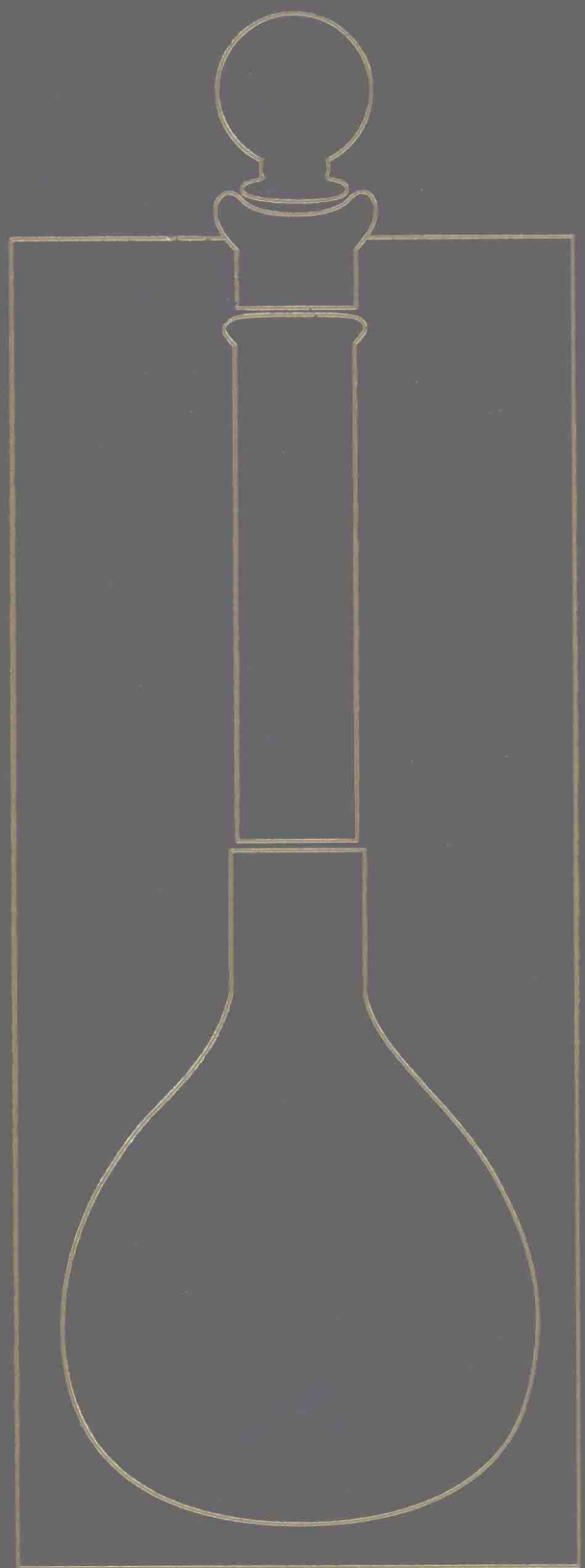
Introduction to the

CHEMICAL ANALYSIS OF FOODS



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List of Abbreviations

AACC	American Association of Cereal Chemists
AAS	atomic absorption spectroscopy
ADC	analog-to-digital converter
ADP	adenosine-5′-diphosphate
AES	atomic emission spectroscopy
AI	artificial intelligence
AOAC	Association of Official Analytical Chemists
AOCS	American Oil Chemists' Society
AOM	active oxygen method
APHA	American Public Health Association
ASCII	American Standard for Information Interchange
ASTM	American Society for Testing Materials
ATP	adenosine-5′-triphosphate
ATR	attenuated total reflectance
BCA	bicinchoninic acid
BCD	binary coded decimal
Be	degrees Baumé
BGG	bovine gamma globulin
BHA	butylated hydroxyanisole
BHT	butylated hydroxytoluene
BOD	biochemical oxygen demand
BSA	bovine serum albumin
BV	biological value
CAST	calf antibiotic and sulfa test
CFR	Code of Federal Regulations
CGC	capillary gas chromatography
CI	chemical ionization
CI	confidence interval
CID	Commercial Item Description
COD	chemical oxygen demand
CPC	cetylpyridinium chloride
C-PER	calculated protein efficiency ratio
CPU	central processing unit
CQC	2,6-dichloroquinonechloroimide
CV	cofficient of variation
CVM	Center for Veterinary Medicine
CW	continuous wave
DAL	defect action level
DC	direct current
DC-PER	discriminant calculated protein efficiency ratio
DHHS	Department of Health and Human Services
DMF	dimethylformamide
DMD	D-malate dehydrogenase
DMTA	dynamic mechanical thermal analysis
DNFB	1-fluoro-2,4-dinitrobenzene
DNP	dinitrophenyl
DSC	differential scanning colorimetry
DTA	differential thermal analysis
DTNB	5,5′-dithiobis-2-nitrobenzoic acid
dwb	dry weight basis
ECD	electron capture detector
EDTA	ethylenediaminetetraacetic acid
EI	electron impact
EIA	enzyme immunoassay
ELISA	enzyme linked immunosorbent assay
EMF	electromotive force
EPA	Environmental Protection Agency
ERH	equilibrium relative humidity
ESR	electron spin resonance
FAB	fast atom bombardment
FAME	fatty acid methyl esters
FAO/WHO	Food and Agricultural Organization/ World Health Organization
FDA	Food and Drug Administration
FD&C	Food, Drug and Cosmetic
FDNB	1-fluoro-2,4-dinitrobenzene
FFA	free fatty acid
FGIS	Federal Grain Inspection Service
FIA	fluoroimmunoassay
FID	flame ionization detector
FID	free induction decay
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FNB/NAS	Food and Nutrition Board of the National Academy of Sciences
F-6-P	fructose-6-phosphate
FPD	flame photometric detector
FT	Fourier transform
FTC	Federal Trade Commission
FT-ESR	Fourier transform - electron spin resonance
FTIR	Fourier transform infrared
FT-NMR	Fourier transform - nuclear magnetic resonance
Gal-DH	β-galactosidase dehydrogenase or galactose dehydrogenase
GC	gas chromatography
GC-AED	gas chromatography - atomic emission detector
GC-FTIR	gas chromatography - Fourier transform infrared

GC-MS	gas chromatography - mass spectrometry
GFC	gel-filtration chromatography
GHz	gigahertz
GMP	Good Manufacturing Practices
