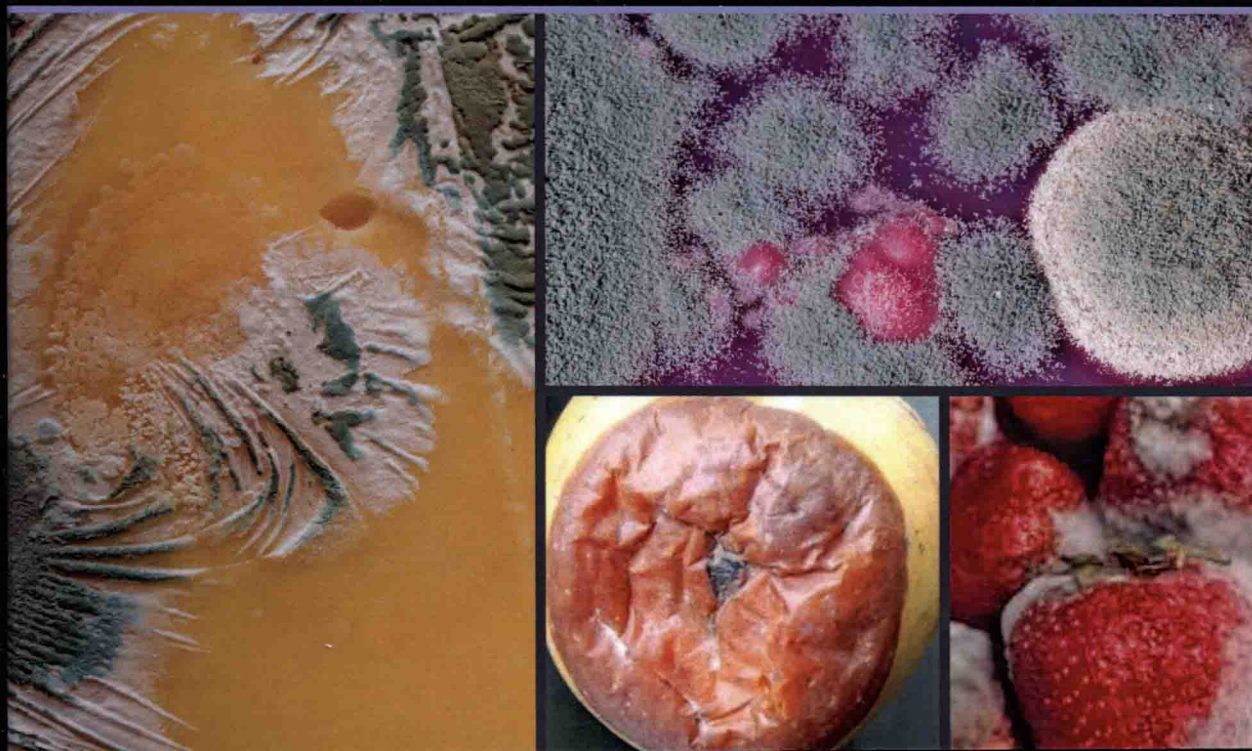




FOOD MICROBIOLOGY SERIES

# Food Spoilage Microorganisms Ecology and Control



Edited by  
Yanbo Wang • Wangang Zhang  
Linglin Fu



CRC Press  
Taylor & Francis Group



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# Food Spoilage Microorganisms

## Ecology and Control



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# Preface

Food spoilage can occur in any segment of the whole food chain and thus threatens both public health and food quality. Therefore, food spoilage significantly affects food supply and our daily life. Microorganisms involved in food spoilage include a wide variety of bacteria, yeasts, and molds. Studying the ecology of these microorganisms and how food spoilage occurs are crucial to develop proper measures to prevent and control food spoilage. This book covers the occurrence, outbreak, important consequences, control, and evaluation of spoilage microorganisms in food.

This book contains nine chapters and each chapter is organized based on a food category so readers may easily understand and access the relevant knowledge. In all given food categories, the authors discuss the taxonomy, characteristics, and possible mechanisms of spoilage microorganisms, specific methods for detection and evaluation, corresponding control, prevention, and management options. In addition, current opinion and future research needs related to food spoilage microorganisms are discussed. Section I (Chapters 1 through 4) covers spoilage microorganisms in foods of plant origin including cereals, legumes, fruits, and vegetables. Section II (Chapters 5 through 9) tackles spoilage microorganisms in foods of animal origin including meat, poultry product, sea food, powdered milk, and egg products.

This book is intended for both food scientists/engineers and nonspecialists, especially for those responsible for food quality, safety, and regulation. This book also provides readers with the necessary basic knowledge in food spoilage consequences and control so as to ensure food safety, and in particular, in developing countries where postharvest food hygiene requires special care.

We would like to thank all the contributing authors for their excellent contribution. We also thank the editorial and production team for their work. We hope that readers will benefit from reading this book.

