PII: S0308-8146(96)00054-4

Food Chemistry, Vol. 57, No. 1, pp. 5–6, 1996

0308-8146/96 $15.00+0.00

Introduction: the early history of food composition analysis — source of artifacts until now

Pekka E. Koivistoinen

Department of Applied Chemistry and Microbiology, P.O. Box 27 (Viikki, Food Chemistry, Bldg B), FIN 00014, University of Helsinki, Finland

Chemical analysis of macronutrients in foods has its roots in many significant contributions by the famous pioneers of chemistry in the last century. Encouraged by our own research we have become interested in the early chemical concepts and procedures applied to food. I have been surprised — and I assume that we all are — at some of the old achievements, which have had a significant impact on the concepts we still apply.

During the first decades of the last century, foundation was laid for organic analysis which was later extensively applied to natural products used as food and feed (see e.g. McCollum, 1959; Hansen & Wendt, 1965; Fennema & Tannenbaum, 1985; Savage, 1992). In this respect credit needs to be given to the French chemists J. L. Gay-Lussac and L. J. Thènard, who in 1811 published the quantitative analysis of carbon, hydrogen, and nitrogen, as well as credit to the Swedish chemist J. J. Berzelius, the Scottish chemist T. Thomsson, and the German chemistry J. von Liebig who found and verified the definite portions of elements also in organic compounds. An attempt for classification of foods based on chemical constituents was made by Liebig. He divided food into nitrogenous or plastic foods (like animal flesh, blood, and casein) and into non-nitrogenous foods (like fats, carbohydrates, and alcoholic drinks) which are responsible for tissue growth and heat production in man.

Progress in natural sciences soon resulted in systematic research on nutritional properties of natural products. Two German research groups at two agricultural experiment stations in Weende and Salzmünde, led by W. Henneberg and H. Grouven, conducted comprehensive feeding experiments on domestic animals (Henneberg, 1865). To our knowledge, in the 1850s Henneberg's group devised a composition analysis of natural products applied to feed and animal excreta. Their scheme became a common procedure for food, and its principles and some details are still applied. Moisture was determined by heat-drying, fat was extracted with ether, nitrogen content was converted by a factor of 6·25 into protein content, crude fibre was measured as insoluble fraction in dilute acid and alkali from which residual ash and fat was subtracted, and nitrogen-free extract or the utilizable carbohydrates was obtained by calculating the difference: dry substance – the sum of (ash + protein + fat + fibre). The conversion factor, 6·25, was based on the nitrogen content (16%) of only some isolated animal proteins with the assumptions that all proteins contain same percentage of nitrogen and all the nitrogen in a natural product derives from proteins — both assumptions being false as we now know. Henneberg is recognised as the father of the chemical composition analysis of feed and food.

Extensive application of the concepts of chemical analysis of food to human nutrition was done by German physician, physiologist, and the pioneer in research of energy metabolism in man, Max Rubner (1885*a*,*b*, 1901). He suggested the gross energy values for carbohydrates (4·1 kcal/g), fat (9·3 kcal/g), and proteins (4·1 kcal/g). His nitrogen to protein conversion factor was first 6·45, but later revised to 6·25. He measured the energy requirements and evaluated the impact of various factors on that. Rubner's procedures to evaluate diets and human nutrition, especially energy requirements, as well as the quality of foods (in terms of the three chemical concepts, carbohydrates by difference, fat by extraction, and protein by conversion via nitrogen) was a scientific success at that time and this system prevailed in Europe for many decades.

Rubner also might have influenced development in the USA, since the American pioneer in food composition analysis and in its application in human nutrition, W. O. Atwater, worked with Rubner in Berlin. Atwater and his team (1899, 1901) at the Storrs Agricultural Experiment Station in Connecticut made enormous contributions in several fields of research: food composition, diet compositions, energy values of foods by calorimeter, digestibility and availability of the macronutrients from foods, and factors for calculating available energy of carbohydrates in man (4·0 kcal/g), fat (9·0 kcal/g), and protein (4·0 kcal/g). Atwater has an enormous impact on later development in the USA and elsewhere.

FAO organized in 1947 an expert meeting which outline the principles on which the food composition figures should be based and explored the means to attain comparability of data for international use. The meeting concentrated on energy values of foods and diets. After discussions on various alternative methods, the meeting recommended procedures established by Atwater.

The experts paid attention to many problems in food composition analysis which still exist and were discussed in Lahti. The meeting specified, for instance, the following problems: inadequacy of sampling, differences in analytical methods, differences in deriving protein values, expressing carbohydrate, and fat content and calculating energy values.

It is well understood that after all the scientific and technical development we have had in this century, and especially after the World War II in relation to food, nutrition, and analytical chemistry, the old traditional concepts and procedures, at one time considered so outstanding and complete, have become gradually less satisfactory, and fail to meet the current needs and circumstances. To be critical, one can insist that there are many aspects of the old concepts of fat, protein and carbohydrate which no longer fit with our current knowledge, but they are still used in practice.

I hope that this symposium will give some of the answers, which already have been called for by the 1947 FAO expert meeting and many other meetings and scientists, for improving the concepts and analytical procedures of food analysis.

REFERENCES

Atwater, W. O. (1901). On the digestibility and availability of food materials. *14th Ann. Rep. Storrs Agric. Exper. Stat.*, pp. 179–245.

Atwater, W. O. & Bryant, A. P. (1899). The availability and fuel value of food materials. *12th Ann. Rep. Storrs Agric. Exper. Stat.*, pp. 79–110.

FAO (1947). Energy-yielding components of food and computation of calorie values, 23 pp.

Fennema, O. R. & Tannenbaum, S. R. (1985). Introduction to food chemistry. In *Food Chemistry* 2nd ed. (ed. O. R. Fennema). Marcel Dekker, Inc., pp. 1–21.

Hansen, E. & Wendt, W. (1965). Geschichte der Lebensmittelwissenschaft. In *Handbuch der Lebensmittelchemie: die Bestandteile der Lebensmittel* (ed. J. Schormüller). Springer Verlag, pp. 1–75.

Henneberg, W. (1865). Die Salzmünder Fütterungsversuche. *J. Landwirtschaft*, **13**(1), 89–192.

McCollum, E. V. (1959). The history of nutrition. In *World Review of Nutrition and Dietetics* (ed. G. H. Bourne). Pitman Medical Publishing Co. Ltd, pp. 1–27.

Rubner, M. (1885*a*). Calorimetrische Untersuchungen, I. *Z. Biol.*, **21**, 250–335.

Rubner, M. (1885*b*). Calorimetrische Untersuchungen, II. *Z. Biol.*, **21**, 337–410.

Rubner, M. (1901). Energiewert der Kost der Menschen. *Z. Biol.*, **42**, 261–308.

Savage, G. (1992). Experiment chemists: the founders of nutrition. *Nutr. Today*, Sept/Oct., pp. 24–29.