

Foreword

This supplement contains papers based on presentations at the International Symposium on low-digestible carbohydrates held at the University of Salford, Greater Manchester, UK, 24–25 June 1999.

The symposium was organised with the view to consider the health benefits of foods containing polyols, fructo-oligosaccharides, resistant starch and other low-digestible carbohydrates (LDCs). It was also designed to consider the extent of alleged tolerance problems arising from the consumption of foods containing naturally occurring or added LDCs, especially polyols. The target participants were principally people involved with food legislation, product management, technical applications of LDCs, academic research scientists, marketers and developers of sugar-free confectionery and LDC food products. The programme was sponsored by major manufacturers of LDCs, namely, Roquette Freres of France, Palatinit GmbH of Germany, Purac biochem BV of Holland, Cerestar of Belgium, and Danisco Sweeteners of the UK. The symposium programme was organised by Professor David Storey, Adam Lee, and Professor Albert Zumbé, each of the Nutritional Biosciences Unit, Division of Biological Sciences, University of Salford. The organisers of the programme gratefully acknowledge the help and advice from members of the Symposium Scientific Committee (Table 1).

Aims of symposium

The symposium brought together experts in the field with the following aims.

- To review the occurrence of LDCs (including polyols) in foods.
- To discuss consumption patterns and public health implications.
- To summarise the current knowledge of the physiology

Table 1. Symposium on low-digestible carbohydrates scientific committee

David Storey, Nutritional Biosciences Unit, Division of Biological Sciences, The University of Salford, UK.
Albert Zumbé, Nutritional Biosciences Unit, Division of Biological Sciences, The University of Salford, UK.
Adam Lee, Nutritional Biosciences Unit, Division of Biological Sciences, The University of Salford, UK.
Albert Bär, Bioresco, Binningen, Switzerland.
Francis Bornét, Eridania Beghin-Say, Vilvoorde, Belgium.
Phillip Lawson, Cerestar, Trafford Park, Manchester, UK.
Saskia Brokx, Purac Biochem bv, Gorinchem, The Netherlands.
Mike Booth, Roquette, Tunbridge Wells, UK
Daniel Wills, Roquette Freres, Lestrem, France.
Tammy Pepper, Danisco Sweeteners, Redhill, Surrey, UK.
Anke Sentko, Palatinit, Mannheim, Germany.
Symposium secretary: Miss Beverley Jones, Division of Biological Sciences, The University of Salford, UK.

and biological effects of LDCs at realistic intakes, corresponding to amounts of LDCs found in the diet and currently added to foods.

- To discuss the case for using LDCs in food products.
- To review the factors influencing the selection and use of LDCs in confectionery manufacture and in other foods.
- To consider the regulatory aspects affecting the use of LDCs in foods, and food labelling requirements.
- To produce a consensus statement with recommendations for legislators and industry.

Tolerance of LDCs

Dr Geoff Livesey of Independent Nutrition Logic gave an overview on the topic of tolerance of LDCs. He is an expert on carbohydrate digestion and tolerance, and his presentation focused on tolerance threshold levels and how individuals actually express tolerance. He considered that for the majority of individuals a consumption of 20 g of disaccharide polyols at any one eating occasion is perfectly acceptable, although there will always be a few individuals who experience some symptoms of intolerance. People who experience discomfort may reduce intake or avoid that particular product in the future. He noted that polyol ingestion will depend on the portion size and frequency of consumption of a given type of food. To put this into perspective, the typical polyol content is about 45 % for sugar-free chocolate, up to 70 % for sugar-free chewing gum, up to 80 % for sugar-free coated chewing gum, and up to 98 % for sugar-free hard-boiled candy.

Sugar-free products containing polyols are completely safe under conditions of intended use, although there may be transient discomfort when consumed to excess. Symptoms may include diarrhoea (loose or watery stools), laxation (increased stool frequency and ease of passage), colic (discomfort or pain in the lower abdomen), flatulence and/or borborygmi (rumbling sounds). There are clearly differences in people's tolerance of the various polyols. For example, disaccharide polyols such as isomalt and maltitol are tolerated better than monosaccharide polyols such as sorbitol and mannitol, which exert a greater osmotic load in the intestine. However, it is difficult to make a general rule based on osmotic pressure alone as individual polyols are digested and metabolised differently. Lactitol is a case in point. It is a disaccharide polyol but its gastrointestinal tolerance is lower than either isomalt or maltitol.

