Dietary Fiber and Human Health

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INTRODUCTION

In the past quarter century, dietary fiber has emerged as a lead-ing dietary component in chronic disease prevention. High fiber in-take lowers risk for cardiovascular disease (Kromhout et al.. 1982). some cancers (Kromhout, 1982a). hypertension (Anderson. 1983a). diabetes (Anderson, 1986) and obesity (Anderson and Bryant. 1986a). In addition. dietary fiber has therapeutic value in treatment of coronary heart disease (CHD) (Arntzenius et al.. 1985). hyper-lipidemia (Anderson and Tietyen-Clark, 1986). hypertension (Anderson, 1983). diabetes (Anderson and Bryant. 1986b). obesity (Anderson and Bryant, 1986c). and gastrointestinal diseases (Anderson, 1985a). An overwhelming consensus recommendation now advises an intake of five to six servings of vegetables and fruits daily (National Academy of Sciences, 1989: U.S. Dept. of Health and Human Services. 1988a), for a dietary fiber intake of 20 to 35 g/day or 10 to 13 g/1000 kcal for healthy adults (Pilch. 1987a).

In its recent report "Diet and Health". the National Academy of Sciences (1989) concluded that "Epidemiologic and clinical studies indicate that a diet characterized by high-fiber foods may be associ - ated with a lower risk of coronary heart disease, colon cancer, dia-betes mellitus, diverticulosis. hypertension. or gallstone formation. but there is no conclusive evidence that it is dietary fiber rather than the other components of vegetables. fruits. and cereal products, that reduces the risk of those diseases."

Table 1 lists the 10 leading causes of death in the United States for 1987 (U.S. Dept. of Health and Human Services, 1988b). Cardiovascular disease (heart disease, strokes, and atherosclerosis). cancer, and diabetes account for 61% of these deaths. Dietary prac - tices. including dietary fiber intake. affect development of all of these diseases and hold the potential to reduce premature death from these causes. This report reviews the characteristics of dietary fiber; the protective value of a vegetarian lifestyle: the health bene-fits of dietary Fiber. the relationships between dietary fiber and dia-betes. hypercholesterolemia, hypertension, and obesity; and outlines practical implications of dietary fiber intake. Preference is given to providing a comprehensive list of relevant references rather than discussing a few selected references.

Table 1. Estimated total deaths and contributing factors for the 10 leading causes of death in the United States. 1987.[z]

Rank	Cause of death	Contributing factors[y]	Number	Percent of total deaths
1	Heart diseases	D,E,L,F	759,000	35.7
2	Cancers	D,L,F	476,700	22.4
3	Strokes	D,E,L,F	148,700	7.0
4	Unintentional injuries	L	92,500	4.4
5	Chronic obstructive lung diseases	L	78,000	3.7
6	Pneumonia and influenza	L	68,600	3.2
7	Diabetes mellitus	D,E,F	37,800	1.8
8	Chronic liver diseases	L	29,600	1.4
9	Chronic liver diseases and cirrhosis	L	26,000	1.2
10	Atherosclerosis	D,E,L,F	23,100	1.1
	All causes		2,125,100	100

[z]Adapted from the Surgeon General's report on Nutrition and Health (1988) and Anderson et al. (1990).
[y]D = diet. E = exercise, L = lifestyle, and F = fiber.

CHARACTERISTICS OF DIETARY FIBER

Dietary fiber can be defined as the endogenous components of plant materials in the diet that are resistant to digestion by human enzymes (Pilch, 1987b). Dietary fibers are predominantly cell wall components that include nonstarch polysaccharides and lignin. These fibers can be classified, simplistically, as water-soluble and water-insoluble. The soluble fibers include pectins, gums, and mucilages, while the insoluble fibers include cellulose, most hemicellulose (or noncellulosic polysaccharides) and lignin (Anderson, 1985b).

