

THESIS



A STUDY OF THE PRESENT AND POTENTIAL APPLICATION
OF ANTIBIOTICS IN FOOD PRESERVATION

by

Robert J. Dunn

AN ABSTRACT

Submitted to the College of Business and Public Service
of Michigan State University of Agriculture and
Applied Science in partial fulfillment of
the requirements for the degree of

MASTER OF ARTS

Department of Marketing and Transportation Administration
Curriculum in Food Distribution

Approved

E. A. Brand

Robert J. Dunn

The strain on world food resources brought about by a rapidly increasing population, coupled with excessive food spoilage losses, create demands upon technologists of the world to develop more efficient methods of preserving and marketing food. This thesis embraces the present and potential uses of antibiotics as food preservatives.

The method used to develop this topic was primarily a review of literature on many aspects of antibiotics: history, mode of action, medical and legal implications, and application to food preservation. Correspondence with workers in the fields of experimentation, production, and sales of antibiotics, and with an authority in food retailing, brought responses of particular importance to this thesis.

The majority of antibiotics are bacteriostatic in nature, while some exhibit anti-fungal properties. As food preservatives, they can delay only that spoilage caused by bacteria or fungi. They have no effect upon spoilage caused by chemical, enzymatic, oxidative, or autolytic activity. For the permanent preservation of foods, antibiotics must be used in conjunction with established methods of sterilization such as heat, refrigeration, antioxidants, or possibly with some of the more recent experimental methods such as atomic radiation, ultrasonic radiation, microwave heating, or freeze-drying.

Experimentation and commercial application of antibiotics has been directed primarily at short-term preservation of highly perishable foods such as meat, fish, poultry, fresh vegetables, and cheese. Antibiotics, when used in conjunction with refrigeration, have extended storage life of fresh poultry meat approximately one week. The storage life of fresh fish held in antibiotic-containing ice can be extended one week or more.

Fresh beef treated with antibiotics can be stored for as long as nineteen days at room temperature without spoiling. In areas where refrigeration facilities are unavailable, antibiotics could revolutionize meat distribution. More rapid tenderization of meat can be accomplished by permitting storage at room temperatures immediately after slaughter.

Experimental preservation of green leafy vegetables by pre-and post-harvest applications of antibiotics has proven effective in adding from one to three days to refrigerated storage life. Commercial application of antibiotics to these foods is hampered by the presence of residues when the food is consumed. Water rinses after treatment may overcome this problem. Such applications may depend upon the discovery of new antibiotics which are not harmful to the human body and are not used in human medicine.

Subtilin and nisin have shown some promise in reducing the time and temperature necessary to sterilize foods by heat. However, neither antibiotic has exhibited the ability to produce complete destruction or permanent inhibition of food poisoning organisms. Nisin has also proved effective in preventing defects in processed cheese.

The future of antibiotics in food preservation lies with the ability to adapt these substances to processes involving many different kinds of preservation techniques, each acting upon one type of food spoilage.

The Curriculum in Food Distribution at Michigan
State University is under the sponsorship of
the National Association of Food Chains

**A STUDY OF THE PRESENT AND POTENTIAL APPLICATIONS
OF ANTIBIOTICS IN FOOD PRESERVATION**

by

Robert J. Dunn

A THESIS

**Submitted to the College of Business and Public Service
of Michigan State University of Agriculture and
Applied Science in partial fulfillment of
the requirements for the degree of**

MASTER OF ARTS

**Department of Marketing and Transportation Administration
Curriculum in Food Distribution**

1958

ACKNOWLEDGMENTS

The writer wishes to express his appreciation to Dr. E. A. Brand, Director of the Food Distribution Curriculum at Michigan State University, for his interest and guidance during the school year and in the preparation of this thesis.

Grateful acknowledgement is extended to The Grand Union Company, and particularly to Mr. Lloyd W. Moseley, Vice President in Charge of Personnel, and to Mr. Charles W. Garrett, Personnel Manager of the New York Region. Without their aid and assistance, the author's attendance at Michigan State University would not have been possible.

Some of the material presented in this thesis was provided by the following organization: The American Cyanamid Company, The Chas. Pfizer Company, and The National Canner's Association. The author is extremely grateful for their assistance.

There are no words to express the gratitude the writer feels toward his wife for her encouragement, hard work, and tireless energy in typing this thesis.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION	1
Prediction of World Population	1
World Food Supplies	3
Waste in Food Marketing	5
Brief History of Food Preservation	7
Antibiotics in Food Preservation	11
II. THE NATURE AND ACTION OF ANTIBIOTICS	13
Definition and Sources of Antibiotics	14
Mode of Action and Limitations of Antibiotics	16
Application of Antibiotics to Food	18
Brief History of Antibiotics	19
Medical Aspects of Antibiotics in Food	21
Legal Aspects of Antibiotics in Food	24
Economic Aspects of Antibiotics in Food Preservation	26
Summary	28
III. MEAT AND FISH PRESERVATION WITH ANTIBIOTICS	30
Spoilage of Meat	30
Methods of Application to Meat	32
Results of Experiments with Meat	33
Commercial Application and Advantages	36
Spoilage of Fish	37

CHAPTER	PAGE
Applications of Antibiotics to Fish	39
Results of Application on Fish	40
Advantages of Antibiotic Treatment of Fresh Fish	43
Summary	45
IV. APPLICATION OF ANTIBIOTICS TO POULTRY	
PROCESSING	47
Observations of Poultry Meat Spoilage	47
Brief History of Experiments	49
Commercial Application of Antibiotics to Fresh Poultry Meat	50
Application of antibiotics to turkeys	52
Labeling of Antibiotic-treated Poultry	52
Commercial Versus Laboratory Results	53
Promotional Efforts of American Cyanamid	55
The Franchise Program	57
Advantages of Antibiotic Preservation of Poultry Meat	58
Application to Frozen Poultry	63
Summary	64
V. SHELF-LIFE EXTENSION OF FRESH FRUITS AND VEGETABLES	66
Spoilage Problems Encountered	66
Present Uses of Antibiotics in Controlling Plant Diseases	68

CHAPTER	PAGE
Preservation with Antibiotics	71
Salad vegetables	71
Vegetables usually cooked	74
Fruits	77
The Problem of Residues	78
Future of Antibiotic Preservation of	
Fresh Produce	80
Summary	80
VI. APPLICATION OF ANTIBIOTICS TO THE	
CANNING INDUSTRY	82
Canning Techniques	82
Sterilization by Canning	83
Experiments with Subtilin and Mild Heat . .	84
Experiments with Nisin	87
The Future of Antibiotics in Canning	89
Summary	90
VII. APPLICATIONS OF ANTIBIOTICS TO DAIRY	
PRODUCTS, EGGS, AND MISCELLANEOUS	
FOODS AND BEVERAGES	92
Antibiotics in Fresh Milk	93
Antibiotics in Canned Milk and Puddings . .	94
Antibiotics in Cheese Manufacture	96
Miscellaneous Applications of Antibiotics .	97
Summary	99

CHAPTER	PAGE
VIII. CONCLUSION: A COMBINATION OF METHODS OF PRESERVATION	101
BIBLIOGRAPHY	105

CHAPTER I

INTRODUCTION

War, the threat of war and the pressure of rapidly expanding populations upon food supplies are slowly focusing world attention upon three things connected with food: the search for new sources, the search for increased production and the prevention of waste.¹

This study was designed to gather together available data on the present and possible future uses of antibiotics in the preservation of foods. It is a compilation of data written by numerous authors in all fields of food production, distribution, marketing, and technology. Because of the importance of food preservation to the entire world population, an effort was made to consider the possibilities of antibiotic food preservation, not only in the United States, but in the entire world.

Prediction of World Population

World population is increasing at the rate of approximately 5,000 persons per hour. A new population equivalent in size to the United States is added every three and one-half years; that of India is added every

¹R. A. Bottomley, "Food Additives--Preservatives, Antioxidants and Antibiotics," Food Technology in Australia X:2 (February, 1958), p. 63.

eight y
populat
1960; t
the yea
from 19
are exp
America
at leas
Carribe
have ex
area of
populat

to an f
Life ex
crease
Hungary
during

Nation

New York
Academy
(March)

eight years.² The United Nations estimates that the population of the world will increase to 2,910,000,000 in 1960; to 3,830,000,000 in 1975; and to 6,270,000,000 in the year 2000. This represents a 115.5 per cent increase from 1960 to 2000.³ Unfortunately, the largest increases are expected in under developed countries such as Latin America, Africa, and Asia. Each of these countries will at least double their populations by the year 2000.⁴ The Carribean Islands, Middle America, and South America, which have exhibited the most rapid human increase of any major area of the world, are expected to increase their populations by 188 per cent by the year 2000.⁵

This tremendous increase in population is due both to an increasing birth rate and a decreasing death rate. Life expectancy of white males in the United States increased three years during the period 1945 to 1954. In Hungary, ten years were added to normal life expectancy during this same period.⁶ There has also been a

²"Five Thousand Million by the Year 2000," United Nations Review IV:1 (July, 1957), p. 30.

³Kingsley Davis, "Recent Population Trends in the New World: An Over-all View," The Annals of the American Academy of Political and Social Science CCCXVI (March, 1958), p. 4.

⁴Ibid.

⁵Ibid., pp. 2-4.

⁶"Five Thousand Million by the Year 2000," p. 31.



revolutionary decline in mortality in the past few years. Sulfa drugs, and more recently, antibiotics, have been responsible for a large percentage of this decrease. It is ironic that technologists are now looking to these same substances to help increase present food supplies to the level necessary to properly feed people over a longer span of life.

World Food Supplies

The Food and Agriculture Organization of the United Nations was established to study and try to solve problems involved in feeding the peoples of the world.

At the time when FAO (Food and Agriculture Organization) was established, at the end of the second world war, one problem above all existed, which it was the new Agency's business to try and solve: there was not enough food in the world.⁷

Many millions of people are still undernourished. This undernourishment has not changed very much since 1945, except that per capita production is now slightly above prewar levels. These are average figures for the entire world, however, and they conceal the extreme levels of per capita production at either end.⁸ To draw a comparison

⁷Food and Agriculture Organization, Millions Still Go Hungry (Rome, Italy: Food and Agriculture Organization, United Nations, 1957), p. 1.

⁸Ibid., p. 2.

between the United States and one of the under developed countries of the world, the following statistics are offered:

	<u>United States</u>	<u>India</u>
Daily Calorie Intake	3,117 calories	1,640 calories
Daily Protein Intake	90 grams	44 grams

The people of India, like the peoples in many areas of the world, are fed only half as well as the people of the United States.

There are, of course, many factors which control the amount of food available to certain peoples of the world. Food surpluses are maintained in many areas of the world while the people of other nations go undernourished. Transportation alone is not the complete answer to this problem. The Food and Agriculture Organization of the United Nations has defined a part of this problem as the "distribution problem."

By 'the distribution problem' is meant not merely the mechanical distribution of such food as is available in any part of the world at any given time, but rather its availability for consumption where, and at times when, it is most needed. It is of little use for a government, a majority of whose people may be living on the verge of starvation, to know that ten thousand miles away there are vast supplies of materials for feeding them, even if those supplies were of a sort acceptable to these famished people, which all too often they are not.⁹

⁹Ibid., p. 3.

Part of the answer to properly feeding the increased population of the world lies in increased production, part lies in improved distribution, part lies in education of the population as to the best foods to eat, and part lies in the reduction of waste by improved preservation practices. This thesis is concerned with one phase of this problem, preservation with antibiotics.

Waste in Food Marketing

There is no exact figure on the amount of food that is wasted during the process of getting it from the producer to the ultimate consumer. Numerous studies have been made to estimate food waste. Waste can be caused by improper use of the elements of production, by an imbalance in production causing some foods to go unwanted, from disease and insects, from poor handling and storage conditions, from bacterial and other types of spoilage, from improper cooking, and from waste in the home due to improper buying. Some of these wastes can be controlled very easily while others require a great deal of re-education of producers, distributors, and consumers.

One author has estimated that, "Each year enough food to maintain 150,000,000 people is lost through spoilage."¹⁰ Losses in various food products varies both

¹⁰Bottomley, loc. cit.



with the perishability of the item and the type of handling it receives. A study of rail shipments of fresh fruits and vegetables received at New York City during the seven year period from July 1, 1935, to August 1, 1942, revealed that the average decay per carlot was 2.1 per cent for fruits and 3.8 per cent for vegetables. The following conclusions were drawn from this study:

By assuming that decay occurred in the carlots not inspected to the same extent as in those inspected, it was estimated that for the period under study decay of these 45 commodities during rail transit to New York City totaled nearly 3,000 carlots annually.¹¹

Another source estimated that of 100,000 cars of vegetables shipped from Florida to New York in 1952 and 1953, the equivalent of 4,000 carlots were discarded as spoiled.¹² According to a scientist from the United States Army Quartermaster Food and Container Institute, approximately \$74.00 of each \$1,000.00 of self-service food store fruit and vegetable sales is lost through spoilage.¹³

¹¹James S. Wiant and C. O. Bratley, Spoilage of Fresh Fruits and Vegetables in Rail Shipments Unloaded at New York City, 1935-42 United States Department of Agriculture, Circular 773 (Washington: Government Printing Office, June, 1948), p. 62.

¹²"Food Antibiotics: Market Meteor," Chemical and Engineering News XXXIV:50 (December 10, 1956), p. 6108.

¹³Harry E. Goresline, "Food Spoilage and Deterioration," Handbook of Food and Agriculture, Fred C. Blanck, Editor (New York: Reinhold Publishing Company, 1955), p. 390.

Losses in the marketing of chickens and turkeys during the period 1942 to 1951 amounted to over \$132,000,000, or 11.5 per cent of total poultry production during this period.¹⁴ Approximately twenty-one per cent of an annual shell egg production of 2,500,000,000 eggs is lost annually, twelve per cent of which is due to quality deterioration.¹⁵ Losses in marketing beef, lamb, pork, or veal have not been estimated by the United States Department of Agriculture.

Brief History of Food Preservation

Man has known for many years that food will spoil before it is consumed unless some method is used to prevent the growth of bacteria and other organisms. People living in ancient times preserved their food by drying it in the sun, keeping it refrigerated in snow or natural ice, and by salting it. Accidental fermentation of grape juice and curdling of milk led to the manufacture of wine and cheese. Meat and fish were preserved while hanging over a burning fireplace. Lime water as a preservative for shell eggs was discovered in China years before the birth of Christ.

¹⁴Agricultural Research Service, Losses in Agriculture, United States Department of Agriculture, Agricultural Research Report ARS 20-1 (Washington: Government Printing Office, June, 1954), p. 157.

¹⁵Goresline, op. cit., p. 396.

The science of food technology probably started with Nicholas Appert's discovery of canning in 1800.¹⁶ However, not until 1895 did Samuel C. Prescott and William L. Underwood apply the science of bacteriology to food spoilage.¹⁷ The discovery of quick freezing by Clarence Birdseye in 1925 was a milestone in food preservation. With this process, foods could be kept in almost a natural state for extended periods of time.

Until the recent discoveries of radiation, ultrasonics, and antibiotics, there were but a few methods of food preservation: (1) drying; (2) salting or pickling; (3) chilling or freezing; (4) chemical preservation; (5) heating or hermetically sealing and heating; and (6) inhibition of oxidation by packaging or antioxidants.

These methods have not been fully adopted by people throughout the world because they cause changes in the taste and consistency of foods. The majority of people prefer to consume foods as close to the natural state as possible. Radiation, ultrasonics, dehydro-freezing, and antibiotic-treatment have been developed to better satisfy these desires.

¹⁶Askel G. Olsen and Daniel A. Mills, "Recent Advances in Food Technology," Mechanical Engineering LXXVIII:9 (September, 1956), p. 803.

¹⁷Ibid.

Radiation preserves food by killing spoilage organisms with ionizing radiations from radioactive substances or high voltage electrical machines. These radiations are capable of destroying bacteria but often cause disagreeable flavors and odors when used in sterilizing doses.

Freeze-drying, which has been used successfully by pharmaceutical manufacturers in the production of sensitive drugs, shows a great deal of promise in food preservation.¹⁸ Such foods as mushrooms, carrots, beef rib and sirloin steaks, veal cutlets, pork chops, lobsters, shrimp, strawberries, and several kinds of fish have been treated. Peas have been changed to miniature ping pong balls and chicken breasts to balsa wood consistency by a process in which the food is frozen and placed in a vacuum chamber which causes ice crystals to turn directly into vapor without melting to water. Some of the advantages of this method of preservation are: (1) that food processed in this way does not have to be refrigerated, and (2) these foods can be reconstituted with almost any liquid. Certain technical problems still must be solved before freeze-drying can become a commercial method of food preservation. The

¹⁸"Freeze-Dried Food," Time LXIX:20 (May 20, 1957), p. 61.

process is difficult to apply and has not yet been adopted commercially to use on low-cost materials like food.

Ultrasonic waves have been successfully used in the prevention of crystallization of honey. "The results were astonishingly successful in every respect."¹⁹ Passage of sound waves through milk have been shown to improve the efficiency of homogenization.²⁰ Mercury-in-gas resonance radiation, which is a type of ultrasonic radiation, proved to be less expensive and produced less flavor change than atomic radiation of milk.²¹ Ultrasonics appear to have limited application in food preservation but perhaps further experimentation will prove these ultra-high frequency sound waves to be helpful in combination with other methods of preservation.

Each of the above new methods of preservation has certain hurdles to pass before it can be accepted on a commercial scale. That one will emerge as the only method, or as an individually important method of preservation is

¹⁹Socrates A. Koloyereas, "Preliminary Report on the Effect of Ultrasonic Waves on the Crystallization of Honey," Science CXXI (March, 1955), p. 340.