Factors affecting tolerance and assessment of tolerance

Dr Marteau of the European Hospital Paris, France considers that LDCs are usually well tolerated but may have dose-related effects due to their inherent osmotic

potential and excessive fermentation in the gastrointestinal tract at high intakes, these being borborygmi, flatulence, bloating, abdominal cramps and diarrhoea. However, the expression of these symptoms depends on the dose, osmotic potential, degree of upper intestinal hydrolysis and/or absorption of LDCs, consumption pattern, consumption of LDCs with other foods/liquids and host factors. Many studies have demonstrated an intersubject variability in tolerance of LDCs, which is probably due to host or 'individual sensitivity factors'. Dr Marteau described these as differences in gastrointestinal transit time, motility patterns, absorption capacity, enzyme activity, visceral sensitivity and colonic flora. Dr Marteau discussed some of the methods to assess the metabolism and tolerance of LDCs, notably breath hydrogen analysis, intubation and perfusion of the intestine. Because of the subjective nature of intolerance symptoms, double-blind, placebo controlled studies are required to investigate the tolerance of LDCs, and even then experimental conditions may influence the result.

Health benefits of LDCs

Professor Scheppach of Wuerzburg University, Germany presented the beneficial aspects associated with the consumption of low digestible carbohydrates, namely reduction of risk factors associated with metabolic diseases, prebiotic effects, and possible health benefits with regard to constipation, diverticulosis and irritable bowel syndrome. LDCs are fermented in the large bowel to short-chain fatty acids (SCFA) and of considerable interest was Professor Scheppach's presentation on the role of SCFA, notably n-butyric acid, in the primary prevention of colorectal cancer and their evaluation as new therapeutics in acute colitis. Professor Scheppach believes that LDCs play a role in the maintenance of human digestive health, although the strength of evidence differs between diseases. The presentation indicated that future research should focus on the molecular mechanisms whereby nutrition including LDCs affects large bowel carcinogenesis.

Implications for sugar-free confectionery

Polyols (otherwise referred to as sugar alcohols) are quite closely related to digestible sugars. They are ingredients defined as saccharide derivatives in which the reducing carbonyl group in the sugar is replaced by an alcohol group, and include for example sorbitol, mannitol, maltitol, lactitol, isomalt, xylitol and erythritol. Polyols are key ingredients because they enable the development of sugar-free confectionery, which offer the benefits of non-cariogenicity, reduced energy intake, and low glycaemia. Sugar-free and no-added-sugar products have been developed in virtually every type of confectionery including chocolate, chewing gum, bubble gum, boiled sweets (hard boiled candy), toffee (caramel), fudge, gums and jellies, liquorice, marshmallow, tablets and lozenges. Product development is usually marketing led to create a niche that satisfies a perceived consumer need for healthier products notably for 'sugar-free', 'no-added-sugar', 'reduced-calorie' and/or 'safe-for-teeth' confectionery.

Although these product claims are very important, and central to the market positioning, the products must taste good, and be certainly as good as the traditional varieties containing sucrose. All these attributes are achievable; polyols have been used in confectionery for many years and confectionery specialists have through continual improvement of the recipes and processes been able to make products that are indeed very appealing.

Companies already in the sugar-free business, or contemplating entry, need to bear in mind the issues relevant to tolerance and how to minimise the risk thereof. *Professor Albert Zumbé* talked about matching reasonable portion size with consumption patterns. For example, boiled strong mints are consumed rather slowly because they are rather hard and difficult to break up prior to swallowing; also the mint flavour lingers for some time making it unnecessary to consume another in rapid succession. In comparison, fruit soft jellies can be rapidly cut and broken up in the mouth, and so can be swallowed more or less instantly. Furthermore, the fruit taste rapidly disappears and repetition is necessary to maintain a pleasant experience. It is not sensible, therefore, to offer sugar-free jellies in portion sizes over 35 g. It is no wonder that sugar-free confectionery has greatest success in product executions of very small portion size; for example, chewing gum and mini-mints. With these products the portion sizes are normally less than 20 g and the risk of intestinal discomfort is very much reduced if not non-existent. There is a need for marketers to get away from the 'tonnage' mentality to an 'added value' confectionery mentality. Indeed, Albert Zumbé indicated that the risk of tolerance is so insignificant for mini-confectionery and chewing gum that he believes labels warning of laxative effects to be unnecessary. For other confectionery categories he believes the warning label should definitely be maintained, even though the confectioner is advised to redesign the recipe and process to minimise the actual polyol content.