Physiologic and clinical effects of soluble and insoluble fiber differ. Soluble fibers tend to delay gastric emptying, slow passage of food through the small intestine, and have little effect on fecal bulk. Insoluble fibers tend to hasten passage of food through the intestine and increase fecal bulk. Most soluble fibers lower serum cholesterol and decrease the glycemic response to food. In contrast. insoluble fibers usually do not lower serum cholesterol, but have important clinical effects on bowel regularity and fecal bulk. Mixtures of both soluble and insoluble fibers may have the greatest therapeutic effects in diabetes and hypertriglyceridemia (Anderson. 1985c).

HEALTH BENEFITS OF A VEGETARIAN LIFESTYLE

Vegetarian dietary habits are associated with several health benefits. Vegetarian individuals, on average, are leaner and have healthier lifestyles than nonvegetarian individuals (Sacks et al., 1975a; Walden et al., 1964; Nieman et al., 1989). Their all-cause mortality is significantly lower that age- and gender-matched nonvegetarian individuals (Lemon and Walden, 1966; Kahn et al., 1984a), and this can be related to lower mortality rates from coronary heart disease (Wynder et al.. 1959a; Hickie and Ruys. 1976a; Kristein, et al., 1977) and cancer (Wynder, 1959b. Lemon and Walden, 1966; Phillips, 1978).

Serum total cholesterol and low-density lipoprotein (LDL) cholesterol, and total to high-density lipoprotein (HDL) cholesterol ratios are lower in vegetarian than in nonvegetarian control subjects (Hardinge and Stare, 1954; Hardinge et al., 1958; Walden, 1964b: West and Hayes, 1968; Sacks, 1975b; Hickie and Ruys 1976b; Burslem et al., 1978; Webster and Rawson, 1979a; Knuiman and West, 1982: Cooper et al., 1982; Abdulla et al.. 1984; Masarei et al.. 1984a; Fisher et al., 1986; Sacks et al., 1986; Thorogood et al.,

1987: Nieman et al.. 1989b). Serum total and LDL-cholesterol levels are associated with increased risk for CHD, while serum HDL-cholesterol levels protect against CHD.

Vegetarian individuals usually also have lower systolic and diastolic blood pressures than nonvegetarians (Malhoua. 1970: Sacks et al., 1974b; Anholm, 1975; Armstrong et al., 1977; Webster and Rawson. 1979b; Haines et al., 1980; Trowell. 1981: Rouse et al., 1983: Beilin et al., 1987; Ophir et al., 1983). Dietary sodium, potassium, calcium, magnesium, carbohydrate, fatty acids (saturated, monounsaturated. and polyunsaturated. as well as omega-3 or omega-6 types) and dietary fiber are among the dietary factors that could contribute to blood pressure differences between vegetarians and nonvegetarians (Rouse et al., 1986a). The specific effects of dietary fiber on serum lipids and blood pressure are reviewed below.

HEALTH BENEFITS OF DIETARY FIBER

The health benefits of dietary fiber intake have been recognized since Old Testament times of the Bible (Burkitt, 1987; Kritchevsky, 1988). Pioneering work of Walker (1947). Cleave (1956). Burkitt (1969). and Trowell and Burkitt (1981) and Trowell (Trowell. 1975) linked low dietary fiber intake to a number of Western diseases. More recently. careful epidemiologic studies (Morris et al., 1977a; Liu et al., 1982a; Khaw and Barrett-Connor. 1987a; Kromhout et al.. 1982b) established the association between high levels of dietary fiber intake and low Prevalence rates of CHD and cancer. Because the links between dietary fiber and CHD appear strongest. these reports will be reviewed here.

Epidemiologic data from a variety of studies suggest that dietary fiber may protect from CHD. Dietary fiber may decrease risk of CHD by decreasing serum lipids, lowering blood pressure, improving glucose metabolism while decreasing serum insulin, and assisting in weight maintenance (Anderson, 1985d). Dietary fiber also may protect against CHD through other mechanisms. The protective effect of dietary fiber is independent of serum cholesterol levels (Morris et al., 1977b. Liu et al., 1982b).