²⁰J. L. Newcomer, et al., "Effect of an Electric Current on the Efficiency of Homogenization of Ultrasonically Irradiated Milk," Journal of Dairy Science XL (November, 1957), p. 1422.

²¹"May Can Fresh Milk," Science News Letter LXVII:13 (March 26, 1955), p. 197.

extremel

other me

Antibiot

must be

tion, s

canning

prevent

Wrensha

number

foods:

bio

(1)

hea

con

exe

for

per

(4)

ons

gro

pro

bio

thesis.

antibio

"Residu
Storage
(New Yo

extremely doubtful. Each will be used in combination with other methods to help prevent food spoilage.

Antibiotics in Food Preservation

Just as atomic radiation and ultrasonic radiation must be used in combination with other methods of preservation, so must antibiotics depend upon refrigeration or canning to provide the greatest benefit in spoilage prevention. R. C. Kersey, F. C. Visor, and C. L. Wrenshall, of the Chas. Pfizer Company, have listed a number of ways in which antibiotics might be used in foods:

The following general applications for antibiotics in foods offer interesting possibilities: (1) as adjuncts in the sterilization of foods by heat; (2) to prevent the build-up of bacterial contaminants prior to organic processing, for example, in the preparation of fruits and vegetables for freezing; (3) delaying the deterioration of perishable foods during transportation and marketing; (4) as an adjunct to refrigeration, thus delaying the onset of spoilage in fresh foods; (5) preventing the growth of food poisoning organisms in certain processed foods; (6) controlling contamination in biological processes such as fermentation.²²

These possibilities will be discussed in this thesis. Chapter II will cover the nature and action of antibiotics, explaining how they work and how they might

²²R. C. Kersey, F. C. Visor, and C. L. Wrenshall, "Residual Antibiotic Levels in Food Products During Storage and Processing," Antibiotics Annual, 1953-1954 (New York: Medical Encyclopedia, 1954), p. 438.

be appli
primarily
some effe
the Food
antibioti
Notes on
determine

Th
antibioti
the use o
States 1
of Canad
their pr
chapter
benefit
poultry
The app
cannin
of dai
covere
alone
be di

be applied to food preservation. Because antibiotics are primarily therapeutic aids, their use in foods could have some effect upon their medicinal values. The attitude of the Food and Drug Administration on the application of antibiotics to food has changed in the past ten years. Notes on this regulatory agency's attitude are made to determine the reason for the change.

The third chapter covers the application of antibiotics in the preservation of meat and fish. Although the use of these drugs in meat and fish sold in the United States is still not sanctioned under law, the governments of Canada, Costa Rica, Brazil, and Columbia now permit their preservation with antibiotics. The fourth and fifth chapters are concerned with methods of application and benefits to be derived from the use of antibiotics on poultry meat and on fresh fruits and vegetables respectively. The application of antibiotics to heat sterilization by canning is discussed in Chapter VI. Antibiotic treatment of dairy products, eggs, and fermentation products are covered in Chapter VII.

The fact that antibiotics will probably not be used alone in food preservation, and the reasons for this, will be discussed in Chapter VIII.

CHAPTER II

THE NATURE AND ACTION OF ANTIBIOTICS

This chapter is designed to acquaint the reader with a few basic facts about antibiotics, what they are, how they act, their limitations, and how they might be applied to the preservation of food. Included will be a brief history of antibiotics and antibiotic substances from the time the foundations for antibiotic knowledge were laid down to the present commercial production of a great number of these extremely beneficial substances.

The medical and legal aspects of the use of antibiotics in food preservation, particularly those used in human medicine, and the effect which their continued ingestion might have upon the human body will be discussed. The development of antibiotic-resistant strains of micro-organisms may effect the future application of antibiotics to food preservation.

The Food and Drug Administration of the United States Department of Health, Education, and Welfare has made statements regarding the commercial use of antibiotics in

food preservation. The attitude of this regulatory agency will be examined in the light of recent developments in antibiotic preservation. Finally, the cost of antibiotics will be discussed in relation to the benefits which they can offer the world in terms of prevention of waste due to food spoilage.

Definition and Source of Antibiotics

The word antibiotic is made of two Greek words, "anti" and "bios," which mean "against life."¹

Selman A. Waksman, a pioneer in the field of antibiotics and discoverer of such well-known substances as streptomycin and neomycin, has defined an antibiotic as follows:

An antibiotic is a chemical substance, produced by micro-organisms, which has the capacity to inhibit the growth of and even to destroy bacteria and other micro-organisms.²

He later modified this definition by adding the words, "in dilute solutions" in order to exclude substances such as acids and alcohols that have weak anti-bacterial activity.³ Later definitions have included substances

¹"Origin of Antibiotics," Today's Health XXXI:4 (April, 1953), p. 4.

²Selman A. Waksman. "What is An Antibiotic or An Antibiotic Substance?," Mycologia XXXIX (1947), p. 568.

³F. A. Robinson, Antibiotics (New York: Pitman Publishing Company, 1953), p. 9.

that are produced by animals and plants in addition to microbes.⁴

The above definitions indicate that antibiotics are substances which are capable of inhibiting or destroying bacteria or micro-organisms. The principal source of these antibiotics are bacteria and molds, the former being the source of the greatest number.

Apart from penicillin and one or two bacterial antibiotics that are made on a comparatively small scale, the antibiotics of clinical importance are all derived from actinomycetes....⁵

Actinomycetes are soil bacteria, normally found in soils and composts which are associated with plants. Soils from all parts of the world have been sampled and tested (and continue to be examined) for actinomycetes which produce antibiotics showing promise in therapeutics. In a search for antibiotics with anti-fungal properties, micro-organisms have been isolated from Indian fruits and vegetables. Thirty-nine isolates from two hundred plant sources were found to have some anti-fungal activity.⁶

⁴Ibid.

⁵Ibid., p. 47.

⁶Majunda and Bose, "Studies on Anti-fungal Antibiotics. I. Anti-fungal Micro-organisms in Indian Fruits and Vegetables," J. Sci. Indus. Res. (India, 1955), pp. 126-128, cited by Food Science Abstracts XXVIII (1956), p. 118.

The sources of antibiotics or antibiotic substances appear almost endless. Although the majority of antibiotics discovered to date have come from soil micro-organisms, there is no indication that the soil will continue to be the major source. Anything which contains bacteria, fungi, or other micro-organisms is a potential source of these substances. Perhaps the next source will be the sea, or even the human body. Nisin, an antibiotic which shows promise in the cheese-making and canning industries, is derived from a cheese-starter organism, Streptococcus lactis, normally present in milk.⁷

Mode of Action and Limitations of Antibiotics

The mode of action of antibiotics is still not completely known. That they inhibit or destroy micro-organisms is sufficient for this discussion.

It has been suggested that the reason why antibiotics have been so brilliantly successful in the treatment of disease is that they represent the end-products of a long process of natural selection in which perhaps tens of thousands of substances have been built up by bacteria and moulds and rejected before the right molecular architecture was found that produced a substance capable of giving the organism some advantage over other organisms in the struggle for living-space.⁸

⁷H. B. Hawley, "Nisin in Food Technology--1," Food Manufacture XXXII:8 (August, 1957), p. 370.

⁸F. A. Robinson, op. cit., p. 118.

This inhibition or destruction, however, varies greatly with the specific antibiotic used and with the medium in which it is used. Each antibiotic is effective against certain microbes, some against a select few, and others, like chlortetracycline and oxytetracycline, against a wide variety or broad spectrum of micro-organisms.

Because of their selectivity against bacteria, many antibiotics may cause an upset in the balance of nature, and allow for the more rapid growth of yeasts and molds. Although this has not been a problem in short-term preservation of highly perishable foods, other applications may be affected.

The food substrate to which the antibiotic is applied can have a detrimental effect on its activity. Such factors as acid content, water content, salt concentration, physical makeup (oil stratification), storage conditions, temperature, and strain of organisms, may have an adverse effect upon the degree of activity exhibited by an antibiotic. Some substrates may even destroy the antibiotic.

Antibiotics affect different species of micro-organisms in different ways. Their presence may cause an organism to germinate (change from spore form to mobile form) more rapidly. The organism may become less heat resistant, it may stop multiplying, or it may multiply at a much slower rate in the presence of certain antibiotics.

Application of Antibiotics to Food

Because of the aforementioned variations in activity of antibiotics, their use as preservatives in food substances must be carefully studied to insure that spoilage is being controlled, and that pathogenic micro-organisms are completely destroyed. Each antibiotic which shows potential for food preservation must be tested under actual field conditions in the food substrate to which it is to be applied, and under conditions of temperature, pressure, acidity, etc., that will exist under actual storage conditions. Since some antibiotics are destroyed by heat, their application in canning is limited; because others work only with heat to destroy certain organisms, their activity in fresh food preservation is limited.

The problem of residues existent when food is consumed must also be studied and solved. Some antibiotics are destroyed by normal cooking procedures and therefore find application in preservation of meat and fish that is normally cooked before eating. Others, such as streptomycin, have exhibited extreme stability in storage and in cooking, and therefore have limited application in food preservation. Others, like nisin, appear to be digested by the human body.

Brief History of Antibiotics

From 1885 to 1939 the real foundation was laid for the development of our knowledge of antibiotics.⁹

The antagonistic activities of micro-organisms were first explained during this time, although no mention was made of the production of specific antibiotic substances. The first names given to what are known today as antibiotics were "lethal principles" and "toxic substances."¹⁰

Antibiotics were discovered as early as 1907, however, these were too toxic to be applied in human medicine.

In 1929, Sir (then Professor) Alexander Fleming isolated a substance from a mold culture and reported that it had a peculiar property of inhibiting bacteria.¹¹ No clinical tests of this substance (which Fleming named penicillin), were attempted at this time although it was tested on many types of bacteria. Not until 1940 did researchers finally succeed in getting a dry, stable broth of the mold which produces penicillin, Penicillium notatum.¹²

⁹Selman A. Waksman, "Historical Background of Antibiotics," Antibiotics Annual, 1954-1955 (New York: Medical Encyclopedia, 1954), p. 5.

¹⁰Ibid.

¹¹Robinson, op. cit., p. 3.

¹²Waksman, "Historical Background of Antibiotics," p. 9.

The second world war had started in Europe at this time and a great need for effective therapeutics for war wounds was expected. American and British scientists and drug manufacturers pooled their talents to find methods of producing penicillin in commercial quantities. Production of a few million units in January, 1943, was increased to 130,000,000 units eighteen months later. At war's end, twenty drug companies were producing 250,000 pounds of penicillin to treat 7,000,000 patients a year.¹³

Actinomycin was isolated from a soil microbe by Rutgers University scientists in 1939, followed in 1942 by streptothricin, and in 1943 by streptomycin.¹⁴ These discoveries culminated almost twenty-five years of research on soil organisms by Selman A. Waksman and his colleagues. Neomycin was also discovered at the Rutgers University laboratories in 1949.¹⁵

Bacteria have yielded nearly one hundred antibiotics; fungi have produced the different penicillins plus one hundred or more others; and one hundred and twenty-five more have come from the actinomycetes, including streptomycin,

¹³Dana L. Thomas, "Broader Spectrum," Barron's XXXVI:45 (November 5, 1956), p. 3.

¹⁴Waksman, "Historical Background of Antibiotics," p. 9.

¹⁵Selman A. Waksman, Neomycin (New Brunswick, New Jersey: Rutgers University Press, 1953), p. vii.

actinomycin, chloramphenicol, the tetracyclines, neomycin, and nystatin.¹⁶ New ones are being discovered and checked for their therapeutic values almost daily.

Medical Aspects of Antibiotics in Food

The principal use for antibiotics at present is in the prevention and cure of human disease. This, then, should be the first consideration in any decision to use antibiotics in food preservation. If there is any doubt about the possibility of food uses of antibiotics preventing or hindering the therapeutic value of these substances, they should not be applied to food. Some of the ways in which antibiotics in food might destroy or lessen their therapeutic value are through a buildup of resistance among pathogenic organisms, a change in the normal bacterial flora of the digestive tract and increased sensitivity to the drugs.

Numerous instances of development of antibiotic-resistant strains of pathogenic bacteria have been reported by medical authorities. Micro-organisms in the bodies of one-fifth of a group of mice which were fed low doses of antibiotics for one month were found to be more resistant to the drugs.¹⁷ There appears to be no doubt that:

¹⁶Waksman, "Historical Background of Antibiotics," p. 11.

¹⁷"Report Danger of Foods Preserved by Antibiotics," Science News Letter LXXI:19 (May 11, 1957), p. 297.

The continued use of an antibiotic in a given locality leads to the appearance of resistant strains there and, for this reason, the antibiotics in common use in American hospitals are changed almost annually.¹⁸

An increase in the resistance of micrococci found in indoor hospital air to the antibiotics used in that hospital has also been noted.¹⁹ However, there have also been reports that the danger from controlled, intelligent use of antibiotics is probably not great.

It appears, therefore, that the danger of the formation of strains of bacteria resistant to antibiotics is not as great as might appear from some of these reports; however, it seems established that the promiscuous use of antibiotics may result in an increased resistance of certain strains to some of them.²⁰

In an experiment in which 243 children in rural Haiti were fed a daily dose of fifty milligrams of oxytetracycline for nine months, no increase in resistant strains of microorganisms could be found.²¹

¹⁸M. Ingram and Ella M. Barnes, "Problems in the Use of Antibiotics for Preserving Meat," The Journal of Applied Bacteriology XVIII (1955), p. 559.

¹⁹Frank B. Engley, Jr. and Joseph A. Boss, "The Comparative Antibiotic Resistance of Airborne Microorganisms Isolated from Hospital Areas," Antibiotics Annual, 1956-1957 (New York: Medical Encyclopedia, 1957), p. 638.

²⁰W. F. Von Oettingen, "Untoward Effects Resulting from the Indiscriminate Use of Antibiotics," Antibiotics Annual, 1954-1955 (New York: Medical Encyclopedia, 1955), p. 371.

²¹Elmer H. Loughlin, Aurele A. Joseph, and Louverture Alcindor, "Extended Low-level Dosage of

1

One effect of antibiotics on the human digestive tract may be to suppress the normal bacterial flora and lead to secondary infections which are usually less serious in nature than the disease but may lead to fatal complications.²² Long-term, low-level feeding of certain antibiotics may also result in a deficiency of certain vitamins.²³ However, in the majority of cases, low-level feeding of antibiotics to school children and to geriatrics has produced only beneficial results, with an increase in growth and general health improvement. The benefits of low-level antibiotic feeding have been demonstrated in animals by a twelve to twenty-two per cent increase in growth of swine over expected basal rates.²⁴ Chickens have also shown improved growth rates, as have other meat animals.

Another problem which may be encountered in the use of antibiotics in food preservation is that of sensitivity and reactions to these drugs by some people. Penicillin

Oxytetracycline," Antibiotics Annual, 1957-1958 (New York: Medical Encyclopedia, 1958), p. 97.

²²Von Oettingen, op. cit., p. 372.

²³Ibid., p. 373.

²⁴Henry Welch and Felix Marti-Ibanez, "Summation and New Perspectives," Antibiotics Annual, 1954-1955 (New York: Medical Encyclopedia, 1955), p. 1143.

1

appears to produce the greatest number and most severe reactions while the broad spectrum antibiotics produce rare and non-severe reactions.²⁵ These facts support the use of oxytetracycline and chlortetracycline in food preservation. The majority of the reports of deaths due to severe reactions to antibiotics have been traced to improper administration. Over 6,000 pounds of beef treated with antibiotics were consumed by known persons during trials with meat preservation without a single instance of reaction or development of sensitivity.²⁶ There have been no reported cases of skin rash or dermatitis in persons working with antibiotics in feed mills or in groups experimenting with fresh meat preservation.²⁷

Legal Aspects of Antibiotics in Food

The use of antibiotics in food preservation is under the regulation of the Food and Drug Administration. Section 408 of the Federal Food, Drug, and Cosmetic Act

²⁵Henry Welch, et al., "Severe Reactions to Antibiotics--A Nationwide Survey," Antibiotics Annual, 1957-1958 (New York: Medical Encyclopedia, 1958), p. 308.

²⁶"Antibiotic Prolongs Meat Storage Life," The National Provisioner LXXXIII:22 (November 26, 1955), p. 104.

²⁷Fred R. Deatherage, "Present Status of Antibiotics in the Preservation of Food," A panel discussion, Antibiotics Annual, 1956-1957 (New York: Medical Encyclopedia, 1957), p. 1120.

provides for the establishment of safe tolerances for residues of pesticides on raw agricultural products. Before a tolerance will be established by the Food and Drug Administration, the drug manufacturer must prove: first, to the United States Department of Agriculture that the drug has usefulness on the product; and second, to the Food and Drug Administration that no harmful effects will result to the consumer.

In February, 1953, the Secretary of Health, Education, and Welfare made the following statement in regard to antibiotic use on foods:

The presence of antibiotic drugs in foods intended for human consumption, or the direct or indirect addition of such drugs to such foods, may be deemed an adulteration within the meaning of section 402 of the Federal Food, Drug, and Cosmetic Act.²⁸

A few years later, Wilton P. Rankin of the Food and Drug Administration, stated the position of that agency after certain experiments had proven the value of antibiotics:

1. They may be used so that no residues remain in the food. This is acceptable.
2. They may be used so that residues remain in the uncooked food provided:
 - a. The food is always cooked.
 - b. The cooking destroys the antibiotics.
 - c. The official tolerance has been established under the Food, Drug,

²⁸"Antibiotics in Food Preservation--Public Health and Regulatory Aspects," Science CXXVI:3248 (December 6, 1957), p. 1160.

and Cosmetic Act for the residue that remains in the uncooked food.

