Physiological effects of fibre-rich types of bread

1. The effect of dietary fibre from bread on the mineral balance of young men

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1. Twelve young adult male volunteers were given a low-fibre white bread diet (9 g neutral-detergent fibre (NDF)/d) and a medium-fibre coarse-bran bread diet (22 g NDF/d), each lasting 20 d. In a third period of 20 d the volunteers were subdivided in groups of four, consuming a high-fibre coarse-bran bread diet (35 g NDF/d), a medium-fibre fine-bran bread diet (22 g NDF/d, bran particle size < 0·35 mm) or a wholemeal bread diet (22 g NDF/d). Retention of calcium, magnesium, iron, zinc and copper were determined during each 20 d period.

2. An increase of the amount of dietary fibre (through bran in bread) from 9 g to 22 g NDF/d resulted in a significantly increased mineral intake, but also faecal excretion increased significantly; mineral retention remained almost constant.

3. Both intake and faecal excretion of all minerals studied, except faecal Ca, increased further ($P < 0·05$) on the diet providing 35 g NDF/d; only Fe balance decreased significantly. No significant differences with respect to intake, excretion (except urinary Ca) and balance of the minerals could be detected between the coarse-bran bread and fine-bran bread diets providing 22 g NDF/d. Faecal Fe, Cu balance and Mg balance increased significantly during the wholemeal bread period compared to the coarse-bran bread diet providing 22 g NDF.

4. Serum cholesterol increased significantly, i.e. by 0·3 mmol/l, during the coarse-bran bread diet providing 22 g NDF, compared to the white-bread diet.

5. It is concluded that increasing the amount of bran in bread does not appear to affect mineral balance considerably but there seems to be an influence on mineral availability. The increased intake was accompanied by increased faecal excretion.

There is an increasing interest in the interaction of dietary fibre and minerals in the gastrointestinal tract. Some authors have already reported that dietary fibre might lower the availability of minerals which may lead to decreased absorption (Reinhold *et al.* 1976; Ismail-Beigi *et al.* 1977; Cummings, 1978; Sandstead *et al.* 1978; Drews *et al.* 1979; Kelsay *et al.* 1979). Dietary fibre is suggested to be effective in preventing the incidence of several diseases (Burkitt *et al.* 1974; Trowell, 1976); specifically the role of dietary fibre from cereal sources on colonic function seems to be of importance (Kelsay, 1978; Spiller *et al.* 1978). Since bread is one of the staple foods in many industrialized countries, the generally recommended increase of dietary fibre consumption might well be reached through fibre-rich bread. However, an over-estimation of the value of dietary fibre could lead to an excessive intake, which may have a negative influence on the mineral status owing to the possibly inhibitory effect of dietary fibre on mineral absorption.

As part of a larger project concerning the significance of bread in human nutrition, we have studied the consequences for human physiology of an increased intake of fibre from bread. The criteria studied included the colonic function, the digestibility of dietary fibre (components) by the intestinal microflora and the balance of calcium, magnesium, iron, zinc and copper. The results of the mineral balances are reported in this paper.

METHODS

The experimental design is shown in Table 1. Twelve male volunteers (mean age 23 ± 2 years, weight 68 ± 6 kg, height $1·82 \pm 0·06$ m and $14 \pm 3\%$ body fat) were given two experimental

Table 1. *Experimental design**

	General adaptation	First experimental period	Second experimental period	Third experimental period	
Period...	A	B	C	D	
Duration (d)...	8	20	20	20	
Type of bread	White bread (entirely white flour)	White bread (entirely white flour)	Bread made from 850 g white flour and 150 g coarse bran/kg	1 Bread made from 680 g white flour and 320 g coarse bran/kg (*n* 4) 2 Bread made from 850 g white flour and 150 g fine bran/kg (*n* 4) 3 Wholemeal bread (*n* 4)	
Approximate total daily fibre intake (g NDF)	9	9	22	1 2 3	35 22 22

NDF, neutral-detergent fibre (Van Soest & Wine, 1967).

* The study was carried out with four volunteers at a time and replicated twice (with other subjects), resulting in three experiments with four volunteers each. Only the last periods of 20 d were different.

diets with different amounts and types of dietary fibre for 20 d each. Results were compared with those on a low-fibre (white bread) diet with 9 g dietary fibre/d.

