Intake and food sources of ascorbic acid in China

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Investigating differences in the intake of nutrients is of potential importance in characterizing diet-disease relationships and determining the level of intake necessary for optimal health. The intake and food sources of ascorbic acids were examined in an ecological study of 64 rural counties in the People's Republic of China and compared with data reported for the United States. The mean (SD) and median individual intakes of ascorbic acid for all counties combined were 140 (28) and 138 mg/day, respectively (range 6-429 mg/day). This compares to a mean intake of 99 mg/day for adult men and 67 mg/day for adult women in the United States. The foods that contributed the most to ascorbic acid intake were sweet potatoes (37.2%), cabbages (23.9%), leafy green vegetables (11.6%), radishes (8.8%), and hot peppers (5.9%). In contrast to the US, where fruit supply is a major source of ascorbic acid to the diet, fruits contributed a relatively small amount to overall ascorbic acid intake in rural China (1%). The wide range of ascorbic acid intake among counties resulted, in part, from differences in the availability of fresh produce which is grown and consumed locally. Despite this, the mean intake was still greater than the US because of the large contribution of plant products (approximately 90%), especially tubers and other vegetables, to the diet.

Introduction

Ascorbic acid (vitamin C) is an essential micronutrient involved in a wide variety of biochemical processes in the human body. Its antioxidant and free-radical scavenging properties, ability to enhance iron absorption, and function as a component in the synthesis of carnitine, norepinephrine, collagen and other compounds are well described. Less established but of potential benefit are its effects on serum cholesterol and cardiovascular disease, blood pressure, immune function, reduction in the toxicity of cancer chemotherapy and the prevention of cancer. In some cases, such as cancer prevention, it is difficult to determine whether the protective effect is due to ascorbic acid per se or other components of fruits and vegetables.

Deficiency of ascorbic acid, usually associated with an intake of less than 10 mg/day, causes scurvy. Less clear is the amount necessary for optimum health. Due to this, in part, there has been controversy concerning the United States Recommended Dietary Allowance (RDA) which is currently 60 mg/day for adults. While most have suggested this amount is adequate or should be raised, some have argued it may be unnecessarily high. The current mean daily intake of ascorbic acid in the US is estimated to be 99 mg for adult men and 84 mg for adult women. The predominant food sources are citrus fruits and juices, non-citrus fruits, potatoes and other vegetables.

The food supply in the US is stable due to an advanced shipping system, and the diet is relatively homogeneous. Adequate amounts of nutrients, including ascorbic acid, are usually available although actual consumption may vary. Less is known about the intake and food sources of ascorbic acid in other countries. In order to better characterize the relationships between ascorbic acid and specific health parameters, information on the intake and food sources of ascorbic acid in populations living under conditions other than those found in developed countries should be examined. Moreover, this may also help to expand the information base used to determine optimal intake.

China provides an opportunity to explore this area of research for a number of reasons. The diet consumed within each region has remained relatively unchanged over time. In contrast, diet and local conditions vary widely among different areas. In addition, there has been little migration. This combination of stable conditions within regions but variable conditions among regions may facilitate the examination of diet-disease relationships not easily demonstrated in more homogeneous populations. First, however, it is necessary to document dietary intake and sources of nutrients, which may lead to more detailed investigations later. The purpose of this paper is to report on the intake and food sources of ascorbic acid in the People's Republic of China and to compare them with data reported for the US.

Methods

A large ecologic study was undertaken in China in 1983 to...
among counties, within each county the diet was relatively homogenous. An average of only 10 plant foods was consumed in each county, and usually five or less foods contributed at least 85% of ascorbic acid to the diet.

