

Descriptive Analysis in Sensory Evaluation

Editors

Sarah E. Kemp, Joanne Hort
and Tracey Hollowood



WILEY Blackwell

Descriptive Analysis in Sensory Evaluation

A series of books on selected topics in the field of Sensory Evaluation

The first book in the Sensory Evaluation series is *Sensory Evaluation: A Practical Handbook*, published in May 2009. It focuses on the practical aspects of sensory testing, presented in a simple, 'how to' style for use by industry and academia as a step-by-step guide to carrying out a basic range of sensory tests. In-depth coverage was deliberately kept to a minimum. Subsequent books in the series cover selected topics in sensory evaluation. They are intended to give theoretical background, more complex techniques and in-depth discussion on application of sensory evaluation that were not covered in the *Practical Handbook*. However, they will seek to maintain the practical approach of the handbook and chapters will include a clear case study with sufficient detail to enable practitioners to carry out the techniques presented.

Descriptive Analysis in Sensory Evaluation

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To George, Elizabeth, George and William
To Mike, Holly and Socks
To Campbell, Emma and Lara
In memory of Pieter Punter

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Editor Biographies

Sarah E. Kemp, BSc (Hons), PhD, CSci, FIFST, RSensSci, is a chartered sensory and consumer science professional with more than 30 years of experience in academia and industry. Dr Kemp gained a BSc in Food Technology in 1986 and a PhD in Taste Chemistry in 1989 from the Food Science and Technology Department at the University of Reading, UK. In 1990, she did a postdoctoral research fellowship in sensory science at the Monell Chemical Senses Center in Philadelphia, USA. Dr Kemp has held many positions in industry, including Manager of Sensory Psychology (US) and Director of European Consumer and Marketing Research (France) in the Fragrance Division at Givaudan, Product Area Leader and Sensory Science Leader in Foods Consumer Science at Unilever Research, Colworth, UK, Head of Global Sensory and Consumer Guidance at Cadbury Schweppes, UK, and Director of Sensory and Consumer Services at Reading Scientific Services Limited, UK. Dr Kemp has also set up and run her own consultancy service and catering company. She has written numerous scientific articles in the field of sensory evaluation, has provided sensory training courses, including lecturing on the European Masters Course in Food Science, and has worked on bodies developing standards in sensory evaluation, including the British Standards Institution and ASTM International. She is a fellow of the Institute of Food Science and Technology and a founder member, past Chair and examiner for the IFST's Sensory Science Group, as well as being a member of other professional sensory societies. Her other activities include Governor of East Kent College, UK.

Tracey Hollowood, BSc (Hons), PhD, MIFST, is currently Managing Director of Sensory and Consumer Research for Sensory Dimensions (Nottingham) Ltd in the UK. She has over 25 years' experience in academia and industry; she worked at Nottingham University for 10 years during which time she achieved her doctorate investigating perceptual taste-texture-aroma interactions. She established the UK's first Postgraduate Certificate in Sensory Science and designed and managed the University's prestigious Sensory Science Centre. Her research focused on psychophysical studies, interactions in sensory modalities and fundamental method development. She has over 30 peer-reviewed publications, has run numerous workshops and delivered oral presentations to many international audiences including at the Pangborn Sensory Science Symposia 2015 in Gothenburg. She has participated in the organization of seven international symposia, including the International Symposium of Taste 2000 and Pangborn 2005 in Harrogate.

Tracey is a previous chair of the Institute of Food Science and Technology (IFST) Midland branch and the Professional Food Sensory Group (PFSG), now the Sensory Science Group (SSG).

Joanne Hort, BEd (Hons), PhD, CSci, FIFST, RSensSci, is the Fonterra-Riddet Chair of Consumer and Sensory Science at Massey University in New Zealand following on from her various academic roles, latterly SABMiller Chair of Sensory Science at the University of Nottingham. Initially, Professor Hort studied food technology and began her career in teaching. However, she returned to university to receive her doctorate concerning the modelling of the sensory attributes of cheese from analytical and instrumental measures in 1998. As a lecturer at Sheffield Hallam University, she carried out sensory consultancy for local industry, developed a sensory programme at undergraduate level and oversaw the installation of new sensory facilities before being appointed as Lecturer in Sensory Science at the University of Nottingham in 2002. There she established the University of Nottingham Sensory Science Centre, which is internationally renowned for both its sensory training and research into flavour perception. She obtained her Chair in 2013 and her multidisciplinary approach combining analytical, brain imaging and sensory techniques provides rich insight into multisensory interactions, individual variation and temporal changes in flavour perception, and the emotional response to sensory properties, leading to over 90 publications. Joanne sits on the editorial board for Food Quality and Preference and Chemosensory Perception. She is a Fellow of the Institute of Food Science and Technology. She is a founder member and past Chair of the European Sensory Science Society and a founder member, past Chair and examiner for the IFST's Sensory Science Group.