Morris and Man (1977) reported that the high dietary fiber intakes of bank and transport workers in London were protective from CHD, independent of other dietary and cardiovascular risk factors. Subsequently, Kromhout et al. (1982) reported that mortality from CHD was ≈4 -fold higher in Dutch males with low fiber intakes than in males with high fiber intakes (Fig. 1). This effect also was independent of other dietary variables and remained significant after
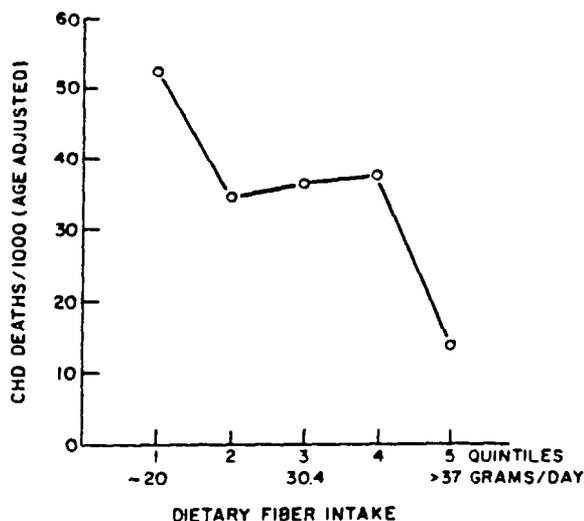
Fig. 1. Mortality from chronic heart disease (CHD) in males in The Netherlands.

multivariate adjustment for other risk factors. This study suggested that including 37 g of dietary fiber daily may protect from CHD.

Using data from 20 economically advantaged countries, Liu et al. (1982) estimated that dietary fiber intake was inversely related to CHD mortality rates. Khaw et al. (1987) reported that a 6-g increase in dietary fiber intake was associated with a 25% reduction in CHD mortality (P < 0.01) independent of other dietary variables, including calorie, fat, cholesterol, protein, carbohydrate, or alcohol intakes. After multivariate adjustment for age. gender, plasma cholesterol. fasting plasma glucose. blood pressure, obesity, and cigarette smoking habit, the protective effect was still statistically significant.

Vegetarians illustrate the possible protective role of fiber, be - cause vegetarians have higher fiber intakes (Kritchevsky et al.. 1984) and a lower risk for CHD than nonvegetarians (Kahn et al., 1984b; Phillips et al.. 1978).

In Great Britain. Burr et al. (1982) reported that 10.943 vegetari-ans were at lower risk for CHD, but that increased dietary fiber in-take alone could not account for this decreased risk.

Other studies also demonstrated an association between higher dietary fiber intakes and lower risk for CHD, including the Baltimore Heart Study (Hallfrisch et al.. 1988) and the Irish-Boston Diet-Heart Study (Kushi et al.. 1986). Three other studies (Gordon et al., 1981a: Garcia-Palmieri et al., 1980: McGee et al., 1984) did not report dietary fiber intake. but noted an inverse relationship be - tween dietary carbohydrate intake and CHD: carbohydrate may have served as a surrogate measure for dietary fiber in some of these studies (Gordon et al.. 1981b).

The Oslo study (Hjerman. 1987) suggests that dietary change plays a significant role in primary prevention of CHD. The inter-vention group in the study ate more vegetables and fish and less fat than the control group. They also had a 47% lower incidence of CHD over a 5-year period. The dietary intervention group ate ≈30 to 42 g of fiber daily, compared to ≈22 to 30.8 g daily for the con-trol group.

Collectively these studies indicate that dietary fiber may provide protection from CHD both through modifying CHD risk factors and through other mechanisms. A dietary fiber intake of 37 g/day may be a protective level (Kromhout. 1982c). while an increase in di-etary fiber intake of 6 g/day may reduce risk for CHD by 25% (Khaw and Barrett-Connor. 1987b).

