

PPN 05566-1165

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BFL - Bericht 3/1973

ELECTRICAL (AC) RESISTANCE OF IRRADIATED FISH -  
QUALITY CONTROL AND DETECTION OF IRRADIATION TREATMENT

Final Report to the International Atomic Energy Agency,  
Vienna on Research Contract No. 929/R1/RB for the Period  
1 October 1970 - 30 September 1972

by

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BFA für Ernährung und Lebensmittel  
Bibliothek Karlsruhe



Ka51\$0003567X

Bundesforschungsanstalt für Lebensmittelfrischhaltung  
Karlsruhe  
April 1973

Bundesforschungsanstalt  
für Ernährung  
75 Karlsruhe 1, Engesserstr. 20

INVENTAR N. Be 2283

Ehlermann, D.

Electrical (AC) Resistance of Irradiated Fish. -  
Quality Control and Detection of Irradiation Treatment.

BFL - Bericht 3/1973

Keywords: Fish, Electric conductivity, Irradiation Treatment  
Detection, Quality Control, Fish-Tester

Summary:

Irradiation of fish with doses of 200 krad and higher causes an alteration of the electrical properties of the tissue. The quantity "Q-value" calculated from impedance measurements at higher frequencies (16 and 100 kHz) are not influenced by an irradiation treatment and are a measure of the true storage time of the fish. The Q-values obtained at lower frequencies (1 and 16 kHz) are rather dose sensitive and can be used to identify fish irradiated with doses above 200 krad if the true storage time is known from measurements at the higher frequencies. However, impedance measurements on single fish have little significance. Because of biological variations, the decision of whether or not a particular batch of fish has been irradiated can only be made on the basis of measurements on a sufficiently large number of samples.

Ehlermann, D.

Der Wechselstrom-Widerstand von bestrahltem Fisch.-  
Eine Methode der Qualitätskontrolle und zum Nachweis einer  
erfolgten Bestrahlung

BFL - Bericht 3/1973

Schlagworte: Fisch, Elektrische Leitfähigkeit, Strahlenbe-  
handlungsnachweis, Qualitätskontrolle, Fisch-  
Tester

Zusammenfassung:

Durch eine Bestrahlung von Fisch mit Dosen von 200 krad und höher werden die elektrischen Eigenschaften des Gewebes verändert. Eine Größe "Q-Wert", die aus Impedanz-Messungen bei höheren Frequenzen (16 und 100 kHz) berechnet wird, ist weitgehend unabhängig von einer etwaigen Bestrahlung; sie ist ein Maß für die Lagerungszeit von Fischen. Bestimmt man den Q-Wert dagegen bei niedrigeren Frequenzen (1 und 16 kHz), so ist er sehr gut für den Nachweis der erfolgten Bestrahlung und auch der angewendeten Dosis geeignet, wenn man die Lagerungszeit aus den Messungen bei höheren Frequenzen kennt. Messungen an einzelnen Fischen haben keine Aussagekraft. Wegen der biologischen Schwankungen muß der Nachweis einer erfolgten Bestrahlung auf einen Stichprobenumfang von ausreichender Größe gestützt werden.

Acknowledgement:

I wish to thank the International Atomic Energy Agency for supporting the reported work by Research Contract No. 929/R1/RB for two years. Only with that help a technical assistant could be employed exclusively for that project.

The laborious measurements and the tiresome preparations of data for computer evaluation were done by Mrs. E.Kranz. I thank her for her efforts and her patience.

I wish to thank the Bundesforschungsanstalt für Fischerei, Hamburg, for the opportunity to participate in the 45th voyage of the fisheries research ship "Walther Herwig". I am especially indebted to Prof. Feldt, scientific head of that voyage, and his participating collaborators for their support during the journey. I thank also the crew of the ship not only for the nice days onboard but also for the many little but important aids.

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## 0. Introduction

As a part of the worldwide efforts to introduce irradiation as a further method for better preservation of the limited food resources, the Federal Republic has created the Institute of Radiation Technology, one of three institutes constituting the Federal Research Centre for Food Preservation in Karlsruhe. It is a part of the portfolio of the Federal Minister of Nutrition, Agriculture and Forestry. Originating from that fact it has likewise the duty to advise the government in provisions of consumer protection.

Since the inauguration of the Institute at the time of the IAEA Symposium on Food Irradiation in 1966 at Karlsruhe (1), the Institute contributed results both on basic and applied aspects of the irradiation of many food items. With relation to fish, changes in the microbial flora, effects on chemical quality indices, and sensory evaluation were studied in several fish species. Under the auspices of EURATOM (2) some studies were conducted on the identification of irradiated foodstuffs. The research contract on "Electrical (AC) Resistance of Irradiated Fish", granted by the IAEA fits very well the scope of studies conducted at the Institute of Radiation Technology.

The "Fish-Tester" manufactured by Intelectron, Hamburg, Fed. Rep. of Germany, was invented in 1962 by Hennings (3) who was at that time an employee of the Federal Research Centre of Fisheries in Hamburg. It has since been used by several veterinary offices at fisheries' ports (4). At the Torry Research Station a modification is being developed (5, 16) to account for storage conditions in Great Britain. In a series of shipping studies with irradiated fish in the USA, the apparatus has been used to control the initial quality and freshness of fish before irradiation (6).

The research project under the IAEA-granted contract was undertaken to follow up on some preliminary experiments carried out in this Institute which had shown an influence

of irradiation on the readings of the "Fish-Tester".

The object of the research contract agrees with the recommendations of a Panel on the Irradiation Preservation of Foods of Marine Origin (7) which had suggested more efforts in the research on new quality indices of fresh fish, as the methods commonly used were not very reliable, especially after irradiation of fish.

## 1. Scientific Background and Scope of Project

### 1.1 Electrical Properties of Fish and Fish Tissue

Tissue generally consists of cell liquid, cell membranes, interconnective tissue, and intercellular liquid. As early as since 1916 the fact was known that the state of conservation of a plant cell can be indicated by an alternating current (ac) measurement (8). The origin of the capacitive part of the ac resistance has been attributed to the cell membranes and to the protoplasm (9). Likewise the observed behavior of the ac resistance of animal tissue may be explained. However, it is still being discussed whether that capacitive part might be due to the membranes or the protoplasm. Hennings tended to attribute the capacitance of tissue to the membranes. Membranes have the property of ion exchange, i.e. the capability to retain or to deliver certain ions selectively. As ions carry a certain charge a total charge is kept on the membranes. That fact is equivalent to capacitance when expressed in terms of theory of electricity. A similar explanation may be suitable for an assumed capacitance of the protoplasm as a certain ion binding capacity or even a polarization ability could easily be ascribed.

For the further considerations we may take membranes: After death of the organism the cell membranes gradually loose