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A STUDY ON THE MINERAL DEPLETION OF THE FOODS AVAILABLE TO US AS A NATION OVER THE PERIOD 1940 TO 1991*

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ABSTRACT

In 1927 a study at King's College, University of London, of the chemical composition of foods was initiated by Dr McCance to assist with diabetic dietary guidance. The study evolved and was then broadened to determine all the important organic and mineral constituents of foods, it was financed by the Medical Research Council and eventually published in 1940. Over the next 51 years subsequent editions reflected changing national dietary habits and food laws as well as advances in analytical procedures. The most recent (5th Edition) published in 1991 has comprehensively analysed 14 different categories of foods and beverages.

In order to provide some insight into any variation in the quality of the foods available to us as a nation between 1940 and 1991 it was possible to compare and contrast the mineral content of 27 varieties of vegetable, 17 varieties of fruit, 10 cuts of meat and some milk and cheese products. The results demonstrate that there has been a significant loss of minerals and trace elements in these foods over that period of time. It is suggested that the results of this study cannot be taken in isolation from recent dietary, environmental and disease trends. These trends are briefly mentioned and suggestions are made as to how the deterioration in the micronutrient quality of our food intake may be arrested and reversed.

*The data used as the basis for this study was published in five editions, initially under the auspices of the Medical Research Council and later the Ministry of Agriculture Fisheries and Foods and the Royal Society of Chemistry: Authors R.A. McCance and E.M. Widdowson.

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INTRODUCTION

The source of the information used to compile this report is data published by the Medical Research Council (1940)[1-3] and the Ministry of Agriculture, Fisheries and Foods (MAFF)[4,5]. These books provide statistics on the chemical composition of foods available to us as a nation between the period 1940 to 1991. Part of the analysis includes the mineral content – in mg per 100gm portion of that food. The analysis provides information – on the amounts of Calcium, Magnesium, Potassium, Phosphorous, Iron, Copper, Sodium and Chloride. It was found that only certain foods within the categories of vegetables, fruits and cuts of meat could be readily traced over this 51 year period.

The result of comparing data available in 1940 with that in 1991 demonstrates that in every sub group of foods investigated there has been a substantial loss in their mineral content.

Background

In 1926 Dr. R. A. McCance undertook – with a grant from the Medical Research Council – to analyse raw and cooked fruits and vegetables for their total 'available carbohydrate'. So began a programme of analysis which resulted, in 1940, with the publication of the Medical Research Council's Special Report No 235, entitled "The Chemical Composition of Foods". This report represented the culmination of a comprehensive research programme on the chemical composition of foods available to the British public. One ounce and 100 grams of different vegetables, fruits, cereals, meats, seafoods, beverages, beers, sugars, preserves, sweetmeats, condiments, and dairy products were analysed for their organic and mineral content as well as portions of traditional British food recipes including cakes, pastries and puddings.

This, then, was the first determined effort by a number of dedicated doctors and food scientists headed by McCance and Widdowson to establish definitive standards by which to quantitatively compare and contrast individual dietary intakes. This First Edition was subsequently updated by the Medical Research Council in 1946 and 1960 as new foods became available, analytical procedures improved and new information regarding constituents of food (e.g. vitamins/amino acids etc.) were considered as being needed. Over the next 30 years the need to continually update information resulted in the 4th and 5th Editions which were published in 1978 and 1991 respectively under the title of 'The Composition of Foods', this time under the auspices of the Ministry of Agriculture Fisheries and Food in conjunction with the Royal Society of Chemistry.

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On comparing and contrasting the 1940 figures with the 1991 figures quite a number of variables exist; enough in some instances, such as cereals, to make comparisons meaningless. Equally there is a wealth of data available which provides very real insights into the change in food values over the 51 years between 1940 and 1991. The 1940 data often incorporates work published in 1929, 1933 and 1936; similarly the 5th Edition published in 1991 contains data that originates from 1987. For consistency I have used the published dates.

The Food Analysis

In the first edition the foods were analysed for

- Water Content
- Total Nitrogen
- Protein
- Fat
- Available Carbohydrate
- Mineral Content
- Acid-Base Balance

In the context of this report only the mineral analysis was of interest and considered. The mineral elements assayed for were Sodium (Na), Potassium (K), Magnesium (Mg), Calcium (Ca), Phosphorous (P), Iron (Fe), Copper (Cu), Nitrogen (N) and Chlorine (Cl). The amounts were recorded in milligrams per 100 gm of the food. Details such as a description of the food, where it was sourced, how many samples were used, its preparation (whole/ with peel/top leaves etc) and its condition – raw or cooked (and if so how and for how long) – was often recorded for each item of food. In this way like could be compared to like with regards to the variety of food and the cooking time. With foods where both raw and cooked values were given the raw value was the one selected.

In later editions information on the dietary fibre, energy values and the vitamin content of foods was incorporated; the nitrogen content was dropped and a more complete breakdown of the amino acid composition was given. Zinc analysis was conducted in the 1978 Edition and Selenium, Iodine and Manganese in the 1991 Edition. Obviously the analytical procedures changed over the years between 1940 and 1991. However, to quote the foreword of the 5th Edition "Those methods (of 40 years ago) were no less accurate than the modern automated ones, but they took a much longer time".

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PRESENTATION OF INFORMATION

Vegetables

The vegetables selected represent those that were described by the authors as being of the same variety e.g. runner beans (raw) in 1940 with runner beans (raw) in 1991. Many of the vegetables on original lists were not subsequently analysed e.g. artichokes, butter beans, celeriac, endive etc. Whilst others such as peppers, yam, plantain, okra, garlic, fennel etc. were only analysed in later years.

Of the original 28 raw vegetables and 44 cooked vegetables detailed in the First Edition, 27 vegetables (together with mushroom) could be traced through to the Fifth Edition. In order to make the summary of results easier to read these vegetables were grouped in order of their dominant characteristic, i.e. bulb, root etc., and the results presented in Table 1. The individual values are presented in Appendix 3. In addition to the individual percentage change in the minerals Na, K, Mg, Ca, P, Fe and Cu the change in the ratios between Ca:P, Na:K, Mg:Ca, and Cu:Fe were also calculated. Where the vegetable has been boiled this was usually in distilled water, normally with no salt. It is interesting to note the change between 1940 and 1991 in what was considered an appropriate time to cook a vegetable. For broccoli in 1991 it was 15 minutes, while in 1940 it was 45 minutes. When comparing the results of the analysis it is pertinent to bear this in mind.

In the 1960 and 1975 editions Zinc was assayed for the first time: where this value has been given it has been included in the table at the appropriate date. Also within the 3rd and 4th editions certain 'new' vegetables were analysed: where these could be traced through to the 5th edition their values have been recorded on Table 2 and their individual analyses have been included in Appendix 4.

Fruits

In a similar manner to the vegetables 17 fruits were 'followed through' from the 1940 to 1991 Editions and changes in their individual mineral content recorded and presented in a summary sheet – see Table 3.

Meats

With regards to comparing Meat, Poultry and Game (1940) with Meat and Meat products (1991) there were, surprisingly, only ten items that were readily comparable. This situation was created because to quote from Edition 5, "The conformation of farm animals had altered and methods of butchering had changed since the nineteen thirties". The results obtained are presented in Table 4.