**Discussion**

Geographic and ethnic differences in food sources influence the macro- and micronutrient composition of the diets of individuals and populations [10.11]. The food supply in the People’s Republic of China is markedly different from that in the US and also varies widely among different regions within the country. The rural Chinese diet derives over 90% of its calories from predominantly unprocessed plant sources [20]. China has in place a rationing policy for grains, oils and other staples, to help meet the minimal nutritional needs of the people [21]. However, the major sources of ascorbic acid, in vegetables and fruits, are not under government control. There is little refrigeration, foods are preserved by salting or fermenting and there is no efficient system for transporting them over long distances. Fruits and vegetables are grown and consumed locally. Consequently, the availability of fresh produce depends upon characteristics of the region in which it is grown. This explains the wide range of ascorbic acid intake among counties, and may explain the low intake among counties in the bottom quartile of intake where vegetables other than sweet potatoes may not be readily available.

Mean and median intakes among counties in this survey were relatively high, 140 and 128 mg/day, respectively. The 1991-1994 National Food Consumption Survey reported the mean daily intake in the US was 99 mg for adult men and 84 mg for adult women [22]. Although these mean intakes exceed the RDA, 40% of adults surveyed consumed less than the RDA. Because of the nature of the current study, in an ecologic study with data reported as the mean individual intake in each county instead of actual individual intakes, it was not possible to determine the number of subjects with intakes below the Chinese RDA of 60 mg/day [23]. The RDAs are set high enough to meet or exceed the needs of practically all the population, so individuals below the RDA may not necessarily be deficient in ascorbic acid, but their likelihood of deficiency is increased.

Based on food availability data, fruits contribute 43% of ascorbic acid to the US food supply, including 28% from citrus fruits, while vegetables provide 49% [24]. This compares to the 7% contributed by fruits in rural China. Further comparisons between the US and China can be made by reclassifying data from the second US National Health and Nutrition Examination Survey (NHANES II) according to major food groups. While tubers contributed 38% to the total intake of ascorbic acid in China, they supply only 9% in the US. Similarly, other vegetables contributed 60% in China and only 21% in the US [25].

The specific foods that contribute most to ascorbic acid intake in the US are orange juice (27%), potatoes, including french fries (8%); grapefruit or grapefruit juice (7%); tomatoes or tomato juice (6%); and fortified fruit drinks (6%). An average of 16 foods for blacks and 22 foods for whites contribute 85% of the ascorbic acid intake [26]. This compares to five or less foods contributing the same proportion among the Chinese counties in this study.

The US diet contains ascorbic acid from sources other than foods. Ascorbic acid is consumed [27] as the most commonly used supplement, consumed by 91% of vitamin users [28]. Based on this, the ascorbic acid supplements may contribute a significant amount of ascorbic acid to the total US intake. However, supplementation is not used at levels that may be used in ascorbic acid from food sources compared to non-users, suggesting that those most likely to take supplements are less likely to need them.

In the US, ascorbic acid is widely used as a food additive, as is erythorbic acid, an epimer of ascorbic acid. Erythorbic acid has antioxidant activity but little or no antimicrobial activity, although it may exert a slight sparing effect on ascorbic acid [29]. Conventional analytical methods used to measure ascorbic acid in foods do not distinguish between ascorbic acid and erythorbic acid [30]. Therefore, overestimation of the ascorbic acid content of processed foods containing erythorbic acid may occur, depending on the methodology used. This is important inasmuch as the amount of ascorbic acid supplied by processed fruits and vegetables in the US increased from 14% after the Second World War to 46% in 1985 [31]. Unlike the US foods in rural China are usually consumed in their natural state. Supplementation with containing additives contribute little ascorbic acid to the diet.

Losses during cooking may lower the actual intake of ascorbic acid in both China and the US. The effect of this on the data reported here cannot be estimated, since the Chinese Food Composition Tables used in this study are based on raw foods [32]. Regardless, the relative differences among counties, although slightly attenuated, should be preserved.

Although the intake values reported here for China are compared with values for the US, caution should be exercised when interpreting these data because of differences in survey methods used. In addition, seasonal variations may contribute to variability in the amount and sources of ascorbic acid intake.

