The International Life Sciences Institute (ILSI) is a non-profit worldwide foundation based in Washington, DC, USA, established in 1978 to advance the understanding of scientific issues relating to nutrition, food safety, toxicology, risk assessment and the environment. ILSI accomplishes its work through its branches, the ILSI Research Foundation (comprising the ILSI Human Nutrition Institute and the ILSI Risk Science Institute), and the ILSI Center for Health Promotion.

Established in 1993, ILSI Southeast Asia Region is located in Singapore and serves as the regional office for the coordination of scientific programs, research and information dissemination in ASEAN, Australia, New Zealand and the Pacific Islands. By bringing together scientists from academia, government, industry and the public sector, ILSI seeks a balanced approach to solving problems of common concern for the well-being of the general public. ILSI receives financial support from industry, government and foundations. To learn more about ILSI, visit our website at www.ilsi.org.

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ROLE OF CARBOHYDRATES IN HEALTH & DISEASE:
EVALUATING SCIENTIFIC EVIDENCE FOR DIETARY GUIDANCE

Editor
Rodolfo F. Florentino

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Carbohydrates provide between 40% to 70% of the total energy intake of different populations in the world, thus constituting the most important energy source in human diets. Over the past 25 years, much progress has been made in our knowledge of carbohydrates ranging from its chemistry and impact on physiology, its role in health maintenance and in the treatment of diseases. Recent scientific debates have centered on the amount and types of carbohydrate intake and their relation to health conditions such as obesity and hyperlipidemia. Popular diet trends and widespread media coverage have impacted on the public’s perception of carbohydrates and caused a rapid change in consumption patterns. As total carbohydrate intake from foods, including staple foods, increases or decreases, the intake of nutrients associated with the carbohydrate food sources also increases or decreases. In particular, foods that are naturally rich in glycemic carbohydrates such as cereals, pulses, seeds, fruit and vegetables, provide a wider range of important micronutrients, dietary fiber and phytochemicals, widely recognized to have beneficial effect on health.

In light of the current interest, nutrition scientists, academics, health care providers and regulators need to understand and evaluate the scientific information and latest research in order to assess dietary implications and formulate dietary guidance. The aims of dietary guidance to promote health and prevent diseases should also be culturally appropriate and economically viable.

The Regional Symposium on the Role of Carbohydrates in Human Health and Disease – Evaluating Scientific Evidence for Dietary Guidance was held from July 26 – 27, 2005 in Kuala Lumpur, Malaysia. The Symposium provided an overview of the current status of carbohydrates science and consumption trends; evaluated the role of carbohydrates in human health and disease; stimulated discussion on science-based dietary guidance with regard to carbohydrates for individuals and population groups; and identified knowledge gaps for further research.

The Symposium successfully brought together international, regional and local scientists and experts working in the area of carbohydrates and health, and was attended by more than 150 scientists, nutritionists, dietitians, medical and health professionals from academia, research institutions, the food industry as well as government and agricultural agencies.

Many have contributed to the success of the Symposium and this Monograph, and we would like to express our special thanks to Dr. David Lineback from JIFSAN, University of Maryland, USA and Dr. Peter Clifton from CSIRO Health Sciences and Nutrition, Australia for their strong support and collaboration. We would also like to express our appreciation to all the Speakers who shared their research, information and expertise at the Symposium, and who have kindly contributed their papers to this Monograph. Our gratitude is also due to the Editor of this Monograph, Dr. Rodolfo R. Florentino, who has done an excellent job in putting this publication together.

By providing an up-date on the current science, we hope that this Monograph will be a useful and informative guide to the regional and international scientific community, regulators and health professionals in the setting of food-based dietary guidelines for carbohydrates.

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Executive Director, ILSI Southeast Asia Region
April 2006
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Carbohydrate Definitions: Are They Important?

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Introduction
Carbohydrates have traditionally been defined according to their chemical structures. Occasionally, this has been modified by the inclusion of some selected properties, such as water solubility (e.g., soluble and insoluble pentosans), or physiological response (e.g., digestible and nondigestible). The challenge then becomes: How does one analytically determine (measure) these substances? Since carbohydrates are quite complex, ranging from monosaccharides to polysaccharides, the analytical methodologies available when many of the definitions were first developed made it virtually impossible to undertake such analytical measurements, and these methodologies continue to pose significant challenges today. Consequently, it is much easier to determine total carbohydrates by subtracting other nutrients or components, i.e., 100\% - (%protein + %fat + %ash + %moisture) = %carbohydrates. However, this method of deriving the value of total carbohydrates is not particularly useful, nor is it accurate. It has been recommended that total carbohydrate content in the diet should be obtained by analytical measurement of the individual carbohydrates.1

Thus begins a debate that is ongoing and has significant impact on furthering our understanding of the role of carbohydrates in health and disease. Are definitions of carbohydrates determined by the analytical methodologies available for their measurement or are the analytical methodologies developed from the definitions of the carbohydrates to be measured? This is further complicated by the desire to more clearly define and understand the roles of simple and complex polymeric carbohydrates in attaining and maintaining good health as well as in mitigating or reducing disease(s) in which they may be involved.

Discussions on this subject seek to clarify how carbohydrates should be classified and defined—according to chemical structure, physiological/nutritional/health impact, or combinations of both. This becomes increasingly important in relation to dietary recommendations directed at: (1) attaining or maintaining good health, coupled with an appropriate amount of exercise; (2) mitigating, reducing, or alleviating health conditions such as obesity, hypertension, hyperlipidemia, hypercholesterolemia, diabetes, oral health, cardiovascular and gastrointestinal health; or (3) improving human performance.

Traditional Definitions
Carbohydrates are traditionally classified on the basis of their degree of polymerization (DP). This results in three major classifications: sugars (DP 1–2), oligosaccharides (DP 3–9) and polysaccharides (DP ≥10). As one would expect, complicating exceptions and further subdivisions have been and are being created, as our understanding of structure, physical function, properties, and physiological
function of carbohydrates increases. Sugar, an important component of diets in many parts of the world, has come to be the common name for sucrose (a disaccharide). The term "sugars" refers to mono- (glucose, galactose, fructose) and di- (sucrose, lactose, trehalose) saccharides. Polysaccharides (sugar alcohols such as sorbitol, mannitol, xylitol) are a sub-group of the sugars classification. Oligosaccharides are commonly divided into two subgroups: malto-oligosaccharides (derived from starch) and other oligosaccharides (raffinose, stachyose, fructo-oligosaccharides). Polyols are often divided into starch and non-starch polysaccharides (NSP), although other subgroup-classifications (such as cellulose, hemicelluloses, pectins, pentosans, hydrocolloids) exist. Starch is primarily an $\alpha_{1,4}$-glucan composed of two polymeric components: amylose (essentially a linear polymer of $\alpha_{1,4}$-linked glucose units with a limited amount of $\alpha_{1,6}$-branching) and high molecular weight, highly branched amyllopectin with $\alpha_{1,4}$ and $\alpha_{1,6}$ bonds. The precise delineation between amylose and amyllopectin is less clear.

**Nutritional Classification**

The challenge/problem is in relating these chemical divisions/classifications of carbohydrates to those that reflect physiological and nutritional responses and health. Each of the classes (sugars, oligosaccharides, polysaccharides) can have several physiological effects, resulting in difficulties in translation to nutritional terms. If the classification is based on physiological properties, a single property, such as reduction in blood glucose response, may be used as the major factor/basis for the classification. A number of terms have arisen from such methods: refined sugar, added sugar, extrinsic and intrinsic sugars, complex carbohydrates, available and non-available carbohydrate, resistant starch, modified starch, dietary fiber, soluble and insoluble fiber. Nonetheless, these terms have generated considerable analytical challenges and problems. Recommendations against the use of some of these classifications have also been made.

Four criteria have been suggested for classifying carbohydrates into nutritional categories. The categories should:

- reflect the physiological and metabolic properties of the carbohydrates;
- be consistent with the known chemistry of the components;
- be measurable by sound and reproducible analytical procedures; and
- predict the nutritional consequences of consuming the mixture of carbohydrates in the human diet.

It can be seen that these criteria present an extremely difficult challenge in bridging physiology/metabolism/nutrition and chemistry/structure.

**Dietary Fiber**

Dietary fiber can be used as an example of the definition debates involving chemistry and physiology (health impact). This discussion has occurred over a period of more than three decades and continues. Current issues involving food labeling as related to health continue to play an important role, particularly so far as appropriate analytical methodology is involved. For food labels to be useful and enforceable, the elements of a definition must be measurable.
The working definition of dietary fiber, utilized for many years, can be considered to have originated from the work and definition of Trowell and colleagues (1972-1976). This definition and the methods of determination have been validated by international surveys by Prosky and Lee (1979-1980). The definition (1981) is as follows:

"Dietary fiber consists of the remnants of edible plant cells, polysaccharides, lignin and associated substances resistant to (hydrolysis) digestion by the alimentary enzymes of humans."

This definition encompasses cellulose, hemicellulose, lignin, gums, modified cellulosics, mucilages, oligosaccharides, and pectins and associated minor substances such as waxes cutin and suberin.

In 1985, Canada developed a formal definition of dietary fiber with an additional definition for novel fiber sources, which are foods that are manufactured to be a source of dietary fiber. This definition of dietary fiber is very similar to that derived from the work of Trowell, i.e., the endogenous components of plant material in the diet which are resistant to digestion by enzymes produced by humans. They are predominantly non-starch polysaccharides and lignin that vary with the origin of the fiber, and include soluble and insoluble substances. Two additional terms were introduced – non-native fibers and novel fibers.

Non-native fibers are from traditional foods but do not occur naturally in the foods to which they have been added. A “novel fiber” or “novel fiber source” means a food that is manufactured to be a source of dietary fiber and (1) that has not traditionally been used for human consumption to any significant extent; or (2) that has been chemically processed (e.g., oxidized), or physically processed (e.g., very finely ground), so as to modify the properties of the fiber contained therein; or (3) that has been highly concentrated from its plant source.

Specific physiological effects were designated as being required of a substance designated as dietary fiber, i.e., regularizing colonic function (laxation), normalizing serum lipids, and attenuating the post-prandial rise in blood glucose. An additional physiological effect was originally proposed - suppression of appetite. This was not included subsequently, but could be included along with others in the future, if studies yielding reliable, reproducible results validate it as an acceptable criterion. A novel fiber that meets the functional criteria, is analyzed as dietary fiber, and has been established as being safe, is listed as a dietary fiber with no distinction from other dietary fibers.

The FAO/WHO Expert Consultancy on the Role of Carbohydrates in the Diet (1997) indicated that dietary fiber is a nutritional concept, not an exact description of a component of the diet. Recommendations concerning dietary fiber included (1) the use of the term dietary fiber should always be qualified by a statement itemizing those carbohydrates and other substances intended for inclusion, and (2) the use of the terms “soluble” and “insoluble” dietary fiber should be gradually phased out. Although these terms are presently used, they are not considered useful classifications either analytically or physiologically.

The USA does not have a formal, approved definition for dietary fiber. AACC International (formerly, the American Association of Cereal Chemists) developed an updated definition (2000) for dietary fiber that introduced the term “analogous carbohydrates” into the definition and also, included physiological responses. The definition is as follows:
Dietary fiber is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Dietary fiber includes polysaccharides, oligosaccharides, lignin, and associated plant substances. Dietary fibers promote beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation.

As part of the process of developing new dietary reference intakes, the Institute of Medicine, U.S. National Academies of Science (IOM), appointed a panel to propose definition(s) for dietary fiber and provide the rationale for them. The proposed definitions reflected the desire to move from an analytically-based definition to one that recognizes physiological effects of fiber. The definitions are as follow:

- **Dietary Fiber** consists of non-digestible carbohydrates and lignin that are intrinsic and intact in plants.
- **Functional Fiber** consists of isolated, non-digestible carbohydrates which have beneficial physiological effects in humans.
- **Total Fiber** is the sum of Dietary Fiber and Functional Fiber.

The definition originally proposed the use of the term "Added Fiber", but was changed to "Functional Fiber" following receipt of comments and further deliberations. This definition has the potential to create some interesting problems, should both terms be used. For example, wheat bran in a wholegrain wheat bread would be dietary fiber while concentrated (isolated) wheat bran added to the same food to increase the content of dietary fiber would be a functional fiber.

The Codex Committee on Nutrition and Foods For Special Dietary Uses (CCNFSDU) is considering a definition for dietary fiber (2004) that includes recommended, recognized, and validated analytical methods. This definition also includes physiological responses that a dietary fiber must demonstrate. The definition under consideration is stated as follows:

Dietary fiber consists either of:

- non-digestible material composed of carbohydrate polymers* with a degree of polymerization (DP) not lower than 3, that are edible and naturally occurring in the food as consumed;
- carbohydrate polymers (DP > 3), which have been obtained from food raw material by physical, enzymatic or chemical means; or
- synthetic carbohydrate polymers (DP> 3).

Dietary fiber is neither digested nor absorbed in the small intestine and has at least one of the following properties:

- increases stools bulk;
- stimulates colonic fermentation;*
- reduces blood total and/or LDL cholesterol levels; or
- reduces post-prandial blood glucose and/or insulin levels.

* When derived from a plant origin, dietary fiber may include fractions of lignin and/or other compounds which are associated with polysaccharides in the plant cell walls, and if these compounds
are quantified by the AOAC gravimetric analytical method for dietary fiber analysis. Fractions of lignin and the other compounds (proteic fractions, phenolic compounds, waxes, saponins, phytates, cutin, phytosterols, etc.) intimately "associated" with plant polysaccharides are often extracted with the polysaccharides in the AOAC 991.43 method. These substances are included in the definition of fiber in so far as they are actually associated with the poly- or oligo-saccharidic fraction of fiber. However, when extracted or even re-introduced into a food containing non-digestible polysaccharides, they cannot be defined as dietary fiber. When combined with polysaccharides, these associated substances may provide additional beneficial effects.

The statement "stimulation of colonic fermentation" is added to take into account the effects resulting from the fermentation of fiber, such as production of metabolites, modification of the flora, effects associated with acidification of the lumen contents, with modification of certain enzymatic activities (e.g., effect on glyco-conjugated estrogens) or the production of a large quantity of short chain fatty acids and in particular, butyrate, which is thought to contribute to the proper functioning of the colonic mucosa and which might be beneficial in the prevention of several types of colon disease, including colon cancer.

The physiological effects of fiber cannot be restricted to the colon. Epidemiological and interventional studies have demonstrated that protective properties of fiber are, above all, observed on cardiovascular diseases.

Part of the effort being made in this case is not only to obtain a definition, but to also determine appropriate, recognized analytical methodology for measuring dietary fiber. This is a draft definition that is under discussion and will undoubtedly undergo revision at subsequent committee meetings.

These definitions differ in some respects that have significant implications. Physiological effects commonly listed in the definitions include regularized colonic function (laxation), normalized serum lipid levels (blood cholesterol attenuation (AACC), reduced blood total and/or LDL cholesterol levels (CCNFSDU)), attenuated post-prandial glucose response (blood glucose attenuation (AACC)), reduced post-prandial glucose and/or insulin levels (CCNFSDU), increased stools bulk (CCNFSDU), and stimulated colonic fermentation (CCNFSDU). Specific physiological effects were not identified in the IOM definition. The rationale given for the omission was that new beneficial effects are likely to be discovered. The criteria for determining these physiological responses are often not clearly defined, although Canada has done so for the ones that are recognized in the definition.

Differences regarding how components of the definition are designated include the use of non-native fibers and novel fibers/novel fiber sources in the Canadian definition; analogous substances in the AACC International definition; and functional fiber in the IOM definition. In general, these refer to the same set of substances, yet they can generate significant analytical problems should they be included in a labeling system. The Canadian system circumvents this difficulty by labeling Total Fiber only. This is not the only problem that could arise should these terms be included in labeling or in general use. Another major concern, then, would be the tendency to confuse consumers about nutrition and health messages concerning dietary fiber.
Several of these definitions attempt to bridge the fields of chemistry and nutrition. The inclusion of physiological responses in the definition raises some significant analytical methodological challenges. Determination of dietary fiber and its components has normally been done using chemically-based analytical methods. It is not clear yet how measurements (analytical determinations) based on the required physiological responses will be developed and incorporated. A major challenge will be to develop in vitro methods that are comparable to the in vivo methods used for these measurements, i.e., human subjects. Another challenge of considerable magnitude will be to combine both chemically- and physiologically-based analytical methods into the determination of what is dietary fiber and how much is present, without undergoing an unduly lengthy and costly process. These are very important questions that are part of the continuing definition(s) debates and discussions. They will be of major significance for a regulatory scheme of labeling foods that aims to reflect the physiological properties, health benefits, and nutritional role of dietary fiber.

References
Available and Non-Available Carbohydrates: Effects on the Health of the Large Bowel

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Introduction
This brief review will focus on the effects of unavailable carbohydrates, including both fiber and resistant starch, on the large bowel. The 1998 definition of fiber from the American Association of Cereal Chemists is a mix of analytical and physiological properties:

“Dietary fiber is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Dietary fiber includes polysaccharides, oligosaccharides, lignin, and associated plant substances. Dietary fibers promote beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation.”

This review will only address the fermentation and laxation aspect of this definition.

Health Effects of Fiber in the Colon
The most well-proven effect of fiber is on laxation. Constipation is common (affecting 5% to 27% of the population) and is associated with diverticular disease and hemorrhoids. In epidemiological studies, a high insoluble fiber diet was associated with 60% less diverticular disease in 44,000 men.

Interventions with fiber tend to improve stool weight, consistency and frequency, but usually have little effect on symptoms in diverticular disease or irritable bowel syndrome. Fecal bulking is greater with wheat bran with an increase of 4.9g stool/g fiber. Less than 50% of this fiber is fermented. More fermentable fibers, such as resistant starch, provide less bulking at 1 to 1.7g stool/g fiber, which is similar to legume non-starch polysaccharides, pectin and fructans.

Fiber and Colorectal cancer
Fiber has been proposed as a dietary component associated with protection from colorectal cancer. However, the evidence is patchy and relatively inconclusive with many negative studies. The EPIC Study with 320,000 people and 1,065 cases has shown a raw 25% reduction in risk from the first (12g fiber/day) to the fifth quintile (32g fiber/day), which after adjustment increased to 42%. The effect was greatest on the left side of the colon and least in the rectum. Once an intake of 21g/day was achieved, a significant fall in risk was observed. In the combined Nurses Health Study and the
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Health Professional Follow Up study with 1,596 cases, no association with fiber was seen.\(^8\) Similarly, in the Breast Cancer Detection and Follow-Up Study with 487 cases, there was no association with fiber intake assessed 5 to 11 years earlier, although in the highest quintile the intake of fiber was low at 18.2g/day.\(^9\) In a breast cancer screening project in Sweden involving 61,500 women with 460 cases of colorectal cancer over 10 years, fiber was not associated with cancer risk. The fiber intake in the fifth quintile was low at 16g fiber, while the first quintile was very low at 4g fiber. In this study though, a low fruit and vegetables intake (<1.5 serves/day) was associated with 65% more cases.\(^10\) This was not seen in the EPIC studies.\(^7\)

In a meta-analysis of all case control studies, which included 5,287 cases and 10,470 controls in aggregate, there was a 31% reduction in risk for each 13g/day increase in fiber.\(^11\) Twelve of the 13 studies showed a protective effect due to fiber. The highest quintile of fiber was associated with a 27% lower risk of polyps in the Prostate, Lung, Colorectal, and Ovarian (PLCO) Cancer Screening Trial which had 33,971 sigmoidoscopy negative subjects and 3,591 subjects with polyps.\(^12\)

Colorectal Cancer and Stool Characteristics

Cummings et al.\(^13\) related colorectal cancer risk to stool weight in 20 populations in 12 countries. Stool weights varied from 72g/day to 470g/day and were inversely associated with cancer risk (\(r=-0.78\)). In the UK cohort of 220 people, average stool weight was 104g/day in men and 99g/day in women but 17% women passed less than 50g/day.

In a combination of 26 study groups containing 206 people on controlled diets of known non-starch polysaccharide (NSP) intake, there was a correlation of \(r=0.84\) between NSP intake and fecal weight. NSP intakes of 18g/day were associated with stool weights of 150g/day or more.\(^15\) Fecal pH has been related to cancer risk in South African populations where blacks had a pH of 6.12, Indians 6.21, and coloreds 6.29. These values were significantly lower (\(p<0.01\)) than that of whites, who had a pH of 6.88.\(^14\) However, de Kok has demonstrated the opposite findings in patients with adenomas.\(^15\) Fecal bile acids have also been related to colorectal cancer risk.\(^16\) A low pH inhibits transformation of primary bile acids into more carcinogenic secondary bile acids.\(^17\)

Colorectal Cancer in Southeast Asia

In Singapore, the rate of colorectal cancer is 33.4 and 31/100,000 for men and women, respectively. It has been increasing at the rate of 0.66/100,000/yr over the last 30 years and is now the most common cancer.\(^18\) In 1983, the fiber intake in Singapore was low at 15g/day,\(^19\) while in Hong Kong in 1995 it was <10g/day. In Australia, the colorectal cancer rate is higher at 56 to 75/100,000 for women and men, respectively,\(^20\) although fiber intake is also higher at about 21g/day.\(^21\)

In an epidemiological study on colorectal cancer conducted in Singapore, results showed that high cruciferous vegetable intake reduced colonic cancer (RR 0.5), while rectal cancer was related to fiber and total vegetables intake.\(^22\) In Malaysia, there are no accurate countrywide statistics but, based on hospital admissions, there has been a 50% increase in the last 8 years. The current estimate is about 11/100,000/year.
Fiber Interventions in Preventing Recurrence of Adenomas
This area has been examined in a Cochrane review which looked at five studies involving 4,349 patients. The interventions included wheat bran fiber, ispaghula husk, or high fiber foods (and thus, more starch as well). No effect was observed over a period of 2 to 4 years. This contrasts with animal models using chemical carcinogens in which insoluble fiber is protective in most studies, but the amount of fiber is very large and equivalent to more than 80g of fiber per day for humans.

Resistant Starch and Colorectal Cancer
Starch intakes, as opposed to non-starch polysaccharide intake, has been associated with colorectal cancer based on a multi-country study with an r value of -0.7 and the assumption that higher starch intakes would lead to higher intakes of resistant starch. In the Health Professional Follow Up study, starch intake was associated with a lower risk of adenomas with risk ratio from top to bottom quintile of 0.47. Four case control studies have examined starch and colorectal cancer and only one has shown a protective relationship while the others have shown either promotion of disease or no effect. Three out of seven studies (men and women were analysed separately in some studies) have shown a protective effect for starch in relation to the development of adenomas.

There has long been an interest in the potential effect of short chain fatty acids (SCFAs), and in particular butyrate, on preventing colorectal cancer. The hypothesis was first proposed by Cummings in 1980 as one mechanism linking fiber and colorectal cancer, and an inhibitory effect of butyrate on cancer cells in vitro was also shown in the same year. Histone deacylation inhibition, which is believed to underlie its nuclear effects, had been shown earlier. Subsequent studies showed that butyrate led to either p53 independent apoptosis or a more differentiated phenotype. Starch fermentation in the colon tends to produce more SCFAs than fiber fermentation, but a cross sectional analysis of 53 individuals showed that those who consumed more non-starch polysaccharides in their diet (19±7 g/day) excreted more than 150g/day and had higher quantities of fecal starch and non-starch polysaccharides, faster transit times, higher concentrations of short chain fatty acids and lower concentrations of potentially harmful ammonia and phenols.

Burkett et al. has estimated that the intake of resistant starch is about 5g/day from a total intake of 130g to 140g of starch/day in the Australian diet. Human interventions with high levels of resistant or malabsorbed starch have shown that resistant starch increases fecal mass (6/7 positive studies) and SCFAs (5/8), reduces ammonia and phenols (1/1), reduces fecal water bile acids (3/4), reduces fecal water cytotoxicity (1/2) and lowers pH (3/6). Increased DNA adducts with resistant starch were shown in the one study that examined this, but it is not clear how this might have occurred.

Animal studies examining the interaction of resistant starch with chemical carcinogens have produced a very mixed picture: 2 protective, 3 no effect, and 2 promotional (for a more complete review on resistant starch and colorectal carcinogenesis, please refer to the publication by Young GP et al.)
Conclusions

Non-absorbable carbohydrate has significant colonic effects and may provide protection from colonic cancer. However, data is currently clearest on fecal bulking and the relief of constipation. There may be other components in fiber-rich foods that provide protection against colorectal cancer.