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Preface to the Series

Sensory evaluation is a scientific discipline used to evoke, measure, analyse and interpret responses to products perceived through the senses of sight, smell, touch, taste and hearing (Anonymous, 1975). It is used to reveal insights into the way in which sensory properties drive consumer acceptance and behaviour, and to design products that best deliver what consumers want. It is also used at a more fundamental level to provide a wider understanding of the mechanisms involved in sensory perception and consumer behaviour.

Sensory evaluation emerged as a field in the 1940s. It began as simple 'taste testing' typically used in the food industry for judging the quality of products such as tea, cheese, beer, and so on. From the 1950s to the 1970s, it evolved into a series of techniques to objectively and reliably measure sensory properties of products, and was typically used to service quality assurance and product development. Through the 1980s and 1990s, the use of computers for data collection and statistical analysis increased the speed and sophistication of the field, so that sensory, consumer and physicochemical data could be combined to design products that delivered to consumer needs.

Today, sensory evaluation is a sophisticated, decision-making tool that is used in partnership with marketing, research and development and quality assessment and control throughout the product lifecycle to enable consumer-led product design and decision making. Its application has spread from the food industry to many others, such as personal care, household care, cosmetic, flavours, fragrances and even the automotive industry. Although it is already widely used by major companies in the developed market, its use continues to grow in emerging markets, smaller companies and new product categories, as sensory evaluation is increasingly recognised as a necessary tool for competitive advantage.

The field of sensory evaluation will continue to evolve and it is expected that faster, more flexible and more sophisticated techniques will be developed. Social networking tools are transforming the way research is undertaken, enabling direct and real-time engagement with consumers. The use of sensory evaluation by marketing departments will continue to grow, particularly in leveraging the link between product sensory properties and emotional benefits for use in branding and advertising. Advances in other fields, such as genomics, brain imaging, and instrumental analysis, will be coupled with sensory evaluation to provide a greater understanding of perception.

Owing to the rapid growth and sophistication of the field of sensory evaluation in recent years, it is no longer possible to give anything but a brief overview of individual topics in a single general sensory science textbook. The trend is towards more specialised sensory books that focus on one specific topic, and to date, these have been produced in an ad-hoc fashion by different authors/editors. Many areas remain uncovered.

We, the editors, wanted to share our passion for sensory evaluation by producing a comprehensive series of detailed books on individual topics in sensory evaluation. We are enthusiastic devotees of sensory evaluation, who are excited to act as editors to promote sensory science. Between us, we have over 70 years of industrial and academic experience in sensory science, covering food, household and personal care products in manufacturing, food service, consultancy and provision of sensory analysis services at local, regional and global levels. We have published and presented widely in the field; taught workshops, short courses and lecture series; and acted as reviewers, research supervisors, thesis advisors, project managers and examiners. We have been active in many sensory-related professional bodies, including the Institute of Food Science and Technology Sensory Science Group, of which we are all past Chairs, the European Sensory Science Society, of which one of us is a past Chair, the Institute of Food Technologists, the British Standards Institute and ASTM International, to name but a few. As such, we are well placed to have a broad perspective of sensory evaluation, and pleased to be able to call on our network of sensory evaluation colleagues to collaborate with us.

The book series *Sensory Evaluation* covers the field of sensory evaluation at an advanced level and aims to:

- be a comprehensive, in-depth series on sensory evaluation
- cover traditional and cutting-edge techniques and applications in sensory evaluation using the world's foremost experts
- reach a broad audience of sensory scientists, practitioners and students by balancing theory, methodology and practical application
- reach industry practitioners by illustrating how sensory can be applied throughout the product life cycle, including development, manufacture, supply chain and marketing
- cover a broad range of product applications, including food, beverages, personal care and household products.

