Bioavailability of Nutrients and Other Bioactive Components from Dietary Supplements

Dietary Supplement Use: Consumer Characteristics and Interests

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ABSTRACT Four major issues should be considered in a discussion of what consumers need to know about supplements and herbal treatments. 1) Usage of supplements is changing as consumers are taking charge of their health and seeking alternative forms of medicine (Eisenberg et al. 1998, Gilbert 1999). 2) The characteristics of supplement users have been profiled in numerous academic and industrial surveys. However, even the best models based on consumers' characteristics can predict <30% of diet-related behavior (Baranowski et al. 1999). 3) Experts in traditional medicine and nutrition lack information on supplements and herbs. The Practice and Policy Guidelines Panel of the National Institute of Health Office of Alternative Medicine (1997) stated that practices used in complementary and alternative medicine were "unsuitable for the development of evidence-based practice guidelines." Well-designed basic and clinical research is needed on the efficacy, bioavailability and safety of supplements and herbs. Significant numbers of consumers do not seem to rely on their physicians for information on alternative forms of medicine (Eisenberg 1997). Despite the obstacles, the traditional medical community (including nutritionists) should focus more research efforts on diet supplements and herbal treatments. Then health care professionals can mount high quality, targeted education programs for consumers. J. Nutr. 131: 1339S–1343S, 2001.

KEY WORDS: • supplements • herbal treatments • consumers • education models • bioavailability

What do consumers need to know about diet supplements and herbal treatments in terms of their efficacy, bioavailability and toxicity? At least four major issues must be considered in this discussion.

1. Usage of supplements is changing. Pollsters suggest that one of the biggest trends in the health care industry is that consumers are taking charge of their health and seeking alternative forms of medicine (Eisenberg et al. 1998, Gilbert 1999). It is likely that the trends oberved in the use of nutrients supplements and herbs reflect this larger trend.

2. The characteristics of supplement users have been profiled in numerous academic and industrial surveys. However, even the best models based on consumers' characteristics can predict <30% of diet-related behavior (Baranowski et al. 1999). Thus, consumer education efforts, even when focused, are apt to have limited success.

3. Experts in traditional medicine lack information on supplements and herbals. The Practice and Policy Guidelines Panel of the National Institute of Health Office of Alternative Medicine (1997) stated that practices used in complementary and alternative medicine were "unsuitable for the development of evidence-based practice guidelines." More research is needed on the efficacy, toxicity and bioavailability of supplements and herbals.

4. It is debatable which agencies and professionals are the best gatekeepers of information on supplements and herbs. Significant numbers of consumers do not seem to rely on their physicians for information on alternative forms of medicine (Eisenberg 1997). Experts also do not agree on the best way to advertise dietary supplements (Dickinson 1999, Mitka 1998, Nestle 1999).

Thus, the initial question in this manuscript splits into a series of questions (Table 1). The answers to these questions are still being developed by investigators in a broad range of fields that includes nutrition, medicine, pharmacology, education, sociology and marketing.

Are consumers taking charge of their health?

One way to assess the interest of Americans in taking charge of their health is to examine their health care exper-
differences. In 1990 Eisenberg et al. (1993) estimated that Americans made $10.3 billion of out-of-pocket expenditures for unconventional medicine, including diet supplements, herbs and services by providers of unconventional therapy. These expenditures were 44% as great as the out-of-pocket expenditures for physician services ($23.3 billion). In 1998 Eisenberg et al. (1998) called these procedures and services alternative medicine, not unconventional medicine. They estimated that the out-of-pocket expenditures of U.S. consumers for alternative medicine in 1997 had more than doubled since 1990 and were between 27% and 34.4 billion. In contrast, out-of-pocket expenditures of consumers for traditional physician services increased at a slower rate and were $29.3 billion in 1997.

Not all categories of alternative medicine treatments grew equally between 1990 and 1997. The U.S. Nutraceutical Report 1997 indicated sales of functional foods and dietary supplements increased 62 and 40%, respectively, between 1992 and 1996 (Anonymous 1998). Similar trends were observed in Western Europe and Japan (Table 2).

