Coconut Bliss: A Research-Based Review of the Health and Nutrition Benefits

By Buck Levin, Ph.D., R.D.

Ice Cream and Public Health Guidelines

Ice cream has not traditionally appeared in public health dietary guidelines except as a member of some negatively-perceived food group—usually labeled as "Fats, Oils and Sweets" or "Discretionary Calories"— and serving as a catch-all for all foods with added fats, added sugars, or both. In the latest version of the U.S. Department of Agriculture's Food Pyramid (available at: http://www.mypyramid.gov/), the USDA classifies ice cream as a food providing "3 teaspoons of solid fat," and it also includes ice cream on a list of foods that "contain most of the added sugars in American diets." Since adults in the U.S. average 124 grams of sugar per day, 82 grams of fat, and 28 grams of saturated fat each day, this placement of ice cream makes sense. Leading brands of nationally-marked ice cream typically contain about 15-20 grams of total fat, 8-12 grams of saturated fat, and 20-25 grams of sugar per serving. Much of the fat comes from ingredients like cream and milkfat, and much of the sugar comes from corn syrup and cane sugar. Ice creams traditionally derive about 50-60% of their calories from fat and 30-40% of their calories from sugar. Total calories in a serving of ice cream typically range from 200-300 per half-cup. In order to understand this placement of ice cream in dietary guidelines from public health organizations in the U.S., it is important to look at rates of chronic disease in the U.S. and their relationship to diet.

Rates of Chronic Disease and The Role of Diet

Increasing rates of chronic disease are a hallmark of many epidemiologic studies on the U.S. population over the past several decades. For example, obesity rates currently fall at a level of 20% or higher in 43 out of 50 states, and if diagnoses of obesity and overweight are considered in combination, 2/3rds of all adults in the U.S. are currently considered to be either overweight or obese. Because this percentage has been steadily increasing since the 1990's, experts predict that 86% of all U.S. adults will be either overweight or obese by the year 2030.

Alongside of obesity, heart disease and type 2 diabetes are widely regarded as two of the most pressing health problems facing the U.S. population. Some form of cardiovascular disease accounts for 42% of all deaths in the U.S, and along with the 21 million people who are now projected to have type 2 diabetes, another 41 million are thought to have pre-diabetes. Those 62 million people account for approximately 20% of the U.S. population.

When risk factors for these chronic diseases (obesity, heart disease, and type 2 diabetes) are considered, lifestyle factors stand at the forefront. And amongst all lifestyle factors—including smoking, exercise, sleep, and stress—no single factor stands out as greater in importance than diet. In general, dietary problems that have been shown to increase the risk of obesity, heart disease, and type 2 diabetes have also been shown to be problems of excess. Too many calories, too much trans fat, too much saturated fat, and too much added sugar are dietary risk factors that top the list of contributors to chronic disease. Even though the U.S. population shows widespread nutrient deficiencies, including dramatic deficiencies of nutrients like omega-3 fatty acids and vitamin D and magnesium, the steady rise in obesity, heart disease, and diabetes seem more closely related to overconsumption than deficiency. Excessive intake of high-calorie foods filled with low-quality fats (including trans fats and long-chain saturated fats) and excessive intake of processed, simple sugars are key themes in the overconsumption and chronic disease research. And it is within this diet-and-chronic disease context that ice cream has been placed within the "Discretionary Calories" category and regarded as a food that must be approached with great caution.

From a public health perspective, avoiding excess is a clear goal when considering ice cream (or other high-fat, high-sugar foods). More specifically, excess involving calories, total fat, saturated fat, and simple sugars is the type of excess specifically targeted in dietary guidelines issued by public health organizations in the U.S.

Coconut Bliss and Dietary Excess

On a per serving (1/2 cup) basis, Coconut Bliss averages 206 calories, 14 grams of fat, 11 grams of saturated fat, and 13 grams of sugar. Based on current dietary intake of the U.S. population, those values represent about 10% of a day's calories, 17% of a day's fat, 39% of a day's saturated fat, and 10% of a day's sugar. Given those percentages, would a serving of Coconut Bliss count as dietary excess? The answer to that question is as follows:

When it comes to dietary intake, there is no question that the average U.S. adult needs to cut back calories, total fat, saturated fat, and simple sugars. Even a 10% reduction in the average intake categories listed above could result in significantly improved health for a large number of individuals. So it would not make sense to say that a serving of Coconut Bliss provides only 10% of a day's calories and leaves 90% of total calories still available for the day. The average U.S. adult needs to cut back in calories (and total fat, saturated fat, and added sugars). However, even if an individual decided to cut back by 15% in all of the nutrient intake areas described above, that individual could still make room for a

serving of Coconut Bliss within a healthy day's food. A cutback of 15% in calories, for example, would set the daily total at about 1,750, making a serving of Coconut Bliss about 12% of the day's total. Could Coconut Bliss throw an otherwise healthy, 1,750-calorie diet over the limit for calories, total fat, saturated fat, and simple sugars? Yes, it could. A 200-calorie serving of any food that was relatively high in fat and sugar could throw an otherwise healthy diet out of balance. But the average macronutrient amounts contained in one serving of Coconut Bliss are amounts that pose no practical problem for an individual who wants a delicious, ready-made ice cream treat and adapts his daily food plan to make room for it.

With respect to dietary excess, the only question raised by the macronutrient content of Coconut Bliss involves its saturated fat content. The fact that saturated fats in Coconut Bliss account for 39% of the amount allowed on a 2,000-calorie diet makes means that the saturated fats in Coconut Bliss represent too high a percentage of the diet. However, it's the unusual type of saturated fat in Coconut Bliss that makes it an exception to the usual guidelines for saturated fat intake. As will be discussed shortly in this review, there is research demonstrating not only acceptability for Coconut Bliss in terms of its saturated fat content, but also potential health benefits.

It's also worth noting that nationally-marketed, leading-brand ice creams average significantly higher calories and sugar than Coconut Bliss. Many leading brand ice creams contain 250-350 calories per half-cup serving and 20-30 grams of sugar. Those numbers place Coconut Bliss in a nutrition category that is about 33% lower in calories and 50% lower in sugar than many leading brands. Coconut Bliss falls into an average range for ice creams in terms of its total fat content, since it contains an average of 14 grams per serving and leading brands typically average between 10-20 grams. This combination of average fat plus fewer calories and less sugar makes Coconut Bliss easier to incorporate into a healthy diet plan than many leading brand ice creams.

Key Ingredients in Coconut Bliss

Because the ingredients in Coconut Bliss are certified organic ingredients—and because Coconut Bliss itself is a certified organic product—it is free from many potential toxic residues that are characteristic of many non-organic ice creams. These residues include heavy metals, industrial solvents, pesticides, and herbicides. In addition, the certified organic status of Coconut Bliss means that it is free from genetically engineered ingredients or ingredients that have been irradiated. These features separate Coconut Bliss from many nationally-marketed, leading-brand ice creams. But there are two ingredients in Coconut Bliss that make it a unique product in the ice cream market. First is its use of coconut milk as a base ingredient, and second is its use of agave syrup as a

sweetener. Each of these ingredients has research-based health benefits as described below.

Coconut Milk

Unlike the milkfat, cream, and palm oil commonly used to provide commercial ice creams with their creamy "mouth-feel" and rich texture, the coconut milk found in Coconut Bliss has a long history of use in cuisines worldwide, including use by many populations that enjoy lower rates of chronic disease than the U.S. population. Thailand, Malaysia, Singapore, Sri Lanka, Indonesia and West Africa are countries in which coconut milk has played an important role in the everyday diet for many generations. There are a greater number of studies on the health benefits of coconut oil than coconut milk, but both coconut oil and coconut milk originate from the pulpy meat of the coconut and so they share some important chemical properties and overlap in their health effects for this reason. The most important part of this overlap involves their fatty acid content. Both coconut-derived products contain an unusually high concentration of saturated fatty acids. For both coconut oil and coconut milk, this percentage is about 85-90%. However, unlike the saturated fat found in most animal foods, the saturated fat found in coconut consists mostly of caprylic (C8), capric (C10), and lauric acid (C12) rather than myristic (C14), palmitic (C16) and stearic (C18). Saturated fatty acids (SFAs) ranging from 6-12 carbons are called medium chain fatty acids (MCFAs) and in coconut milk they constitute 65% of the total SFAs. Saturated fatty acids (SFAs) ranging from 14-18 carbons are called long chain fatty acids (LCFAs) and in coconut milk they constitute only 35% of the total SFAs. By comparision, approximately 40-45% of the fat in a high-fat animal food like beef shortrib is saturated, and 90-95% of the SFAs in beef shortrib are LCFAs.