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Understanding Carbohydrates and Health

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Introduction
The International Life Sciences Institute (ILSI), through a global network of scientists from industry, academia, and government agencies, is devoted to enhancing the scientific basis for public health and regulatory decision-making by sponsoring research, workshops, and symposia, and encouraging publication of the outcomes in the peer-reviewed literature. Among many other nutrition-related topics, ILSI has an ongoing interest in scientific issues related to dietary carbohydrates - including starches, fibers, sugars, and whole grains - and their impact on nutrition and health.

Research

Supplemental Research Grants
Dietary guidance, during the early 1990s, focused largely on the amount and type of fat in the diet. Relatively little attention was given to dietary carbohydrates, even though they usually comprised more than 50% of total energy intake. Dietary guidance for carbohydrates in the 1900s consisted mostly of advice to moderate sugars intake and to increase dietary fiber. The scientific advisors of the ILSI Human Nutrition Institute (HNI) wisely thought that more attention should be paid to understanding the physiological effects of dietary carbohydrates. As a result, HNI decided to help stimulate research in this area by awarding supplemental grants to projects that were funded primarily by other sources. ILSI’s decision to support research aimed at understanding the physiological effects of dietary carbohydrates was prescient given the current, widespread scientific and media attention on this topic.

ILSI initiated the awards program in 1994 and has since annually advertised a request for proposals (RFP). The RFP is modified each year as appropriate to reflect the most current scientific issues. The RFP for 2005 is seeking projects aimed at identifying in vivo endpoints that link dietary carbohydrates (sugars, starch, fiber, and whole grains) intake to a physiological or health-related outcome. Although not exclusive, some of the research topics needing further investigation that would be considered for funding include the impact of dietary carbohydrates on: (1) appetite control in the context of energy balance, (2) glycemic response as it relates to risk for overweight/obesity and chronic diseases, (3) food intake behavior and physical activity patterns, and (4) human behavior and/or performance.

Since the initiation of the awards program, 16 projects have been funded with 14 completed. After the first few years, the awards were restricted to new investigators so as to identify and support future leaders in carbohydrates research in addition to generating important scientific information.
Another key aspect of the awards program has been its international scope - the awards are open to investigators in any country and have thus far been granted to five investigators at institutions outside the United States (USA). The findings have resulted in the publication of more than 20 research papers, reviews, and abstracts. Seven awards have addressed issues related to food and energy intake, five have addressed substrate oxidation and energy expenditure, six have examined blood lipids and lipoprotein kinetics, and two have assessed effects on cognitive and physical performance. Summaries of the research projects are available at www.hni.ilsi.org.

**Carbohydrate Intake and Glycemic Control**

There has been increased speculation that dietary carbohydrates, especially refined starches and sugars, are contributing to the development of insulin resistance and Type 2 diabetes mellitus. There also has been concern that the high carbohydrate, low fat diets that have been recommended to reduce the risk for cardiovascular disease might actually be contributing to the development of glucose intolerance and insulin resistance. To address these issues, ILSI supported a research project with Michigan State University, USA and the University of Alabama, USA to evaluate the association between carbohydrates intake and biomarkers of glycemic control in a nationally representative sample of 11,855 healthy US adults who participated in the third National Health and Nutrition Examination Survey, a cross sectional study conducted during 1988-1994. The results showed that carbohydrates intakes were not associated with HbA1c, plasma glucose, or serum insulin in men or women after adjusting for confounding variables, and that intakes were associated inversely with serum C-peptide. When carbohydrate intakes were further adjusted for intakes of total and added sugars, the association of serum C-peptide with carbohydrates intake was strengthened in men. The results support current recommendations regarding carbohydrate intakes in healthy adults.

**Sugars and Short-term Satiety**

Contradictory perspectives exist on the roles of sugars and insulin in promoting satiety. Some argue that a low post-prandial glucose and insulin response promotes satiety, whereas others argue that post-prandial glycemia and insulinemia actually promote short-term satiety. To help develop the science base on the association between sugars and satiety, ILSI supported a research project with the University of Toronto, Canada to determine the effect of varying the glucose to fructose ratios in test solutions (75g per 300mL water) consumed by young men. Over the course of two experiments the glucose to fructose ratios ranged from 80:20 to 20:80. The post-prandial area under the curve for blood glucose was directly related to the glucose content of the test solution, and the ad libitum food intake 90 minutes after ingesting the test solution was inversely related to the glucose content. These preliminary results were presented at Experimental Biology 2005 in San Diego, California, USA (Akhava and Anderson, personal communication). Analyses for blood levels of insulin, glucagon, GLP-1, and ghrelin are in progress.

**Fructose Intakes**

Over the past several years, there has been an increased interest in the physiological effects of dietary fructose, especially as related to hypertriglyceridemia and obesity. The last comprehensive estimates for fructose intake in the USA are from a study based on 1977-1978 food consumption data. Recent concerns over the health effects of fructose, however, are based on food supply
Therefore, changes in both fructose availability in the food supply and dietary fructose intakes need to be examined. To this end, ILSI is supporting a collaborative agreement with the US Food and Drug Administration (FDA) and the Joint Institute for Food Safety and Applied Nutrition (JIFSAN), University of Maryland, USA to update dietary fructose intake estimates. Nationally representative dietary data will be combined with food supply data and the USDA Pyramid Servings database. The primary goal is to develop a contemporary assessment of fructose intakes as well as possible changes since 1977-1978; a secondary goal is to assess the relation between fructose intakes and selected health outcomes for several population groups.

Workshops

Glycemic Response
The concept of the glycemic index, a standardized measurement of the blood glucose response to individual foods, has led to a re-examination of the role of starches and sugars in the prevention, etiology, and management of obesity, Type 2 diabetes mellitus, and cardiovascular disease. However, considerable scientific disagreement exists on the health impact and utility of using the glycemic index of individual foods and diets and derivatives such as the glycemic load. In 2003, ILSI in collaboration with JIFSAN invited a group of international experts to Washington, DC, USA to help advance scientific discussion on this topic. The experts were asked to provide their informed but divergent viewpoints on questions related to the different types of dietary carbohydrates, blood glucose and insulin responses, and health outcomes. These viewpoints, along with a call for well-controlled research with healthy subjects, have been summarized.

Low Carbohydrate
The use of very low carbohydrate diets to reduce and control body weight increased in popularity during the early part of the new millennium, and food manufacturers responded quickly to the increased consumer demand for foods that contain no or very little metabolizable carbohydrate. However, nutrition and health experts expressed concern about the potential adverse effects of such diets, questions about safety and efficacy were raised, and terms such as net and available carbohydrates were being used on food labels despite a lack of regulations to define them.

Even though the current popularity had subsided, ILSI decided to hold a workshop to discuss issues related to low carbohydrate diets because of the periodic re-emergence of consumer appeal in such diets. Held in April 2005, the workshop consisted of a group of academic researchers, clinical practitioners, food industry scientists, and representatives from regulatory agencies and professional organizations. Presentations provided perspectives on the marketplace and consumers, state of the science on the efficacy of low carbohydrate diets, definitions suggested for describing the carbohydrate content of foods and associated analytical issues, regulatory considerations, dieter behaviors, and use for pediatric populations. Other presentations addressed possible mechanisms accounting for the efficacy of low carbohydrate diets in achieving weight reduction, at least in the short-term, including the roles of dietary energy density, carbohydrates, and protein, as well as for the observed reductions in blood triacylglycerides and increase in HDL-cholesterol levels despite the relatively high fat content of the diets. Lastly, the group identified areas where there appeared to be agreement on scientific and consumer issues and where questions still remained. A summary of the workshop will be submitted for publication in the peer-reviewed literature.
Fiber Definitions
Several definitions to describe the fiber content of food either exist or have been proposed.8-10 The definitions vary in which substances are included as fiber, the analytical methods used to identify and measure them, and whether physiological criteria are part of the definition. The Institute of Medicine's8 (IOM) proposed definitions for dietary fiber and functional fiber have been of particular concern in the US in terms of issues associated with implementation for food labeling, food composition databases, assessment of dietary intakes, and dietary guidance. In June 2004, ILSI convened a group of representatives from academia, industry, scientific associations, and US and Canadian government agencies to discuss and educate one another about these issues. Presentations were made on the history and description of fiber definitions, the rationale behind the IOM definitions, criteria for physiological functionality, methodological issues associated with chemical analysis and assessment of functionality, regulatory issues, the Canadian experience with physiological criteria for functionality, and consumer awareness and understanding of dietary fiber. The workshop concluded with an assessment of where gaps in the understanding of the physiological effects of fiber still exist. A summary of the workshop has been accepted for publication.9

Sugars and Health
In the early 2000s, several groups had reviewed the potential adverse effects of over-consumption of sugars.8,12,13 Despite continuing concerns about over-consumption, adverse health effects specifically attributable to sugars remained controversial. The research community was challenged to further address the potential relation between sugars and chronic disease. ILSI took up this challenge by convening a workshop on Sugars and Health that was held in Washington, DC, USA in 2002. Internationally recognized experts on selected topics related to sugars were asked to draft papers in advance of the workshop. These papers were circulated among the other authors and workshop participants for review and critical commentary. The commentaries were provided to the authors prior to the workshop, during which the papers and commentaries were extensively discussed. The following topics were addressed: (1) definition of sugars-related terms, (2) assessment of sugars intakes, rationale for current public guidance, (3) hedonic and satiety aspects as related to energy balance and weight control, (4) insulin sensitivity and diabetes management, (5) hypertriglyceridemia and cardiovascular disease, and (6) oral health. Workshop participants extensively discussed the complex relation between sugars and chronic disease and urged additional research. A summary of the workshop and the individual papers have been published.14,15

Summary
Interest in understanding the health impact of carbohydrates - both potentially beneficial and adverse - has intensified since the mid 1900s and ILSI has been an active participant in contributing to the science base. Through the Human Nutrition Institute and its regional branches, ILSI has supported young investigators, research, workshops, and publications in the peer-reviewed literature that have addressed the spectrum of carbohydrates (e.g., total carbohydrates, dietary fiber, sugars, fructose), a wide variety of parameters (e.g., chemical analysis, definition of terms, assessment of intakes) and physiological outcomes (e.g., glycemic response, substrate metabolism and energy expenditure, satiety, energy balance, insulin sensitivity, blood lipids and lipoprotein kinetics, oral health, and cognitive and physical performance).
References
Glycemic Indexes, Glycemic Impact and Virtual Food Components: Present and Future

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Introduction
Accumulating evidence that blood glucose loading from highly glycemic diets plays a role in the development of diabetes, of conditions that predispose to diabetes, and of the complications that arise from diabetes, has brought dietary carbohydrates sharply into focus.

The concentration of glucose in the blood is central in the network of factors responsible for the diabetic syndrome of hyperglycemia and its complications, and exerts its effects in a number of general ways:

- Glycation of proteins throughout the body by glucose and its immediate metabolic products leads to systemic malfunction at the molecular level.
- Pathways to ease the metabolic flooding by glucose and downstream glycolytic products lead to intermediates and by-products that cause diffuse molecular damage, partly by changing the oxidative environment of the cell.
- Insulin released in response to blood glucose is a potent cell factor that has its own harmful effects.
- Compensatory physiological/hormonal responses to acute blood glucose loading brought about by large doses of readily available glycemic carbohydrate may lead to a hypoglycemic overshoot. Resulting poor homeostatic control of appetite may lead to over-consumption and obesity, which is one of the major factors in glucose intolerance.

As the effect of food carbohydrates cannot be divorced from the effects of foods, the question has arisen as to whether or not the measure of the glycemic potency of foods would be better for dietary management of glycemia than some derivative of it, such as the glycemic index of carbohydrates in foods, or whether a combination of the two would be ideal.

\( \text{GI}_{\text{carb}} \) is a constant value for a food and shows the relative glycemic impact of the food when consumed in sufficient quantity to provide 50g of carbohydrate, relative to the effect of 50g of glucose. It is, therefore, a surrogate indicator of the relative glycemic potency of carbohydrate in a food, is constant for a food, and does not reflect the effects of changing food composition or intake.
The post-prandial relative glycemic impact (RGI) of a food, on the other hand, is a food variable that expresses the glycemic effect of any quantity of a food relative to that of glucose, as the weight of glucose that would be required to have an effect equal to that of the given amount of food. RGI is therefore expressed as the glycemic glucose equivalent (GGE) dose consumed in a single food intake event. Because GGE is expressed as a weight of reference, but in fact represents an effect, it has been termed a virtual food component (VFC).

As glycemic load (GL) is the product of GIcarb and carbohydrate intake, and is calculated as such for a single food intake event it is approximately the same as RGI, and can equal RGI when a correction factor to account for the effect of non-linearity in the glucose dose-glycemic response relationship at the time of GIcarb measurement is included.

In this paper, the relationship between GIcarb, and RGP, and GL and RGI, as various expressions of GGE content, will be discussed.

**Studies on Links to Health Support GIcarb and GL also Support GGE**

There is now a substantial amount of evidence that controlling glycemic impact has positive benefits for health. Most of the experimental evidence that supports control of GGE intake as a contributor to better health comes from the studies of GIcarb (GGE intake/100g carbohydrate consumed) and of GL (estimated GGE/food intake). Because GIcarb and GL are both expressions of GGE content and GGE dose respectively, most of the associations found between between GIcarb and health, and GL and health, are associations between GGE and health.

Many studies of GIcarb have involved varying GIcarb while keeping carbohydrate dose constant, in which case GGE intake was varied as a function of GIcarb. Similarly, the large epidemiological studies that have shown associations between GL and the incidence of Type 2 diabetes and coronary heart disease, "establish associations between health and GGE intake, because GL is an estimate of GGE dose.

**GIcarb, GL, RGP and RGI Are All Expressions of GGE**

GIcarb, GL, RGP (GIfood) and RGI are all closely related because they are based on the clinical measurement of glycemic response to food relative to response to glucose, i.e., GGE, but they differ in the way that the measurement of response is obtained and used.

**Communications of Glycemic Potency Are All Based On Relative Response To Food**

The measurement and expression of glycemic potency is subject to two unavoidable constraints:

- Glycemic response is always measured as a response to food, whether or not the glycemic potency of a food is communicated in food terms (RGP and RGI), or in terms of food carbohydrate as in the case of GIcarb (GGE/100g carbohydrate in food).
- Individuals differ so greatly in glycemic responsiveness that glycemic potency of foods must be expressed relative to a reference, rather than as an absolute effect. Comparing the effects of all foods with the effect of the same reference material allows the foods to be compared with one another, without the influence of individual variability except in the error term associated
Glycemic Glucose Equivalent (GGE) is the Basic Datum Describing Glycemic Impact

Measuring the glycemic effect of a food relative to the effect of a reference provides a ratio that may be expressed in the following ways:

- **As a Unitless Index**: "Index" is defined in the Oxford Dictionary as "Number expressing physical property etc. in terms of a standard". Thus, if the effect of a food is expressed relative to the effect of a reference, a glycemic index of a food (Glfood) is obtained, and it would be expressed as a percentage if multiplied by 100. If an index compares the effect of a carbohydrate dose in a food with an equal amount of glucose, it would be the glycemic index of carbohydrate, not of a food. However, it is not possible to make such a measurement directly for food carbohydrate, so it is approximated by a Glcarb value which is essentially Glfood weighted by the proportion of available carbohydrate in the food.

- **As a Virtual Food Component (VFC)**: A VFC is in effect an index applied to a varying quantity of food, because it expresses the glycemic impact "in terms of a standard". In the case of GGE it is the weight of glucose reference that would have an effect equal to that of the food, that is, its glycemic glucose equivalent (GGE) content.

GGE is the basic measurement of the relative glycemic potency of a food. It is measured as the incremental area under the blood glucose response curve for a food (IAUCfood) relative to the incremental area under the blood glucose response curve for glucose (IAUCglucose). The basic expression for GGE content of a portion of a food is:

\[
GGE = \frac{\text{IAUC}_{\text{food}}}{\text{IAUC}_{\text{glucose}}} \times \frac{\text{Wt glucose used for IAUC}_{\text{glucose}}}{\text{Wt food used for IAUC}_{\text{food}}} \times \text{Wt of food portion}
\]

GGE expressed per 100g food is a food glycemic index (Glfood), but because the term "glycemic index" had already become known as the term for glycemic index of food carbohydrate (Glcarb), the term relative glycemic potency (RGP = Glfood) was proposed.

**Definitions**

Glcarb and GL can be regarded as different expressions of GGE. The former is GGE/100g available carbohydrate, and the latter is an estimate of GGE per given weight of a food, not necessarily consumed in a single intake.

The relationship of a clinically determined GGE value to the derivatives of it that are used to describe the relative glycemic potency of foods and food carbohydrates are shown in Figure 1.
Figure I. The relationship between carbohydrate (CHO)-referenced and food-referenced measures of glycemic potency. Use of the Q factor to adjust for non-linearity in GI_{carb} makes GL equal to GGE dose (RGI).

Glycemic Index of Carbohydrate (Food-based, Carbohydrate-Weighted)

Glycemic index of carbohydrate (GI_{carb}) is measured as the glycemic response to a portion of food containing 50g carbohydrate, expressed as a percentage of the response to 50g glucose. It can, therefore, be regarded as the relative glycemic potency of a food adjusted by the proportion of available carbohydrate (P_{ac}) in the food.

**Equation 1:**

\[
\text{GI}_{\text{carb}} = \frac{\text{IAUC/g food}}{\text{IAUC/glucose}} \times \frac{(50/P_{\text{ac}})}{50} \times 100 \%
\]

\( \text{GI}_{\text{carb}} \) can therefore be alternatively expressed as glycemic glucose equivalent per 100g of food carbohydrate.
Equation 1 shows that although GI_{carb} is sometimes referred to as a measure of the quality of carbohydrate in a food, it is, strictly speaking, the glycemic quality of a food adjusted by its available carbohydrate content because, despite such emphasis on carbohydrate, the glycemic index of carbohydrate in food can only be derived from measurement of a food effect.

**Glycemic Load (Food Based, Calculated From GI_{carb})**

Glycemic load (GL) was originally calculated as a measure of glycemic stress or insulin demand imposed over a period of time, and calculated as the average glycemic index multiplied by the carbohydrate intake. For the purposes of dietary management, it has been contracted to a single food portion consumed at one time, and is calculated as GI_{carb} multiplied by the carbohydrate intake.

GL is simply the carbohydrate-weighted GI (GI_{carb}; Equation 1 above) put back onto a food basis by multiplying by the proportion of a food that is carbohydrate, and the weight of the food:

$$GL = \frac{\text{IAUC/g food}}{\text{IAUC/g glucose}} \times \frac{(50/P_{ac})}{50} \times P_{ac} \times \text{Wt. food}$$

Thus, a food weighing 50g, with a GI_{carb} of 30%, and in which the proportion of carbohydrate (P_{ac}) was 0.5 would have a GL of 30% x 0.5 x 50 g = 7.5 g.

**GL Contains an Intrinsic Error**

GL is an apparently straightforward derivation of GI_{carb}, and it is widely used as the product of GI_{carb} and food carbohydrate intake. If the assumption of linearity that underlies GL were true, GL could be expressed as total GGE intake (g). However, a GL value calculated from GI_{carb} is not equal to a GGE value measured directly as response to food relative to response to glucose, because GL values contain a distortion that arises from the fact that the glucose (or glucose equivalent) dose–glycemic response relationship is quadratic. The non-linearity of the response is incorporated into GI_{carb} values, and when these are then used to calculate GL as a linear function of carbohydrate dose, the non-linearity is proportionally amplified and may become a significant error for low GI_{carb} values unless a correction factor (Q) is applied.

A more correct calculation of GL is therefore:

$$GL = GI_{carb} \times P_{ac} \times \text{Food wt.} \times Q$$

Q is the factor required for dose-transformation of GI so that GL = GGE.

An additional source of error in GL is in the available carbohydrate value used to calculate P_{ac}. The error in P_{ac} is incurred twice in arriving at a GL value, firstly in calculating the weight of food required to deliver a 50g available carbohydrate dose for GI_{carb} measurement, and again in calculating GL from GI_{carb}. 
To avoid the above errors in GL, it is advisable to measure GL directly against an appropriate glucose reference, when GL would equal RGI.

**RGP and RGI (Food-based, Determined directly) Adjusted for Non-Linearity**

RGI is GGE dose per given weight of food. RGP is GGE per 100g food, so it is a true glycemic index of a food (GI<sub>food</sub>), but because GI had already been used with reference to carbohydrate in food, the term RGP was proposed<sup>16</sup>.

Measuring the relative blood glucose response to food has been the subject of an extensive recent review<sup>20</sup> and will not be covered here other than to say that the procedures for measuring glycemic potency of a food are basically the same as are used when determining GI<sub>carb</sub>.

When GGE is determined directly, response to food is compared with response to a glucose reference dose in the vicinity of the GGE content of the food, so that both the reference and the food effects will be in about the same region of the dose-response curve, that is, at about the same glycemic sensitivity. The error incurred due to the non-linearity of the GGE dose–blood glucose response curve will then be minimized. Approximate matching of the glucose reference dose to GGE intake in a food portion is easily achieved from a knowledge of the carbohydrate content of the food or of similar foods, and the GI<sub>carb</sub> value of similar foods.

If the GGE content determined for the food, and the GGE dose (grams of glucose) used as the reference are sufficiently separate, a correction factor may be applied based on a universal equation for the dose–response curve that adjusts for non-linearity<sup>12</sup>.

\[
\text{GGE} = \frac{\text{IAUC/g food}}{\text{IAUC/g glucose}} \times \frac{\text{Wt glucose used}}{\text{Wt food used}} \times \text{Correction for non-linearity} \times \text{Wt. food}
\]

As a VFC, GGE can be used to compare foods by glycemic potency on an equal weight basis, per 100g for example, as in the case of RGP<sup>16</sup> or to provide a relative measure of the glycemic impact of a given amount of food, as in the case of RGI<sup>9</sup> which would be the same as a GL value derived from a single food intake event and calculated from a dose–transformed GI<sub>carb</sub> or measured against a matched GGE (glucose) reference dose.

**Meeting the Needs of Consumers**

It is important that the form in which glycemic potency is communicated is appropriate to those who wish to use the information to make food choices. The communication should allow accurate control of glycemia despite the differences in food composition, food intakes and portion sizes that vary from food to food, and from person to person in the normal environment. Actual food intakes will continue to be governed by food producers, natural morphology, and individual preferences more than by the convenience for glycemia management of having standardized intakes and glycemic impacts per food portion.

In short, the communication of glycemic impact may be most applicable if based on foods, because people choose and consume foods and not food carbohydrates, and it should be responsive to the variations in food intakes and compositions that occur in life.
Criteria for Assessing Measures of Glycemic Potency and Glycemic Impact

A measure of glycemic potency for use as a guide to food selection should:

- make sense to the users;
- be easy to apply accurately;
- be able to be used directly, without complex calculation;
- be adaptable enough to be applied consistently from formulation of general guidelines to quantitative management of glycemic impact for the more skilled, depending on the needs of the user population;
- be applicable to foods of identical or different carbohydrate content;
- be applicable to foods of the same or different portion sizes;
- be appropriate for use with the foods and food practices of the user population;
- be additive for use in both individual foods and in meals;
- be safe to use; and
- encourage healthy food choices.

The degree to which the measure of the relative glycemic potency of carbohydrate that is GI\textsubscript{carb} (GGE/100g available carbohydrate) and the measure of the glycemic impact of foods that is RGI (GGE dose), satisfy the above criteria is summarized in Table 1 below. Table 1 shows that the fact that GGE may be used as a virtual food component without equicarbohydrate restriction, should give it numerous advantages over GI\textsubscript{carb} in practical management of glycemia.