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TABLE 1

Summary of changes in the Mineral Content of 27 Vegetables between1940 and 1991

Year of Analysis	Mineral	Brassicas	'Bulb' Veg	'Fruit' Veg	'Leaf	'Pods'	'Shoot' Veg	'Root' Veg	1940 Total	1991 Total	Change over 51 years
1940	Sodium	67.8	29.6	18.5	205.1	7	144.3	287.7	760		
1991	(Na)	21	16	14	191	1	61	83		387	Less 49%
1940	Potassium	922	641	976	1967	618	460	2098	7682		
1991	(K)	1030	570	730	940	550	490	2180		6490	Less 16%
1940	Phosphorous	194.4	81.1	76.9	240.7	130	52.6	239.5	1015.2		
1991	(P)	240	91	108	137	164	48	314		1102	Plus 9%
1940	Magnesium	55.8	31	37.8	113.2	53.2	22.2	105.1	418.3		
1991	(Mg)	54	18	36	67	53	11	81		320	Less 24%
1940	Calcium	349.3	226.7	85.5	908.8	48.1	70.6	299.4	1988.4		
1991	Ca	204	84	64	393	54	62	220		1081	Less 46%
1940	Iron	4.53	3.54	1.51	10.89	2.68	1.3	5.18	29.63		
1991	(Fe)	4	2.9	1.5	5.5	4	0.8	3		21.7	Less 27%
1940	Copper	0.41	0.3	0.35	0.67	0.32	0 25	0.72	3.02		
1991	Cu	0.11	0.13	0.05	0.09	0.07	0.06	0.21		0.72	Less 76%

Each analysis figure represents a cummulative figure obtained from individual tables – see Appendix 1

Ratio Changes

Ca: P	1:2	1:1
Na:K	1:10	1:17
Mg:Ca	1:4.8	1:3.4
Cu:Fe	1:10	1.30

These statistics have been calculated by comparing and contrasting data first published in 1940 by McCance and Widdowson – 'Chemical Composition of Food', which was commissioned by the Medical Research Council – with that data published by the same authors in 1991 – The Composition of Food, which was commissioned by the Royal Society of Chemistry and the Ministry of Agriculture Fisheries and Food.

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TABLE 2

Summary of changes in the Mineral Content of 7 Vegetables between 1978 and 1991.

Year of Analysis	Mineral	Beetroot	Broccoli	Leek	Marrow	New Potatoes (Boiled)	Pepper/Green	Sweetcorn	Totals	Change
1978	Sodium	84	12	8.8	1	41	2	1	149.8	
1991	(Na)	66	8	2	1	9	4	1	91	Less 39%
1978	Potassium	303	340	314	210	330	210	280	1987	
1991	(K)	380	370	260	140	250	120	140	1660	Less 16%
1978	Phosphorous	32	67	43.2	20	33	25	120	340.2	
1991	(P)	51	87	44	17	28	19	48	294	Less 14%
1978	Magnesium	15	18	10.3	12	20	11	45	131.3	
1991	(Mg)	11	22	3	10	12	10	20	88	Less 33%
1978	Calcium	24.9	100	62.7	17	5	9	4	222.6	
1991	(Ca)	20	56	24	18	5	8	2	133	Less 40%
1978	Iron	0.37	1.5	1.12	0.2	0.4	0.4	0.9	4.89	
1991	(Fe)	1.2	1.7	1.1	0.2	0.3	0.4	0.3	5.2	Plus 6%
1978	Copper	0.07	0.07	0.1	0.03	0.15	0.07	0.15	0.64	
1991	(Cu)	0.02	0.02	0.02	0.02	0.06	0.02	0.02	0.18	Less 72%
1978	Zinc	0.4	0.6	–	0.2	0.3	0.2	1	2.7	
1991	(Zn)	0.4	0.6	0.2	0.2	0.1	0.1	0.2	1.1	Less 59%

Each individual numerical amount refers to mg per 100gm. These statistics have been calculated by comparing and contrasting data published in the 1978 edition of The Composition of Foods with that published in the 1991 edition. Both editions were by the same authors – McCance and Widdowson – and published by the Royal Society of Chemistry and MAFF.

Ratio Changes		
Ca : P	1:1.5	1: 2.2
Na : K	1:13	1: 18
Mg : Ca	1:1.7	1: 1.5
Cu : Fe	1:7.6	1: 29

DISCUSSION OF RESULTS

Vegetables

With most vegetables, when they are harvested, it is usually the whole plant that is taken. An exception would be the 'Pod and Seeds' and 'Fruit' groups where there is the possibility of the rest of the plant being ploughed back into the soil. Consequently, vegetables are probably the best indicators of change relating to the mineral depletion of soils. If the soils become depleted in minerals, the minerals are simply not there to become incorporated within the

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TABLE 3

Summary of changes in the Mineral Content of 17 Fruits between 1940 and 1991

Year of Analysis	Mineral	Apple	Apricot	Avocado	Blackberry	Cherry	Damson	Lemon	Melon	Nectarine	Orange	Passion Fruit	Peach	Pineapple	Raspberry	Rhubarb	Strawberry	Banana	Totals	Change
1940	Sodium	2	<1	16	3.7	2.8	2.2	6	13.5	9.1	2.9	28.4	2.7	1.6	2.5	2.2	1.5	1.2	98.3	
1991	(Na)	3	2	6	2	1	2	5	8	1	5	19	1	2	3	3	6	1	70	less 29%
1940	Potassium	120	320	396	208	275	290	163	319	268	197	348	259	247	224	425	161	348	4568	
1991	(K)	120	270	450	160	210	260	150	210	170	150	200	160	160	170	290	160	400	3690	less 19%
1940	Phosphorous	8.5	21.3	30.8	23.8	16.8	16.4	20.7	30.4	23.9	23.7	54.2	18.5	7.8	28.7	21	23	28.1	397.6	
1991	(P)	11	20	39	31	21	14	18	13	22	21	64	22	10	31	17	24	28	406	plus 2%
1940	Magnesium	4.3	12.3	29.4	29.5	9.6	11	11.6	20.1	12.6	15.6	38.6	7.9	16.9	21.6	13.6	11.7	41.9	305.5	
1991	(Mg)	5	11	25	23	10	10	12	11	10	10	29	9	16	19	13	10	34	257	less 16%
1940	Calcium	3.5	17.2	15.3	63.3	15.9	23.5	107	19.1	3.9	41.3	15.6	4.8	12.2	40.7	103	22	6.8	515.1	
1991	(Ca)	4	15	11	41	13	22	85	20	7	47	11	7	18	25	93	10	6	435	less 16%
1940	Iron	0.29	0.37	0.53	0.85	0.38	0.41	0.35	0.81	0.46	0.33	1.12	0.38	0.42	1.21	0.4	0.71	0.41	9.43	
1991	(Fe)	0.1	0.5	0.4	0.7	0.2	0.4	0.5	03	0.4	0.1	1.3	0.4	0.2	0.7	0.3	0.4	0.3	7.2	less 24%
1940	Copper	0.07	0.12	0.21	0.12	0.07	0.08	0.26	0.04	0.06	0.07	0.12	0.05	0.08	0.21	0.13	0.13	0.16	1.98	
1991	(Cu)	0.2	0.06	0.19	0.11	0.07	0.07	0.26	Tr	0.06	0.05	–	0.06	0.11	0.1	0.07	0.07	0.1	1.58	less 20%
1978	Zinc	0.1	0.1	–	–	0.1	–	0.1	0.1	0.1	0.2	–	0.1	0.1	–	–	0.1		1.1	
1991	(Zn)	Tr	0.1	0.4	0.2	0.1	–	0.1	Tr	0.1	0.1	0.8	0.1	0.1	0.3	0.1	0.1		2.6	less 27%

Each individual figure represents mg per 100gm

These statistics have been calculated by comparing and contrasting data first published in 1940 by McCance and Widdowson – 'Chemical Composition of Food', which was commissioned by the Medical Research Council – with that data published by the same authors in 1991 – The Composition of Food, which was commissioned by the Royal Society of Chemistry and the Ministry of Agriculture Fisheries and Food.

