SHORT COMMUNICATIONS

Effect of microwave heating on vitamins A, E, B_1, B_2 and B_6 in milk

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The use of microwaves is a very convenient method of heat treating food, and is also used for heating milk. The effect of this process on the components of milk has been extensively reviewed (Sieber *et al.* 1995). Like every heat treatment, microwave energy influences the vitamin content: vitamins B_1 and B_6 are especially sensitive, vitamins A and E to a lesser extent. The effect of microwaves on the vitamins in milk has been the subject of many recent investigations (Demel *et al.* 1990; Sigman-Grant *et al.* 1992; Brinkmann *et al.* 1993; Sieber *et al.* 1993; Vidal-Valverde & Redondo, 1993; Wagner *et al.* 1993; Medrano *et al.* 1994). No loss of vitamins A, B_1, B_2 or β-carotene after microwave heating of milk was found by Demel *et al.* (1990), Medrano *et al.* (1994) or Sieber *et al.* (1993). In infant formula, Sigman-Grant *et al.* (1992) reached the same conclusion for vitamins B_2 and C. Some authors have reported a significant loss of vitamin A (Brinkmann *et al.* 1993; Wagner *et al.* 1993; Medrano *et al.* 1994), vitamin B_1 (Vidal-Valverde & Redondo, 1993), vitamin E (Demel *et al.* 1990), vitamin B_2 (Medrano *et al.* 1994), vitamin B_{12} (Steiner *et al.* 1993*a*) and vitamin C (Demel *et al.* 1990; Sieber *et al.* 1993). Vidal-Valverde & Redondo (1993) reported a thiamin loss of $> 50\%$ in whole milk and 65% in skim milk after microwave heat treatment at 80 °C for 4 min. These results are surprising in view of the effects of conventional heat treatments (Tagliaferri *et al.* 1992*a*).

In the present investigation we studied the effect of microwave heat treatment of pasteurized milk with a household microwave oven on the content of various vitamins.

MATERIALS AND METHODS

Milk samples

Two batches of commercial pasteurized whole milk (42·0 and 42·3 g fat/kg) were treated on two separate days. Two samples of 150 and 500 ml in 250 (diam. 55 mm) and 800 ml (diam. 95 mm) glass beakers were exposed to microwave radiation of 520 W at 2450 MHz (Model NF 4076, Electrolux, CH-5506 Mägenwil) with no special protection from light. Details of the equipment used have been given elsewhere (Eberhard *et al.* 1990). A temperature of ~ 83 °C was maintained for 4 min. The milk was cooled in ice water after heat treatment.

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Table 1. *Influence of microwave heat treatment of milk on the content of vitamins A, E, B_1, B_2 and B_6*

(Values are means with SD for $n = 4$)

	Control	With 150 ml milk	With 500 ml milk
Vitamin A, i.u./l	1606 ± 23	1550 ± 30	1567 ± 35
Vitamin E, mg/l	0·81 ± 0·02	0·84 ± 0·02	0·85 ± 0·02
Vitamin B_1, mg/l	0·20 ± 0·02	0·21 ± 0·01	0·21 ± 0·01
Vitamin B_2, mg/l	1·56 ± 0·02	1·64 ± 0·06	1·63 ± 0·05
Pyridoxamine, μg/l	52·5 ± 2·1	61·3 ± 7·8	58·3 ± 10·4
Pyridoxal, μg/l	207 ± 5	217 ± 30	200 ± 25

Determination of total nitrogen, non-casein nitrogen and vitamins

Total nitrogen and non-casein nitrogen were determined after Collomb *et al.* (1990), vitamins B_1 and B_2 by HPLC using the methods of Tagliaferri *et al.* (1992*a*, *b*), B_6 by HPLC according to Bognar (1985) and vitamins A and E by HPLC (Bütikofer & Bosset, 1994).

Temperature course

Temperature changes were recorded by a data logger (Mikromek, Suprag AG, CH-8051 Zürich).

