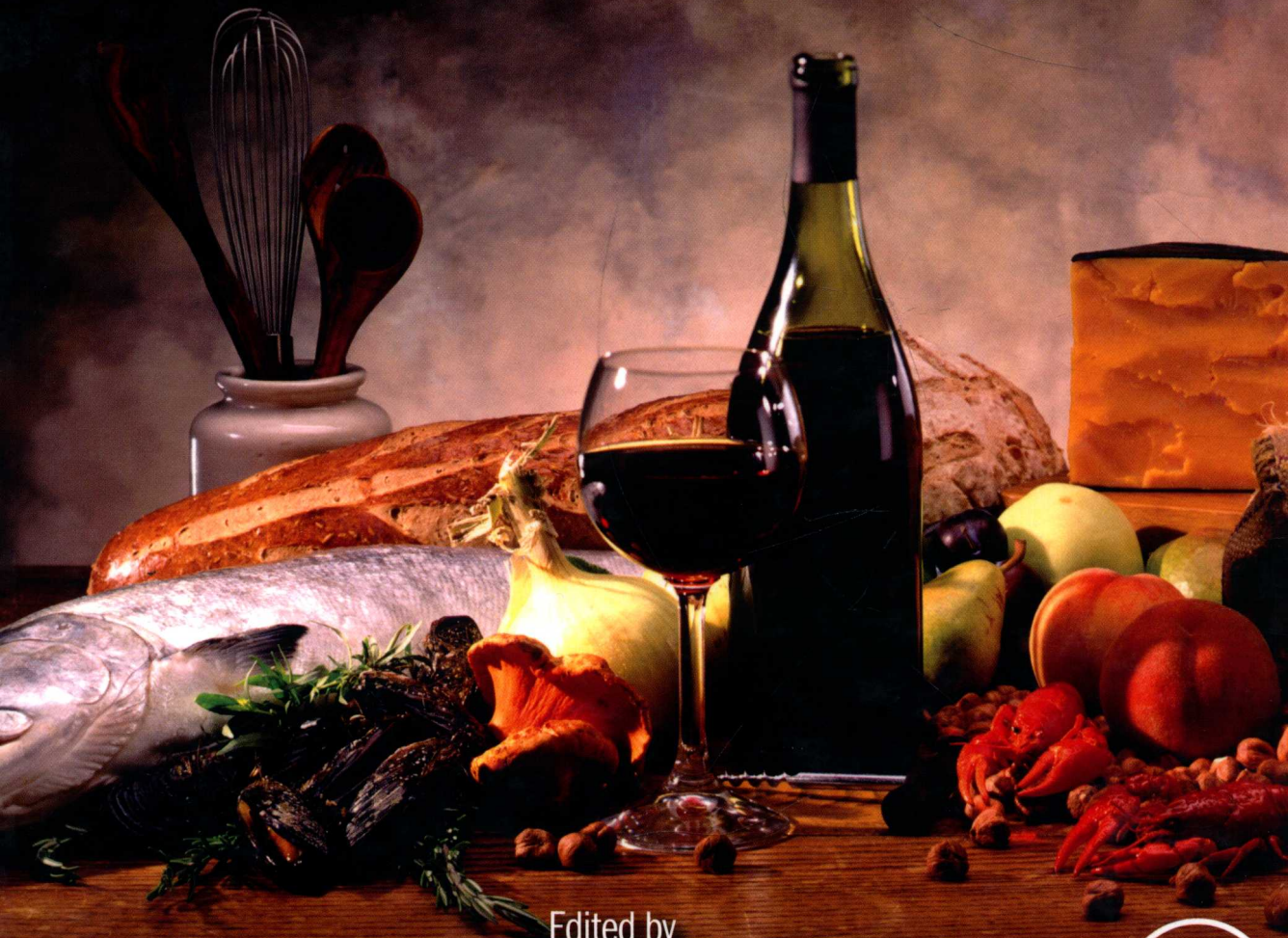


MODERN TECHNIQUES FOR FOOD AUTHENTICATION



Edited by
DA-WEN SUN



Modern Techniques for Food Authentication

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About the Editor



Born in Southern China, Professor Da-Wen Sun is an internationally recognized figure for his leadership in food engineering research and education. His main research activities include cooling, drying and refrigeration processes and systems, the quality and safety of food products, bioprocess simulation and optimization, and computer vision technology. In particular, his innovative studies on the vacuum cooling of cooked meats, pizza quality inspection by computer vision, and edible films for shelf-life extension of fruit and vegetables have been widely reported

in the national and international media. Results of his work have been published in over 180 peer-reviewed journal papers and more than 200 conference papers.