- d. The residue is within this tolerance.
3. Antibiotics have been proposed for uses that will leave some of the chemical in the food as it is eaten. Their safety under these conditions has not been established. They should not be used in this way until we know more about the effect of the residues on man and on micro-organisms.²⁹

The use of antibiotics on poultry has been established and sanctioned under law by the Food and Drug Administration. The tolerance of antibiotic on raw poultry has been set at seven parts per million. This food is presently the only one on which antibiotics may be used in the United States. However, petitions have been placed with the Food and Drug Administration for tolerances of antibiotics on fresh fish.

The government of Canada has approved the use of antibiotics in the preservation of fresh fish, with an established tolerance of five parts per million. Columbia and Costa Rica permit antibiotic preservation of beef, and the government of Brazil allows antibiotic preservation of beef, poultry, and fish.

Economic Aspects of Antibiotics in Food Preservation

The first chapter has indicated the amount of loss in food supplies throughout the world. If antibiotics

²⁹"Antibiotics for Fishery Products Preservation," Commercial Fisheries Review XVIII:12 (December, 1956), pp. 27-28.

could reduce this loss a few percentage points, their use would be economically feasible. The justification for food additives such as antibiotics are primarily from the standpoint of consumer benefits: they should maintain the nutritional quality of the foods; they should enhance the keeping quality or stability of the food, thus reducing waste; they should make the food attractive; or they should provide essential aids in the processing of foods, thus reducing cost.³⁰

Antibiotics have been shown to prevent waste and maintain the nutritional quality of foods over extended storage periods. The cost of doing this has been minimal and some retailers and processors are willing to absorb this added cost for insurance of a better product. Oxytetracycline treatment would cost approximately a mill to one cent per pound of food treated;³¹ the cost of chlortetracycline treatment is about one-third of a cent per pound;³² the cost of oxytetracycline to the poultry processor is only about four-tenths of a cent per

³⁰R. A. Bottomley, "Food Additives--Preservatives, Antioxidants and Antibiotics," Food Technology in Australia X:2 (February, 1958), pp. 64-65.

³¹Loughlin, Joseph, and Alcindor, op. cit., p. 95.

³²"Antibiotics and Food," Chemical and Engineering News XXXIII:50 (December 12, 1955), p. 5368.

pound;³³ and the cost of subtilin treatment of canned foods has been estimated at one-tenth of a cent per can.³⁴

As new techniques are devised and more antibiotics are produced synthetically, costs will be reduced without any reduction of benefits. Antibiotics can be a less expensive method of preservation than refrigeration in certain under developed countries.

Summary

Antibiotics are substances produced by micro-organisms capable of destroying or inhibiting other micro-organisms. They vary in their bacteriostatic properties in that some are capable of inhibiting a wide range of bacteria while others can affect only a select few. The majority of antibiotics are effective only against bacteria, while a few are effective against yeasts and molds.

Problems may arise as a result of food preservation with antibiotics in that certain bacteria are capable of building up resistance to these substances. This danger is apparent particularly with the use of antibiotics against human parasites. Should human pathogens develop resistance to a therapeutic antibiotic as a result of long term

³³"Food Antibiotics--Market Meteor," Chemical and Engineering News XXXIV:50 (December 10, 1956), p. 6108.

³⁴"Antibiotic Preserves Food," Science News Letter LVII:21 (May 27, 1950), p. 325.

ingestion, new methods of disease control must be devised. Some persons exhibit reactions to certain drugs and their presence in food products could present medical problems. This sensitivity might be built up as a result of long-term feeding. Because there is limited proof both for and against these theories, food uses of antibiotics must be limited to those substances which will be destroyed prior to consumption.

The Food and Drug Administration of the Federal Government regulates the use of antibiotics in foods under the Food, Drug, and Cosmetic Act. Tolerances must be established by this agency, but only after the United States Department of Agriculture is satisfied that the drug has definite usefulness in the food.

The cost of antibiotic preservation of food is very minor compared with the amount of money and food that could be saved as a result of reduction in spoilage. As new antibiotics are discovered that have potential in food preservation, and as new methods are devised to produce these substances at lower cost, antibiotic preservation of foods will become more widespread.

CHAPTER III

MEAT AND FISH PRESERVATION WITH ANTIBIOTICS

The flesh of meat and fish are ideal media for the growth of bacteria. Man has learned to preserve meat and fish in many ways: by salting, canning, pickling, and drying. All of these processes have an effect upon the taste and appearance of the meat or fish. Freezing and refrigeration have proven valuable means of holding flesh foods satisfactorily for short periods of time, however, mechanical refrigeration facilities are not available in many parts of the world.

Antibiotics have proven to be of value in retarding bacterial decomposition of fish and red meats. Preservation of these foods with antibiotics has already been approved by the governments of at least three countries. In the laboratory, and under simulated commercial conditions, certain broad spectrum antibiotics have not only extended the shelf-life of fish and meat, but have also sharply reduced the length of time necessary for enzymatic tenderizing of meat.

Spoilage of Meat

Scientists at the Ohio State Agricultural Experiment

1

Station have isolated ninety-two micro-organisms responsible for meat spoilage.¹ Bacteria are responsible for surface spoilage and for deep spoilage in meats. In order to prevent micro-organism from causing deep spoilage of beef, the carcass must be placed under refrigeration immediately after killing and dressing. The activity of enzymes naturally present in meats, which are responsible for the "aging" or "tenderizing" process, are slowed down at low temperatures. The future population of this country may eventually require the marketing of more and more lower grade cattle in retail stores. In order to tenderize these tougher steers, beef must be hung under refrigeration for periods of up to three or four weeks.

In addition to bacterial spoilage of meats, there is also damage by yeasts and molds. Although these micro-organisms are innocuous from the standpoint of the health of the consumer, they must be reckoned with from the standpoint of appearance of the product. Two other types of loss in quality of meat are oxidative and physical in nature. The oxidative loss causes a darkening and browning of the surface of the meat, and occurs even if microbial growth can be controlled. The physical loss, or "drip loss," is a reduction in weight (body fluids) which can eventually lead

¹Milton Silverman, "New Way to Keep Food Fresh," Readers Digest LXVIII:410 (June, 1956), p. 73.

to dehydration (quality loss).²

Methods of Application to Meat

"The first method used for the introduction of antibiotics into whole animals was the infusion method."³ This method involved bleeding the animal and pumping an antibiotic solution through the blood system. The procedure was difficult to administer and required well-trained personnel; it was time consuming; a possibility existed of pumping foreign matter into the animal; and water absorption by the carcass was excessive.⁴

Other methods such as spraying and dipping were found to protect the surface of the meat but had little control over deep spoilage. Injection of individual rounds proved satisfactory, but this, too, was time consuming and required skilled operators.

The most recent method of application of antibiotics to beef cattle, swine, and sheep, is an injection prior to slaughter. The antibiotic is mixed in a saline solution

²C. F. Niven, Jr., and W. R. Chesbro, "Complementary Action of Antibiotics and Irradiation in the Preservation of Fresh Meats," Antibiotics Annual, 1956-1957 (New York: Medical Encyclopedia, 1957), p. 858.

³E. M. Sacchi, J. R. McMahan, R. C. Ottke, and C. L. Wrenshall, "New Methods of Pre-Slaughter Administration of Antibiotics," Paper presented at 17th Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 12-16, 1956, p. 1.

⁴Ibid.

and injected into the peritoneal cavity of the animal one to four hours before slaughter. The circulatory system of the live animal acts as the carrier and distributes the antibiotic evenly throughout the carcass. The method is easy to administer, and regular packinghouse employees can easily be taught where and how to inject the animals.⁵

In addition to pre-slaughter injection of hogs, an antibiotic spray was found helpful in reducing discoloration of exposed areas of flesh.⁶

Results of Experiments With Meat

Some remarkable results have been recorded on the antibiotic preservation experiments carried out to date. A comparison of treated and untreated rounds of beef kept for forty-eight hours at room temperatures indicates that

⁵J. R. McMahan, H. E. Downing, R. C. Ottke, H. G. Luther, and C. L. Wrenshall, "Antibiotic Preservation of Meats. I. Preliminary Experiments with Intraperitoneal Injection of Animals before Slaughter," Antibiotics Annual, 1955-1956 (New York: Medical Encyclopedia, 1956), pp. 727-730; E. E. Sacchi, J. R. McMahan, R. C. Ottke, and R. C. Kersey, "Antibiotic Preservation of Meats. II. Intraperitoneal Injection of Oxytetracycline in Beef Cattle," Antibiotics Annual, 1955-1956 (New York: Medical Encyclopedia, 1956), pp. 731-733; H. E. Downing, W. B. Hardie, J. R. McMahan, and D. C. Billman, "Antibiotic Preservation of Meats. III. Intraperitoneal Injection of Oxytetracycline in sheep," Antibiotics Annual, 1955-1956 (New York: Medical Encyclopedia, 1956), pp. 734-736; and H. E. Downing, J. R. McMahan and C. Baker, "Antibiotic Preservation of Meats. IV. Intraperitoneal Injection of Oxytetracycline in Hogs," Antibiotics Annual, 1955-1956 (New York: Medical Encyclopedia, 1956), pp. 737-738.

⁶Downing, McMahan, and Baker, op. cit., p. 738.

all rounds infused with chlortetracycline were sound. Seven of the ten untreated rounds exhibited some off-color at some point.⁷ Some beef rounds have been held for as long as nine days at room temperature without spoiling.⁸

Perhaps more significant were the results of experiments by the same group of workers on whole animals infused with chlortetracycline. The carcasses were split, and one side was immediately chilled whereas the other was allowed to stay at room temperature for forty-eight hours prior to chilling. Steaks from the sides kept at room temperature for forty-eight hours and then chilled were as tender at five days post-mortem as the others were at two weeks post-mortem and from a taster's point of view, indistinguishable from normal meat.⁹

The storage life of fresh ground beef held at 10°C (50°F) was extended to nine days by the addition of one-half to two parts per million of chloraphenicol, chlortetracycline, and oxytetracycline. Controls, and penicillin-, bacitracin- and streptomycin-treated samples spoiled in

⁷H. H. Weiser, H. S. Goldberg, V. R. Cahill, L. E. Kunkle, and F. E. Deatherage, "Observations on Fresh Meat Processed by the Infusion of Antibiotics," Food Technology VI (1953), p. 496.

⁸"Antibiotic Prolongs Meat Storage Life," The National Provisioner CXXXIII:22 (November 26, 1955), p. 105.

9. Weiser, et al., op. cit., p. 498.

five days.¹⁰

Camaguey, Cuba was the site of an experiment carried out by American scientists exploring the possibilities of the use of antibiotic-treatment in warm climates. Thirty freshly slaughtered steers, fifteen of which had been infused with antibiotics prior to slaughter, were sent by refrigerated truck over a 300 mile journey. The truck broke down enroute and the beef stayed under the hot sun for two days while repairs were made. When the beef finally reached its destination, it was carefully examined by the researchers. The fifteen untreated carcasses were completely spoiled while the other fifteen were "surprisingly fresh."¹¹

Fresh pork sausage treated with two parts per million of chlortetracycline could be stored at 5°C (41°F) for thirteen days whereas untreated sausage was spoiled at seven days.¹² Ten parts per million of the same drug added to hamburger increased refrigerated shelf-life of this highly perishable commodity from approximately four

¹⁰H. S. Goldberg, H. H. Weiser, and F. E. Deatherage, "Studies of Meat. IV. Use of Antibiotics in Preservation of Fresh Beef," Food Technology VI (1953), p. 166.

¹¹Silverman, op. cit., p. 71.

¹²Frank Gerard, "Meat," Food Manufacture XXII:2 (February 1, 1957), p. 62.

1

days to at least ten days.¹³

Commercial Application and Advantages

In December, 1956, the government of Brazil adopted antibiotic treatment of beef.¹⁴ Shortly thereafter, the government of Costa Rica permitted commercial treatment of beef with antibiotics. The advantages to be gained from the use of antibiotics in tropical climates are much greater than those which could be gained in a temperate area like the United States, or where refrigeration facilities are readily available.

The principal advantage to be gained from the use of antibiotics in preservation of beef in this country is the more rapid tenderization of beef because of the possible use of higher initial storage temperatures. Since meat treated with antibiotics can be stored at temperatures of seventy or eighty degrees for up to nine days without spoiling, the tenderization process is speeded up. Treated meat after five days of storage proved to be as tender as untreated meat after two weeks of refrigerated storage.¹⁵

¹³"'Antibiotic-Burgers' May Be On The Way," Science News Letter LXVIII:18 (October 29, 1955), p. 280.

¹⁴"Food Antibiotics: Market Meteor," Chemical and Engineering News XXXIV:50 (December 10, 1956), p. 6108.

¹⁵Weiser, et al., op. cit., p. 498.

The rapid tenderization of meat can help the packinghouse operator move his stock faster and may allow for the use of lower grade cattle without long aging periods.

In areas like Columbia, South America, where an estimated forty per cent of beef production is wasted through shipment delays and spoilage, antibiotics could be a tremendous aid.¹⁶ Live animals would not have to be taken to the consumption point for slaughter, but could be killed up to five hundred miles away and shipped by truck.¹⁷ The long distances over which some animals must be driven on hoof to slaughter causes a loss in body weight and a loss in any "finish" which the animal may have had before it started. It may also be "economical to fly meat 1,500 miles or more to market."¹⁸

Spoilage of Fish

Fish is one of the most difficult foods to keep fresh. The temperature of storage of fresh fish must be rigidly controlled, for fish flesh will spoil twice as fast at 4°C (39°F) than it will at 0°C (32°F).¹⁹ Of the three

¹⁶"Food Antibiotics: Market Meteor," loc. cit.

¹⁷"New Tricks with Antibiotics," Business Week No. 1371 (December 10, 1955), p. 88.

¹⁸Ibid.

¹⁹"Antibiotics Use and Quality Assessment Highlights Fish-Processing Technologists Meeting," Commercial Fisheries Review XVIII:8 (August, 1956), p. 58.

main types of fish spoilage - bacterial, oxidative, and enzymatic - bacterial is the most important in terms of economic loss. Fish flesh provides an excellent medium for the growth of bacteria. Drying, smoking, and methods of cooking devised to prevent bacterial spoilage change the flavor and consistency of the fish. Freezing is a successful method of preservation but this is expensive and not always feasible. Refrigeration or storage with ice, the most common methods of keeping fish, can only be used for a limited period of time.

The fishing industry is as yet in a black eddy in regard to sanitation, and it is extremely doubtful whether the sanitary conditions in any fish plant would ever remotely approach those found in a modern milk plant.²⁰

There is little application of Pure Food regulations in the fishing industry. This is due to the rare spread of communicable diseases directly attributable to fish and to the seasonal character of the fishing industry.²¹ The fishing industry is widely scattered, consists of many large and small businesses, and uses a great deal of transient labor. The "fishing industry is at least two decades behind the dairy industry" as far as sanitary

²⁰H. L. A. Tarr, "Present Status of Antibiotics in the Preservation of Food," A panel discussion, Antibiotics Annual, 1956-1957 (New York: Medical Encyclopedia, 1957), p. 1115.

²¹Ibid.

conditions are concerned.²²

Because these conditions exist, antibiotics, used properly, could help to keep fish fresh for longer periods of time, and also help to improve the sanitary conditions in the fishing industry.

Application of Antibiotics to Fish

For maximum effectiveness, antibiotics must be applied to fish immediately after the catch. At this time the fish flesh is almost bacteriologically sterile. Contamination comes from the viscera of the fish and the unsanitary storage places on the ship.

Antibiotics may be applied to fish by spraying, dipping, or by incorporation in the ice used to hold fish while at sea. On shipboard, the two most practical means would be either spraying or the use of antibiotic ice, the latter being the most economical and the easiest to apply. Antibiotics may be applied at the processing plant by dipping either the fillets or the eviscerated fish into an antibiotic brine prior to shipment. Dipping might also be accomplished prior to freezing to provide insurance against loss due to accidental thawing during shipment or

²² J. W. Boyd, H. M. Bluhm, C. R. Muirhead, and H. L. A. Tarr, "Use of Antibiotics for the Preservation of Fish and Sea Foods," American Journal of Public Health XLVI:12 (December, 1956), p. 1531.

storage.

Ices containing four parts per million of chlortetracycline or five parts per million of oxytetracycline have been effectively used both on shipboard and dockside for storing fish.²³ Sprays containing one hundred to two hundred parts per million oxytetracycline and dips varying from ten to twenty-five parts per million concentration have proven effective in extending storage life.

Results of Application on Fish

Experiments have been carried out to determine the effectiveness of antibiotics on the keeping quality of fresh salmon prior to canning. The salmon canning industry is unique in that the fish can be caught only during very short periods of the year, varying from one week to one month in a particular location. The average pack for sockeye (or red) salmon for the years 1945 to 1955 was slightly greater than 1,750,000 standard cases of forty-eight pounds each with a total value of approximately \$50,000,000.00.²⁴ Because of the short period during which the fish can be caught, canning facilities are under terrific pressure to

²³H. L. A. Tarr, John W. Boyd, and H. M. Bissett, "Antibiotics in Food Processing. Experimental Preservation of Fish and Beef with Antibiotics," Agricultural and Food Chemistry II (March 31, 1954), p. 372.

²⁴Pacific Fisherman LIV:L (January, 1956), p. 83.

process the fish before spoilage begins. Any extension of the storage period over which the fresh salmon can be held prior to canning would be welcomed by the salmon canning industry.

Organoleptic taste tests of fresh salmon treated with antibiotics indicated the fish so treated were considered good until the twenty-fourth to the twenty-seventh day of storage. This compares with a storage life of eighteen days for untreated salmon.²⁵

In other instances, fish fillets treated with antibiotics were held for eight to thirteen days in satisfactory condition while untreated samples could be held for only four days.²⁶ Haddock treated with antibiotics on board ship were found to remain at top quality one week longer than untreated fish.²⁷ Shucked oysters packed in half-pint cans could be stored in crushed ice for seventeen to twenty days after treatment with chlortetracycline. The normal

²⁵Joseph A. Stern, Harmon L. Liebman, Robert E. Munkelt and Byron Hatherell, "The Potential Application of Antibiotics in the Salmon Canning Industry. I. Organoleptic Evaluations," Antibiotics Annual, 1956-1957 (New York: Medical Encyclopedia, 1957), p. 981.