Table 1. Carbohydrate-based glycemic index (GI\textsubscript{carb}; GGE/100g food carbohydrate) and food-based relative glycemic impact (RGI = GGE/food intake) in glycemia management.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>GI\textsubscript{carb}</th>
<th>RGI</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicts the glycemic effect of an intake of food.</td>
<td>-</td>
<td>+</td>
<td>GI\textsubscript{carb} is carbohydrate (CHO)-based, not a food-based measure.</td>
</tr>
<tr>
<td>Directly usable.</td>
<td>±</td>
<td>+</td>
<td>GI\textsubscript{carb} is used directly only with foods of equal CHO, whereas GGE dose may be applied also beyond the equicarbohydrate limit.</td>
</tr>
<tr>
<td>Usable with foods of equal carbohydrate (CHO) content.</td>
<td>+</td>
<td>+</td>
<td>GGE dose (RGI) acts as GI\textsubscript{carb} for equal CHO contents.</td>
</tr>
<tr>
<td>Usable with foods of different carbohydrate content.</td>
<td>-</td>
<td>+</td>
<td>GI\textsubscript{carb} was designed specifically for equal CHO comparisons.</td>
</tr>
<tr>
<td>Provides a measure of carbohydrate quality.</td>
<td>±</td>
<td>±</td>
<td>Under equal carbohydrate conditions GGE functions as GI\textsubscript{carb} to show differences in carbohydrate quality, but both are based on measurement of a food effect.</td>
</tr>
<tr>
<td>Usable irrespective of difference in portion size.</td>
<td>-</td>
<td>+</td>
<td>Portion size variation leads to different carbohydrate intakes which prevent GI\textsubscript{carb} from indicating glycemic impact.</td>
</tr>
<tr>
<td>Additive.</td>
<td>-</td>
<td>+</td>
<td>GGE is usable as an additive function of food intake, GI\textsubscript{carb} is a constant ratio that does not change with food intake.</td>
</tr>
<tr>
<td>Suitable for use in both individual foods and in meals.</td>
<td>-</td>
<td>+</td>
<td>Calculating a GI\textsubscript{carb} value for a meal is reasonably complex, whereas GGE values can be simply added.</td>
</tr>
</tbody>
</table>
Table 1. Carbohydrate-based glycemic index (Glcarb; GGE/100g food carbohydrate) and food-based relative glycemic impact (RGI = GGE/food intake) in glycemia management (continued)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Glcarb</th>
<th>RGI</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can be used to formulate dietary guidelines.</td>
<td>+</td>
<td>+</td>
<td>Guidelines such as “Choose carbohydrate foods of relatively low glycemic impact” could be based on Glcarb or GGE.</td>
</tr>
<tr>
<td>Can be used for quantitative glycemia management.</td>
<td>-</td>
<td>+</td>
<td>Glcarb is an index that is independent of food intake, so cannot be used in quantitative glycemia management. GGE can.</td>
</tr>
<tr>
<td>Safety depends on usage.</td>
<td>+</td>
<td>+</td>
<td>Both Glcarb and GGE can be unsafe if used without regard to other food components.</td>
</tr>
<tr>
<td>Encourages healthy food choices.</td>
<td>±</td>
<td>±</td>
<td>If used with food composition both may encourage food choices that are healthier with respect to glycemic effect. Both may also lead to unhealthy choices if used apart from other food properties and components.</td>
</tr>
<tr>
<td>Provides information on an actual food effect.</td>
<td>-</td>
<td>+</td>
<td>As a virtual food component GGE will inform of a real relative food effect. Glcarb is not food-referenced so can not do so.</td>
</tr>
</tbody>
</table>

The Nutritional Context of Glycemia Management

Neither GGE, nor any other relative of it, such as Glcarb, should be used independently of the nutrient composition of the foods. Glycemic impact may be important, but low glycemic impact on its own will not make a food healthy. Food choices based on either the RGI (GGE dose) of a food quantity or on the glycemic potency of the carbohydrate in it (Glcarb) alone, may lead to unhealthy food choices - low glycemic potency does not mean high health if the saturated fat and salt content is high and the phytochemical and vitamin content is low.

There has been concern that providing a glycemic load or GGE value on a food label will lead to unhealthy food choices, because low GGE content may be achieved by displacing carbohydrate from a food with fat. While this is true, it applies equally to Glcarb, because a Glcarb value refers only to available carbohydrate, and gives no information about other food components present. A food of low Glcarb may or may not have a high fat content. A low GGE content in a food would at least alert one to check the fat content, knowing that GGE content, but not Glcarb, depends on food composition. While substituting with unhealthy ingredients may give a low GGE value, Glcarb will not alert to substitution effects because it is based on carbohydrate alone.

The problem may be overcome by using measures of glycemic potency in conjunction with food guidelines. Another possibility is to restrict the use of GGE and Glcarb to foods that meet certain nutritional criteria. However, in the case of GGE, such a restriction would mean withholding potentially useful information about a real food property. It seems preferable that the information be available, and the public is helped to use it correctly, in which case GGE would be treated like any other beneficial food component seen in a nutrient information panel, such as vitamin C.

By recommending that people base their diets on carbohydrate foods, the foods will form a high carbohydrate cluster of relatively low fat foods. Foods may subsequently be chosen by glycemic potency without compromising the carbohydrate basis of the diet. When foods are selected from
a recommended group of carbohydrate foods relatively low glycemic potency, they will be associated with low Gl\textsubscript{carb}. Nonetheless, GGE dose will continue to be a better guide to glycemic impact than Gl\textsubscript{carb}, because, despite the foods all being grouped as high in carbohydrate, and relatively low in glycemic impact, variations in composition and portion size will exist that make Gl\textsubscript{carb} inaccurate to use, because it was designed for equicarbohydrate comparisons.

The best way to ensure that nutritional balance is achieved is to always base choices on the nutritional balance in the diet, and never on a single variable such as glycemic impact. As a VFC, GGE has the advantage of being able to be used concurrently with other nutrients and virtual food components, so that the multi-dimensional nature of a food, or even of nutrition within a lifestyle, can be displayed. Figure 2 below shows a multi-dimensional display in which real food components, virtual food components that represent food effects, and aspects of lifestyle such as stress and exercise, together provide the context in which glycemic impact is managed.

Figure 2. Multidimensional representation of nutrients, virtual food components including GGE, and lifestyle factors that collectively affect health.

Notes:
* The value of 100 on each dimension would be set as the optimum for an individual after personal assessment of individual requirements and responsiveness.
* Light gray is the ideal, and dark gray is typical of a modern lifestyle.
* GGE: glycemic glucose equivalent (glycemic impact)
* WBE: wheat bran equivalent (fecal bulk)
* IE: inulin equivalent (prebiotic efficacy)
* BBE: blueberry equivalent (antioxidant)
* SFA: saturated fatty acids.

The Future: Food Effects, Individual Responsiveness, Personalized Nutrition and Virtual Food Components
The nutritional quality of foods has been described in terms of composition - the nutrients that are measured using a finely ground sample in an analytical laboratory and displayed in a standard
nutrient information panel. However, it is food effects and properties, many of which cannot be represented by chemical analysis, that are of ultimate concern to the consumer. With the importance of functional foods, and the realization that it is critical to health to be able to choose foods according to effects, the need for virtual food components (VFCs) to overcome the limitations of some real food components as indicators of effect has arisen.

As a VFC is a food effect expressed in terms of the weight of a reference material that would have an effect equal to that of a given quantity of food, it shows the relative potency of a food with respect to an effect. The actual potency depends on individual responsiveness to the virtual food component. With the advent of simple physiology monitoring systems such as blood glucose meters, it may soon be easy to establish the average glycemic responsiveness of an individual, and to thereby design personalized meals of known RGI. Once an individual’s responsiveness is established, GGE could be amongst a number of virtual food components to guide food choices for personalized diet construction, according to predetermined individual susceptibilities or needs.

Personalized VFCs would facilitate nutritional management by being continuous, and using intake responsive variables applicable across foods of differing composition and quantity. Because they are expressed as a weight, they may be used alongside nutrients in modern nutrition management systems to give a more complete picture of the quality of a diet than can be obtained from food components alone. With increased emphasis on identifying individuals at risk, and intervening to avert harmful long term dietary effects on health, VFCs may be used to manage syndromes such as diabetes and the metabolic syndrome for which outcomes depend on many aspects of diet in addition to glycemic impact.

Conclusion
The glycemic potency of foods has been expressed as a GGE intake per 100g carbohydrate consumed, as in the case of Glcarb, and as GGE per 100g weight or per given weight of food, as in the case of RGP and RGI. Glcarb and GGE can, under equicarbohydrate conditions, be used to indicate the quality of carbohydrate in a food. Because it may be used to directly represent the glycemic impact of food, GGE intake per weight of food may be more versatile than Glcarb as it has the capacity to act as a virtual food component alongside other dietary variables that contribute, along with glycemia, to the eventual health outcomes of syndromes such as diabetes.

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Carbohydrates and Obesity

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Introduction
In the past, Asian and African populations consumed a much higher percentage of their energy as carbohydrates, and had lower body weights than individuals in Europe and America. However, their energy intake was also lower and their activity level higher, so it is difficult to attribute the lower body weights to carbohydrate. In Western countries, it has been quite difficult to relate body weights to specific macronutrient intakes, although Romieu et al.\textsuperscript{1} found in a small cross sectional study of 141 women that fat intake accounted for 4% of the variance in weight after adjustment for energy intake. In a longitudinal study of 300 normal adults, Klesges et al.\textsuperscript{2} found that fat intake was a predictor of weight gain over 3 years. The higher energy density of fat appears to play more of a role in weight loss and weight regain studies. Leser et al.\textsuperscript{3} found that after weight loss on a very low calorie diet, weight regain in 27 women over 3 years was related to fat intake ($r=0.55$). Data from the National Weight Control Register also demonstrated that weight regain was related to fat intake.\textsuperscript{4}

In a meta-analysis of ad libitum low fat diets by Astrup et al.\textsuperscript{5} 16 trials containing 1,728 individuals were examined. The average weight loss compared with the control diet was 2.5kg. The effect on weight was related both to pre-treatment weight and to the percentage reduction in fat with a weight loss of 0.37kg per 1% absolute reduction in fat calories. Thus, for a subject with a BMI of 30, a 10% reduction in fat would result in weight loss of 4.4kg.

Fructose
One carbohydrate that has been adversely related to obesity is fructose.\textsuperscript{6} In relation to obesity, it is probably not intrinsically any different from glucose, sucrose or even starch, but intakes have increased dramatically over the last 20 years as both fruit juice and soft drink consumption has doubled and soft drinks have been sweetened with high fructose corn syrup. From 1970 to 2000, added sugar consumption in the USA increased by 5%, while total calories increased by about 25%, mostly from refined grain products (Figure 1, USDA). High fructose corn syrup constitutes between 10% to 16% of total calories\textsuperscript{8}, depending on the study. Thus, intakes of free fructose from fruit have risen from about 16g/day to 17g/day to 60g/day to 100g/day, as intakes of fruit juices and soft drinks have increased. In an ecological study in the USA, the incidence of Type 2 diabetes was associated with the intake of fructose after adjustment for energy density ($p=0.04$), while fat was not.\textsuperscript{7} Fiber was inversely related to the incidence of Type 2 diabetes ($P<.01$). The glycemic index of high fructose corn syrup 55 is 73, so it is a high GI carbohydrate. Despite fructose being 73% sweeter than sucrose, the same amounts as sucrose are usually added to drinks. Fructose enters cells via a non-insulin mediated Gut 5 mechanism which is present in glial cells but not in neurons, so there
is no apparent satiety signal from a large dose of fructose. Overweight subjects fed 28% of energy as sucrose (152g/day) who did not compensate for this extra energy gained 1.6kg over 10 weeks, in comparison with subjects fed a non-sucrose sweetener with a lower energy level. Ludwig et al. has shown that the baseline consumption of sugar-sweetened drinks was related to BMI in 548 children, and that the BMI gain over 19 months was also related with a gain of 0.24 kg/m² per serve.

Figure 1. Change in total carbohydrate consumption in the United States between 1909 and 1997, reflected by the replacement of whole grains (smaller circles) with corn syrup (larger circles)

Metabolism of Fructose
Metabolically, fructose behaves quite differently from glucose by not provoking a dramatic insulin response (about 40% of glucose) and is additive to the insulin response induced by protein. The glycemic index is low at 20 to 25 (rather than zero) and it appears to provoke (or fails to suppress) the release of glucose from the liver over the 2 hour test period. It augments the insulin response to starch or glucose (up to 3 fold higher), particularly when glucose is high by stimulating pancreatic glucokinase which is required for the insulin response. Therefore, it has been recommended for diabetic patients in low doses to improve glucose control. It also appears to be slightly more thermogenic than glucose (7.5% versus 6.2%) and leads to increased gluconeogenesis at 4 hours as it is rapidly taken up by a very active fructokinase split into trioses and converted into glycogen.

Fructose and Lipids
As fructose is rapidly taken up into the liver via an unregulated fructokinase and split into trioses, it can either be converted into glycogen through the controlling fructose 1,6 bisphosphatase, or into triglycerides. Thus, it is possible, depending on the glycogen stores of the liver and the amount of fructose ingested, for an elevation of post-prandial triglyceride and even fasting triglyceride. Both of these have been shown in men consuming 17% of energy as fructose in comparison with glucose. This intake of fructose is now not extreme as 1 in 4 children may consume this amount. Many studies have shown no rise in fasting triglyceride but several studies have shown both a rise in fasting triglyceride and LDL cholesterol and apoB or LDL alone.
Feeding fructose at high levels to rats (35% of energy) was shown long ago to lead to both elevated triglyceride and to insulin resistance (as assessed by a glucose clamp) in comparison with glucose. Lingelbach et al. showed that this effect persisted over 26 months and was not related to an increase in body weight which was similar on cornstarch, glucose, fructose or a mixture of glucose and fructose (fed as 66% of energy).

In humans, dietary fructose was related to insulin resistance (as assessed by an elevated C-peptide) in 2,000 women in the Nurses Health Study, while Faeh et al. (25% additional calories from fructose) found that there was impaired insulin suppression of free fatty acid released from adipose tissue (thus insulin resistance) in comparison with glucose. Fasting glucose was also elevated by 7%, fasting triglycerides by 79%, while endogenous glucose production rose by 14% and de novo lipogenesis was elevated six fold. There was no change in whole body insulin mediated glucose disposal. Teff et al. also demonstrated high plasma triglyceride with fructose and lower insulin and leptin as well as absent post-prandial suppression of ghrelin. All of the last three effects may impair satiety and induce greater food intake.

Resistant Starch and Obesity
Resistant starch is that fraction of starch that escapes absorption in the small intestine which is frequently fermented in the large bowel to short chain fatty acids which are absorbed in the colon. Thus, depending on the contribution of the starch to microbial mass, some of the energy is excreted. Behall et al. has computed that the energy value of resistant starch is 2.8 Kcal/g or (11.7kJ/g) rather than 4 Kcal/g. High amylose diets produce less hydrogen in subjects with hyperinsulinemia and a high BMI suggesting they are more efficient at metabolising or fermenting the starch with less energy wastage, although the number of subjects was very small. Resistant starch does not appear to impact on satiety or energy intake, energy expenditure or carbohydrate or fat oxidation even though post-prandial glucose and insulin responses are lower, and there is some evidence that it may enhance insulin sensitivity. Resistant starch does not lower glycemic index as only available carbohydrate is counted for the 50g carbohydrate load.

Fiber and Obesity
High fiber diets (48g/day) promote starch and protein malabsorption, and lead to losses of about 150Kcal compared with low fiber diets (19.7g/day). Baer et al. demonstrated that increasing fiber from 18g/day to 36g/day in men led to the loss of about 540KJ/day in metabolisable energy. Dietary fiber itself is not inert and is partially fermented and contributes from 2.5Kcal/g (cereal fiber) to 3.1Kcal/g (fruit and vegetable). Sugar alcohols also have a similarly reduced energy.

High fiber diets have been associated with a lower BMI in the 5,000 subjects in the Swedish Obesity Study and in other small and large study cohorts, while ecological analysis shows that high fiber consuming populations tend to have lower rates of obesity. Longitudinal studies have shown that weight gain is inversely associated with fiber intake and whole grain foods.

Interventions in obese subjects with fiber have produced very variable results ranging from no effect to about 2.2 kg loss of weight. A meta-analysis of all studies that supplied a supplement
of 14g/day or more for greater than two days was associated with a short term reduction in energy intake of about 10% and a weight loss of 1.9kg over an average of 3.8 months. Fiber may work by enhancing satiety, possibly via an increase in cholecystokinin.

Conclusions

The association of high carbohydrate diets with reduction in obesity are most likely related to fiber content of the carbohydrate source and to the content of whole grain cereals, fruit and vegetables, while starch per se, whether highly available or resistant, probably plays a minor role. Fructose may contribute to weight gain.

References

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Carbohydrates and Oral Health - Dental Caries: Population Approaches to Prevention

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Introduction
There have been various theories regarding the causation of dental caries. However, the theory which has accumulated and sustained evidence over more than a century has its origins in the chemico-parasitic theory of WD Miller in 1890.1

In essence, the theory holds that: fermentable carbohydrates (sugars) metabolised by oral microflora (bacteria) produce organic acid. When sustained in close proximity to the tooth surface over time, such organic acid will cause a demineralisation of the dental enamel and the consequent initiation of dental caries.2

Animal studies, in vitro laboratory studies, observational population studies3-7 and the Vipeholm Dental Caries Study8 provide extensive and strong evidence of the causal link between fermentable carbohydrates (especially fermentable sugars), normal oral flora (particularly streptococcus and lactobacillus) and the formation of organic acids. In recent decades, the nature and formation of dental plaque has added to the environmental matrix which sustains bacterial growth, adherence of bacteria to the tooth surface and a medium through which organic acids demineralise the enamel structure of the tooth surface.9 Dental plaque also acts as the medium through which saliva buffers and fluoride may interact in a dynamic process related to waves of demineralisation followed by remineralisation of the tooth surface.2 Depending upon the mix of ions, the pH and the presence of fluoride, the enamel surface of the tooth may either lose or gain enamel crystals.2

The declining rates of dental caries in many industrialised nations9 together with stable or increasing level of sugar consumption, have led some to argue that the role of fermentable sugars in the diet is no-longer a concern as the impact on the causation of dental decay is substantially outweighed by the benefits of fluoride toothpaste, water fluoridation, greater emphasis on personal oral hygiene, and better access to dental care.

There is little doubt from the extensive literature on the use of fluorides, especially water fluoridation and fluoride toothpaste usage, that fluorides have had a significant impact on reducing dental caries at a population level.9 What is clouded by this major decline in dental decay across large population groups has been the differential impact of fluorides and fluoridation across social sub-groups within the broader population. Higher exposures of low-income and other groups to risk factors have increased the gap between those with decay and those without.
Population Health
Population health has been defined by Health Canada\(^1\) as:

"... an approach to health which aims to improve the health of an entire population and to reduce the health inequities among population groups. In order to reach these objectives, it looks at and acts upon the broad range of factors and conditions (commonly referred to as the determinants of health) that have a strong influence on our health."

The population health approach builds on the principles of public health, community health, and health promotion. Key objectives of a population health approach are to improve health status outcomes and reduce inequalities and inequities.

Watt and colleagues\(^2\) eloquently illustrate the integration of the myriad of factors - social, cultural, economic, behavioural, and biological - which impact on oral health status (Figure 1.) Diet, hygiene and the biology of the disease process impact on oral health but are influenced by major behavioural, social and economic aspects of an individual's total environment.

Figure 1. Social determinants of oral health

The challenge then, is to balance our understanding of individual responsibility for the causation of diseases against the cultural, social and economic drivers that influence our diet and behavioural choices and opportunity. There is a public obligation on governments and their agencies, through public health laws, regulations, policy and funding disbursements, to make corrections for inequities in both power and health outcomes across certain population groups within their jurisdictions.

Within the New Zealand context,\(^3\) intervention strategies to reduce inequalities in health outcome are conceptualised at four levels of activity:
• **Structural level pathways** - which tackle the root causes of health inequalities, for example, social, economic, cultural and historic factors that have fundamentally determined health outcome;

• **Intermediate level pathways** - targeting materials, psychological and behavioural factors that mediate the impact of structural factors on health;

• **Health and disability services pathways** - which undertake specific actions within a service delivery framework; and

• **Impact pathways** - promoting those activities which minimise the impact of disability and illness on socio-economic position.

Burt,\textsuperscript{14} drawing on population oral health experience, described strategic oral health promotion intervention at differing levels, for example: personal; group/family; and population level.

Table I illustrates the types of oral health intervention which could be associated with the four predominant risk factors related to the causation of dental caries. For example, with respect to fermentable sugars, at a personal level, an individual should be informed about a particular product, the type and potential of the product to initiate dental decay, and have developed the necessary decision-making skills to select a product appropriate to his/her needs and/or concerns. At a group level, for example a school setting, a school should have health-related policies consistent with their community’s informed aspirations and the capacity to raise funds, provide food and drinks within the school environment supportive to the health needs of their children. At a broader population level, sensible and balanced information on diet and nutrition should be provided by health and educational agencies which incorporates the oral health relationships to general health outcomes. Governments and industry need to work collaboratively to determine the best strategies for making healthy and easy choices for their communities. This may take the form of accords between industry and public institutions, or regulations. Finally, alternatives to fermentable sugars, for example, xylitol or other alcohol sugars or sugar substitutes, should be clearly labelled and available across confectionary and other products.

Table 1. Relationship between level of intervention (personal, group and population) risk factors and health promotion activity.

<table>
<thead>
<tr>
<th>Risk factors/Level of Intervention</th>
<th>Personal</th>
<th>Group</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sugars</strong></td>
<td>• Information • Personal decision skills</td>
<td>• Supportive environments • Food policy</td>
<td>• Information • Accord vs Regulation • Alternatives</td>
</tr>
<tr>
<td><strong>Bacteria</strong></td>
<td>• Oral hygiene • Therapeutic dentifrices</td>
<td>• Supportive environments • Health policy</td>
<td>• Information • Intersectoral collaboration • Tax options</td>
</tr>
<tr>
<td><strong>Acid</strong></td>
<td>• Salivary stimulants • Buffers</td>
<td>• Awareness</td>
<td>• Information • Intersectoral collaboration</td>
</tr>
<tr>
<td><strong>Tooth</strong></td>
<td>• Access to services • Fluoride • Sealants</td>
<td>• Supportive environments • Health policy</td>
<td>• Easy service access • Priority programs • Fluoridation • Intersectoral collaboration</td>
</tr>
</tbody>
</table>
The population health approach also focuses attention on the social disparities in disease distribution across a nation or population. Oral diseases are not equally distributed across communities, low income, minority ethnic groups, and people with co-morbidities tend to carry higher burdens of dental disease. Information collected through the New Zealand School of Dental Service illustrate both the overall improvement in oral health in New Zealand children over the past two decades, the plateauing of disease levels from the early 1990s, and the variation in distribution of dental decay by fluoride exposure and ethnic background.

Figure 2 shows the change in the severity of dental decay in five and 12 year-old New Zealand children from the 1950s through to 2004. The major decline in dental decay occurred in the decades between 1960 and 1990. Since the early 1990s, there has been little change in the "average" severity of dental decay in 5 and 12 year-old New Zealand school children.

Figure 2. Changing severity of dental decay in New Zealand children

Note:
Severity of dental disease in the primary dentition is expressed as the dmft index and in the permanent dentition as the DMFT index. Each of these indices represents the accumulative decay, extracted or filled teeth present at the time of dental examination.

However, breaking down these aggregate data by water fluoridation (Is the child’s school in a fluoridated area?) and by ethnic background (M_ori, Pacific and other) shows marked variation in dental decay (Figures 3 and 4).
Figure 3. Severity of dental caries in New Zealand in 5 and 12 year-old children by water fluoridation in 2003

For example, 5 year-old New Zealand children had, on average, 1.9 primary teeth affected by dental decay (dmft). However, in non-fluoridated areas this rate was 2.4 dmft compared with 1.4 dmft in fluoridated areas, a difference of some 71 percent. Similarly, for 12 year-old children, the DMFT experience in non-fluoridated areas was, on average, 1.8 teeth, whereas in fluoridated areas, on average, the experience was 1.3 DMFT.

Similarly, when aggregate data are broken down by ethnic background and fluoridation status, variations are also apparent (Figure 4.) This example of five year-old children shows both the benefit of water fluoridation – irrespective of ethnic group, there is, on average, a lower rate of dental decay – and variation by ethnic group. Where Mãori children have on average, about two-and-half times the rate of dental decay than “other” (largely European) children in fluoridated and non-fluoridated areas.

