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From *The Composition of Foods* using chemical analysis . . . to micronutrients and beyond

BY ANN F. WALKER

Hugh Sinclair Unit of Human Nutrition, Department of Food Science and Technology, The University of Reading, Whiteknights, Reading RG6 6AP

In the early 1930s, after obtaining her PhD on the carbohydrates in apples, Dr Elsie Widdowson embarked on a postgraduate course in dietetics at King's College of Household and Social Science, London. During the hospital training element of this course at St Bartholomew's Hospital, she was appalled at the inaccuracy of the food compositional data being used to formulate medically-prescribed diets. She resolved to change matters, and after she had joined Dr McCance's team she realized that they had already obtained sufficient new analytical data on the majority of the food groups to form the basis of completely new tables.

The novel features of the McCance and Widdowson approach were to assemble food tables based on their own newly-acquired analytical data and to make them user-orientated. Indeed, Dr Widdowson was very keen to use them herself in her planned dietary survey of individual men, women and children. Other innovative features were the inclusion of data for prepared dishes and the provision of analytical values of carbohydrate content, rather than simply calculating carbohydrate 'by difference'.

The pioneering work on the composition of foods was demanding and time consuming. It involved analytical procedures based on wet chemistry methods, calculation by slide rules and the manual recording of all data. By contrast, modern compilers are aided by instrumental analytical techniques, computers of vast capacity and on-line access to nutritional databases and other information resources.

THE ORIGINAL McCANCE AND WIDDOWSON CONCEPT OF FOOD TABLES

The fifth edition of *McCance and Widdowson's The Composition of Foods* (Holland *et al.* 1990) is one of three bibles of the nutritional scientist or dietitian working in the UK today. The others are tables of dietary reference values (e.g. Department of Health, 1991), and, stemming from these two, the third and newest tool on intake data of nutrients based on weighed surveys of large numbers of individuals (e.g. Gregory *et al.* 1990).

Modern food tables are used for three main purposes (Table 1): nutritional information, diet analysis and diet or menu construction. When I was asked to give this talk, my first reaction was, why me? What did I know about food tables? Then I realized that, like any nutritional scientist, I was a user and that user requirements were very important in the development of UK food tables and continue to be important in their development to this day. I reflected that over the last 6 months I have used the McCance and Widdowson food tables for teaching, with my research students for analysis of nutrients from surveys for studies of Mg and Zn intakes, and in construction of a suitable menu for those wishing to eat according to current guidelines.

My other link with the food tables goes back to the early 1970s when I first met Dr Elsie Widdowson. At that time I was registered for a Masters Degree in Food Science at

Table 1. *Uses of food composition tables*

Nutritional information
Teaching, labelling
Diet analysis
Dietary survey:
– individual: weighed, recall, food-frequency questionnaire, food diary, diet history
– household
– population
Diet or menu construction
Food aid, medical, armed forces, low energy, nutritional synthesis programmes

The University of Reading. For my dissertation project Dr Widdowson kindly put me in touch with Dr David Southgate with whom I worked for 3 months at the Dunn Nutritional Laboratory in Cambridge on the analysis of dietary fibre of vegetables for the fourth edition of the tables (Paul & Southgate, 1978).

The early work

The story of the origins of the McCance and Widdowson food tables goes back to beyond the time when they met. Thus, although there are three publications on which the first edition of the tables was based (McCance & Lawrence, 1929; McCance & Shipp, 1933; McCance *et al.* 1936), only one of these involved Dr Widdowson. Professor McCance had been involved in the first two publications under the aegis of the Medical Research Council. It was during the preparation of the second document that Dr Elsie Widdowson and Dr McCance met and the 60 years of scientific partnership began.

At the time of their meeting, Dr Widdowson had already obtained her PhD working on the carbohydrates in apples during development, and she had got the 'research bug' (to use her own words). However, she was finding it difficult to get a job, so she was persuaded to join the new postgraduate dietetics course at King's College of Household and Social Science in Professor Mottram's department. She had been told that dietetics was an up-and-coming career for girls. She knew little about cooking, so she was sent to King's College Hospital to learn about cooking on a large scale. That is where she met Dr McCance. He used to come into the kitchen to cook joints of meat for his study *The Chemistry of Flesh Foods and Their Losses on Cooking* (McCance & Shipp, 1933). As Dr Widdowson said: 'I was interested in what he was doing, but when he told me about his study on carbohydrates in foods I realized that his results for carbohydrates in fruit which he had already published were wrong, because by boiling them with acid he was destroying some of the fructose. I plucked up courage and told him. He wasn't annoyed, but he said he would get some money and I could repeat all the analyses and get the right answers.' That was the start of the famous McCance and Widdowson partnership and their publication was *The Nutritive Value of Fruits, Vegetables and Nuts* (McCance *et al.* 1936).