Ratio Changes		
Ca: P	1:14	1:17
Na:K	1:43	1:48
Mg:Ca	1:1.9	1:1.9
Cu:Fe	1:5	1.4.6

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TABLE 4

Summary of changes in the Mineral Content of 10 samples of Meat between 1940 and 1991

Year of Analysis	Mineral	Beef/Topside (Roast)	Beef/Sirloin (Roast)	Beef/Steak (Fried)	Chicken Meat (Boiled)	Chicken Meat (Roast)	Duck (Roast)	Pork Leg (Roast)	Bacon/Back (Fried)	Bacon/Streaky (Fried)	Turkey (Roast)	Totals	Change
1940	Sodium	76	62	80	98	80	195	66	–	–	130	787	
1991	(Na)	49	54	54	82	81	96	79	–	–	57	552	Less 30%
1940	Potassium	370	290	371	381	355	319	308	517	462	367	3740	
1991	(N)	370	300	360	300	310	270	350	300	290	310	3160	Less 16%
1940	Phosphorous	286	237	257	270	271	231	363	229	238	320	2702	
1991	(P)	210	170	220	190	210	200	200	170	160	220	1950	Less 28%
1940	Magnesium	28.1	19.9	24.8	26.4	23	23.9	22.6	25.7	25.1	28.2	247.7	
1991	(M)	24	19	24	25	24	20	22	20	19	27	224	Less 10%
1940	Calcium	6.2	5.8	5.2	10.7	14.5	19	5.2	11.5	52.3	38.3	168.7	
1991	(Ca)	6	10	7	11	9	13	10	13	12	9	100	Less 41%
1940	Iron	4.7	4.6	6	2.1	2.6	5.8	1.7	2.8	3.2	3.8	37.3	
1991	(Fe)	2.8	1.9	3.2	1.2	0.8	2.7	1.3	1.3	1.2	0.9	17.3	Less 54%
1940	Copper	0.25	0.17	–	–	–	–	–	–	–	–	0.42	
1991	(Cu)	0.14	0.18	–	0.2	0.12	0.31	0.29	0.12	0.12	–	0.32	Less 24%

Each individual figure represents mg per 100 gm

These statistics have been calculated by comparing and contrasting data first published in 1940 by McCance and Widdowson – 'Chemical Composition of Food', which was commissioned by the Medical Research Council – with that data published by the same authors in 1991 – The Composition of Food, which was commissioned by the Royal Society of Chemistry and the Ministry of Agriculture Fisheries and Food.

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plant structure, and this ultimately effects the plant's 'health' and consequently the farmer's profitability when harvesting the crop.

Obviously this situation has been known to farmers since the land was first cultivated and hence the tradition in primitive cultures to move on after ten years growing at one site, or to regularly replenish the nutrients with fertilisers, or to leave the fields to 'fallow'. It was discovered early in the 1900s that Nitrogen, Phosphorous and Potassium were the main minerals required for plant growth. These minerals together with adequate water, light and carbon dioxide seemingly allowed for optimum growth. Consequently, since the 1920s, NPK fertilisers have routinely been added to agricultural soils in the UK. Calcium – in the form of lime – and iron are also sometimes added to fertilisers.

The initial 1940 figures used in the tables presented must, therefore, not be considered as a 'true, unadulterated' representation of the mineral content of any specific vegetable. In this regard it is interesting to note that in their introduction to the vegetable section of the 5th Edition the authors state, "Any differences arising from the method of cultivation, for example 'organic' methods, appear to be small and inconsistent". Also in their introduction to the 5th Edition (page 1), the authors acknowledge that "the nutritional value of many of the more traditional foods has changed. This can happen when there are new varieties or sources of supply for the raw materials with new farming practices which can effect the nutritional value of both plant and animal products". Tables 1 and 2 provide evidence of an alarming change over 51 years. These data illustrate that – for whatever reason – there has been a severe depletion in the mineral content of the vegetables available to us as a nation.

During this time there has been an average

Loss of 49% of their Sodium content
Loss of 16% of their Potassium content
Loss of 24% of their Magnesium content
Loss of 46% of their Calcium content
Loss of 27% of their Iron content and a
and a **Loss of 76%** of their Copper content

Perhaps not too surprisingly given the regular use of NPK fertiliser, the only exception is Phosphorous, which shows a 9% rise. These losses include the analytical results of vegetables which were boiled at least twice as long in 1940 as in 1991 – with the probable ensuing greater loss of mineral content. The individual analysis tables provide insights as to the ranges of highs and lows within these figures.

Perhaps two of the most concerning results relate to two regularly used vegetables in the British diet, 'old' potatoes and 'old' carrots. During the 51 year period carrots lost 75% of their magnesium, 48% of their calcium, 46% of their iron and 75% of their copper, whilst our traditional 'spud' lost 30% of its magnesium, 35% of its calcium, 45% of its iron and 47% of its copper and you

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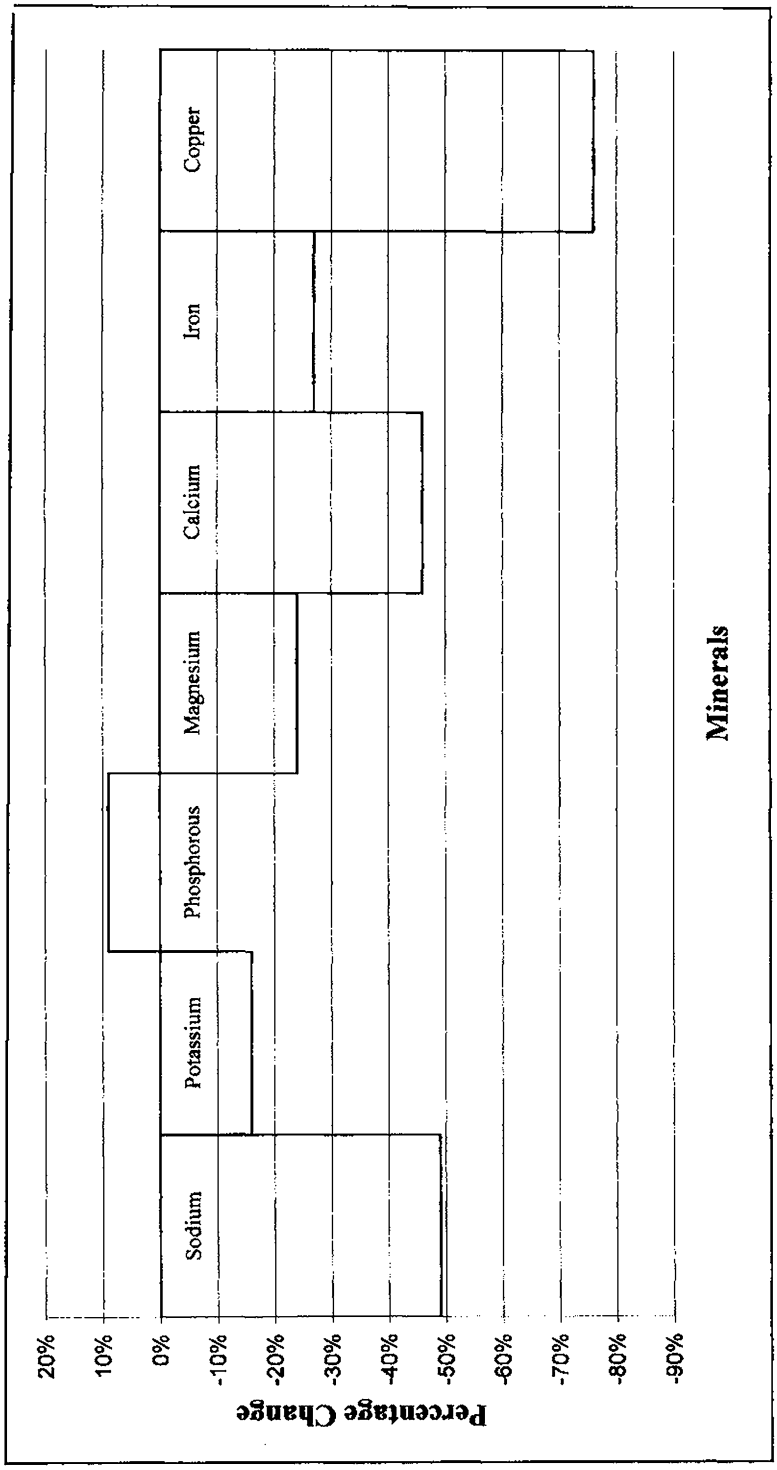

Figure 1. Mineral Changes in Vegetables Since 1940>

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would need to have eaten ten tomatoes in 1991 to have obtained the same copper intake as one tomato would have given you in 1940.

