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Effect of microwave and conventional cooking on insoluble dietary fibre components of vegetables

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Abstract

Effects of microwave and conventional cooking methods were studied on neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose, hemicellulose and lignin contents of 10 vegetables. Cabbage, carrots, cauliflower, eggplant, onions, peas, potatoes, radish, spinach and turnips were cooked by these methods. Dietary fibre components from these vegetables were reduced to various extents, depending on the type of cooking method. Pressure-cooking showed a more pronounced effect on the reduction of these dietary fibre components than ordinary and microwave cooking. Pressure cooking caused reductions in NDF (22.6–38.8%), ADF (18.1–33.6%), cellulose (24.4–43.8%) and hemicellulose (31.3–47.4%). Lignin contents remained almost unchanged on cooking. It is apparent that reduction in NDF contents was comparatively greater than that of ADF contents as a result of cooking. Similarly, amount of hemicellulose was greatly reduced compared to cellulose on cooking the vegetables.

Keywords: Vegetables; Cooking methods; Insoluble dietary fibre components

1. Introduction

Dietary fibre plays an important role in human health. Numerous studies have shown that vegetarian and other persons with high fibre intakes have blood pressures lower than those with low fibre intake. (Brand, Snow, Nobhan, & Truswell, 1990; Kritchevsky, 1982; Scheeman, 1987). Soluble fibre also lowers serum cholesterol and helps in reducing the risk of heart attack and colon cancer (Burkitt, 1971; Burkitt, Walker, & Painter, 1974; Kelsey, 1978; Sharma & Kawatra, 1995; Trowell, 1972). A high fibre diet prevents or relieves constipation in humans due to absorption of water from the digestive track (Hill, 1974). Dietary fibre consists mainly of cellulose, hemicellulose and lignin, which exert different physiological effects on human health. In view of the beneficial clinical effect of dietary fibre, it is important to collect data on both dietary fibre contents and its profile in different foods.

Vegetables are usually used as a source of plant protein in the human diet. However, dietary fibre is also present as one of the main constituent of the vegetables. It is a common practice that most of the vegetables are cooked by a simple boiling process before use. However, pressure cookers and microwave ovens are also being used for this purpose. Cooking brings about a number of changes in physical characteristics and chemical composition of vegetables and other food materials. Cooking processes also produce some structural changes in dietary fibre components of various vegetables (Roehring, 1990; Spiller, 1986; Sukhwant, Harvinder, & Tejinder, 1992). However, very little information is available in the literature regarding the dietary fibre components in raw and cooked vegetables. Therefore, the present study was undertaken to investigate the effects of different cooking methods on insoluble dietary fibre components of various vegetables.

2. Materials and methods

2.1. Materials

Fresh vegetables (cabbage, carrots, cauliflower, eggplant, onion, peas, potatoes, radish, spinach, turnips) were purchased directly from the local market to study

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the effects of three different cooking methods on dietary fibre components. Non-edible parts were removed manually with the help of a sharp knife. Edible parts of the vegetables were properly chopped and then cooked by three different methods in triplicate, as given below.

2.2. Ordinary cooking

Chopped vegetables were put in flat bottom flasks fitted with air condensers. Tap water (1 g: 4 ml) was added and the samples were cooked on a hot plate for 10 min.

2.3. Pressure cooking

Chopped vegetables were placed in 1-l beakers containing water (1 g: 4 ml). Tops of the beakers were covered with aluminium foil and then cooked in a pressure cooker at 15 lbs/inch^2 for 10 min.

2.4. Microwave cooking

Chopped vegetables were placed in 1-l beakers containing water (1 g: 4 ml) and cooked in a domestic microwave oven (Panasonic 115,550 cooking power) for 10 min. After each cooking, excess water was drained off and then homogenized in a domestic electric grinder (Moulinex-France) before drying in a hot-air oven (Horizontal Forced Air Drier, Proctor and Schwartz Inc. Philadelphia PA) at 55 °C for 24 h. Raw and processed vegetables were ground in a Wiley mill to pass through a 40-mesh sieve before chemical analysis.

2.5. Chemical analysis

Neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose, hemicellulose and lignin contents in raw and cooked vegetables were estimated according to the methods described by van Soest and Wine (1967) and McQueen and Nicholson (1979). In accordance with these researchers, a preliminary overnight incubation with bacterial alpha amylase was employed to remove starch. Triplicate determinations of all samples were performed for all parameters on dry basis. Statistical analysis data of raw and cooked vegetables were recorded and standard deviations (S.D.) were calculated according to the method of Steel and Torrie (1980). Duncan's multiple range test was used to determine significant difference.

3. Results and discussion

The amount of each dietary fibre component (NDF, ADF, cellulose, hemi-cellulose, lignin) was determined in 10 raw and cooked vegetables on a dry basis. The raw vegetables contained 11.3–34.1 g kg^{-1} NDF and 9.6–28.2 g kg^{-1} ADF, whereas the amounts of cellulose, hemicellulose and lignin contents were 7.0–18.2, 1.1–5.9 and 0.9–10.0 g kg^{-1}, respectively (Tables 1 and 2). These values showed variations from the reported values in the literature. In fact, soil, climate, collection time and varietal difference are factors, which might be responsible for the variations observed. Reductions in these dietary fibre component values, in each vegetable, were observed, to various extents, on cooking by three different methods.