²⁶"Antibiotics Use and Quality Assessment Highlights Fish-Processing Technologists Meet," pp. 58-59.

²⁷"Antibiotic Prolongs Meat Storage Life," loc. cit.

storage life is approximately six days.²⁸ Experiments with other fish indicate a two to three-fold extension of refrigerated shelf-life. Storage of round herring in sea water containing ten parts per million chlortetracycline on board ship and in ice containing five parts per million of the antibiotic after landing, prolonged the storage life approximately ninety per cent at 59°F to 68°F and approximately forty per cent at near-freezing temperatures.²⁹

Two methods have also been devised to prevent deterioration of whale meat. One involves the use of an antibiotic-dipped harpoon used to catch the whales.³⁰ The other consists of injecting the antibiotic into the peritoneal cavity of the whale.³¹ Crab meat, peeled shrimp, and shucked clams have also responded well to antibiotic treatment for extension of shelf-life.

²⁸Anthony Abbey, A. Richard Kohler, and Sidney D. Upham, "Effect of Aureomycin Chlortetracycline in the Processing and Storage of Freshly Shucked Oysters," Food Technology XI (1957), p. 270.

²⁹T. Tomiyama, S. Kuroki, D. Maeda, S. Hamada, and A. Honda, "A Study of the Effects of Aureomycin-containing Sea Water and Ices Upon the Storage Life of Round Herring," Food Technology X (1956), p. 218.

³⁰"Terramycin Tested on Whale Meat," Commercial Fisheries Review XVIII:12 (December, 1956), p. 74.

³¹"Antibiotics Tested on Whale Carcasses," Commercial Fisheries Review XVIII:7 (July, 1956), p. 76.

Advantages of Antibiotic Treatment of Fresh Fish

"It was announced on October 1, 1956, that the Canadian Department of National Health and Welfare approved the use of antibiotics in the preservation of freshly-caught fish."³² This process is "expected to reduce sharply Canada's fish-spoilage losses, estimated at some 15% of its million ton annual catch."³³ In addition, the five parts per million which Canada allows on any part of the fresh fish, is expected to upgrade the quality of fish which reaches the ultimate consumer.³⁴ A recent survey by the Fisheries Research Board of Canada showed that forty per cent of the ocean fish reaching consumers in Ottawa, Montreal, and Toronto had lost its original fresh taste and appearance, although it was still edible.³⁵

There are a great many people in the world who depend for their economic and nutritional sustenance on whale meat. Since this is an extremely perishable product, and

³²"Antibiotics Approved for Fish Preservation," Commercial Fisheries Review XVIII:11 (November, 1956), p. 73.

³³"Canada Eats 'Acronized' Fish," Food Manufacture XXXII:5 (May 1, 1957), p. 245.

³⁴R. A. Bottomley, "Food Additives--Preservatives, Antioxidants and Antibiotics," Food Technology in Australia X:2 (February, 1958), p. 75.

³⁵"Antibiotics Approved for Fish Preservation," p. 74.

very difficult to chill because of its size, antibiotics could prevent a great deal of loss.

The Norwegian fishing industry would benefit from the application of antibiotics to fresh fish by an expansion of the shipment of fresh cod to the large British market.

Dr. Fred Deatherage of the Ohio Agricultural Experiment Station has observed a fringe about ten miles deep along the coast of India inhabited by people who are better nourished than the people living further inland. This is the result of plentiful fish supply on the coast. Antibiotics could provide the means for extending this area to one hundred miles from the coast with little added cost.³⁶

Other advantages to the entire fishing industry have been listed by Jack D. Langlois of the Chas. Pfizer Company:

1. An extension of fishing areas, allowing for a larger load of higher quality fish per trip.
2. A leveling of production by more normal scheduling of canning operations.
3. Increased protection against spoilage during storage and in transit to the consumer and to the freezing plant.
4. Expansion of the selling area of fresh fish to markets presently out of reach.
5. A better quality product will result in

³⁶Fred E. Deatherage, "Present Status of Antibiotics in the Preservation of Food," A panel discussion, Antibiotics Annual, 1956-1957 (New York: Medical Encyclopedia, 1957), p. 1121.

better consumer acceptance and a possible increase in sales.³⁷

Summary

Experiments with antibiotic preservation in beef and other meats have shown that the presence of small amounts of antibiotics will allow meat to be stored for as long as nineteen days at room temperature without spoiling. The advantages of this treatment are that it will allow for more rapid tenderization of meats in countries where refrigeration facilities are available, and antibiotics can provide protection against spoilage so that fresh meat can be provided to people great distances from the point of slaughter. Proper nutrition can thus be provided to persons who do not receive sufficient protein in their diets at a cost which, in some cases, would be less than the cost of the power necessary to refrigerate the meat. Brazil and Costa Rica have already adopted the use of antibiotics in beef on a commercial scale, and it appears to be a matter of time before other tropical countries and perhaps the United States will adopt this method.

The spoilage of fish creates important economic loss in many countries of the world. Antibiotics have been

³⁷"Pfizer Fishing New Antibiotic Pool," Oil, Paint and Drug Reporter CLXIX:16 (April 16, 1956), p. 42.

shown to add one week to the storage life of many types of fresh fish and to provide the consumer with a higher quality fish than that to which she is presently accustomed. The frozen and canned fish industries can also benefit from the use of antibiotics by giving added insurance against spoilage during transportation and storage. Fresh fish could provide an economical source of high quality protein to many people of the world now deprived of this type of nutrition due to distance from fishing areas.

CHAPTER IV

APPLICATION OF ANTIBIOTICS TO POULTRY PROCESSING

Poultry is the first food product treated with antibiotics on a commercial scale in the United States. A study of its effects and benefits is therefore the only guide available for determining the future possibilities for antibiotic preservation in other foods.

Antibiotics, because of their bactericidal action, cannot make spoiled poultry fresh. Their use on poultry with an initially high bacterial load (due to poor sanitary conditions in the processing plant) may permit the same shelf-life as untreated poultry processed under sanitary conditions. A system of inspection of processing plants which use antibiotics is therefore essential to prevent their use as substitution for proper sanitation.

With proper sanitation and refrigeration, however, antibiotics may allow for prepackaging poultry at the processing level, with resulting economies for retailer and consumer alike.

Observations on Poultry Meat Spoilage

The spoilage of fresh, chilled poultry meat presents a considerable problem to the producer, the processor, the distributor, and the consumer. "The yearly economic loss due to the spoilage of poultry meat in this country is

estimated at more than \$132,000,000."¹ Under normal refrigerated storage conditions, untreated poultry meat will develop slime and odors and may become sour sometime during the second week of storage. With the growing trend of selling pre-packaged cut-up poultry at the retail level, the problem of spoilage is further increased because of extra handling. The tendency for centralized growing and processing of broilers in a few areas of the country (the Delmarva Peninsula, Georgia, Missouri, and California) increases the distance over which killed poultry must be shipped before it reaches the ultimate consumer. Central pre-packaging of cut-up poultry at the processor level increases the exposed area upon which bacteria can grow.

Since bacteria appear to be the prime causative agents of slime and off-odors in poultry,² the first consideration in preservation should be the destruction of these organisms. Methods such as refrigeration, freezing, and canning have helped to increase the storage life of poultry, but each has its disadvantages. Refrigeration is

¹H. P. Broquist, A. R. Kohler, and W. H. Miller, "Retardation of Poultry Spoilage by Processing with Chlortetracycline," Agricultural and Food Chemistry, IV:12 (December, 1956), p. 1030.

²J. C. Ayres, W. S. Ogilvy, and G. F. Stewart, "Post Mortem Changes in Stored Meats. I. Microorganisms Associated with Development of Slime on Eviscerated Cut-Up Poultry," Food Technology, IV (1950), p. 199.

1

2

40

capable of retarding bacterial spoilage for only seven or eight days. Freezing requires the use of expensive equipment and requires that poultry be kept frozen until the time of use. Canning changes the flavor of poultry considerably and limits the number of ways in which the housewife can serve the poultry meat.

Brief History of Experiments

The first experiment with antibiotics as a preservative for fresh poultry meat was carried on by three members of the Research Division of the American Cyanamid Company in 1954. A. R. Kohler, W. H. Miller, and H. P. Broquist found that the use of chlortetracycline (the trade name of the American Cyanamid Company for chlortetracycline is Aureomycin) significantly extended the shelf-life of poultry meat both in the laboratory and under commercial conditions.³ In early 1955, Frank Zeigler and W. J. Stadelman of the Washington State College staff reported approximately the same results--poultry shelf-life was "increased from 8.7 to about fourteen days by this treatment."⁴

³A. R. Kohler, W. H. Miller, and H. P. Broquist, "Aureomycin, Chlortetracycline and the Control of Poultry Spoilage," Food Technology, IX (1955), p. 153.

⁴Frank Zeigler and W. J. Stadelman, "The Effect of Aureomycin on the Shelf Life of Fresh Poultry Meat," Food Technology, IX (1955), p. 108.

Throughout 1955, reports from various universities and drug companies substantiated the facts first published in the above references. The climax to these experiments came on November 30, 1955, when tolerances for the residues of chlortetracycline in uncooked poultry were published in the Federal Register.⁵ Approximately one year later, the tolerances for residues on uncooked poultry of another antibiotic, oxytetracycline (the trade name of the Chas. Pfizer Company for oxytetracycline is Terramycin) were published.⁶

Commercial Application of Antibiotics to Fresh Poultry Meat

Two drug companies have produced antibiotics capable of extending the refrigerated storage life of fresh poultry meat from fifty to one hundred per cent.

The American Cyanamid Company has developed Acronize PD (Poultry Dip) chlortetracycline which is a formulation containing a food grade aureomycin (approximately 10 per cent), salt, and citric acid. Citric acid is used to

⁵Federal Register, The National Archives of the United States, XX (Washington: Government Printing Office, November 30, 1955), p. 8776.

⁶Federal Register, The National Archives of the United States, XXI (Washington: Government Printing Office, October 23, 1956), p. 8104.

stabilize the antibiotic and salt is used as a diluent.⁷ The solution is added to the slush tank at the time the birds are chilled after killing to remove body heat. The birds remain in this tank for approximately two hours, or until the internal body temperature is 40° F or below. During this time the birds absorb about six per cent of their body weight in water. As this water is absorbed, the dissolved Acronize penetrates into the tissues of the bird and remains attached to the tissue protein.⁸

On November 30, 1955, the Food and Drug Administration established a tolerance of seven parts per million of chlortetracycline in or on any part of the uncooked poultry.⁹ This paved the way for the first full scale commercial use of antibiotics as an aid to food preservation in the United States. The tolerance of seven parts per million in or on any part of the uncooked poultry was established by The Food and Drug Administration after extensive tests by the American Cyanamid Company proved that the normal methods of cooking (boiling, broiling, frying, or baking) destroyed the antibiotic.

⁷"Antibiotics and Food," Chemical and Engineering News, XXXIII:50 (December 12, 1955), p. 5368.

⁸Melvin C. Firman, Director of Technical Service of the Farm and Home Division of the American Cyanamid Company, New York, New York, (January 3, 1958), Personal Correspondence.

⁹Federal Register, November 30, 1955, op. cit.

The second drug company to produce a poultry dip for the reduction of bacterial spoilage was Chas. Pfizer and Company. Their commercial product, Biostat-PA, is a combination of oxytetracycline and citric acid. It is applied in the same manner as Acronize, and does not require changes in the normal processing procedure.

The tolerance for oxytetracycline on or in uncooked poultry was established by the Food and Drug Administration on October 23, 1956, at seven parts per million on any part of the carcass.

Application of Antibiotics to Turkeys. The procedure for applying antibiotics to turkey carcasses is the same as for chickens. The only exception being that the larger turkey carcass must be left in the chill tank for a longer period of time. This did not appear to increase the amount of antibiotic absorbed by the turkey meat, and the same beneficial results were obtained.¹⁰

Labeling of Antibiotic-treated Poultry

Section 403K of the Federal Food, Drug and Cosmetic Act states the following in reference to the use of

¹⁰ H. Windlan, et al., "An Investigation of the Process Using Food Grade Chlorotetracycline as Applied to Turkeys," Antibiotics Annual, 1956-1957 (New York: Medical Encyclopedia, 1957), p. 854.

1

chemical preservatives in foods which are produced for human consumption:

A food shall be deemed to be misbranded if it bears or contains any artificial flavoring, artificial coloring, or chemical preservative, unless it bears labeling stating that fact....¹¹

A section of the franchise agreements of both the American Cyanamid Company and the Chas. Pfizer Company, Incorporated, specify that each chicken which has been treated with an antibiotic shall be labeled "Acronized---Chlortetracycline added to retard spoilage" or "Oxytetracycline added to retard spoilage," respectively.

Commercial Versus Laboratory Results

Although the original research on the possible use of antibiotics in the preservation of poultry meat was done both in the laboratory and under commercial conditions, the majority of evidence supporting claims for extension of poultry shelf-life from fifty to one hundred per cent have come from laboratories. Obviously, sanitary conditions are much easier to control in a laboratory capable of processing only a few hundred birds per day than in a commercial plant, processing many thousands of birds per day.

¹¹Federal Food, Drug and Cosmetic Act and General Regulation for its Enforcement, U. S. Department of Health, Education and Welfare, Food and Drug Administration, Service and Regulatory Announcements, Food Drug, and Cosmetic No. 1, Revision 4, with Addenda, (Washington: Government Printing Office, April, 1955), p. 17.

Such factors as size of plant, number of employees, variation in source of live birds, and number of birds cooled in one slush tank will tend to increase bacterial contamination. There exists, then, the possibility that antibiotic treatment would not materially increase the shelf-life of poultry meat processed under commercial conditions.

There is at least one study which indicates the aforementioned. This test, conducted in only one commercial processing plant, indicated that:

Fresh chicken meat treated commercially with chlortetracycline in a single processing plant was no more effective in extending shelf-life than untreated birds from the same plant...Chlortetracycline-treated commercial birds were considered unacceptable from seven to eight days sooner than similarly treated laboratory birds according to results of a raw odor panel.¹²

Because chlortetracycline and oxytetracycline are bacterial inhibitors only, there exists a possibility that the balance of nature would be upset as a result of this inhibition, and molds and yeasts would grow rapidly. However, when this question was posed to a panel of experts on the uses of antibiotics in food preservation, the reply was: "We have not seen any evidence of an increase in the yeast and mold spoilage in poultry treated with antibiotics

¹²Robert James McVicker, "The Effect of Certain Bacterial Inhibitors on Shelf-life of Fresh Poultry Meat," (unpublished Master's thesis, Michigan State University, East Lansing, 1957), pp. 69-70.

as compared with controls."¹³ It appears that refrigeration sufficiently retards the growth of yeasts and molds throughout even the extended shelf-life offered by antibiotics.

Promotional Efforts of American Cyanamid

In January, 1956, nobody outside of American Cyanamid knew of Acronize. By December, 1956, about one-half of the fifty leading chain store organizations were selling Acronized poultry. "One, Grand Union, has adopted the preservation plan 100%."¹⁴

Following basic marketing techniques, the American Cyanamid Company tested their product in the cities of Memphis, Tennessee; Richmond, Virginia; and Jacksonville, Florida. These areas were chosen because of their geographical proximity to the processing area. If the process could gain acceptance, which it did, in these areas where commercial poultry could be obtained at its freshest, it would probably also be successful in areas further from the producing and processing centers.

¹³Dr. Jukes, "Present Status of Antibiotics in the Preservation of Food," A panel discussion, "Antibiotics Annual, 1956-1957" (New York: Medical Encyclopedia, 1957), p. 1119.

¹⁴"Food Antibiotics: Market Meteor," Chemical and Engineering News, XXXIV:50 (December 10, 1956), p. 6108.

The promotion campaign for Acronize has been aimed at the processor, at the retailer, and directly at the consumer. Advertising in Poultry Processing and Marketing and in Poultry and Eggs Weekly was centered on "testimonial copy and the big news of our Acronize consumer promotion."¹⁵ Chain Store Age, Progressive Grocer, and Supermarket News are used to reach the overall market potential of some 300,000 retail stores. These ads feature testimonials and consumer promotion plans. Free promotional materials are supplied to retail markets to be used at their discretion. These include plastic meat case cards, and a Good Housekeeping Fact Plack containing interesting material on the antibiotic preservation process.

A comparison between Acronized chicken and pasteurized milk will be made in all consumer promotions for 1958. The prime target for consumer advertising is the local market. Don McNeill, radio personality, heard over 306 ABC Radio Network stations, will advertise Acronize to American housewives every morning, before they go shopping.

Such a promotion campaign has paid well for American Cyanamid. They claim that at least twenty out of every

¹⁵Jim N. Burton, Assistant Advertising Manager, Farm and Home Division, American Cyanamid Company, New York 20, New York, February 20, 1958, Personal Correspondence.

one hundred housewives had a specific consciousness of Acronize in late 1957.¹⁶ Only two years work were required to build a twenty per cent awareness of their process.

The Franchise Program

Because antibiotics are primarily bacteriostatic in nature, they cannot make spoiled poultry fresh. The drug manufacturers recognize this and have established their sales program on a franchise basis. Biostat and Acronize can be sold only to those processors who sign a contract stating that certain sanitary standards will be met.