DIETARY FIBER AND DIABETES

Diabetic individuals gain both specific and general health bene-fits by increasing their dietary fiber intake. The specific benefits in-clude decreased insulin requirements or increased insulin sensitivi -ty, improved blood glucose control. and reduced frequency of hype -glycemic episodes. The general benefits include decreased serum cholesterol and triglycerides, lower blood pressure. improved bowel function. and assistance in weight management (Anderson and Bryant. 1986d; Anderson et al. 1987). These health benefits of di-etary fiber for diabetic individuals have been documented by two types of studies: dietary fiber supplementation studies and high-fiber diet studies.

Dietary fiber supplementation studies. Jenkins et al. (1976. 1978) pioneered studies documenting that soluble fibers such as guar and pectin decreased blood glucose response to meals. Nondiabetic as well as diabetic individuals had significantly small rises in blood glucose after meals containing soluble fibers than after control meals without fiber. To extend these studies, Jenkins et al. (1977) fed guar-supplemented diets to diabetic *subjects* for 5 to 7 days. In comparison to control diets, guar-supplemented diets decreased *urine* glucose by 50%. This group developed guar crisp-bread for long-term diabetes management (Jenkins et al.. 1978) and documented lower insulin requirements and less glycosuria when both insulin-dependent and non-insulin dependent diabetic individ -uals consumed guar crispbread that provided 14 to 26 g of guar/day. Furthermore, they noted no serious intolerances *or* adverse effects on mineral status with long-term crispbread use (Jenkins et al., 1980). Numerous other investigators confirmed these observations. as reviewed elsewhere (Anderson and Bryant. 1986e).

High-fiber diet studies. In 1974. we (Kiehm et al., 1976) devel-oped high-carbohydrate, high-fiber (HCF) diets for the management of diabetes. These weight-maintaining diets provided 70% of ener-gy as carbohydrate, 18% as protein. 12% as fat. and 70 g of fiber daily. Lean diabetic individuals entered the metabolic research ward and ate a traditional diabetes control diet for 7 days, followed by an HCF diet for 14 to 21 days. HCF diets significantly lowered insulin requirements without changes in body weights (Anderson and Ward, 1979). For lean, insulin-dependent diabetic individuals, HCF diets lowered insulin doses by 17% to 77%. with an average reduction of 38%. For lean. insulin-treated diabetic individuals later determined to be non-insulin-dependent, HCF diets lowered insulin doses by an average of 97%; 24 of 25 consecutive diabetic individuals were able to discontinue insulin with HCF diets. Figure 2 illustrates the responses of representative insulin-dependent (Type 1) and non-insulin-dependent (Type 2) diabetic individuals to HCF diets. These diets also decreased fasting serum cholesterol by 27% and triglycerides by 3% (Anderson, 1986a).

We also developed high-fiber maintenance (HFM) diets for practical management of ambulatory diabetic individuals. The HFM diets provided 55% to 60% of energy as carbohydrate, 20% as protein, 20% to 25% as fat, and ≈50 g of fiber per day. Most dia-betic individuals have demonstrated good adherence to these diets
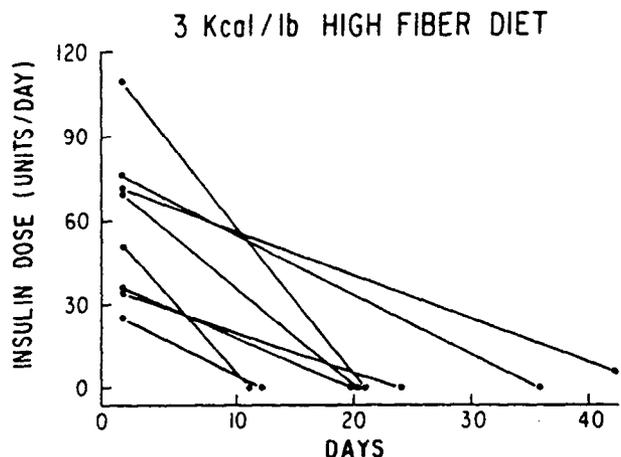

Fig. 2. Responses of representative insulindependent and non-insulin-dependent diabetic individuals to HCF diets.