Experimental procedure

All volunteers consumed the white-bread diet (periods A and B) and the 150 g coarse-bran/kg bread diet (period C). The amount of dietary fibre in the latter type of bread was the same as that in conventional wholemeal bread; the organoleptic properties were different however. In the third experimental period (period D), three other types of bread were consumed, each type by four of the twelve volunteers. The 150 g fine-bran/kg bread was included to study the effect of the bran particle size on e.g. mineral balance. The 320 g coarse-bran/kg bread contained twice the amount of dietary fibre as compared to conventional wholemeal bread, which was included as well. The particle size of the coarse and fine bran were $> 0{\cdot}35$ mm and $< 0{\cdot}35$ mm respectively.

The volunteers gave informed written consent according to the Institute's procedures and were housed in the Institute's controlled metabolic ward, but they continued their normal daily routines. They passed beforehand a clinical examination and a nutritional evaluation. The routine haematological values were all within normal ranges. The basal diet, which was constant throughout the study, consisted of conventional low-fibre foods and provided 7 g NDF/d (see Table 2). The diet characteristics, based on analyses of individual duplicate daily samples, are given in Table 3.

In practice an increased bran consumption automatically results in a higher mineral intake. The objective being to study the mineral availability under these conditions, no supplementation of minerals (e.g. in the white-bread period) was applied.

The energy intake was adjusted to the individual energy requirements based on a constant body-weight during the study and a dietary history before the experiment. Reduction of body-weight by more than 2% was corrected for by sugar, soft drinks and other carbohydrate equivalents. This procedure was necessary for four volunteers.

The food was prepared in the diet kitchen according to standard procedures, weighed to the nearest g, packed in individual portions and deep-frozen when necessary.

Only demineralized water was allowed in restricted amounts (maximum approximately 200 ml daily, apart from water for coffee and tea). All types of bread were prepared from

Table 2. *Composition (g) of the basal diet*
(Mean daily values)

Bread*	240	Ground beef	100
Cheese	60	Ice cream	50
Smoked beef	15	Whipped cream	25
Ham	15	Vegetables†	
Orange juice	250	Instant tea	0·9
Vegetable margarine	30	Instant coffee	3
Custard (low-fat)	150	Sugar	20
Jelly	30	Soft drinks	400
Potatoes	200	Whisky	35

* Various types; for details, see Table 1.

† Each 4 d the following rotating order: day 1: 75 g string beans, 5 g margarine, 100 g apple sauce; day 2: 30 g lettuce, 40 g carrot salad, 40 g celeriac salad; day 3: 75 g sliced beans, 5 g margarine, 100 g apple sauce; day 4: 200 g tomatoes, 5 g margarine, 5 g rusk.

one batch of wheat flour. All meals were served at the Institute. The basal diet and the breads were analysed separately.

Urine samples (24 h) were collected in polyethylene bottles with hydrochloric acid as preservative. Stools were collected in 3 l plastic buckets, one for every 4 d, stored at 4°. Composites (4 d) of urine and stools were made for analysis and stored at −20°.

Blood was withdrawn from the antecubital vein before breakfast at the beginning and at the end of each period.

Analytical procedures

The analytical procedures included mineral determinations by means of atomic absorption spectrophotometry (Perkin-Elmer 303). As wheat bran dietary fibre is low in water soluble components and in addition the basal diet (without bread) was low in dietary fibre, neutral-detergent fibre analyses were carried out according to the Van Soest method (Van Soest & Wine, 1967), as an approximation for dietary fibre, applying predigestion with pancreatin to remove residual starch (Terry & Outen, 1973). Blood haemoglobin levels were determined with the cyanmethaemoglobin method; for packed cell volume the micromethod was used; erythrocyte count by a Coulter counter; serum cholesterol was determined by means of the Huang method (Huang *et al.* 1961); serum triglycerides, enzymically, with the Eggstein (1968) method. For serum Mg, Zn and Cu, atomic absorption spectrophotometry was applied, serum Fe determination was carried out according to the Führ (1965) method and serum Ca with a Ca titrator (Raman & Chang, 1974).

Mineral balance was calculated from 20 d dietary intake and urinary+faecal excretion in each experimental period (subdivided in five 4 d periods). For statistical evaluation the results of each dietary treatment were compared with the preceding treatment by means of analysis of variance (Snedecor & Cochran, 1967), using Student's t test for paired observations. The means for period D (four subjects) were compared with those of the corresponding subjects in period C.