"The maintenance of freshness means keeping the bacterial life in food as nearly as possible at the same level as when life left the healthy fish, bird or animal."¹⁷

The quality control section of American Cyanamid's staff specifies to the processor the level of antibiotics to be used, the preparation and handling of solution, period of processing, kind of poultry to be processed, refrigeration requirements, packaging, and sanitation practices.¹⁸

¹⁶ Ibid.

¹⁷ Wilbur H. Miller, "Comprehensive Studies of the Use of the Food Grade of Chlortetracycline in Poultry Processing. I. The Franchise Program in Action," Antibiotics Annual, 1956-1957 (New York: Medical Encyclopedia, 1957), p. 817.

¹⁸ Ibid., 819.

A technical representative visits the plant to determine if these basic requirements are met. He then works with plant personnel to insure that they understand the process, and makes occasional follow-up visits to verify that quality control standards are met.

This extensive inspection procedure insures that processors are not failing in some sanitation procedure and covering it up with the use of antibiotics. Since antibiotics do not kill bacteria but merely stop their growth at a certain point, there is no danger of spoiled poultry getting by undetected. There is danger, however, of selling poultry under the Acronize or Biostat labels which is no fresher than non-treated poultry. This is the danger which the drug companies wish to avoid.

Advantages of Antibiotic Preservation of Poultry Meat

The benefits to be derived from the use of antibiotics in poultry meat hinge upon the premise that under commercial conditions of processing, the same extension of shelf-life can be obtained as is done in the laboratory. The extension of shelf-life of poultry has been reported to be from the normal refrigerated case life of seven days to as high as twenty-nine days.¹⁹ A conservative estimate would probably

¹⁹C. L. Wrenshall and J. R. McMahan, "How Newly OK'd Antibiotic Boosts Poultry Shelf-life," Food Engineering

place the shelf-life of treated poultry at about fourteen days.

The possibilities that extended shelf-life offer to the producer, the processor, the retailer, and the consumer are far-reaching. One of the principal advantages offered by antibiotic preservation is that a higher quality, tastier poultry will be available to many more people.

Quality of poultry as defined from a marketing point of view is very closely correlated with freshness. If antibiotics can keep poultry fresh for a longer period of time, consumers in areas which lie great distances from poultry raising and processing centers may be served with a product that is of higher quality than that to which they are presently accustomed. The quantity of fresh poultry which

XXVIII:12 (December, 1956), p. 56; Windlan, et al., op. cit., p. 854; W. J. Stadelman, W. W. Marion, and M. L. Eller, "Antibiotic Preservation of Fresh Poultry Meat," Antibiotics Annual, 1956-1957 (New York: Medical Encyclopedia, 1957), p. 841; Kohler, Miller, and Broquist, op. cit., p. 154; Broquist, Kohler, and Miller, op. cit., p. 1031; J. V. Spencer, Frank Ziegler, and W. J. Stadelman, Recent Studies of Factors Affecting the Shelf-life of Chicken Meat, Washington Agricultural Experiment Station, Institute of Agricultural Sciences, Station Circular 254 (Spokane: State College of Washington, September, 1954), p. 3; Frank Zeigler and W. J. Stadelman, "The Effect of Aureomycin Treatment on the Shelf-life of Fresh Poultry Meat," Food Technology IX (1955), p. 108; W. H. Miller, "Antibiotic Prolongs Meat Storage Life," The National Provisioner CXXXIII:22 (November 26, 1955), pp. 104-106; "New Tricks With Antibiotics," Business Week No. 1371 (December 10, 1955), p. 80; John Harms, "Antibiotics Enter Poultry Meat Field," Poultry Processing and Marketing LXI:12 (December, 1955), p. 18.

was shipped over one thousand miles from the processing plants to market in 1952 amounted to only two per cent of total. In 1956-1957, the quantity had risen to seven per cent of marketed poultry.²⁰ Whether or not antibiotic preservation had anything to do with this increase is difficult to determine, but it seems possible that extended shelf-life might allow processors to ship more poultry over these long distances. This fact could easily lead to greater volume of sales and increased turnover of fresh poultry meat.

The poultry processor would benefit from the use of antibiotics in at least two ways. The normal processing of poultry in a dressing plant includes a dip into hot water to loosen the feathers before they are removed by an automatic picking machine. The normal temperature of the water used in these dips ranges from 138° to 140° F.²¹ Temperatures above this level have not been used because of damage to the outer layer of skin of the bird and a subsequent reduction of the bacterial resistance of the carcass. Antibiotics could supplant this natural bacteria barrier and

²⁰Marketing Research Division, Interstate Trucking of Fresh and Frozen Poultry Under Agricultural Exemption, Agricultural Marketing Service, United States Department of Agriculture, Marketing Research Report No. 224 (Washington: Government Printing Office, March, 1958), p. 22.

²¹Spencer, Zeigler, and Stadelman, op. cit., p. 1.

allow the use of higher scald temperatures (148°F) which would create a great saving in pinning labor.²² The second advantage to the processor would be a leveling of work loads enabling orderly, unrushed operation which would result in a better looking carcass with fewer bruises.²³

Inventories at the retail level would be easier to maintain because of a longer shelf-life. There would be no need to sell out all poultry prior to the weekend to eliminate the possibility of spoilage. Because of an upgrading of quality, processors and retailers will be able to sell more fresh poultry under their own brand names, with less danger of returns.

An advantage to the processor, retailer, and the consumer would arise from central pre-packaging of cut-up poultry. Antibiotics would:

Make possible further shift of packing and wrapping operations back through distribution channels to the processing plant... Some indication of such economies was shown in a limited study carried out by our sales department (American Cyanamid). It was found that the cost of cutting up and packaging poultry in a large North Carolina supermarket, handling 1,500 birds a week, was about 3½ cents a bird. But in one of the large processing plants of Virginia, handling

²²"Antibiotics and Food," op. cit.

²³Advertisement, "Three Profitable Reasons Why Your Poultry Should Be Acronized," Poultry Processing and Marketing LXIV:5 (May, 1958), p. 23.

many thousands of birds a day, the labor cost was calculated at $\frac{1}{2}$ cent a bird.²⁴

The American Cyanamid Company has outlined a procedure by which poultry can be cut-up, packaged, and shipped dry from a central processing plant. Because the poultry is not packed in ice, the principal danger in such an operation is an increase in the temperature of the bird. Provided rigid sanitation controls are established, poultry can be processed in this manner, and shipped to the retail level in a saleable condition. The total shelf-life of pre-packaged poultry held at temperatures no higher than 40° would be approximately five days. This time includes storage time at the processor level, at the distributor level, and would allow a two day case life at the retail level.²⁵ The advantages of this process are obvious:

1. Less expensive.
2. Tray-packed poultry require less space in delivery truck.
3. Not necessary to ship ice along with poultry.
4. Frees store help for other tasks.
5. Easier handling.
6. More uniform packages.
7. Less storage space required at retail level.

²⁴Wilbur H. Miller, "Antibiotic Introduced as Spoilage Inhibitor for Fresh Poultry," Food Engineering XXVIII:1 (January, 1956), p. 47.

²⁵Acronized Tray-packed Poultry (New York: The American Cyanamid Company, 1957), pp. 1-6.

An example of the ways in which antibiotics have aided the food chains can be seen from the following remarks made by Mr. J. D. Hughes, General Manager of Merchandising for the New York Region of the Grand Union Company:

Acronized poultry was first tried in our Central Division in the early summer of 1956 on a three week basis. Generally speaking, the tests proved quite satisfactory and we then introduced the acronized poultry into our Metro, Suburban and Northern Divisions in July, 1956. We were supplied and continued to be supplied with what we cared to use of their in-store promotional material. The term acronized poultry was used from time to time in our newspaper advertising.

We have had no important customer reaction of either a complimentary or adverse nature to speak of. Actually it is our feeling that the Acronizing process provides a longer keeping time for the customer. We have not extended the tolerance case life of poultry in our stores because of this protective process, preferring to give the additional time to the housewife.

As you are probably aware, we have a backed by bond guarantee on all of our meat products...and we do know that our complaints on poultry have considerably lessened since the advent of acronizing this merchandise. We therefore feel that we can absorb the additional acronizing cost for reason of better customer satisfaction.²⁶

Application to Frozen Poultry

One of the characteristics of the two antibiotics presently being applied to poultry is that they are capable

²⁶ J. D. Hughes, General Manager, Merchandising, New York Region, The Grand Union Company, 333 North Bedford Road, Mount Kisco, New York, May 28, 1959. Personal Correspondence.

of lying dormant while in the frozen state and exerting their bacteriostatic properties upon thawing. Since existing laws allow frozen poultry to be thawed and sold as fresh,²⁷ this quality could provide additional protection against deterioration. Antibiotic treatment of poultry prior to freezing also provides protection against spoilage due to refrigeration failure or excessive storage periods at above freezing temperatures.

That thawed frozen poultry will deteriorate more rapidly than iced poultry is a fairly well established fact.²⁸ Antibiotics might therefore be of greater benefit in frozen poultry than in fresh poultry, particularly during the holiday seasons of Thanksgiving and Christmas when a large percentage of turkeys sold are frozen. The benefits derived from this application would benefit both the retailer and the consumer.

Summary

The commercial application of broad spectrum antibiotics to poultry meat is well established. Experiments in the laboratory and under commercial conditions

²⁷"Antibiotics Proving Value as Food Freezing Ally," Quick Frozen Foods XVIII:12 (July, 1956), p. 60.

²⁸"Acronize Chlortetracycline For Use in Processing of Turkeys," (New York: American Cyanamid Company, n.d.), p. 2. (Mimeographed.)

have proven that the application of small amounts (ten parts per million) of either chlortetracycline or oxytetracycline can extend the refrigerated shelf-life of fresh chicken and turkey meat fifty to one-hundred per cent.

Although there are no indications that some processors are not obtaining full benefit from the use of these substances, a more rigidly controlled franchise program would insure that plant sanitation met required standards. Federal inspection of poultry processing plants could also further this end.

The extension of shelf-life of refrigerated poultry meat has been the principal advantage of the use of antibiotics in processing. Future developments resulting from their use might include packaging of both cut-up poultry and of poultry parts at the processor level; more widespread use of brand names on fresh poultry; wider distribution of fresh poultry meat from fewer centralized processing areas; and finally, delivering a better quality product to the ultimate consumer.

This last advantage is the one which appears to be most important to the retailer. By passing on whatever extension in shelf-life antibiotics can give to the housewife, the retailer can be assured of fewer returns because the housewife kept the bird in her home refrigerator for a week or more.

CHAPTER V

SHELF-LIFE EXTENSION OF FRESH FRUITS AND VEGETABLES

Considerable loss is experienced each year in the marketing of fresh fruits and vegetables. These foods are perhaps the most perishable of any handled in the markets of the world, some having a market life of only a few days, even when held under refrigeration. The principal causes of deterioration are poor handling practices and bacterial spoilage.

Antibiotics are presently being used in agricultural sprays to reduce disease. The bactericidal effects of some of these sprays are carried over to the picked fruit or vegetable, providing protection against post-harvest decay. Some of the medical antibiotics have been shown to increase shelf-life of highly perishable produce and may have application commercially in the near future.

The dangers of the use of antibiotics to retard spoilage of fresh fruits and vegetables lie primarily in the area of public health hazards. Residual levels of antibiotics must be established and methods developed to eliminate traces of antibiotics prior to consumption.

Spoilage Problems Encountered

Losses of certain fresh fruits and vegetables in marketing channels have been estimated to be as much as

1

forty-three per cent of production.¹ A recent survey by the United States Department of Agriculture disclosed that vegetable crops perish more readily in marketing channels than do fruits. More than fifteen per cent of the total value of twenty-seven major vegetable crops marketed was lost during transportation and storage.² Marketing losses in nineteen important fruits amounted to nearly eleven per cent of the total of these fruits marketed.³

In analyzing the results of the United States Department of Agriculture study on losses in marketing fruits and vegetables, the two most common causes of spoilage are rot and mold. Of the twenty-seven vegetables mentioned in the study, eighteen are either rendered unmarketable or seriously damaged by bacterial soft rot.⁴ Experiments (which will be discussed in detail later in this chapter), have shown that certain of the common medical antibiotics are capable of inhibiting the growth of the causative organism of this disease. Of the other types of rot indicated to cause spoilage of both fruits and

¹W. Kling, "Food Waste in Distribution and Use," Journal of Farm Economics XXV (November, 1943), p. 865.

²Agricultural Research Service, Losses in Agriculture, United States Department of Agriculture, ARS 20-1 (Washington: Government Printing Office, June, 1954), pp. 107-108.

³Ibid., p. 103.

⁴Ibid., pp. 106-112.

vegetables, it is safe to assume that at least some of them can be controlled with antibiotics.

Thirteen of the seventeen fruits, and nine of the twenty-seven vegetables studied were damaged by various types of molds.⁵ Although the majority of antibiotics known today are primarily bacteriostatic in their action, there are a few which exhibit inhibitory action on the growth of yeasts and molds.

Refrigeration can retard a large percentage of the losses presently encountered in marketing fresh produce. However, refrigeration facilities are not available for all produce presently marketed. If antibiotics could perform the same function as refrigeration on presently unrefrigerated produce, and further extend the shelf-life of produce stored and shipped under refrigeration, substantial savings could be realized.

Present Uses of Antibiotics in Controlling Plant Diseases

To date, the application of certain medical antibiotics and some antibiotics which exhibit antifungal activity to the control of plant diseases has been confined to tree fruits and certain vegetable crops. In order to eliminate the possibilities of residues of antibiotics remaining on the produce after harvesting, the applications

⁵Ibid., pp. 102-112.

must be made either after harvesting or a long time before harvest. In some cases, the antibiotics are applied before the seed sends its shoot through the ground.

Some of the fruits which have responded well to treatment with antibiotics are the stone fruits, apples, pears, and cherries. Actidone, the only commercial antibiotic with antifungal properties, "is used primarily as a postharvest spray against cherry leaf spot...."⁶ This treatment has limited application at present because of the high toxicity of the antibiotic.

An application of streptomycin to eliminate fire-blight cankers in apple trees involves sealing a capsule in the trunk of the tree. Streptomycin could still be detected in fruit on August 28th after treatment on May 6th.⁷ Such applications would be dangerous, even if all the fruit from treated trees were used in commercial processes such as the making of applesauce or pies because cooking does not destroy streptomycin as it does the broad spectrum antibiotics, chlortetracycline and oxytetracycline. A combination of streptomycin and oxytetracycline was found to be

⁶"For Antibiotics, Uses Galore," Chemical and Engineering News XXXII:47 (November 19, 1956), p. 4641.

⁷R. N. Goodman and M. R. Johnston, "Stability of Streptomycin in Apple and Potato Tissue," Antibiotics Annual, 1956-1957 (New York: Medical Encyclopedia, 1957), p. 1007.

more effective than either alone on certain diseases of apples, pears, and stone fruits.⁸

Another antifungal antibiotic, anisomycin, has been found to protect beans from powdery mildew.⁹ Some other vegetable and field crops which have responded to a treatment of a combination of streptomycin and oxytetracycline are beans, corn, tomatoes, peppers, castor beans, and sesame.¹⁰

Research has shown, however, that a number of antibiotics are able to penetrate the epidermal or outside layers of plants and can be absorbed by the roots.¹¹ Finding such as this tend to minimize the chances of early field applications of antibiotics in plant disease prevention and treatment because of the public health hazard of residues of medical antibiotics on or in the food parts of the plant.

⁸F. C. Visor, V. J. Carroll, and E. F. O'Neill, "Use of Antibiotics Against Agricultural Plant Pathogens," Antibiotics Annual, 1954-1955 (New York: Medical Encyclopedia, 1955), p. 543.

⁹"Antibiotics Keep Steaks Young," Chemical and Engineering News XXXIV:45 (November 5, 1956), p. 5392.

¹⁰Visor, et al., loc. cit.

¹¹Goodman and Johnston, op. cit., p. 1006.

Preservation With Antibiotics

Results of experiments on the use of antibiotics in the retardation of post-harvest decay of fresh fruits and vegetables published to date center on the ability of these substances to increase the storage life of fresh vegetables. Most of the experimentation is concerned with the organism causing bacterial soft rot, Erivinia carotovora.¹² This is in accordance with the findings of the Department of Agriculture survey which concluded that bacterial soft rot was the most prevalent cause of decay.¹³ Because green leafy vegetables lack the protective covering that some vegetables have, they are more vulnerable to bacterial attack.

Salad Vegetables. Some nine salad vegetables, and eight vegetables that normally require cooking prior to consumption have been found to respond quite satisfactorily to treatment with antibiotics for extension of shelf-life. Included in the salad vegetables are chopped salad greens, cole slaw, radishes, lettuce, escarole, endive, celery, cucumber, and chicory. Lettuce, a highly perishable and

¹²R. F. Becker, R. N. Goodman, and H. S. Goldberg, "Prolonging the Shelf-life of Refrigerated Prepackaged Spinach with Antibiotics," Antibiotic Annual, 1957-1958 (New York: Medical Encyclopedia, 1958), p. 229.

¹³Agricultural Research Service, op. cit., pp. 106-112.

economically important crop, is attacked by two bacterial rots, slime head and jelly rot. By painting the butts of freshly cut lettuce with a solution containing 250 parts per million of a combination of streptomycin and oxytetracycline, decay was reduced from sixty per cent in the controls to approximately four per cent in the treated lettuce.¹⁴

The Chas. Pfizer Company found that their antibiotic, terramycin, could extend the refrigerated shelf-life of cut-up raw salad vegetables from three to six days when the vegetables were rinsed with a terramycin solution.¹⁵ The room temperature shelf-life could be increased by one day, or from two to three days. Rinsing with clear water after the antibiotic treatment reduced the amount of antibiotic remaining on the vegetables, but did not effect the extension in shelf-life. This may indicate that very low levels of antibiotic are all that are necessary to prevent deterioration and that perhaps the initial concentration was too high.