He received a first-class BSc Honors and MSc in Mechanical Engineering and a PhD in Chemical Engineering in China before working in various universities in Europe. He became the first Chinese national to be permanently employed in an Irish University when he was appointed College Lecturer at the National University of Ireland, Dublin (University College Dublin) in 1995; he was then continuously promoted in the shortest possible time to Senior Lecturer, Associate Professor and full Professor. Dr Sun is now Professor of Food and Biosystems Engineering and Director of the Food Refrigeration and Computerized Food Technology Research Group in University College Dublin.

As a leading educator in food engineering, Professor Sun has significantly contributed to the field of food engineering. He has trained many PhD students, who have made their own contributions to the industry and academia. He has also given lectures on advances in food engineering on a regular basis in academic institutions internationally, and delivered keynote speeches at international conferences. As a recognized authority in food engineering, he has been conferred adjunct/visiting/consulting professorships by ten top universities in China, including Zhejiang University, Shanghai

Jiaotong University, Harbin Institute of Technology, China Agricultural University, South China University of Technology, Southern Yangtze University. In recognition of his significant contribution to food engineering worldwide, and for his outstanding leadership in the field, the International Commission of Agricultural Engineering (CIGR) awarded him the CIGR Merit Award in 2000 and again in 2006; the Institution of Mechanical Engineers (IMechE) based in the UK named him “Food Engineer of the Year 2004”.

He is a Fellow of the Institution of Agricultural Engineers. He has also received numerous awards for teaching and research excellence, including the President’s Research Fellowship, and has twice received the President’s Research Award of University College Dublin. He is a member of CIGR Executive Board and Honorary Vice-President of CIGR, Editor-in-Chief of *Food and Bioprocess Technology – an International Journal* (Springer), Series Editor of the “Contemporary Food Engineering” book series (CRC Press/Taylor & Francis), former Editor of the *Journal of Food Engineering* (Elsevier), and editorial board member for the *Journal of Food Process Engineering* (Blackwell), *Sensing and Instrumentation for Food Quality and Safety* (Springer) and *Czech Journal of Food Sciences*. He is also a Chartered Engineer registered in the UK Engineering Council.

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Preface

With the greater awareness of food safety and quality, consumers are increasingly demanding reassurance regarding the origin and content of their foods, while manufacturers need to be able to confirm the authenticity of components of their products and comply with government legislation. Therefore, protection of the rights of consumers and genuine food processors, and prevention of fraudulent or deceptive practices and the adulteration of food is an important and challenging issue facing the food industry. As a result, rapid scientific and technological advances have taken place in recent years regarding the determination of food authenticity. *Modern Techniques for Food Authentication* focuses on novel techniques developed and their recent applications in authenticating food products. The techniques covered in this book include various spectroscopic technologies, methods based on isotopic analysis and chromatography, and other techniques based on DNA, enzymatic analysis, electrophoresis and thermal methods.

Modern Techniques for Food Authentication is written by international peers who have both academic and professional credentials, highlighting the truly international nature of the work. Each chapter examines one type of technique, providing a comprehensive overview of the food authentication technology. *Modern Techniques for Food Authentication* aims to provide the engineer and technologist working in research, development and operations in the food industry with critical and readily accessible information on the art and science of food authentication technology. The book will also serve as an essential reference source to undergraduate and postgraduate students and researchers in universities and research institutions.