The greatest individual mineral losses (mg per 100 gm sample

Sodium	Runner Beans 6.5 to trace (nearly 100% loss)
Potassium	Spinach (boiled) 490 to 230 (less 53%) Potatoes 568 to 360 (less 36%)
Phosphorous	Spinach (boiled) 93 to 28 (less 70%) Potatoes 0.15 to 0.08 (less 47%)
Magnesium	Carrots 12 to 3 (less 75%)
Calcium	Broccoli (boiled) 160 to 40 (less 75%) Spring Onion 135 to 35 (less 74%)
Iron	Spinach (boiled) 4 to 1.6 (less 60%) Swede 0.35 to 0.1 (less 71%)
Copper	Spinach (boiled) 0.26 to 0.01 (less 96%) Watercress 0.14 to 0.01 (less 93%)

Greatest Increases in Mineral content (mg per 100gm sample)

Sodium	Peas 0.5 to 1.0 (could have been rounded up)
Potassium	Broccoli 103 to 170 (plus 46%) Onion 137 to 160 (plus 30%)
Phosphorous	Swede 19 to 40 (plus 110%)
Magnesium	Cauliflower (boiled) 6.6 to 12 (plus 82%)
Calcium	Peas 15.1 to 21 (plus 40%)
Iron	Runner Beans 0.8 to 1.2 (plus 50%)
Copper	there were no increases in any vegetables analysed: the least loss was potatoes 0.15 to 0.08 (less 47%)

In addition to the overall mineral depletions recorded, significant changes in the ratios of the minerals to one another have taken place. Given that there are known critical ratios of certain minerals within our physiology (Ca:P, Na:K, Mg:Ca, Fe:Cu) the changes in these ratios were calculated for each individual vegetable. An overall summary is shown in Figure 2.

The figures, therefore, represent a significant change in the ratios between the minerals which in turn could well have a significant influence on our bio-chemistry.

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	1940	1991
Calcium (Ca): Phosphorous (P)	01:02	01:01
Sodium (Na): Potassium (K)	01:10	01:17
Magnesium (Mg) : Calcium (Ca)	01:04.8	01:03.4
Iron (Fe) : Copper (Cu)	01:10	01:30

Figure 2. Changes in some element ratios 1940–1991

Vegetables (1978–1991)

Unfortunately only seven vegetables could be traced over this 13 year period – see Table 2 and Appendix 5. The results are again disconcerting. During this time there has been an average:

Loss of 39% of their Sodium content
Loss of 16% of their Potassium content
Loss of 14% of their Phosphorous content
Loss of 33% of their Magnesium content
Loss of 40% of their Calcium content
Increase of 6% of their Iron content
Loss of 72% of their Copper content
Loss of 59% of their Zinc content

These are very disturbing results. The seemingly anomalous result of iron is due to a significant increase reported in beetroot (from 0.37mg to 1.2mg), which has skewed the overall result and may have been related to the addition of iron sometimes used in fertilisers.

The worrying concern regarding trace mineral availability is again the significant loss of copper (72%) and zinc (59%), this time over a 13-year period. In the 5th Edition Manganese (Mn), Selenium (Se) and Iodine (I) were included in the list of minerals assayed for. If the depletion of copper and zinc are considered typical for trace minerals, it is quite likely that all other trace minerals have also been significantly depleted: consequently the 1991 'official' values for Mn, Se and I must be considered in this light.

Trace minerals play a huge role in human physiology to help maintain homeostasis. The significant loss of these essential trace minerals within the vegetables available to us again highlights the difficulties in achieving a fully adequate diet with currently available foodstuffs. An alternative is supplementation of our poorer diet with a well balanced, naturally derived, readily assimilated, liquid food supplement.

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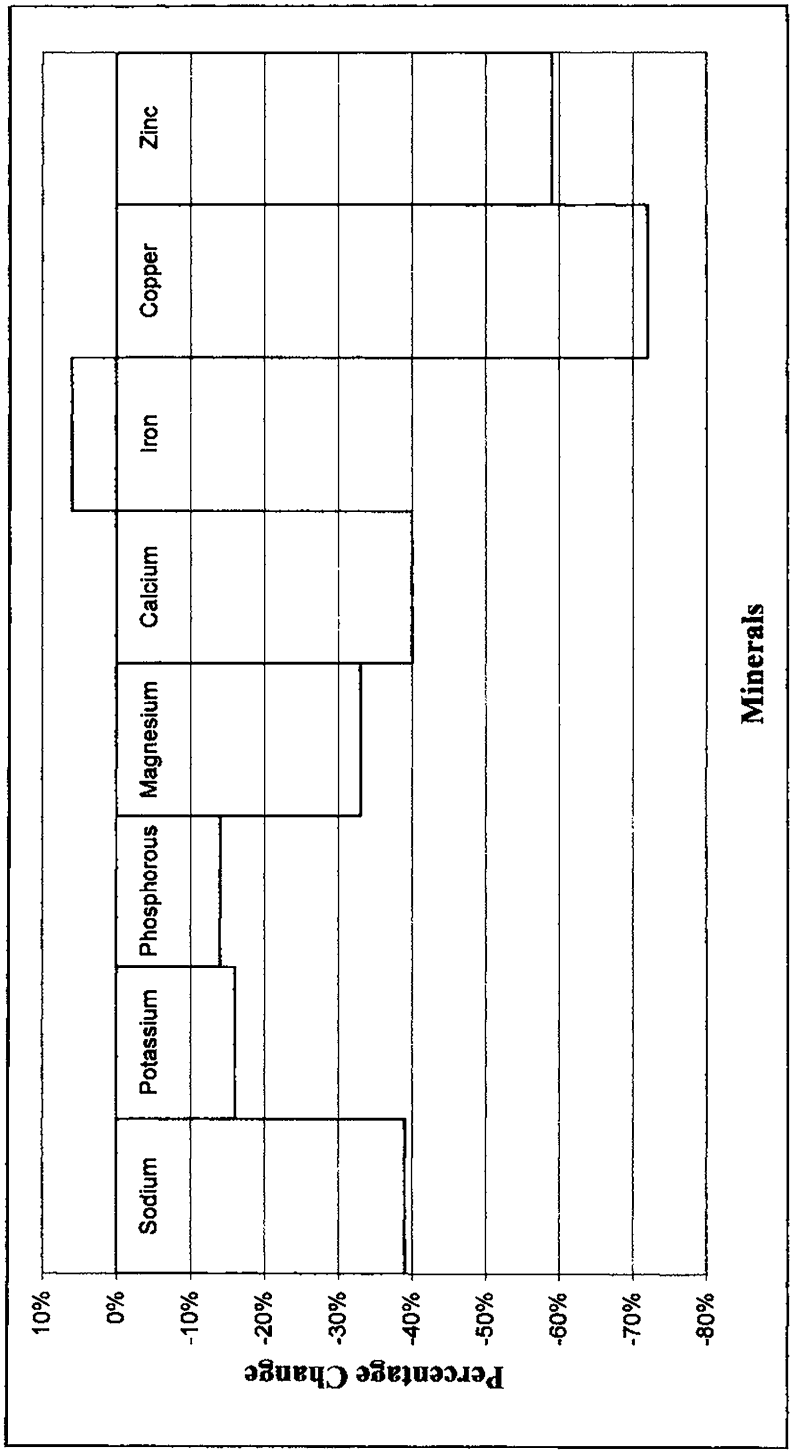

Figure 3. Mineral changes in vegetables 1978-1991

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Fruit

The analytical results of 17 fruits traced through from 1940 to 1991 given in Table 3. A summary is given below:

Loss of 29% of their Sodium
Loss of 19% of their Potassium
Increase of 2% of their Phosphorous
Loss of 16% of their Magnesium
Loss of 16% of their Calcium
Loss of 24% of their Iron
Loss of 20% of their Copper
Loss of 27% of their Zinc

Unlike a vegetable, when a fruit is harvested the whole plant is not taken. Consequently the changes evident are not so startling. Nevertheless, there are significant overall losses in mineral content. Also when individual fruits are considered, you would have needed to eat three apples or oranges in 1991 to supply the same Iron content as one in 1940. It is also pertinent to note that the ten fruits assayed for Zinc in 1978 show an overall 27% loss in their 1991 values. As blackcurrants, olives and tangerines have exactly the same values in 1991 as given in 1940 they have probably not been re-assayed.