This research was approved from an ethical standpoint by a working group responsible for human nutrition studies.

RESULTS

The mineral balance data are presented in Tables 4–7.

An increased cereal-fibre intake (through bran in bread) resulted in statistically significantly ($P < 0{\cdot}01$) increased intake of all minerals studied, as shown by the values of the 150 g coarse-bran/kg bread period (period C) and those of the white-bread period (period B).

Table 3. *Diet characteristics of the various experimental periods**

(Mean daily values with values for the contribution of bread (%) to the total daily intake in parentheses)

Experimental period...		B White bread (*n* 12)	C 150 g coarse-bran/kg bread (*n* 12)	D_1 320 g coarse-bran/kg bread (*n* 4)	D_2 150 g fine-bran/kg bread (*n* 4)	D_3 Wholemeal bread (*n* 4)
Energy	(MJ)	11·1 (26)	11·1 (24)	11·5 (21)	9·9 (27)	11·5 (24)
Total fat	(energy %)	36 (8)	36 (8)	41 (8)	35 (10)	36 (9)
Total available carbohydrate	(energy %)	49 (40)	48 (37)	42 (33)	49 (39)	50 (33)
Total protein	(energy %)	12 (29)	12 (30)	12 (33)	13 (30)	12 (31)
Linoleic acid	(energy %)	5·5 (5)	5·5 (5)	5·5 (5)	5·5 (5)	5·5 (5)
Alcohol	(energy %)	3 (0)	4 (0)	5 (0)	3 (0)	2 (0)
NDF	(g)	8·7 (25)	21·2 (69)	34·9 (83)	22·8 (65)	22·0 (71)
Calcium	(mg)	956 (4)	1003 (6)	1087 (12)	966 (6)	1022 (8)
Magnesium	(mg)	213 (23)	373 (55)	537 (68)	384 (56)	397 (59)
Iron	(mg)	8·3 (26)	12·2 (51)	12·2 (77)	12·8 (52)	15·0 (55)
Zinc	(mg)	9·0 (14)	11·3 (31)	13·5 (43)	11·6 (32)	12·7 (38)
Copper	(mg)	1·24 (30)	1·48 (44)	1·95 (49)	1·24 (52)	1·76 (49)

NDF, neutral-detergent fibre (Van Soest & Wine, 1967).

* For details, see Table 1.

Table 4. *Intake, excretion and balance of calcium, magnesium, iron, zinc and copper (mg/d) of human subjects on a white-bread diet and a 150 g coarse-bran/kg bread diet during 20 d*

(Mean values and standard deviations)

Experimental period...	B (*n* 12)		C (*n* 12)	
Type of bread...	White bread		150 g coarse-bran/kg bread	
NDF intake (g/d)...	9		22	
	Mean	SD	Mean	SD
Ca				
Intake	956	40	1003	90*
Urinary	225	79	209	90
Faecal	717	99	836	99*
Balance	14	118	−42	109
Mg				
Intake	213	13	373	15*
Urinary	116	8	136	14*
Faecal	105	16	240	24*
Balance	−8	15	−3	22
Fe				
Intake	8·3	0·6	12·2	0·5*
Urinary	0·1	0·05	0·1	0·02
Faecal	7·4	1·1	11·4	0·9*
Balance	0·8	1·2	0·7	0·7
Zn				
Intake	9·0	0·2	11·3	0·2*
Urinary	0·7	0·3	0·6	0·3
Faecal	8·9	1·5	11·1	0·9*
Balance	−0·6	1·7	−0·4	1·0
Cu				
Intake	1·24	0·23	1·48	0·19*
Urinary	0·05	0·01	0·05	0·01
Faecal	0·97	0·16	1·18	0·11*
Balance	0·22	0·29	0·25	0·24

NDF, neutral-detergent fibre (Van Soest & Wine, 1967).
Mean values significantly different from those for period **B**: * $P < 0·01$.

This change in the type of bread consumed also resulted in significantly ($P < 0·01$) increased faecal mineral excretion; urinary excretion of Ca, Fe, Zn and Cu remained constant ($P > 0·05$), whereas urinary Mg excretion increased significantly ($P < 0·01$) during the 150 g coarse-bran/kg bread period; no significant differences in any of the mineral balance values could be detected however.