The explanation of differentials in decay rates between ethnic groups cannot therefore be explained simply on the basis of difference in exposure to water fluoridation. Other key diet and cultural differences need further exploration. A survey on the nutritional and health status on New Zealand children aged between 5 and 14 years\(^7\) may provide some insight into diet-culture related variation which could at least in part help explain the differences in decay experience.
The NZ Food: NZ Children (2003) report documented significant variation in food and sugar consumption patterns between various social and ethnic groups in New Zealand. Specifically, the report noted that:

- Māori and Pacific children were more likely to buy food from a shop, tuck-shop or take away;
- Māori and Pacific children were more likely to drink powdered fruit drink, cola drinks and soft drinks;
- sucrose was the main contributor to total sugars consumed;
- the highest intake of sugars was among Māori children; and
- the main sources of sucrose were non-alcoholic beverages (26%), sugar and sweets (21%) and biscuits and fruit (11%).

Reconstructing Appropriate Population Models of Oral Health Promotion

There have been a number of suggestions related to how best the promoters of improving population oral health may reconfigure an approach to prevention which is built upon the WHO Model of the Ottawa Charter and a closer integration of oral health and general health outcomes.

Sheiham and Watt proposed a "Common Risk Factor" approach. Their theory holds that the causation of oral disorders (dental decay, periodontal diseases) has similar origins (diet, stress, hygiene, smoking, alcohol etc) to the causation of general disorders (such as diabetes, obesity, cancers, cardiovascular, respiratory diseases etc.) The prevention of oral disorders therefore should be based on a strategic framework linking oral and general medical health promotion activities and resources. A wider range of partnerships and sector involvements would be involved in preventing dental disease and dental caries.

Similar conceptual models have been advanced by the Ministry of Health (New Zealand) in their "Leading for Outcomes" approach - which again takes a holistic approach to managing a range of chronic diseases. Figure 5 summarises the relationships between the major social and system outcomes in reducing health inequalities and the prevention of chronic diseases.

Figure 5. Leading for outcomes approach
Both the Common Risk Factor and the Leading for Outcomes approaches provide integrative models which link the biological causes of chronic diseases through the range of behavioural intermediaries to the social determinants of disparities in health outcome.

Within the population health approach therefore, although there is recognition of the importance of biological causation and individual health interventions, increasingly the focus is toward prevention at a population level involving multiple strategies and inter-sector alliances in the prevention of oral disorders and dental decay. The growing evidence base to support the use of non-caloric sugars at a population level, alliances between industry, professions and health agencies and linkages outside traditional oral health service activities will be a feature of changing attitudes and strategies to the prevention of dental caries in the next two decades.

Summary
The original paradigm of the relationship between sugars and dental decay has accumulated high levels of supportive evidence over a century of research and enquiry. Although the relationship between sugars and dental decay is modified in contemporary society by socio-cultural differences in risk exposure, environmental fluorides and level of community empowerment, the paradigm remains essentially intact. Public health agencies will continue to explore a comprehensive mix of interventions and strategies to prevent dental caries, including sugar restriction and fluoride promotion policies, across multiple settings and working across sectors with collaborative alliances.

References


Carbohydrates in the Prevention and Treatment of Diabetes

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*Australia*

**Introduction**

For most people, carbohydrate-containing foods are the major source of kilojoules in their daily diet. Evidence is growing that carbohydrate-containing foods are causally related to the development of Type 2 diabetes via their effect on post-prandial glycemia. Also, the type and amount of carbohydrate can be manipulated to achieve and maintain optimal glycemic control in people with existing diabetes.

**Definitions**

In 1998, the World Health Organisation/Food and Agriculture Organisation (WHO/FAO) recommended that the term "glycemic carbohydrate" be adopted to describe digestible carbohydrates, and that they be defined as carbohydrate for metabolism'. Glycemic carbohydrate can be calculated by summing the average quantity of total available sugars, starch, oligosaccharides, glycogen and maltodextrins2.

Non-glycemic carbohydrate, otherwise known as non-digestible carbohydrate or dietary fiber, was originally described as: "...that portion of food which is derived from cellular walls of plants which is digested very poorly by human beings". Despite several decades of research, there is currently no single analytical method for the measurement of dietary fiber in foods.2

By definition, the glycemic index (GI) compares equal quantities of available carbohydrates in foods, and provides a measure of carbohydrate quality. The glycemic load (GL), on the other hand, is a function of a food's glycemic index and its total available carbohydrate content and defined by the equation:

\[
\text{Glycemic Load} = \text{Glycemic Index} \times \text{Carbohydrate (g)}
\]

The GL gives a more complete picture of the effect of a "typical" serve of carbohydrate-containing food on blood glucose levels. Foods with a GL \(\leq 10\) have a low GL, and those with a GL \(\geq 20\) have a high GL3. The higher the GL, the greater the expected elevation in blood glucose levels1.

It can be seen from the equation that either a low GI-high carbohydrate food or a high GI-low carbohydrate food can have a low GL. However, while the effects on post-prandial glycemia may be similar, there is evidence that the two approaches will have very different metabolic effects, including differences in β-cell function5, triglyceride concentrations6, free fatty acid levels6 as well as effects on satiety7. Hence the distinction has important implications for the prevention and management of diabetes and associated cardiovascular disease.
Carbohydrates in the Prevention of Diabetes

In the last decade, a significant number of studies have investigated the relationship between GI, GL and dietary fiber, and the risk of developing Type 2 diabetes. The first was in 1997 by Salmeron et al.,8 who studied prospectively a cohort of 65,173 American women, aged 40 to 65 years, using a food frequency questionnaire (FFQ) to assess nutrient intake. The ability of the FFQ to accurately assess the individual’s carbohydrate intake was determined by comparison with weighed food records and found to be relatively high (r=0.81). Overall, it was found that high GI diets increase the risk of developing diabetes by 37%, compared to low GI diets. The average GI of those at least risk was 44, total carbohydrate was moderate at 184g/day (41% of energy), GL was 81, total fiber intake was 24g/day, and cereal fiber intake was 7.5g/day.

Later that year, Salmeron et al.9 published results of a methodologically similar study, this time looking at 42,759 American men aged 40 to 75 years. This study also found that high GI diets increase the risk of developing diabetes by 37%, compared to low GI diets. The average GI of those at least risk was 46, total carbohydrate was higher at 222g/day (44% of energy), GL was 101, total fiber intake was 29.7g/day, and cereal fiber intake was 10.2g/day.

In 2004, Schulze et al.10 published the results of their prospective study of a cohort of 91,249 American women, aged 24 to 44, using a similar FFQ to that in the Salmeron et al. studies. Correlation of the FFQ with weighed food records was good at 0.64 for total carbohydrate. The study found that the high GI diet increased the risk of developing Type 2 diabetes by 59%. The median GI of those at least risk was 49, total carbohydrate was higher at 215g/day (47% energy), GL was 107, total fiber intake was 23.1g/day, and cereal fiber intake was 9.9g/day.

Also published in 2004, Hodge et al.11 studied prospectively a cohort of 36,787 Australian men and women, aged 40 to 69. Unfortunately, no objective measures of FFQ validity were reported. The study found that the high GI diet increased the risk of developing Type 2 diabetes by 32%. The GI of those at least risk was <46, total carbohydrate was moderate at 237g/day (41% energy), GL was <109, total fiber intake was 31g/day, and cereal fiber intake was 10.4g/day.

In 2000, Meyer et al.12 published the results of their prospective study of a cohort of 35,988 American women, aged 24 to 44, using a FFQ that was stated as being similar to that in the Salmeron et al. studies. Correlation of the FFQ with weighed food records was relatively low at 0.45 for total carbohydrate. The study did not find that a high GI/GL diet increased the risk of developing Type 2 diabetes. Instead, the study found that a diet high in dietary fiber (>23.6g/day) decreased the risk of Type 2 diabetes by 32%.

In 2002, Stevens et al.13 published the results of their prospective study of a cohort of 12,251 African-American and American white men, aged 45 to 64, using a FFQ that was stated as being similar to that in the Salmeron et al. studies. Unfortunately, no objective measures of FFQ validity were reported. Again, this study did not find that a high GI/GL diet increased the risk of developing Type 2 diabetes. Instead, it found that a diet high in total dietary fiber (26.1g/day to 27.5g/day) and in particular cereal fiber (4g/day to 5.1g/day) decreased the risk of Type 2 diabetes by 14% to 25%. The total carbohydrate intake of the groups with the highest fiber intake was 226g/day to 231g/day (50% to 51% of energy).
In summary, epidemiological evidence suggests that the consumption of moderate-high carbohydrate (184g/day to 215g/day or 41% to 47% of energy in women; and 222g/day to 237g/day or 41% to 51% of energy in men), high total (>23g/day) and cereal fiber (>5g/day), low GI (44 to 49), low GL (81 to 109) diets are effective in the prevention of Type 2 diabetes. Based on this evidence, it is unlikely that a low carbohydrate, low fiber, high GI (and as a consequence) low GL diet will have the same protective effect.

Carbohydrates in the Management of Diabetes

There have been two recent meta-analyses of the role of carbohydrates in the dietary management of diabetes. In 2003, Brand-Miller et al. analysed evidence from 14 studies of either randomised crossover or parallel experimental design and between 12 days' to 12 months' duration, with a total of 356 subjects. Low-GI diets reduced HbA1c by 0.43% points over and above that produced by high-GI diets. Taking both HbA1c and fructosamine data together and adjusting for baseline differences, glycated proteins were reduced by 7.4% (8.8 to 6.0) more on the low-GI diet than on the high-GI diet.

In 2004, Anderson et al. analysed evidence from over 56 clinical trials conducted over the previous 25 years. Their analysis suggested that a higher carbohydrate (55% to 65% of energy), high fiber (25g/day to 50g/day), lower GI diet facilitates optimal nutritional management of existing diabetes. Globally, most Diabetes Associations are now recommending this approach for people with diabetes.

Hypothesised Mechanisms

Two major pathways have been proposed to explain the protective effect of low GI/GL diets. Firstly, the same amount of carbohydrate from high GI foods produces higher blood glucose concentrations and a greater insulin demand. The chronically increased insulin demand eventually results in pancreatic exhaustion. Secondly, there is evidence that high GI diets may directly increase insulin resistance.

The protective effect of dietary fiber is thought to relate specifically to the cereal fractions. In their recent review, Venn and Mann suggest that the improvement in glucose handling that is associated with diets high in cereal fiber appears to be related to the presence of the intact structure of the food. Food processing disrupts cell structures, rendering starches more available for digestion and absorption. The net result will be a food with a higher GI.

Putting Recommendations into Practice

The simplest way to habitually consume a moderate-high carbohydrate, high fiber, low GI diet is to follow official Dietary Guidelines, like those for Australians listed in Table 1, which are similar to those released by government health authorities throughout most of the world, and to incorporate into these, the recommendations of the WHO/FAO. The Dietary Guidelines promote a moderate-high carbohydrate diet and the WHO/FAO recommends that GI be used to compare foods of similar composition within food groups, and to choose the lower GI option. By choosing the lowest GI food within a food group, an individual will most likely be choosing the food with the lowest GL, because by definition, the macronutrient profile is essentially the same within a food group.
Table 1: The Dietary Guidelines for Australians

<table>
<thead>
<tr>
<th>Enjoy a wide variety of nutritious foods:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Eat plenty of vegetables, legumes and fruit;</td>
</tr>
<tr>
<td>• Eat plenty of cereals (including breads, rice, pasta and noodles), preferably whole grain;</td>
</tr>
<tr>
<td>• Include lean meat, fish, poultry and/or alternatives;</td>
</tr>
<tr>
<td>• Include milks, yoghurts, cheeses and/or alternatives. Reduced-fat varieties should be chosen, where possible; and</td>
</tr>
<tr>
<td>• Drink plenty of water.</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Take care to:</th>
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<tbody>
<tr>
<td>• Limit saturated fat and moderate total fat intake;</td>
</tr>
<tr>
<td>• Choose foods low in salt;</td>
</tr>
<tr>
<td>• Limit your alcohol intake if you choose to drink; and</td>
</tr>
<tr>
<td>• Consume only moderate amounts of sugars and foods containing added sugars.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Prevent weight gain:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Be physically active and eat according to your energy needs.</td>
</tr>
</tbody>
</table>

Consumer Understanding of Glycemic index

It has been suggested that the glycemic index is too complicated for the average consumer to understand and use in food planning. The Glycemic Index Symbol Program (GISP) was launched in Australia in July 2002 to help everyday consumers use the GI when shopping for food. The program aims to identify foods that have had their GI tested at an accredited facility, contain at least 10g of carbohydrate per serve, and meet strict nutritional criteria for kilojoules, total and saturated fat, fiber and/or sodium, depending on their food group.

In January 2002, a representative random sample of approximately 500 adult grocery buyers was surveyed in Australia, and follow up surveys have been conducted annually since. Before the launch of the GISP, 28% of respondents had heard of the GI. By Jan 2005, 86% had heard of the GI, and 84% said it would be likely that they would use the GI when making food choices. In 2005, 77% said that GI measures the rate at which food raises blood glucose levels and 59% correctly identified low GI foods as being the most beneficial for general health. The results of the GISP research suggest that consumers are able to understand and use the GI when shopping for food.

Conclusions

There is growing evidence that moderate to high carbohydrate, high fiber (particularly cereal fiber) diets with a lower glycemic index, and as a consequence lower glycemic load, may prevent Type 2 diabetes. Similarly, clinical trials suggest that this pattern of eating facilitates optimal management of people with existing Type 2 diabetes, and as a consequence is recommended by most Diabetes Associations, globally. The simplest way for people with diabetes, and those trying to prevent it, to achieve this dietary pattern, is to follow national dietary guidelines for healthy eating, and to choose foods with lower GI's within each food group.
References
6. Wolever TMS and Mehling C. Long-term effect of varying the source or amount of dietary carbohydrate on postprandial plasma glucose, insulin, triacylglycerol, and free fatty acid concentrations in subjects with impaired glucose tolerance. Am J Clin Nutr. 2002;76 (1): 5-56.
Non-Digestible Carbohydrates: Blood Pressure, Cholesterol and Cardiovascular Health

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Background
Diet and lifestyle factors are the major causes of cardiovascular disease. Changing diet and lifestyle is also the most effective population-based approach for the prevention of cardiovascular disease. A range of dietary factors, such as plant food intake, total, saturated and omega-3 fat intake, sodium and potassium intake, alcohol intake, B-group vitamin intake, and intake of antioxidants have been related to cardiovascular health. These dietary factors are believed to influence an array of pathogenic processes such as inflammation and oxidative stress, impaired coagulation and thrombosis, endothelial dysfunction and atherosclerosis. These processes result in features of the metabolic syndrome, which include hypertension, hypercholesterolemia, insulin resistance and diabetes, and obesity.

There has been considerable interest over the past 25 years in the role of carbohydrates in cardiovascular health. Much of the research in this area has focused on the amount and type of carbohydrate, as well as the composition of the carbohydrate ingested in relation to cardiovascular disease and related endpoints. One of the major components thought to be protective are the non-digestible carbohydrates, or dietary fiber.

Definitions
Dietary fiber consists of non-digestible carbohydrates that are naturally present in plant foods. Non-digestible means that the carbohydrate is not digested in the small intestine. Isolated sources of non-digestible carbohydrates can also be included in the diet as added fiber. These sources of fiber have been particularly useful in addressing hypotheses relating to potential beneficial effects of fiber in the diet using randomized controlled trials. An important difference between dietary fiber and added fiber is that dietary fiber is present together with other macronutrients, micronutrients and phytochemicals, which might also influence outcomes of interest.

Dietary Fiber and Cardiovascular Disease: Population Studies
Many cross-sectional and prospective epidemiological studies have examined the association between dietary fiber intake and cardiovascular disease endpoints. The results of these studies are consistent in pointing to an inverse association of fiber intake and foods rich in dietary fiber with risk of cardiovascular disease. Higher fiber intake is also often inversely associated with risk factors for cardiovascular disease, including body weight and abdominal fat distribution, blood glucose and insulin and risk of diabetes, blood pressure, and cholesterol and triglyceride concentrations.
The best available evidence for a link between dietary fiber and cardiovascular disease comes from prospective cohort studies. Pereira and others\(^6\) performed a pooled analysis of 10 prospective cohort studies that examined the relationship of dietary fiber with risk of heart disease. All these studies were from US and European populations. Relationships with risk of coronary heart disease of total dietary fiber, and cereal, fruit and vegetable fiber were assessed. A subset of the studies also included data on soluble and insoluble fiber. Estimates of risk reduction were based on a 10g/day increment in fiber intake. Total dietary fiber intake was associated with a 14% and 27% reduction in risk of a coronary event and death, respectively. Both cereal and fruit fiber were associated with similar (10% to 30%) and independent reductions in risk. Vegetable fiber was not associated with any change in risk. In those studies that assessed soluble and insoluble fiber, the risk reduction appeared to be greatest for soluble fiber. The overall risk reductions were similar in men and women.\(^6\)

Legumes are not a major contributor to fiber intake in US and European populations. Therefore, the relationship between legume fiber with cardiovascular disease risk within populations remains uncertain. Furthermore, there are few population data linking intake of resistant starch with cardiovascular disease. However, a protective effect of resistant starch as part of whole grain foods remains plausible.\(^7\)

A limitation of population studies is that it can be very difficult to dissociate responses to fiber itself from consuming a diet rich in high-fiber foods. The relationships of fiber intake with cardiovascular disease endpoints are usually independent of a range of other dietary, lifestyle and socioeconomic factors that could confound the relationships. However, statistical techniques are unlikely to fully account for all possible confounding factors. Therefore, randomized controlled trials are needed to establish causality. To date, there are no randomized controlled trials with fiber for primary or secondary prevention of cardiovascular disease. We must therefore rely on data on effects of fiber on features of the metabolic syndrome. The focus of this review is on hypertension and hypercholesterolemia.

**Blood Pressure and Cholesterol: Importance for Cardiovascular and Total Mortality**

High blood pressure and cholesterol are major risk factors for cardiovascular disease. High blood pressure is the most important risk factor and high blood cholesterol the third most important risk factor (after tobacco) for total mortality worldwide.\(^6\) Both risk factors increase risk of mortality primarily through increased risk of cardiovascular disease, which is now responsible for more than 30% of all deaths worldwide. In addition, significant health gains could be achieved by reducing the prevalence of these risk factors.\(^9\)

The prevalence of hypertension and hypercholesterolemia is projected to increase considerably in the next 25 years, with much of the increase to occur in countries in the Asian region.\(^8\) Important questions then are: "Can fiber intake play a role in reducing blood pressure and cholesterol concentrations?"; and "Might an increase in fiber intake reduce the risk of cardiovascular disease via effects on blood pressure and cholesterol?".
Fiber and Blood Pressure: Randomized Controlled Trials

Research into the potential blood pressure-lowering effect of dietary fiber began more than 25 years ago. Early studies identified populations with higher fiber intake and lower blood pressure, such as vegetarians. Epidemiological studies have generally found an inverse association between fiber intake and blood pressure.

During the past 20 years, more than 20 randomized controlled trials have reported the effects of dietary fiber on blood pressure. Two recent meta-analyses have assessed the effect of fiber on blood pressure. Similar findings were reported from each of these analyses. The average increase in fiber intake in all studies was about 1.1g/day. Overall, systolic blood pressure was reduced by approximately 1.1mm Hg, which did not reach significance, and diastolic blood pressure fell by approximately 1.5mm Hg, which was significant. Both analyses also went on to look at factors that might predict a greater response to fiber. There was little or no change in blood pressure in normotensive individuals. Amongst individuals with hypertension, the falls in systolic and diastolic blood pressure were greater (approximately 6 mm Hg and 4 mm Hg, respectively). Other factors that were associated with greater falls in blood pressure were older age and being overweight, both of which may be related to hypertension, and longer-term interventions. The source of fiber was not strongly related to the effects observed. These analyses indicate that an increase in fiber intake, particularly in Western populations with low fiber intake, can lower blood pressure.

The effects on blood pressure of an increase in dietary fiber from whole foods have also been investigated. For example, a higher fiber vegetarian diet and the DASH-type diet have been found to reduce blood pressure. These higher fiber diets have been shown to reduce systolic and diastolic blood pressures by between 3 and 5 mm Hg, and 2 and 3 mm Hg, respectively. However, other components of the diet including fatty acids, antioxidants and phytochemicals are also likely to have contributed to these effects.

Fiber and Cholesterol: Randomized Controlled Trials

The effects of fiber on blood cholesterol and triglyceride concentrations have been thoroughly investigated using randomized controlled trials. There have been about 150 trials, with most of these focusing on the effects of added soluble/viscous fiber. Meta-analyses and systematic reviews of these trials show that 10g/day of added soluble fiber results in an 8% to 10% reduction in total and LDL cholesterol concentrations. The major sources of fiber have included oat bran, psyllium, pectin and guar gum, and the magnitude of the effect appears to be similar across sources. There is a dose-response relationship up to about 10g/day. Although higher initial cholesterol concentrations are related to a greater magnitude of cholesterol lowering, the difference in responsiveness is not large. The effects of soluble fiber on HDL cholesterol and triglycerides are minimal. Insoluble fiber from cereals has little impact on total and LDL cholesterol concentrations, but may lower triglyceride concentrations.

More consistent effects on the entire lipid profile are observed when food is used as the source of dietary fiber. For example, controlled trials that have assessed the effects of legumes (not including soybeans) generally find significant reductions in total and LDL cholesterol and triglycerides, and suggest an increase in HDL cholesterol. However, other components of legumes, or fiber-rich, wholegrain diets are likely to contribute to observed benefits.
Limitations of Randomized Controlled Trials
A major limitation of randomized controlled trials is that to specifically test a hypothesis, isolated sources of fiber are used. Any conclusions then are limited to these added isolated fiber sources. However, in the diet, fiber is not consumed in isolation. There is potential for interaction with other components in the diet, and it is likely that dietary fiber will have a greater impact on blood pressure, cholesterol and other cardiovascular risk factors when accompanied with a range of other nutrients and phytochemicals. Trials that have used food sources of fiber would support this suggestion. The limitation of this approach is that any conclusions are not limited to the fiber itself.

Effects of Fiber on Blood Pressure, Cholesterol and Cardiovascular Health: Summary
The link between higher intake of fiber-rich foods, including wholegrain cereals, legumes, vegetables, fruits and nuts, and lower risk of cardiovascular disease and better risk factor profile is now quite strong. What continues to be less certain are the roles of fiber itself and other components of the diet that go along with the intake of fiber-rich foods in influencing cardiovascular risk. Another major difficulty is that dietary fiber includes many complex substances, each having unique physical properties.

Many randomized controlled trials have investigated the effect of fiber on two of the most important risk factors for cardiovascular disease: blood pressure and cholesterol. Dietary fiber and added fiber can reduce both blood pressure and cholesterol concentrations. The overall effect of fiber on both blood pressure and cholesterol is small, but is likely to be important in reducing risk of cardiovascular disease in populations. However, the effects of purified fibers on blood pressure and cholesterol may or may not be similar to intact dietary fibers because of the presence of other factors and the potential for interaction. This makes valid generalizations, based on results of randomized controlled trials, about the effects of added fiber difficult.

Conclusions
Results of population studies and randomized controlled trials suggest that fiber-rich foods can reduce blood pressure and cholesterol concentrations, and improve the risk of cardiovascular disease. The sources of dietary fiber most strongly related to reduction in cardiovascular risk are fruit and cereal fibers. There is good evidence for a causative link between fruit fiber and cardiovascular disease risk. Evidence for a causative link between cereal fiber and cardiovascular disease is less clear: there may be other attributes of fiber-rich cereals that reduce risk.