The contents of NDF and ADF of each vegetable were significantly ($P<0.05$) reduced on cooking (Table 1). Ordinary cooking reduced (7.7–22.6%) NDF in these vegetables whereas pressure-cooking and microwave cooking caused reduction in NDF contents of 22.6–38.8 and 13.4–28.5%, respectively (Table 1). Similarly ADF contents were reduced by 10.9–19.3% when vegetables were cooked by the ordinary method. However, pressure-cooking and microwave cooking reduced ADF contents in these vegetables by 18.1–33.6

Table 1
Effects of different cooking methods on neutral detergent fibre (NDF) and acid detergent fibre (ADF) contents[a] of various vegetables

Vegetables	NDF (g kg^{-1})				ADF (g kg^{-1})			
	Raw	Ordinary cooking	Pressure cooking	Microwave cooking	Raw	Ordinary cooking	Pressure cooking	Microwave cooking
Cabbage	14.8±0.26 a	11.9±0.12 b	10.8±0.13 c	12.6±0.09 b	11.6±0.15 a	9.2±0.08 b	8.6±0.09 c	9.8±0.08 b
Carrot	13.5±0.12 a	11.4±0.10 b	10.00.12 c	10.6±0.10 c	11.6±0.14 a	10.0±0.08 b	8.8±0.08 c	9.1±0.06 c
Cauliflower	12.7±0.06 a	10.2±0.17 b	9.6±0.10 c	11.0±0.11 b	10.6±0.11 a	8.5±0.07 b	8.2±0.08 c	9.3±0.05 b
Egg plant	22.1±0.13 a	17.8±0.13 b	15.1±0.15 c	18.5±0.14 b	17.8±0.15 a	14.5±0.09 b	12.2±0.09 c	15.0±0.07 b
Onion	11.3±0.09 a	9.3±0.14 b	7.6±0.08 c	8.7±0.13 b	9.6±0.08 a	8.2±0.08 b	6.6±0.06 c	7.6±0.04 b
Peas	34.1±0.32 a	29.4±0.21 b	26.4±0.16 c	28.3±0.14 b	28.2±0.15 a	25.0±0.13 b	23.1±0.17 c	23.8±0.12 c
Potatoes	15.1±0.11 a	13.0±0.16 b	9.4±0.09 c	10.8±0.10 c	11.2±0.11 a	10.5±0.09 b	8.3±0.09 c	9.8±0.09 b
Radish	16.8±0.14 a	15.5±0.15 b	12.5±0.07 c	13.8±0.12 c	12.2±0.14 a	10.8±0.06 b	9.4±0.10 c	10.0±0.09 b
Spinach	18.5±0.12 a	14.9±0.11 b	13.1±0.05 c	15.2±0.14 b	12.8±0.11 a	10.8±0.06 b	10.1±0.11	11.0±0.07 b
Turnips	13.3±0.09 a	10.3±0.12 b	8.8±0.09 c	9.7±0.13 b	12.2±0.11 a	9.4±0.07 b	8.1±0.12 c	8.8±0.08 c

Mean values in a row with different letters are significantly different at $P<0.05$.
[a] Mean values $\pm n=3$ (on dry basis).

Table 2
Effect of different cooking methods on cellulose, hemicellulose and lignin contents[a] of various vegetables