RESULTS AND DISCUSSION

The mean times to reach a temperature of ~ 83 °C in the centre of the beaker were 2 and 4 min for the two volumes. Mean temperatures of 78 ± 1 °C (150 ml) and 81 ± 2 °C (500 ml) were measured during the holding time of 4 min.

Total nitrogen was not affected by the microwave heat treatment. The content of non-casein nitrogen decreased from 64·5 ± 0·7 to 43·3 ± 1·7 (150 ml) and to 39·3 ± 1·5 mmol/kg (500 ml). There was no loss of vitamins E, B_1, B_2 or pyridoxamine after microwave treatment (pyridoxine was not found in milk). Vitamin A decreased by 3·5 (150 ml) and 2·4% (500 ml), pyridoxal by 3·1% in the 500 ml sample (see Table 1).

These results agree with most reports on the effect of microwave heat treatment on vitamins in milk. Demel *et al.* (1990) found no or only negligible decrease of vitamins A, B_1 and B_2. Medrano *et al.* (1994) reached the same conclusion for vitamin B_2 and Sieber *et al.* (1993) for vitamin B_1. These results strongly contrast with reports claiming significant losses of specific vitamins by microwaves, e.g. vitamins A and E, thiamin and riboflavin (Table 2). For thiamin, it is known that classic pasteurization does not reduce the content by more than 10% (Tagliaferri *et al.* 1992*a*). However, higher losses were found by Wodsack (1960) and Haddad & Loewenstein (1983). Horak (1980) showed in an extensive investigation on UHT milk that thiamin is only affected by extreme time and temperature conditions, and found thiamin losses of 10% under the following conditions: 120 °C for 400 s, 130 °C for 100 s, 140 °C for 100 s and 150 °C for 50 s. For microwave heating of foodstuffs other than milk, such as rice, bread and potatoes, no significant losses of vitamins B_1, B_2 and B_6 have been reported (Steiner *et al.* 1993*b*).

Our investigation shows that heat treatment of milk in household microwave ovens does not damage vitamins A, E, B_1, B_2 and B_6. The high thiamin loss reported by Vidal-Valverde & Redondo (1993) could not be confirmed. The differences cannot be explained by different energy input (180 W lower in this study). The almost negligible influence of varying microwave power has been shown in meat with two

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Table 2. *Influence of microwave heat treatment on the content of vitamins in milk after various authors*

Reference	Energy, W	Milk†	Volume, ml	Time, min	Temperature, °C	Vitamins tested	Vitamin loss, %
Brinkmann *et al.* (1993)		R, P, U				A	27, 7, 10
Demel *et al.* (1990)	650	PW	200	2·5	96	A/carotene/B_1/B_2/C/E	3/3/4/2/36/17
Medrano *et al.* (1994)	700	UW	150	2; 4	56; 80	E/A/B_2	3/3/1; 4/0/3
		UL	150	2; 4	53; 80	E/A/B_2	14/9/1; 14/9/0
		US	150	2; 4	54; 77	B_2	0; 0
Sieber *et al.* (1993)	510	RS	1000	5	78	B_1/C	0/18‡
Steiner *et al.* (1993*a*)	325	W	200	2; 4	60; 100	B_{12}	6; 19
Vidal-Valverde & Redondo (1993)	700	UW	150	2; 4	53; 80	B_1	24; 55
		UL	150	2; 4	53; 80	B_1	46; 62
		US	150	2; 4	53; 80	B_1	49; 66
Wagner *et al.* (1993)	650	UW	480	4·5; 10	80–90	A	8/5
		UL					3/10

† R, raw; P, pasteurized; U, UHT; W, whole milk; L, low-fat milk; S, skim milk.
‡ Mean value of top and bottom zones.

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ovens of 2000 and 940 W. The difference of 1060 W caused differences in thiamin contents of only 2% in minced pork, 5% in pork steak and 4% in chicken (Uherova *et al.* 1993). The high thiamin loss reported by Vidal-Valverde & Redondo (1993) is probably due to the use of a u.v. method for vitamin determination. The fluorescence procedure used in the present investigation seems more reliable for this application.

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