Another index of the interest of Americans in taking charge of their health is the increased number of Americans taking herbal medications and supplements regularly. Eisenberg et al. (1998) reported that although only 2.5% of adults in the United States reported using herbs in the past 12 mo in 1990, 12.1% did in 1997. The 1999 HealthFocus Trend Report indicated that 35% of U.S. adults used herbs in 1998 (Gilbert 1999). On the basis of the 1986 National Health Interview Survey, Moss et al. (1989) estimated that 36% of U.S. adults consumed nonprescription vitamin and minerals. The 1999 HealthFocus Trends Report indicated that 48 and 54% of American used vitamin/mineral supplements once a week in 1990 and 1998, respectively (Gilbert 1999). Kim et al. (1999) observed that the apparent increased use of supplements reflected not just the “passage of time” but also the changing demographics of those surveyed.

Other smaller surveys have indicated that 3–93% of the groups studied used herbs, vitamins or diet supplements (Lyle et al. 1998, Rock et al. 1998, Winslow and Kroll 1998). The prevalence of supplement use varied with the populations, the definition of supplements and the definition of what constituted regular supplement usage.

Which Americans are most apt to consume supplements?

The following demographic characteristics generally have been associated with a higher usage of supplements (especially multimineral supplements): being female, education beyond high school, higher income, being white and being older

### Table 1

<table>
<thead>
<tr>
<th>Questions that must be addressed if health care professionals are going to develop effective education and intervention programs for consumers on diet supplements and herbal treatments in terms of their efficacy, bioavailability and toxicity</th>
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<tbody>
<tr>
<td>Are consumers taking charge of their health?</td>
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<tr>
<td>Which Americans are most apt to consume supplements?</td>
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<tr>
<td>Can educators use consumer profiles to plan education and intervention programs?</td>
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<tr>
<td>What should we teach about complementary and alternative medicine?</td>
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<tr>
<td>Who should provide information on supplements and herbal treatments to consumers?</td>
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</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Global market value of nutraceuticals $^1$</th>
<th>1992</th>
<th>1996</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diet supplements</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>5.6</td>
<td>7.9</td>
</tr>
<tr>
<td>United Kingdom, France and West Germany</td>
<td>2.9</td>
<td>4.3</td>
</tr>
<tr>
<td>Japan</td>
<td>2.0</td>
<td>2.8</td>
</tr>
<tr>
<td><strong>Functional foods</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>5.4</td>
<td>8.9</td>
</tr>
<tr>
<td>United Kingdom, France and West Germany</td>
<td>5.8</td>
<td>6.9</td>
</tr>
<tr>
<td>Japan</td>
<td>5.2</td>
<td>6.7</td>
</tr>
</tbody>
</table>

$^1$ Data from anonymous (1998).
Several groups have noted that supplement users tended to consume more nutrient-dense diets (especially for nutrients contained in the supplements) than did nonusers (Koplan et al. 1986, Looker et al. 1988, Lyle et al. 1998, Rock et al. 1997). Supplement users have been reported to consume more fruits and/or vegetables (Joshi et al. 1999, Looker et al. 1988, Lyle et al. 1998, Patterson et al. 1998) and to consume less dietary fat (Lyle et al. 1998, Patterson et al. 1998, Rock et al. 1997) than nonsupplement users.

The relationship of health status to supplement usage is complex. Individuals who reported their health to be excellent or very good were more apt to use supplements than were those who reported poor health (Bender et al. 1992, Moss et al. 1989). In contrast, Lyle et al. (1998) also reported that that supplement usage was more likely among individuals with one or more health problems. However, Lyle et al. (1998) reported that generally individuals with hypertension, cancer or heart disease did not use more supplements than did individuals without these conditions. These apparent inconsistencies may reflect the importance of age, seriousness of conditions and time since diagnosis. For example, men between 43 and 54 y of age with a history of heart disease were more apt to use multivitamin supplements and women older than 75 y with a history of cancer were more apt to consume supplemental vitamin E (Lyle et al. 1998). Newman et al. (1998) noted that the use of nutrient supplements and herbals by women with breast cancer declined with time after diagnosis. Patients with more advanced stages of cancer were more apt to use nonnutritional supplements, such as shark cartilage (Newman et al. 1998).