¹⁴C. L. Wrenshall, "Advances in Food Technology Made Possible Through the Use of Antibiotics," Antibiotics Annual, 1956-1957 (New York: Medical Encyclopedia, 1957), p. 812.

¹⁵C. L. Wrenshall, "Can Antibiotics Solve Food Sterilization Problems?," Food in Canada XIII (November, 1953), pp. 26-27.

1

A ten to fifteen minute wash in water containing thirty parts per million oxytetracycline followed by a distilled water rinse was found to extend the shelf-life of chopped fresh vegetables by thirty to fifty per cent.¹⁶ The vegetables so tested were cabbage, red cabbage, lettuce, escarole, endive, celery, and spinach.

Dr. Wilson L. Smith, Jr., of the United States Department of Agriculture, one of the first scientists to explore the possibilities for extending shelf-life of fresh vegetables with antibiotics, found that a 0.1 per cent solution of streptomycin sulfate extended the shelf-life of packaged cole slaw from one day to three days.¹⁷ His research also found that a combination of streptomycin and sodium bicarbonate (NaHCO_3) or sodium bisulphate (NaHSO_4) equaled or exceeded the shelf-life extension of streptomycin alone.¹⁸ Streptomycin-treated cole slaw in non-ventilated packages (as it is often sold in supermarkets) showed no discoloration, no break-down due to decay, and little or no off-odor after three days. He also

¹⁶R. C. Kersey, F. C. Visor, and C. L. Wrenshall, "Residual Antibiotic Levels in Food Products During Storage and Processing," Antibiotics Annual, 1953-1954 (New York: Medical Encyclopedia, 1954), p. 445.

¹⁷W. L. Smith, Jr., and R. E. Hardenburg, "Antibiotics and Other Chemical Dips Reduce Discoloration of Packaged Cole Slaw," Phytopathology XLIV (1954), p. 389.

¹⁸Ibid.

discovered that terramycin and aureomycin in 0.1 per cent concentrations, controlled decay but caused severe injury to the slaw.¹⁹

Radish nit, a post-harvest disease which causes lesions on radishes three to five days after harvesting, was partially controlled by treatment with a solution of oxytetracycline.²⁰ Approximately fifty per cent of the symptoms of the disease were prevented with an oxytetracycline dip.

Some other economically important salad vegetables were found to remain in saleable condition up to forty-eight hours at temperatures of 30°C (86°F) and even longer at 5°C to 10°C (41° to 52°F). Oxytetracycline controlled spoilage of cucumbers, chicory, escarole, and lettuce for this period of time.²¹

Vegetables Usually Cooked. Since some of the broad-spectrum antibiotics appear to be destroyed during normal cooking of poultry and other flesh foods, it seems more obvious that public health authorities might first allow

¹⁹Ibid., p. 390.

²⁰"Radishes -- Antibiotic Treatment," Food Manufacture XXXII:7 (July 1, 1957), p. 339.

²¹v. J. Carroll, R. A. Benedict, and C. L. Wrenshall, "Delaying Vegetable Spoilage with Antibiotics," Food Technology XI (1957), p. 493.

the addition of antibiotics to those items of produce which are usually cooked before eating. The antibiotics which have been found useful in preventing post-harvest decay of vegetables in this category are streptomycin, filipin, oxytetracycline, neomycin and polymyxin. At least two days can be added to the shelf-life of fresh, refrigerated pre-packaged spinach by the addition of a 0.1 per cent water solution of streptomycin sulfate, whether by dip or by spray.²² One day of shelf-life can be added when spinach is stored at 70°F. In most cases, a post-harvest dip has been more effective in extending shelf-life than a pre-harvest spray.²³ Filipin, a new antibiotic discovered by the Upjohn Company of Kalamazoo, Michigan, has shown good results in preventing a type of rot of peas.²⁴

An experiment which appears to be particularly significant to the supermarket industry involved the use of four different antibiotics on five vegetables.²⁵ The

²²"For Antibiotics, Uses Galore," p. 4642.

²³"Nonpharmaceutical Uses of Antibiotics," Journal of Agricultural and Food Chemistry I:18 (November 25, 1953), p. 1101.

²⁴"Antibiotics Proving Value as Food Freezing Ally," Quick Frozen Foods XVIII:12 (July, 1956), p. 140.

²⁵G. Koch and V. J. Carroll, "Prevention of Post-harvest Decay with Antibiotics," Antibiotics Annual, 1956-1957 (New York: Medical Encyclopedia, 1957), pp. 1010-1012.

Vegetables were purchased from the central produce markets New York City at a time when their storage life would represent the retail store life of the produce. The vegetables, peas, broccoli, lima beans, cauliflower, and spinach, were dipped in the various antibiotic solutions and stored at 30°C (86°F) for forty-eight hours. Inspections were made at twenty-four and forty-eight hours, and the condition of the vegetables recorded according to the following scale:

- 1, 2, 3 - small areas of damage visible, still marketable.
- 4, 5, 6 - all showed some rot, non-marketable.
- 7, 8 - definite rot present, discoloration,
- 9, 10 - complete rot.

Of the four antibiotics tested (oxytetracycline, streptomycin, neomycin, and polymyxin), oxytetracycline and neomycin gave the best results. Although the streptomycin-and polymyxin-treated vegetables were better than the controls, they were not marketable after forty-eight hours.

Decay of peas, broccoli, cauliflower, and lima beans was slowed down by the addition of minute quantities of oxytetracycline and neomycin. At the end of the forty-eight hour storage period, (at conditions of temperature which accelerated decay), the oxytetracycline-treated vegetables showed the least decay. Following are the results of a fifteen second dip of solutions containing thirty-five parts per million of the two antibiotics on the spoilage of fresh spinach:

1

<u>Treatment</u>	<u>Scale of Damage</u>	
	<u>After 24 Hours</u>	<u>After 48 Hours</u>
Oxytetracycline	1.0	2.0
Neomycin	2.3	5.3

The authors of the preceeding research sum up their findings in the following sentence: "Under the conditions offered in these tests, oxytetracycline treatment of twenty-five parts per million in a fifteen second solution dip extended the shelf-life of the vegetables."²⁶

A thirty-minute dip in a solution containing ten parts per million of streptomycin has been found to be effective in reducing rot caused by black leg and soft rot in slices and seed pieces of white potatoes.²⁷ Reiner Bonde, author of the research, also found that terramycin was less effective than streptomycin in preserving potatoes and offered the suggestion that perhaps a combination of several antibiotics would be more effective than any one alone.

Fruits. A German scientist has discovered that the use of small amounts of penicillin in stored grapes

²⁶Ibid., p. 1013.

²⁷Reiner Bonde, "Preliminary Studies on the Control of Bacterial Decay of the Potato with Antibiotics," American Potato Journal XXX (1955), p. 147.

maintained, and even enhanced, the organoleptic qualities of the fruit.²⁸ The samples so treated were kept in good condition approximately two months longer than untreated grapes. The preservative qualities of antibiotics on other fruits have been noticed primarily as an aftermath of pre-harvest treatment to prevent diseases of plants. An example is the aforementioned treatment of the trunks of apple trees.²⁹

The Problem of Residues

Because a great many fruits and vegetables are eaten raw, a certain public health hazard is obvious from the application of antibiotics as preservatives. The Food and Drug Administration established its position in the use of antibiotics in food preservation when tolerances for levels of chlortetracycline and oxytetracycline on poultry were set forth. The F. D. A. required proof that normal methods of cooking poultry would destroy all or the greatest part of the antibiotic.

Streptomycin has shown some promise in the retardation of spoilage of such crops as spinach, cole slaw,

²⁸"The Use of Germicides (antibiotics and sulphonimides) in the Preservation of Grapes in Cold Storage," (In German), A. Geron. Indus. Cons. XIX (1954), pp. 32-35, Cited by Food Science Abstracts XXVII (London: Her Majesty's Stationery Office, 1955), p. 669.

²⁹Goodman and Johnston, loc. cit.

lettuce, and potatoes. Since two of these products are eaten raw, the problem of residues is a serious one. Even the use of streptomycin on vegetables which are to be cooked can present residue problems because streptomycin is only partially heat liable, persisting after a three minute boiling.³⁰ In an experiment in which potatoes were dipped in a solution of streptomycin and actidione on July 7th, traces of the antibiotic could still be detected in the potatoes on November 10th.³¹ Streptomycin could also be detected in apples three and one-half months after treatment of the tree.³²

It appears from these experiments that the application of streptomycin to fresh fruits and vegetables does not have commercial significance at this time because of the residues remaining for such a long period of time after treatment. If rinses or cooking can eliminate residues of other antibiotics which show promise in the preservation of fresh produce, they may find more rapid application on a commercial scale. Perhaps the concentrations presently being experimented with are too high and much lower concentrates can be effective without the danger of potentially harmful residues.

³⁰Becker, et. al., op. cit., p. 234.

³¹Goodman and Johnston, op. cit., p. 1008.

³²Ibid., p. 1007.

Future of Antibiotic Preservation of Fresh Produce

A much lower concentration of a combination of antibiotics may be the answer to the problem of preservation of fresh produce in the future. Because of the nature of fruit and vegetable spoilage, there is a need not only for a bactericidal or bacteriostatic antibiotic to eliminate rot organisms, but also for a fungicidal or fungistatic antibiotic to control molds and yeasts.

Antibiotics, at best, can probably be counted upon to add one or two days of shelf-life to fresh fruits and vegetables. This is all that is necessary.

In most cases, properly handled refrigerated pre-packaged spinach has a shelf-life sufficient for commercial marketing purposes. However, under conditions of heavy natural bacterial soft rot infection and high temperatures, which favor bacterial growth, refrigeration alone is insufficient. These adverse conditions frequently become apparent during the summer months and during spring and fall when temperatures rise abnormally.³³

Summary

Losses in fruits and vegetables alone amount to more than one billion dollars a year.³⁴ Most of these losses are due to improper handling which causes breaks in the natural protective barrier of the produce, allowing for easier entry of bacteria and molds.

³³Becker, et al., loc. cit.

³⁴Wrenshall, "Advances in Food Technology Made Possible Through The Use of Antibiotics," p. 812.

Antibiotics are presently being used in limited applications for the prevention and treatment of various plant diseases. Absorption of the antibiotic by plant leaves and roots presents certain problems in residues remaining in the fruit for long periods of time.

Various experiments have shown that antibiotics such as streptomycin, oxytetracycline, and neomycin can effectively add one to three days to the shelf-life of produce. In combination with refrigeration, antibiotics could reduce some of the tremendous loss presently encountered in produce marketing.

Residues of antibiotics must be eliminated before widespread commercial use of this type of preservation can become a reality. Perhaps the discovery of new antibiotics which do not have medical significance and have no adverse affects upon the human body can solve some of these problems. Antibiotics may find use in preserving fruits and vegetables during transportation and storage prior to freezing and canning. The heat used in these two processes may be sufficient to destroy existing residues and provide the consumer with a higher quality product.

CHAPTER VI

APPLICATION OF ANTIBIOTICS TO THE CANNING INDUSTRY

Present methods of canning foods leave something to be desired in the nutritional and organoleptic properties of foods permanently preserved in this manner. Certain antibiotics have shown promise in improving the quality of canned foods and exhibit potential for the complete automation of the canning process. Both subtilin and nisin have proven valuable in reducing spoilage in canned foods, but neither has exhibited the ability to either completely destroy or permanently inhibit the toxin-producing ability of Clostridium botulinum, the organism responsible for botulism, a food poisoning lethal to man and animals.

Application of antibiotics to fresh produce prior to canning might reduce losses due to spoilage in storage. They might also allow for the permanent preservation of foods which cannot be canned with existing techniques.

Canning Techniques

Present methods of canning foods for preservation are based upon the principle of using heat to destroy spoilage organisms and eliminate pathogens. There are, however, certain disadvantages to the use of heat for preservation. C. L. Wrenshall defines two of them as

follows:

1. The loss of desirable flavor and sometimes texture through prolonged high temperature processing.
2. Partial destruction of some of the vitamins, also due to processing at high temperatures.¹

The majority of products which are canned require high temperatures and some require long-term heating to insure the proper degree of sterilization, (30 to 60 minutes under pressure at temperatures above 212°F).² Because of this time-temperature relationship, canning is not, in most cases, adapted to a production-line type of processing. Batch cooking is the most accepted type of heat sterilization, and this method is not adapted to automation.

Sterilization by Canning

The first objective of sterilization by canning is the destruction of Clostridium botulinum, a spore-forming organism which produces a toxin lethal to man. Secondary objectives include the control of other heat-resistant spoilage organisms which are nonpathogenic.

¹C. L. Wrenshall, "Can Antibiotics Solve Food Sterilization Problems?," Food in Canada XIII (November, 1953), p. 26.

²"Use of Antibiotics in Canning Advanced by U. S. D. A. Research," Food Industries XXII:2 (February, 1950), p. 327.

The commercial application of a particular method of sterilization depends upon its ability to produce the complete destruction of Clostridium botulinum. In establishing a plan for the study of the use of antibiotics in canning, the National Cannery Association, in cooperation with the American and Continental Can Companies, placed botulism studies first, "since the basic requirement would be the ability of the antibiotic to prevent elaboration of the toxin of Clostridium botulinum."³

Experiments With Subtilin and Mild Heat

The preservation of foods through the combined action of an antibiotic, subtilin, and mild heat was announced as 'a new principle in food preservation,' by Andersen and Michener of the U. S. D. A. Western Regional Research Laboratory in May, 1950.⁴

The process developed was based on two principles:

1. Destruction of non-spore-forming bacteria, yeasts, fungi and natural enzymes by mild heat treatment.
2. The destruction of spore-forming bacteria with mild heat and subtilin or other antibiotics singly or in combination.⁵

³C. W. Bohrer, "N. C. A. Experimental Program With Subtilin," Proceedings of the N. C. A. Technical Session at the 44th Annual Convention, February 19, 1951, Reprinted from Association Information Letter No. 1325 (Washington: National Canner's Association, 1951), pp. 21-22.

⁴Wrenshall, op. cit.

⁵Ariel A. Andersen and H. David Michener, "Preservation of Foods with Antibiotics. I. The Complementary Action of Subtilin and Mild Heat," Food Technology IV (May, 1950), p. 188.

The following foods were preserved by this method:
peas, asparagus, corn, green beans, peeled potatoes, tomato juice and milk.⁶ Some of the specific results of the experiments were: all fourteen controls of peas spoiled while no swells occurred in forty-six treated with subtilin over a sixty-four day period; those cans of peas which had been treated with either five parts per million of subtilin and ten minutes heat, or ten parts per million with five or ten minutes heat, or twenty parts per million with five or ten minutes heat, showed no signs of spoilage.⁷

On June 21, 1950, Dr. K. F. Meyer, a University of California authority on food poisoning, advised the California Cannery Board that a serious health hazard was involved in the use of this method of processing. It was his feeling that there was no assurance of 100 per cent destruction of the toxin-producing ability of Clostridium botulinum organisms. As a result, the Cannery Board issued a warning to all Canners in the state under their jurisdiction, that "no early application of this method of preservation can be expected, particularly for products packed under state cannery inspection."⁸

⁶Ibid., p. 189.

⁷Ibid.

⁸"Subtilin Preservation of Food," National Canners' Association Information Letter No. 1301 (Washington: National Canner's Association, September 2, 1950), p. 265.

In October, 1950, Roy E. Morse published the results of experiments carried out in the laboratories of the Monsanto Chemical Company. Vegetables successfully canned and stored for eight months after treatment with five to twenty parts per million subtilin and ten minutes boiling were peas, corn, asparagus, cauliflower, brussels sprouts, broccli, wax beans, and mushrooms. Over 700 cans of vegetables were prepared in this manner. Cooking temperatures of 206° to 212°F were used and "only the controls and samples having minimum subtilin and heat treatments spoiled."⁹

A study reported in early 1951 proved beyond doubt that subtilin caused no decline in numbers of Clostridium botulinum. The Research Division of American Can Company reported that "subtilin in concentration as high as eighty parts per million permitted 100 per cent spoilage in inoculated lots with both Type A and B toxins found present."¹⁰ Burroughs and Wheaton of the American Can Company, authors of the research, also discovered that other antibiotics (gramicidin, methylol-gramicidin,

⁹Roy E. Morse. "Canning with Antibiotics--Pro and Con," Food Industries XXII:10 (October, 1950), p. 1680.

¹⁰"Antibiotics Not Effective Against Clostridium botulinum," Food Engineering XXIII:5 (May, 1951), p. 158.

bacitracin, and streptomycin) had no effect at all, not even on the natural bacterial flora of the vegetables.¹¹

In 1951, Cameron and Bohrer of the National Canners' Association, summarized the work to date by saying that "there is no early prospect of using antibiotics for the preservation of canned foods which are presently sterilized by high temperature processing."¹²

Studies with subtilin and with other antibiotics have continued until the present time with no appreciable improvement in results.

To date, antibiotics only inhibit the spores from germinating for a period of time. If the antibiotic is removed, the spores will germinate. Most antibiotics decay in potency and allow growth on incubation. Certain antibiotics, such as subtilin, act with heat to destroy the spores. However, to date, none has been found which will reduce the heat process to a point where enough heat processing time would be saved to make the use of these antibiotics economical.¹³

Experiments with Nisin

While American scientists have been working with

¹¹J. D. Burroughs and I. E. Wheaton, "Studies on the Preservative Action of Antibiotics in Processed Foods," The Canner CXII:10 (March 10, 1951), p. 55.

¹²E. J. Cameron and C. W. Bohrer, "Food Preservation With Antibiotics: The Problem of Proof," Food Technology V (August, 1951), p. 340.