Our philosophy is to include cutting-edge theory and methodology, as well as illustrating the practical application of sensory evaluation. As sensory practitioners, we are always interested in how methods are actually carried out in the laboratory. Often, key details of the practicalities are omitted in journal papers and other scientific texts. We have encouraged authors to include such details in the hope that readers will be able to replicate methods themselves. The focus of sensory texts often tends to be food and beverage products assessed using

olfaction and taste. We have asked authors to take a broad perspective to include non-food products and all the senses.

The book series is aimed at sensory professionals working in academia and industry, including sensory scientists, practitioners, trainers and students; and industry-based professionals in marketing, research and development and quality assurance/control, who need to understand sensory evaluation and how it can benefit them. The series is suitable as:

- reference texts for sensory scientists, from industry to academia
- teaching aids for senior staff with responsibility for training in an academic or industrial setting
- course books, some of which to be personally owned by students undertaking academic study or industrial training
- reference texts suitable across a broad range of industries; for example, food, beverages, personal care products, household products, flavours, fragrances.

The first book in the series, *Sensory Evaluation: A Practical Handbook* was published in May 2009 (Kemp et al. 2009). This book focuses on the practical aspects of sensory testing, presented in a simple, 'how to' style for use by industry and academia as a step-by-step guide to carrying out a basic range of sensory tests. In-depth coverage was deliberately kept to a minimum. Further books in the series cover the basic methodologies used in the field of sensory evaluation: discrimination testing, descriptive analysis, time-dependent measures of perception and consumer research. They give theoretical background, more complex techniques and in-depth discussion on application of sensory evaluation, whilst seeking to maintain the practical approach of the handbook. Chapters include clear case studies with sufficient detail to enable practitioners to carry out the techniques presented. Later books will cover a broad range of sensory topics, including applications and emerging trends.

The contributors we have selected are world-renowned scientists and leading experts in their field. Where possible, we have used originators of techniques. We have learned a lot from them as we have worked with them to shape each book. We wish to thank them for accepting our invitation to write chapters and for the time and effort they have put in to making their chapters useful and enjoyable for readers.

We would also like to thank our publisher, Wiley Blackwell, and particularly extend our thanks to David McDade, Andrew Harrison and their team for seeing the potential in this series and helping us bring it to fruition. We would also like to thank the anonymous reviewers of the series for their constructive comments.

We hope you will find the *Sensory Evaluation* book series both interesting and beneficial, and enjoy reading it as much as we have producing it.

Sarah E. Kemp
Joanne Hort
Tracey Hollowood

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Preface

Descriptive analysis is one of the cornerstone techniques in sensory evaluation. The aim of this book is to provide a comprehensive and up-to-date overview of the technique.

Descriptive analysis is covered in classic general sensory science texts, including Meilgaard et al. (2007), Lawless and Heymann (2010) and Stone et al. (2012). These have limited space to give to the topic, which makes it difficult to strike a balance between theory and practical application. To the editors' knowledge, there are four previous publications devoted to descriptive analysis. ASTM (1992) produced a manual that gives a brief comparison of different descriptive methodologies. Gacula (1997) is a textbook on descriptive analysis, and although it was a good source of information for its time, it is now a relatively old text, written prior to the introduction of newer methods. Delarue et al. (2014) and Varela and Ares (2014) are books that focus on newer methods.

The editors saw a need for a book devoted to descriptive analysis that would provide in-depth theoretical and practical coverage of traditional and recently developed descriptive techniques. The scope of this book includes history, theory, techniques and applications of descriptive analysis. It does not include time intensity descriptive techniques, which are covered in a separate book in the Sensory Evaluation series (Hort et al. 2017).

The book is structured in four sections. Section 1 is an introduction covering general topics in descriptive analysis, including panel training, panel monitoring and statistical analysis. Section 2 covers different techniques in descriptive analysis, ordered approximately according to historical development. Section 3 covers applications of descriptive analysis. Section 4 provides a summary that compares different methods.

Each chapter includes theory, psychological aspects, methodology, statistical analysis, applications, practical considerations, including hints/tips and dos/don'ts for carrying out methodology, case studies and examples, future developments and a reference list. The aim is to give a balance between theory and practice, with enough theory for readers to fully understand the background and underlying mechanisms of the technique, and in many instances enough detail to enable the reader to carry out the methodology.

Wherever possible, the authors invited to write chapters on particular techniques are the originators or early users of that technique and have extensive expertise and experience in its application. We wish to thank all authors for giving their time and effort to their chapter despite their busy schedules, and for

their patience with the process. We would particularly like to thank Alejandra Muñoz for providing additional guidance.

We hope you find this book as interesting and beneficial to read as we did to produce.

