish Fish., Rep. Comm. 1878, p. XXI-XXIV.

Furlow, W. G. 1880. On the nature of the peculiar reddening of salted codfish during the summer season. U.S. Comm. Fish Fish., Rep. Comm. 1878, p. 969-974.

Maynard, L.A. 1962. Wilbur O. Atwater - A biographical sketch. J. Nutr. 78:3-9.



*MFR Paper 1312. From* Marine Fisheries Review, *Vol. 40, No. 7, July 1978. Copies of this paper, in limited numbers, are available from D822, User Services Branch, Environmental Science Information Center, NOAA, Rockville, MD 20852. Copies of* Marine Fisheries Review *are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 for $1.10 each.*