G-6-P	glucose-6-phosphate
GPC	gel-permeation chromatography
G6P-DH	glucose-6-phosphate dehydrogenase
HACCP	Hazard Analysis Critical Control Point
HETP	height equivalent to a theoretical plate
HK	hexokinase
HMDS	hexamethyldisilazane
HMF	5-hydroxymethyl-2-furfural
HPCE	high-performance capillary electrophoresis
HPLC	high-performance liquid chromatography
HPLC-MS	high-performance liquid chromatography - mass spectroscopy
HPTLC	high-performance thin-layer chromatography
HRGC	high-resolution gas chromatography
HRP-B	horseradish peroxidase-benzidine
IC	integrated circuit
ICP	inductively coupled plasma
ICP-AES	inductively coupled plasma - atomic emission spectroscopy
ICTA	International Confederation for Thermal Analysis
IDEA	immobilized digestive enzyme assay
IMS	Interstate Milk Shippers
INT	indonitrotetrazolium
IR	infrared
ISA	ionic strength adjustor
ISE	ion-selective electrode
IU	International Units
IUPAC	International Union of Pure and Applied Chemistry
KFR	Karl Fischer reagent
KFReq	Karl Fischer reagent water equivalence
KHL	keyhole limpet hemocyanin
KHP	potassium acid phthalate
LALLS	low-angle laser light scattering
LAN	local area network
LC	liquid chromatography
LC-MS	liquid chromatography - mass spectroscopy
LDH	lactate dehydrogenase
LIMS	laboratory information management system
MAS	magic angle spinning
MCL	maximum contaminant level
MECC	micellar electrokinetic capillary chromatography
MFL	million fibers per liter
MHz	megahertz
MPIP	Meat Poultry Inspection Program
MRI	magnetic resonance imaging
MRMs	multiresidue methods
MS	mass spectrometry (or spectrometer)
MW	molecular weight
NAD	nicotinamide-adenine dinucleotide
NADP	nicotinamide-adenine dinucleotide phosphate
NADPH	reduced NADP
NCWM	National Conferences on Weights and Measures
NIR	near-infrared
NIST	National Institute of Standards Technology
NMFS	National Marine Fisheries Service
NMR	nuclear magnetic resonance
nOe	nuclear Overhauser enhancement
NPR	net protein ratio
NPU	net protein utilization
NRC	National Research Council
NSSP	National Shellfish Sanitation Program
OCls	organochlorines
ODS	octadecylsilyl
OPs	organophosphates
PAGE	polyacrylamide gel electrophoresis
PAM I	Pesticide Analytical Manual, Volume I
PAM II	Pesticide Analytical Manual, Volume II
PCBs	polychlorinated biphenyls
PDCAAS	protein digestibility - corrected amino acid score
PEEK	polyether ether ketone
PER	protein efficiency ratio
PGI	phosphoglucose isomerase
pI	isoelectric point
PID	photoionization detector
PMO	Pasteurized Milk Ordinance
ppb	parts per billion
PPD	Purchase Product Description
ppm	parts per million
PUFA	polyunsaturated fatty acids
PVPP	polyvinylpolypyrrolidone
RAC	raw agricultural commodity
RF	radio frequency
RIA	radioimmunoassay
RPAR	Rebuttable Presumption Against Registration
RPER	relative protein efficiency ratio
RCS	rapid scan correlation
SD	standard deviation
SDH	sorbitol dehydrogenase
SDS	sodium dodecyl sulfate
SDS-PAGE	sodium dodecyl sulfate - polyacrylamide gel electrophoresis
SEC	size-exclusion chromatography
SFC	solid fat content
SFC	supercritical-fluid chromatography

