BENEFITS OF DIETARY FIBRE FOR HUMANS

D.J. Farrell and Lorraine Girle

Department of Biochemistry and Nutrition,
University of New England,
ARMIDALE, N.S.W....2351.

If one could select a topic in human nutrition that has aroused great interest in the community in recent years it is the consideration of dietary fibre.

With increased affluence in Western Society where dietary habits are largely centred upon succulent, high energy, and usually low fibre foods, that normally have a high level of acceptance and palatability, the concept of fibre in nutrition appears to be a retrograde step. But there is now convincing epidemiological evidence that the increasing incidence of several common non-infective diseases may be related to the small amounts of fibre in the diet. Thus fibre appears to play a central role in gut function and in maintaining man's health (Burkitt & Trowell, 1975).

Dietary fibre, roughage or 'bulk' is the collective term for the intestinally indigestible components of food, mainly of polysaccharides in origin. Distinction should be made between dietary fibre which is essentially the constituents of the cell wall, and crude fibre a very old system (Weende) of placing the carbohydrate fraction of foods into arbitary categories (Van Soest, 1963).

There is much discussion as to whether total daily intake of dietary fibre has diminished over the past one hundred years or whether the sources of fibre have changed. Robertson (1972) suggested that the contribution from grain products has declined from 25 to 13% in the British diet; while that of fruit, vegetable and nuts has increased. A similar trend was reported in Australia by Heywood (1975). Unfortunately neither author appears to recognise that during the last 100 years daily energy intake has increased, thus dietary fibre expressed as mg/kJ has probably declined.

Dr. Denis Burkitt, an Irish surgeon, was one of the first to increase our awareness of the importance of fibre in western diets. He pointed out that in advanced western societies there exists diseases of unknown causation and are apparently rare or unknown in communities that have departed least from traditional dietary patterns. Most common of these conditions is constipation, followed by diverticular disease, appendicitis, cancer of the colon, varicose veins, gallstones, haemorrhoids, diabetes, obesity and atherosclerosis. At least 50% of the British population is troubled by constipation (Tunaley, 1974), and probably in Australia there is a similar high incidence.

There are several known effects of a diet high in fibre. Firstly, there is increased transit time of food through the digestive tract reported by Burkitt et al, (1972). This may be due to the water holding capacity of fibre, and to increased peristalsis which is thought to occur on such diets. Usually high fibre diets are low in energy and in fat content. But excretion of bile acids, which is important in fat absorption, is apparently increased in the presence of dietary fibre since vegetable fibre can absorb bile acids in its capacity as an adsorber of organic compounds (Eastwood, 1973). Cholesterol, a precursor of bile acids, is therefore required in large amounts, consequently serum cholesterol levels may fall.

There are other good reasons underlying the beneficial effects of dietary fibre. Eastwood (1973) has summarised several of the physical characteristics of plant fibre. Several of the polysaccaharides in fibre can act as cation exchangers, in that they bind heavy metals. Eastwood & Mitchell (1976) showed that subjects receiving 16 g of bran each day significantly increased the daily faecal excretion of Na, K, Mg and to a lesser extent Ca. Other characteristics of vegetable fibre are in the formation of a gel filtration system and as a bacterial sieve. Although the full implications of these characteristics are not well understood, it has been suggested that toxins and carcinogens of bacterial origin are less likely to be elaborated on high fibre diets, consequently cancer of the large bowel may be reduced (Hill *et al.*, 1971).

On the other hand the whole wheat flour compared with white flour contains substantial quantities of phytic acid which can reduce availability of important mineral elements, in particular calcium, zinc and iron. Thus it must be stressed that dietary fibre is not a panacea for all ills. For example miller's bran, in the treatment of 'irritable bowel syndrome', was successful in improving the condition of only a minority of patients (Soltoft *et al.*, 1976). Luy (1976) discussed many of the theories put forward by Burkitt, and reports comments of emminent surgeons who are extremely cautious about the usefulness of dietary fibre in preventing many of the non-infective diseases which Burkitt claims are associated with low levels of fibre in Western diets. Thus there is a lack of consistency in results of experiments with fibre both in its capacity to reduce blood cholesterol levels, as well as its effects on the apparent digestibility of major chemical components in the diet. Often these inconsistencies may have stemmed from the composition of the dietary fibre, as well as the influences of the food ingredients present in the experimental diets. Other studies appear to fall short of their objectives by failing to adequately control such factors as dietary variables or by employing unusual situations or unrepresentative population samples.

