Effect of bran particle size on stool weight

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SUMMARY The increase in stool weight after feeding 20 g (dry weight) of bran daily was measured when this was of large particle size and after milling to small particle size. Twenty-eight investigations were carried out in 21 normal subjects. With coarse bran, stool weight was significantly greater than with the fine bran (mean 219.4 g/d coarse bran, 199.0 g/d fine bran: difference 20.4 g SE $\pm$ 6.4, $P < 0.01$). The coarse bran also had a greater water-holding capacity (7.3 g water/g coarse bran, 3.9 g water/g fine bran). Coarse bran was $2\frac{1}{2}$ times the volume of fine bran for a given weight and more fine bran will, therefore, be taken when bran is prescribed by the spoonful.

Wheat bran is now consumed in large quantities as a concentrated form of dietary fibre supplement. Different varieties are available varying in palatability, fibre content, and particle size (Southgate, 1976a, b). It has been suggested that particle size is important in determining the therapeutic effectiveness of bran (Kirwan *et al.*, 1974). The finer it is, the less its water-holding capacity (McConnell *et al.*, 1974), and the more susceptible it may be to bacterial digestion within the colon (Nutritional Reviews, 1975). A study was, therefore, carried out to determine whether a change in particle size alone affects the laxative properties of bran.

Method

Twenty-one volunteers, nine men and 12 women, measured their daily stool weight before, during, and after eating coarse and fine bran. This was carried out a total of 28 times, as several subjects repeated the study. The volunteers, aged 20 to 40 years, were doctors, science lecturers, nurses, paramedical staff, technicians, and medical students.

A large quantity of extremely coarse bran was carefully blended and then half of this was hammer-milled very finely with no further extraction. Both varieties were sterilised in dry heat at 160°C for one hour and were subsequently sterile on culture. The water content of each bran was determined, and the bran divided into portions equivalent to 20 g dry weight in self-sealing plastic bags.

A normal diet was eaten for the first week of the study and all stool specimens were weighed using spring balances which had previously been checked as accurate to the nearest gram. One type of bran

was then eaten for two weeks, 20 g dry weight daily, and all stool specimens weighed during the second week. The other variety of bran was then eaten for two weeks and stool weight measured for the second week. Finally, no bran was eaten for the sixth and seventh weeks and stool weight was measured for the seventh week. Subjects were randomly allocated to eat coarse or fine bran first and were asked to maintain a similar diet throughout the seven week period, without changes in fibre intake apart from the bran.

Dietary fibre, hemicellulose, cellulose, lignin, crude fibre, and neutral detergent fibre values for each bran were obtained (Southgate, 1976b). Particle size was determined by a standardised sieving test in which bran was passed through a series of screens of different mesh size and the weight retained on each was measured. Water-holding capacity was determined by the method described by McConnell *et al.* (1974), in which the weight of water held by the bran after centrifugation was measured.

Results

The fibre content, particle size and water-holding capacity of the two types of bran are shown in Table 1.

It will be noted that, while there are only minimal differences in fibre content, there are considerable differences in particle size and water-holding capacity between the two types of bran.

The basal daily stool weight was calculated as the mean of 14 days (first and seventh weeks). The increase in daily stool weight was calculated as the difference between this and the mean daily stool weight for weeks 3 or 5. The statistical significance

*Effect of bran particle size on stool weight*Table 1 *Properties of coarse and fine bran*

	Coarse bran (g)	Fine bran (g)
Fibre content per 100 g dry wt.		
Crude fibre	11.8	12.1
Neutral detergent fibre	47.7	48.8
Total dietary fibre	49.3	46.7
Non-cellulose polysaccharide	30.4	29.9
Cellulose (as glucose)	13.0	11.9
Lignin	5.9	4.9
Particle size distribution		
% by weight of each fraction (sieve aperture in microns)		
> 1500	82.8	5.6
1500/710	12.7	13.6
710/500	1.5	22.9
500/210	0.5	31.9
< 210	2.5	26.0
Water-holding capacity		
Wt. of water held by 1 g bran (dry weight)	7.3	3.9

Table 2 *Laxative effect of coarse and fine bran*

Mean daily stool weight (g)			Bran eaten first
Basal	Increase with coarse bran	Increase with fine bran	
47	6	38	Fine
68	98	43	Coarse
80	54	34	Coarse
81	78	72	Coarse
88	68	34	Coarse
90	104	63	Fine
93	42	62	Fine
102	82	21	Fine
117	109	162	Coarse
120	78	45	Fine
120	44	63	Fine
129	47	44	Fine
133	15	37	Coarse
140	85	54	Coarse
141	87	56	Fine
142	154	40	Fine
146	87	89	Coarse
146	74	25	Coarse
147	56	49	Fine
155	68	25	Fine
174	117	68	Coarse
185	72	39	Coarse
187	125	78	Coarse
195	84	73	Coarse
202	122	101	Coarse
204	63	70	Coarse
219	63	51	Fine
272	139	124	Fine
Mean: 140.1	79.3	58.9	

of the difference between the mean increase in stool weight on coarse and fine bran was calculated by Student's *t* test. The results are tabulated in Table 2, with the lowest basal stool weight first and the largest last.

The increase in mean stool weight with coarse bran was 79.3 g and with fine bran 58.9 g. The mean difference in increase between the two was 20.4 g, SE $\pm$ 6.4, $P < 0.01$ ($t = 3.17$).