Can educators use consumer profiles to plan education and intervention programs?

These surveys provide data that could be used to target health education and behavior modification efforts in regard to the use of supplements, herbs and nutraceuticals. Prochaska et al. (1997) hypothesized that health intervention programs should be matched to each individual’s stage of change in the transtheoretical model (Table 3). However, Baranowski et al. (1999) reported that assessing the stage of change of participants in dietary intervention programs was often difficult. For example, is an individual who has used megavitamin supplements in dietary intervention programs was often difficult. For example, men between 43 and 54 years of age with a history of heart disease were more apt to use multivitamins and women older than 75 years with a history of cancer were more apt to consume supplemental vitamin E (Lyle et al. 1998). Newman et al. (1998) noted that the use of nutrient supplements and herbals by women with breast cancer declined with time after diagnosis. Patients with more advanced stages of cancer were more apt to use nonnutritional supplements, such as shark cartilage (Newman et al. 1998).

TABLE 3

The transtheoretical (stages of change) model predicts the readiness of consumers to modify their diet-related behaviors.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precontemplation stage</td>
<td>Consumer has no intention to act within the next 6 mo</td>
</tr>
<tr>
<td>Contemplation stage</td>
<td>Consumer intends to act within the next 6 mo</td>
</tr>
<tr>
<td>Preparation stage</td>
<td>Consumer intends to act within 30 days and has taken some positive steps</td>
</tr>
<tr>
<td>Action stage</td>
<td>Consumer has changed overt behavior for &lt;6 mo</td>
</tr>
<tr>
<td>Maintenance stage</td>
<td>Consumer has changed overt behavior for &gt;6 mo</td>
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What should we teach about complementary and alternative medicine?

Ferguson (1998) noted that targeting the audience was the first step in planning a health intervention program; the second was deciding on the content of the educational message. This is problematic because experts do not know what constitutes optimal complementary and alternate medicine practices (Angell and Kassirer 1998, Fontanarosa and Lundberg 1998). Recently the Practice and Policy Guidelines Panel of the National Institutes of Health Office of Alternative Medicine (1997) stated that practices used in complementary and alternative medicine were “unsuitable for the development of evidence-based practice guidelines, in part because of the lack of relevant outcomes data from well-designed clinical trials.”

Experts in traditional medicine have recognized their lack of information on herbal medications in a variety of ways in recent years. The National Institutes of Health has created an Office of Alternative Medicine and funded centers and clinical trials of popular herbal medications (Marwick 1998). In 1998, several major medical journals published research evaluating the efficacy and the potential toxicity of herbal medications (DiPaola et al. 1998, Ernst 1998, Miller 1998, Wilt et al. 1998, Winslow and Kroll 1998). Many investigators have reported that a number of common plants (including mushrooms, soybeans and teas) may have disease-preventing properties (Blot et al. 1997, Borchers et al. 1999, Messina et al. 1998). Unfortunately, scientists have only begun to identify the active components in these herbal medicines and foods and to standardize the amounts and bioavailability of active ingredients in products. These research activities must be completed before well-designed clinical trials can be conducted.

Our knowledge of the bioavailability and toxicity of micronutrients also is incomplete. However, vitamin/mineral supplementation trials, evaluations of food fortification programs and clinical and animal studies of interactions among nutrients and other substances in food provide considerable data on the bioavailability and toxicity of micronutrients (Blot 1997, Greger 1987, Mertz et al. 1994, Patterson et al. 1997, Pfeiffer et al. 1997, Sandström 1998). These limited data were the basis of standards, such as the Tolerable Upper Intake Levels established by the Food and Nutrition Board (Yates et al. 1998) and the position article of the American Dietetics Association on vitamin and mineral supplementation (American Dietetics Association 1996).