Meats

Ten items of meat were able to be compared, and the results are given on Table 4. As with some of the fruits, some analyses given in the 5th Edition are exactly the same as given in the 1st Edition. These include Pork Loin (grilled), Rabbit, Veal Fillet, Venison (roasted), Tripe (dressed), Sheep's Tongue, Ox Tongue, Grouse, Goose, Partridge, Pheasant and Pigeon. A summary of the mineral losses is given below, there has been an average:

Loss of 30% of their Sodium
Loss of 16% of their Potassium
Loss of 28% of their Phosphorous
Loss of 10% of their Magnesium
Loss of 41 % of their Calcium
Loss of 54% of their Iron
Loss of 24% of their Copper

Again there is a significant loss in all minerals assayed for, which could reflect the fact that these animals are fed on produce that itself is mineral deficient – including one another! The alarming 41% loss in calcium could be a spurious reading due to the difficulty of extracting all bone from the flesh in the original

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analysis but the 54% loss of Iron cannot be so readily explained. Copper in meats and meat products was not routinely assayed for in 1940, hence the lack of data – see Table 4.

Cereals

Within this category of foods it proved very difficult to compare like with like. Also since 1984, iron, calcium and thiamin have been added, by law, to all white and most brown flours. As with items in Fruit and Meat, cornflour, sage and tapioca all have the same 1991 values as given in 1940 and probably reflect analyses done in the 1930s.

Fish and Seafood

These creatures may be considered wild – consequently time related comparisons would be inappropriate. It is interesting to note, however, that two relatively modern 'farmed' – fish salmon and trout – in the 1991 5th Edition have the same mineral content values as given in the 1940 1st Edition and again it seems likely these are values derived from the original assay of the 1930s.

Dairy Products

In a similar manner it is difficult to compare like with like. The only reasonable comparisons are milk (fresh/whole) and cheddar cheese. Comparisons of these are shown below.

Milk

	1940	1991	change
Sodium (Na)	50	55	**Plus 10%**
Potassium (K)	160	140	**less 12.5%**
Phosphorous (P)	95	92	**Less 3%**
Magnesium (Mg)	14	11	**Less 21%**
Calcium (Ca)	120	115	**Less 4%**
Iron (Fe)	0.08	0.05	**Less 38%**
Copper (Cu)	0.02	Tr	

Figure 4. Changes in milk between 1940 and 1991.

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Cheddar Cheese

	1940	1991	change
Sodium (Na)			
Potassium (K)	116	77	**Less 34%**
Phosphorous (P)	545	490	**Less 10%**
Magnesium (Mg)	46.9	25	**Less 47%**
Calcium (Ca)	810	720	**Less 11%**
Iron (Fe)	0.57	0.3	**Less 47%**
Copper (Cu)	0.03	0.03	**Same**

Figure 5. Changes in Cheddar Cheese between 1940 and 1991.

TABLE 5

Summary of Changes in the Mineral Content of Vegetables, Fruit and Meat between 1940 and 1991

Year of Analysis	Mineral	Vegetables (27 varieties)	Fruit (17 varieties)	Meat (10 cuts)
1940	Sodium			
1991	(Na)	Less 49%	Less 29%	Less 30%
1940	Potassium			
1991	(K)	Less 16%	Less 19%	Less 16%
1940	Phosphorous			
1991	(P)	Plus 9%	Plus 2%	Less 28%
1940	Magnesium			
1991	(Mg)	Less 24%	Less 16%	Less 10%
1940	Calcium			
1991	(Ca)	Less 46%	Less 16%	Less 41%
1940	Iron			
1991	(Fe)	Less 27%	Less 24%	Less 54%
1940	Copper			
1991	(Cu)	Less 76%	Less 20%	Less 24%

These statistics have been calculated by comparing and contrasting data first published in 1940 by McCance and Widdowson – 'Chemical Composition of Food', which was commissioned by the Medical Research Council – with that data published by the same authors in 1991 – The Composition of Food, which was commissioned by the Royal Society of Chemistry and the Ministry of Agriculture Fisheries and Food.

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DISCUSSION OF RESULTS

This comparative study, over a 51 year period, of the mineral content of the food available to us as a nation has demonstrated that in every category, where meaningful comparisons can be made, there have been significant losses – a summary is given in Table 5. Perhaps the most dramatic loss relates to the copper present in vegetables between 1940 and 1991 76% and zinc between 1978 and 1991 59% (see Table 2).

There could be many reasons why the minerals and trace elements have been diminished. These include trace mineral depletion of the soil itself, the excessive use of NPK fertilisers, changes in varieties of plants, the loss of micro flora/fauna within the soil[6], etc. However, irrespective of the cause, what is evident is that there has been an alarming loss of those minerals and trace elements that make up this essential part of our food chain.

It is also important to note that the reason why copper was analysed for the first edition published in 1940 was because it was found to be an essential trace element in 1928. Since then a number of other trace elements have proven to be beneficial.

*Essential Trace Elements by Year of Recognition**

Manganese	1931
Zinc	1934
Cobalt	1935
Molybdenum	1953
Selenium	1957
Chromium	1959
Tin	1970
Vanadium	1971
Flourine	1971
Silicon	1972
Nickel	1964
Arsenic	1975
Cadmium	1977
Lead	1977
Boron	1990

*Essentiality demonstrated in animals, not necessarily humans[7]

The analysis for Selenium, Iodine and Manganese was given for the first time in the 1991 edition of *The Composition of Foods*. Given that the results of this study demonstrate the loss of trace minerals over a certain period of time, it is relevant to note that any similar future comparative studies would need to question the validity of their initial values. It is also worthy of note that these trends of mineral losses within foods are not unique to the UK. Bergner[7] has demonstrated similar losses in fruit, vegetables, grains and meat in the US.

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Wider Issues

So what conclusion may be drawn from these findings? There appear to be two opposing viewpoints. The first is that these findings may be considered irrelevant. It could be argued that we have an innate ability to adapt, compensate and adjust to our environment and the fact that, as a nation overall, our health and longevity has increased over the past 50 years demonstrates the success of our health service and our farming and food industry policies.

An opposing consideration would suggest that over the last 50 years we have subjected ourselves to an increased environmental toxic load (pesticides, herbicides, fungicides, hormones, heavy metals, antibiotics, colourings, flavourings, preservatives etc.) that is unprecedented in our evolutionary history. Also there has been a radical change in dietary habits towards convenience foods comprised principally of fats, carbohydrates and proteins. As a consequence we have created a society that may be considered overfed yet malnourished of micro-nutrients. These circumstances contribute significantly towards the rise in chronic disease conditions now present in all age groups – including arthritis, obesity, diabetes, M.S., M.E., osteoporosis, cancer, asthma, eczema, leukaemia, cardio-vascular disease etc.

Which of these scenarios is true? The current consensus undoubtedly favours the former. However, there is now a growing body of research evidence that minerals and trace elements can and do play a major role in our physical and psychological well-being (Appendix 1.) and that heavy metals cause disease disorders (Appendix 2.). It has been shown that some chemical substances derived from the diet and/or from environmental exposure affect human behaviour[8, 9] and lack of micronutrients predisposes us to degenerative conditions[10]. Recently Gesch, Director of Natural Justice and Senior Researcher in the Physiology Department at Oxford University[11], has demonstrated that providing Recommended Daily Allowance levels of micronutrients assists in correcting the anti-social behaviour of juveniles[9], and Pick[12] has demonstrated that even the 'healthy' (i.e. asymptomatic) A and B social/economic classes are micronutrient deficient.