Dr Sarah E. Kemp
Professor Joanne Hort
Dr Tracey Hollowood

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SECTION I

Introduction

CHAPTER 1

Introduction to Descriptive Analysis

Sarah E. Kemp, May Ng, Tracey Hollowood and Joanne Hort

1.1 Introduction

Descriptive analysis is a method used to objectively describe the nature and magnitude of sensory characteristics. It was a pioneering development for its day, and represented a major step forward that gave sensory evaluation a scientific footing through the ability to produce objective, statistically reliable and statistically analysable data. Today, it remains a cornerstone method in sensory analysis.

A wide range of descriptive analysis techniques have been developed since its inception. Traditional descriptive techniques, such as profiling-based methods and quantitative descriptive analysis, involve a panel of trained assessors objectively measuring the quality and strength of the sensory attributes of samples. More recently, faster descriptive techniques, such as sorting, projective mapping and polarized sensory positioning, involve untrained consumers grouping samples based on holistic similarities and differences in sensory characteristics. Over the years, descriptive analysis has proved itself to be flexible and customizable, which has contributed to its usefulness and hence its longevity.

As descriptive analysis enables objective, comprehensive and informative sensory data to be obtained, it acts as a versatile source of product information in industry, government and research settings. Descriptive analysis was first applied to foods and beverages, but is now applied to a broad range of products including home, personal care, cars, environmental odours, plants, etc. It is used throughout the product lifecycle, including market mapping, product development, value optimization, and quality control and assurance. Descriptive analysis is particularly useful in product design, when sensory data are linked to consumer hedonic data and physico-chemical data produced using instrumental measures. This allows product developers and marketing professionals to understand and identify sensory drivers of product liking in order to design products with optimal liking. Sensory descriptive information can also be linked to other types of

consumer data to enhance brand elements, emotional benefits, functional benefits and marketing communication.

There are many general texts and reviews on descriptive analysis and the reader is directed to the following: ASTM (1992), Gacula (1997), Murray et al. (2001), Meilgaard et al. (2006), Kemp et al. (2009), Lawless and Heymann (2010a,b), Varela and Ares (2012, 2014), Stone et al. (2012) and Delarue et al. (2014).

1.2 Development of Descriptive Analysis

1.2.1 Evolution

Descriptive analysis grew from the need to assess products in a reliable fashion. Originally, product sensory quality relied on assessment by experts, such as brewers, wine tasters, tea tasters and cheese makers, who judged quality on key product attributes and made recommendations on how ingredients and process variables affected production and the finished product, which might often have a very fixed, invariable specification over a long period of time. The expert, sometimes called the 'golden tongue', was often a single person, who had product experience or had been trained by other experts. Businesses relied heavily on a few key individuals, which could be problematic if they left, particularly if they were the prime expert on the unique sensory characteristics of a company's product. Attributes were often important to the manufacturing process, rather than the consumer, and might comprise defects or complex terms that were difficult to understand. Attributes were often assessed using grading on quality scales that might be idiosyncratic to a company, an industry or a country. Indeed, experts could also be idiosyncratic and subjective in their judgements. Data often comprised a single value, which could not be interrogated statistically, making it difficult to compare scores in a meaningful way. In many cases, only the expert could interpret differences in scores between products.

As the market became more complex and fast-paced, with increasing numbers of ingredients, processing technologies, products, competition and consumer choice, the need arose for a more robust system for assessing product quality. The introduction of descriptive analysis moved away from a single expert to a trained panel of assessors, removing the reliance on a single person and making the data more reliable. Controls were introduced, such as experimentally verified scales, physical sensory references rather than descriptive words, consistent assessment methodology and thorough training. As sensory evaluation became recognized as a scientific discipline, good experimental design as used in other scientific areas was introduced, such as elimination of variability and bias, and use of experimental design and replication. This enabled the production of robust, objective data that could be analysed statistically. In a similar fashion, food production had moved from a craft to a science, and data produced

from descriptive analysis now became available for food scientists and technologists to use in conjunction with physico-chemical instrumental measures to understand food quality in a science-based, rigorous manner.

The market continued to grow, and became increasingly international and global. Companies began to manufacture greater volumes, often at many national and international sites, and the rigorous nature of descriptive analysis now made it easier to compare data across studies and across panels, for example, to check that product quality was consistent across manufacturing sites. At this point, descriptive analysis was a key tool for quality assurance and control, and the sensory department was essentially providing a service based on routine testing. Traditional methodologies continued to be honed. In the US, several dominant descriptive analysis methods emerged driven by sensory agencies. In Europe, where the market for sensory agencies was more fragmented, the trend was towards customizing descriptive methodology to suit the needs of individual companies.