(Anderson and Gustafson, 1989) and have maintained reasonable diabetic control with significantly lower insulin doses for periods of 2 to 15 years; these HFM diets also sustain significantly lower serum cholesterol and triglycerides (Story et al., 1985). As reviewed elsewhere (Anderson and Bryant, 1986f). many other inves-tigators have confirmed the multiple benefits of high-fiber diets for diabetic individuals.

DIETARY FIBER AND SERUM CHOLESTEROL

Hypercholesterolemia is a major contributor to atherosclerosis, leading to coronary. cerebral, and peripheral vascular disease (Anderson et al., unpublished data). Dietary treatment is the first and most important approach to management of hypercholesterolemia. and an estimated 75% of hypercholes-terolemic individuals respond to diet (Anderson et al.. unpublished data). In the past, dietary management of hypercholesterolemia fo-cused on reducing saturated fat and cholesterol intake (Grundy et al., 1982). Recent studies (Anderson et al., 1984; Thuesen et al., 1986a; Anderson et al., 1989) indicate that increasing dietary fiber intake, especially soluble fibers. can significantly augment the cholesterol-lowering effects of a low-fat diet. These studies are re-viewed in detail elsewhere (Anderson et al.. unpublished data; Anderson and Tietyen, 1986b) and will be only reviewed briefly here.

Since the early 1960s. many investigators have documented the cholesterol-lowering effects of dietary fiber for humans. Soluble fibers such as pectins, guar (and other gums), and psyllium were studied extensively (Anderson et al., unpublished data). Foods rich in soluble fiber such as fried beans. oats, vegetables and hits also significantly lower serum cholesterol (Anderson et al., unpublished data). Table 2 summarizes studies representative of the extensive work in this area.

Guar gum, a water-soluble polysaccharide that is almost com-pletely fermented in the colon, has been studied extensively in hu-mans. It decreases serum cholesterol 11% and LDL-cholesterol 17% (Anderson et al., unpublished data). Xanthan gum. locust bean gum. karaya gum, and gum arabic, in general. have significant cholesterol-lowering effects in humans, but appear to be slightly less hypocholesterolemic than guar (Anderson et al., unpublished data).

Pectin, which is water-soluble and completely fermented in the colon, also has been studied extensively in humans. It decreases serum cholesterol 11% (Anderson et al., unpublished data). Pectin administration does not significantly affect serum HDL-cholesterol or triglycerides; the effects on serum LDL-cholesterol are not well-documented (Anderson et al., unpublished data).

Psyllium. a hydrophilic mucilloid that is water-soluble and fer-mentable, has been used for >50 years as a fecal bulking agent. Earlier clinical studies, which did not have optimal control periods or groups (Anderson et al.. 1988a). suggested that psyllium might lower serum cholesterol significantly. Using a double-blind, place -

bo-controlled, parallel design, our group demonstrated recently that psyllium at 10.4 g/day decreased serum cholesterol by 14.8% and decreased LDL-cholesterol by 20.2% over an 8-week period (Anderson et al.. 1988b). Another carefully controlled study (Bell et al.. 1989) recently confirmed these observations.

Soy fiber, which provides ≈37% of its fiber in the soluble form (my unpublished observations), also has significant hypocholes-terolemic effects in humans (Anderson et al.. unpublished data). On average, the intake of 25 g of **soy** fiber (18.8 g of dietary fiber and 5.9 g soluble fiber) reduces serum cholesterol from 5% to 9%. Because soy fiber is not as gelatinous as the gums, pectin. and psyl-lium, it has better formulation and "mouth feel" properties than some of the purified water-soluble fibers.