The MCFAs in coconut milk, and coconut milk itself, have been show to have health benefits. Most of the benefits from MCFAs have been studied in foods other than coconut. For example, the health benefits of fermented dairy products—particularly digestive tract and immune system-related benefits—have been partly attributed to MCFA content. When substituted for more polyunsaturated vegetable oils, MCFAs (in the form of MCT oil, or medium chain triglyceride oil) have been shown to lessen fat deposition. MCFAs have also been successfully used in parenteral nutrition studies to improve immune function in patients with severe intestinal problems. The tendency of MCFAs to be supportive of digestive tract and immune system function is paralleled by research studies on coconut milk and coconut oil. In terms of digestive support, these coconut-based foods have been shown to have antiulcer properties, and to digest in such a way that abdominal obesity gets reduced in women with excess abdominal body fat. In terms of immune support, coconut milk has been shown to contain a cytokine that directly impacts adaptive immune response. Further

benefits from these coconut-based foods include the ability to improve HDL cholesterol levels and to improve calcium absorption.

Unlike coconut oil, coconut milk is significantly more concentrated in vitamins and minerals and brings along with it these unique nutrient benefits. Small but still valuable amounts of magnesium, phosphorus, potassium, iron, and manganese are provided by coconut milk, and in the case of some Coconut Bliss flavors, 10% of the Daily Value for iron is provided in one half-cup serving. With the exception of vitamin B12, all B vitamins—including B1, B2, B3, B5, B6, folate, biotin and choline—are provided by the coconut milk in Coconut Bliss, as is vitamin E and vitamin K.

Agave Syrup

The sweetener used in Coconut Bliss ice cream has become its most controversial component, despite the value of this sweetener from a health and nutrition perspective. The controversy surrounding agave syrup has centered almost exclusively on fructose. However, before addressing that controversy in full detail, it is worth noting some characteristics of agave itself, and particularly in comparison to other widely-used sweeteners in commercial ice creams.

Agavaceae are a well-studied plant family and within the *Agave* genus are found several hundred equally well-studied *Agave* species. Agave has a long history of food use in Mexico and Central America, and the flowers, leaves, and sap of agave have found their way into many different culinary traditions in this region. Agave's history of use as a whole, natural food is important—especially in contrast other sweeteners commonly used in commercial ice creams. High fructose corn syrup, for example, is commonly produced from genetically engineered corn, and the presence of this sweetener in ice cream raises questions about genetic modification of food that simple do not exist for agave or agave syrup.

Agave syrup also differs greatly from other sweeteners in terms of its glycemic index (GI) value. Testing of several different commercially-marketed agave nectars has shown GI value of agave syrup to fall in the 10-20 range. Since low GI values are generally interpreted to range from 1-50, agave syrup is correctly classified as a low GI sweetener. (Fructose has also been shown to have a low GI value that falls into the 11-23 range.) By comparison, the GI value for both sucrose (table sugar) and high fructose corn syrup (HCFS)—two sweeteners commonly used in commercial ice creams— is about 85-92. Some ice creams also contain glucose, which of course is a common measurement standard in the calculation of GI and carries a GI value of 100.

The above-described features of agave and agave syrup make it a preferrable choice to other commonly-used ice cream sweeteners from a health standpoint.

Fructose in Food

Fructose is a naturally-occurring sugar that is present in the majority of foods commonly consumed in cuisines worldwide. Fructose is present in most vegetables, fruits, grains, legumes, nuts, seeds and spices. Because fructose is such a widespread component of whole, natural foods, fructose tolerance in healthy persons is generally estimated to fall into the 25-50 grams-per-meal range. In individuals diagnosed with fructose malabsorption, tolerance is lower. However, even in this clinical situation, low fructose diets often allow for 20 grams of fructose intake per meal. Attempts to reduce fructose intake to lower levels are seldom undertaken since the widespread presence of fructose in whole, natural foods would mean too great a risk of malnourishment.