SFI	solid fat index
SIM	selected ion monitoring
S/L	solid/liquid
SNF	solids-not-fat
SO	sulfite oxidase
SRMs	single residue methods
STOP	swab test on premises
TBA	thiobarbituric acid
TCD	thermal conductivity detector
TEMED	tetramethylethylenediamine
TEPA	tetraethylenepentamine
TGA	thermogravimetric analysis
TIC	total ion current
TLC	thin-layer chromatography
TMCS	trimethylchlorosilane
TMS	tri-methylsilyl
TNBS	trinitrobenzenesulphonic acid
TOC	total organic carbon
TS-MS	thermospray - mass spectrometry
TSS	total soluble solids
TSUSA	Tariff Schedules of the United States of America
USCS	United States Customs Service
USDA	United States Department of Agriculture
UV	ultraviolet
UV-Vis	ultraviolet-visible
Vis	visible
VPP	vegetable protein product
wwb	wet weight basis

Preface and Acknowledgments

This book was designed for use as a text primarily for undergraduate students majoring in food science who are currently studying the chemical analysis of foods. It should also be useful to workers in the food industry who do food analysis. Chapter authors are primarily university faculty members who are teaching or have taught a food analysis course, and who are very familiar with the specific topic of the chapters by nature of their research programs. Each chapter has been reviewed by persons working in the food industry who are familiar with and utilize that technique.

The book is not a laboratory manual but instead is designed to provide the lecture materials in an easy-to-follow outline format, with a brief discussion for each section. It provides much of the information on techniques that students must possess before they are able to conduct those laboratory experiments that normally accompany a food analysis course.

This book covers only the analysis of chemical properties of foods, and not physical properties. It is not intended as a detailed reference, but as a general introduction to the techniques used in food analysis. The course instructor can expand on the information in lecture, as desired, providing more details for any particular technique.

General information on sampling and data handling provides the background for discussing specific methods to determine the chemical composition and characteristics of foods. Large sections on spectroscopy and chromatography are included to explain principles of the techniques themselves and how they relate to methods of food analysis. Other methods and instrumentation such as ion selective electrodes, enzymes, immunoassays, and thermal analysis are also covered from the perspective of their use in the chemical analysis of foods. A chapter is included that relates food analysis to government regulations and recommendations.

All topics include information on the basic principles, procedures, advantages, limitations, and applications of food analysis. All chapters have summaries and study questions, and key words or phrases are identified. Many also have practice problems and a comparison of possible methods.

Most of the material covered in this book requires an understanding of general, organic, analytical and food chemistry, as well as biochemistry. With this basic knowledge, along with a food analysis course and other relevant food science courses, it is hoped that students can function within the food industry as necessary relevant to food analysis. This book will provide a good basis for food scientists and technologists as they begin work in the food industry, whether or not they are the persons directly involved in analysis of the food products. I would greatly appreciate comments from students, instructors and food industry professionals as to how well this book meets their needs, as well as any suggestions for later editions.