Prior to the major experiment to be described, we analysed several common foods to determine their fibre content, and to categorise the various components in fibre. There is much discussion as to the 'active' components in fibre which provide the beneficial effect in reducing the incidence of disease. The results are shown in Table 1.

Unprocessed and natural bran are similar in composition and are a more concentrated source of fibre than the commercially available breakfast cereals (San Bran and All-Bran). These contain a number of added ingredients to improve acceptability. Celery is a very useful source of dietary fibre the majority of which is as cellulose. The two varieties of bread tested contained substantial quantities of total fibre.

Table 1. Comparison of the composition of fibre from different food sources on a dry matter basis. (Girle & Farrell, unpublished data).

Food	% Cellulose	% Hemi-Cellulose	% Lignin	% Total Dietary Fibre+
Unprocessed bran	15.3	38.0	3.5	56.8
Natural bran	12.5	39.9	3.5	55.9
All bran	7.7	23.0	2.5	33.2
San Bran	8.6	26.7	2.1	37.4
Rolled oats	0.7	6.3	0.9	7.9
Vogel bread	1.5	8.1	0.6	10.2
Pilgrim's 7-grain bread	1.7	6.4	0.8	8.9
Unpeeled potato	2.2	4.0	0.3	6.5
Celery	17.8	1.6	1.1	20.5

+ cell wall constituents of van Soest

Experiment to determine some effects of dietary fibre in humans

The fifteen male subjects were all apparently healthy and aged from 27 to 46. From their height and weight measurements for age none of the subjects could be considered obese. The range of weights was from 72 to 88 kg with a mean of 77 kg.

The study was divided into two distinct periods and within each period there was a modified adaptation period, a strict adaptation period, and an experimental period. Subjects in the first major period were disallowed specific foods high in fibre for 2 weeks. They were then prescribed two menus which they alternated on a daily basis for four days and for the last four days they were on a single menu. All food was weighed out and certain ingredients were provided to each subject. 'Chromic oxide capsules (400 mg) were taken by some of the subjects thrice daily. All subjects took a gelatin capsule of 600 mg of carmine at the start of the four day period in order to identify stools from the experimental diet. A carmine capsule was taken after the final meal at the end of Day 4. Thus digestibility was determined in two ways: a) by total collection for all subjects using carmine as a marker to identify the start and finish of the experimental menu, and b) chromic oxide for six subjects.

The second experimental period was similar to the first in that there was a preliminary period, but this was of four weeks when the subjects were placed on a high fibre diet which included 12 g of bran each day. This was followed by the strict adaptation and experimental period of the same duration as previously. In this second experimental period whole meal bread, All-Bran or Muesli, a

Table 2. Apparent digestibility of dietary components by 13 experimental subjects on a low and high dietary fibre regime, and 2 control subjects on the low fibre regime continuously.

		Low Fibre	High Fibre
DRY MATTER	Experimental	$94.7 \pm 0.3^{a+}$	91.5 ± 0.3^{b}
	Control	94.3^{a}	94.8^{a}
ENERGY	Experimental	94.7 ± 0.3^{a}	92.4 ± 0.4^{b}
	Control	94.8 ± 0.5	93.9 ± 1.3
ASH	Experimental	$79.6^{a} \pm 0.9$	$72.7^{b} \pm 1.3$
	Control	$79.4^{a} \pm 4.0$	$75.4^{a} \pm 5$
NITROGEN	Experimental	$90.7^{a} \pm 0.7$	$89.2^{b} \pm 0.5$
	Control	$90.8^{a} \pm 0.6$	$88.7^{a} \pm 1.6$
FAT	Experimental	$97.1^{a} \pm 0.2$	96.8 ± 0.3
	Control	$97.6^{a} \pm 0.8$	$96.6^{a} \pm 0.7$

+, a, b values within a column with the same superscript are not different (P>0.05).

Table 3. Blood components of 13 experimental subjects on the low and high fibre dietary regimes, and of 2 control subjects on the low fibre regime continuously. Period 1 is pre-experimental, Period 2 is the low fibre, and Period 3 is the high fibre regime.