With one exception, there is no research evidence that fructose—when obtained from whole, natural foods and in the context of a balanced diet—poses any health risks or serves as a risk factor for any chronic disease. The one exception here involves individuals with diagnonsed fructose malabsorption/fructose intolerance. In clinical research studies, sugar intolerances have been shown to monosaccharides including fructose, galactose, glucose, and xylose; to disaccharides, including sucrose and lactose (and to disaccharides as a group); and to sugar alcohols including sorbitol and xylitol. For individuals clinically diagnosed with fructose malabsorption/intolerance, intake of any food containing 10 grams of fructose or greater (including Coconut Bliss) should be discussed with a healthcare provider.

Fructose in Processed Sweeteners

The unblemished record of fructose as a naturally-occurring simple sugar that belongs in the diet of virtually all individuals when obtained from whole, natural foods in balanced proportion is not nearly so pristine in the world of processed sweeteners. Foremost in the public spotlight has been high fructose corn syrup (HFCS), a high-fructose, processed sweetener that now accounts for about half of all added sweeteners in the U.S. diet and represents 5-10% of total calories consumed per day. Processed sweeteners clearly represent a different level of health risk that sugars obtained from whole, natural foods. Processed sweeteners are affected by nutrient loss in the same way as other processed foods, and the nutrient density of processed sweeteners is always less than the nutrient density of their whole food sources. In the case of HFCS, there is increasing research evidence that links excessive intake of HFCS to unwanted risk of obesity and type 2 diabetes, and also with certain biochemical

mechanisms (like changes in insulin secretion and leptin production) that may underlie these unwanted disease risks. In the research on HCFS, there has been also been considerable emphasis on the total amount of HCFS consumed and the risk involved with overconsumption and excessive intake.

Agave syrup, like HFCS, is a processed sweetener that lacks the nutrient density of its precursor whole food (agave). For this reason—and like most processed sweeteners—research has shown that agave syrup has poor antioxidant capacity in comparison to the agave plant used to produce it. While this nutrient loss is a disadvantage from a health standpoint, there is no practical method for using agave as an ice cream sweetener in a less processed form. It is not clear what practical sweetener alternatives would accomplish the same goals as agave syrup in terms of desirable taste, texture, and product stability while at the same time providing equivalent or greater nutritional and health benefits.

Like HFCS, agave syrup also provides fructose in a much higher concentration than occurs naturally in the agave plant. Some production processes can result in agave syrups that are 90% fructose in their composition, even though the average fructose concentrations in agave syrups are typically lower, in the 60-75% range.

There are some important health-related differences, however, between agave syrup and HFCS. Unlike HFCS, the organic agave syrup used to sweeten Coconut Bliss is never obtained from a genetically modified food, and it never contains potentially toxic residues present in other processed sweeteners including heavy metals, industrial solvents, pesticides, and herbicides. In addition, as previously described, agave syrup is also characterized by a much lower GI value. (The GI value of 10-20 for agave syrup compares to a GI value for HCFS of 85-92.)

Given the health advantages offered by organic agave syrup, including its low GI value, its purity in terms of heavy metals, industrial solvents, pesticides, and herbicides, and its independence from genetic modification, the only potentially offsetting health issue involves the fructose concentration achieved through the processing of agave and its potential impact on health. This issue requires a look at the research studies on fructose as a dietary risk factor, as discussed below.

Fructose as a Dietary Risk Factor

At least one team of well-qualified health researchers has hypothesized a link between fructose consumption and the development of chronic diseases, and in particular, type 2 diabetes and metabolic syndrome. Their hypothesis incorporates several features of fructose metabolism, including the ability of fructose intake to alter lipid profiles, increase uric acid concentrations in the blood, and decrease hepatic insulin sensitivity. Importantly, when formulating

their hypothesis, these researchers stipulate fructose excess as the required condition for any chronic disease development.

A review of dietary studies shows that fructose excess is the only fructose-related risk factor supported by peer-reviewed research. Time and time again, low and moderate intake of fructose fails to correlate with chronic disease diagnoses or with biomarkers of metabolic imbalance. In type 2 diabetics, for example, daily doses of 60 grams of fructose or higher are required for triglyceride-raising effects. That same fructose threshold (greater than 60 grams per day) holds true for the triggering of any unwanted changes in serum glucose, fasting triglycerides, LDL cholesterol, or serum insulin. Researchers at the Lipid Metabolism Laboratory at the Jean Mayer USDA Human Nutrition Research Center on Aging at Tufts University have concluded that the addition of fructose to a diet at the level of 30-60 grams per day (or 4-12% of energy) results in no significant effect on lipid or glucose biomarkers. And researchers at the University of Kuopio in Kuopio, Finland have found that risk of type 2 diabetes is only significantly increased by high of fructose-plus-glucose combined. In practical terms, at levels of fructose intake under 50 grams, no research studies on human subjects in free-living situations have suggested a correlation between fructose intake and the development of chronic disease.