It is difficult to separate effects due to dietary fiber alone from those of other components of fiber-rich foods. The dietary fiber itself is likely to benefit cardiovascular health. Added fiber can reduce blood pressure and cholesterol concentrations, but the effects are modest. Added fiber may be useful for treatment of hypertension and hypercholesterolemia. However, use of added fiber is not the optimal approach to increasing fiber intake for cardiovascular risk reduction within populations. From a public health perspective, advice to increase fiber intake from fiber-rich whole foods will result in more pronounced benefits on blood pressure, cholesterol and cardiovascular disease risk.
References


Carbohydrates and Gut Health: Probiotics and Prebiotics

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Probiotics
The human intestine constitutes an ecologically complicated flora made up of more than 500 bacterial species, of which over 99% are anaerobic. They comprise an aggregate biomass of approximately 15kg, amounting to a hundred trillion (approx $10^{12}$ micro-organisms/cm$^3$ in the colon) and they possess an enormous range of enzymatic and metabolic activities that have an important impact on host nutrition and health. Habitual intestinal bacteria that are detrimental to the human host possess different enzyme activities to beneficial bacteria. An increase in both Bacteroides sp. and Clostridium sp. which form part of the human intestinal gut commensal has been measured in colorectal cancer patients, accompanied by a low percentage of Bifidobacteria. Intestinal bacteria such as Bifidobacterium sp. and Lactobacillus sp. act as probiotics. Probiotics are microbial supplements in food that beneficially affect the host by improving the intestinal microbial balance and have been demonstrated to significantly prevent diseases and improve human health. Ingestion of probiotics also helps to strengthen the gastrointestinal barrier to diseases. Specific strains of clinically demonstrated probiotics are presented in Tables 1 and 2.

The population of probiotic bacteria in the gastrointestinal tract could be supplemented by foods containing the desired strain of probiotics. In addition to host–bacteria and bacteria–bacteria relationships, diet has a very strong influence on the extent to which different intestinal bacteria colonize the intestine. Thus, an alternative approach in health promotion is to enrich the indigenous beneficial bacterial population through the consumption of prebiotics.

Prebiotics
A prebiotic is a food ingredient that selectively stimulates the growth and/or activity of one or a limited number of beneficial bacteria in the gastrointestinal tract, and thus improving host health. There are some advantages of using prebiotics to encourage the growth of indigenous beneficial bacteria over that of dietary probiotic supplement. Prebiotics are nonviable dietary components and therefore culture viability need not be maintained (as opposed to the case of probiotics). For the same reason, a much wider range of food and beverage carriers can be used. Heat stability (in the case of viable bacterial cells) and oxygen sensitivity (in the case of obligate anaerobic probiotics) are non-issues. An added advantage is that there is no question of the ability of colonization and persistence of exogenous probiotics in the gut. A bacterium needs to be able to remain in the gastrointestinal tract for a sufficiently long period of time in order to exert its probiotic effects. Exogenously administered probiotic bacteria have been found to persist in fecal samples for more than a few weeks after their administration has been stopped.
In order to promote the indigenous probiotics in the intestinal lumen, it is necessary that the prebiotic supplement must not be hydrolyzed and absorbed in the stomach or intestine. Prebiotics are therefore often in the form of: (1) resistant starch, (2) non-starch polysaccharides (pectin, cellulose, hemicellulose, guar, xylan), (3) oligosaccharides, and (4) complex sugars (lactulose, raffinose, stachose).\textsuperscript{19-22} Some of the common commercially available prebiotics are presented in Table I. Prebiotics could also be endogenous in their origin. These include mucin glycoproteins, muco-polysaccharides (chondroitin sulfate, heparin), and pancreatic and bacterial secretions.\textsuperscript{23, 24}

The advantage of prebiotics is their selectivity in promoting the growth and activities of beneficial components of the indigenous gut flora, without promoting the growth of potential pathogens. The specificity of prebiotics is determined by several factors.\textsuperscript{25}

- **Monosaccharide composition:** Glucose, galactose, xylose, fructose and fucose each form polymers of various length and complexities, and the breakdown products could be utilized by various range of bacteria;
- **Glycosidic linkage:** It determines selectivity of fermentation (e.g., cell-associated $\beta$-fructofuranosidase of bifidobacteria could hydrolyze fructooligosaccharides) and digestibility in intestine (e.g., a 1-6 glucosyl linkages in isomaltoooligosaccharides cannot be digested by human digestive enzymes); and
- **Molecular weight:** Long-chain inulin exerts effect in distal colonic regions than low molecular weight fructooligosaccharide. Thus, a mixture containing the two prebiotics, such as Orafti Synergie II may promote bifidobacteria along the whole stretch of the intestinal tract.

### Table I. Examples of commercially available prebiotics

<table>
<thead>
<tr>
<th>Prebiotic</th>
<th>Benefactors</th>
<th>Sources</th>
<th>Manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oligosaccharides</strong></td>
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<td></td>
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<tr>
<td>Fructooligosaccharides</td>
<td>Bifidobacteria</td>
<td>Jerusalem artichoke tubers $\beta$-fructofuranosidase Conversion of sucrose/inulin Chemical synthesis</td>
<td>Meiji Seika Kaisha (Japan) Beghini-Meiji Ind. (France) Golden Tech. (USA) Cheil Foods &amp; Chrm. (Korea) ORAFTI (Belgium) Cosucra (Belgium)</td>
</tr>
<tr>
<td>4’ Galactooligosaccharides</td>
<td>Bifidobacteria, Lactobacilli</td>
<td>Human/cow milk $\beta$-D-galactosidase conversion of lactose</td>
<td>Yakult Honsha (Japan) Nissin Sugar Man. (Japan) Snow Brand Milk Prod. (Japan) Borculo Whey Prod. (Holland)</td>
</tr>
<tr>
<td>4’ Galactosyl-lactose</td>
<td>Bifidobacteria</td>
<td>Human milk Palatinose synthase conversion of sucrose Intermolecular condensation of glucose</td>
<td>Mitsui Sugar (Japan)</td>
</tr>
<tr>
<td>Soy oligosaccharides</td>
<td>Bifidobacteria, Lactobacilli</td>
<td>Soybean/whey</td>
<td>Calpis Food Ind. (Japan)</td>
</tr>
<tr>
<td>Xylo-oligosaccharides</td>
<td>Bifidobacteria</td>
<td>Controlled endo 1,4-(\beta)-xylanase hydrolysis</td>
<td>Suntory (Japan)</td>
</tr>
</tbody>
</table>
Prebiotic Benefactors Sources Manufacturers

<table>
<thead>
<tr>
<th>Disaccharide &amp; polyol</th>
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</thead>
<tbody>
<tr>
<td>Lactulose</td>
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<tr>
<td>Lactosucrose</td>
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</table>

Scientific and Clinical Evidence for Prebiotic Effects

**Promote Growth of Lactic Acid Bacteria**
Fructooligosaccharides (FOS) and inulin have been demonstrated to selectively stimulate bifidobacteria in the human colon. In a study of Bouhnik et al. involving 20 volunteers, each received 12.5g/day FOS or placebo (saccharose) in three oral doses over three consecutive 12-day periods, the fecal bifidobacterial counts were observed to increase by 10-fold. Many lactic acid bacteria (strains of lactobacilli and bifidobacteria) have demonstrated probiotic properties (Tables 2 and 3).

Table 2. Probiotic bifidobacteria and their reported effects (after Salminen et al., 2004)

<table>
<thead>
<tr>
<th>Probiotic</th>
<th>Beneficial Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Lactis Bb-12</td>
<td>Treatment of viral diarrhea Balancing intestinal microbiota Reduce risk of traveler’s diarrhea Treatment of food allergy in infants</td>
</tr>
<tr>
<td>B. Lactis HN019</td>
<td>Immune enhancement Balancing intestinal microbiota</td>
</tr>
</tbody>
</table>

Table 3. Probiotic lactobacilli and their reported effects (after Salminen et al. 2004)

<table>
<thead>
<tr>
<th>Beneficial Effect</th>
<th>Probiotic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce recurrence of superficial bladder cancer</td>
<td>L. casei Shirota</td>
</tr>
<tr>
<td>Lower fecal enzyme activity</td>
<td>L. acidophilus NCFB L. acidophilus NFCM L. casei Shirota L. gasseri ADH</td>
</tr>
<tr>
<td>Decrease fecal mutagenicity</td>
<td>L. acidophilus NCFB</td>
</tr>
<tr>
<td>Reduce Streptococcus mutants activity</td>
<td>L. Rhamnosus GG</td>
</tr>
<tr>
<td>Prevent radiotherapy-related diarrhea</td>
<td>L. acidophilus NCFB</td>
</tr>
<tr>
<td>Treatment of rotavirus diarrhea</td>
<td>L. Rhamnosus GG, L. reuteri</td>
</tr>
</tbody>
</table>
Table 3. Probiotic lactobacilli and their reported effects (after Salminen et al. 2004) (continued)

<table>
<thead>
<tr>
<th>Beneficial Effect</th>
<th>Probiotic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevent antibiotic-associated diarrhea</td>
<td><em>L. Rhamnosus GG</em></td>
</tr>
<tr>
<td>Prevent traveler’s diarrhea</td>
<td><em>L. acidophilus La-5</em></td>
</tr>
<tr>
<td>Treatment of relapsing <em>C. difficile</em> diarrhea</td>
<td><em>L. Rhamnosus GG</em></td>
</tr>
<tr>
<td>Produce bacteriocins</td>
<td><em>L. acidophilus NFCM</em></td>
</tr>
<tr>
<td>Balance intestinal microbiota</td>
<td><em>L. johnsonii LAi</em></td>
</tr>
<tr>
<td></td>
<td><em>L. casei Shirota</em></td>
</tr>
<tr>
<td></td>
<td><em>L. acidophilus La-5</em></td>
</tr>
<tr>
<td></td>
<td><em>L. reuteri</em></td>
</tr>
<tr>
<td></td>
<td><em>L. rhamnosus DR10</em></td>
</tr>
<tr>
<td>Immune enhancement</td>
<td><em>L. johnsonii LAi</em></td>
</tr>
<tr>
<td></td>
<td><em>L. acidophilus La-5</em></td>
</tr>
<tr>
<td></td>
<td><em>L. rhamnosus DR10</em></td>
</tr>
<tr>
<td>Adjuvant in <em>H. pylori</em> treatment</td>
<td><em>L. johnsonii LAi</em></td>
</tr>
<tr>
<td>Alleviate atopic azema in infants</td>
<td><em>L. Rhamnosus GG</em></td>
</tr>
<tr>
<td>Prevention of atopic disease</td>
<td><em>L. Rhamnosus GG</em></td>
</tr>
<tr>
<td>Reduce cystic fibrosis symptoms</td>
<td><em>L. Rhamnosus GG</em></td>
</tr>
<tr>
<td>Enhance <em>Bifidobacteria</em></td>
<td><em>L. Rhamnosus GG</em></td>
</tr>
<tr>
<td>Treatment of lactose intolerance</td>
<td><em>L. acidophilus NFCM</em></td>
</tr>
<tr>
<td>Improve constipation</td>
<td><em>L. acidophilus NCFB</em></td>
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**Anti-Colon Cancer**

Dietary oligofructose and inulin have been shown to suppress the formation of colonic preneoplastic aberrant crypt foci formation in rat model. Studies suggested that the anti-cancer effects of prebiotics could be the following:

- Production of butyrate (by clostridia, eubacteria), which is known to stimulate apoptosis in colonic cell lines.
- Diversion of colonic metabolism from proteolysis (formation of carcinogens) to saccharolysis amongst clostridia & bacteroides; and
- Encourage growth of probiotics, thus leading to the suppression of carcinogenic enzyme producing bacteria (clostridia, *Escherichia coli*).

**Protect Against Pathogens**

Probiotics have been widely shown to protect the host from intestinal pathogens (Tables 1 & 2). A study in mice showed that dietary oligofructose and inulin protect the host from enteric and systemic pathogens and tumor inducers, which include the verocytotoxin producing *Escherichia coli* O157:H7 and campylobacters.

**Enhance Mineral Absorption**

In a study feeding 15g of FOS per day to 12 adolescent boys (14-16 years) for 9 days in placebo-controlled trial against sucrose, the outcome showed a 10.8% increase in calcium balance with no
significant effect on urinary excretion. The following mechanisms have been suggested to enhance calcium absorption:

- Fermentation lead to production of short chain fatty acid (SCFA) and luminal pH reduction, which increases calcium solubility;
- Calcium exchange with proton (from SCFA) liberated into lumen; and
- Metabolize insoluble phytate from vegetative dietary components to release calcium.

**Effect on Blood Lipid & Sugar**

In an animal model using rat, dietary supplement of 10g/100g body weight of FOS was observed to decrease serum triacylglycerol as a consequence of a reduction of de novo liver fatty acid synthesis. The depression in the activity of all lipogenic enzymes and fatty acid synthase mRNA suggests that FOS modifies the gene expression of lipogenic enzymes. FOS also significantly decreases serum insulin and glucose, which are both known to participate in the regulation of lipid synthesis.

**Food Application of Prebiotics**

A daily dosage of at least 4g to 8g of FOS has been cited as necessary to significantly elevate bifidobacteria in an adult human gut. Most of the prebiotics used in food application are targeted at bifidobacteria and lactobacilli. In Yakult 80 Ace (containing 3x10^9 L. casei Shirota), 2.5g oligosaccharides are added into the 80 mL cultured milk to promote the growth of the probiotic lactobacilli in the intestinal tract. In this case, the inclusion of prebiotic synergistically aids the defined probiotic lactobacilli in its establishment in the intestinal tract, and the mixture is termed synbiotics. The formula could be beneficial to the elderly, when fecal bifidobacterial counts markedly decrease. In an infant milk formula (Nestle Lactogen 2 Prebio), FOS and inulin are included to promote bifidobacteria, as in breast-fed infant.

**References**


Grains in the Diet: A Historical Perspective of Grain Nutrition

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The Philippines

Introduction
Grains coming from cereals constitute the major part of the diet in most of the world, especially in developing countries. The most widely cultivated grains are wheat, rice, maize, barley, oats, and rye. Other grains include sorghum, millet and triticale, and sometimes, a number of non-grass plants are called grains as well, such as buckwheat, flax and soybean, which in fact is a legume.

Cereals have all been cultivated since ancient times. Rice, for example, is a native of Asia, originating perhaps in India or Southeast Asia, and has been cultivated for more than 7,000 years. Evidence of cultivation has been found in eastern China dating from before 5,000 BC, and in a cave in northern Thailand from about 6,000 BC.

Grains appear in the diet in many forms, and Asia is particularly noted for the numerous varieties in which they are prepared. As a staple in most populations of Asia, milled rice is simply boiled, although some practice parboiling. Some cultures boil rice wrapped in banana leaves or coconut leaves and it is eaten as a staple, sometimes filled with fish or meat, or sweetened and mixed with coconut milk to make a wide assortment of delicious and attractive desserts. Ground rice, especially glutinous rice, may find itself made into tasty rice cakes of varied textures and colors.

Wheat has been cultivated as a food source for more than 9,000 years by the peoples of the temperate zone, probably originating in the Tigris and Euphrates river valley. The main use of wheat is in the manufacture of flour for making bread, cakes, and other bakery products, noodles and a variety of pastas, and the now popular breakfast cereals and extruded snack products. It is said that more foods are made with wheat than any other cereal grain.

Maize ranks with wheat and rice as one of the world's chief grain crop, grown mainly for food and animal feed. Maize is a native of the Americas, originating perhaps in southwestern North America and Mexico. It has been used as a staple in that region for many centuries before the arrival of the Europeans. In Asia, corn is mainly used as animal feed, but white corn is actually mixed with rice as a staple in some parts of the Philippines. It has also found its way into extruded snack products.

Production, Supply and Consumption of Rice in Southeast Asia
In Asia, rice is the major staple; thus it is not surprising that more than 90% of the world's rice is produced and consumed in Asia. The biggest rice producers are China and India, followed by
Indonesia, Bangladesh, Vietnam and Thailand (Table 1). In fact, rice production in Asia has been increasing more rapidly than the increase in population. Production of wheat is comparatively low; production in Asia was highest in China, India and Pakistan in 2004. Again, China was the highest producer of maize among the Asian countries in the same year, followed by India, Indonesia and the Philippines, although maize production was only about 26% of total cereal production in the case of the Philippines, and 17% in the case of Indonesia, in 2004.

Cereals Supply

More or less the same pattern was shown in the case of the supply of cereals as a whole. Among ASEAN countries, Indonesia had the highest supply in 2002, followed by Vietnam, Myanmar and the Philippines, corresponding with their population size. In terms of per capita supply, however, Myanmar topped the list, followed by Indonesia, Laos and Vietnam (Table 2). Cereals were the biggest supplier of dietary energy, supplying 1,180 to 2,066 Kcal/cap/day in ASEAN countries in 2002, with the highest in Myanmar, followed by Indonesia, Vietnam and Laos.

For the last two decades, rice supply has been contributing more than 70% of the total calorie supply in Cambodia, Laos, Myanmar and Vietnam, while it was much lower in Malaysia (Table 3). However, for most of the countries of ASEAN, supply of rice as food has been decreasing on a per capita basis.

Looking at the Food Balance Sheet of developing countries in Asia, the total domestic supply of cereals in 2002 amounted to 830 million MT, 71.7% (595 million MT) of which was used for food. Of the total domestic supply of wheat amounting to 255 million MT, 87.1% was used for food; while of the total domestic supply of rice amounting to 347 million MT, as much as 90.2% was used for food. Of the total domestic supply of corn amounting to 176 million MT, only 22% was used for food. Thus, cereals supplied 1,502 Kcal in the developing countries in Asia, of which 32% was supplied by wheat, 58% by rice and 9% by corn.

Table 1. Cereals production in selected Asian countries, Yr 1985 - 2004 in MT(000)

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<tbody>
<tr>
<td>Bangladesh</td>
<td>22,556</td>
<td>26,778</td>
<td>26,399</td>
<td>37,628</td>
<td>37,960</td>
<td>1.463</td>
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<td>11</td>
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<td>0.3</td>
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<td>42.8</td>
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<td>89,814</td>
<td>117,734</td>
<td>177,134</td>
<td>85,807</td>
<td>98,232</td>
<td>102,211</td>
<td>102,211</td>
<td>91,330</td>
<td>64,102</td>
<td>97,232</td>
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<td>98,960</td>
<td>105,440</td>
<td>127,400</td>
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<td>44,069</td>
<td>49,850</td>
<td>49,850</td>
<td>76,369</td>
<td>72,060</td>
<td>6,444</td>
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<td>Indonesia</td>
<td>39,033</td>
<td>45,177</td>
<td>49,744</td>
<td>54,061</td>
<td>54,061</td>
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<td>67,744</td>
<td>67,744</td>
<td>67,744</td>
<td>67,744</td>
</tr>
<tr>
<td>Korea (ROK)</td>
<td>7,855</td>
<td>7,722</td>
<td>2,016</td>
<td>7,897</td>
<td>6,800</td>
<td>11.9</td>
<td>10.2</td>
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<td>12</td>
<td>12</td>
<td>74</td>
<td>64</td>
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<tr>
<td>Laos</td>
<td>1,396</td>
<td>1,508</td>
<td>6,387</td>
<td>2,202</td>
<td>2,529</td>
<td>33.2</td>
<td>43.4</td>
<td>33.2</td>
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<td>33.2</td>
<td>43.4</td>
<td>33.2</td>
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</tr>
<tr>
<td>Malaysia</td>
<td>1,745</td>
<td>1,885</td>
<td>1,488</td>
<td>2,311</td>
<td>2,383</td>
<td>25</td>
<td>35</td>
<td>43</td>
<td>65</td>
<td>75</td>
<td></td>
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<tr>
<td>Myanmar</td>
<td>14,317</td>
<td>17,957</td>
<td>21,324</td>
<td>22,000</td>
<td>206</td>
<td>126</td>
<td>84</td>
<td>94</td>
<td>130</td>
<td>299</td>
<td>187</td>
<td>275</td>
<td>363</td>
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<tr>
<td>Nepal</td>
<td>2,804</td>
<td>3,502</td>
<td>3,579</td>
<td>4,216</td>
<td>4,300</td>
<td>534.6</td>
<td>855</td>
<td>941</td>
<td>1,184</td>
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<td>7,487</td>
<td>47,034</td>
<td>14,306</td>
<td>17,002</td>
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<td>1,009</td>
<td>1,185</td>
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<td>9,885</td>
<td>10,541</td>
<td>12,389</td>
<td>14,497</td>
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<td>5,135</td>
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<td>2,538</td>
<td>2,880</td>
<td>2,860</td>
<td>2,900</td>
<td>30</td>
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<td>31</td>
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<td>17,937</td>
<td>22,016</td>
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<td>0.6</td>
<td>0.8</td>
<td>0.8</td>
<td>5,934</td>
<td>3,722</td>
<td>4,155</td>
</tr>
<tr>
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<td>15,875</td>
<td>19,225</td>
<td>24,964</td>
<td>32,530</td>
<td>36,188</td>
<td>587</td>
<td>671</td>
<td>1,177</td>
<td>2,006</td>
<td>3,454</td>
<td>26</td>
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</tbody>
</table>
Table 2. Cereals and rice supply in ASEAN countries (excluding Singapore), 1998 - 2002.

<table>
<thead>
<tr>
<th></th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>Rice Supply in Kg/Cap/Yr</th>
<th>Rice Supply in Cal./Cap/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brunei</td>
<td>45</td>
<td>56</td>
<td>54</td>
<td>55</td>
<td>52</td>
<td>140.8</td>
<td>171.0</td>
</tr>
<tr>
<td>Cambodia</td>
<td>1,991</td>
<td>2,082</td>
<td>2,322</td>
<td>2,208</td>
<td>2,238</td>
<td>189.5</td>
<td>162.5</td>
</tr>
<tr>
<td>Indonesia</td>
<td>40,466</td>
<td>41,617</td>
<td>43,301</td>
<td>44,100</td>
<td>44,900</td>
<td>203.7</td>
<td>199.4</td>
</tr>
<tr>
<td>Laos</td>
<td>999</td>
<td>989</td>
<td>995</td>
<td>1,026</td>
<td>1,055</td>
<td>190.5</td>
<td>161.9</td>
</tr>
<tr>
<td>Malaysia</td>
<td>3,174</td>
<td>3,393</td>
<td>3,496</td>
<td>3,546</td>
<td>3,747</td>
<td>144.5</td>
<td>150.9</td>
</tr>
<tr>
<td>Myanmar</td>
<td>10,255</td>
<td>10,562</td>
<td>10,273</td>
<td>10,349</td>
<td>10,441</td>
<td>222.0</td>
<td>218.9</td>
</tr>
<tr>
<td>Philippines</td>
<td>18,329</td>
<td>9,984</td>
<td>10,247</td>
<td>10,784</td>
<td>10,993</td>
<td>141.9</td>
<td>131.0</td>
</tr>
<tr>
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<td>7,326</td>
<td>7,435</td>
<td>7,534</td>
<td>7,524</td>
<td>7,607</td>
<td>122.7</td>
<td>123.3</td>
</tr>
<tr>
<td>Vietnam</td>
<td>13,970</td>
<td>14,274</td>
<td>14,585</td>
<td>14,774</td>
<td>14,985</td>
<td>133.6</td>
<td>135.1</td>
</tr>
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</table>

Table 3. Rice calorie supply as percentage of total calories, 1985 - 2000.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cambodia</td>
<td>76</td>
<td>80</td>
<td>79</td>
<td>78</td>
<td>75</td>
</tr>
<tr>
<td>Indonesia</td>
<td>54</td>
<td>56</td>
<td>55</td>
<td>46</td>
<td>50</td>
</tr>
<tr>
<td>Laos</td>
<td>74</td>
<td>77</td>
<td>70</td>
<td>73</td>
<td>66</td>
</tr>
<tr>
<td>Malaysia</td>
<td>39</td>
<td>31</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Myanmar</td>
<td>76</td>
<td>71</td>
<td>78</td>
<td>76</td>
<td>71</td>
</tr>
<tr>
<td>Philippines</td>
<td>42</td>
<td>44</td>
<td>41</td>
<td>40</td>
<td>42</td>
</tr>
<tr>
<td>Thailand</td>
<td>61</td>
<td>57</td>
<td>50</td>
<td>45</td>
<td>44</td>
</tr>
<tr>
<td>Vietnam</td>
<td>65</td>
<td>71</td>
<td>71</td>
<td>68</td>
<td>66</td>
</tr>
</tbody>
</table>

Cereals and Carbohydrate Intake in Some Southeast Asian Countries

While production and supply of rice has been increasing in recent years in an attempt to keep pace with population growth, rice consumption per capita has in fact been decreasing in many of the ASEAN countries, perhaps in consonance with the socio-economic transition now prevailing in the region. Rice is increasingly being replaced by wheat products as well as other foods including animal foods. For example, in Vietnam, there was a remarkable change in dietary intake from 1990 to 2000 as shown in their national nutrition surveys (Table 4). While rice intake was not much different between 1985 and 1990, there was a significant decrease from 1990 to 2000, accompanied by an increase in intake of other cereals, as well as in meats, eggs, fish, and oil/fat.