Non-polyol LDCs

There are many non-polyol LDCs that have innovative food applications and functional benefits, for example, inulin, oligosaccharides, resistant starch and polydextrose. These LDCs were described by *Dr Olive Murphy* of the Leatherhead Food Research Association, UK, in terms of their food applications and perceived functional benefits. Such benefits have led to considerable interest from the food industry and to the development of new 'healthy' products. The 'functional foods' market is valued at £6.7 billion in Europe for 1997. Many non-polyol LDCs can be formulated into foodstuffs to replace sucrose, but also fat, or in the case of inulin act as a total fat replacer. Such products can offer the consumer considerable functional benefits in terms of reduced energy intake, prebiotic effects, possibly reduced cariogenicity and physiological effects similar to dietary fibre. Furthermore, many products formulated with non-polyol LDCs, e.g. breads, confectionery and dairy-based products, offer good organoleptic qualities compared to classical products formulated with sucrose and fat. Because many non-polyol LDCs have a high molecular

weight and high degree of polymerisation their gastrointestinal tolerance is expected to be good compared to more osmotically active LDCs such as polyols. However, some, for example the fructo-oligosaccharides, have a sufficiently low molecular weight that tolerance is an issue, as shown in *Dr Philip Marteau's* presentation. Dr Murphy considers that the market for functional foods containing many non-polyol LDCs with prebiotic and dietary fibre-like effects will continue to expand in the future.

Regulatory affairs

Dr John Howlett, an expert in Regulatory Affairs, was formally the Scientific Secretary to the Scientific Committee on Food and is now an independent consultant. He demonstrated that, within the European Union, polyols are anomalously considered as food additives, whereas other LDCs are considered as ingredients. There is an inconsistency because foodstuffs classed as food additives are vigorously evaluated whereas ingredients enjoy a relaxed regulatory scrutiny. Furthermore, within the European Union, foodstuffs containing more than 10 % of added polyols should bear the warning label 'excessive consumption may produce a laxative effect'. In the USA, the label 'excess consumption may have a laxative effect' is mandatory on a case-by-case basis; for example, 50 g/day or more for sorbitol intake and 20 g/day or more for mannitol. For lactitol, maltitol and isomalt no statement is required. In Japan there are currently no regulations concerning laxative statements.

Workshops

The second day of the symposium was dedicated to workshop sessions of which there were three.

- Physiology and tolerance of low digestible carbohydrates, convened by Dr John Cummings of the University of Dundee.
- Consumption and consumer perceptions, convened by Don Stewart, formerly of SRU Ltd, a specialist market research company.
- Regulatory affairs, convened by Dr Sue Barlow, who is a current member of the Scientific Committee on

Food, and the Chairwoman of the Additives Working Group.

Summary

Polyols and non-polyol LDCs are considered safe to consume, although in the case of monosaccharide polyols with moderation. In the event of gastrointestinal discomfort and/or excess laxation, reducing or stopping one's intake can mitigate symptoms. Occasional gastrointestinal disturbance is a fact of life for most people and may potentially arise because of consumption of naturally occurring LDCs in the diet. The potential risk of gastrointestinal symptoms that arise from excess consumption of LDCs added to the diet must be balanced against their beneficial health effects, notably reduced cariogenicity, reduced energy value, prebiotic effects, low glycaemia, and the possible benefit in the long term of a lower risk of cancer of the colon. It should be considered that many Western, nutritionally linked, diseases such as dental caries, obesity, diabetes, and colorectal cancer are difficult to treat, let alone reverse and LDCs (both naturally occurring in the diet and as added ingredients in foods) may have a significant role to play in their prevention. A prime example has been the development of consumer products made with polyols to enable the consumer to have access to alternative healthier confectionery; essentially sweets that can be consumed for pleasure without the worry of either dental caries or excess energy intake. Those individuals who find themselves sensitive to the effects of polyol ingestion (or other non-polyol LDCs) can limit, or stop their intake with no further effects. Furthermore, manufacturers of polyol-based confectionery have restricted the portion size compared to classical sucrose-based confectionery and new sugar substitutes with good gastrointestinal tolerance are being developed. The symposium highlighted a concern over the current regulatory status of polyols in the EU and how this limits the future development of beneficial, functional foods for the consumer.

David Storey, Adam Lee
University of Salford