List of Abbreviations

AAA	aromatic amino acids
ADCS	automatic distillation control system
AFPL	amplified fragment polymorphism
AGE	agarose gel electrophoresis
Agm	Agmatine
AIJN	Association of the Industry of Juice and Nectars from Fruits and Vegetables of European Union
ANCA-MS	automated N/C (nitrogen/carbon) analyzer-mass spectrometry
ANN	artificial neural network
AOTF	acousto-optical tunable filter
APCI	atmospheric pressure chemical ionization
As	asymmetry factor
ATR	attenuated total reflectance
Bar	<i>Bar</i> , marker gene conferring resistance to the non-selective herbicide phosphinothricin or PPT
BHA	3-tert-butyl-4-hydroxy-anisole
BHT	2,6-di-tert-butyl-4-methylphenol
Bla	<i>Bla</i> , marker gene originating from a cloning vector that encodes a beta-lactamase not expressed in corn
BP-ANN	back-propagation artificial neural network
BSE	bovine spongiform encephalopathy
Bt	<i>Bacillus thuringiensis</i>
C16:0	palmitic acid
C18:0	stearic acid
C18:1	oleic acid
CAM	Crassulacean acid metabolism
CaMV	tobacco mosaic virus
CaMVX35S	cauliflower mosaic virus promoter
CART	classification and regression trees
CB	cocoa butter
CBE	cocoa butter equivalents

CBM	castor bean meal
CCA	canonical correlation analysis
CCD	charge-coupled device
CCSWA	common component and specific weights analysis
CDT	Canyon Diablo Troilite
CE	capillary electrophoresis
CEC	capillary electrochromatography
CGE	capillary gel electrophoresis
CI	chemical ionization
CIEF	capillary isoelectrofocusing
CLA	cluster linear analysis
CP	cloud point
Cry9C	gene encoding one of several crystalline protein delta toxins from <i>Bacillus thuringiensis</i>
CryIA(b)	gene encoding one of several crystalline protein delta toxins from <i>Bacillus thuringiensis</i>
CS	corn syrup
CTAB	hexadecyltrimethyl-ammonium bromide
CV	coefficient of variation
CVA	canonical variate analysis
Cy3	a cyanine reporter dye that fluoresces orange with a peak emission at ~550 nm
Cy5	a cyanine reporter dye that fluoresces red with a peak emission at ~670 nm
DA	discriminant analysis
DAG	diacylglycerol
DETA	dielectric thermal analysis
DFA	difuctose anhydride
DGGE	denaturing gradient gel electrophoresis
DIG	digoxigenin
DMA	dynamic mechanical analysis
DNA	deoxyribonucleic acid
dNTP5'	deoxynucleotide phosphate
DOSC	direct orthogonal signal correction
DPLS	discriminant partial least squares
DSC	differential scanning calorimetry
dsPCR	double-stranded PCR
DTA	differential thermal analysis
DTGS	deuterated triglycine sulfate
EA-IRMS	elemental analyzer isotope ratio mass spectrometry
EB	ethidium bromide
EB-AGE	ethidium bromide-agarose gel electrophoresis
ECD	electron-capture detector
ECL	electrochemiluminescence
EDTA	ethylene-diamine-tetraacetic-acid

EGD	evolved gas detection
EI	electron impact
ELISA	enzyme-linked immunosorbent assay
ELS	evaporative light-scattering
ENZ	enzyme-specific sequence
EPSPS	5-enolpyruvylshikimate-3-phosphate synthase
EQCS	European Quality Control System
ESI	electrospray ionization
ESI-MS/MS	electrospray ionization-tandem mass spectrometry
EU	European Union
EVA	evolved gas analysis
EVOO	extra-virgin olive oil
EXT	extension
FA	factor analysis
FAB	fast atom bombardment
FAM	6-carboxyfluorescein
FAME	fatty acid methyl esters
FAN	free amino nitrogen
FDA	factorial discriminant analysis
FFA	free fatty acids
FFFS	front-face fluorescence spectroscopy
FG	flavanone glycosides
FID	flame ionization detector
FINS	forensically informative nucleotide sequencing
FITC	fluorescein isothiocyanate
FMF	fully methoxylated flavones
FMRP	fluorescent Maillard reaction products
FSCE	free solution capillary electrophoresis
FT-IR	Fourier transform infrared
FT-MIR	Fourier transform mid-infrared
FT-NIR	Fourier transform near-infrared
FT-NIRM	Fourier transform near-infrared microscopy
FTR	Fourier transform Raman
GA	genetic algorithms
GC	gas chromatography
GC-IRMS	gas chromatography with isotope ratio mass spectrometry
GC-C-IRMS	gas chromatography combustion isotope ratio mass spectrometry
GC×GC	comprehensive bidimensional gas chromatography
GC-MS	gas chromatography coupled with mass spectrometry
GC-P-IRMS	gas chromatography pyrolysis isotope ratio mass spectrometry
GC-TC-IRMS	gas chromatography high-temperature conversion isotope ratio mass spectrometry
GDS	glucono- δ -lactone