The amount of fructose provided by one serving of Coconut Bliss (between 10-12 grams) falls well under the risk threshold established in these dietary studies. It's not only an amount of fructose that falls well under the health risk level, but it's also an amount of fructose that is readily matched and exceeded in many whole, natural foods. A large apple, for example (3.25 inches in diameter), contains slightly more fructose (13 grams). So does 1 medium-sized banana plus 1 cup of blueberries. And if you compare the amount of fructose in one serving of Coconut Bliss with the amount of fructose in 200 calories' worth of many other commonly-consumed foods, it is dramatically lower. 200 hundred calories' worth of unsweetened applesauce, for example, contains 25-30 grams of fructose. So does 200 calories' worth of unsweetened apple juice or grape juice. Even 200 calories' worth of red grapes contain about twice as much fructose (23 grams) as a serving of Coconut Bliss with the same caloric value. Given these everyday food comparisons and the health research on fructose as a dietary risk factor, the use of agave syrup as an ice cream sweetener seems far from excessive and also removed from research-based health concerns in this area.

Summary

Like other high-fat, high-sugar treats, Coconut Bliss ice cream falls into the category of "discretionary calories" that require food awareness and dietary planning on the part of all individuals. But for persons wanting to make room for a satisfying, ready-made ice cream treat, Coconut Bliss ice cream poses no

practical problem with respect to incorporation into a healthy eating plan. In fact, as a product with 33% fewer calories and 50% fewer sugars than many leading brands of ice cream, Coconut Bliss is actually easier to fit within an everyday diet than most nationally-marketed ice creams. Unlike other leading-brand ice creams, two key ingredients in Coconut Bliss—coconut milk and agave syrup—come from foods with a long history of culinary use worldwide. Each ingredient has research-based health benefits, which include support of the digestive tract, support of the immune system, and low glycemic index value. In combination with these health benefits, the ingredients in Coconut Bliss provide small but valuable amounts of more than a dozen key nutrients, including both vitamins and minerals. Research on fatty acids and fructose also give a clean bill of health to Coconut Bliss in terms of its unusually high saturated fat content (primarily from medium chain fatty acids) and its reliance on fructose as a sweetener. In comparison to many leading brands of nationally-marked ice cream that obtain their rich texture from cream and milkfat and their sweetness from corn syrup and cane sugar, the ingredients in Coconut Bliss stand out in clear contrast and present an ice cream that's free of health burdens when consumed in single serving size amount and within the context of a balanced diet.

About the Author

Buck Levin is Adjunct Associate Professor of Nutrition at Bastyr University, where he has taught since 1990. He received his Ph.D. in food and nutrition from the University of North Carolina at Greensboro, where he was selected first annual Alumni Fellow. While there, he also became certified as a registered dietitian. He received a master's degree in phenomenological psychology from Duquesne University, and a bachelor's in psychology from Yale University, where he graduated Magna Cum Laude, Phi Beta Kappa, Distinction in Psychology.

Dr. Levin has extensive experience in private practice and has published broadly, including contributions to the Textbook of Complementary and Alternative Medicine, the Textbook of Natural Medicine, The Encyclopedia of Alternative Medicine, and Alternative Medicine-The Definitive Guide. His contributions to professional journals include Advances: Mind-Body Journal, Journal of the Ecological Design Association, Society for Nutrition Education, and Quarterly Review of Natural Medicine, where he served as nutrition editor. Dr. Levin is also the author of Environmental Nutrition—Understanding the Link between Environment, Food Quality, and Disease published in 1999 by HingePin Integrative Learning Materials, the company he founded to promote education in this area. He co-authored the revised 21st Century addition of the nutrition classic, Staying Health with Nutrition for Ten Speed Press together with primary author Elson Haas, MD.

References

Assunção ML, Ferreira HS, dos Santos AF et al. Effects of dietary coconut oil on the biochemical and anthropometric profiles of women presenting abdominal obesity. Lipids. 2009 Jul;44(7):593-601. Epub 2009 May 13.

