Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of Home Affairs FDHA
Federal Office of Public Health FOPH
Consumer Protection Directorate

Date: Bern, september 2009

Nutrition on Carbohydrate Intake: Summaries of the chapters

1. Chemical and physiological aspects of food carbohydrates

Carbohydrates are the most widespread organic compounds in nature and play an outstanding role in human nutrition, representing the quantitatively most important energy source. Starch, the plant reserve polysaccharide, as well as glucose, fructose and sucrose, the mono- and disaccharides predominantly present in fruit, are of particular importance. Carbohydrates are used in large amounts in food processing as well, where they serve as sweeteners or as versatile texture enhancers. Furthermore, carbohydrates can contribute to colour or flavour development in food based on their chemical reactivity.

The chemical classification of carbohydrates is based on the number of monomers. Polysaccharides form linear or branched structures, what strongly influences their physico-chemical characteristics and in particular their hydration properties. This is not only important for the effects of carbohydrates in food but also for their behaviour in the human body.

The physiological classification of carbohydrates differs from the chemical one and is based on digestibility as well as fermentability. Digestible carbohydrates yield energy at different rates depending on their degradability by the human digestive enzymes. As bioactive substances, the indigestible dietary fibre contributes to health and well-being. The importance of this group of carbohydrates has for a long time been under-estimated. However, the dietary fibre exhibits multiple positive effects both in the gastro-intestinal tract and in the metabolism. An increased daily consumption can definitively be recommended.

2. Consumption of carbohydrates and dietary fibre in Switzerland

Carbohydrates and dietary fibre are among the indispensable nutrients of human nutrition. The last four issues of the Swiss Report on Nutrition indicated the Swiss population's daily consumption of carbohydrates and dietary fibre as ranging between 350 and 380 gm/per head for carbohydrates (corresponding to 46 - 51 % energy) and between 22 and 26 gm/per head for dietary fibre. Cereals and sugars are the most important sources of carbohydrates, whilst the most important sources of dietary fibre are cereals, fruit and vegetables. In addition, surveys on nutrition have been

conducted among selected groups in Switzerland over the past 25 years, which have indicated a very broad range in daily consumption levels of carbohydrates and dietary fibre. Based on recommendations, the daily intake of dietary fibre should be increased, whilst that of sugars should be reduced.

3. Carbohydrates for growth and development in the child, and carbohydrate-related diseases

Glucose is the most important energy source for the human body. Its role in early intrauterine growth of the embryo and foetus and later in the development of the young child is of fundamental importance.

The occurrence of intrauterine growth restriction or intrauterine nutritional excess have far reaching consequences for future health in childhood and adulthood and carbohydrate metabolism plays a pivotal role during this vulnerable period.

The immediate post-partal period is characterised by a changeover to enteral feeding and nutritional uptake. In healthy term newborns this change is, in terms of carbohydrate metabolism, established by the fourth day of life.

Carbohydrate and particularly lactose play a central role in early infant nutrition and with the introduction of solid foods, higher molecular carbohydrates will be of increasing importance.

Carbohydrates play a subordinate role in the genesis of pediatric overweight, with the exception of an excessive intake of soft drinks and fruit juices, which not only are associated with an increase of BMI, but also does fructose contained in these drinks unfavourably influence lipid metabolism. Overweight-related insulin resistance is the most frequent disturbance of carbohydrate metabolism during childhood and entails fatty liver disease and cardiovascular damages already at young age. As for the therapy of overweight, very low carbohydrate diets are scientifically not sufficiently proven in children and adolescents, but only the efficacy of a multidisciplinary treatment has been attested, including, amongst others, an increase of physical activity and intake of carbohydrates with low glycaemic index.

Disease in infancy related to carbohydrate intake generally presents as a digestive or malabsorptive disturbance with potentially severe metabolic disturbances which can, on occasion be lethal.

Many of these conditions are associated with an autosomally recessive inheritance. Lactose intolerance is one such commonly diagnosed defect of carbohydrate absorption. However the spectrum of disorders of carbohydrate metabolism extends to other seemingly unrelated conditions. Attention deficit hyperactivity syndrome (ADHS) is one such example where the causative role of nutrition including carbohydrate intake has been postulated.