Oat products gained popularity in recent years, partly because of their hypocholesterolemic effects. Preliminary studies of deGrott et al. (1963) suggested that oatmeal had cholesterol-lowering proper-ties in humans. In 1977. our group began testing oat bran and found it to have substantial hypocholesterolemic effects in humans with high serum cholesterol levels (Kirby et al., 1981). Subsequent studies (Anderson et al., unpublished data) confirmed these obser-vations, indicating that the intake of 100 g of oat bran daily (provid-ing 16 g of dietary fiber and 9 g of soluble fiber) lowered serum cholesterol by 13% to 19% on a metabolic research ward. Figure 3 illustrates the response of hypercholesterolemic males to oat bran intake during a metabolic ward study. Intake of ≈50 g of oat bran in ambulatory studies lowered serum cholesterol by 5% to 10%.

Beans and legumes, both good sources of both soluble fiber and vegetable protein, also significantly lower serum cholesterol effects in humans. Groen et al. (1962) fruit suggested that beans had spe-cific hypocholesterolemic effects. Subsequent studies (Anderson et al., unpublished data) including our metabolic ward studies (Anderson et al., 1984; Anderson et al., unpublished data), further documented that daily intake of 68 to 115 g (dry-weight basis) of beans daily lowered serum cholesterol of hypercholesterolemic males by 13% to 19%. Further studies are required to determine if these hypocholesterolemic effects are related primarily to the solu-ble fiber content. to the vegetable protein content, to antinutrients such as amylase inhibitors, or to a combination of these factors.

Vegetables and fruits appear to have cholesterol-lowering ef-fects in humans, but further studies are required to assess these ef-fects (Anderson et al., unpublished data). The available studies (Fraser et al., 1981; Masarei et al., 1984b; Robertson et al., 1979; Stasse-Wolthuis et al., 1979a. 1979b. 1980) are difficult to interpret because inclusion of large amounts of vegetable in the diet usually alters the intake of other nutrients, which may affect serum choles -

Table 2. Serum lipid responses to different fibers. Values are ex-pressed as median percentage change with number of studies in par-entheses (Anderson et al.. 1990).

Fiber	TC	LDL	HDL	TG[z]
Guar	−11	−17	0	−3
	(23)	(10)	(14)	(18)
Pectin	−11	---	−2	+4
	(16)	---	(6)	(10)
Psyllium	−14	---	---	−14
	(10)	---	---	(4)
Oat bran	−16	−24	+2	−8
	(8)	(6)	(5)	(5)

[z]TC = total cholesterol: LDL = low-density lipoprotein cholesterol; HDL = high density lipoprotein chollesllerol; TG = triglyocride.
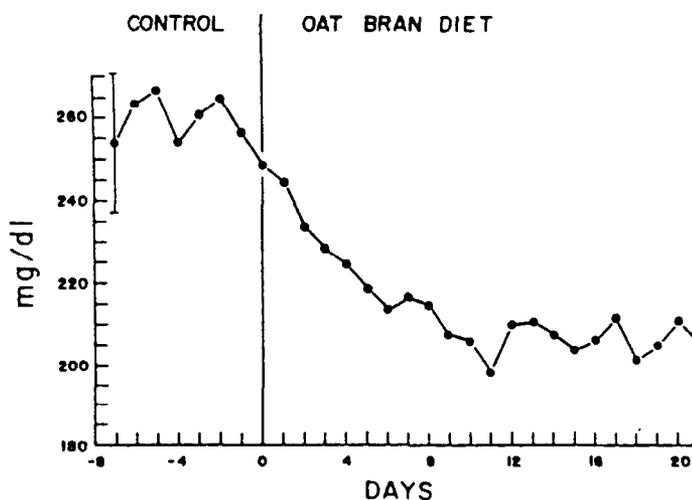

Fig. 3. Response of hypercholesterolemic males to oat bran intake during a metabolic ward study.

terol. Nevertheless. the data available from vegetarians (see above) and from these clinical studies suggest that the intake of large quan- tities of vegetables and fruits lower serum cholesterol levels.