Bazzano LA, Serdula M, and Liu S. Prevention of type 2 diabetes by diet and lifestyle modification. J Am Coll Nutr. 2005 Oct;24(5):310-9.

Johnson RJ, Perez-Pozo SE, Sautin YY et al. Hypothesis: could excessive fructose intake and uric acid cause type 2 diabetes? Endocr Rev. 2009 Feb;30(1):96-116.

Kobayashi H, Morisaki N, Tago Y et al. Identification of a major cytokinin in coconut milk. Cellular and Molecular Life Sciences 1995, Volume 51, Number 11: 1081-1084.

Le KA, Ith M, Kreis R et al. Fructose overconsumption causes dyslipidemia and ectopic lipid deposition in healthy subjects with and without a family history of type 2 diabetes. Am J Clin Nutr 89: 1760-1765, 2009. First published April 29, 2009; doi:10.3945/ajcn.2008.27336.

Montonen J, Jarvinen R, Knekt P et al. Consumption of Sweetened Beverages and Intakes of Fructose and Glucose Predict Type 2 Diabetes Occurrence. American Society for Nutrition J. Nutr. 137:1447-1454, June 2007.

Muir JG, Shephard SJ, Rosella O et al. Fructan and free fructose content of common Australian vegetables and fruit. Journal of agricultural and food chemistry. 01/09/2007; 55(16):6619-27.

Murphy SP. The State of the Science on Dietary Sweeteners Containing Fructose: Summary and Issues to Be Resolved. Supplement: The State of the Science on Dietary Sweeteners Containing Fructose. Journal of Nutrition, doi:10.3945/jn.108.097964, Vol. 139, No. 6, 1269S-1270S, June 2009.

Nneli RO and Woyike OA. Antiulcerogenic effects of coconut (Cocos nucifera) extract in rats. Phytother Res. 2008 Jul;22(7):970-2.

Phillips KM, Carlsen MH and Blomhoff R. Total antioxidant content of alternatives to refined sugar. J Am Diet Assoc 2009 Jan; 109(1):64-71.
Regine M, Van Der Hee RM, Miret S et al. Calcium Absorption from Fortified Ice Cream Formulations Compared with Calcium Absorption from Milk. Journal of the American Dietetic Association. Chicago: May 2009. Vol. 109, Iss. 5; pg. 830.

Schaefer EJ, Gleason JA and Dansinger ML. Dietary Fructose and Glucose Differentially Affect Lipid and Glucose Homeostasis. Supplement: The State of the Science on Dietary Sweeteners Containing Fructose. *J. Nutr.* (April 29, 2009). doi:10.3945/jn.108.098186.

Sievenpiper JL, Carleton AJ, Chatha S et al. Heterogeneous effects of fructose on blood lipids in people with type 2 diabetes: Systematic review and meta-analyses of experimental trials in humans. Diabetes Care, 2009 Jul 10. Epub ahead of print.

Thompson WG, Cook DA, Clark MM et al. Treatment of Obesity. Mayo Clin. Proc., Jan 2007; 82: 93—102.

U.S. Department of Agriculture. 2008. What We Eat in America, NHANES, 2005-2006, individuals 2 years and over (excluding breast-fed children). Day 1 dietary intake data, weighted. U.S. Department of Agriculture, Agricultural Research Service. Washington, D.C.

Wang Y, Beydoun MA, Liang L et al. Will All Americans Become Overweight or Obese? Estimating the Progression and Cost of the US Obesity Epidemic. *Obesity* (2008) 16 10, 2323–2330.

Wanten GJ and Calder PC. Immune modulation by parenteral lipid emulsions. Am J Clin Nutr 2007 May; 85(5):1171-84.

Willett WC, Koplan JP, Nugent R et al. Prevention of Chronic Disease by Means of Diet and Lifestyle Changes. Chapter 44 in: Disease Control Priorities in Developing Countries (2nd Edition). Jamison DT, Breman LG, Measham AR et al, Eds. Disease Control Priorities Project, Washington, D.C., April 2006.

World Health Organization. Diet, nutrition and the prevention of chronic diseases. Report of a Joint WHO/FAO Expert Consultation, 2003 WHO Technical Report Series 916, WHO Geneva.