4. Carbohydrates and dental caries

Nutrition during the time of tooth formation has no clinically relevant systemic effect on the caries susceptibility of human teeth after their eruption. Caries is consequently not a nutritional disease. Erupted teeth are, however, subject to local, topical effects of foodstuffs contacting the surfaces of the teeth before the food is swallowed. Carious lesions are the result of a chronic undermining demineralisation of dental hard tissue. This demineralisation is caused by organic acids produced by the microorganisms of dental plaque while fermenting carbohydrates from the human diet. Caries consequently is a diet-related disease. The aim of this paper is to explain and illustrate the physico-chemical processes involved in the demineralisation and remineralisation of dental hard tissue using schematic diagrams. The dietary recommendations of the Food Guide Pyramid of the Swiss Society for Nutrition (SGE) comply with the aims of caries prevention.

5. Sweeteners - current use and potential impact on health

Sweetness is provided in our nutrition by natural (e.g. sugar) as well as by artificial sweeteners and by sugar alcohols (also called polyols). Latter two groups differ from sugars in their sweetness (artificial sweeteners are sweeter whereas polyols are less sweet than sugar) and their energy density (they contain no or less calories than sugar). Artificial sweeteners and sugar alcohols are food additives. In Switzerland food additives have to be approved by the Federal Office of Public Health (FOPH). The FOPH checks thoroughly the safety of any food additive before authorization by reviewing the available evidence as well as by consulting the reports of the Joint WHO/FAO Expert Committee on Food Additives (JECFA) and of the European Food Safety Authority (EFSA). Consumers can calculate their safe daily dose for any food additive by using the ADI (Acceptable Daily Intake).

Based on the available evidence the use of artificial sweeteners and of sugar alcohols is safe for healthy individuals, when consumed within the ADI. Artificial sweeteners and sugar alcohols can be used by diabetic individuals as they show no or only little influence on blood glucose levels and as they don’t influence insulin response. They can prevent or reduce overweight, if combined to lifestyle changes and if used as part of a balanced diet.

6. The importance of carbohydrates in sports

Dietary carbohydrates are the main source of energy for athletes, and there is general agreement that a daily amount of 5 - 12 gm (or more, depending on the intensity) per kilogram is necessary for optimal performance. The carbohydrate intake should not only be quantitatively sufficient during 24 hours, it is also of central importance during an athletic performance when it lasts longer than two hours. An improvement of performance by an intake of carbohydrates during exercise of short duration is likely, but the data in this situation are not 100 % sure.

The reason why a high carbohydrate intake in athletes, in contrast to physically inactive subjects does not adversely affect health, it is not clear. It is likely that carbohydrates are not per se (like other nutrients per se) “unhealthy” but develop only in combination with physical inactivity their “unhealthy” potential.

7. Impact of glycemic index on health

Epidemiological studies have shown associations between nutrition with high GI or GL and increased risk for diabetes, conorary artery disease and overweight. In addition, it has been demonstrated in interventional studies that nutrition rich in fibres with low GI can positively influence the metabolic control of diabetes. Up to date there are however no big randomized intervention studies proving that due to the modification of GI or GL diabetes, overweight or coronary artery disease can be prevented. It is of interest that recently it has been shown that sugars such as fructose which have a low GI may contribute to the weight gain and insulin resistance. These effects may be mediated by increased “De Novo Lipogenesis”.

A balanced diet consisting of daily consumption of fruits, vegetables and fibre rich products together with physical activity probably is more suited to improve common health as compared with specific recommendation based in specific composition of carbohydrates.

8. Psychological impact of carbohydrates on mood, memory, appetite and satiety

Out from animal research it is postulated that carbohydrate craving exists as a form of substance addiction. As a hypothesis, sweet nutrients might act similarly in humans. Case reports and clinical experience make it likely that such phenomena might exist also in humans. Controlled studies in humans, however, reveal that a single form of carbohydrate craving does not exist in humans and therefore a scientific rationale for an isolated carbohydrate craving seems not to exist in humans. Moreover, various forms of dependence can apparently be observed. Whether such dependences are classified as "non-substance addiction" (as various authors propose) or are taken as one form of eating behaviour biologically ascertaining the existence of the human race, is rather academical. Rather a coexistence of excessive fat and carbohydrate craving can be observed in humans. In addition, form and intensity of such a drive towards sweet and fatty nutrients vary over the life-span which again makes it difficult to classify the behaviour as a distinct form of craving.

Concerning the importance of carbohydrates as therapeutic agents in improving concentration, alleviating deficits in attention or positively influencing memory functions, the scientific evidence is even weaker. Whereas an adequate blood glucose level is clearly essential in the function of the human brain, with the exception of patients suffering from diabetes, attentional hyperactivity disorder, or dementia, no studies have revealed any additional benefit in healthy individuals of elevating temporarily blood glucose levels. Thereby, neither memory function, attention, nor

concentration or recall functions are influenced positively in the short as well as in the long run. In patients suffering from dementia, a glucose-induced elevation for central 5-HT levels has been found to improve memory function only temporarily. In parallel, patients with attentional hyperactivity disorder experienced a short term calming effect probably due to deactivations in the autonomic nervous system indirectly induced by glucose. Nevertheless, data on substantial and sustainable effects of isolated carbohydrate application on brain functions in humans do actually not exist.

