European Journal of Cancer Prevention 1998, 7, 331–335

Effects of home-based food preparation practices on the micronutrient content of foods

S Severi[1], G Bedogni[1], G P Zoboli[2], A M Manzieri[1], M Poli[1], G Gatti[2], N Battistini[1]

(Received 16 October 1997; accepted 3 May 1998)

We studied the effects of cooking on the vitamin and mineral content of vegetables (vegetable soup, cauliflower), meat (beefsteak) and fish (sole) and those of cutting (fruit salad) and squeezing (orange juice) on the vitamin content of fruits. In cooked dishes, vitamin retention ranged between 0 (folic acid, all dishes) and 94% (retinol, sole) and mineral retention between 63 (copper, cauliflower) and 96% (iron, vegetable soup). In orange juice, ascorbic acid appeared to be protected from oxidation for at least 12 h as compared with fruit salad. Our study shows that preparation of foods with techniques available at home may be responsible for losses of vitamins and minerals. Further studies are needed to ascertain the effects of these losses on nutritional status.

Key words: Cooking, minerals, vitamins

Introduction

Knowledge of nutrient intake is essential to establish whether the food consumed by an individual covers his/her nutritional needs (Gibson, 1990; Battistini *et al*, 1992). Food processing has the potential to reduce the nutrient content of foods and therefore to negatively influence nutrient intake (Somogyi, 1990). It follows that, when evaluating the nutrient intake of an individual, one should take into account the possible effects of food processing.

Unfortunately, only few data are available on the effects of home-based food preparation practices on the micronutrient (vitamin and mineral) content of foods (Adams and Erdman, 1988; Severi *et al*, 1997). Moreover, techniques with low precision have often been employed to measure the retention of micronutrients, as shown by a high coefficient of variation (CV) associated with repeated measures of food samples (Murphy *et al*, 1975).

The present study aimed, therefore, to assess the effects of some food preparation techniques available at home on the vitamin and mineral content of selected foods.

Materials and methods

We studied the effects of cooking on the vitamin and mineral content of vegetables, meat and fish and those of cutting and squeezing on the vitamin content of fruits. Measured micronutrients are listed in Table 1.

Vitamins and minerals

Thiamine was extracted by hot acid hydrolysis (Helrich, 1990; par 942.23) and measured by HPLC; riboflavin was extracted by hot acid hydrolysis (Helrich, 1990; par 970.65) and measured by HPLC;

[1]*Human Nutrition Chair, Department of Biomedical Sciences, Modena University, Via Campi 287, 41100 Modena, Italy.* [2]*NEOTRON Laboratories, Stradello Agazzotti 104, 41100 Modena, Italy. Correspondence to N Battistini. Fax: (+39) 59 428 236.*

Table 1. Measured micronutrients and lower detection limits of the employed analytical methods (see text for details)

Micronutrient	Lower detection limit
Thiamine (vitamin B_1)	0.02 mg/100 g
Riboflavine (vitamin B_2)	0.01 mg/100 g
Pyridoxine (vitamin B_6)	0.02 mg/100 g
Ascorbic acid (AA, vitamin C)	0.5 mg/100 g (enzymatic method)
	1.0 mg/100 g (HPLC)
De-hydro-ascorbic acid (DHA, vitamin C)	0.5 mg/100 g
Niacin (vitamin PP)	0.05 mg/100 g
Folic acid (FA)	2.0 μg/100 g
Retinol (vitamin A)	0.01 mg/100 g
Tocopherol (vitamin E)	0.1m g/100 g
Calcium (Ca)	0.5 mg/100 g
Magnesium (Mg)	0.5 mg/100 g
Phosphorus (P)	1.0 mg/100 g
Sodium (Na)	0.5 mg/100 g
Potassium (K)	0.5 mg/100 g
Iron (Fe)	2.0 μg/100 g
Copper (Cu)	2.0 μg/100 g
Zinc (Zn)	2.0 μg/100 g
Manganese (Mn)	1.0 μg/100 g
Selenium (Se)	2.0 μg/100 g

pyridoxine was extracted by hot acid hydrolysis and measured by microbiological method (Helrich, 1990; par 961.15); ascorbic acid (AA) was extracted with metaphosphoric acid (Helrich, 1990; par 967.21) and measured by enzymatic method (Boerhinger #409677) and HPLC; de-hydro-ascorbic acid (DHA) was extracted with metaphosphoric acid (Helrich, 1990; par 967.21) and measured by an enzymatic method (Boerhinger #409677); niacin was extracted by hot acid hydrolysis and measured by a microbiological method (Helrich, 1990; par 944.13); folic acid was extracted by hot acid hydrolysis and measured by a microbiological method (Helrich, 1990; par 944.12); retinol was extracted with petroleum ether (Helrich, 1990; par 981.17) and measured by HPLC and fluorimetry; tocopherol was extracted with petroleum ether (Helrich, 1990; par 981.17) and measured by HPLC and fluorimetry.