	CHOLESTEROL (g/L)		TRIGLYCERIDES (mg/100 ml)	
	Experimentals	Controls	Experimentals	Controls
PERIOD 1	1.42^{a+}	$1.85^{a} \pm 0.3$	74 ± 7^{a}	$147^{a} \pm 51$
2	1.69^{b}	$1.71^{ab} \pm 0.24$	49 ± 5^{b}	$98^{a} \pm 39$
3	1.39^{a}	$1.35^{b} \pm 0.29$	45 ± 4^{b}	$63^{a} \pm 21$

+, a, b values within a column with the same superscript are not different (P>0.05).

range of fruit and vegetables, in addition to the 12 g/day of bran, were prescribed in the menu.

Throughout this experiment subjects were encouraged to eat butter rather than margarine, at least one egg a day, with a regular serving of meat,daily,to provide a significant amount of saturated fat. All subjects took the Cr203 capsules thrice daily for the last seven days of the experimental period.

It was calculated that the experimental diets provided daily 2,800 kcal. This was 100 kcal less than the recommended allowance for an Australian man of 25 years of age weighing 75 kp. About 35% of the energy came from fat and oil.

Two of the fifteen subjects acted as controls in that they remained on the low fibre regime throughout the experimental period.

Blood samples were taken a) initially, b) at the end of the low fibre period, and c) at the end of the high fibre period.

The determined neutral detergent fibre was 6.6%, and the acid detergent fiber 2.9%, on the low fibre experimental diet (500 g/d), and 12.9% and 6%, respectively on the high fibre diet (535 g/d) providing 2.66 Mcal and 2.89 Mcal of gross energy, respectively. The main results of these studies are given in Tables 2 and 3. The increase in dietary fibre significantly decreased the apparent dry matter digestibility, energy, ash, nitrogen but not fat (Table 2). Although there was variation between these parameters in the two control subjects, no significant difference was observed during the two experimental periods.

Cholesterol concentrations in plasma increased on the low fibre diet, and declined to the initial low levels on the high fibre diet. While the values for the controls continued to decline. Triglycerides for both the experimental and the control subjects declined substantially from the initial value but showed no further change when subjects were on the high fibre diet in Period 3.

On the basis of dry matter digestibility coefficients it can be calculated that addition of dietary fibre in the second regimen should have contributed about 135 g to faecal dry matter for the 4 d period assuming zero digestibility, but the dry matter excretion increased by only 84 g, about 9 g of this could be attributed to the additional daily dry matter intake of 35 g on the high fibre diet. Thus a considerable amount of the dietary fibre was apparently digested.

Mancini et *al*, (1973) maintained that plasma triglyceride levels above 1.6 g/l are abnormal. Thus, the mean values for all neriods for both the experimental and control subjects were always below this value (Table 3). The significant reduction in triglyceride levels observed after Period 1 may perhaps be attributed to the low daily energy intake which was about 150 kcal per day less in Period 2 than that recommended, and in Period 3 the reduced digestibility of the diet would probably have resulted in a similar energy deficit. The preliminary results of this study confirm in many respects those reported previously, in that plasma cholesterol levels were reduced when fibre was added to the diet, however the diet used in this study was high in fat, particularly in saturated fat, and under these circumstances bran appears to have an overriding effect on cholesterol levels. But suppression of fat digestion per se does not appear to be the underlying cause. Fat was the only major chemical component, whose digestibility was not significantly reduced as a consequence of changing from a low to a high fibre regime. Southgate and Durnin (1970) showed that only in young men and women was digestibility of fat reduced on diets high in fibre, but not in the elderly. Mendeloff (1975) also reported that dietary fibre had little effect on fat digestion. On the other hand, the rather small but significant decline in digestibility coefficients of the other components examined are in agreement with much published data. However the addition of bran did not further depress triglyceride levels in plasma following an initial fall which was perhaps attributed to a reduction in total energy intake by subjects during the experimental period. Large amounts of wheat bran (18-100 g/d) have reduced triglyceride levels (Heaton and Pomore, 1974) but this amount would be considered to be outside the normal range and is perhaps "unphysiological".

Any comparison between results of this study and those published on effects of dietary fibre on the various parameters is difficult. Confusion must arise from the different components that make up dietary fibre in the various menus, the actual physical characteristics of the fibre, as well as the other ingredients present.

Although the clinical evidence is substantial to support the general concept that dietary fibre or "bulk" is beneficial to health, and that western diets are generally low in this component, the underlying reasons supporting this evidence are little known.

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