Moreover, investigators have documented excessive intake of micronutrients through supplementation in several surveys. In the National Health Interview Survey, supplement users at the 95th percentile consumed daily from supplements >2-fold the Recommended Dietary Allowance (RDA)3 for vitamin A, 7-fold the RDA for riboflavin and 17-fold the RDA for vita-

3 Abbreviation: RDA, Recommended Dietary Allowance.
min C (Subar and Block 1990). Stewart et al. (1985) found that individuals (at the 95th percentile) who reported using specific nutrient supplements in a national telephone survey consumed >5-fold the RDA for thiamin, riboflavin, vitamin C, vitamin E, vitamin B-12, niacin, vitamin B-6 and iron. Rock et al. (1998) noted that a few (< 4.4%) women at risk of breast cancer consumed potentially toxic levels daily of vitamin A, vitamin B-6, iron and zinc. Obviously some consumers need information on the potential toxicity of megasupplements and herbs. The educational messages on diet supplements for consumers should be evidence-based (Fontanarosa and Lundberg 1998), admit the limitations of available data and emphasize what is important. Goodwin and Tangum (1998) stated that the only important issues to consumers using dietary supplements were efficacy, toxicity and cost of treatments. Bioavailability is an aspect of both efficacy and toxicity. Consumers should be alerted also to the potential that excessive levels of some nutrients could be ingested in a combination of fortified foods, nutraceuticals and supplements.

Who should provide information on supplements and herbal treatments to consumers? Supplement users in several surveys reported that books, magazines, health food stores and even fitness and/or nutrition classes were more useful sources of nutrition information than were physicians or dietitians/nutritionists (Barr 1986, Levy and Schucker 1987, Schutz et al. 1986). Moreover, Levy and Schucker (1987) reported that individuals who consumed more than two supplements daily were less likely to rely on physicians than were individuals who consumed less than two supplements daily.

Not only do many consumers not consider physicians a major source of nutrition information, they also do not appear to report their usage of supplements to physicians. Hensrud et al. (1999) found that 30.5% of patients reported use of supplements on a standard medical questionnaire that was part of a routine physical. During a more intensive survey conducted for research purposes, 61% of the same patients reported use of supplements, including herbs. Eisenberg et al. (1993) noted that 72% of patients who used unconventional therapies did not inform their physicians.

Consumers may not rely on traditional health care providers for information on dietary supplements for several reasons. Most physicians receive limited training on clinical nutrition (Halsted 1999) or on complementary and alternative medicine (Wetzel et al. 1998). Similarly, few graduate nutrition programs offer a course on nonnutrient substances in food. Furthermore, consumers may perceive that traditional health care providers have negative attitudes toward alternative medical therapies (Goodwin and Tangum 1998). Wetzel et al. (1998) noted that instructors in elective course on complementary or alternative medicine should encourage medical students to communicate professionally with alternative health care clinicians and should teach students to talk to patients about alternative therapies. The same advice should be given to nutrition professors.

Finally, the Dietary Supplement Health and Education Act of 1994 changed the type of information available to consumers on dietary supplements. The Dietary Supplement Health and Education Act of 1994 allowed manufacturers (without preauthorization by the Food and Drug Administration) to describe on the label how a product affects the structure or function of the body but not to make claims in regard to disease prevention. Manufacturers, federal officials and medical and nutrition professionals have extensively debated the impact of this act and the recently published Federal Trade Commission guidelines for advertising (Angell and Kassirer 1998, Dickinson 1999, Mitka 1998, Nestle 1999). The debate seems to have made consumers more interested in diet supplements and to have encouraged them to change their behavior in regard to supplement usage.

Now is the time for the medical community (including nutritionists) to focus more research efforts on herbal treatments and diet supplements and to increase training on these topics for students majoring in health care fields. Then health care professionals can mount high quality, targeted education and intervention programs for consumers.

LITERATURE CITED
CHARACTERISTICS AND INTERESTS OF SUPPLEMENT USERS

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