Diversity, tenacity and industry

Dr Elsie Widdowson's long career in nutrition has been characterized by the diversity of the subjects tackled and her ability to embark on new projects whilst still following up older lines of enquiry. Whilst working with Dr McCance on the composition of foods she began to plan a study of individual diets of men, women and children, which had never been done before. This turned out to be yet another mammoth task, this time involving

sixty-three men and sixty-three women (Widdowson, 1936; Widdowson & McCance, 1936), and 1000 children, this publication being held up until 1947 due to the outbreak of World War II (Widdowson, 1947).

As part of the course on dietetics she was required to go to work in the hospital kitchen in St Bartholomew's Hospital, London under the direction of Margery Abrahams. She quickly realized that the food tables which they were using for calculating prescribed diets were all based on American data going back to the analyses of Atwater at the turn of the century. The values were all on raw foods and the carbohydrate values were calculated 'by difference'.

Box Hill, Surrey was the scene of a family picnic for Dr Elsie Widdowson in 1934. Whilst relaxing from the toils of analysis, she realised that she and Dr McCance had the basis for a new set of food tables, based on their earlier publications and their new analyses. All that was necessary was analysis of dairy and cereal products and some miscellaneous items. She put the idea to Dr McCance on the following Monday morning and the work began.

True to form, whilst engrossed in food analyses, Dr Widdowson continued other lines of interest. Well used to hard work by now, her evenings were spent writing her first book, *Modern Dietary Treatment* with Margery Abrahams, first published in 1937 (Abrahams & Widdowson, 1937). The book went into a second edition and was a great help to dietitians in compiling prescribed diets. Even though this book was published before the first edition of the food tables, it contained some of the new analytical data, and included cooked as well as raw items.

The first three editions of the food tables

The first edition of McCance and Widdowson's *The Composition of Foods* was published in 1940 (McCance & Widdowson, 1940). However, during wartime, new foods appeared such as dried egg and whole milk powder, and so a second edition was necessary for calculating the nation's diet (McCance & Widdowson, 1946). Many of these values were for foods only available for the duration of the war, so they were subsequently removed in the third edition (McCance & Widdowson, 1960).

The first and second editions were all based on analytical data, but an innovation came into the third edition with the introduction of values for vitamins based on scrutinized literature sources. Dr Elsie Widdowson's involvement continued until the publication of the third edition, after which, Dr David Southgate, who had joined them during the preparation of the third edition, took up the leadership of the work.

In the 1930s, when the concept of the McCance and Widdowson food tables was conceived, there were food tables in other countries, notably in Germany and the USA. The American tables were derived from data of Atwater, whilst the German ones went back to Konig in the 19th century. Moreover, these tables were compiled by analysts using raw foods.

Table 2. *Unique features of the McCance and Widdowson concept of composition of food tables*

De novo analysis (the 'direct' method)
User orientated
Carbohydrate by analysis
Inclusion of cooked foods
Inclusion of composite foods (recipe dishes)

The unique features of the McCance and Widdowson concept of food tables can be seen in Table 2. The most important feature was that they were user orientated, the prime user being Dr Widdowson herself for her individual dietary surveys. They also provided better data for the analysis of prescribed diets (Dr McCance was concerned with diets for diabetics, for example). Other features included new analysis, the analysis of carbohydrates directly rather than 'by difference' as had been used in the American tables, the inclusion of cooked foods and composite dishes from recipes, some of which were taken from Dr Widdowson's mother's own recipe book. Some of these were dropped for the third edition, and new recipes were provided by members of the staff at King's College of Household and Social Science. It should be remembered that most foods eaten in the home were home-made in those days. The only shop-bought foods were cakes, jam and some cereals.

Inspiration, motivation and perspicacity

The spirit of those early days of the McCance and Widdowson partnership is revealed in this quote from Dr Widdowson (personal communication, 1996): 'For individual foods we took six samples and mixed them up by hand – we had no mixers. Separate analysis would have been impossible. Everyone in the laboratory contributed. We calculated our own results using slide rules and gathered together at the end of the day to compare them. This was part of the fun. We didn't put them into a machine and wait for weeks and months for them to emerge!'