Perhaps it is time for both sides of this argument to respect the research evidence of the other and to work together. Current DNA research indicates that individuals are genetically predisposed towards differing chronic disease conditions. Consequently this school of thought suggests that the way forward is to discover appropriate vaccinations and/or drug therapies to 'protect' those susceptible.

Given that each of us, as a result of hereditary predispositions, has inherent genetic vulnerabilities towards certain physiological and psychological conditions and that these may now be definitively identified by modern research, would it not be appropriate to help the body optimise its adaptive capacity[13] to better cope with the situation? Such a route, using modern scientific techniques, together with appropriate educational programmes concerning diet, exercise and attitude of mind, would allow for the opportunity

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to monitor the capacity to adapt to environmental challenges. In this manner the individual concerned would be less likely to be continually compromised and ultimately surprised by the body expressing its difficulty in coping with the environmental challenge presented by developing a chronic disease condition.

CONCLUSION

By comparing the lists of foods given in the First Edition of *The Composition of Foods* with those in the Fifth Edition, it can be seen that the dietary habits of the people in the UK have changed dramatically. Since the publication of the 4th Edition in 1978 there has been a dramatic rise in the popularity of refined processed foods – 'fast' foods – which are often high in saturated fats, sugars, colourings, preservatives and flavourings. These foods have, over the past 30 years, become the 'norm'. Consequently we now have a generation that considers this situation as normal and their children are growing up to regard 'fast' foods and drinks as an appropriate diet.

The 'raw materials' from which these foods have been manufactured are themselves often contaminated by herbicides, fungicides, pesticides, antibiotics and hormones. As this study has demonstrated, there has also been a significant deterioration in the mineral content of those foods – vegetables, fruit, meat – that may be considered the foundation of a 'good diet'.

Minerals are what we are made of, to quote the Bible – "ashes to ashes, dust to dust". We are an amalgam of the 'stuff' of the earth and a quality often understood as 'life force'. It is improbable that we can function at our optimum on a physical, mental and emotional level if the foods we have available to us are deficient in vital minerals and trace elements - and by inference other micronutrients.

Physiologically it would be very difficult to underestimate the importance of minerals and trace elements. They often act as the catalyst for all the other nutrients the body uses to develop and maintain good health. Magnesium for instance is known to be required to be present in the metabolic pathway of 300 enzyme reactions whilst zinc is known to be required in 200 enzyme reactions. The deterioration in the mineral content of the 64 foods that could be traced over the 51-year period between 1940 and 1991, therefore, should be considered as alarming.

The wider issues that could relate to the loss of micronutrients in our food chain have been touched upon, it could be concluded that as a nation we are overfed but malnourished and there is a need to recognise that minerals and trace elements are generally deficient in our diets. The author suggests that a good quality prophylactic supplement should be taken whilst changes take place in our education policy as well as at the highest level in our food growing, procurement and manufacturing policies to ensure the quality of the food available to us is of the highest standard.

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APPENDIX 1

Signs and symptoms of deficiencies of calcium, magnesium, zinc, iron and copper*

acne	zinc
agitation	calcium, magnesium
alopecia	zinc, copper
anemia	iron, magnesium, copper
anorexia	iron, magnesium, zinc
anxiety	calcium, magnesium
apathy	zinc
brittle nails	calcium, iron, zinc
cognitive impairment	calcium, potassium
cold hands and feet	magnesium
cold, sensitivity to	iron
constipation	iron
delusions	calcium
depression	calcium, iron, magnesium, zinc, copper
diarrhea	zinc, copper
disorientation	magnesium
dizziness	iron
eczema	zinc, calcium
edema	magnesium
emphysema	copper
fatigue	iron, magnesium, zinc, copper
hallucinations	magnesium
headache	iron
hyperactivity	calcium, iron, magnesium, zinc
hypercholesterolemia	zinc, copper
hypertension	calcium, magnesium
hypotension	magnesium
immunodepression	iron, magnesium, zinc
impotence	zinc
infections	copper
infertility (male)	zinc
insomnia	calcium, iron, magnesium
irritability	calcium, iron, magnesium
kidney stones	magnesium
legs, restless	calcium, magnesium
lethargy	zinc
leukopenia	copper
memory, poor	zinc
mental confusion	iron, magnesium
muscle cramps	calcium, magnesium
muscle pain	magnesium
muscle spasm	calcium
muscle tension	calcium
muscle tremor	magnesium
muscle weakness	magnesium
myocardinal degeneration	copper
nausea	magnesium
nervousness	calcium, magnesium
neutropenia	copper

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numbness of limbs	calcium
osteoporosis	calcium, magnesium, copper
palpitations	calcium, iron
paranoia	zinc
parasthesia	calcium, magnesium
periodontal disease	calcium
startle reflex	magnesium
tooth decay	calcium
vertigo	magnesium
wound healing, slow	zinc

*Melvyn R. Werbach, M.D. *Nutritional Influences on Illness* 1993 – Second Edition, Published by Third Line Press.

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APPENDIX 2

Symptoms associated with toxicity of aluminium, cadmium, lead and mercury*

alopecia	cadmium
anemia	aluminium, cadmium, mercury, lead
anorexia	cadmium, mercury, lead
anosmia	cadmium
anxiety	lead
atoxia	aluminium, mercury
colic	aluminium
colitis	mercury
concentration impairment	lead
confusion	lead
constipation	lead
dementa	aluminium
depression	lead, mercury
dizzyness	lead, mercury
drowsiness	lead, mercury
dyspnea	aluminium
emotional instability	mercury
emphysema	cadmium
eophagitis	aluminium
erethism	mercury
fatigue	cadmium, mercury, lead
gastroenteritis	aluminium
headaches	lead, mercury
hearing impairment	mercury
hepatic dysfunction	aluminium, cadmium
hypertension	cadmium, mercury, lead
in coordination	lead, mercury
indigestion	lead
insomnia	mercury
irritability	lead, mercury
joint soreness	cadmium
kidney dysfunction	mercury
memory impairment	lead, mercury
metallic taste	mercury
nephocalcinosis	cadmium
nephritis	aluminium
numbness	mercury
osteoporosis	cadmium
pain in bones	lead
pain in muscle	aluminium, cadmium, lead
paresthesios	mercury
psychosis	aluminium, mercury
restlesness	lead
skin-dry and scaly	cadmium
stomatitis	lead
teeth – yellow	cadmium
tremours	lead, mercury
weakness	aluminium, lead

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APPENDIX 3

Individual analysis of vegetables that could be traced from 1940 to 1991 are listed alphabetically within groups of similar characteristics – for summary see Table 1. Each numerical figure refers to the mg amount of mineral per 100gm of vegetable analysed.