Thus, the carbohydrate intake per capita diminished from 1985 to 2000, as did the proportion of carbohydrates to total caloric intake. The 2000 survey also showed a large difference in rice intake between urban and rural areas: 337g/cap/day in the urban areas, while only 416.4g/cap/day in the rural areas, taking up 69.8% of total calories in the urban areas and 76.4% in the rural areas.
Table 4. Average daily per capita food intake and percent energy from macronutrients, Vietnam, 1985, 1990 and 2000 (Partial list)³

<table>
<thead>
<tr>
<th>Food Group</th>
<th>1985 (n=733 HH)</th>
<th>1990 (n=12,641 HH)</th>
<th>2000 (n=7,658 HH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>457</td>
<td>451.6</td>
<td>397.3</td>
</tr>
<tr>
<td>Other cereals</td>
<td>3.6</td>
<td>6.2</td>
<td>16.0</td>
</tr>
<tr>
<td>Tubers</td>
<td>68.2</td>
<td>37.8</td>
<td>8.9</td>
</tr>
<tr>
<td>Meats</td>
<td>113.6</td>
<td>24.4</td>
<td>51.0</td>
</tr>
<tr>
<td>Eggs/milk</td>
<td>1.7</td>
<td>2.9</td>
<td>10.3</td>
</tr>
<tr>
<td>Fish</td>
<td>40.1</td>
<td>50.0</td>
<td>52.6</td>
</tr>
<tr>
<td>Oil.fat</td>
<td>1.7</td>
<td>3.0</td>
<td>6.8</td>
</tr>
</tbody>
</table>

% Energy from:

<table>
<thead>
<tr>
<th></th>
<th>1985</th>
<th>1990</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>11.2</td>
<td>12.3</td>
<td>13.2</td>
</tr>
<tr>
<td>Lipid</td>
<td>6.2</td>
<td>8.4</td>
<td>12.0</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>82.6</td>
<td>79.3</td>
<td>74.8</td>
</tr>
</tbody>
</table>

In Thailand, the average per capita intake of cereals decreased from the years 1986 to 1995, while the intake of fish and fish products increased (Table 5).⁴ Thus, the contribution of carbohydrates to total caloric intake decreased from 66% to 63.3%, while the contribution of protein and fat increased.

In the latest national nutrition survey conducted in the Philippines in 2003, rice occupied 34.2% to total food intake (equivalent to 303g/cap/day), a slight reduction from 35% in the 1987 and 1993 surveys (Table 6).⁵ However, the proportion of wheat and wheat products increased dramatically from 1987 to 2003. So did the intake of meat and poultry. Thus, the contribution of carbohydrate to total caloric intake diminished from 74% in 1987 to 69.9% in 2003, while that of fat increased from 14.9% to 18.3%.

Table 5. Average daily per capita food intake and percent energy from macronutrients, Thailand, 1986 and 1995 (Partial list)⁴

<table>
<thead>
<tr>
<th>Food Group</th>
<th>1986</th>
<th>1995</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>350.9</td>
<td>305.7</td>
</tr>
<tr>
<td>Fats and oil</td>
<td>45.6</td>
<td>14.0</td>
</tr>
<tr>
<td>Fish and products</td>
<td>36.9</td>
<td>46.1</td>
</tr>
<tr>
<td>Meat, poultry</td>
<td>80.0</td>
<td>71.4</td>
</tr>
<tr>
<td>Eggs</td>
<td>23.9</td>
<td>21.4</td>
</tr>
<tr>
<td>Milk and products</td>
<td>80.9</td>
<td>29.3</td>
</tr>
<tr>
<td>Vegetables</td>
<td>115.9</td>
<td>113.4</td>
</tr>
<tr>
<td>Fruits</td>
<td>99.2</td>
<td>73.6</td>
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</table>

% Energy from:

<table>
<thead>
<tr>
<th></th>
<th>1986</th>
<th>1995</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>11.4</td>
<td>13.3</td>
</tr>
<tr>
<td>Fat</td>
<td>21.6</td>
<td>23.4</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>66.0</td>
<td>63.3</td>
</tr>
</tbody>
</table>
Table 6. Average daily per capita food intake and percent energy from macronutrients, Philippines, 1987, 1993 and 2003 (Partial list)

<table>
<thead>
<tr>
<th>Food Group</th>
<th>1987</th>
<th>1993</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice and products</td>
<td>303</td>
<td>282</td>
<td>303</td>
</tr>
<tr>
<td>Wheat and products</td>
<td>18</td>
<td>22</td>
<td>30</td>
</tr>
<tr>
<td>Tubers</td>
<td>22</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>Fish</td>
<td>111</td>
<td>99</td>
<td>104</td>
</tr>
<tr>
<td>Meat</td>
<td>37</td>
<td>34</td>
<td>61</td>
</tr>
<tr>
<td>Poultry</td>
<td>9</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>Fats and oils</td>
<td>14</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>% Energy from:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>11.2</td>
<td>11.5</td>
<td>11.8</td>
</tr>
<tr>
<td>Fat</td>
<td>14.8</td>
<td>14.9</td>
<td>18.3</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>74.0</td>
<td>73.6</td>
<td>69.9</td>
</tr>
</tbody>
</table>

In contrast to the dietary pattern in Vietnam, Thailand and the Philippines, the pattern of dietary intake in Singapore tends towards Western diets.

In the 1998 Singapore National Nutrition Survey, plain rice/porridge and dishes contributed only 29.4% of total food intake of adult males (equivalent to 549.2g/cap/day, average of the three ethnic groups) and 26.3% of total food intake of adult females (407.8g/cap/day) (Table 7). On the other hand, bread and breakfast cereals together with noodles and dishes mostly made from wheat flour contributed as much as 18% of total food intake of adult males (335.9g/cap/day, average of the three ethnic groups) and 18.8% of total food intake of adult females (291.8g/cap/day). The Chinese population of Singapore had the highest intake of rice and porridge as well as noodles among the other ethnic groups, namely the Malays and Indians, while they had the lowest intake of bread and breakfast cereals. Compared to the developing countries in Southeast Asia, Singapore has a low proportion of carbohydrate intake to total caloric intake (55.1%, average of both sexes in 1998), and a correspondingly high proportion of fat intake (30.1%).

Table 7. Average daily per capita food intake and percent energy from macronutrients, Singapore, 1998

<table>
<thead>
<tr>
<th>Food Group</th>
<th>Male</th>
<th>Female</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>Chinese</td>
<td>Malay</td>
<td>Indian</td>
<td>Chinese</td>
</tr>
<tr>
<td>Breads &amp; breakfast cereals</td>
<td>53.3</td>
<td>70.1</td>
<td>81.5</td>
<td>44.1</td>
</tr>
<tr>
<td>Rice/porridge &amp; dishes</td>
<td>561.0</td>
<td>513.8</td>
<td>485.7</td>
<td>414.1</td>
</tr>
<tr>
<td>Noodles dishes</td>
<td>309.1</td>
<td>161.3</td>
<td>168.9</td>
<td>268.9</td>
</tr>
<tr>
<td>Vegetables &amp; beans</td>
<td>177.5</td>
<td>163.7</td>
<td>209.6</td>
<td>172.7</td>
</tr>
<tr>
<td>Fruits</td>
<td>271.7</td>
<td>231.5</td>
<td>293.5</td>
<td>265.0</td>
</tr>
<tr>
<td>Poultry &amp; dishes</td>
<td>29.6</td>
<td>24.8</td>
<td>26.8</td>
<td>22.6</td>
</tr>
<tr>
<td>Meat &amp; dishes</td>
<td>43.3</td>
<td>22.1</td>
<td>23.7</td>
<td>30.5</td>
</tr>
<tr>
<td>Fish/seafood &amp; dishes</td>
<td>48.2</td>
<td>64.9</td>
<td>42.8</td>
<td>44.1</td>
</tr>
<tr>
<td>Eggs</td>
<td>21.0</td>
<td>26.1</td>
<td>19.7</td>
<td>14.3</td>
</tr>
<tr>
<td>Milk &amp; dairy products</td>
<td>103.1</td>
<td>152.9</td>
<td>192.5</td>
<td>96.7</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>277.0</td>
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<td>181.9</td>
</tr>
<tr>
<td>% Energy from:</td>
<td>Male</td>
<td>Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>14.8</td>
<td>14.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>29.8</td>
<td>30.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>55.4</td>
<td>54.6</td>
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<td></td>
</tr>
</tbody>
</table>
Nutritional Value of Grains
Grains are a low-cost source of food supplying significant amount of nutrients in the diet because of the large amount consumed. As discussed above, grains are the major supplier of dietary energy in the Asian diet, arising from their high starch content.

Apart from starch, grains also contain proteins, some fat, and a long list of vitamins and minerals, together with other phytochemicals that are starting to be recognized as beneficial to health. About 80% of the grain is the endosperm, 80% of which is starch and 10% protein, together with fat, and soluble fiber. The bran (14% to 16% of wheat) is rich in dietary fiber, vitamins and minerals, and antioxidants, together with some protein and fat, except that it is partially or wholly removed by milling. The germ or embryo which is about 5% of the grain contains fat and anti-oxidants, and is also removed by milling.7

Rice contains more carbohydrates (almost 80%), than wheat and corn (75%), but less protein, about 7%, compared to wheat which contains about 11% to 12% protein, although the protein quality in rice is better than that of wheat. Owing to a better amino acid composition, the protein quality of rice (79.3% casein) is better than wheat (38.7% casein), and better again than maize (32.1% casein). Grains contain some amino acids that are relatively low compared to requirements, so-called limiting amino acids, principally lysine, and to some extent S-amino acids and tryptophan, thus reducing their protein quality. Nevertheless, consuming cereals with even small amounts of animal foods, beans or legumes which supply the limiting amino acids, greatly improves the protein quality of the diet.

Due to the macro- and micronutrients in grains, they constitute the major source of nutrients in poorer countries. Rice, for example, apart from contributing 53% of energy and 37% of protein in the Filipino diet as shown in the 2003 National Nutrition Survey, supplied 17.5% of calcium, 28.8% of iron, 32.5% of thiamin, 34.8% of riboflavin, and 43.3% of niacin in the Filipino diet. In countries where micronutrient deficiencies are prevalent, grains like rice and wheat serve as excellent vehicles for food fortification.

Fortification of wheat flour with iron, zinc, and B vitamins is now practiced in Indonesia, and iron fortification of wheat flour is now going on in the Philippines.

The efficacy of iron fortification of rice using extruded premix technology has recently been completed (Agdeppa, et al., unpublished), and hopefully will soon be used for the iron fortification of rice in the Philippines as mandated by law. Biofortification through both traditional plant breeding and genetic modification of rice and wheat holds promise in supplying deficient micronutrients such as iron, zinc and beta-carotene to micronutrient-deficient populations.

Apart from the traditional macro- and micronutrients, grains, particularly whole grains are rich in dietary fiber. The 1998 Singapore National Nutrition Survey showed an average dietary fiber intake of 15.7g/cap/per/day, higher in males than females, and highest among the Indians. This represented a slight improvement from 12.9g in 1993.
Dietary fiber comprises the edible parts of plant foods that cannot be digested or absorbed in the small intestine and passes into the large intestine largely intact. There, it either passes out into the feces, carrying with it substances such as unabsorbed bile supposedly resulting in reducing blood cholesterol, or is fermented by colonic bacteria, giving rise to short-chain fatty acids (SCFA) and other by-products which supposedly contribute to the beneficial effects of dietary fiber.9

The main physiologic effects attributed to dietary fiber includes improved bowel function by increasing stool weight and slowing gut transit time, therefore helping to relieve constipation.9,10 SCFAs (especially butyrate and propionate) are important substrates for energy metabolism in colonocytes and might inhibit the growth and proliferation of gut tumor cells. However these same benefits have been attributed to resistant starch, the form of starch found in pulses and lentils, partially milled grains, and some breakfast cereals, that is not digested in the small intestine similar to dietary fiber.11

Another purported beneficial effect of dietary fiber is in lowering the risk of cardiovascular disease by reducing the blood level of both total cholesterol and LDL-cholesterol,10 helping in weight management because of its high satiety value,10 and probably helping to lower mild to moderate hypertension.15 Another purported beneficial effect of dietary fiber is in improving glycemic control and lowering Glycemic Index, thus helping in the management of diabetes.9,31 Its beneficial effect in the prevention of cancer, particularly colon cancer, however, remains controversial.9 Nonetheless, the majority of epidemiologic studies and meta-analysis have suggested that fiber-rich diets are protective of colorectal cancer. An odds ratio of 0.57 was computed when the prevalence of colorectal cancer got the the highest fiber group was compared with that of the lowest group.14

Beneficial Effects of Whole Grains
Current research around the world is discovering the many and varied health benefits of whole grains, particularly in reducing the risk of chronic degenerative diseases such as coronary heart disease, diabetes, hypertension and even, some forms of cancer.

In the 1970’s, fiber was recognized as the food component that could prevent constipation and cancer.15 More recently, it has been demonstrated that whole grain intake is positively associated with enhancing insulin sensitivity, better weight control management, and prevention of heart disease.16 The Iowa Women’s Health Study has shown that fiber from whole grains, but not refined cereals, is inversely associated with all-cause mortality in older women.17

It is now clear that the beneficial effect of whole grains does not reside in the dietary fiber alone, but in in host of phytochemicals and phytoestrogens that occur in conjunction with vitamins and minerals in whole grains. Whole grains are also a good source of antioxidants including vitamin E and selenium, as well as phytochemicals including phytoestrogens like lignans, phytic acid, phenolic compounds, flavonoids, phytosterols, tocotrienols, and many others.18,19 The US Food and Drug Administration now allows food manufacturers to make a health claim on whole grain food products, as long as the product contains 5% or more wholegrain ingredients by weight per reference amount, with dietary fiber of 2.3g per 50g or 1.7g per 35g, together with a low fat diet.
Summary and Conclusion

Grains, particularly rice, constitute the major part of the diet of Asia, consumed as the staple and in a wide variety of forms. While production and supply has kept pace with rise in population, rice consumption per capita has in fact been decreasing, rice being replaced by wheat products and other foods. Nevertheless, rice is the major contributor to dietary energy, and is a significant source of protein, carbohydrate and micronutrients in the diet of the region besides being an excellent vehicle for micronutrient fortification.

Apart from the traditional nutrients, more and more functional components such as dietary fiber and resistant starch, phytochemicals and phytoestrogens, are starting to be recognized as promotive to health or even preventive of chronic diseases. Thus grains, with emphasis on whole grains, should form the base of a well balanced and nutritious diet.

References


Introduction
The rising prevalence of overweight and obesity – and associated co-morbidities, especially metabolic syndrome and Type 2 diabetes mellitus – in both children and adults around the world, has led to much research and discussion on its principle causes. Some hypothesize that an increase in sugars intake is a major contributing factor. Key issues related to assessing sugars intake and its impact on nutrition and health are reviewed in this paper.

Definitions of Sugars
One area of confusion encountered when trying to assess the impact of sugars intake on nutrition and health is the use and meaning of terms used to describe sugars. Different terms mean different things to consumers, the media, researchers, and regulatory agencies. Chemically, sugar refers to any mono- or disaccharide, such as glucose, fructose, galactose, sucrose, lactose, and maltose. These mono- and disaccharides sometimes are referred to as simple sugars or simple carbohydrates. To most consumers, however, sugar simply means table sugar or sucrose.

In the US, the terms sugar, sugars, added sugars, and caloric sweeteners each have specific definitions for regulatory or policy applications for dietary guidance or food labeling. The US Food and Drug Administration (FDA) defines sugar to mean sucrose for the purpose of ingredient labeling, and sugars to mean all mono- and disaccharides and polyols in processed or prepared foods for the purpose of nutrition labeling. Added sugars is used in the Dietary Guidelines for Americans to mean sugars and syrups that are added to foods at the table or during processing, such as white sugar, brown sugar, raw sugar, corn syrup, high fructose corn syrup, honey, and molasses. The Economic Research Service of the US Department of Agriculture (USDA) uses caloric sweeteners to describe sucrose from refined cane and beet sugars, honey, dextrose, edible syrups, and corn sweeteners including high fructose corn syrups. High fructose corn syrups contain oligosaccharides (3–9 monomers), which are captured in estimates of added sugars and caloric sweeteners but are not included in the FDA’s nutrition labeling definition for sugars. Another source of sugars in the US diet is boiled, stripped, deodorized, and decolored fruit juices (usually apple, pear, grape). These sugars are not included in the added sugars of dietary guidance but are included in the FDA’s regulation for the nutrition labeling declaration of sugars. However, FDA’s regulation for labeling claims of “No added sugars” prohibits the claim for any product containing any amount of sugars added during processing or packaging or any other ingredient that contains sugars that functionally substitute for added sugars. These different terms and definitions have implications for estimating sugars intake. Intakes would be overestimated if oligosaccharides are included and underestimated if "stripped" fruit juices are excluded.
The terms “extrinsic” and “intrinsic” sugars originated in a UK Department of Health committee to help consumers choose between what were considered to be healthy sugars and those which were not. Intrinsic sugars were those sugars occurring within cell walls of plants, whereas extrinsic sugars were those usually added to foods. A joint FAO/WHO expert panel recommended against use of these terms. Free sugars is a recently introduced term which includes all mono- and disaccharides added to foods by manufacturer, cook, or consumer, plus sugars naturally present in honey, syrups and fruit juices.

In addition to variability in terms and definitions used to describe sugars, another inconsistency is how scientists express “sugar” dietary treatments or variables in their research papers. Intakes have been expressed as kilograms per year, grams per day, grams per kilogram body weight, percent of total carbohydrate, percent of total energy, and teaspoons per day. Some researchers and health professionals describe intakes as high or low but without defining what high or low means. Such inconsistency and ambiguities make it difficult to compare results across studies.

Food Balance Sheets

A major source of information used to assess trends in sugars intake are the Food Balance Sheets compiled by the Statistics Division of the Food and Agricultural Organization (FAO). Members of FAO provide a country level estimate of the amounts of major food groups – such as cane sugar, beet sugar, and sweeteners made from corn – grown within the country, imported, and exported as well as an estimate of food diverted to animal feed, food wastage, and other non-human food usage. The difference between supply and non-human use represents the food that is available for consumption. The amount of food that is available for consumption is divided by an estimate of the population of the country to arrive at an average of the amount available per capita. Estimates of per capita availability do not represent actual food consumption. Also, the quality of the data reported by countries to FAO is not consistent. These factors must be considered when attempting to interpret the per capita data and raise caution when trying to make diet–related policy decisions.

Sugars and sweeteners data for the years 1961 to 2002 are available from Food Balance Sheets for several countries in Southeast Asia and Oceania. When expressed as kilograms per person per year, there has been an increase over time for New Zealand, Malaysia, Thailand, Philippines, Indonesia, and Vietnam; a decrease for Australia; and fluctuations for Samoa and Cambodia. Countries differ widely in the amount of sugars and sweeteners available for consumption; e.g., in 2002, from a low of 11kg per person in Cambodia to 59kg per person in New Zealand, which is equivalent to 30g and 162g per day, respectively.

Because total energy available for consumption has also increased over time in these countries, the amount of sugars and sweeteners available for consumption as kilograms per year needs to be examined as a percentage contribution to total energy. This allows an assessment in trends of the relative contribution of sugars and sweeteners versus other major sources of energy. Expressed this way, the contribution of sugars and sweeteners to total energy increased for Malaysia (from 12% of Kcal in 1961 to 14% in 2000), the Philippines (from 8% to 12%), and Thailand (from 2% to 12%). The contribution to total energy available for consumption actually decreased for Australia (from
18% to 13%) and Samoa (from 10% to 8.5%), and remained somewhat stable for New Zealand (16–17%), Indonesia (5%), Vietnam (2% to 4%), and Cambodia (3%). The relative contribution of sugars and sweeteners to total energy availability varies greatly across countries, e.g., from 5% to 6% for Indonesia, Cambodia, and Vietnam to 18% for New Zealand in 2002.

The WHO has published statistics on the prevalence of preobesity (BMI ≥ 25 but < 30kg/m²) and obesity (BMI ≥ 30kg/m²) in the adult population of several Western Pacific countries. These data allow for a comparison of prevalence rates with sugars and sweeteners availability. However, a clear pattern of relation between sugars availability (either as kilograms per year or percentage of total energy availability) and the rate of preobesity plus obesity is not evident. For example, New Zealand had 59kg per year of sugars and sweeteners available for consumption (18% of Kcal) and a prevalence rate for preobesity plus obesity of 41% for males and 30% for females, whereas Samoa had 28kg per year of sugars and sweeteners available for consumption (9% of Kcal) and preobesity plus obesity prevalence rates of 47% for males and 66% for females (Figure 1). Clearly, factors other than sugars and sweeteners are contributing to obesity.

Figure 1. Sugars and sweeteners availability and prevalence rates of preobesity plus obesity in adult males and females by country

Dietary Surveys
Actual consumption of sugars by individuals within a country is needed to obtain a clearer picture of associations, if any, with nutrition and health parameters. But, even dietary intake data have limitations. Firstly, good food composition tables are needed. Ideally, data for the individual monosaccharide and disaccharide contents of foods should be made available, but that is not always the case. Furthermore, there are the issues of whether to include oligosaccharides as sugars or as other carbohydrates, the inability to differentiate analytically the naturally occurring and added sugars in a prepared food, and the uncertainty of the exact sugars content in food recipes of unknown composition. Secondly, food intakes in general tend to be underreported due to problems with remembering foods consumed, estimating portion sizes, and literacy barriers. Certain foods may, also, be selectively underreported – especially by overweight and obese individuals – based on what is perceived to be a socially desirable intake. Also, it is useful to have an estimate of an individual’s usual dietary intake, which requires collection of more than one day’s food intake. If reasonably accurate dietary intakes are obtained, the data should be examined by mean and percentiles of
Role Of Carbohydrates in Health & Disease: Evaluating Scientific Evidence for Dietary Guidance

intake, population subgroups (e.g., based on age, gender, race, ethnicity, urbanicity, socioeconomic status, and body weight status), and food sources. These various ways of analyzing sugars intake data are helpful in identifying specific issues and potential problems.

**Nutrition and Health Impact**
Reviews of the literature on the relation between sugars intake and nutrition and health variably focus on (1) dental caries, (2) dietary quality and nutrient intakes, (3) energy balance and body weight management, (4) glycemic response, insulin sensitivity and diabetes mellitus, (5) lipoprotein metabolism, kinetics and blood levels, and cardiovascular disease, (6) hyperactive behavior in children, (7) cognitive and physical performance, and (8) cancer. Some reviews address topics directly for the effect of sugars intakes, whereas other topics are addressed indirectly, e.g., through sugars' putative impact on energy balance or through general effects of carbohydrates. Expert groups have drawn different conclusions about the strength of the evidence linking sugars intake with these conditions or parameters. However, certain observations appear to be consistent. Some examples will follow.

**Dental Caries**
Sugars play a significant role in dental caries, but dental caries is a disorder of multifactorial causation and the role of sugars cannot be rationalized as a single cause and effect relationship. Sugars and all other fermentable carbohydrates are acidogenic in dental plaque and exert a caries risk. The risk is related to form, retentiveness, exposure duration, frequency of consumption, and nutrient composition, and is significantly reduced with the use of fluoride vehicles.

**Dietary Quality**
Diets that are higher in added sugars (e.g., > 25% of energy) may contain more calories and smaller amounts of micronutrients than diets with lower amounts of added sugars. Not all foods that contain added sugars, however, are poor sources of nutrients (e.g., pre-sweetened cereals and flavored yogurts and milk) and the intakes of certain nutrients are at risk of inadequacy at very low levels of added sweeteners intake (e.g., < 5% of energy). Excessive intakes of sugars which compromise micronutrient density should be avoided. However, dietary guidance may be more effective if language conveys the desirability of choosing foods with a higher nutrient density rather than avoiding/limiting sugars per se.

**Energy Balance**
No clear and consistent association between increased intake of added sugars and BMI has been found, and no data suggest that different types of carbohydrates differentially affect total energy intake. Additionally, evidence is conflicting on whether or not liquid and solid foods differ in their effect on calorie compensation. Overall, many questions about sugars, appetite control, and energy balance have not yet been resolved.