GLC	gas-liquid chromatography
GM	genetically modified
GMO	genetically modified organism
GOX	gene encoding glucose oxidase
GPC	gel-permeation chromatography
GSC	gas-solid chromatography
h	peak height
H	height equivalent to theoretical plate
HCA	hierarchical cluster analysis
HEC	2-hydroxyethyl cellulose
HETP	height equivalent to theoretical plate
HEX	a reporter dye with peak emission at 556 nm
HFCS	high-fructose corn syrup
HLA	histocompatibility complex
Hm	high mobility
HPAEC-PAD	high-performance anion-exchange chromatography
HPDSC	high-performance differential scanning calorimetry
HPGC	high-performance gas chromatography
HPLC	high-performance liquid chromatography
HPLC-ESI-MS/MS high performance liquid chromatography coupled with electrospray	ionization-tandem mass spectrometry
HPLC-GC	high performance liquid chromatographic and gas chromatographic system
HR-MAS-NMR	high-resolution magic angle spinning nuclear magnetic resonance
HRP-SA	horse radish peroxidase-streptavidin conjugate
HS	headspace
HSM	hot-stage microscopy
IBa	i-butyl amine
ICP-MS	inductively coupled plasma mass spectrometry (ICP)-MS
ICTA	International Confederation for Thermal Analysis
ICTAC	International Confederation for Thermal Analysis and Calorimetry
i.d.	internal diameter
IEF	isoelectric focusing
IOOC	International Olive Oil Council
iPCR	inverse PCR
IR	infrared
IRMS	isotope ratio mass spectrometry
IS	internal standard
IT	ion trap
IV	iodine value

k	capacity factor
k'	average of the capacity factors
k	retention factor
k-NN	k-nearest neighbors
L	length of column
LC	liquid chromatography
LDA	linear discriminant analysis
LDR	ligation detection reaction
LED	light-emitting diode
LIF	laser-induced fluorescence
LOO	dioleoyl-linoleyl glycerol
LPH	liquid phase hybridization
LS	light-scattering
2MeBa	2-methylbutylamine
3MeBa	3-methylbutylamine
MBM	meat and bone meal
MDA	multiple discriminant analysis
MDGC	multidimensional gas chromatography
MEKC	micellar electrokinetic chromatography
MGB	minor groove binding
MIR	mid-infrared
MPCR-MHA	PCR/membrane hybridization assay
MRE	meal ready to eat
MS	mass spectrometry
MSC	multiplicative scatter correction
MS/MS	tandem mass spectrometry
mtDNA	mitochondrial DNA
MW	molecular weight
N	theoretical plate number
NA	nucleic acid
Nd:YAG	neodymium-doped yttrium aluminium garnet
NIR	near-infrared
NMR	nuclear magnetic resonance
NOS	nopaline synthase
NOS-P	promoter for nopaline synthase from <i>Agrobacterium tumefaciens</i>
NOS-T	terminator for nopaline synthase from <i>Agrobacterium tumefaciens</i>
NPN	non-protein nitrogen
npII	neomycin phosphotransferase II, marker gene
OSC	orthogonal signal correction
OWAVEC	orthogonal wavelet correction
P&T	purge-and-trap
PAD	pulsed amperometric detector
PAGE	polyacrylamide gel electrophoresis