During the 320 g coarse-bran/kg bread period (period D_1, see Table 5) all mineral intakes were higher when compared with the 150 g coarse-bran/kg bread period; except for Ca, faecal mineral excretion increased significantly ($P < 0·05$) as well, whereas urinary mineral output did not change significantly. As to the mineral balance values, only Fe balance decreased significantly ($P < 0·01$) during period D_1. However, except for Cu, all mineral balance values were negative in the 320 g coarse-bran/kg bread period.

Apart from a significant decrease ($P < 0·01$) in urinary Ca in period D_2 (150 g fine-bran/kg bread) as compared with period C (150 g coarse-bran/kg bread), intakes of all minerals as well as excretion in urine and faeces were not changed significantly (see Table 6). Although all mineral balance values seem to have improved on the fine-bran bread diet, none of the differences compared with the 150 g coarse-bran/kg bread diet was statistically significant.

Table 5. *Intake, excretion and balance of calcium, magnesium, iron, zinc and copper (mg/d) of four human subjects on a 150 g coarse-bran/kg bread diet and a 320 g coarse-bran/kg bread diet during 20 d*

(Mean values and standard deviations)

Experimental period...	C (*n* 4)		D_1 (*n* 4)	
Type of bread...	150 g coarse-bran/kg bread		320 g coarse-bran/kg bread	
NDF intake (g/d)...	22		35	
	Mean	SD	Mean	SD
Ca				
Intake	1019	30	1087	30**
Urinary	224	53	211	43
Faecal	816	155	906	98
Balance	−21	123	−30	42
Mg				
Intake	377	8	537	8**
Urinary	128	12	130	9
Faecal	234	12	410	22**
Balance	15	16	−3	14
Fe				
Intake	11·8	0·6	12·2	0·6**
Urinary	0·1	0·02	0·1	0·03
Faecal	10·5	0·6	15·0	0·8**
Balance	1·2	0·9	−2·9	0·4**
Zn				
Intake	11·2	0·2	13·5	0·2**
Urinary	0·5	0·2	0·5	0·2
Faecal	10·8	1·3	13·6	0·9*
Balance	−0·1	1·6	−0·6	0·8
Cu				
Intake	1·64	0·06	1·95	0·06**
Urinary	0·05	0·01	0·05	0·01
Faecal	1·11	0·11	1·41	0·10*
Balance	0·48	0·17	0·49	0·12

NDF, neutral-detergent fibre (Van Soest & Wine, 1967).
Mean values significantly different from those for period C: * $P < 0·05$, ** $P < 0·01$.

During the wholemeal-bread period (D_3) all mineral intakes, except the Ca intake, were significantly higher than those during the 150 g coarse-bran/kg bread period (see Table 7); a significant increase in faecal Fe excretion ($P < 0·01$) could be detected whereas faecal excretions of the other minerals and all urinary mineral excretions did not differ significantly from the 150 g coarse-bran/kg period. The balance values of Ca, Zn and Fe were also similar in both periods; Cu balance and Mg balance however, increased significantly ($P < 0·05$) during the wholemeal-bread period.

Table 8 shows the results in blood serum obtained at the beginning and at the end of the 20 d experimental periods B and C.

Small, but significant increases ($P < 0·05$) in haemoglobin levels, packed cell volume and the erythrocyte count were observed during the white-bread period. The mineral concentrations in blood serum appeared to be constant in most instances; though small differences were found, none reached statistical significance.

A significant increase of serum cholesterol ($P < 0·05$) during the 150 g coarse-bran/kg

Table 6. *Intake, excretion and balance of calcium, magnesium, iron, zinc and copper (mg/d) of four human subjects on a 150 g coarse†-bran/kg bread diet and a 150 g fine†-bran/kg bread diet during 20 d*

(Mean values and standard deviations)