DIETARY FIBER AND BLOOD PRESSURE

Vegetarians have lower blood pressures, on average, than non-vegetarians matched for age and gender. These observations led to the hypothesis that increased fiber intake may lower blood pressure independent of other dietary variables (Wright et al., 1979). The hypothesis is difficult to prove because increasing dietary fiber intake from high-fiber foods also alters macro- and micronutrient intake (Anderson, 1983b). while feeding subjects purified fibers may fail to show a blood-pressure lowering effect because of fiber changes during the refining process. Several studies will be summarized here to review the potential effects of dietary fiber on blood pressure.

Dobson et al. (1983, 1984a. 1985a) documented the significant blood-pressure-lowering effects of high-fiber diets that also were low in fat and sodium content. While important from a therapeutic standpoint. these studies do not examine the specific effects of dietary fiber on blood pressure.

Lindahl et al. (1984a) noted that a vegan diet lowered blood pressure and medication needs for 29 hypertensive individuals. Both systolic and diastolic blood pressure decreased significantly, and hypertensive symptoms improved over the l-year period of study. Because this intervention was associated with the change from an omnivore to a vegan diet and with a weight loss of 10 kg, the independent effects of dietary fiber intake cannot be assessed.

The Perth, Australia group has rigorously examined the effects of vegetarian diets and dietary fiber on blood pressure. Their first clinical trial (Rouse et al., 1983) noted that the change from an om-nivore diet to a lacto-ovo-vegetarian diet was associated with a sig-nificant reduction in blood pressure. Subsequently (Rouse et al.. 1986b). they subjected these results to principle components analy-sis and noted that changes in one group of dietary factors-in-creased intake of polyunsaturated fat. fiber. vitamin C. vitamin E. calcium. and magnesium and decreased intake of protein and vira-min B12-were significantly and negatively correlated to blood pressure changes. Blood pressure changes were unrelated to changes in body weight or sodium intake. Another study (Margetts et al., 1985) showed that a vegetarian diet lowered blood pressure in mildly affected, untreated omnivores.

Margetts et al. (1987) used a randomized, controlled, cross-over trial to examine the specific effects of dietary *fiber* intake on blood pressure. Healthy omnivore subjects with normal blood pressure were allocated randomly to one of three groups. One group re-mained on a control diet while two groups received a low-fiber diet for one of two periods and a high-fiber diet for one of two periods. While blood pressure decreased over time in all three groups, di-etary fiber had no consistent effects on systolic or diastolic blood pressure. These findings suggest that dietary fiber may not be the major component of a vegetarian diet contributing to decreased in blood pressure. These observations, consistent with a previous re-port (Brussaard et al., 1981). indicate that the hypothetical blood-pressure-lowering effects of dietary fiber are not established by careful clinical studies.

DIETARY FIBER AND OBESITY

The intake of high-fiber foods. usually low in fat and energy, protects from obesity, is useful in weight loss, and facilitates weight maintenance. In the modem era. Yudkin (1959). Heaton (1973). and Trowell (1975) suggested a role for dietary fiber in the preven-tion or management of obesity. Vegetarians, in general, have lower body weights than age- and gender- matched omnivores (Walden et al., 1964c; Sacks et al.. 1975c). Furthermore, when individuals are placed on vegetarian diets for therapeutic purposes, weight loss usu-ally results (Dobson et al.. 1984b. 1985b, Lindahl et al.. 1984b; Thuesen et al.. 1986b).

The mechanisms by which high-fiber diets or fiber supplements promote weight loss and facilitate weight maintenance are still under study. Some of the proposed reasons high-fiber foods pro-mote weight loss are: they the longer to eat. increasing satiety and satisfaction: they slow gastric emptying, contributing to a feeling of fullness; they lower serum insulin. decreasing food intake since in-sulin stimulates hunger: they decrease the absorption of nutrients. providing less energy than comparable low-fiber foods; they may increase rates of dietary thermogenesis compared to low-fiber foods; their fermentation products, such as gas or short-chain fatty acids, may act to decrease food intake: they may stimulate the re-lease of peptides that could modify feeding behavior. and they may enhance adherence to the diet (Anderson and Gustafson, 1986; Leeds, 1987; Levine et al., 1989; Rodin et al.. 1985; Smith. 1987).