**Glycemic Response**
The evidence is convincing that overweight, obesity, and abdominal obesity decrease insulin sensitivity and increase the risk for Type 2 diabetes. While animal studies have shown a decrease in insulin
sensitivity with high sucrose and high fructose diets, there is no conclusive evidence that humans respond similarly to high sucrose diets or that sucrose and other sugars are directly implicated in the etiology of diabetes. Some research has shown associations between high dietary glycemic load and Type 2 diabetes, but sugars per se are not the largest contributor to dietary glycemic load. With respect to diabetes management, a moderate amount of sugars may be consumed as part of mixed meal within energy allowance and nutritionally adequate diet.

**Blood Lipids**

Convincing evidence exists that overweight contributes to the risk for cardiovascular disease. Fructose is more lipogenic than glucose or starches and high intakes (>~20% of energy) of sucrose and fructose over the short term can raise blood triglycerides. However, a link between sugars-induced hypertriglyceridemia and cardiovascular disease risk over the long term is not evident. Other dietary factors need to be considered, e.g., the amount of total carbohydrates and fiber and type of dietary fat. Sedentary and obese individuals with metabolic syndrome appear to be most sensitive to effects of dietary sugars.

**Summary**

Research and dietary guidance on sugars would benefit by clear definitions and consistency in the use of sugars-related terms and expressions of intake. Caution is needed in how data on sugars availability from Food Balance Sheets are used. Per capita availability does not represent actual intakes by individuals or even groups of individuals, and can underestimate or overestimate actual intake. It is more desirable to estimate actual sugars intakes from dietary survey data. Good dietary intake data require good food composition data and rigorous methods to ensure accurate reporting and validating of food intake. The relation between sugars intake and many nutritional and health parameters has been examined. The general consensus appears to be that sugars intake is only one component of a complex mix of factors associated with diet-related performance, health, and chronic disease.

**References**


10. Murphy SP, Johnson RK. *The scientific basis of recent guidance on sugars intake.* Am J Clin Nutr 2003;78 (4S):827S-833S.


Carbohydrate Dietary Guidelines from Around the World

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Introduction
One of the identified strategies of the World Declaration and Plan of Action for Nutrition, adopted at the International Conference on Nutrition (ICN) in 1992, was the promotion of appropriate diets and healthy lifestyles. Member countries were urged to provide dietary guidelines to the public, relevant for different age groups and lifestyles and appropriate for the country’s population. Following up on the ICN, the FAO/WHO jointly held an expert consultation on the preparation and use of food-based dietary guidelines in 1995. Dietary guidelines (DGs) are sets of advisory statements that give dietary advice for the population to promote overall nutritional well-being. DGs relate to all diet-related conditions. The FAO/WHO Consultation emphasized that DGs should be clearly differentiated from dietary goals and recommended nutrient intakes (RNI, RDA or RDI). DGs are broad targets for which people can aim, while RNI indicate what should be consumed on the average every day. Hence, dietary guidelines need to reflect food patterns rather than numerical goals. It is preferable that the messages to the public be in terms of foods, i.e., food-based dietary guidelines (FBDGs).

FBDGs are developed in a specific socio-cultural context, and need to reflect relevant social, economic, agricultural and environmental factors affecting food availability and eating patterns. Public health issues should determine the direction and relevance of dietary guidelines. These guidelines need to be positive and encourage enjoyment of appropriate dietary intakes. Countries around the world have developed and been using dietary guidelines for many years. The purpose of the above mentioned FAO/WHO Consultation was to establish the scientific basis and recommended process for the development and evaluation of FBDGs in various regions of the world.

This paper aims to highlight those aspects of dietary guidelines that are related to carbohydrate nutrition. Several sections of the FAO/WHO Consultation on Carbohydrates in Human Nutrition, 1997 are first highlighted. The recommendations of the Consultation on the role of carbohydrates (including dietary fiber) in human nutrition and its role in the maintenance of health and disease are summarized. The relevant parts of the WHO Monograph on Diet, Nutrition & Prevention of Chronic Diseases pertaining to carbohydrates and dietary fiber are also briefly mentioned. The main part of the paper examines the dietary guidelines of 18 selected countries around the world, including Asian countries, Australia, New Zealand, Canada, USA, South Africa and some European countries. The references used are mostly official dietary guidelines from the Ministries of Health.
or equivalent authorities and also include guidelines by professional bodies, e.g., nutrition, dietetics and medical associations. Only guidelines for adults are considered in the paper although it is recognized that several countries have developed guidelines for specific population groups such as children and pregnant mothers. The focus shall be on carbohydrates and dietary fiber recommendations in these guidelines. The interesting array of pictorial presentations of dietary recommendations from these countries shall also be discussed.

**FAO and WHO Carbohydrate Dietary Guidelines**

*FAO/WHO Joint Expert Consultation on Carbohydrates in Human Nutrition*

The report of the FAO/WHO Joint Expert Consultation on Carbohydrates in Human Nutrition, 1997\(^1\) (1997 Report) touched on several aspects of the subject, including the basic description and physiology of carbohydrates, their role in maintenance of health and causation of diseases, the role of glycemic index in food choice as well as goals and guidelines for carbohydrate food choices. Some of the recommendations that the Consultation made in the context of the role of carbohydrates in nutrition are summarized as follows:

- The many health benefits of dietary carbohydrates should be recognized and promoted.
- Carbohydrate foods provide more than energy alone.
- Energy balance should be maintained by consuming a diet containing at least 55% total energy from carbohydrate from various sources and engaging in regular physical activity.
- Carbohydrates, including carbohydrate-containing beverages, should not be consumed above optimum levels for recreational physical activity purposes. Higher carbohydrate intakes are only needed for long-term extreme endurance physical activities.
- A wide range of carbohydrate-containing foods should be consumed so that the diet is sufficient in essential nutrients as well as total energy, especially when carbohydrate intake is high. The bulk of carbohydrate-containing foods consumed should be those rich in non-starch polysaccharides and with a low glycemic index. Processed cereals, vegetables, legumes, and fruits are particularly good food choices.
- A nutrient-dense, high carbohydrate diet may be considered optimal for the elderly, but individualization is recommended because their specific nutritional needs are complex.

The 1997 Report also noted that excess energy intake in any form will cause body fat accumulation. Excessive intakes of sugars which compromise micronutrient density should be avoided. There is, however, no evidence of a direct involvement of sucrose, other sugars and starch in the etiology of lifestyle-related diseases.

*WHO Monograph on Diet, Nutrition & Prevention of Chronic Diseases*

The WHO Monograph on Diet, Nutrition & Prevention of Chronic Diseases also makes several references to the importance of carbohydrates and dietary fiber in human health.\(^4\) In the ranges of population nutrient intake goals tabulated in Table I, references have also been made to total carbohydrates, free sugar and dietary fiber. Population nutrient intake goals represent the population average intake that is judged to be consistent with the maintenance of health in a population. For carbohydrates, this goal has been recommended to be from 55% to 75% of the total energy intake.
whereas free sugars intake is to be less than 10%. A high daily intake of more than 400g of fruits and vegetables has been recommended. Total dietary fiber has been recommended to be more than 25 gram per day, of which more than 20 gram should be from non-starch polysaccharides (NSP). Whole grain cereals, fruit and vegetables are the preferred sources of NSP, of which the major components are the polysaccharides of the plant cell wall such as cellulose, hemicellulose and pectin.

Table 1. Ranges of population nutrient intake goals

<table>
<thead>
<tr>
<th>Dietary factor</th>
<th>Goal (% of total energy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total fat</td>
<td>15-30%</td>
</tr>
<tr>
<td>Saturated fatty acids</td>
<td>&lt;10%</td>
</tr>
<tr>
<td>Polyunsaturated fatty acids (PUFAs)</td>
<td>5-10%</td>
</tr>
<tr>
<td>n-6 Polyunsaturated fatty acids (PUFAs)</td>
<td>5-8%</td>
</tr>
<tr>
<td>n-3 Polyunsaturated fatty acids (PUFAs)</td>
<td>1-2%</td>
</tr>
<tr>
<td>Trans fatty acids</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Monounsaturated fatty acids (MUFAs)</td>
<td>9-13%</td>
</tr>
<tr>
<td>Total carbohydrate</td>
<td>55-75%</td>
</tr>
<tr>
<td>Free sugars</td>
<td>&lt;10%</td>
</tr>
<tr>
<td>Protein</td>
<td>10-15%</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>&lt;300 mg per day</td>
</tr>
<tr>
<td>Sodium chloride (sodium)</td>
<td>&lt;5 g per day</td>
</tr>
<tr>
<td>Fruits and vegetables</td>
<td>≥400 g per day</td>
</tr>
<tr>
<td>Total dietary fiber</td>
<td>&gt; 25 g per day</td>
</tr>
<tr>
<td>Non-starch polysaccharides (NSP)</td>
<td>&gt; 20 g per day</td>
</tr>
</tbody>
</table>

The WHO Monograph also presents the strength of evidence on factors that might promote or protect against various chronic diseases. Those factors that are related to carbohydrates are extracted and presented in Table 2. Dietary fiber has been specified to have “convincing” evidence for being protective against obesity and “probably” beneficial for Type 2 diabetes and cardiovascular diseases (CVD). Wholegrain cereals are also probably protective against CVD. With regard to dental disease, the consumption of free sugars has been convincingly shown to promote the condition, whereas sugar-free chewing gum may have protective effect. There is no relationship between the consumption of starch and dental disease.

Table 2. Strength of evidence on carbohydrate factors that might promote or protect against chronic diseases

<table>
<thead>
<tr>
<th></th>
<th>Obesity</th>
<th>Type 2 diabetes</th>
<th>CVD</th>
<th>Cancer disease</th>
<th>Dental disease</th>
<th>Osteoporosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>High intake of NSP (dietary fiber)</td>
<td>C↓</td>
<td>P↓</td>
<td>P↓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free sugars (frequency and amount)</td>
<td>C↑</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar-free chewing gum</td>
<td></td>
<td></td>
<td>P↓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starch</td>
<td>C-NR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole grain cereals</td>
<td></td>
<td></td>
<td>P↓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
C : convincing
P : probable
NR: no relationship
Carbohydrate Dietary Guidelines in Southeast Asia

The Malaysian dietary guidelines developed by the Ministry of Health Malaysia, with the collaboration of an inter-sectoral, multi-agency committee, include the following three messages that are relevant to this paper:

- Enjoy a variety of foods;
- Eat more rice and other cereal products, legumes, fruit and vegetables; and
- Reduce sugar intake and choose foods low in sugar.

The aims of these messages are to ensure that an individual meets all of his nutrient needs by eating a wide variety of foods; to encourage balanced meals with emphasis on consumption of grain products, legumes, vegetables and fruits; and to highlight that sugars are devoid of other nutrients and tend to displace more nutritious foods from the diet.

In an elaboration of the first of the 3 listed main messages, the Guidelines explain the reason for eating a variety of foods. Obtaining the nutrients the body needs depends on the amount and variety of foods that an individual eats daily. All foods can be enjoyed as part of a nutritious diet. The best way to ensure that an individual meets all of his nutrient needs is to eat a variety of foods.

In an elaboration of the second message above, the Guidelines encourage a balanced meal with emphasis on consumption of grain products for example rice, corn, wheat, wheat products, oats, barley, legumes, vegetables and fruits. Cereal products, legumes, vegetables and fruits provide complex carbohydrates, vitamins, minerals, fibers and other components that are important for good health. It is further explained that complex carbohydrates, also known as polysaccharides include starch and fiber. The Guidelines also provide some brief notes on dietary fiber, its sources and importance to human health. The recommended intake for fiber is 20g to 30g per day. It is also pointed out that the approach should ensure that the diet is not only rich in fiber but also balanced in the other nutrients that the body needs.

The third message above highlights that sugars are devoid of other nutrients and tend to displace other more nutritious foods from the diet. The Guidelines also emphasize on the importance of looking out for "hidden sugars" in a variety of foods including desserts, ice cream, candies, pastries, cookies, soft and sweetened drinks, kuih and syrups.

While emphasizing the importance of looking out for "hidden sugars" in a variety of foods, the Guidelines further explain that complex carbohydrates, also known as polysaccharides, include starch and fiber. Brief notes on dietary fiber, its sources and importance to human health are also provided, with the recommended intake of 20g to 30g fiber per day.

The 2003 Singapore Dietary Guidelines by the Singapore Health Promotion Board include four messages that are related to carbohydrates:
• Enjoy a variety of foods using the healthy diet pyramid as a guide;
• Eat sufficient amounts of grains, especially whole grains;
• Eat more fruit and vegetables every day; and
• Choose beverages and food with less sugar.

The Singapore Food Pyramid places grains and grain products at the base of the pyramid as they are a major component of the diet. The Guidelines also encourage the consumption of whole grains or unpolished grains as they contain more vitamins, minerals, dietary fiber and phytochemicals than refined grains.

In addition to encouraging increased consumption of fruit and vegetables, the explanatory notes proceed to explain the beneficial health effects of soluble fiber and insoluble fibers found in fruit and vegetables, including lowering blood cholesterol, promoting healthy bowel function as well as lowering risk to diseases such as heart disease, stroke and certain types of cancers.

The Guidelines also highlight that sugars are found naturally in many foods such as milk, fruit and vegetables. Sugars are also added during food processing or preparation, and frequent consumption of sweet foods and drinks between meals promotes dental caries, especially if oral hygiene is neglected. The Guidelines recommend reduction in the intake of added sugar, to no more than 10% of dietary energy.

**Dietary Guidelines of Thailand (2001)**
The Thai National Dietary Guidelines are jointly developed by the Institute of Nutrition, Mahidol University and the Ministry of Public Health. Four of these messages are relevant to carbohydrate nutrition:

• Eat a variety of foods from each of the 5 food groups and maintain proper weight;
• Eat adequate amount of rice or alternative carbohydrate sources;
• Eat plenty of vegetables and fruit regularly; and
• Avoid sweet and salty foods.

To provide a pictorial guide to the consumer in choosing the correct “portion”, “quantity” and “variety” of foods required daily, Thailand has adopted the “Nutrition Flag” (See Table 3) which is conceptually similar to the food pyramid. The Guidelines note that fiber in vegetables and fruit helps the body to remove waste as well as eliminate cholesterol and some carcinogenic compounds. It is also highlighted that unpolished rice or home-pounded rice is more nutritious than milled rice as it contains substantial amounts of important nutrients such as protein, fat, dietary fiber, minerals and vitamins. The Guidelines further recommend that not more than 10% of a person’s total food energy should be from sugar.

The official Dietary Guidelines of the Philippines, developed by the Food and Nutrition Research Institute (FNRI), has two messages that are relevant to carbohydrates:

• Eat a variety of foods everyday; and
• Eat more vegetables, fruit and root crops.
The Guidelines provide information on each of the major nutrients required, food groups and the concepts of a balanced diet. Consumers are encouraged to consume more vegetables, fruit and root crops, such as potato, sweet potato, yam, cassava and taro, in order to tackle the micronutrient deficiencies that are prevalent amongst some segments of the population. Eating root crops will also add dietary energy to the meal. In addition, these foods also provide dietary fiber in the diet. The supporting notes in the Guidelines provide details of the nutritional value of vegetables, fruits and root crops.

The Dietary Guidelines booklet of FNRI (2000) does not have a food guide pyramid. The Institute had, however, published a pyramid guide separately. The Philippines Association for the Study of Obesity (PASOO) also published a pictorial guide for healthy eating (See Table 3).

**Dietary Guidelines of Indonesia (2003)**
The Dietary Guidelines of Indonesia are developed by the Department of Health. Two of these messages are relevant to carbohydrate nutrition:

- Eat a variety of foods; and
- Consume carbohydrate foods to meet half of energy needs.

The Indonesian Dietary Guidelines have adopted the cone as a pictorial guide, which is in principle similar to the food pyramids used by several other countries. The Guidelines recommend that approximately 50% to 60% of the energy needs of an individual should be derived from complex carbohydrates such as rice, maize, tubers and sago. Consumption of sugars or simple carbohydrates should not exceed 5% of the total energy requirement of an individual.

The Guidelines do not include specific messages about dietary fiber. However, they emphasize the importance of having a balanced diet and sufficient dietary fiber intake (25 gram per day) to prevent or reduce risk of degenerative diseases such as coronary heart disease, hypertension and diabetes mellitus.

The Brunei Ministry of Health Dietary Guidelines include four messages that are related to carbohydrate nutrition:

- Eat a variety of foods from each of the groups according to the amounts recommended;
- Eat 2 to 3 servings of vegetables and 2 to 3 servings of fruit everyday;
- Prepare dishes that are less salty and less sweet; and
- Enjoy more legumes and cereal foods.

As a pictorial guide to the consumer, Brunei Darulssalam has adopted the food trays, with four layers of different sizes. Conceptually, it is similar to the food pyramid and the largest tray is at the bottom, containing complex carbohydrate foods such as rice and rice products, wheat and wheat products and tubers. The smallest tray, at the top, contains fats and oils, sugars and salt.

**Dietary Guidelines of Vietnam (1997)**
The Vietnamese Guidelines for appropriate food intake, jointly developed by the National Institute of Nutrition and the Vietnam Woman’s Union, has two key messages that are related to carbohydrate nutrition:
• Consume a small amount of sugar; and
• Increase the intake of vegetables, tubers and fruit.

Sugar has been specifically mentioned in the Guidelines, and it is recommended that a person should only consume an average of 500g of sugar per month. The Guidelines also provide recommended amounts of the other food groups that should be consumed per month.

Table 3. Carbohydrate (and dietary fiber) related key messages in the dietary guidelines of Southeast Asian countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Food Guide</th>
<th>Variety</th>
<th>Cereals and Grains, Root Crops (Legumes)</th>
<th>Fruit and Vegetables</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaysia (1999)</td>
<td>Enjoy a variety of foods.</td>
<td>Eat more rice and other cereal products, legumes.</td>
<td>Eat more fruit and vegetables.</td>
<td>Reduce sugar intake and choose foods low in sugar.</td>
<td></td>
</tr>
<tr>
<td>Singapore (2003)</td>
<td>Enjoy a variety of foods using the healthy diets pyramid as a guide.</td>
<td>Eat sufficient amounts of grains, especially whole grains.</td>
<td>Eat more fruit and vegetables every day.</td>
<td>Choose beverages and food with less sugar.</td>
<td></td>
</tr>
<tr>
<td>Thailand (2001)</td>
<td>Eat a variety of foods from each of the 5 food groups and maintain proper weight.</td>
<td>Eat adequate amount of rice or alternative carbohydrate sources.</td>
<td>Eat plenty of vegetables and fruit regularly.</td>
<td>Avoid sweet and salty foods.</td>
<td></td>
</tr>
<tr>
<td>Philippines (2000)</td>
<td>Eat a variety of foods everyday.</td>
<td>Eat more fruit, vegetables and root crops.</td>
<td>Consume milk, milk products or other calcium rich foods such as small fish and dark-green leafy vegetables everyday.</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Indonesia (2003)</td>
<td>Eat a variety of foods.</td>
<td>Obtain about half of total energy from complex carbohydrate-rich food.</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Carbohydrate (and dietary fiber) related key messages in the dietary guidelines of Southeast Asian countries (continued)

<table>
<thead>
<tr>
<th>Country</th>
<th>Food Guide</th>
<th>Variety</th>
<th>Cereals and Grains, Root Crops (Legumes)</th>
<th>Fruit and Vegetables</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brunei Darussalam (2000)</td>
<td></td>
<td>Eat a variety of foods from each of the groups, according to the amounts recommended.</td>
<td>Enjoy more legumes and cereals.</td>
<td>Take 2-3 servings of vegetables, ulam and 2-3 servings of fruit every day.</td>
<td>Take foods that are less salty and less sweet.</td>
</tr>
<tr>
<td>Vietnam (1997)</td>
<td></td>
<td>Increase intake of vegetables, fruit and tubers.</td>
<td>Increase intake of vegetable and fruit.</td>
<td>Consume a small amount of sugar.</td>
<td></td>
</tr>
</tbody>
</table>

**Dietary Guidelines of China (1997)**
Guidelines for the general population of the People’s Republic of China has two messages which are related to carbohydrate nutrition:2

- Eat a variety of foods, with cereals as the staple; and
- Consume plenty of vegetables, fruit and tubers.

The Dietary Guidelines released by the Chinese Nutrition Society emphasize the importance of maintaining the favorable traditional Chinese diet which comprises primarily of cereals. Additionally, the cereals in the diet should include a certain amount of coarse grains such as millet and corn, other than refined or milled rice and wheat flour. The Guidelines also emphasize the importance of consuming plenty of vegetables, fruits and tubers for the prevention of cardiovascular diseases, enhancement of immunity, reduction of risk of blindness and increased mortality in young children and even prevention of some cancers. Vegetables and fruit are rich in a variety of vitamins, minerals and dietary fiber. Besides vitamins and minerals, tubers are also rich in starch and dietary fiber.

To help consumers put the dietary guidelines into practice, the Food Guide Pagoda provides a visual guide to the types and amounts of foods to be consumed in order to achieve a balanced diet. Culturally more familiar to the Chinese people, the pagoda is nevertheless based on the same principles as the food pyramid, with the foods to be consumed most at the base of the pagoda and decreasing at the higher levels of the structure. Carbohydrate-rich and fiber-containing cereals and cereal products are at the base of the pagoda, whereas fats and oils are placed at the tip. The amount to be consumed are given in weight (grams).

In the dietary guidelines for Japanese, proposed by the Ministry of Health, Labour and Welfare, 13 four messages relate to carbohydrate nutrition:

- Eat well-balanced meals with staple food, as well as main and side dishes;  
- Eat enough grains such as rice and other cereals;  
- Combine vegetables, fruit, milk products, beans and fish in your diet; and  
- Take advantage of your dietary culture and local food products, while incorporating new and different dishes.

The Guidelines emphasize the importance of eating a variety of foods cooked in various ways. They also encourage individuals to combine home-made meals wisely with processed and prepared foods eaten out. Intake of sufficient grains such as rice and other cereals is encouraged to maintain adequate intake of energy from carbohydrates. The importance of consuming sufficient amounts of vegetables and fruit everyday to obtain enough vitamins, minerals and dietary fiber is further highlighted.

**Dietary Guidelines of Republic of Korea (2002)**

The Dietary Guidelines of Korea have two messages that are related to carbohydrate intake and emphasizes on rice consumption:

- Eat a variety of grains, vegetables and fruits, fish, meat, poultry and dairy products; and  
- Enjoy a rice-based diet.

The Guidelines include action guides for adults and the elderly. A food pagoda is also used as a pictorial guide on food choices to the consumer.

**Dietary Guidelines of India (1998)**

The Indian Dietary Guidelines were developed by the National Institute of Nutrition in Hyderabad, India. 5 Five of the key messages deemed relevant to carbohydrate nutrition, are listed below:

- A nutritionally adequate diet should be consumed through a wise choice from a variety of foods;  
- Plenty of green leafy vegetables, other vegetables and fruit should be consumed; and  
- Processed and ready-to-eat foods should be used judiciously. Sugar should be used sparingly.

The supporting notes for message 1 above, highlight the importance of consuming nutritionally adequate diet, providing all essential nutrients in the required amounts, at any age throughout life. Daily intakes lower or higher than the body requirements can lead to under-nutrition (deficiency diseases) or over-nutrition (diseases of affluence), respectively. In a balanced diet, carbohydrates, preferably starch, should provide around 60% to 70% of total calories, proteins should provide about 10% to 12%, and fat should provide about 20% to 25%. In addition, a balanced diet should provide other non-nutrients such as dietary fiber, antioxidants and phytochemicals which provide positive health benefits. The required nutrients must be obtained through judicious choices and combination of a variety of foods.
The key messages in the official Australian Dietary Guidelines, developed by the National Health and Medical Research Council, include four messages that are related to carbohydrates nutrition:

- Enjoy a wide variety of nutritious foods;
- Eat plenty of vegetables, legumes and fruit;
- Eat plenty of cereals, preferably whole grains; and
- Consume only moderate amounts of sugars and foods containing added sugars.

