Chromium in refined and unrefined sugars—possible nutritional implications in the etiology of cardiovascular diseases

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Abstract

It has recently been discovered that chromium is an essential element, particularly in relation to carbohydrate metabolism. Food refinement leads to a loss of chromium as well as of other trace elements. The nutritional significance, particularly in relation to cardiovascular diseases, of the excessive consumption of refined food, poor in trace elements, is not well understood. The first results of a WHO study on the chromium content of different brands of refined and unrefined sugars obtained from various countries are described here. Flameless atomic absorption was used for chromium analysis. Molasses have the highest chromium content (0.266 mg/kg), followed by unrefined (0.162) and brown (0.064) sugars. Refined sugar has the lowest chromium content (0.020 mg/kg). No differences associated with the geographic origin of the sugars were observed.

Within the framework of WHO activities aimed at investigating the possible roles of trace elements in the etiology of cardiovascular diseases, studies were initiated to assess the concentration of chromium in sugar samples from different countries. The rationale of these studies is based on the following three observations:

First, excessive consumption of refined sugar was reported by some authors to be statistically associated with high cardiovascular mortality (1), although a direct cause-and-effect relationship has not been ascertained. Among the countries for which cardiovascular and nutritional data were available, the 10 countries with the lowest cardiovascular death rates (mean 23 per 100,000, all ages, both sexes) showed an average consumption of refined sugar of 56 g per day per person (range 25–81), while in the 10 countries with the highest cardiovascular death rates (mean 285 per 100,000) refined sugar consumption was 118 g per day per person (range 87–136). The consumption of unrefined sugar in the first group of countries was fairly high (mean 31 g per day per person), while in the second it was practically nil.

Secondly, it has recently become known that chromium is an essential trace element, particularly in relation to insulin action and to the maintenance of normal glucose tolerance in animals and in man (2, 3). Impaired glucose tolerance may develop into a diabetic state—an important risk factor in the etiology of atherosclerosis and myocardial infarction—and chromium deficiency may possibly play a harmful role. Other studies were reported to have shown that chromium exerts protective effects against experimentally induced atherosclerosis and decreases blood cholesterol levels in rats (4, 5).

Thirdly, the tissues of subjects from more affluent countries, where coronary heart disease is highly prevalent, have a very low chromium content while the tissues of subjects from developing areas of the world, whose populations are less susceptible to this disease, have a higher chromium content (4).

The above observations may be linked together by the findings that refined sugar contains less chromium than brown and unrefined sugar (4) and that pure sugar, e.g., glucose, promotes the mobilization and depletion of body chromium (6).

A better understanding of the relationship between dietary habits and the geographical distribution of cardiovascular diseases (mainly arteriosclerotic heart disease) would result from internationally coordinated and standardized studies in which widely used foodstuffs would be collected in various countries and analysed for trace elements by means of various techniques. As a first step, various types of refined and unrefined sugar (83 samples) and of polished and unpolished rice (126 samples) were collected from about 20 countries with the help of the WHO Regional Advisers in Nutrition. The samples

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are being analysed by means of atomic absorption and neutron activation techniques. The first set of results on the chromium content of dietary sugar as determined by the technique of flameless atomic absorption is summarized here. A more detailed description of the technique used, as well as of other analytical procedures that were employed to cross-check the results, is in preparation and will appear elsewhere.

Samples of molasses, unrefined sugar, brown sugar, and refined white sugar were analysed by means of a technique involving low-temperature, activated oxygen plasma ashing, dissolution in acid, and the introduction of the samples into an atomic absorption spectrophotometer equipped with a graphite furnace for flameless atomization of the sample. The results show that chromium content is highest in the molasses (0.266 mg/kg), followed by unrefined (0.162) and brown (0.064) sugars, and is lowest in the refined sugars (0.020). This pattern of chromium loss follows the refinement sequence of sugar. The water-insoluble material, apparently of vegetable fibres, that is present in the unrefined sugars is very rich in chromium (4.2 mg/kg). No significant differences in chromium content were found between the different brands of molasses or unrefined, brown, or refined sugars in relation to their geographic origin. However, the darker coloured brands usually contained more chromium than the lighter ones.

Chromium in sugar, as in many biological sources, may occur in different forms whose biological, chemical, and analytical characteristics are poorly understood. At the present stage of knowledge, therefore, it is essential that chromium analyses be performed and cross-checked by different techniques—for example, different methods of pre-ashing or the direct reading of non-ashed sugar solutions give different results. In comparison with low-temperature pre-ashing, the introduction of the sample directly into the graphite furnace at a charring cycle of 1 000°C led to a loss of 0.01–0.03 mg of chromium per kg of refined and brown sugars, and to a loss of 0.13–0.23 mg of chromium per kg of unrefined sugar and molasses.

Inorganic chromium is not lost, so the loss is probably of naturally occurring organic complexes of chromium upon heating. It seems therefore that decomposition of these complexes to inorganic chromium by low-temperature ashing is an essential step in the analysis of biological samples.

The fact that a greater loss of chromium in the analytical procedure occurs in the unrefined sugars than in the refined ones suggests a loss of organically-bound chromium during refinement. Since the biologically active form of chromium, i.e., the glucose tolerance factor, is known to be an organically-bound complex—whereas inorganic chromium is known to have very little biological activity (3)—this chromium loss during sugar refinement may have significant nutritional consequences.

The average diet in the USA supplies about 60 (range 30–140) μg of chromium per day (8), which is thought to be insufficient to cover the minimum human daily requirement. Chromium balance is upset by a high intake of refined sugar (about 120 g per day per person in the typical United States diet), which not only contributes practically nothing to chromium intake but, as indicated previously (6, 7), may lead to a loss of body chromium through the chromium-depleting action of glucose. On the other hand, taking the same amount of dietary sugar in the unrefined form would increase the daily chromium intake by about one-third. Moreover, the chromium carried by the unrefined sugar could counteract the chromium loss induced by the glucose moiety.

The finding that refinement of sugar causes a depletion of chromium suggests that other minerals may also be lost from other foodstuffs during refinement and processing. The modern diet, particularly in highly industrialized countries, contains much refined, preservative-added, or otherwise processed food. The impact of such industrial processes on the availability of trace elements to man is only poorly understood. Nor do we know the effects of lifelong exposure to such nutritionally-induced imbalance in trace elements, and in particular whether such an imbalance may cause the development of chronic diseases, including cardiovascular diseases.

The present work is part of a broader WHO-coordinated research project on the assessment of the trace element content in staple food and in typical diets of countries with a contrasting prevalence of cardiovascular diseases. The progress of these investigations will be published as data become available.

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