I wish to thank the persons who prepared each of the chapters in this book. Those of us who teach or have taught food analysis are indebted to our former students, who gave us the needed perspective as we prepared our chapters, intended to meet the needs of future students. I also wish to thank the authors of articles and books, as well as the publishers and industrial companies, for their permission to reproduce materials used here. Special thanks is extended to Dr. Y. H. Hui who advised me throughout this project. Becky Atkinson-Hitt is acknowledged for providing exceptional secretarial assistance. I thank the many persons from the food industry, government, and academia who kindly reviewed one or more chapters in this book. They offered their assistance on this project with the hope that this book might meet the needs of present employees in their companies, and that it might also meet the needs of students who will be their future employees. They are:

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PART

I

General Information

CHAPTER

1

Introduction to Food Analysis

S. Suzanne Nielsen

1.1 INTRODUCTION

Investigations in food science and technology, whether in universities, governmental agencies, or the food industry, often require determination of food composition. Various types of samples may require analysis as part of a research program, as new food products are developed, or as part of a **quality assurance** program for existing products. The chemical composition of foods is often determined to establish the acceptability or nutritive value of the food product. The nature of the sample and the specific reason for the analysis commonly dictate the choice of analysis method. Speed, **precision,** and **accuracy** are often key factors that determine the choice of method. In addition to actually performing the assay, the success of any analysis method relies on the proper selection and preparation of the food sample and on the appropriate calculations and interpretation of the data. **Official methods** of analysis developed by several nonprofit scientific organizations allow for comparison of results between different laboratories, and for comparisons to less standard procedures. Such official methods are critical in the analysis of foods, to ensure that they meet the legal requirements established by governmental agencies. **Government regulations** most relevant to the chemical analysis of foods will be covered in Chapter 2.

1.2 TYPES OF SAMPLES ANALYZED

The chemical analysis of foods is an important part of the quality assurance program in food processing, from ingredients and raw materials, through processing, to the finished products (1–3). It is also important in formulating and developing new products and evaluating new processes for making food products, and in identifying the source of the problem for unacceptable products (Table 1-1). For each type of product to be analyzed, it may be necessary to determine either just one or many components. The nature of the sample and the way in which the information obtained will be used may dictate the specific method of analysis. For example, process control samples are usually analyzed by rapid methods, whereas nutritive value information for **nutritional labeling** generally requires the use of official methods of analysis. Critical questions, including those listed in Table 1-1, can be answered by analyzing various types of samples in a food processing system.

TABLE 1-1. Types of Samples Analyzed in a Quality Assurance Program for Food Products

Sample Type	*Critical Questions*
Raw Materials	Do they meet your specifications? Do they meet required legal specifications? Will a processing parameter have to be modified because of any change in the composition of raw materials? Are the quality and composition the same as for previous deliveries? How does the material from a potential new supplier compare to that from the current supplier?
Process Control Samples	Did a specific processing step result in a product of acceptable composition or characteristics? Does a further processing step need to be modified to obtain a final product of acceptable quality?
Finished Product	Does it meet the legal requirements? What is the nutritive value, so that label information can be developed? or Is the nutritive value as specified on an existing label? Will it be acceptable to the consumer? Will it have the appropriate shelf life?
Competitor's Sample	What are its composition and characteristics? How can we use this information to develop new products?
Complaint Sample	How do the composition and characteristics of a complaint sample submitted by a customer differ from a sample with no problems?

Adapted from (4,5)

1.3 STEPS IN ANALYSIS

1.3.1 Select and Prepare Sample

In analyzing food samples of the types described above, all results depend on obtaining a representative sample and converting the sample to a form that can be analyzed. Neither of these is as easy as it sounds! **Sampling** and **sample preparation** are covered in detail in Chapter 3.

1.3.2 Perform the Assay

Performing the assay is the step in food analysis that is unique for each component or characteristic to be analyzed and may be unique to a specific type of food product. Single chapters in this book address the other two steps in analysis described here (sections 1.3.1 and 1.3.3), while the remainder of the book addresses this step of actually performing the assay. The descriptions of the various specific procedures are meant to be overviews of the methods. To actually perform the assays, details regarding chemicals, reagents, apparatus, and step-by-step instructions should be found in the referenced books and articles.