Experimental period...	C (n 4)		D_2 (n 4)	
Type of bread...	150 g coarse-bran/kg bread		150 g fine-bran/kg bread	
NDF intake (g/d)...	22		22	
	Mean	SD	Mean	SD
Ca				
Intake	964	25	966	25
Urinary	130	30	160	22*
Faecal	841	40	758	91
Balance	−7	57	48	94
Mg				
Intake	374	15	384	15
Urinary	130	13	134	10
Faecal	247	29	240	37
Balance	−3	16	10	22
Fe				
Intake	12·4	0·3	12·8	0·3
Urinary	0·1	0·02	0·1	0·02
Faecal	12·1	0·2	11·4	0·8
Balance	0·2	0·3	1·3	0·8
Zn				
Intake	11·4	0·2	11·6	0·2
Urinary	0·6	0·2	0·6	0·1
Faecal	11·5	0·2	10·8	0·8
Balance	−0·7	0·3	0·2	1·0
Cu				
Intake	1·24	0·04	1·24	0·04
Urinary	0·05	0·01	0·05	0·01
Faecal	1·21	0·05	1·11	0·11
Balance	−0·02	0·04	0·08	0·07

NDF, neutral-detergent fibre (Van Soest & Wine, 1967).
Mean values significantly different from those for period C: * $P < 0·01$.
† Coarse-bran, particle size > 0·35 mm, fine-bran, particle size < 0·35 mm.

bread period (compared with the white-bread period) was observed. During the periods D none of the measured parameters in blood were statistically different from the corresponding periods C (results not presented).

DISCUSSION

McCance & Widdowson (1942) suggested a possible relation between the type of bread consumed and mineral retention or absorption. The availability for absorption of minerals from wholemeal bread was considered to be less than that from white bread. The first explanation of an impaired mineral retention following the consumption of the darker types of bread seemed to be the presence of phytates which might make divalent electrolytes unavailable for absorption by the formation of insoluble complexes. Reinhold *et al.* (1976) and Ismail-Beigi *et al.* (1977) came to the conclusion that particularly dietary fibre from

Table 7. *Intake, excretion and balance of calcium, magnesium, iron, zinc and copper (mg/d) of four human subjects on a 150 g coarse-bran/kg bread diet and a wholemeal bread diet during 20 d*

(Mean values and standard deviations)

Experimental period...	C (*n* 4)		D_3 (*n* 4)	
Type of bread...	150 g coarse-bran/kg bread		wholemeal bread	
NDF intake (g/d)...	22		22	
	Mean	SD	Mean	SD
Ca				
Intake	1033	170	1022	114
Urinary	273	110	203	40
Faecal	850	97	829	91
Balance	−90	141	−10	64
Mg				
Intake	369	21	397	23*
Urinary	151	3	145	16
Faecal	238	30	240	32
Balance	−20	19	12	12*
Fe				
Intake	12·6	0·2	15·0	0·9**
Urinary	0·1	0·02	0·1	0·02
Faecal	11·6	0·9	12·7	0·9**
Balance	0·9	0·7	2·2	0·2
Zn				
Intake	11·2	0·2	12·7	0·4**
Urinary	0·8	0·3	0·7	0·3
Faecal	10·9	0·8	11·4	0·4
Balance	−0·5	0·9	0·6	0·3
Cu				
Intake	1·54	0·12	1·76	0·12*
Urinary	0·05	0·01	0·05	0·01
Faecal	1·21	0·14	1·29	0·12
Balance	0·28	0·18	0·42	0·16*

NDF, neutral-detergent fibre (Van Soest & Wine, 1967).
Mean values significantly different from those for period C: * $P < 0·05$, ** $P < 0·01$.

bread could have an inhibitory effect on mineral absorption, possibly by mechanisms adsorbing the minerals to fibre. The presence of the enzyme phytase (*EC* 3.1.3.8) during the baking process of bread and in the intestinal tract of man might however increase the availability of the minerals by splitting the phytate–mineral complexes. A decreased mineral balance as a result of a more Western type of diet was also reported by Sandstead *et al.* (1978). Our results did not indicate an apparent influence on the mineral balance when the dietary fibre content was increased from 9 g NDF/d (white-bread diet) to 22 g NDF/d (bread with 150 g coarse-bran). The increased amount of minerals, which accompany the increased amount of bran (and thus of dietary fibre) did not appear to be available for absorption since faecal excretions of the minerals studied also increased. The significantly decreased Fe balance during period D_1 with 35 g NDF/d, together with the negative balance values for Ca, Mg, Fe and Zn as well as the significant further increase of faecal mineral excretions (except for Ca), not only shows the influene of dietary fibre on mineral absorption, but also indicates that by increasing the quantity of bran in bread, the mineral utilization becomes less favourable.