BRASSICAS

Broccoli (boiled) 1940 for 45 mins: 1991 for 15 mins
Brussel Sprouts (boiled) 1940 for 30 mins: 1991 for 15 mins
Cabbage 1940 (red): 1991 (average)
Cauliflower (boiled) 1940 for 30 mins: 1991 for 13 mins
Spring Greens (boiled) 1940 for 30 mins: 1991 for 12 mins

Brocolli (boiled)

	1940	1978	1991	change
Na	6.8			
K	103		170	plus 65%
P	54		57	plus 6%
Mg	13.5		13	less 4%
Ca	160		40	less 75%
Fe	1.52		1	less 34%
Cu	0.1		0.02	less 80%
Zn			0.4	
Na:K				
Mg:Ca	1:12		1:3	
Cu:Fe	1:15		1:50	

Cabbage

	1940	1978	1991	change
Na	31.6		5	less 84%
K	302		270	less 11%
P	32.1		41	plus 28%
Mg	16.5		8	less 52%
Ca	53.2		52	less 2%
Fe	0.57		0.7	plus 23%
Cu	0.09		0.02	less 78%
Zn				
Na:K	1:9.6	1:54		
Mg:Ca	1:3.2	1:6.5		
Cu:Fe	1:6.3	1:35		

Brussel Sprouts (boiled)

	1940	1960	1991	change
Na	7.7		2	less 74%
K	247		310	plus 26%
P	44.8		61	plus 36%
Mg	10.6		13	plus 23%
Ca	27.1		20	less 26%
Fe	0.63		0.5	less 21%
Cu	0.08		0.03	less 63%
Zn		0.4	0.3	less 25%
Na:K	1:32		1:155	
Mg:Ca	1:27		1:1.5	
Cu:Fe	1.79		1:17	

Cauliflower (boiled)

	1940	1978	1991	change
Na	11.4		4	less 65%
K	152		120	less 21
P	33		52	plus 57%
Mg	6.6		12	plus 82%
Ca	23		17	less 26%
Fe	0.48		0.4	less 20%
Cu	0.06		0.02	less 67%
Zn				
Na:K	1:13		1:30	
Mg:Ca	1:3.5		1:1.4	
Cu:Fe	1:8		1:20	-

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Spring Greens (boiled)

	1940	1978	1991	change
Na	10.3		10	less 3%
K	118		160	less 36%
P	30.5		29	less 5%
Mg	8.6		8	less 7%
Ca	86		75	less 13%
Fe	1.33		1.4	plus 5%
Cu	0.08		0.02	less 75%
Zn				
Na:K	1:11		1:16	
Mg:Ca	1:10		1:9.3	
Cu:Fe	1:17		1:70	

'BULB' VEGETABLES

Leeks (boiled) 1940 for 30 mins: 1991 for 22 mins.
Spring Onion 1940 bulb only: 1991 bulb plus top

Leeks (boiled)

	1940	1991	change
Na	8.8	6	less 32%
K	314	150	less 52%
P	43.2	22	less 26%
Mg	10.3	2	less 81%
Ca	62.7	20	less 49%
Fe	1.12	0.7	less 38%
Cu	0.1	0.02	less 80%
Zn		0.2	
Na:K	1:36	1:130	
Mg:Ca	1:6	1:8	
Cu:Fe	1:11	1:55	

Spring Onion

	1940	1991	change
Na	13	7	less 46%
K	226	260	plus 15%
P	23.6	29	plus 23%
Mg	10.9	12	plus 10%
Ca	135	35	less 74%
Fe	1.24	1.9	plus 53%
Cu	0.13	0.06	less 54%
Zn		0.4	
Na:K	1:17	1:37	
Mg:Ca	1:12	1:2.9	
Cu:Fe	1:9.5	1:32	

Onion

	1940	1978	1991	change
Na	10.2		3	less 71%
K	137		160	plus 17%
P	30		30	same
Mg	7.6		4	less 47%
Ca	31.2		25	less 20%
Fe	0.3		0.3	same
Cu	0.08		0.05	less 38%
Zn		0.1	0.2	plus100%
Na:K	1:13		1:53	
Mg:Ca	1:4.1		1:6	
Cu:Fe	1:3.7		1:6	

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'FRUIT' VEGETABLES

Aubergine, Cucumber, Pumpkin and Tomatoes.

Aubergine

	1940	1978	1991	change
Na	2.5		2	less 20%
K	238		210	less 12%
P	12.1		16	plus 32%
Mg	9.5		11	plus 16%
Ca	10.4		10	less 4%
Fe	0.39		0.3	less 23%
Cu	0.08		0.01	less 87%
Zn			0.2	
Na:K	1:95		1:105	
Mg:Ca	1:1.1		1:0.9	
Cu:Fe	1:4.9		1:30	

Pumpkin

	1940	1978	1991	change
Na	1.3		Tr	less 99%
K	309		130	less 58%
P	19.4		19	less 2%
Mg	8.2		10	plus 22%
Ca	39		29	less 26%
Fe	0.39		0.4	plus 3%
Cu	0.08		0.02	less 75%
Zn		–	0.2	
Na:K	1:238		1:0	
Mg:Ca	1:4.8		1:2.9	
Cu:Fe	1:4.9		1:20	

Cucumber

	1940	1978	1991	change
Na	13		3	less 77%
K	141		140	same
P	24.1		49	plus 103%
Mg	9.1		8	less 12%
C	22.8		18	less 12%
Fe	0.3		0.3	same
Cu	0.09		0.01	less 89%
Zn				
Na:K	1:11		1:47	
Mg:Ca	1:2.5		1:2.3	
Cu:Fe	1:3.3		1:30	

Tomatoes

	1940	1978	1991	change
Na	3		9	plus 200%
K	288		250	less 13%
P	21.3		24	less 13%
Mg	11		7	less 36%
Ca	13.3		7	less 47%
Fe	0.43		0.5	plus 16%
Cu	0.1		0.01	less 90%
Zn		0.2	0.1	less 100%
Na:K	1:96		1:28	
Mg:Ca	1:1.2		1:1	
Cu:Fe	1:4.3		1:50	

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'LEAF' VEGETABLES

Spinach (boiled) 1940 15 mins:1991 12 mins.

Lettuce

	1940	1978	1991	change
Na	3.1		3	less 3%
K	208		220	plus 6%
P	30.2		28	less 7%
Mg	9.7		6	less 38%
Ca	25.9		28	plus 8%
Fe	0.73		0.7	less 4%
Cu	0.15		0.01	less 93%
Zn		0.02	0.2	plus 1000%
Na:K	1:67		1:73	
Mg:Ca	1:2.7		1:4.7	
Cu:Fe	1:4.9		1:70	

Spinach (Boiled)

	1940	1978	1991	change
Na	123		120	same
K	490		230	less 53%
P	93		28	less 70%
Mg	59.2		34	less 43%
Ca	595		160	less 73%
Fe	4		1.6	less 60%
Cu	0.26		0.01	less 96%
Zn		0.4	0.5	plus 20%
Na:K	1:4		1:2	
Mg:Ca	1:10		1:5	
Cu:Fe	1:15		1:160	

Mustard & Cress

	1960	1978	1991	change
Na	19		19	same
K	337		260	less 23%
P	65.5		29	less 56%
Mg	27.3		12	less 56%
Ca	65.9		35	less 47%
Fe	4.54		1	less 78%
Cu	0.12		0.06	less 50%
Zn		–	0.3	
Na:K	1:18		1:14	
Mg:Ca	1:2.4		1:2.9	
Cu:Fe	1:38		1:17	

Watercress

	1940	1978	1991	change
Na	60		49	less 18%
K	314		230	less 27%
P	52		52	same
Mg	17		15	less 12%
Ca	222		170	less 23%
Fe	1.62		2.2	plus 36%
Cu	0.14		0.01	less 93%
Zn		0.2	0.7	plus 250%
Na:K	1:5.2		1:4.7	
M:Ca	1:13		1:11	
Cu:Fe	1:12		1:220	

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PODS AND SEEDS

Peas and Runner Beans.