9. Recommendations for carbohydrate intake in general, and in the prevention and treatment of obesity and type 2 diabetes

Traditional dietary recommendations for a “healthy nutrition” published by professional organisations (e.g. WHO, DRI from USA, DACH) indicate a relatively high carbohydrate content of 50 - 75 % of calories consumed per day. This resulted from the recommendation to limit fat intake to about 30 % of daily energy, with the aim of improving serum lipids such as cholesterol, and thereby reducing cardiovascular complications. Daily protein intake was recommended at 10 - 15 % energy shares. A higher amount of carbohydrates in the diet has a tendency to enhance weight gain, insulin resistance and dyslipidemia (high serum triglycerides, low HDL cholesterol), this diet also leads to increased inflammatory proteins in the serum and a small increase in blood pressure. These changes are particularly observed when foods containing carbohydrates with a relatively high glycemic index (high GI) are selected. Recent intervention studies in overweight subjects with low carbohydrate diets (20 - 35 % of energy) showed slightly lower body weights and serum lipids than diets with a higher carbohydrate content. This explains the recent proliferation of Low-carb diets which are relatively fat and protein-rich, particularly in the United States. The duration of previous studies with these diets, however, was never more than 2 yrs. Moreover, fat and protein-rich diets increase LDL cholesterol which is unfavourable for the formation of atherosclerotic disease. It may also reduce endurance exercise capacity, deteriorate kidney damage in incipient nephropathy and lower bone density decrease. In addition, they are relatively expensive.

There is no clear scientific basis for the recommendation of a discrete proportion of carbohydrates in a “healthy” diet, an optimal proportion is estimated to be between 45 - 55 % of total energy intakes. More important than the total amount of carbohydrates is the type of carbohydrates consumed (including their glycaemic index, fructose, and dietary fibre) and other simultaneously consumed food ingredients. In diabetes, the amount of carbohydrates in a meal is the most important determinant for the postprandial increase in blood glucose.

10. Fructose and health

For persons with normal weight, the scientific body of evidence allows the following conclusions: As a replacement for glucose, small amounts of fructose (approximately 0.2 grams per kilogram bodyweight per day) have potentially positive properties for body health. In moderate amounts, (up to about 0.5 grams per kilogram bodyweight per day) fructose does not appear to exert harmful effects, as long as it does not lead to an excess of energy intake. Larger amounts of fructose (more than about 1 gram per kilogram bodyweight per day) may increase the risk for overweight as well as for metabolic and cardiovascular disease. According to official sources, the consumption of added sugars should not exceed 10 % of the daily energy expenditure.

In recent years there has been an increasingly industrial production of corn starch-derived syrups with (free) of fructose and glucose (so-called High Fructose Corn Syrup [HFCS]); especially in the USA. Usually HFCS55, ie 55 % fructose and 45 % glucose is used, especially in sweetened beverages. The metabolic effects of free and bound fructose are probably equal, ie HFCS55 and sucrose show identical metabolical effects. Addition of fructose alone without glucose is not disseminated, as large quantities of fructose without glucose often cause gastrointestinal discomfort.

The question of the health risks of fructose yields contradictory answers possibly, fructose exerts more harmful effects in high risk populations compared to healthy, physically active persons without genetic predispositions. Populations at risk may include persons with excess body weight, with physical inactivity, with pre-existing diseases or with genetic predisposition for diabetes or other metabolic disorders. Results from animal studies should be interpreted cautiously. It is also not clear whether natural sources of fructose differ from pure sucrose or fructose with respect to their effect on the human organism. It is however certain that fructose consumption can easily lead to a positive energy balance. In light of increasing prevalence rates of obesity it makes thus sense to control and possibly reduce the consumption of fructose in the Swiss population. A replacement of fructose by other caloric sugars does however not appear recommendable based on the actual scientific evidence.

Further information:
Federal Office of Public Health, Consumer Protection Directorate, Food Safety Division, phone +41 31 322 95 86, Lebensmittelsicherheit@bag.admin.ch
Nutrition on Carbohydrate Intake: Summaries of the chapters
This factsheet is also available in French and German.
Bern, september 2009