With globalization, the marketplace has evolved to be highly competitive. Consumers have become increasingly sophisticated and demanding, with a wide range of choices. To gain a competitive advantage, it is important to deliver consumers' needs, wants and desires. Product push has given way to consumer pull, and it is now consumers who are the ultimate judges of product nature and quality (Kemp 2013). The applications of descriptive analysis have evolved to become a key tool for use in product design and development, in order to interpret and deliver consumers' sensory requirements. New product development can be guided to create products based on consumer likes and dislikes. Descriptive data are now routinely combined with consumer data to determine sensory attributes that drive consumer liking, aided by the advances in technology outlined below that have enabled sophisticated, rapid statistical modelling and analysis. Physico-chemical and process data can also be combined in these models to enable manipulation of product characteristics to optimize consumer liking. Sensory attributes of key importance to the consumer can be comprehensively understood, and are now routinely used in quality control and assessment.

As the marketplace has become complex and sophisticated, so has the means of marketing products. There are many ways in which product sensory characteristics play a role in marketing, as described in section 1.4.3, including sensory pleasantness leading to repeat purchase, as an essential brand characteristic, as a functional benefit or indicator of a functional benefit, and as part of the brand/product experience, which is increasingly highlighting emotional aspects. Statistical modelling using descriptive data has been able to illuminate and design sensory characteristics linked to brand elements, functional benefits and emotional benefits. Hence, descriptive analysis is now an important tool for marketing and can be used across the product life cycle. As a result, the sensory department itself has now evolved to become a full partner to marketing and technical functions, rather than a service provider in the quality department.

As factors related to the commercial environment have influenced the evolution of descriptive analysis, and indeed sensory evaluation in general, so have advances in technology. Methods of data collection have changed considerably. In the early days, all data had to be collected using pen and paper, and then transcribed into raw data tables by hand. The chance of error was higher and data entry was usually double checked, further slowing progress. Preparing paper questionnaires was time-consuming, and could be complex given the experimental design. Transcribing data from a continuous line scale involved measuring the distance from the end of the scale to the assessment mark with a ruler, which was a daunting task made exponentially larger by the number of attributes, samples, assessors and replicates. The size and complexity of descriptive analysis studies were limited, as was the statistical analysis that was feasible.

The introduction of computers in the 1980s considerably speeded up operations. Initially, computers were expensive and one computer might be used in a conjunction with an optical reader to carry out data input and analysis. As computers became faster and cheaper, the process of descriptive analysis became increasingly more automated. Computers were introduced into sensory booths for direct data entry. Bigger studies, more complex experimental designs and faster, more comprehensive data analysis were possible. At the same time, computerized systems were developed to design, manage and run sensory testing, making descriptive analysis easier and more streamlined to perform.

Much more complex and sophisticated data analysis, such as multidimensional scaling (MDS) and generalized Procrustes analysis (GPA), became feasible and routine, leading to the symbiotic development of descriptive methods that relied on this analysis, such as free choice profiling, sorting and other techniques. This also enhanced the application of descriptive data, as complex statistical modelling linking descriptive data to consumer and physico-chemical, instrumental data became possible, using techniques such as preference mapping and response surface methodology (RSM). This enabled the sensory drivers of liking to be identified for consumer-led product development, so that today consumer-driven product design using this approach is the norm for larger companies with the available resources. Sophisticated graphics became possible, making it easier to illustrate results to lay audiences, and hence increase interest and use of descriptive analysis.

The introduction of wireless technology freed computers, so that they became portable, enabling descriptive testing to be carried out on the go in real-life environments. Technology has also become smaller and more robust, so that it can be used easily wherever and whenever necessary. For example, descriptive analysis of shower gels can now be carried out in consumers' home bathrooms using waterproof tablets in their showers, with data sent for analysis in real time. Mobile phone apps enable data to be collected conveniently as consumers go about their daily lives. The widespread use of the internet and social media has also had an impact, although care needs to be taken to ensure that the identity

and location of the assessor has been verified. Virtual descriptive panels have been set up with group training carried out via web-based sessions, with references and products sent to consumers' homes. Central location testing still remains convenient, and advances in virtual reality environments have made it more realistic although this is not yet widespread.