As demonstrated by this data, a dietary pattern composed of predominantly plant products can provide a large quantity of ascorbic acid when fresh produce is available. It is somewhat ironic that the diet in certain urban areas of China is becoming "westernized", with the encouragement of the Chinese Government, through the introduction of more animal products and a corresponding decrease in plant sources of foods [33]. It will be important to monitor trends in the intake of ascorbic acid and other nutrients if these changes occur, and to correlate them with changes in health status.

**Acknowledgement** — We are indebted to Banoo Parpia for providing technical assistance and reviewing the manuscript.

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Fig. 1. Geographic distribution of ascorbic acid intake in 64 survey counties in China. The values (e.g. 5.9 to 69.9) are symbols above — are mg/day. One county was excluded because of its extraordinarily high intake of ascorbic acid from the consumption of fresh Chinese dates which was highly seasonal.

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**Results**

The mean intake of ascorbic acid for each county is shown geographically in Figure 1. The mean (±SEM) individual intake for all counties combined was 140(±38) mg/day while the median intake was 128 mg/day. Intake ranged from 6 mg/day to 429 mg/day. One county was excluded because of an extraordinarily high intake of ascorbic acid (1361 mg/day) from the seasonal consumption of fresh Chinese dates, which contain 540 mg ascorbic acid per 100 g.

The foods contributing the largest amounts of ascorbic acid to intake are ranked in Table 1. Sweet potatoes contributed the largest amount overall, 37.2%, and were consumed in 51 of the 65 counties surveyed. Cabbage contributed 23.9% and were the most widely consumed vegetable, eaten in 62 of the counties. Following these foods were other leafy green vegetables (10.9%), radishes (8.8%), and hot peppers (6.5%). The five foods contributing the largest amounts of ascorbic acid were determined for each of the 65 counties. A total of 45 foods comprised this list, reflecting the variability of food sources of ascorbic acid among the counties.

When categorized by major food groupings, vegetables (other than tubers) contributed 60% and tubers (predominantly Table 1. Major food sources of ascorbic acid among 64 counties surveyed in China.

<table>
<thead>
<tr>
<th>Food</th>
<th>Contribution to ascorbic acid intake, percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet potatoes</td>
<td>37.2</td>
</tr>
<tr>
<td>Cabbage</td>
<td>23.9</td>
</tr>
<tr>
<td>Leaky green vegetables other than cabbages*</td>
<td>10.6</td>
</tr>
<tr>
<td>Radishes</td>
<td>8.8</td>
</tr>
<tr>
<td>Hot peppers</td>
<td>6.5</td>
</tr>
<tr>
<td>Beans</td>
<td>3.3</td>
</tr>
<tr>
<td>Sweet peppers</td>
<td>1.8</td>
</tr>
<tr>
<td>Rutabagas</td>
<td>1.0</td>
</tr>
<tr>
<td>All others</td>
<td>7.9</td>
</tr>
</tbody>
</table>

*Primarily mustard greens, kale and spinach.

*Normally sweet potatoes* 38%. Fruits contributed only about 1% to the total intake of ascorbic acid. Vegetables supplied the majority of ascorbic acid intake in all regions of the country. When broken down by quartiles of intake among counties, vegetables supplied the majority of ascorbic acid intake in the top three quartiles. However, sweet potatoes contributed the most ascorbic acid intake among counties in the bottom quartile of intake.

Although there was a large variety of foods consumed
among counties, within each county the diet was relatively homogeneous. An average of only 10 plant foods was consumed per day, and usually five or less foods contributed at least 85% of ascorbic acid to the diet.