Peas

	1940	1978	1991	change
Na	0.5		1	plus 100%
K	342		330	less 3.5%
P	104		130	plus 40%
Mg	30.2		34	plus 7%
Ca	15.1		21	plus 40%
Fe	1.88		2.8	plus 49%
Cu	0.23		0.05	less 78%
Zn		0.7	1.1	plus 57%
Na:K	1:7		1:3	
Mg:Ca	1:0.5		1:0.6	
Cu:Fe	1:8		1:56	

Runner Beans

Bean	1940	1978	1991	change
Na	6.5	2	Tr	less 100%
K	276	280	220	less 20%
P	26	47	34	plus 31%
Mg	23	27	19	less 17%
Ca	33	27	33	same
Fe	0.8	0.8	1.2	plus 50%
Cu	0.09	0.07	0.02	less 78%
Zn		0.4	0.2	less 50%
Na:K	1:42			
Mg:Ca	1:1.2		1:1.74	
Cu:Fe	1:9		1:60	

'SHOOT' VEGETABLES

Celery and Chicory

Celery

	1940	1978	1991	change
Na	137		60	less 56%
K	278		320	plus 15%
P	31.7		21	less 29%
Mg	9.6		5	less 48%
Ca	52.2		41	less 21%
Fe	0.61		0.4	less 34%
Cu	0.11		0.01	less 90%
Zn		0.1	0.1	same
Na:K	1:2		1:5.3	
Mg:Ca	1:5.4		1:8.2	
Cu:Fe	1:5.5		1:40	

Chicory

	1940	1978	1991	change
Na	7.3		1	less 86%
K	182		170	less 7%
P	20.9		27	plus 29%
Mg	12.6		6	less 52%
Ca	18.4		21	plus 14%
Fe	0.69		0.4	less 42%
Cu	0.14		0.05	less 64%
Zn		0.2	0.2	same
Na:K	1:25		1:170	
Mg:Ca	1:1.5		1:3.5	
Cu:Fe	1:4.9		1:8	

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'ROOT' VEGETABLES

Beetroot (boiled) 1940 for 2 hours:1991 in salted water for 45 mins.
Carrot (old), Parsnip, Potatoes (old), Radish, Swede and Turnip.

Beetroot (boiled)

	1940	1978	1991	change
Na	64		110	plus 72%
K	350		510	plus 46%
P	35.6		87	plus 144%
Mg	16.9		16	less 6%
Ca	30		29	less 3%
Fe	0.7		0.8	plus 14%
Cu	0.14		0.03	less 79%
Zn		0.4	0.5	plus 25%
Na:K	1:5.5		1:4.6	
Mg:Ca	1:1.8		1:1.8	
Cu:Fe	1:5		1:27	

Potatoes (old)

	1940	1978	1991	change
Na	7		7	same
K	568		360	less 36%
P	40.3		37	less 16%
Mg	24.2		17	less 30%
Ca	7.7		5	less 35%
Fe	0.75		0.4	less 45%
Cu	0.15		0.08	less 47%
Zn		0.3	0.3	same
Na:K	1:87		1:51	
Mg:Ca	1:0.3		1:0.4	
Cu:Fe	1:5		1:5	

Carrots (old)

	1940	1978	1991	change
Na	95		25	less 74%
K	224		170	less 24%
P	21		15	less 33%
Mg	12		3	less 75%
Ca	48		25	less 48%
Fe	0.56		0.3	less 46%
Cu	0.08		0.02	less 75%
Zn		0.4	0.4	same
Na:K	1:2.4		1:6.8	
Mg:Ca	1:4		1:8.3	
Cu:Fe	1:7		1:15	

Radish

	1940	1978	1991	change
Na	59		11	less 81%
K	240		240	same
P	27.1		20	less 26%
Mg	11.4		5	less 56%
Ca	43.7		19	less 57%
Fe	1.88		0.6	less 68%
Cu	0.13		0.01	less 92%
Zn		0.1	0.2	plus 100%
Na:K	1:4		1:22	
Mg:Ca	1:3.8		1:3.8	
Cu:Fe	1:14		1:60	

Parsnip

	1940	1978	1991	change
Na	16.5		10	less 40%
K	342		450	plus 30%
P	69		74	plus 7%
Mg	22.4		23	plus 3%
Ca	54.8		41	less 25%
Fe	0.57		0.6	same
Cu	0.1		0.05	less 50%
Zn		0.1	0.3	plus 200%
Na:K	1:20		1:45	
Mg:Ca	1:2.5		1:1.8	
Cu:Fe	1:6		1:12	

Swede

	1940		1991	chance
Na	52.2		15	less 71%
K	136		170	plus 25%
P	19		40	plus 110%
Mg	10.8		9	less 17%
Ca	56.4		53	less 6%
Fe	0.35		0.1	less 71%
Cu	0.05		0.01	less 80%
Zn		–	0.3	
Na:K	1:2.6		1:11	
Mg:Ca	1:5.2		1:5.9	
Cu:Fe	1:7		1:10	

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Turnip

	1940	1978	1991	change
Na	58		15	less 74%
K	238		280	plus 18%
P	27.5		41	plus 49%
Mg	7.4		8	plus 8%
Ca	58.8		48	less 18%
Fe	0.37		0.2	less 46%
Cu	0.07		0.01	less 85%
Zn			0.1	
Na:K	1:4.1		1:19	
Mg:Ca	1:7.9		1:6	
Cu:Fe	1:5.3		1:20	

APPENDIX 4

Individual analysis of vegetables introduced either in 1960 or 1978 that could be traced through to 1991. For a summary of results see Table 2.

Beetroot (raw)

	1960	1978	1991	change
Na	84		66	less 21%
K	303		380	less 24%
P	32		51	plus 59%
Mg	15		11	less 27%
Ca	24.9		20	less 25%
Fe	0.37		1.2	plus 224%
Cu	0.07		0.02	less 71%
Zn		0.4	0.4	same
Na:K	1:3.6		1:5.8	
Mg:Ca	1:1.7		1:1.8	
Cu:Fe	1:5.3		1:60	

Brocolli (raw)

	1940	1978	1991	change
Na		12	8	less 50%
K		340	370	plus 9%
P		67	87	plus 30%
Mg		18	22	plus 22%
Ca		100	56	less 44%
Fe		1.5	1.7	plus 13%
Cu		0.07	0.02	less 71%
Zn		0.6	0.6	same
Na:K		1:28	1:46	
Mg:Ca		1:5.6	1:2.5	
Cu:Fe		1:8.6	1:85	

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Leeks (raw)

	1960	1991	change
Na	8.8	2	less 78%
K	314	260	less 17%
P	43.2	44	plus 2%
Mg	10.3	3	less 71%
Ca	62.7	24	less 61%
Fe	1.12	1.1	less 1%
Cu	0.1	0.02	less 80%
Zn	–	0.2	
Na:K	1:36	1:130	
Mg:Ca	1:6	1:8	
Cu:Fe	1:11	1:55	

Marrow (raw)

	1978	1991	change
Na	1	1	same
K	210	140	less 33%
P	20	17	less 10%
Mg	12	10	less 17%
Ca	17	18	plus 6%
Fe	0.2	0.2	same
Cu	0.03	0.02	less 33%
Zn	0.2	0.2	same
Na:K	1:210	1:140	
Mg:Ca	1:1.4	1:1.8	
Cu:Fe	1:6.7	1:10	

New potatoes (boiled)

	1978	1991	change
Na	41	9	less 78%
K	330	250	less 24%
P	33	28	less 15%
Mg	20	12	less 40%
Ca	5	5	same
Fe	0.4	0.3	less 25%
Cu	0.15	0.06	less 60%
Zn	0.3	0.1	less 67%
Na:K	1:8	1:28	
Mg:Ca	1:0.2	1:0.4	
Cu:Fe	1:2.7	1:5	

Green pepper (raw)

	1978	1991	change
Na	2	4	plus 100%
K	210	120	less 43%
P	25	19	less 24%
Mg	11	10	less 9%
Ca	9	8	less 11%
Fe	0.4	0.4	same
Cu	0.07	0.02	less 87%
Zn	0.2	0.1	less 50%
Na:K	1:105	1:30	
Mg:Ca	1:0.8	1:08	
Cu:Fe	1:5.7	1:20	

Sweetcorn (boiled)

	1978	1991	change
Na	1	1	same
K	280	140	less 50%
P	120	48	less 60%
Mg	45	20	less 56%
Ca	4	2	less 50%
Fe	0.9	0.3	less 67%
Cu	0.15	0.02	less 87%
Zn	1	0.2	less 80%
Na:K	1:280	1:140	
Mg:Ca	1:0.1	1:0.1	
Cu:Fe	1:6	1:10	

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