Table 8. *Blood constituents values and serum biochemical criteria of human subjects on a white-bread diet and a 150 g coarse-bran/kg bread diet during 20 d*

(Mean values and standard deviations)

Experimental period†...		A (*n* 12) White bread 9		B (*n* 12) White bread 9		C (*n* 12) 150 g coarse-bran/kg bread 22	
Type of bread...							
NDF intake (g/d)...							
		Mean	SD	Mean	SD	Mean	SD
Haemoglobin	(mmol/l)	9·3	0·4	9·6	0·4*	9·8	0·5
Packed cell volume		0·45	0·02	0·46	0·02*	0·47	0·02
Erythrocyte count	(10^{12}/l)	4·6	0·3	4·8	0·3*	4·7	0·4
Serum Iron	(μmol/l)	21	6	17	4	18	6
Calcium	(mmol/l)	2·40	0·10	2·45	0·07	2·45	0·09
Magnesium	(mmol/l)	0·95	0·14	0·91	0·12	0·85	0·14
Zinc	(μmol/l)	16·8	4·6	15·3	6·1	18·4	3·1
Copper	(μmol/l)	17·3	6·3	17·3	4·7	15·7	4·7
Total cholesterol	(mmol/l)	4·6	1·0	4·5	0·6	4·8	0·8**
Triglycerides	(mmol/l)	1·33	0·53	1·30	0·54	1·27	0·44

NDF, neutral-detergent fibre (Van Soest & Wine, 1967).
† Blood was withdrawn at the end of each period indicated; for details, see Table 1.
Mean values significantly different from those for period A: *$P < 0·05$.
Mean value significantly different from that for period B: **$P < 0·05$.

No apparent influence of the bran particle size on mineral retention could be demonstrated, although the increased balance values during the fine-bran bread period indicate some effect; however, the inter-individual variations for the balance values were such that the mean differences were not statistically significant. During the wholemeal-bread period the dietary fibre intake was the same as during the 150 g coarse-bran/kg bread period. The significant increase of the Cu and Mg balances could possibly be explained by the higher intakes during the wholemeal-bread period as excretion of both minerals remained almost constant.

For an explanation of the effects observed, we have to distinguish between: (1) the availability of the minerals for absorption and (2) the actual absorption step. The mineral balance (retention) is dependent on both availability and absorption.

Dietary fibre does not only seem to reduce the availability of minerals but we might also assume that the absorptive capacity of the intestinal wall is limited: excessive amounts cannot be absorbed. In other words, the intestinal wall only absorbs such amounts of minerals to maintain homoeostasis, which seems to be indicated by a rather constant urinary output. Finally, one should not underestimate the interactions of the minerals themselves when accounting for the findings observed, both during the digestion step (competition as to the availability) and during the actual absorption step (competition as to the transport mechanisms through the intestinal wall) (Davies, 1974).

Whether the suggested decreased mineral availability (whatever the cause may be) is a real problem in the Western type of diet is not easy to indicate. It is not impossible that in the long-term a physiological adaptation of the body to the increased consumption of dietary fibre (from bread) will occur, until, in a new equilibrium the absorption of the minerals will meet the requirements (Anderson *et al.* 1980). Besides, the risk of an impaired mineral absorption seems to be higher in countries where phytate-rich bread is consumed and where the daily diet is less varied as compared to the possibilities in the Western World. The negative balance for Ca, Mg, Fe and Zn in period D_1 in which the amount of bran consumed is high, however, is an indication that even on a Western type of diet a too high

wheat-fibre intake bears the risk of insufficient mineral absorption due to decreased availibility. No effects of alterations in the wheat-fibre intake on the mineral concentrations in blood serum of our subjects were observed, although it is questionable whether any changes are to be expected within 20 d.

Increased serum cholesterol levels on a high wheat-fibre intake (through bran in bread) were also reported by other authors (Jenkins *et al.* 1975; Kay & Truswell, 1977; Stasse-Wolthuis *et al.* 1980). Some investigators did not find elevated levels (Heaton & Pomare, 1974; Dixon, 1978; Van Berge-Henegouwen *et al.* 1979). However, one may wonder whether the increase of serum cholesterol will be of any significance in a mixed diet with fruit and vegetables (in our study only low-fibre vegetables and no fresh fruit were consumed) since dietary fibre from fruit and vegetables (pectins) have been reported to decrease serum cholesterol levels (Grande *et al.* 1974; Stasse-Wolthuis *et al.* 1980).

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