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In memoriam of Nils-Georg Asp

1944–2012

We remember our valued colleague and friend, Nils-Georg Asp, professor emeritus in Applied Nutrition at Lund University and the former executive director of the *Swedish Nutrition Foundation*, with deep affection. Nils-Georg died on June 1, 2012, after a long brave fight against cancer. He is deeply missed by his wife Marianne, his four daughters and their families, as well as by many colleagues and researchers in the field of food science and nutrition.

Education

Nils-Georg Asp was born in Svedala in southern Sweden and began his medical studies at Lund University in 1963. During his PhD studies, he joined the group led by Arne Dahlqvist, in which lactase was characterized in detail and separated from other small intestinal β-galactosidases. By improving the enzymatic methods and introducing new biochemical techniques, he succeeded in characterizing and monitoring three different intestinal β-galactosidases in the human small intestine. Nils-Georg defended his PhD thesis in medical chemistry in 1971 (1). His enzymatic work was combined with experimental and clinical studies on human biopsies and contributed to better diagnostic tools of chronic diseases and food intolerances in the gastrointestinal tract, and this research has been important to many other researchers in the field. It also paved the way for the next step in Nils-Georg's career.

Research

As a qualified physician and Associate Professor in medical and physiological chemistry with specialist competence in clinical nutrition, Nils-Georg started to conduct his postdoc research at the Department of Applied Nutrition, Kemicentrum, Lund University, in 1972. The department belonged to both the faculties of Medicine and Engineering, implying teaching of nutrition for both future physicians and engineers, and was led by his former supervisor, Professor Arne Dahlqvist. Together they became pioneers in this new research area at Lund University. By now, nutrition was established as an academic discipline in Sweden and four professor chairs were created with different profiles: Global Nutrition (Uppsala), Clinical Nutrition (Gothenburg), Medical Nutrition (Stockholm), and Applied Nutrition, that is, Nutrition and Food Engineering (Lund).

At the beginning of the 1970s, protein-energy malnutrition was common in developing countries (third world). To prevent and reduce famine and undernourishment, the food industry in the more developed countries began to produce infant formulas and gruels based on powdered milk and/or grains or blends thereof. Milk and cereals are cheap and good sources of proteins and carbohydrates. As was already known at that time, reducing sugars and amino groups from proteins and amino acids could cause a reaction (the so-called Maillard reaction), and produce an array of Maillard reaction products (MRPs). These MRPs affect the food quality both positively (aroma, color, shelf-life) and negatively (protein quality, safety).

Nils-Georg and Arne Dahlqvist, both focused on protein and carbohydrate biochemistry, decided to turn their pioneer efforts in applied nutrition into reducing the protein-damaging effects of the Maillard reaction in processed foods. Since more than 70–75% of the global population is lactose intolerant it was important to develop efficient ways to manufacture lactose-free milk and milk powder. However, the hydrolysis of the milk sugar lactose into glucose and galactose doubled the amounts of reducing sugar on a molar basis as compared with traditional milk. Hence, the effects of the Maillard reaction on protein quality became more pronounced. Whereas the protein quality in freshly produced lactose-free UHT-milk was relatively unaffected, spray-drying of lactose-free milk reduced the biological value of protein substantially, especially during storage (2). Lactose-free milk produced with lactase is now commercially available in several countries.

The evaluation of protein quality required nitrogen balance trials on growing rats (rat bioassays). This method is resource demanding and reflects only the limiting essential amino acid. However, other essential amino acids are also affected during food processing. Serious attempts were therefore performed to develop an enzymatic *in vitro* method for hydrolysis of the food protein. Such a method

Citation: Food & Nutrition Research 2014, **58**: 24317 - http://dx.doi.org/10.3402/fnr.v58.24317

should better reflect the content of biologically available amino acids remaining, following processing and storage (3). In a specific PhD project, the role of MPRs on intestinal proteolytic enzymes was studied (4). It was shown that these products inhibited some of the proteolytic intestinal enzymes involved in the dietary protein digestion but not those enzymes involved in the hydrolysis of starch and sugars.

For cereals, the essential amino acid, lysine, with its extra amino group, was especially prone to be lost through the Maillard reaction. By the end of 1970s, a quite new, high temperature, short time process, extrusion cooking, was introduced in the food industry. The extrusion cooking produced dry foods, such as snacks, biscuits, and breakfast cereals, all usually based on cereals. The low water content in combination with high temperature and pressures are typical for this process and favorable conditions for the Maillard reaction. Nils-Georg and his graduating student, Inger Björck (5), were among the first researchers to evaluate the effects of extrusion cooking on protein quality, that is, biological value and digestibility. Alternative chemical methods for measuring true lysine availability was developed and compared with rat bioassays. A notable finding was the strongly enhancing effect that extrusion cooking had on the rate of starch digestion resulting in elevated blood glucose responses.