The choice of the energy conversion factors was important in the development of the food tables and greatly occupied Dr Widdowson's mind. This quote from Dr Widdowson in a review entitled 'Assessment of the energy value of human foods' which she published in 1955 in the *Proceedings of the Nutrition Society* (Widdowson, 1955), not only indicates the complexity of the subject, but also shows the forthright and no-nonsense writing style which is such a joy to read and will continue to inspire nutritionists for many years into the future: 'The whole subject is very complicated and the attempts which people have made to assess the energy value of human food can only be described as a comedy of errors'.

Dr Widdowson was a great admirer of Atwater, as this quote from the same publication shows: 'I think I can safely say that Atwater has contributed more to our knowledge about the assessment of the energy value of human foods than anyone who has ever lived, either before or since his time.' Nevertheless, this was not admiration without criticism of the great man, as she goes on to say: '... Atwater & Bryant found very little variation among their three men as regards their ability to digest and absorb the nutrients in their diet. It looks as though they were very fortunate in this respect, for the usual findings in work of this nature on human beings are wide individual variations from one person to another. If Atwater had studied more individuals he would undoubtedly have discovered this,' and: 'Atwater & Bryant's mixed diets would hardly qualify as normal mixed diets by present-day standards in Britain. Apart from baked beans, not one of them contained any vegetables and none of them any wholewheat bread.'

FUTURE DIRECTIONS FOR COMPOSITION OF FOOD TABLES

Developments since the 1930s

It is important when contemplating the future of the UK food tables to reflect on developments which have occurred in related and dependent subjects since the 1930s.

For Dr Widdowson's early work in the 1930s, only slide rules were available for calculation. During World War II the first computer was made, the Colossus decoder. Main

Table 3. *Advances in epidemiology since the 1930s*

1930s	Individual food/energy intake
1950s	Framingham study
1970s	Correlation studies
1980s	Large-scale cohort studies using food-frequency questionnaires, intervention studies
1990s	Large-scale weighed dietary surveys, international studies

frame computers were introduced in the 1960s followed by development of computer language in the 1970s. The introduction of personal computers and vast database capacity in the 1980s extended the scope of food tables, as does the access to international databases in the 1990s. Computerization has improved speed of data calculation, handling and exchange.

The wet chemistry and gravimetric methods used by McCance and Widdowson have been greatly augmented since World War II with the introduction of TLC and GLC, automated equipment and HPLC. These advances have enabled analyses of vitamins without animal assay, and, together with advanced computer data handling, are set to enable ever more detailed food analyses in the future.

Advances in epidemiology have moved alongside developments in food tables (Table 3). Food tables are essential to assess nutrient intake, but, as epidemiology becomes more sophisticated with large-scale cohort studies replacing earlier correlation studies, details are not only required of major components of the diet, but of minor components and of foods eaten within individual countries. One only has to look at the diversity of eating habits across Europe to see the problems involved in cross-European studies. In many respects the Framingham study in the USA, which started in the 1950s, was a cohort study before its time. Decades later other prospective studies of a similar nature were set up.

The key issues in nutrition have evolved since the 1930s and this also has led to user demands for more information on the composition of foods (Table 4). These have moved from interest in energy balance, vitamins and minerals to protein and then, in the 1970s, to the link between nutrition and chronic disease, dietary fibre, fatty acids and obesity. In the 1990s interest is increasing in antioxidant nutrients and phytochemicals such as flavonoids.

In the 1930s there was no 'nutrition policy', although the tables were important for calculation of diet during food rationing in World War II. Dietary guidelines, which first appeared in the UK in the early 1980s led to a demand for more dietary surveys in the UK to monitor food intake and have led to requirements for fatty acid data. The focus of nutrition policy in the 1990s with the *Health of the Nation* policy document (Department of Health, 1992) and expert committee reports on dietary reference values (Department of Health, 1991) and cardiovascular disease (Department of Health, 1994) continues to emphasise the importance of increased fruit and vegetable intake. This has led to demand for food tables to carry more information on antioxidants, including antioxidant phytochemicals.

