

Statistical Aspects of the Microbiological Examination of Foods

Second Edition

Basil Jarvis



CONTENTS

LIST OF TABLES	ix
LIST OF FIGURES	xii
LIST OF EXAMPLES	xv
PREFACE	xvii

1

Introduction	1
--------------	---

2

Some Basic Statistical Concepts

Populations	3
Lots and Samples	4
Average Sample Populations	5
Statistics and Parameters	6
Variance and Error	6
The Central Limit Theorem	7
References	11

3

Frequency Distributions

Types of Frequency Distribution	13
Statistical Probability	19
The Binomial Distribution	21
The Normal Distribution	24
The Poisson Distribution	26
The Negative Binomial Distribution	30
Relationship Between the Frequency Distributions	37
Transformations	37
References	43

4

The Distribution of Microorganisms in Foods in Relation to Sampling

Random Distribution	47
Regular Distribution	56
Contagious (Heterogeneous) Distributions	57
Effects of Sample Size	63
References	68

5

Statistical Aspects of Sampling for Microbiological Analysis

Attributes and Variables Sampling	72
Binomial and Trinomial Distributions	73
Accuracy of the Sample Estimate	77
Acceptance Sampling by Attributes	82
Acceptance Sampling by Variables	93
References	100

6

Errors in the Preparation of Laboratory Samples for Analysis

Laboratory Sampling Errors	103
Diluent Volume Errors	104
Pipette Volume Errors	105
Other Sources of Error	109
Calculation of the Relative Dilution Error	110
Effects of Gross Dilution Series Errors on the Derived Colony Count	118
References	119

7

Errors Associated with Colony Count Procedures

Specific Technical Errors	121
Pipetting and Distribution Errors	124
Limiting Precision and Confidence Limits of the Colony Count	128
General Technical Errors	135
Comparability of Colony Count Methods	137
Overall Error of Colony Count Methods	138
References	141

8

Errors Associated with Quantal Response Methods

Dilution Series and Most Probable Number counts	143
Multiple Test Dilution Series	148
Quantification Based on Relative Prevalence of Defectives	162
Some Statistical Aspects of Multi-stage Tests	165
References	175

9

Statistical Considerations of Other Methods in Quantitative Microbiology

Direct Microscopic Methods	177
Indirect Methods	180
References	184

10

Measurement Uncertainty in Microbiological Analysis

Accuracy and Precision	186
Measurement Uncertainty	187
How is Uncertainty Estimated?	188
Reporting of Uncertainty	190
Sampling Uncertainty	190
The Use of Uncertainty Measures in Assessing Compliance	191
References	191

11

Estimation of Measurement Uncertainty

The 'Generalized Uncertainty Method' (GUM) or Bottom-Up Procedure	195
The Top-Down Approach to Estimation of Uncertainty	198
Analysis of Variance (ANOVA)	198
Robust methods of ANOVA	208
Measurement of Intermediate Reproducibility	215
Estimation of Uncertainty Associated with Quantal Methods	217
References	222

12

Statistical Process Control (SPC) using Microbiological Data

What is SPC?	225
Trend Analysis	226
Tools for SPC	227
Setting Control Limits	229
Shewhart's Control Charts for Variables Data	230
Conclusion	258
References	258

13

Validation of Microbiological Methods For Food

(Dr Sharon Brunelle, Brunelle Biotech Consulting, Technical Consultant to AOAC International and AOAC Research Institute, Woodinville, WA, USA)

The Stages of Method Development	260
What is Validation?	261
Future Directions	273
References	276

14

Risk Assessment, Food Safety Objectives and Microbiological Criteria for Foods

Food Safety Objectives and Risk Assessment	280
Microbiological Criteria	285
The Relevance of Microbial Measurement Uncertainty to Microbiological Criteria	292
Conclusion	297
References	297