By focusing the research on proteins and carbohydrates and their interactions, for example, the Maillard reactions, the Department of Applied Nutrition became an attractive collaborative partner. For example, in a project together with Swedish Meat Research Institute, the digestibility of collagen was evaluated. It was shown that collagen was efficiently digested and contributed well to the protein quality of cured meat products (6). Another collaboration was with the Centre for Health Care Sciences at Dalby, outside Lund. The purpose of the Dalby project was to chemically quantify and characterize nutrients by analyzing duplicate portions collected from adults, elderly, and vegetarians in order to link dietary habits to health status. New and detailed data on daily intakes of protein and amino acids, starch, sugars, and dietary fiber, based on chemical analyses, were provided by the Department of Applied Nutrition (7–9).

The research on the Maillard reaction in foods also attracted collaboration with food scientists at national and international levels. This brought groups of food scientists from Lund, Gothenburg (SIK), and Uppsala (SLU) together. They organized the first international symposium on the Maillard reaction in food in Uddevalla, 1979 (10). Since then, international symposia on the Maillard reaction has been held every 4 years.

In 1980, Nils-Georg was appointed professor in food chemistry and formed a new department at Lund University. As a result, he decided to leave the research on Maillard reactions to Arne Dahlqvist and co-workers and move to the area of dietary fiber. The physiological aspects of dietary fiber emerged as an important scientific field during the 1970s. Nils-Georg took this field under his special responsibility and started several new PhD projects focusing on analytical as well as physiological aspects of dietary fiber. Dietary fiber was a relatively new research area and Nils-Georg was one of the first to publish within this area. His first study investigated the incidence of experimental colon cancer in rats by adding different types of fibers to the diet (11). An unexpected finding, which attracted much attention, was that pectin, a water soluble dietary fiber, increased the number of tumors compared with a fiber-free diet. The study was repeated, but again pectin gave more tumors in rats initiated with 1, 2-dimethylhydrazine (12). Others confirmed this finding later. In another study, it was found that the soluble and gel-forming fibers, guar gum and pectin, affected plasma cholesterol levels differently compared with a fiber-free diet, which was somewhat confusing (13). Today, we know that guar gum and pectin stimulates the growth of different types of colonic bacteria and also the bacterial metabolites formed, which may be an explanation. In subjects with type II diabetes, it was found that dietary fiber in intact foods elicited lower postprandial glucose than foods low in fiber (14).

Nils-Georg's great interest in dietary fiber began now, and perhaps he was known best internationally for his work on the analyses of dietary fiber. In the beginning, different methodologies for analyses of dietary fiber were tried with varying results. The limitations of the existing methods were that only insoluble dietary fibers were quantified, and since soluble fiber had important physiological effects it was important to include them in the analysis. Some enzymatic methodologies for assay of soluble and insoluble fiber also existed, but these employed long incubation times and/or laborious centrifugation procedures. Nils-Georg realized that the analytical problems had to be solved and, in consistency with the definition, soluble dietary fiber also has to be included. The efforts on the analytical side resulted in an international approved gravimetric AOAC-method for quantification of dietary fiber (15), which became the standard assay in use for labeling of dietary fiber content of foods. The method based on several enzymatic steps was able to separate the dietary fiber into soluble and insoluble fiber. These two fractions showed different physiological effects; the soluble dietary fibers were fermented by the microbiota in the colon and might have metabolic effects, while the insoluble fibers were more resistant to colonic degradation and therefore showed other interesting health effects, for example, a decreased risk for constipation and possibly colon cancer. The methodology was also shown to correlate with more detailed analyses of dietary fiber as the Uppsala-method based on gas chromatography (16). Several new PhD projects were now

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initiated and directed toward the physiological effects of dietary fiber in health and disease. Together with a PhD student, studies on fermentation of various groups of dietary fiber started. This research field is still in progress and under the leadership of Professor Margareta Nyman, now head of the unit.

The analytical and experimental tools were further developed and established and an important tool for future studies was the development of a rat model for analyzing the availability of dietary fiber for the colon microbiota (17). A finding of great interest was that the fermentation of various dietary fibers differed extensively, preferably due to the composition of the fiber polysaccharides (18). The model was shown to correlate with studies in humans (19) and therefore suitable for ranking of various fiber-rich foods and also for studying the effects of processing (20–24). The methodology is routinely used today for studies on the fermentability of various indigestible carbohydrates and has been further developed for studying the formation of short-chain fatty acids, fermentation products of significance for human health.

Nils-Georg's research continued to explore the physiological effects of dietary fiber such as mineral binding capacity (25) and the impact of dietary fiber on mineral bioavailability (26). Clinical studies included glucose and/or the cholesterol-lowering effects of dietary fiber of different foods (27–30). The role of processing and composition of vegetable dietary fiber for these clinical effects were studied (31). Nils-Georg's group became internationally recognized, with many invitations to conferences and successful funding from research councils and foundations.