PC	principal component
PCA	principal component analysis
PCR	principal component regression
PCR	polymerase chain reaction
PDA	photo diode array
PDB	PeeDee belemnite
PDO	protected designation of origin
PEPC	phosphoenolpyruvate carboxylase
PGI	protected geographical indication
Phe	phenylethylamine
PLP	dipalmityl-linoleyl glycerol
PLS	palmityl-linoleyl-stearyl glycerol
PLS	partial least squares
PMF	polymethoxylated flavones
PNA	peptide nucleic acid
PNN	probalistic neural network methods
PNPP	para-nitro-phenyl phosphate
POP	2-oleopalmitin
POP	dipalmityl-oleoyl glycerol
POS	2-oleopalmitostearin
POS	oleoyl-palmitylstearylglycerol
PPP	tripalmitin
PPT	non-selective herbicide phosphinothricin
PSS	distearyl-palmityl glycerol
PTV	programmed temperature vaporizer
QC-PCR	quantitative competitive PCR
QDA	quadratic discriminant analysis
QMS	quadrupole mass spectrometry
R ²	coefficient of determination
R _s	resolution
RAPD	random amplified polymorphic DNA
RBF	radial basis Gaussian function
REs	restriction enzymes
RFLP	restriction fragment length polymorphism
RHOD	a rhodamine reporter dye with peak emission at 550 nm
RI	refractive index
RMS	root mean square
RMSECV	root mean standard error in cross-validation
RMSEP	root mean square error in prediction
RP	reversed-phase
RPD	ratio of standard deviation to root mean square error of prediction
RPD	ratio of standard deviation to standard error of prediction
rRNA	ribosomal RNA
RSD	relative standard deviation

SA	streptavidin
SCIRA	stable carbon isotope ratio analysis
SD	standard deviation
SDE	simultaneous distillation-extraction
SDS	sodium dodecyl sulphate
SECV	standard error of cross-validation
SEL	standard error of laboratory
SEP	standard error of prediction
SFC	solid fat content
SFLP	satellite fragment length polymorphism
SIMCA	soft independent modeling of class analogy
SINEs	short interspersed elements
SLAP	standard Light Arctic Precipitation
SLDA	stepwise linear discriminant analysis
SOS	distearyl-oleoyl glycerol
SOS	distearyl-oleoyl glycerol
SMP	slip melting point
S/N	signal-to-noise
SNIF	site-specific natural isotope fractionation
SNIP-IRMS	specific natural isotope profile studied by isotope ratio mass spectrometry
SNV	standard normal variate
SOS	2-oleodistearin
SPME	solid-phase microextraction
SSCP	single strand conformation polymorphism
ssDNA	single-stranded DNA
SVM	support vector machines
t_R	retention time
t_R'	corrected retention time
t_0	column dead time or hold-up time
TA	thermal analysis
TAG	triacylglycerol
TAMRA	6-carboxy-N,N,N',N'-tetramethylrhodamine quencher dye
TBARS	thiobarbituric acid reactive substances
TBR	tris-2,2'-bipyridy-ruthenium II
TD	thermal desorption
TET	tetrachloro-6-carboxyfluorescein
TG	thermogravimetric analysis
TIC	total ion current
TIMS	thermo-ionization mass spectrometry
TL	thermoluminescence
TLC	thin-layer chromatography
TM	thermomagnetometry
TMA	thermomechanical analysis

TMDSC	temperature-modulated differential scanning calorimetry
TMS	trimethylsilyl
TN	total nitrogen
ToF	time-of-flight
TPA	tris-propylamine
TS	target sequence
TS	thermosonimetry
TSE	transmissible spongiform encephalopathy
TSG	Traditional Specialty Guaranteed
Tyr	tyramine
UA	universal array
Unk	unknown
UPLC	ultra performance liquid chromatography
USFDA	United States Food and Drug Administration
UV	ultraviolet
UV/VIS	ultraviolet visible
V_R	retention volume
VIC	proprietary dye, Applied Biosystems
VIS	visible
VOO	virgin olive oil
V-SMOW	Vienna Standard Mean Ocean Water
w	peak width
$w_{1/2}$	peak width measured at half peak height
$w_{4.4\%}$	peak width measured at 4.4% peak height
WB	Warner-Bratzler
WILMA	wavelet interface to linear modeling analysis
WSN	water-soluble nitrogen
α	separation factor or relative retention or selectivity