Table 4. *Key issues in nutritional science since the 1930s*

1930s	Deficiency disease, energy balance
1940s	Vitamins and minerals
1960s	Protein–energy malnutrition
1970s	Chronic disease, NSP
1980s	Fatty acids
1990s	Antioxidants, phytochemicals

Table 5. *Possible future micronutrient requirements for composition of foods databases*

Trace elements
Retinoids
Carotenoids: isomeric forms
Folates: isomeric forms and glutamate conjugates
Trans fatty acids
Vitamin E: isomeric forms of tocopherols
Phytochemicals (examples):
flavonoids, including isoflavonoids
lignans, procyanidins
steroidal substances
coumarins

Food industry practices are enormously different now from the 1930s, when few packaged foods were available. The introduction of frozen foods in the 1960s and development of the cold chain in the 1970s greatly stimulated product development. Furthermore, the introduction of ready meals, health foods and soft drinks in the 1980s has meant an immense escalation in the number of foods available, making further demands on food tables. Nutritional labelling, which was introduced in the 1980s, has extended the application of food tables. In the future, developments of functional foods (foods with specific physiological function, aimed at promoting health) and the introduction of health claims on foods may add further challenges for the compilers of modern food tables (Table 5). To quote Greenfield & Southgate (1992): 'The number of nutrients is reasonably finite, although this is not the case when non-nutrient components are included.' Nevertheless, the inclusion of non-nutrient components of foods in the tables is not new. A precedent was set in the second edition (McCance & Widdowson, 1946) with the inclusion of the phytate content of plant foods. These values were required for McCance and Widdowson's study of the absorption of Ca from wholewheat bread during World War II.

Health promoting and therapeutic effects of plant foods

Already carotenoid, flavonoid and cruciferous extracts of fruit and vegetables, which carry implicit messages of health protection, are being marketed in Europe. The use of plant foods as medicine is particularly interesting to me since qualifying in phytotherapy (herbal medicine) three years ago. Many plant foods like garlic, bilberry, celery, artichoke and asparagus contribute to the European materia medica. Their regular consumption on a daily basis offers health benefits in a wide range of disease conditions. The dividing line between foods and herbal medicines is blurred. Indeed, the active constituents of herbal medicines, such as flavonoids, are also present in foods. Clearly, the concept of using medicinal herbs as foods is traditional to the Chinese and people of the Far East, who have already developed a functional-foods market. If functional foods containing herbal medicines should become popular in Europe then many challenges are ahead for compilers of food tables.

International databases

The International Network of Food Data Systems (INFOODS) was initiated in 1984 as part of the United Nations University Food and Nutrition Programme (Scrimshaw, 1994). It has already set up networks for the compilation of regional data on several continents. Data compatibility and quality control are serious problems which will continue to have to be

faced in future. However, the introduction of these international databases will be important in future for between-country epidemiological studies as well as international trading.

CONCLUSIONS

The success of McCance and Widdowson's composition of food tables and their wide-range of application has brought further demands for data. Hence, as epidemiology has progressed and the consumption of manufactured foods has increased, there has been an expanding scientific interest in the links between diet and disease. This, in turn, has resulted in a progressive development of national and international nutrition policy. None of this could have been foreseen when the food tables were in their early stages of development and yet, without the pioneering work of Professor McCance and Dr Widdowson, much of our current understanding of the effects of diet on health would be lacking in substance.

Looking ahead, there are many difficulties facing the compilers of modern food composition databases. The conventions for international use and quality control of analysis must be observed; and an ever-increasing demand met for detailed food composition, including values for trace elements, for isomeric forms of fatty acids and vitamins, and for phytochemicals. These are exciting new areas, but they are fraught with difficulty and will present challenges for the years to come. However, problems with food composition databases are nothing new, as Dr Elsie Widdowson pointed out in 1955: 'My conclusion must be confession. We have all made mistakes, even Atwater. But we can console ourselves by thinking that "the man who makes no mistakes does not usually make anything". He certainly does not make food tables.'

Dr Elsie Widdowson's cottage at Barrington near Cambridge, which has been her home since the 1930s, has not only seen the growth of *McCance and Widdowson's The Composition of Foods*, but of many other studies which will be described by other speakers.

I would like to end, Elsie, by thanking you for helping me to prepare this talk. I would also like to thank you for the inspiration of your work in the field of human nutrition which has not only inspired my own approach to the subject, but also that of nutritionists past, present and future. I wish you a happy 90th birthday.

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