Discussion

Geographic and ethnic differences in food sources influence the macro- and micronutrient composition of the diets of individuals and populations. The food supply in the People’s Republic of China is markedly different from that in the US and also varies widely among different regions within the country. The rural Chinese diet derives over 90% of its calories from predominately unprocessed plant sources. China has in place a rationing policy for grains, oils and other staple foods, to help meet the minimal nutritional needs of the people. However, the major sources of ascorbic acid are vegetables and fruits, which are not under government control. There is little refrigeration, foods are preserved by salting or fermenting and there is no efficient system for transporting them over long distances. Fruits and vegetables are grown and consumed locally. Consequently, the availability of fresh products depends upon characteristics of the region in which it is grown. This explains the wide range of ascorbic acid intake among counties, and may explain the low intake among counties in the bottom quartile of intake where vegetables other than sweet potatoes may not be readily available.

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The US diet contains ascorbic acid from sources other than foods. Ascorbic acid is consumed by 7% of the US population, while multi-vitamins containing ascorbic acid are consumed by 17%. In one survey of supplement users, ascorbic acid was the most commonly used supplement, consumed by 94% of vitamin users. Based on this, ascorbic acid supplements may contribute a significant amount of ascorbic acid to the total US intake. However, supplement intake has been measured from food sources compared to non-asers, suggesting that those most likely to take supplements are less likely to need them.

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Letter to the editors

Dear Sirs,

The profession of dietetics (clinical nutrition) has been operative in Malaysia for over 30 years. There are now over 100 practicing dietitians, the majority of whom are in hospitals and the remainder in other fields. Training in clinical nutrition, however, is still in its infancy. The degree course in dietetics started in 1985 and up till 1993 Universiti Kebangsaan Malaysia (UKM) had produced 43 graduates in dietetics. In the fourth year, training in dietetics concentrates on dietetics, community dietetics, catering and practical training (internship) for 12 weeks.

The overall aims of clinical internship are to enable students to develop their practitioner skills and to use these to extend, consolidate and apply their knowledge of nutrition and dietetics in a clinical setting and to assist students in developing attitudes and ethical practices that will allow them to function as capable health professionals.

It is perceived that a 12-week internship in various hospitals is too short and there has been criticism as to the inadequacy of the student's knowledge and confidence to lead in this field.

There is a move to update the present dietary curriculum and to address the criticism. The internship will be extended from 12 weeks to 12 weeks. The first 12-week internship will be in UKM Hospital, an alternating eight weeks in both University Hospitals and General Hospitals. These objectives cannot be achieved without the assistance and commitment of all dietitians in Malaysia.

Undergraduate medical course

Nutrition in the medical curriculum is taught both in the preclinical and medical years. However, the medical students perceive it as unimportant and are unable to see the link to a patient's medical management. They do not have the confidence to transfer that knowledge to patients due to limited theoretical input and limited emphasis on clinical nutrition during bedside teaching.

Nutrition carries only one credit unit in the second preclinical year. In the clinical year, clinical nutrition is taught in the second clinical year for four hours during the community health posting. In the third clinical year, students have the opportunity to focus on the clinical nutritional management in one of three cases and write it up during their medical posting. Perhaps this confidence can be improved and the importance of clinical nutrition be taken seriously by having related diet therapy lectures at every posting such as pediatric, medical, surgical, oncology, O&G, orthopedic, etc. instead of at the community health posting alone, so as to cover a wider scope of clinical nutrition. It may be even more effective if clinicians emphasize clinical nutrition where appropriate during bedside teaching.

Post-graduate medical course

In 1993, the Department of Community Health, Universiti Kebangsaan Malaysia offered specialization in nutrition in the Master of Public Health. To fulfill this specialization, students are required to take up seven credit units on the clinical nutrition course out of the 17 credit units of nutrition components. This is considered a good move towards recognizing the importance of clinical nutrition in preventive medicine. Perhaps it would improve the perception that clinicians have of clinical nutrition if several units of clinical nutrition were incorporated into the curriculum of the post-graduate courses in medicine.

In-service courses for medical graduates and paramedics

It is of the utmost importance that in-service courses be conducted regularly for medical graduates and paramedics, and especially general practitioners. A collaborative effort from dietitians in various hospitals and universities in determining the curriculum and coordinating the appropriate in-service clinical courses is very much in need.

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