In some ways, descriptive analysis has become a victim of its own success. It is now used routinely throughout the new product development cycle, as described above, but this cycle is becoming increasingly faster and shorter. Despite the gains in speed from computerization and other new technologies, traditional descriptive analysis can be perceived as slow to set up, to complete a study and to produce actionable results. Ever faster product launch cycles have led to the development of more rapid methods for descriptive analysis, such as sorting and flash profiling, in which sensory characteristics for products are compared together rather than individually assessed. Some of these methods can be run with untrained assessors, eliminating what can be several months of set-up time. A study can be completed more rapidly, and although analysis can be complex, speed is on a par with modelling techniques used to link descriptive data with consumer and physico-chemical data. There may, however, be compromise of detail for speed.

Today, descriptive analysis remains a key sensory tool that is highly flexible, with the choice of many standard methods to suit a wide range of applications and the possibility of customization for specific applications. The history of the development of descriptive analysis methods is described in section 1.2.2.

1.2.2 History

1.2.2.1 To 1950s

The early history of descriptive analyses often relied upon 'golden tongue' experts, such as brew masters, wine tasters, perfumers, flavourists and others, to guide product development and quality assurance. It was possible for these experts to be reasonably successful when the marketplace was less competitive. From the 1910s to the 1950s, various score cards and sheets were developed by companies and government departments primarily for quality evaluation, and the need for accurate, reliable methods using the appropriate assessors and scales gradually became apparent (see Amerine et al. (1965) and Dehlholm (2012) for a review of early literature, and the latter for an overview of the history of descriptive methods to the present).

With the rapid introduction and proliferation of new products into the marketplace, a need for a formal means of describing food arose. Researchers at the Arthur D. Little laboratory were the first to take the ground-breaking step of developing a robust method called the *flavor profile method** (FPM) to meet this need (Cairncross & Sjostrum 1950). They demonstrated that it was possible for

* 'Flavor profile' is a formal name in common usage using American English spelling and is therefore cited in this manner.

trained assessors to produce actionable results without depending on individual experts and this was a key change in the philosophy of sensory science. The main features of the method involved analysing a product's perceived aroma, flavour and aftertaste characteristics, their intensities, order of appearance, aftertaste and overall impression using a panel of 4–6 assessors. However, one weakness of this method was that the data could not be statistically treated.

Several methods based on FPM have been developed. A step in FPM uses *consensus profiling*, in which a group of assessors work together to produce group intensity scores for attributes, and this is still used as a stand-alone method, although statistical analysis of the data is not possible (see Chapter 6). Other early derivations of the method include the *modified diagram method* (Cartwright & Kelly 1951) and the *dilution flavour profile* (Tilgner 1962a,b), although these have not been widely used. A later extension was *profile attribute analysis* (PAA) (Neilson et al. 1988), developed by Arthur D. Little, Inc., which involved the use of individual assessments of visual, tactile and auditory attributes on category/line scales and incorporated statistical analysis using ANOVA.

1.2.2.2 1960s

As there was a need to apply descriptive methods to food texture assessment, a new method called the *texture profile method* (TPM) was developed at the General Foods Technical Center by a team of researchers, under the leadership of Dr Alina Szczesniak in the 1960s (Brandt et al. 1963; Szczesniak 1963; Szczesniak et al. 1963). This method involved assessing the quality and intensity of a product's perceived texture and mouthfeel characteristics categorized into three groups: 'mechanical', 'geometric' and 'other' (alluding mostly to the fat and moisture content of foods). This technique used the 'order of appearance' principle from FPM and is conducted in order of first bite to complete mastication by a panel of 6–10 assessors, who must receive the same training in the principles of texture and TPM procedures. The type of scale used in TPM has expanded from a 13-point scale to category, line and magnitude estimation scales (Meilgaard et al. 2006). Similar to FPM, many reference products were not available to researchers outside the UK (Murray et al. 2001). Although data could not be statistically treated, the foundation of rheological principles upon which the method is built are still applicable. However, a few papers have suggested a solution to this by modifying TPM scales (Bourne et al. 1975; Hough et al. 1994). TPM has been applied to many specific product categories, including breakfast cereal, rice, whipped topping, cookies, meat, snack foods and many more (Lawless & Heymann 2010a).

1.2.2.3 1970s

In the mid-1970s, Tragon Corporation developed a method called *quantitative descriptive analysis* (QDA), later modified and registered under the name Tragon