The clinical studies on interactions between dietary fiber and glucose response in healthy subjects and diabetic patients indicated interesting roles for dietary starch (32). Depending on the composition and botanical origin of food starch, variations in blood glucose responses were found (33–37). The group decided to further explore the role of food starch in terms of glycemic index. This was a new emerging area in the international literature during the 80s thought to be a very useful tool in the dietary treatment of diabetics and/or obesity. Professor Inger Björck, former PhD student of Nils-Georg, who graduated in food chemistry (5), took over the leadership in this field. The group has been very successful since then and is still very active.

Interactions between academia and society

When Nils-Georg was appointed successor of Arne Dahlqvist's chair in 1987, the two departments were combined into Applied Nutrition and Food Chemistry under the head of Nils-Georg. Now, Nils-Georg's career became more directed toward the interactions between Academy and Society. In 1989, Nils-Georg was approached to take responsibility for and be Managing Director for the Swedish Nutrition Foundation (SNF), a task he was well suited for in view of his background as a medical doctor and his experience in food nutrition research. He started to work part-time (20%), but the engagement was expanded to 80% after some years. At SNF he had a key role in establishing the self-regulating program on Health claims (38) in the labeling and marketing of food products, and enabled the use of health claims in Sweden, as the first country in the world, until the European Community took over in 2007. The work resulted in a number of publications (inter alia 39, 40) and also gave the Swedish industry a leading position within this area. For this work, he was well known far beyond Sweden and he was highly engaged in several European projects related to this topic, for example FUFOSE (European Commission Concerted Action on Functional Food Science in Europe) (41) and PASSCLAIM (Process for the Assessment of Scientific Support for Claims on Foods) (42). His work was tinged by the belief that health claims could be a useful tool for the food industry as well as of importance for public health, helping consumers to make healthy choices, if used in a responsible manner. For example, he suggested that health claims used in the labeling and marketing of foods should not only be scientifically substantiated, but also relevant and meaningful for the consumer. This was an important principle applied within the Swedish self-regulating program (43).

One of Nils-Georg's most professional contributions at SNF, and one of which he was justly proud, was the issuing of SNF's journals *Näringsforskning*/*Scandinavian Journal of Nutrition*/*Scandinavian Journal of Food and Nutrition* (~72 issues since 1990) and which he was Editor in Chief of, from 2006. In 2008, he launched two new publications, the open-access scientific journal *Food and Nutrition Research* (published by Co-Action Publishing) and the magazine (in Swedish) *Nordisk Nutrition.*

Nils-Georg's activities at SNF also included the arrangement of national and international conferences (>40). Among other meetings he organized the Marabou Symposium, which became an annual event. Internationally leading scientists were invited speakers on timely topics and the Symposia Proceedings were published as supplements in Scandinavian Journal of Nutrition. Additionally, he organized symposia in collaboration between SNF, the Swedish National Committee of Nutrition and 'Läkarsällskapet' (Swedish Society of Medicine), at least once a year.

Nils-Georg had a number of national and international assignments. He also travelled a great deal and he had many collaborators and friends abroad. He was an appreciated speaker and therefore invited to lectures at many symposia. To mention some of his honorary assignments, he was a member of the Royal Physiographic Society, the Swedish National Committee of Nutrition and Food

Sciences within the Royal Swedish Academy of Sciences, and the Swedish National Food Administration's external scientific council. He was also an international expert to FAO/WHO for scientific updating on food carbohydrates and for the definition of prebiotics. He was a member of the working group for a strategic research agenda on food and health (ETP) and was also involved in several EU projects, such as EURESTA, EUROSTARCH, HEALTHGRAIN, and a member of various expert groups within ILSI.

Nils-Georg combined successful research in significant areas of nutrition with regular teaching and education during his whole carrier. He was a much-appreciated lecturer. His leadership in nutrition was highly ranked in Sweden as well as internationally. Here, we have only mentioned his main activities. He made a very substantial contribution to the development of the area of dietary fiber, and indeed to nutritional science. His bibliography is extensive, containing around 600 titles of original papers, books, and chapters, proceedings and popular work. He is on the ISI highly cited, that is, a list containing the most highly cited works within certain categories for the period 1981–1999, comprising less than 1% of all publishing researchers. Moreover, he supervised about 20 graduating students, some of whom continue to work with nutrition and food science at Lund University and others who are active in the food industry or physicians.

Privately, Nils-Georg had many interests in addition to his professional activities. He liked old classic cars and once did a trip with English sport cars to different castles. He was a warm person, with a great sense of humor. He was further very interested in music, a talented singer, and regularly went to classical concerts. Nils-Georg was supported by a big family, his wife Marianne, four daughters, Åsa, Kajsa, Elin, and Kristina, and grandchildren. His summerhouse for many years was located in the beautiful Österlen, not far from Ravlunda Church, where he now rests in peace after an outstanding life's work. With Nils-Georg's death, we lost one of the pioneers in the area of dietary fiber research. He was a mentor for many, and always saw possibilities instead of problems and he was a never-ending source of encouragement. We can all honor his memory by contributing to the skill of nutritional research. He will be lovingly remembered both as a scientist and a friend.

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Citation: Food & Nutrition Research 2014, **58**: 24317 - http://dx.doi.org/10.3402/fnr.v58.24317

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