Further studies are required to critically examine the effects of high-fiber diets on weight loss. In obese diabetic individuals, high-*fiber* diets may be especially useful in promoting weight loss as well as improving glycemic control. enhancing insulin sensitivity, and decreasing blood lipids (Anderson, 1986b; Dobson et al.. 1984c, 1985c). In nondiabetic individuals, the low-energy density of high-fiber foods may contribute importantly to the weight-loss process (Duncan et al., 1883; Weinsier et al.. 1982).

Fiber supplements have a significant. but small, impact on weight loss for individuals participating in a structured diet and weight-loss program. The use of 18 to 24 tablets of a fiber supple-ment produced significantly more weight loss than observed when placebo tablets were provided (Rossner et al., 1987; Ryttig et al., 1984, 1989; Solum et al.. 1987).

PRACTICAL IMPLICATIONS

Most individuals in the West ingest suboptimal amounts of di-etary fiber. The consensus recommendations of health organiza-tions in western countries is for increased fiber intake; most recom-mend increases of 50% to 100%. on average, to levels of 20 to 35 g/day. Most Western people are unwilling *or* unable to modify their eating habits, over the short-term, to include five to six servings of fruits and vegetables plus five to six servings of high-fiber breads, cereals, and legumes daily. Innovative education and marketing ef-forts may be required to enable consumers to increase. over the long-term, their intake of dietary fiber. In addition to fiber-rich foods, use of concentrated forms of fiber, such as psyllium and soy, may be useful in increasing dietary fiber intake over the short-term.

For individuals with diabetes, hyperlipidemia, obesity and other metabolic conditions, our research group developed high-fiber ex-changes (Anderson. 1987a. 1987b). A book for diabetic individuals (Anderson, 1989) outlines specific steps to increase fiber in the dia-betes diet. For the general consumers, a cookbook (Anderson, 1986b) and a manual for reducing risk for heart disease (Anderson. 1989) give guidance for increasing fiber intake through use of high-fiber foods. Even with very specific educational material and ex-pert dietetic counseling, many individuals have difficulty achieving the levels of fiber widely recommended.

Because many individuals find it difficult to increase their fiber intake by 50% to 100% through use of high fiber foods, we now recommend use of concentrated forms of fiber in our medical prac-tice. For individuals with diabetes, hyperlipidemia. or obesity. we use psyllium or soy fiber to increment their fiber intake Since clini-cal research studies (Anderson, 1988c; Shorey et al., 1985) indicate that it lowers serum cholesterol.

CONCLUSIONS

Dietary fiber provides important health benefits by reducing risk for major common diseases among people in the West High levels of dietary fiber intake may protect from development of atheroscle-rotic cardiovascular disease. certain types of cancer. some gastroin-

testinal disorders, hypertension, obesity, and non-insulin-dependent dishes. Furthermore, increasing fiber intake provides therapeutic advantages for management of high blood lipids. certain gastrointestinal disorders, hypertension, obesity, and diabetes.

Dietary fiber, plant cell wall material indigestible in the human small intestine, has water-soluble and -insoluble components. Soluble fibers. including pectins, gums. and mucilages. have hypocholesterolemic effects and decrease blood glucose rises after meals. Insoluble fibers, including cellulose, hemicellulose. and lignin. have important gastrointestinal effects. such a laxation and fecal-bulking properties. Mixtures of soluble and insoluble fibers improve diabet - ic glucose control and lower serum triglycerides.

The consensus recommendations of health agencies is for increased fiber intake to 50% to 100% above current levels, or to 20 to 35 g/day. The recommended manner to achieve this increase is by intake of five to six servings of vegetables and fruits daily plus five to six servings of high-fiber grain and bean products daily. Concentrated forms of fiber, such as psyllium or soy fiber, may en - able some individuals to achieve these targeted levels of daily fiber intake. Innovative education and marketing ventures will be required to enable consumers to achieve fiber intakes of 20 to 35 g/day, but will be cost-effect because of the general health benefits related to high fiber intakes.

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