Vegetables	Cellulose ($g\ kg^{-1}$)				Hemicellulose ($g\ kg^{-1}$)				Lignin ($g\ kg^{-1}$)			
	Raw	Ordinary cooking	Pressure cooking	Microwave cooking	Raw	Ordinary cooking	Pressure cooking	Microwave cooking	Raw	Ordinary cooking	Pressure cooking	Microwave cooking
Cabbage	9.3±0.26 a	7.0±0.12 b	6.5±0.06 c	7.5±0.06 b	3.2±0.11 a	2.7±0.12 b	2.2±0.07 c	2.6±0.11 b	2.3±0.09 a	2.2±0.07 b	2.1±0.02 c	2.2±0.5 b
Carrot	8.8±0.08 a	7.2±0.10 b	6.0±0.87 c	6.8±0.02 b	1.9±0.25 a	1.4±0.11 b	1.2±0.06 c	1.5±0.10 b	2.8±0.08 a	2.8±0.09 b	2.7±0.06 c	2.8±0.03 b
Cauliflower	9.0±0.06 a	7.0±0.26 c	6.8±0.06 c	8.0±0.03 b	2.1±0.27 a	1.7±0.09 b	1.4±0.01 b	1.7±0.10 b	1.6±0.10 a	1.5±0.08 b	1.4±0.07 b	1.5±0.04 b
Egg plant	16.0±0.12 a	13.0±0.12 b	10.5±0.07 c	13.4±0.08 b	4.3±0.20 a	3.3±0.10 b	2.9±0.11 c	3.5±0.11 b	1.8±0.09 a	1.7±0.07 b	1.7±0.06 c	1.6±0.03 b
Onion	8.7±0.08 a	7.5±0.13 b	6.0±0.02 c	6.7±0.06 b	1.7±0.21 a	1.1±0.13 b	1.0±0.09 c	1.1±0.12 b	0.9±0.10 a	0.8±0.02 b	0.7±0.06 c	0.8±0.06 b
Peas	18.2±0.21 a	15.0±0.27 b	13.3±0.08 c	14.0±0.06 c	5.9±0.21 a	4.4±0.14 b	3.3±0.05 c	4.5±0.13 b	10.0±0.05 a	9.8±0.09 b	9.8±0.05 c	9.8±0.07 b
Potatoes	8.0±0.22 a	6.5±0.29 b	4.5±0.06 c	5.7±0.07 b	3.9±0.12 a	2.4±0.11 b	2.1±0.08 c	2.3±0.11 b	3.2±0.09 a	3.0±0.02 b	2.8±0.05 c	2.9±0.08 b
Radish	8.4±0.05 a	7.0±0.22 b	5.9±0.05 c	6.3±0.09 b	4.6±0.16 a	3.7±0.13 b	3.1±0.06 b	3.8±0.10 b	3.8±0.08 a	3.7±0.02 b	3.6±0.06 b	3.6±0.09 b
Spinach	9.0±0.06 a	6.1±0.06 b	5.8±0.09 c	6.1±0.07 b	5.7±0.09 a	4.1±0.15 b	3.0±0.07 c	4.2±0.18 b	4.3±0.11 a	4.2±0.03 b	4.1±0.08 c	4.2±0.08 b
Turnips	7.0±0.08 a	6.1±0.06 b	5.1±0.08 c	5.8±0.05 b	1.1±0.08 a	0.9±0.02 b	0.7±0.02 c	0.9±0.03 b	3.2±0.08 a	3.2±0.04 b	3.0±0.09 c	3.2±0.07 b

Mean values in a row with different letters are significantly different at $P<0.05$.
[a] Mean values$\pm n=3$ (on dry basis).

and 12.3–27.6%, respectively (Table 1). It is apparent from these results that reductions in NDF contents were comparatively greater than those of ADF contents as a result of cooking. Table 1 also shows that the reductions in NDF and ADF contents were distinctly higher in the case of pressure-cooking than the other two cooking methods. Reduction in NDF and ADF contents in vegetables could be attributed to partial degradation of cellulose and hemicellulose into simple carbohydrates on cooking. However, extent of losses of these dietary fibre components became higher on cooking in a pressure cooker, due to the severe conditions of temperature and pressure involved during this cooking process. These results are in agreement with those obtained by earlier workers who also reported distinct reductions in NDF and ADF contents due to heat treatment (Rehman & Shah, 1994; Vidal-Valverde, Frias, & Esteban, 1992).

The cellulose, hemicellulose and lignin contents were significantly ($P<0.05$) reduced, to various extents, when vegetables were cooked by three different methods (Table 2). However, pressure-cooking showed more reduction of these dietary fibre components than ordinary and microwave cooking methods. As a result of pressure cooking, 24.4–43.8% of the cellulose and 31.3–47.4% of the hemicellulose (Table 2) were reduced in these 10 vegetables. It is apparent from these findings that reduction in hemicellulose was comparatively greater than that of cellulose on cooking the vegetables. However, lignin contents remained almost unchanged on cooking by these three methods. In general, the observed effect of cooking process on individual dietary fibre components in the vegetables depended, not only on the type of vegetable, but also on the cooking method involved. Reduction in cellulose and hemicellulose was reflected by the lower values of NDF and ADF of the cooked vegetables. Ellis, Dunning, and Flask (1947) had already reported the conversion of cellulose into simple carbohydrates as a result of stream-pressure treatment. Chemical degradation of cellulose into glucose and hemicellulose into arabinose, xylose and galactose might account for the reduction of the dietary fibre components of the vegetables on cooking (Robinson & Lawler, 1986). These results are consistent with the findings of earlier workers who observed that cellulose and hemicellulose contents in vegetables and legumes were greatly reduced as a result of boiling. (Anderson & Clydesdale 1980; Herranz, Vidal-Valverde, & Rojes-Hodelgo, 1981; Vidal-Valverde & Frias, 1991).

4. Conclusion

It is apparent, from this study, that insoluble dietary fibre components, especially cellulose and hemicellulose, of the vegetables were lost to various extents, depending on the type of cooking method. However, lignin contents of the vegetables remained almost unchanged as a result of cooking. Maximum losses in the contents of cellulose (24.4–43.8%) and hemicellulose (31.3–47.4%) were observed due to pressure cooking. Similarly, maximum amounts of NDF and ADF were also lost on cooking the vegetables in a pressure cooker. In order to minimize the losses of insoluble dietary fibre components, it is suggested that vegetables should be cooked, either by the ordinary method or in a microwave oven instead of a pressure-cooker.

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