Calcium, phosphorus, sodium, potassium, iron, copper, zinc, magnesium and selenium were subjected to mineralization with high pressure microwaves and measured by inorganic mass spectrometry (the internal method used was accredited to SINAL (Sistema Nazionale Accreditamento Laboratorie) as NEOT/DIR/002/05).

Cooking

The effects of cooking were evaluated on vegetable soup, cauliflower, beefsteak and sole. The vegetable soup was made of potatoes, 200 g; vegetable marrows, 120 g; celery, 20 g; carrots, 80 g; parsley, 2 g; tomatoes, 100 g; dry beans, 30 g. The soup was cooked in 900 ml of bi-distilled water for 95 min. The cauliflower weighed 360 g and was boiled at 100°C in 450 ml of bi-distilled water for 10 min. The beefsteak (hind quarter), weighing 280 g and with a thickness of 1 cm, was roasted on a grill for 4 min. The sole (Atlantic Ocean) weighed 192 g and was roasted on a grill for 5 min.

Fruit cutting and squeezing

The effects of fruit cutting and squeezing were evaluated on fruit salad and orange juice, respectively. The fruit salad was made of bananas, 100 g; kiwis, 100 g; and oranges, 50 g. Fruits were cut with a plastic knife and put into a glass container. The fruit juice was obtained by squeezing 1 kg of oranges ('tarocco' variety) using an electric citrus squeezer with a plastic base. Vitamins were measured immediately, then 3, 6 and 12 h after the preparation of the fruit salad and orange juice.

Data collection and analysis

Cooked dishes. Three samples of the raw and cooked forms of each dish were prepared for analysis. Each of the samples was analysed in triplicate to obtain a total of 9 values for each form. True retention (TR) was then calculated according to Murphy *et al* (1975).

$$TR = \frac{W_c \times N_c}{W_r \times N_r} \times 100$$

Where W_c and N_c are the weight and the quantity of nutrient in the cooked dish, and W_r and N_r are the same variables in the raw dish. The CV of TR was calculated from the nine raw and nine cooked values. (Note that 'True loss' can be calculated as (100 – *TR*.)

Fruit salad and orange juice. For fruit salad and orange juice, retention (R) was calculated as:

$$R = \frac{N_{bt}}{N_{at}} \times 100$$

Table 2. Precision of measurements based on coefficient of variation

Good	$CV \leq 0.10$
Acceptable	$0.10 < CV \leq 0.20$
High	$0.20 < CV \leq 0.30$
Unacceptably high	$CV > 0.30$

Table 3. True retention of vitamins in cooked dishes. Values are given as mean and CV

Food	B_1	B_2	B_6	C	PP	FA	A	E
Vegetable soup	123 (0.18)[1]	ND	79 (0.14)	131 (0.57)[2]	79 (0.07)	0	ND	150 (0.11)[3]
Cauliflower	42 (0.11)	77 (0.20)	70 (0.16)	70 (0.04)	60 (0.02)	0	ND	172 (0.09)[4]
Beefsteak	76 (0.13)	87 (0.11)	27 (0.07)	ND	79 (0.04)	0	96 (0.30)[5]	60 (0.12)
Sole	94 (0.10)	78 (0.08)	48 (0.07)	ND	72 (0.06)	0	71 (0.63)[6]	65 (0.08)

Abbreviations: ND = not detectable; other abbreviations explained in Table 1.
[1]TR is clearly unreliable; vitamin B_1 was under the acceptable limits of sensitivity of the method in both the raw (SI = 1.7) and cooked forms (SI = 1.6) of the dish.
[2]TR and CV are unreliable mainly because of high CV in both the raw (CV = 0.31) and cooked (CV = 0.30) forms of the dish.
[3]TR is clearly unreliable; CV in the raw and cooked forms were 0.24 and 0.20 respectively.
[4]Vitamin E concentration was under the limits of sensitivity of the method in both raw (SI = 1.0) and cooked (SI = 0.6) forms of the dish. Moreover, vitamin E was not detectable in samples #1 and #2 of the cooked form so that TR is calculated for nine raw vs three cooked values.
[5]CV = 0.20 and CV = 0.24 for the raw and cooked forms, respectively. In the cooked form, vitamin A concentration was higher in sample #2 as compared to samples #1 and #3. Since the CV for sample #2 was low (0.14), its values were maintained for the analysis.
[6]CV = 0.67 and CV = 0.30 for the raw and cooked forms, respectively. In the raw form, vitamin A concentration was higher in sample #2 as compared to samples #1 and #3. Since the CV for sample #2 was low (0.06), its values were maintained for the analysis.