The number of bowel actions per week increased with bran from a mean of 7.8 to 10.1 on coarse bran and 9.7 on fine bran. There was no significant difference in defaecation rate between the two types of bran. Those with smaller basal stool weights had a slightly smaller increase in stool weight after bran, but the difference was much less than that of the basal weights.

There was no statistical difference in response to bran between those who ate the fine and those who ate the coarse bran first.

Discussion

The two types of bran were taken from the same pooled sample and it was, therefore, not surprising that their fibre content was similar. The small differences were almost certainly attributable to sampling problems. It was more difficult to get good replicates with the coarse bran, possibly because of slight fractionation of the sample. The method for determining water-holding capacity was not entirely satisfactory, as the samples did not form coherent pellets on centrifugation, but agreement between duplicates was good. The higher value for the coarse material is probably partly due to water held between individual fragments as opposed to water held within the structure of the fragment. The finer sample would be expected to drain more thoroughly under the test conditions. The present results are comparable with those of Weinreich (1976).

The water content of the bran was variable, especially after sterilising, and all measurements were, therefore, done on a dry weight basis. The water content of each batch was monitored and the bran kept in water-tight containers until it had been weighed out, as water was readily absorbed from the atmosphere.

Cereal fibre is normally eaten after heat treatment as bread, cake, biscuits, or breakfast cereals, so this was not considered detrimental to the value of the study, although the biological effect of cooking cereal fibre has not been clearly defined.

The subjects were allowed to eat their normal diet throughout the study and carefully avoided changes in fibre intake apart from the additional bran. The considerable difference in basal stool weight may reflect differences in the amount of fibre consumed from one individual to another. Other studies in progress suggest that this can vary from less than 3 g to more than 48 g dietary fibre daily. Diet is often different at the weekend compared with the working week, so stool weights were measured for a complete week to allow for such normal fluctuations. Weighing was not difficult with the use of accurate spring balances and was

found to be a convenient method that allowed for immediate disposal of the specimen. Nearly all subjects had received a scientific training and were used to making precise measurements and keeping accurate records.

The fine bran was much more palatable than the coarse, and most subjects found the latter a struggle. Both types were consumed with breakfast cereals, fruit, or soups mixed with the normal diet. Both tended to cause sensations of fullness, borborygmi, and wind. The stools became soft, solid, of uniform consistency and colour, were more bulky, and often floated.

Table 2 shows that there was considerable individual variation both in basal stool weights and in the response to the two different types of bran. This is probably due, not only to differences in diet and transit time, but also to variations in bacterial flora and innate differences in colonic function. There was much less variation between studies repeated with the same individual.

Coarse and fine brans have previously been compared by Fantus *et al.* (1941). They detected no difference in stool weight, but different subjects ate coarse and fine bran, the period of bran eating and stool collection for some was only three days, and the dietary fibre content of each type of bran was not shown to be comparable.

Kirwan *et al.* (1974) studied the effectiveness of two types of commercially available bran in reducing colonic intraluminal pressure and transit time and found that fine bran was less effective than coarse bran after four weeks' treatment. The water-holding capacity of the coarse bran was 6.15 g water per g bran and 2.36 g water per g for the fine bran. They concluded that the particle size of bran was important in determining stool bulk and therapeutic efficacy. This conclusion has been criticised because the two groups were not closely matched and the amount of fibre present in each bran was different, patients on coarse bran receiving over 3.0 g acid detergent fibre daily compared with 1.9 g on fine bran.

The present study shows that particle size is important in determining the effect of bran in increasing stool weight. It can no longer be assumed that fibre of the same chemical composition has the same biological or therapeutic effect on the colon, even if from the same source and consumed in identical quantities. This might explain some of the inconsistencies between different clinical trials.

There are at least three different ways in which particle size could influence stool weight. The larger particles have a higher water-holding capacity and could, therefore, increase the relative amount of water present in the stool. In fact, bran does not greatly increase the percentage water content of the

faeces (Cowgill and Anderson, 1932; Wyman *et al.*, 1976), and *in vitro* water-holding capacity tests may not be relevant to intracolonic behaviour. Coarse bran particles are probably less readily digested by bacteria and this may result in a higher fibre content of the faeces. Williams and Olmstedt (1936) concluded, however, in their classical study that stool weight was probably greater when more fibre was digested within the colon. Thirdly, the larger particles may trap more finely dispersed gas, produced by the colonic bacteria, increasing stool bulk (Walker, 1947) and thereby increasing transit time, with a consequent increase in stool weight. Several subjects noticed that the coarse bran resulted in stools containing more gas bubbles, which floated. All three mechanisms may contribute to the difference between the coarse and fine bran.

Bran is usually prescribed by volume. One spoonful of fine bran was equivalent in weight to 2½ spoonfuls of coarse bran. A larger weight of fine bran will, therefore, be consumed when measured volumetrically. Similarly, if bran is given *ad libitum* more of the fine bran will be eaten, as it is more palatable. There is no evidence of a therapeutic difference between coarse and fine bran, provided that the amount taken results in the same increase in stool weight.

We wish to thank The Energen Foods Company, Ashford, Kent, for the supply of bran; Dr D. A. T. Southgate, Dunn Nutrition Laboratory, Cambridge, for the dietary fibre analysis; Dr D. J. Stevens, Flour Milling and Baking Research Association, Chorley Wood, for crude fibre, neutral detergent fibre, particle size and water-holding capacity measurements; Dr D. Quantrell, Radcliffe Infirmary, for bran water content measurements; and particularly the volunteers for their help.

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