¹³C. A. Greenleaf, Associate Director, Washington Research Laboratory, National Canners Association, Washington, D. C., May 13, 1958, Personal Correspondence.

subtilin in most of their studies, researchers in England have sought the answers to antibiotic sterilization of canned foods with another antibiotic, nisin. Nisin was found to have preservative properties in cheese manufacture and is being used commercially in Holland for the preservation of Edam cheese.¹⁴ Although the majority of the reports are based on rather meager evidence, certain of the theories proposed by British scientists do appear to be of value.

Among the most promising qualities that nisin possesses is its inhibitory effect on all clostridia,¹⁵ the chief cause of most food poisoning, and of food spoilage. Despite this fact, individual experiments must be carried out with each food substrate because of the possibility of the substrate either destroying or rendering useless, quantities of the antibiotic necessary for inhibition under commercial conditions in non-food substances.

Some of the possible uses of nisin in the canning industry have been mentioned in the preceding paragraphs. In all cases, nisin is proposed as a supplement, not a substitute for normal canning procedures. Nisin may be especially valuable in the canning of tomatoes and tomato

¹⁴H. B. Hawley, "Nisin in Food Technology--1," Food Manufacture XXXII:8 (August 1, 1957), p. 372.

¹⁵H. B. Hawley, "Nisin in Food Technology--2," Food Manufacture XXXII:9 (September 1, 1957), p. 432.

products because of the desirability to keep processing temperatures at a minimum to avoid heat damage. There exists the possibility of nisin aiding in the canning of pears and pineapple, gelatins used in meat canning, pickles, and in the reduction of flat-sour spoilage in evaporated milk products. The possibilities are logical because of the type of organism causing spoilage and the effect that nisin has shown upon these organisms. However, tests must be made with the actual food product to insure that the inhibitory effect of nisin is not destroyed or masked by the food substrate.

The Future of Antibiotics in Canning

While results with antibiotics have thus far not proven their worthiness in controlling Clostridium botulinum and other food spoilage organisms, the search continues.

The N. C. A. is constantly looking for a new antibiotic which will destroy the spores of Clostridium botulinum.... The ideal antibiotic would be a cheap one which would destroy the spores and at the same time be destroyed itself by a short heat process.¹⁶

Until such antibiotics can be discovered, the canning industry might benefit from research being done in pre- and post-harvest antibiotic sprays of fresh fruits and vegetables. A reduction in loss of fresh produce from the time it leaves the field until it reaches the finished

¹⁶Greenleaf, op. cit.

stage, (including transportation to the cannery and storage prior to processing), could provide a substantial savings for the canning industry.

The benefits to be derived from use of antibiotics in canning have been listed by Morse:

The canner:

1. Would thus have available a method which could be adapted to automatic processing at a moderate cost.
2. He could eliminate batch processing with its inherent high labor cost.
3. He could reduce processing time, on those packs which require long-time high temperature cooks, with a consequent saving in steam and labor.
4. He could raise considerably the productive capacity, especially where the processing unit is the limiting factor.
5. He could get products of higher quality from the short-time low-temperature cook.
6. The resulting low-cost high-quality canned foods, with potentially higher nutritive value, could prove of tremendous aid to him if he were in the marginal income of canners. There would, of course, be advantages for all others concerned with canning.¹⁷

Summary

In order to obtain the benefits offered by antibiotics in canning, the following must be demonstrated:

1. Ability of the process to produce one hundred per cent kill of all pathogenic organisms.
2. Proper time-temperature-antibiotic relationships

¹⁷Morse, op. cit.

- must be established to provide maximum protection at minimum cost.
3. No adverse medical effects of the antibiotic to the consumer.¹⁸

Certain antibiotics have demonstrated their ability to reduce the thermal resistance of certain spoilage-producing organisms associated with heat sterilization. Further experiments must prove the aforementioned three facts before commercial utilization of antibiotic-mild heat treatment can be realized.

To sum it up, the advantages offered by mild heat-antibiotic processing of canned foods are extremely tempting. But if the canning industry is to continue the splendid record it has now established, a long and careful look is required before plunging into the inviting water.¹⁹

¹⁸Ibid.

¹⁹Ibid.

CHAPTER VII

APPLICATION OF ANTIBIOTICS TO DAIRY PRODUCTS, EGGS, AND MISCELLANEOUS FOODS AND BEVERAGES

Because of the success of antibiotics in the extension of storage life of perishable meat and vegetable products, food technologists have experimented with many other food and beverage substances. Milk, one of the most important nutrient foods available to mankind, is highly perishable. Children in under developed areas are deprived of this food early in life because of lack of refrigeration facilities. Antibiotics could greatly increase the nutritional level of many countries by reducing bacterial spoilage of fresh and pasteurized milk.

Cheese and butter have also been treated with antibiotics for reduction of spoilage. Some European countries are now using antibiotics in cheese manufacture on a commercial scale. Other milk products such as custards and milk puddings may be preserved with small amounts of antibiotics.

Certain fermentations have been improved by the use of antibiotics. The production of beer and whisky can be increased by the action of certain antibiotics. Dried eggs, subject to bacterial spoilage by salmonella organisms, may be treated with antibiotics to reduce spoilage.

Antibiotics in Fresh Milk

Since the discovery that antibiotic treatment of mastitis in cows would eliminate the disease, milk marketers have been faced with a problem of residues of antibiotics in milk. The Food and Drug Administration has ruled that the label on penicillin intended for treatment of mastitis warn against marketing milk from treated cows for at least seventy-two hours.¹ In addition to the public health hazard these residues represent, milk contaminated with antibiotics presents serious economic problems in the production of cheese and other cultured milk products. Residues in one sample of milk could prevent an entire lot from being processed.

Recent experiments on preservation of raw fresh milk have shown that storage life could be extended twenty-four hours with the addition of a few parts per million of oxytetracycline.² In areas where pasteurization and refrigeration facilities are not available, milk could be transported to people living outside present delivery areas.

¹"Antibiotics in Food Preservation--Public Health and Regulatory Aspects," Science CXXVI:3284 (December 6, 1957), p. 1160.

²C. L. Wrenshall, "Advances in Food Technology Made Possible Through the Use of Antibiotics," Antibiotics Annual, 1956-1957 (New York: Medical Encyclopedia, 1957), p. 814.

Pasteurized milk can also be prevented from spoiling for several weeks beyond normal storage periods with the addition of a broad spectrum antibiotic.³

Antibiotics in Canned Milk and Puddings

The use of antibiotics as an aid in the heat sterilization of canned milk and milk products have thus far not been successful. One experiment with the use of subtilin and mild heat proved that the process was not safe or effective for preserving normally produced whole or concentrated milk.⁴ H. B. Hawley, a British scientist who has experimented with the use of nisin in many types of foods, has little doubt that much of the flat-sour spoilage of evaporated milk could be prevented with the use of nisin.⁵ Hawley suggests that nisin might also prevent clotting of canned milk which is caused by certain bacillus.⁶

³C. L. Wrenshall and J. R. McMahan, "Recent Developments in Food Uses for Antibiotics," Journal of Milk and Food Technology XIX:4 (April, 1956), p. 105.

⁴Fred R. Evans and Harold R. Curran, "The Preserving Action of Subtilin and Mild Heat in Normal and Concentrated Milk," Journal of Dairy Science XXXV:12 (December, 1952), p. 1105.

⁵H. B. Hawley, "Nisin in Food Technology--1," Food Manufacture XXXII:8 (August 1, 1957), p. 374.

⁶H. B. Hawley, "Nisin in Food Technology--2," Food Manufacture XXXII:9 (September 1, 1957), p. 431.

This clotting, which occurs before milk leaves the cannery, caused serious economic loss in Belgium in 1947.⁷

Subtilin has proven effective in preserving custards used in fillings for baked goods so that they could safely be stored for up to three days.⁸ Subtilin was effective both in reducing spoilage and in retarding food poisoning organisms while chlortetracycline and oxytetracycline were only effective against food poisoning organisms. Perhaps a combination of two of these antibiotics would be more effective than subtilin alone.

Nisin might also find application in the preservation of fresh cream in places like Australia where cream and milk are separated at the farm, the cream being sent to butter plants once or twice a week.⁹ Hydrogen peroxide has been used, but it appears possible that nisin may do better. The application of nisin to increase the shelf-life of butter may also be possible, but the diverse microflora present may effect antibiotic activity. The practicality of these applications would have to be tested.

⁷Ibid.

⁸W. J. Godkin and W. H. Cathcart, "Effect of Antibiotics in Retarding the Growth of Micrococcus pyrogenes var. aureus in Custard Fillings," Food Technology VI (June, 1952), p. 229.

⁹Hawley, "Nisin in Food Technology--2," p. 432.

1

Antibiotics in Cheese Manufacture

The existence of residues of antibiotics in milk used for cheese manufacture has presented certain problems to cheese processors. These residues, the result of therapeutic treatment of cows, have an inhibitory effect on the growth and acid production of cheese starter organisms.¹⁰ However, certain non-therapeutic antibiotics such as nisin, have aided in the manufacture of cheese by eliminating organisms which produce side effects during processing. "Already Alpin and Barrett (Alpin and Barrett, Limited, of England) have successfully treated almost 1,000 tons of processed cheese with the antibiotic, nisin."¹¹ Nisin is claimed to completely control the blowing of processed cheese by clostridia.¹² "Edam containing nisin is now being produced commercially in Holland."¹³ Parmesan cheese, which may have defects occurring as late as twelve

¹⁰Robert Angelotti, "Studies on the Physiological Activities of Terramycin-resistant and Terramycin-susceptible Cultures of Cheese-ripening Strains of Streptococcus lactis," (unpublished Doctor's thesis, The Ohio State University, Columbus, 1955), cited by Dissertation Abstracts (Ann Arbor, Michigan: University Microfilms, 1955), XV, p. 1373.

¹¹"Food Preservation with Antibiotics," Food Manufacture XXX:1 (January 1, 1955), p. 1.

¹²Ibid.

¹³Hawley, "Nisin in Food Technology--1," p. 372.

to eighteen months after manufacture, may be preserved with nisin.¹⁴

There is abundant evidence that nisin is effective in processed cheese only when it is processed and packaged under hygienic conditions. In these respects nisin differs greatly from the broad spectrum antibiotics such as chlortetracycline and oxytetracycline, which, because of their wide range of antimicrobial activity may mask the effects of poor hygiene and poor-quality raw materials.¹⁵

Miscellaneous Applications of Antibiotics

Fresh shell eggs, subject to rapid quality deterioration, have been dipped in antibiotic solutions to determine effectiveness in retarding spoilage. Three experiments so far have shown no evidence that antibiotics help reduce spoilage of shell eggs. The number of bacteria on the eggs or the number of eggs undergoing spoilage were not affected by various antibiotic treatments.¹⁶ One group of researchers found strong evidence that a five minute dip in a ten parts per million solution of antibiotics considerably increased the rate of spoilage.¹⁷

¹⁴Ibid.

¹⁵Hawley, "Nisin in Food Technology--2," p. 433.

¹⁶W. A. Miller, "The Effect of Coating the Shells of Washed Eggs, That Formerly Were Dirty, with Antibiotics, Upon Subsequent Spoilage," Poultry Science XXV:1 (January, 1956), p. 243.

¹⁷F. J. Schmidt and W. J. Stadelman, "Effects of Antibiotics and Heat Treatment of Shell Eggs on Quality

The chief bacterial problem in the preservation of dried eggs are organisms of the salmonella family. Nisin has been shown to have no effect upon these organisms,¹⁸ while oxytetracycline exhibits some control but only at very high concentrations.¹⁹

Antibiotics have been successful in suppressing the activity of organisms (of the type which cause souring of milk), in the fermentation of whisky and beer. Tyrothricin, oxytetracycline, chlortetracycline, chloromycetin, and penicillin have all been effective in preventing side effects during the production of whisky without harming the yeasts which do the fermenting.²⁰ A patent has been issued to the F. and M. Schaefer Company for inhibiting microbiological growth in beer. The method involves the use of two antibiotics, polymyxin and thiolutin.²¹ These

After Storage," Poultry Science XXXVI:5 (September, 1957), p. 1026.

¹⁸Hawley, "Nisin in Food Technology--2," p. 430.

¹⁹R. C. Kersey, F. C. Visor, and C. L. Wrenshall, "Residual Antibiotic Levels in Food Products During Storage and Processing," Antibiotics Annual, 1953-1954 (New York: Medical Encyclopedia, 1954), p. 447.

²⁰"Antibiotics Make Better Whisky," Science News Letter LXIV:13 (September 26, 1953), p. 207.

²¹Bochermann and Strandkov, assignors to the F. and M. Schaeffer Brewing Company, United States Patent 2,798,811, July 9, 1957.

antibiotics stimulate fermentation and keep the yeast free from contamination so that it may be used again.

Other miscellaneous uses of antibiotics are in the manufacture of edible and baker's yeast, and in the stabilization of wines. In both of these instances, antibiotics serve to suppress the activity of bacteria and allow yeasts and molds to grow more rapidly.

Summary

The use of small amounts of antibiotics in fresh and pasteurized milk could provide the necessary extension in shelf-life needed to supply many people who do not now receive fresh milk. A twenty-four hour extension in the storage life of raw milk could allow distribution in areas where pasteurization and refrigeration are not available. Certain milk custards used in the baking industry are excellent carriers of food poisoning organisms. These can successfully be preserved for up to three days by the addition of subtilin. Flat-sour spoilage in canned milk will probably be successfully controlled with nisin. This same type of spoilage has been sharply reduced in canned tomatoes and tomato juice.

Antibiotics are presently being used commercially in the production of Edam cheese in Holland with very good results. The blowing of cheese, caused by organisms of the

clostridia family, can safely be controlled with nisin. This antibiotic is digested by the human body and is in no way cross-resistant to medical antibiotics.

Beer-brewing and whisky-fermenting processes have been improved with antibiotics by a more closely controlled fermentation process. Tyrothricin, oxytetracycline, chlortetracycline, chloromycetin, penicillin, thiolutin, and polymyxin have all proven effective in preventing side effects and keeping yeast cultures free of contamination.

As new antibiotics are developed and tested, there appear to be endless possibilities for their use in food and beverage processing. In addition to the prevention of spoilage, antibiotics have shown to be capable of improving those products produced by controlled fermentation.

CHAPTER VIII

CONCLUSION: A COMBINATION OF METHODS OF PRESERVATION

An expected increase in world population of 115 per cent between 1960 and 2000 will place a tremendous burden upon food production and marketing resources. The greatest increase in population is expected to occur in under developed areas where undernourishment of the populace is a problem. These estimates, plus the fact that enough food is wasted each year to feed almost the entire population of the United States, places a tremendous responsibility upon all phases of the food industry to be as efficient as possible in producing, processing, and marketing food products.

Throughout this thesis, mention has been made of the fact that antibiotics will probably be used in combination with other methods of preservation to help reduce the tremendous spoilage losses presently being encountered in food marketing. Dr. Joseph A. Stern, Food Technologist of the School of Fisheries of the University of Washington in Seattle, made the following statement at a recent meeting of antibiotics experts from all parts of the world:

Most of the applications and proposed applications of the antibiotics have been at localized points in the production line, avoiding expensive changes, but perhaps failing to utilize fully the antibiotics.

To realize the full potential, it probably will be necessary to engineer and integrate the use of the antibiotic compounds into production lines. This will create new problems in packaging, handling, refrigeration, storage, and transportation. In such cases, we have the problem of whether the use of antibiotics will warrant expensive changes.

For example, one can possibly conceive of the following production line for certain types of foods: (1) The early use of the antibiotics to reduce the bacterial populations. Such use in conjunction with refrigeration to lower the rate of autolytic and chemical reactions and with antimycotic agents to inhibit forms of microbial life other than bacterial; (2) the packaging of the food in a vacuum type container, either flexible or rigid, to reduce oxidative changes, perhaps in conjunction with the use of an antioxidant; (3) microwave heating to inactivate enzymes and reduce the rate of autolytic activity; (4) radiation with an extremely low dosage to bring about surface sterilization with or without the inclusion of certain chemicals to reduce possible flavor changes; (5) low temperature storage to reduce autochemical reactions.

Such a procedure would produce foods and food products certainly different from those that we are accustomed to today, but with extended storage lives much greater than we now visualize.

In such a process line engineered with the overall objectives and handling procedures in mind, the antibiotics, with their attendant advantages, would certainly play an integral part.¹

Another example of the use of antibiotics in conjunction with newer methods of preservation is the series of experiments carried out by two members of the

¹Joseph A. Stern, "Present Status of Antibiotics in the Preservation of Food," A panel discussion, Antibiotics Annual, 1956-1957 (New York: Medical Encyclopedia, 1957), pp. 1118-1119.

staff of the American Meat Institute Foundation of Chicago. The results of their tests with ionizing radiations of 100,000 rep (roentgen equivalent physical) in combination with ten parts per million of oxytetracycline have been somewhat gratifying.² Scorbic acid was also added to the meat to reduce yeast development.

The combination of these agents (radiation, oxytetracycline, and scorbic acid) proved to be sufficiently effective so that microbial spoilage would no longer be the determining factor in the shelf-life of fresh meats.... Although it appears probable that means are now available to control microbial spoilage of prepackaged fresh meats, many factors must be taken into consideration before such methods will become feasible on a commercial basis. The color of meat as it is displayed is difficult to retain in an appealing form even when microbial growth is controlled. An improved package film to help maintain the desired color probably will be desired.³

Whenever a new method of food preservation is discovered, there is a fear that more established methods will disappear. When frozen foods were introduced, there was a great deal of concern for the future of the canning industry. However, in 1955, more cans and glass containers for processed food were manufactured than in any prior year.⁴

²C. F. Niven and W. R. Chesbro, "Complimentary Action of Antibiotics and Irradiation in the Preservation of Fresh Meats," Antibiotics Annual, 1956-1957 (New York: Medical Encyclopedia, 1957), pp. 855-856.

³Ibid., p. 858.