The food plate is used as a guide to the choice of types of food and the amounts of each to be consumed daily. Consumers are encouraged to consume plenty of vegetables, legumes (lentils, beans and peas) and fruit. Together with nuts and seeds, these foods provide the body with many of the essential nutrients needed daily. In addition, they also protect against the ageing process and common diseases such as high blood cholesterol, diabetes, cataracts in the eyes and even some forms of cancers. Cereals (including wheat, maize, rice, barley, sorghum, oats, rye and millet) form the foundation of the daily meals and are highlighted in the third key message above. These foods are eaten in relatively large amounts and provide half the energy and half the protein needs of communities. They are also excellent sources of B-group vitamins and contain useful amounts of vitamin E, essential fatty acids, minerals and dietary fiber. The Guidelines also recognize that sugar does provide extra calories in the diet without adding any other beneficial nutrients, and plays a significant role in tooth decay. Hence, the Guidelines recommend consuming only moderate amounts of sugars and foods containing added sugars.

Table 4. Carbohydrate (and dietary fiber) related key messages in the dietary guidelines of other Asian countries and Australia

<table>
<thead>
<tr>
<th>Country</th>
<th>Food Guide</th>
<th>Variety</th>
<th>Cereals and Grains, Root Crops (Legumes)</th>
<th>Fruit and Vegetables</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>China (1997)</td>
<td>Enjoy a variety of foods.</td>
<td>Use cereals as the staple food. Consume beans or bean products everyday.</td>
<td>Consume plenty of vegetables, fruit and tubers.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Japan (2000)</td>
<td>Eat well-balanced meals with staple food, as well as main and side dishes. Combine vegetables, fruit, milk products, beans and fish in your diet.</td>
<td>Eat enough grains such as rice and other cereals.</td>
<td>Eat enough of vegetables and fruit everyday to get vitamins, minerals and fiber.</td>
<td>-</td>
<td></td>
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</tbody>
</table>
Table 4. Carbohydrate (and dietary fiber) related key messages in the dietary guidelines of other Asian countries and Australia (continued)

<table>
<thead>
<tr>
<th>Country</th>
<th>Food Guide</th>
<th>Variety</th>
<th>Cereals and Grains, Root Crops (Legumes)</th>
<th>Fruit and Vegetables</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Republic of Korea</td>
<td>–</td>
<td>Eat a variety of grains; enjoy your rice-based diet.</td>
<td>Eat a variety of vegetables and fruit.</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>(2002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>–</td>
<td>Nutritionally adequate diet should be consumed through wise choices from a variety of foods.</td>
<td>–</td>
<td>Green leafy vegetables, other vegetables and fruit should be used in plenty.</td>
<td>Processed and ready-to-eat foods should be used judiciously. Sugars should be used sparingly.</td>
</tr>
<tr>
<td>(1998)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>Enjoy a variety of nutritious foods.</td>
<td>Eat plenty of cereals, preferably whole grain, eat plenty of legumes.</td>
<td>Eat plenty of vegetables and fruit.</td>
<td>Consume only moderate amounts of sugars and foods containing added sugars.</td>
<td></td>
</tr>
<tr>
<td>(2002)</td>
<td></td>
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</table>

Dietary Guidelines of the USA (2005)

The US Department of Health and Human Services and the US Department of Agriculture jointly released the new Dietary Guidelines for Americans in 2005. Three of the 10 chapters contain messages that are related to carbohydrate nutrition:

- Adequate nutrients within calorie needs (Chapter 2);
- Food groups to encourage (Chapter 5); and
- Carbohydrates (Chapter 7).

In Chapter 2, the Guidelines point out that many Americans consume more calories than they need without meeting recommended intakes for a number of nutrients. Hence, the Dietary Guidelines recommend that most people need to choose meals and snacks that are high in nutrients but low to moderate in energy content; that is, meeting nutrient recommendations must go hand in hand with keeping calories under control. Doing so offers important benefits - normal growth and development of children, health promotion for people of all ages, and reduction of risk for a number of chronic diseases that are major public health problems. The emphasis was to consume a variety of nutrient-dense foods and beverages within and among the basic food groups while choosing foods that limit intake of saturated and trans fats, cholesterol, added sugars, salt and alcohol.
The dietary guidelines also emphasize that intake levels of the following nutrients may be of concern for adults: calcium, potassium, fiber, magnesium, and vitamins A (as carotenoids), C, and E. For children and adolescents, the following nutrients are important: calcium, potassium, fiber, magnesium, and vitamin E. For specific population groups (e.g., pregnant women and the elderly), vitamin B12, iron, folic acid, and vitamins E and D are important.

Chapter 5 of the Dietary Guidelines emphasizes the important health effects of increased intakes of fruit, vegetables, whole grains, and fat-free or low-fat milk and milk products. The consumer is encouraged to choose a variety of fruits and vegetables each day, particularly, dark green, orange, legumes, starchy vegetables, and other vegetables. An array of evidence points to beneficial health effects of increased intake of fruit and vegetables and reduced risk of chronic diseases including stroke and perhaps other cardiovascular diseases, Type 2 diabetes, and cancers in certain sites (oral cavity and pharynx, larynx, lung, esophagus, stomach, and colon-rectum). Diets rich in foods containing fiber, such as fruit, vegetables, and whole grains, may reduce the risk of coronary heart disease. Diets rich in milk and milk products can reduce the risk of low bone mass throughout the life cycle. The consumption of milk products is especially important for children and adolescents who are building their peak bone mass and developing lifelong habits. Although each of these food groups may have a different relationship with disease outcomes, the adequate consumption of all food groups contributes to overall health.

Chapter 7 emphasizes that carbohydrates are part of a healthful diet, contributing 45% to 65% of total calories. Dietary fiber is composed of nondigestible carbohydrates and lignin, intrinsic and intact in plants. Diets rich in dietary fiber have been shown to have a number of beneficial effects, including decreased risk of coronary heart disease and improvement in laxation. There is also interest in the potential relationship between diets containing fiber-rich foods and lower risk of Type 2 diabetes. Sugars and starches supply energy to the body in the form of glucose, which is the only energy source for red blood cells and is the preferred energy source for the brain, central nervous system, placenta, and fetus. Sugars can be naturally present in foods (such as the fructose in fruit or the lactose in milk) or added to the food. Added sugars, also known as caloric sweeteners, are sugars and syrups that are added to foods at the table or during processing or preparation (such as high fructose corn syrup in sweetened beverages and baked products). Although the body’s response to sugars does not depend on whether they are naturally present in a food or added to the food, added sugars supply calories but few or no nutrients.

Consequently, it is important to choose carbohydrates wisely. Foods in the basic food groups that provide carbohydrates - fruit, vegetables, grains, and milk - are important sources of many nutrients. Choosing plenty of these foods, within the context of a calorie-controlled diet, can promote health and reduce chronic disease risk. However, the greater the consumption of foods containing large amounts of added sugars, the more difficult it is to consume enough nutrients without gaining weight. Consumption of added sugars provides calories while providing little, if any, of the essential nutrients.

In 2005, the United States Department of Agriculture released a new food pyramid to help consumers choose the appropriate types and amounts of foods. An online version of MyPyramid (www.mypyramid.gov) has been made available. MyPyramid makes recommendations for the amounts (given in cups and ounces) of each of the main food groups, namely grains, vegetables, fruits, milk
and meat and beans to be consumed daily, taking into consideration the activity level of the individual. For each food group, the Guidelines provide brief notes on the types of foods and the nutritional properties.

**Dietary Guidelines of Canada (1997)**

Canadian Dietary Guidelines were released by Health Canada, the Federal department responsible for helping Canadians maintain and improve their health a few years ago. Two of them relates to carbohydrates nutrition:

- Enjoy a variety of foods; and
- Emphasize cereals, breads and other grain products, vegetables and fruit.

The Guidelines recommend that the Canadian diet should provide 55% of energy as carbohydrate from a variety of sources. Eating patterns that are high in complex carbohydrate and fiber are associated with a lower incidence of heart disease and certain types of cancer. Canada’s Food Guide to Healthy Eating promotes carbohydrates in a rainbow design that places grain products, vegetables and fruit in the outermost arcs and shows a wide range of foods in both groups. A larger number of servings are recommended for both grain products and vegetables and fruit. Consumers are also encouraged to choose dried peas, beans and lentils more often, as alternatives to meat.

The Food Guide also discusses the consumption of simple carbohydrates and sugars. Sugars occur naturally in foods like milk, fruit and vegetables, as well as fructose, dextrose, liquid invert sugar, molasses, honey and corn syrup. Examples of foods that are mostly sugars are soft drinks, candy and jams. All added sugars, including honey and molasses, contribute primarily energy and taste and have no other significant nutritional advantages. With the exception of dental caries, there is no conclusive evidence that sugars, when consumed at current levels, are hazardous to the health of the general public. However, people with lower energy needs may need to be more careful with their intake of foods that are high in sugar in addition to foods that are high in fat because they may not need to consume this extra energy.

**Dietary Guidelines of the UK (2004)**

The Dietary Guidelines of the Department of Health, UK has the following four key messages that relate to carbohydrate nutrition:

- Eat a variety of different foods;
- Eat plenty of foods rich in starch and fiber;
- Eat plenty of fruit and vegetables; and
- Don’t have sugary foods and drinks too often.

The Balance of Good Health (BGH), a pictorial representation of the recommended balance of foods in the diet, is in the shape of a plate. It shows the types of foods and the proportion in which they should be eaten to have a well-balanced, healthy diet. BGH is based on five food groups. Choosing a variety of foods from the first four groups every day will provide the body with the wide range of nutrients needed. Foods in the fifth group – foods containing fat and foods containing sugar
- are not essential to a healthy diet but add extra variety, choice and palatability to meals. This group of foods should form the smallest part of the diet.

**Dietary Guidelines for Adults in Greece (2000)**
The Greek Dietary Guidelines, issued by the Hellenic Ministry of Health, also emphasize eating a variety of foods.21 As with the other guidelines reviewed so far, the emphasis is for the consumer to consume carbohydrate and dietary fiber-rich cereals and products, particularly non-refined ones. These foods, such as wholegrain bread, whole grain pasta and brown rice, etc., are placed at the base of the pictorial presentation of the food-based dietary guidelines, in the shape of a pyramid. Sweets are close to the top of the pyramid and are to be consumed weekly. The Guidelines encourage the consumption of fruits and nuts as snacks, instead of sweets or candy bars and water instead of soft drinks.

**South African Food-Based Dietary Guidelines (2001)**
There are 10 prime messages in the South African Dietary Guidelines,22 four of which are related to carbohydrates and elaborated below:

- Enjoy a variety of foods;
- Make starchy foods the basis of most meals;
- Eat plenty of fruit and vegetables; and
- Eat dry beans, split peas, lentils and soya regularly.

The key message of making starchy foods the basis of most meals is directly relevant to this paper. Starchy or high carbohydrate foods such as cereals, grains and some root vegetables, the main sources of dietary energy and valuable sources of micronutrients and dietary fiber when they are eaten in minimally processed forms. These foods also contribute protein to the diet. Foods rich in carbohydrates in the form of starch, resistant starch, sugars and non-starch polysaccharides or dietary fiber influence health and prevent chronic diseases by various effects and mechanisms.

The recommendation to eat dry beans, peas, lentils and soy regularly is one of the key messages in the South African dietary guidelines. Also known as legumes, these foods are rich and economical dietary sources of good quality protein, carbohydrates, soluble and insoluble dietary fiber components and a variety of minerals and vitamins. In addition, soya beans also contribute significantly to polyunsaturated fatty acid intake, including α-linolenic acid, an n-3 fatty acid not commonly found in plant foods. Legumes are excellent foods to increase dietary fiber consumption and most individuals can incorporate legumes into their diet without difficulty. Including legumes in a health-promoting diet is important to meet the major dietary recommendations to improve the nutritional status of undernourished as well as to reduce risk for chronic diseases such as cardiovascular disease, diabetes mellitus, cancer and osteoporosis.

The dietary guidelines developed by the Argentine Dietitian and Nutritionist Association has 10 key recommendations for healthy living; three of them refer to carbohydrates (and fiber) consumption.
• Consume a variety of breads, grains and cereals, pasta, flour, starches and legumes (dry beans);
• Reduce the consumption of sugar and salt; and
• Consume a variety of vegetables and fruit each day.

Grains in these Dietary Guidelines include rice, maize, wheat, oat, barley and rye, whereas legumes include lentils, peas and soya bean. The Guidelines also encourage the consumption of whole grain products. Calories from carbohydrate is recommended to contribute 50% to 60% of total daily energy requirement. An intake of 25g to 30g of dietary fiber a day is recommended.

The Guidelines also recommend reducing consumption of sugar and limiting food and beverages with added sugar for occasional situations. With regards to fruit and vegetables, five portions of these are recommended each day. It is also encouraged to consume raw vegetables and fruit at least once a day. For cooking, large pieces of vegetables with their skin are recommended to be steamed or boiled in a small amount of water.

Instead of a pyramid, the Argentine Dietary Guidelines have adopted the use of an oval pictorial with the graphics of six food groups, starting with water.

Table 5. Carbohydrate (and dietary fiber) related key messages in the dietary guidelines of other countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Food Guide</th>
<th>Variety</th>
<th>Cereals and Grains, Root Crops (Legumes)</th>
<th>Fruit and Vegetables</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States of America (2005)</td>
<td>[Pyramid Image]</td>
<td>Consume a variety of nutrient-dense foods and beverages within and among the basic food groups.</td>
<td>Choose fiber-rich fruits, vegetables, and whole grains often.</td>
<td>Choose a variety of fruit and vegetables each day. In particular, select from all five vegetable subgroups (dark green, orange, legumes, starchy vegetables, and other vegetables) several times a week.</td>
<td>Choose and prepare foods and beverages with little added sugars or caloric sweeteners.</td>
</tr>
<tr>
<td>Canada (1997)</td>
<td>[Maple Leaf Image]</td>
<td>Enjoy a variety of foods.</td>
<td>Emphasize cereals, bread, other grain products.</td>
<td>Emphasize vegetables and fruit.</td>
<td>–</td>
</tr>
<tr>
<td>United Kingdom (2004)</td>
<td>[Plate Image]</td>
<td>Eat a variety of different foods.</td>
<td>Eat plenty of foods rich in starch and fiber.</td>
<td>Eat plenty of fruit and vegetables.</td>
<td>Do not have sugar-containing foods and drinks too often.</td>
</tr>
</tbody>
</table>
Discussions and Conclusions

The dietary guidelines of 18 countries across seven regions of the world have been reviewed in this paper. Two key expert consultation reports of the FAO and WHO have also been reviewed and the relevant information discussed. The key messages of each of the country guidelines were examined and those messages related to carbohydrates (including dietary fiber) were listed out and discussed. It is evident that there is a great deal of similarity across the countries surveyed.

Guidelines of some of the countries also emphasized nutrient-dense foods and beverages. All but one of the countries (India) support the consumption of cereals, grains and root crops to provide carbohydrate (starch) as the main source of energy for daily activities, as well as dietary fiber, vitamins, minerals and phytochemicals that are important for health. Several countries, namely Malaysia, Thailand, Korea, Japan and Argentina, focus specifically on rice as one of the recommended cereals. A few countries - Singapore, Australia, USA and Argentina - further encourage consumption of whole grains for their dietary fiber content.

Although not specifically mentioned in the key messages, all guidelines reviewed stated the importance of dietary fiber to human health in their supporting notes. This mention of dietary fiber can be in conjunction with consuming cereals and grains and legumes, as well as with increasing intake of fruits and vegetables. Several countries specifically mentioned the association of fiber consumption and lowering risk of chronic diseases. The amount of dietary fiber recommended for daily consumption is not specifically mentioned in most of the dietary guidelines with the exception of 2 countries - Malaysia (20g to 30g per day) and Indonesia (25g per day). In the WHO (2003) nutrient intake
goals, the recommended total dietary fiber per day is more than 25g, of which more than 20g should be from non-starch polysaccharides. WHO (2003) has indicated dietary fiber as having “convincing” evidence for being protective against obesity and “probably” beneficial for Type 2 diabetes and cardiovascular diseases (CVD). Whole grain cereals are also probably protective against CVD.

The message on sugar is less consistent for all the countries surveyed. Eleven of the 18 countries (Malaysia, Singapore, Thailand, Brunei, Vietnam, India, Australia, USA, UK, Greece and Argentina) have a key message recommending consuming less sugar or less sweet foods. These foods are generally placed at the tip of the pyramid or comprise the smallest portion of the food plate. Even for those countries with key a message on sugar or sweet foods, the supporting information on this message is not consistent. The message is generally to reduce intake of sugars, and the amount is not stipulated. A few countries do recommend reduced intake of added sugar to no more than 5% (Indonesia) or 10% (Singapore and Thailand) of dietary energy. The WHO (2003) population nutrient intake goals have recommended daily free sugars intake to be not more than 10% of total energy intake.

Dietary guidelines should remain as important educational tools in promoting healthy eating amongst the community. There should be greater efforts amongst all relevant parties to make these truly effective tools. FAO and WHO should continue to play leadership roles in making dietary guidelines as one of the effective strategies for the promotion of appropriate diets and healthy lifestyles.

References


Panel Discussion I

Carbohydrates and Nutrition Labeling Issues

The first Panel Discussion, which dealt with nutrition labeling issues with respect to carbohydrates, was chaired by Dr. David Lineback who steered the discussion towards a number of important issues: What do we like to see in the label concerning carbohydrates? What do the consumers want? Will they use the information? How are they going to use it? Related to these issues is the problem of defining qualitative terms such as “sugar free”, “low carbohydrates”, “reduced sugar”, “no added sugar”, “unsweetened”, etc. Despite the fact that there are a number of health claims approved by regulatory bodies, the health claims stated on the label may be unclear, confusing and misleading.

While there was a general agreement on the need for nutrition labeling as an instrument of consumer education as well as consumer and professional guidance, the participants expressed the need not only for stating the amounts of carbohydrates, dietary fiber and sugar, but voiced the question of how the values should be expressed, whether by weight per serving or per 100g of food, or per cent of Daily Value. It was suggested that the Codex recommendation of expressing the amounts in terms of NRV for comparison purposes should be followed for uniformity.

The issue of the need to include classes of carbohydrates and dietary fiber, such as soluble and insoluble dietary fiber, psyllium, β-glucan, etc., or functional properties such as glycemic index, glycemic load, GGE, etc., or added components such as pre- and probiotics, was more contentious on account of the absence of clear definitions and guidelines on their use such as on how much is enough. There is still a need for clear definitions of such terms as “low carbohydrate food”, “low carbohydrate diet”, “whole grains”, “high fiber”, etc. The need for a virtual food component to represent food effects separate from food composition label was suggested. More scientific studies will be required to clarify all these issues, but ultimately, the question boils down to what information would be useful to consumers and how the consumers are going to use the information in the label. On the matter of what is useful to consumers, it was suggested to consider the priority public health problems in the country.

On the issue of health claims that may be included in the label, it is clear that they could only apply to the reduction of risk and not the cure of any disease. Approval of health claims is subject to strict regulations by the country’s regulatory bodies. Only a limited number of health claims are permitted based on scientific studies, and any question of permissibility is subject to deliberation and approval by the regulatory body.

Consumer research has shown some of the information consumers want. Consumers, particularly those who are health conscious, do read labels, but they want to know if the product is “good” or “better”. Most consumers understand basic nutrition information, but could not compare foods, such as which processed food is a healthier choice compared to another. They need guidance on what food to choose through a simple system of indicating a healthy food as pronounced by a reputable body. Thus, there is a need to move from the scientific area to the area of effective communication to consumers, in a way that is simple and positive. The challenge is how to effectively educate consumers on how to apply the nutrition information in food labels, and therefore the need for a continuing consumer education program.
Panel Discussion II

Dietary Guidance - Forecasting the Future

The second Panel Discussion, focusing on dietary guidance on carbohydrates and its future, was chaired by Dr. E-Siong Tee. Dr. Tee guided the discussion along the relevance of current dietary guidelines with respect to carbohydrates, their utilization by professionals and the community, and the new directions that the guidelines should take in the face of new scientific information and changing public health problems.

The participants agreed that the purpose of dietary guidelines is to encourage the general public to consume the proper amount and balance of foods in order to live healthy lives. Hence, there should, first, be a clear definition of what is needed for a healthy diet, or what the "gold standard" for the population is. While this should be based on science, we should understand the dietary patterns of the consumers, and what behaviors or behavior changes are encouraged. When changes in dietary pattern are advised, the question of whether the public is ready for such change should be considered, and whether there may be a need for transitional messages. The bottom line is whether the current dietary guidelines are understood, utilized and followed by the consumers.

With respect to the relevance of current messages, the guidelines should not only be culturally specific for the country but population specific as well. There may be urban–rural differences that need to be considered. The participants agreed that the messages should reflect the changing public health problems of the population, such as the increasing incidence of obesity and chronic diseases like diabetes and heart disease in relation to the trend in carbohydrate intake. While agreeing with the FAO/WHO recommendations of 55% to 70% of total calories as carbohydrates, the participants felt that consideration should be given to the caloric intake of the population, the effect of changing the level of carbohydrate intake on the other macronutrients especially fat, and on the intake of micronutrients and other functional food components that are present in carbohydrate-rich foods. Consideration should also be given to the different physical activity levels in the population. Moreover, it is not enough to express carbohydrate recommendations in terms of total amounts and proportion to total calories, but there is a need to be more specific as to the type of carbohydrates such as starch and complex or unrefined carbohydrates, simple sugars, dietary fiber, under-milled grains, etc. The effect of carbohydrates on performance, as well as the role of carbohydrates in obesity, diabetes, metabolic syndrome, and other metabolic abnormalities should be taken into account. However, any recommendations on these matters should be based on science.

The current dietary guidelines in the Southeast Asian region appear to be simple enough and stated in layman's terms to be understandable. However, there is a need for a supporting framework to help the public apply the messages. Accompanying explanatory text in the form of brochures and other informational strategies would be useful. The use of a pictorial guide such as the Food Guide Pyramid may be helpful, but again this should be culturally appropriate. Care should be taken with regards to the amounts and portion sizes recommended as these may be unrealistic and difficult to follow. The wording of the guidelines should be carefully examined for clarity. For example,
“unrefined grains” may be better understood than “whole grains”. Descriptive terms such as “high” or “low” need to be defined. Apart from the guideline for the general population, there may be a need for guidelines for specific groups such as the elderly, pregnant and nursing women, adolescents, and those suffering from chronic diseases like diabetes, heart disease, etc., where the recommendations could be more specific and focused. Likewise, distinction may be made between guidelines for professionals and guidelines for the general public.

The issue of whether current guidelines are being utilized by the public and their impact on the population was extensively discussed. There is a dearth of information on how the current guidelines are being understood and used by the public. There is thus a need for monitoring and evaluating the effectiveness of the guidelines in improving the diet of the population. Monitoring the efficiency by which the guidelines are being delivered and disseminated in addition to evaluating their effectiveness was also suggested. It is important to know if the guidelines are reaching the people who need to know, and not only the individuals who are already health-conscious. All this information is essential in formulating effective strategies to convey the messages of the guidelines. Ultimately, the challenge is how best to inform and educate the public together with the media on the recommended dietary guidelines.

The participants also recognized the important role of the guidelines in industry. Industry is in fact looking at the guidelines as an expression of policy with regards to the recommended dietary pattern for the population. Based on this, industry may take certain directions in terms of product development. As such, there is a need to consider the contribution of processed foods and fast foods to achieving the objective of the guidelines.

Finally, the issue of harmonizing the different country guidelines currently being used in the region was discussed. ILSI SEA Region has in fact taken steps towards this direction. In 1996, ILSI SEA Region organized the Regional Workshop on Food-Based Dietary Guidelines (FBDG) for Asian Countries held in Singapore. and in 1998, ILSI SEA Region together with FAO followed this up with the Seminar/Workshop on FBDG and Nutrition Education held in Kuala Lumpur, Malaysia. The recent review of Dr. Tee on the dietary guidelines in the region and around the world focusing on carbohydrates has again shown the similarities and differences of the guidelines used in the region. Nevertheless, it was apparent that there were striking similarities among them, particularly on carbohydrates.

The Panel Discussion ended with a summary by Dr. Tee of the major points taken up, such as the need to consider the changing trends in public health problems in the region, the importance of monitoring and evaluating dietary patterns not only for evaluating the effectiveness of the recommended dietary guidelines but to point to future directions that the guidelines should take, and the need for guidelines directed to specific population groups and targets.
Editor

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