Table 4. True retention of minerals in cooked dishes. Values are given as mean and CV

Food	Ca	Mg	P	Na	K	Fe	Cu	Zn	Mn	Se
Vegetable soup	90 (0.05)	91 (0.03)	94 (0.09)	97 (0.03)	91 (0.08)	96 (0.07)	95 (0.11)	89 (0.08)	95 (0.08)	96 (0.34)[1]
Cauliflower	77 (0.07)	67 (0.04)	92 (0.01)	73 (0.06)	68 (0.03)	78 (0.04)	63 (0.11)	65 (0.08)	77 (0.09)	ND
Beefsteak	79 (0.04)	76 (0.03)	79 (0.07)	76 (0.04)	73 (0.06)	95 (0.20)	90 (0.10)	90 (0.08)	75 (0.16)	88 (0.31)[2]
Sole	78 (0.04)	93 (0.04)	91 (0.06)	75 (0.11)	82 (0.06)	91 (0.20)	89 (0.22)	80 (0.09)	63 (0.33)[3]	66 (0.34)[4]

Abbreviations: ND = not detectable; other abbreviations explained in Table 1.
[1]SI = 1.5(CV = 0.20) and SI = 1.3(CV = 0.40) for the raw and cooked forms, respectively.
[2]SI = 1.3 (CV = 0.19) and SI=1.9 (CV = 0.24) for the raw and cooked forms, respectively.
[3]SI = 1.3(CV = 0.20) and SI = 1.3 (CV = 0.19) for the raw and cooked forms, respectively.
[4]SI = 1.3 (CV = 0.18) and SI = 1.8 (CV = 0.14) for the raw and cooked forms, respectively.

Table 5. Retention of vitamins in fruit salad. Values are given as mean and CV

	Time (h)			
Vitamin	0	3	6	12
B_1	ND	ND	ND	ND
B_2	NR	NR	NR	NR
B_6	100 (0.10)	76 (0.11)	80 (0.07)	80 (0.11)
C-AA	ND	ND	ND	ND
C-DHA	100 (0.03)	100 (0.03)	100 (0.01)	100 (0.01)
PP	100 (0.20)	90 (0.15)	90 (0.13)	81 (0.16)
FA	100 (0.30)	90 (0.30)	90 (0.18)	72 (0.14)

Abbreviations: ND = not detectable; NR = not reliable (concentration of vitamin B_2 was under the limits of sensitivity of the method; SI ≤ 0.08); other abbreviations are explained in Table 1.

Table 6. Retention of vitamins in orange juice. Values are given as mean and CV

	Time (h)			
Vitamin	0	3	6	12
B_1	100 (0.11)	93 (0.07)	91 (0.03)	82 (0.13)
B_2	ND	ND	ND	ND
B_6	100 (0.16)	82 (0.22)	82 (0.18)	80 (0.16)
C-AA	100 (0.05)	100 (0.04)	100 (0.04)	100 (0.03)
C-DHA	100 (0.23)	100 (0.21)	100 (0.28)	100 (0.28)
PP	100 (0.15)	88 (0.20)	84 (0.12)	82 (0.09)
FA	100 (0.19)	74 (0.12)	74 (0.12)	66 (0.12)

Abbreviations: ND = not detectable; other abbreviations are explained in Table 1.

Table 7. Precision of measurements (see Table 2)

Food	Precision (number of determinations)			
	Good	Acceptable	High	Unacceptably high
Vitamins (cooking)	11	9	1	2
Minerals (cooking)	28	6	1	4
Vitamins (cutting)	6	8	2	0
Vitamins (squeezing)	7	12	5	0
Total	52	35	9	6

Where N_{bt} and N_{at} are the quantities of nutrient before (bt) and after treatment (at) of the dish (R was used instead of TR because no significant changes in weight were expected for the duration of the experiment). The CV of R was calculated from the nine values available for each sampling time. (Note that 'Loss' can be calculated as 100 – *R*.)