⁴Bernard E. Proctor, "Food Horizons," Food Technology X (1956), p. 394.

The frozen food industry, originally on the defensive when antibiotic preservation was proposed, has decided that these substances will prove to be a strong ally to frozen food processing.⁵

Antibiotics have proven to be one of the most powerful weapons in the therapeutic arsenal available to medical science. In less than fifteen years, the application of these substances to preservation of food has become a commercial reality, saving an undetermined amount of food from bacterial spoilage. As new and more effective antibiotics are discovered, the possibilities for antibiotic preservation will increase. There will be no danger of any of the presently accepted means of preservation being made obsolete; rather, antibiotics will help food freezers and canners to produce a better product, in greater quantities, to feed an ever-increasing population both in this country, and in the rest of the world.

⁵Editorial, "Antibiotics Proving Value as Food Freezing Ally," Quick Frozen Foods XVIII:12 (July, 1956), p. 140.

BIBLIOGRAPHY

BIBLIOGRAPHY

BOOKS

Goresline, Harry E. "Food Spoilage and Deterioration," Handbook of Food and Agriculture, Fred C. Blanck, editor. New York: Reinhold Publishing Company, 1955. Pp. 389-410.

Robinson, F. A. Antibiotics. New York: Pitman Publishing Company, 1953.

Waksman, Selman A. Neomycin. New Brunswick, New Jersey: Rutgers University Press, 1953.

Welch, Henry, and Felix Marti-Ibanez (eds.). Antibiotics Annual, 1953-1954. New York: Medical Encyclopedia, 1954.

_____. Antibiotics Annual, 1954-1955. New York: Medical Encyclopedia, 1955.

_____. Antibiotics Annual, 1955-1956. New York: Medical Encyclopedia, 1956.

_____. Antibiotics Annual, 1956-1957. New York: Medical Encyclopedia, 1957.

_____. Antibiotics Annual, 1957-1958. New York: Medical Encyclopedia, 1958.

PUBLICATIONS OF THE GOVERNMENT, LEARNED SOCIETIES, AND OTHER ORGANIZATIONS

Agricultural Research Service. Losses in Agriculture. United States Department of Agriculture, Agricultural Research Report ARS 20-1. Washington: Government Printing Office, 1954. 190 pp.

Bochermann, and Strandkov. Assignors to the F. and M. Schaeffer Brewing Company, United States Patent 2,798,811, July 9, 1957.

Bohrer, C. W. "N. C. A. Experimental Program with Subtilin," Proceedings of the N. C. A. Technical Session at the 44th Annual Convention, February 19, 1951, cited by Association Information Letter, Number 1325. Washington: National Cannery Association, 1951.

Federal Register, The National Archives of the United States, XX (November 30, 1955), p. 8776.

Federal Register, The National Archives of the United States, XXI (October 23, 1956), p. 8104.

Food and Agriculture Organization. Millions Still Go Hungry. Rome, Italy: Food and Agriculture Organization, United Nations, 1957. 102 pp.

Food and Drug Administration. Federal Food, Drug, and Cosmetic Act and General Regulation for its Enforcement. United States Department of Health, Education, and Welfare, Service and Regulatory Announcements, Food, Drug, and Cosmetic Number 1, Revision 4, with Addenda. Washington: Government Printing Office, April, 1955. 68 pp.

Marketing Research Division. Interstate Trucking of Fresh and Frozen Poultry Under Agricultural Exemption. Agricultural Marketing Service, United States Department of Agriculture, Marketing Research Report Number 224. Washington: Government Printing Office, March, 1958. 88 pp.

National Canners' Association. "Subtilin Preservation of Food," Association Information Letter, Number 1301. Washington: National Canners' Association, September 2, 1950.

Spencer, J. V., Frank Ziegler, and W. J. Stadelman. Recent Studies of Factors Affecting the Shelf-life of Chicken Meat. Washington Agricultural Experiment Station, Circular 254. Spokane: State College of Washington, September, 1954. 5 pp.

Wiant, James S., and C. O. Bratley. Spoilage of Fresh Fruits and Vegetables in Rail Shipments Unloaded at New York City, 1935-42. United States Department of Agriculture, Circular 773. Washington: Government Printing Office, 1948. 62 pp.

PERIODICALS

Abbey, Anthony, A. Richard Kohler, and Sidney D. Upham. "Effect of Aureomycin Chlortetracycline in the Processing and Storage of Freshly Shucked Oysters," Food Technology, XI (1957), pp. 265-271.

- Advertisement. "Three Profitable Reasons Why Your Poultry Should Be Acronized," Poultry Processing and Marketing, LXIV:5 (May, 1958), p. 23.
- Anderson, Ariel A., and H. David Michener. "Preservation of Foods with Antibiotics. I. The Complementary Action of Subtilin and Mild Heat," Food Technology, IV (May, 1950), pp. 188-189.
- Angellotti, Robert. "Studies on the Physiological Activities of Terramycin-resistant and Terramycin-susceptible Cultures of Cheese-ripening Strains of Streptococcus lactis." Unpublished Doctor's thesis, The Ohio State University, Columbus, 1955, cited by Dissertation Abstracts, XV (1955), pp. 1973-1974.
- "Antibiotic Preserves Food," Science News Letter, LVII:21 (May 27, 1950), p. 325.
- "Antibiotic Prolongs Meat Storage Life," The National Provisioner, LXXXIII:22 (November 26, 1955), pp. 103-106.
- "'Antibiotic-burgers' May Be on the Way," Science News Letter, LXVIII:18 (October 29, 1955), p. 280.
- "Antibiotics and Food," Chemical and Engineering News, XXXIII:50 (December 12, 1955), p. 5368.
- "Antibiotics Approved for Fish Preservation," Commercial Fisheries Review, XVIII:11 (November, 1956), pp. 73-74.
- "Antibiotics for Fishery Products Preservation," Commercial Fisheries Review, XVIII:12 (December, 1956), pp. 27-28.
- "Antibiotics in Food Preservation--Public Health and Regulatory Aspects," Science, CXXVI:3248 (December 6, 1957), pp. 1159-1161.
- "Antibiotics Keep Steaks Young," Chemical and Engineering News, XXXIV:45 (November 5, 1956), p. 5392.
- "Antibiotics Make Better 'Whisky,'" Science News Letter, LXIV:13 (September 26, 1953), p. 207.
- "Antibiotics Not Effective Against Clostridium botulinum," Food Engineering, XXIII:5 (May, 1951), p. 158.
- "Antibiotics Tested on Whale Carcasses," Commercial Fisheries Review, XVIII:7 (July, 1956), p. 76.

"Antibiotics Use and Quality Assessment Highlights Fish-processing Technologists Meeting," Commercial Fisheries Review, XVIII:8 (August, 1956), pp. 58-60.

Ayres, J. C., W. S. Ogilvy, and G. F. Stewart. "Post Mortem Changes in Stored Meats. I. Micro-organisms Associated with Development of Slime on Eviscerated Cut-up Poultry," Food Technology, IV (1950), pp. 199-205.

Bonde, Reiner. "Preliminary Studies on the Control of Bacterial Decay of the Potato with Antibiotics," American Potato Journal, XXX (1955), pp. 143-147.

Bottomley, R. A. "Food Additives--Preservatives, Antioxidants and Antibiotics," Food Technology in Australia, X:2 (February, 1958), pp. 63-77.

Boyd, J. W., et al. "Use of Antibiotics for the Preservation of Fish and Sea Foods," American Journal of Public Health, XLVI:12 (December, 1956), pp. 1531-1539.

Broquist, H. P., A. R. Kohler, and W. H. Miller. "Retardation of Poultry Spoilage by Processing with Chlortetracycline," Agricultural and Food Chemistry, IV:12 (December, 1956), pp. 1030-1032.

Burroughs, J. D., and I. E. Wheaton. "Studies on the Preservative Action of Antibiotics in Processed Foods," The Canner, CXII:10 (March 10, 1951), pp. 50-55.

Cameron, E. J., and C. W. Bohrer. "Food Preservation with Antibiotics: The Problem of Proof," Food Technology, V (August, 1951), pp. 340-342.

"Canada Eats 'Acronized' Fish," Food Manufacture, XXXII:5 (May 1, 1957), p. 245.

Carroll, V. J., R. A. Benedict, and C. L. Wrenshall. "Delaying Vegetable Spoilage with Antibiotics," Food Technology, XI (1957), pp. 490-493.

Davis, Kingsley. "Recent Population Trends in the New World," The Annals of the American Academy of Political and Social Science, CCCXVI (March, 1958), pp. 1-10.

Editorial. "Antibiotics Proving Value as Food Freezing Ally," Quick Frozen Foods, XVIII:12 (July, 1956), pp. 59-60, 140.

- Evans, Fred R., and Harold R. Curran. "The Preserving Action of Subtilin and Mild Heat in Normal and Concentrated Milk," Journal of Dairy Science, XXXV:12 (December, 1952), pp. 1101-1106.
- "Five Thousand Million by the Year 2000," United Nations Review, IV:1 (July, 1957), pp. 30-31.
- "Food Antibiotics: Market Meteor," Chemical and Engineering News, XXXIV:50 (December 10, 1956), p. 6108.
- "Food Preservation with Antibiotics," Food Manufacture, XXX:1 (January 1, 1955), p. 1.
- "For Antibiotics, Uses Galore," Chemical and Engineering News, XXXII:47 (November 19, 1956), pp. 4640-4642, 4717.
- "Freeze-dried Food," Time, LXIX:20 (May 20, 1957), p. 61.
- Gerard, Frank. "Meat," Food Manufacture, XXII:2 (February 1, 1957), pp. 61-64.
- Godkin, W. J., and W. H. Cathcart. "Effect of Antibiotics in Retarding the Growth of Micrococcus pyrogenes var. aureus in Custard Fillings," Food Technology, VI (June, 1952), pp. 224-229.
- Goldberg, H. S., H. H. Weiser, and F. E. Deatherage. "Studies on Meat. IV. Use of Antibiotics in Preservation of Fresh Beef," Food Technology, VI (1953), pp. 165-166.
- Harms, John. "Antibiotics Enter Poultry Meat Field," Poultry Processing and Marketing, LXI:12 (December, 1955), p. 18.
- Hawley, H. B. "Nisin in Food Technology--1," Food Manufacture, XXXII:8 (August, 1957), pp. 370-376.
- _____. "Nisin in Food Technology--2," Food Manufacture, XXXII:9 (September, 1957), pp. 430-434.
- Ingram, M., and Ella M. Barnes. "Problems in the Use of Antibiotics for Preserving Meat," The Journal of Applied Bacteriology, XVIII (1955), pp. 549-564.
- Kling, W. "Food Waste in Distribution and Use," Journal of Farm Economics, XXV (November, 1943), pp. 848-859.

- Kohler, A. R., W. H. Miller, and H. P. Broquist. "Aureomycin Chlorotetracycline and the Control of Poultry Spoilage," Food Technology, IX (1955), pp. 151-154.
- Koloyereas, Socrates A. "Preliminary Report on the Effect of Ultrasonic Waves on the Crystallization of Honey," Science, CXXI (March, 1955), pp. 339-340.
- Lewis, J. C. et al. "Antibiotics in Food Processing," Journal of Agriculture and Food Chemistry, II:6 (March 17, 1954), pp. 298-302.
- Majunda, and Bose. "Studies on Anti-fungal Antibiotics. I. Anti-fungal Micro-organisms in Indian Fruits and Vegetables," J. Sci. Indus. Res., (India, 1955), pp. 126-128, cited by Food Science Abstracts, XXVIII (1956), p. 188.
- "May Can Fresh Milk," Science News Letter, LXVII:13 (March 26, 1955), p. 197.
- Miller, Wilbur H. "Antibiotic Introduced as Spoilage Inhibitor of Fresh Poultry," Food Engineering, XXVIII:1 (January, 1956). pp. 43-48, 194.
- _____. "Antibiotic Prolongs Meat Storage Life," The National Provisioner, CXXXIII:22 (November 26, 1955), pp. 103-106.
- Miller, W. A. "The Effect of Coating the Shells of Washed Eggs, That Formerly Were Dirty, with Antibiotics, Upon Subsequent Spoilage," Poultry Science, XXXV:1 (January, 1956), pp. 1023-1026.
- Morse, Roy E. "Canning with Antibiotics--Pro and Con," Food Industries, XXII:10 (October, 1950), pp. 1679-1680.
- "New Tricks with Antibiotics," Business Week, Number 1371 (December 10, 1955), pp. 80-88.
- Newcomer, J. L., et al. "Effect of an Electric Current on the Efficiency of Homogenization of Ultrasonically Irradiated Milk," Journal of Dairy Science, XL (November, 1957), pp. 1416-1423.
- "Nonpharmaceutical Uses of Antibiotics," Journal of Agricultural and Food Chemistry, I:18 (November 25, 1953), pp. 1096-1102.

Olsen, Askel G., and Daniel A. Mills. "Recent Advances in Food Technology," Mechanical Engineering, LXXVIII:9 (September, 1956), pp. 802-814.

"Origin of Antibiotics," Today's Health, XXXI:4 (April, 1953), pp. 4,6.

"Pfizer Fishing New Antibiotic Pool," Oil, Paint and Drug Reporter, CLXIX:16 (April 16, 1956), pp. 3, 42.

* Proctor, Bernard E. "Food Horizons," Food Technology, X (1956), pp. 393-396.

"Radishes--Antibiotic Treatment," Food Manufacture, XXXII:7 (July 1, 1957), p. 339.

"Report Danger of Foods Preserved by Antibiotics," Science News Letter, LXXI:19 (May 11, 1957), p. 297.

Schmidt, F. J., and W. J. Stadelman. "Effects of Antibiotics and Heat Treatment of Shell Eggs on Quality After Storage," Poultry Science, XXXVI:5 (September, 1957), pp. 1023-1026.

Silverman, Milton. "New Way to Keep Food Fresh," The Reader's Digest, LXVIII:410 (June, 1956), pp. 71-74.

Smith, W. L., Jr., and R. E. Hardenburg. "Antibiotics and Other Chemical Dips Reduce Discoloration of Packaged Cole Slaw," Phytopathology, XLIV (1954), pp. 389-390.

Tarr, H. L. A., John W. Boyd, and H. M. Bissett. "Antibiotics in Food Processing. Experimental Preservation of Fish and Beef with Antibiotics," Agricultural and Food Chemistry, II (March 31, 1954), pp. 372-375.

"Terramycin Tested on Whale Meat," Commercial Fisheries Review, XVIII:12 (December, 1956), p. 74.

"The Use of Germicides (Antibiotics and Sulphonamides) in the Preservation of Grapes in Cold Storage," (In German), A. Geron. Indus. Cons., XXIX (1954), pp. 32-35, cited by Food Science Abstracts, XXVII (1955), p. 669.

Thomas, Dana L. "Broader Spectrum," Barron's, XXXVI:45 (November 5, 1956), pp. 3, 18.

Tomiyama, T., et al. "A Study of the Effects of Aureomycin-containing Sea Water and Ices Upon the Storage Life of Round Herring," Food Technology, X (1956), pp. 215-218.

"Use of Antibiotics in Canning Advanced by USDA Research," Food Industries, XXII:2 (February, 1950), p. 327.

Waksman, Selman A. "What is an Antibiotic or an Antibiotic Substance?," Mycologia, XXXIX (1947), pp. 565-569.

Weiser, H. H., et al. "Observations on Fresh Meat Processed by the Infusion of Antibiotics," Food Technology, VI (1953), pp. 495-499.

Wrenshall, C. L. "Can Antibiotics Solve Food Sterilization Problems?," Food in Canada, XIII (November, 1953), pp. 25-28.

_____, and J. R. McMahan. "How Newly OK'd Antibiotic Boosts Poultry Shelf Life," Food Engineering, XXVIII:12 (December, 1956), pp. 53-56.

_____. "Recent Developments in Food Uses for Antibiotics," Journal of Milk and Food Technology, XIX:4 (April, 1956), p. 105.

Zeigler, Frank, and W. J. Stadelman. "The Effect of Aureomycin on the Shelf-life of Fresh Poultry Meat," Food Technology, IX (1955), pp. 107-108.

UNPUBLISHED MATERIALS

American Cyanamid Company. "Acronize Chlortetracycline for Use in Processing of Turkeys." New York: The American Cyanamid Company, n. d. (Mimeographed.)

Burton, Jim N. Assistant Advertising Manager, Farm and Home Division, The American Cyanamid Company, New York, New York. Personal Correspondence, February 20, 1958.

Firman, Melvin C. Director, Technical Service, Farm and Home Division, The American Cyanamid Company, New York, New York. Personal Correspondence, January 3, 1958.

Greenleaf, C. A. Associate Director, Washington Research Laboratory, National Cannery Association, Washington, D. C. Personal Correspondence, May 13, 1958.

Hughes, J. D. General Manager, Merchandising, New York Region, The Grand Union Company, Mount Kisco, New York. Personal Correspondence, May 28, 1958.

McVicker, Robert James. "The Effect of Certain Bacterial Inhibitors on Shelf-life of Fresh Poultry Meat." Unpublished Master's thesis, Michigan State University, East Lansing, 1957.

Sacchi, E. M., et al. "New Methods of Pre-slaughter Administration of Antibiotics." Paper read at the 17th Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 12-16, 1956.

PAMPHLET

The American Cyanamid Company. Acronized Tray-packed Poultry. New York: The American Cyanamid Company, 1957. 10 pp.

ROOM USE ONLY

NOV 20 1961

~~APR 12 1962~~

APR 27 1962

MAY 12 1962

~~MAY 24 1962~~

~~FEB 22 1964~~

~~MAY 8 1966~~

~~MAR 20 1964~~

MAR 21 1964

~~FEB 15 1966~~

MICHIGAN STATE UNIVERSITY LIBRARIES



3 1293 03071 2768