**Junshi Chen**

*Senior Research Professor*

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# Editors

**Prof. Yanbo Wang** is a professor of Food Science and Technology at Zhejiang Gongshang University, Hangzhou, China. He earned his PhD degree from Zhejiang University, Hangzhou, China in June 2006. In February 2008, he was invited to the Marine Research Institute, Florida Institute of Technology (FIT), as a visiting scholar and then to the Institute of Food and Agricultural Sciences, University of Florida (UF) for 2-year postdoctoral research. Dr. Wang is currently an associate editor of the *Journal of Fisheries and Aquaculture*. Since 2008, he has received extensive research funding from the National Natural Science Foundation of China (NNSFC), the Ministry of Science and Technology of the People's Republic of China, and other related agencies. He has published 40 papers in international academic journals contained in the Science Citation Index (SCI). These papers are cited 739 times in total and 719 times by the other authors in SCI journals. Dr. Wang has published two papers as the corresponding author, which has been contained in the database of highly cited papers through Essential Science Indicators (ESI) based on the web of science. Additionally he has published four international academic books and has obtained four authorized national patents. Based on his achievements, Dr. Wang has obtained recognition as the Excellent Young Teacher in the Colleges and Universities of Zhejiang Province and the Zhejiang Provincial Natural Science Foundation for Distinguished Young Scientists. He also has been elected to the New Century Training Program (151) for Talent from Zhejiang Province and the Academic Discipline Leaders for the Young and Middle-Aged Teachers in the Colleges and Universities of Zhejiang Province.

**Prof. Wangang Zhang** is a professor of College of Food Science and Technology at Nanjing Agricultural University of Jiangsu, province of China. He received his bachelor and master degrees from China Agricultural University in 2001 and 2004, respectively. He earned his PhD degree from Iowa State University (Ames, Iowa) in May of 2009. His research mainly focuses on investigating the biochemical factors, particularly in structure and function of proteins, contributing to the quality of meat and meat products. He has been the Associate Editor of *Meat Science* since last year. Recently, he has been nominated as the Associate Editor of the *Chinese Journal of Animal Science*. Since joining Nanjing Agricultural University in 2011, Dr. Zhang has been awarded many research projects as principal investigator from the National Natural Science Foundation of China, Ministry of Science and Technology, and Ministry of Education of China. He has published more than 60 peer-reviewed papers among which 48 were published in SCI journals.

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# *Section I*

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# 1 Spoilage Microorganisms in Cereal Products

*Wenjian Yang, Dapeng Li, and Alfred Mugambi Mariga*

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## 1.1 INTRODUCTION

Cereal grains are the most important food commodity for the world population and represent up to 80% of the diet in some cultures. Grains are often contaminated with microorganisms during harvest, transport, and storage, and the safety and quality of grains also decrease. Immediately after harvesting, cereal grains contain microbial contaminants from several sources, such as dust, water, ill plants, insects, soil, fertilizers, biofilm on surface of equipment, humans, and animal feces (Butscher et al., 2015).

A wide range of cereal products, including bakery items, frozen dough, fresh pasta products, dried cereal products, snack foods, and bakery mixes, are manufactured for food consumption. These



products are also subject to microbial spoilage that affects the taste, aroma, leavening, appearance, and overall quality of the end product. Microorganisms are ubiquitous in nature and have the potential to cause food spoilage and foodborne disease. However, compared to other categories of food products, bakery products rarely cause food poisoning. The heat that is applied during baking or frying usually eliminates pathogenic and spoilage microorganisms and the low moisture content of the final product contributes to product stability (Cook and Johnson, 2009). Nevertheless, microbial spoilage of these products occurs, resulting in substantial economic losses.

Many cereal products are often contaminated with spoilage or pathogenic microorganisms making them nonedible or affecting their taste by the production of undesirable flavors. For example, lactic and coliform bacteria can make wet mash of grains suffering acid fermentation. Molds are the most important spoilage organisms in cereal grains as they can reduce the nutritional value, properties, cause dry matter loss, heating of grain, off-odors, and in the worst case, form mycotoxins and allergenic spores. These microorganisms can sometimes produce toxic substances causing a serious hazard in human and animal health besides a very high economic loss (Gupta and Srivastava, 2014). Food poisoning can arise either through the ingestion of food containing toxigenic microorganisms or by the ingestion of food containing only toxins that are formed by the microorganisms. In particular, during the postharvest period many toxin-producing microorganisms can grow heavily on several food products (Magan and Aldred, 2007). Microbes involved in spoilage of cereal products are shown in Table 1.1.

The quality and the safety of cereal products are of major concern to producers, quality control authorities, and end product consumers. In addition to the economic losses incurred because of spoilage, possible foodborne illnesses could cost billions of dollars to the industry due to costly adverse health effects, the loss of productivity, medical expenses, and most importantly, adverse publicity for the industry. Additional costs in international trade include the costs of rejections, detention of products, recalls, and the resulting adverse publicity for the industry and even for the country. Food spoilage and the resulting waste of nutritious food is a problem worldwide. Approximately, 5%–10% of the world food supply is lost annually because of the presence of fungi and mycotoxin alone.

**TABLE 1.1**  
**Microbes Involved in Spoilage of Cereal Products**

Organism	Types of Food Spoiled	Type of Spoilage
Fungi		
<i>Aspergillus</i>	Bread	Black mold
	Grains	Black mold rot (aflatoxin)
<i>Candida</i>	Breads	Yeasty
<i>Cladosporium</i>	Bread	Brown/black mold rot
<i>Claviceps purpurea</i>	Corn, grain	Ear rot (ergotism)
	Breads	Black rot
<i>Fusarium</i>	Corn	Pink mold rot (fumonisins)
<i>Penicillium</i>	Breads	Blue-green mold
<i>Rhizopus</i>	Breads	Black mold
<i>Saccharomyces</i>	Breads and pastas	Yeasty
<i>Zygosaccharomyces</i>	Breads and pastas	Yeasty
Bacteria		
<i>Bacillus</i>	Bread	Slime
<i>Clostridium</i>	Bread	Ropy
<i>Lactobacillus</i>	Bread	Ropy
<i>Leuconostoc</i>	Bread	Ropy