Sensitivity of analytical methods

To ensure better reproducibility of the data, we decided to consider under the 'acceptable' limits of sensitivity of a method, the concentration of a micronutrient inferior to the double of the lowest value detectable by the method (Table 1). The evaluation was performed by using a sensitivity index (SI),

$$SI = \frac{N_d}{N_t}$$

Where N_d is the quantity of nutrient in the dish (d) and N_t is the lowest quantity of the nutrient detectable by the method (t). Thus, according to our criterion, a value of SI < 2.0 characterizes a determination under the acceptable limits of sensitivity of the method. When SI < 1.0, the determination is under the limits of sensitivity of the method and is not reliable at all.

Precision of measurements

The precision of measurements was evaluated on the basis of their associated CV (Table 2). Albeit arbitrary, these values are much more stringent than those commonly used in the literature (Murphy *et al*, 1975).

Results

The values of TR for vitamins and minerals in cooked dishes are given in Tables 3 and 4; those of R for vitamins in fruit salad and orange juice are given in Table 5 and 6.

For some vitamins, the values of TR are clearly unreliable: this is the case of vitamins B_1, C and E for vegetable soup, of vitamin E for cauliflower, and of vitamin A for beefsteak and sole (Table 3). Moreover, among minerals, Mn in sole and Se in vegetable soup, beefsteak and sole (Table 4) had a CV > 0.30 which, according to our criterion (Table 2) is unacceptably high. In fruit juice vitamin B_2 could be detected but its value was too low for the measurement to be considered reliable (SI ≤ 0.8). For the majority of determinations, however, the precision of measurements was satisfactory (Table 7).

Discussion

Our study shows that micronutrients may be lost in variable quantity when foods are prepared with techniques available at home. A point of strength of the present study is the low variability associated to the measurement of most micronutrients (Table 7).

Generally, the values of TR for vitamins are similar or higher than those published in the literature, with the advantage of a better reproducibility (Murphy *et al*, 1975). As compared with the few studies available on minerals (Adams and Erdman, 1988; Severi *et al*, 1997), the present study is characterized by highly reproducible measurements. However, some dishes were especially difficult to analyse: this is the case of vegetable soup, in which only vitamin B_6, vitamin PP (niacin) and folic acid could be detected in a satisfactory manner.

Interesting data have emerged from the analysis of vitamin C retention in fruit salad and orange juice. In the former, ascorbic acid (AA) could not be detected immediately after its preparation, as shown by both the enzymatic and HPLC methods. However, DHA was present at high concentration (37 mg/100 g) and its level was unmodified after 12 h. In contrast, AA was the prevailing form of vitamin C (55 mg/100 g) in orange juice and its concentration was not modified after 12 h. In comparison, DHA concentration in orange juice was only of 1 mg/100 g and it was also unmodified after 12 h. Based on these data and the evidence coming from previous studies (Basu and Dickerson, 1996), one can hypothesize that AA in orange juice was protected from oxidation by an unknown factor which was absent in fruit salad.

In conclusion, our study shows that preparation of foods with techniques available at home may be responsible for losses of vitamins and minerals.

Further studies are needed to establish the effects of these losses on nutrition status.

Acknowledgements—This study was funded by a grant from Bayer SPA, Milan, Italy.

References

Adams CE, Erdman JW (1988). Effects of home food preparation practices on nutrient content of foods. In *Nutritional Evaluation of Food Processing* (eds Karmas E, Harris RS); Van Nostrand Reinhold Company, NY.

Basu TKB, Dickerson JW (1996). Vitamin C (ascorbic acid). In *Vitamins in Human Health and Disease* (eds Basu TKB, Diverson JW); CAB International, Wallingford, 125–47.

Battistini N, Caselli D, Bedogni G, Gatti G (1992). Food intake in University students and its impact on nutritional status. *Nutr Res* **12:** 222–33.

Gibson RS (1990). Assessment of nutrient intakes from food consumption data. In *Principles of Nutritional Assessment* (ed Gibson RS); Oxford University Press, NY, pp. 55–84.

Helrich KH (1990). *Official Methods of Analysis of the Association of Official Analytical Chemists.* Association of Official Analytical Chemists, Arlington, USA.

Murphy EW, Criner PE, Gray BC (1975). Comparison of methods for calculating retentions of nutrients in cooked foods. *J Agric Food Chem* **23:** 1153–7.

Severi S, Bedogni G, Manzieri AM, Poli M, Battistini N (1997). Effects of cooking and storage methods on the micronutrient content of foods. *Eur J Cancer Prev* **6(Suppl 1):** S21–4.

Somogyi JC (1990). Influence of food preparation on nutritional quality: introductory remarks. *J Nutr Sci Vitaminol* **36(Suppl):** S1–6.