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EFFECT OF CULINARY AND TECHNOLOGICAL TREATMENT ON MAGNESIUM RETENTION IN FOURTEEN SPECIES OF VEGETABLES

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ABSTRACT

In this study we tested the hypothesis that a product subjected to a single treatment in water (modified technology – a convenience food) will contain more magnesium than the one subjected to a twofold treatment (traditional technology). Moreover, with higher magnesium retention, the nutrient density (ND) of the product will also be higher, as will be the intake of magnesium in a portion of vegetables expressed as a percentage of recommended dietary allowance (RDA). In fresh vegetables, the highest magnesium content was found in spinach and the lowest in white cauliflower. In vegetables prepared for consumption, magnesium retention was highest in frozen products obtained using the modified technology, followed by cooked fresh vegetables, with the lowest retention in product obtained using the traditional technology. The above sequence of magnesium content also applied to ND and RDA values, the ND values easily exceeding 100% for all the samples examined.

Key words: vegetables, blanching, cooking, freezing, Nutrient Density, Magnesium

INTRODUCTION

Although magnesium is common in food, its content in individual products varies widely. Significant differences are also observed within a vegetable group depending on species and variety, soil and weather conditions during growth, use of fertilizers, plant maturity at harvest, and the part of the edible portion [4, 17, 26, 27, 33]. Potable water, especially hard water, can also be a good source of magnesium [21].

The skeleton contains about 60% of all magnesium found in the human body. This element is also essential to about 300 enzymatic reactions [12]. It also generates alkalinity and neutralizes free radicals, helping to conserve skeletal calcium. Currently, according to the European Commission Directive [10], the value of the recommended daily intake of magnesium is 375 mg per day. According to Bohl and Volpe [6] the dietary allowance for adults was between 310 and 420 mg. Utilising data from nutritional studies from various countries, several authors have suggested that a great number of individuals may suffer from magnesium deficiency [6, 38]. Xie et al. [37] claimed that deficiency may be prevented by increased consumption of fruits and vegetables rich in magnesium.

Magnesium assimilation in average diets is about 50%, despite the fact that the influence of phytic acid on magnesium absorption would seem to be of minor importance [13]. There are now a number of ways in which nutrients may be introduced into the diet, e.g., in the form of dietary supplements or enriched foods [34]. However, according to White and Broadley [36], increasing the amount of bioavailable micronutrients in plant foods for human consumption could be activated by increasing their total content in edible parts. One method of achieving this may be to establish parameters of culinary and technological treatment which would limit losses during the preparation of products for consumption. Food sample preparations may then be modified to exploit these features for minimising magnesium losses.

In this study we tested the hypothesis that a product subjected to treatment in water only once (cooking or cooking and then reheating in the air in a microwave oven after freezing and storage) will contain more magnesium than the product subjected to a

traditional procedure using treatment in water twice (blanching before freezing and then cooking after frozen storage). The studies presented allowed the assessment of magnesium retention during preservation and the preparation for consumption of fourteen vegetable species, commonly consumed in countries characterized by temperate climate. The research comprised traditional and modified freezing technologies and different ways of culinary preparation of vegetables. With higher magnesium retention, the nutrient density (ND) of the product will also be higher, as will be the intake of magnesium in a portion of vegetables expressed as a percentage of recommended dietary allowance (RDA)..

MATERIAL AND METHODS

Raw Material

The main factors in the selection of the vegetable species were their popularity, suitability for freezing, and necessity of cooking before consumption. The material investigated consisted of four species of brassicas: Brussels sprouts – *Brassica oleracea* var. *gemmifera* L. (Lunet F1 cv.), broccoli – *Brassica oleracea* var. *italica* Plenck (Lord F1 cv.), green cauliflower – *Brassica oleracea* var. *botrytis* L. (Trevi F1 cv.), and white cauliflower – *Brassica oleracea* var. *botrytis* L. (Planita F1 cv.); three species of leafy vegetables: kale – *Brassica oleracea* L. var. *acephala* D.C. (Winterbor F1 cv.), New Zealand spinach – *Tetragonia expansa* Murr., and spinach – *Spinacia oleracea* L. (Greta F1); four species of root vegetables: celeriac – *apium graveolens* L. (Dukat cv.), carrot – *Daucus carota* L. (Koral cv.), parsnip – *Pastinaca sativa* L. (Fagot cv.), and red beet – *Beta vulgaris* L. (Czerwona Kula cv.); and three species of leguminous vegetables: broad bean – *Vicia faba* L. var. *major* (Windsor Biały cv.), French bean – *Phaseolus vulgaris* L. (Delfina cv.), and pea – *Pisum sativum* L. (Consul cv.). Broad bean and pea seeds were at milk-wax maturity. The vegetables were cultivated in an experimental field belonging to the authors' academic department. The field is located in southern Poland, on the western outskirts of Kraków. The soil was characterized by good horticultural quality. Cultivation procedures included mineral fertilization and sprinkler watering adapted to the plant requirements, mechanical weed control, and, where necessary, protective treatments against diseases and pests. A 20–25 kg batch of fresh vegetables was harvested in the morning, and then, within 2–4 hours, vegetables were subjected to culinary and technological treatment, and analysis.

Magnesium content was determined in fresh vegetables; vegetables boiled to consumption consistency in 2% (w/w) table salt brine; and frozen products prepared for consumption after 12 months of storage at -20°C. Frozen products from blanched samples were cooked in brine, while frozen products from cooked samples were defrosted and heated in a microwave oven.

Preparation of frozen products

Directly after harvest, samples representative of the whole batch of material were taken for analysis and preparation of frozen products. Vegetables were chopped, peeled, washed and the non-edible portions discarded as previously described [19, 31].

On completion of the processing (washing and appropriate cutting), the vegetables were ready for boiling (treatment 1); blanching before freezing (treatment 2); or boiling before freezing (treatment 3) [19, 31].

Two types of treatment were applied before freezing. In treatment 2, vegetables were traditionally blanched, frozen and freeze stored. The product was then boiled to consumption consistency. In treatment 3, the raw material was boiled to consumption consistency to obtain a ready-to-eat (convenient) product which, after freezing and storage, merely required defrosting and heating in a microwave oven.

In treatment 2, the fresh material was blanched in water at 95–98°C in a stainless steel vessel, the proportion of water to raw material being 5:1. The blanching time applied reduced catalase and peroxidase activity to within 5% of the initial level. After blanching, the material was immediately cooled in cold water and left to drip on sieves for 30 min.

In treatment 3, vegetables were boiled in brine containing 2% (w/w) table salt (NaCl) in a stainless steel vessel, the proportion by weight of the raw material to brine being 1:1. The vegetables were boiled to consumption consistency. After boiling, the material was left on sieves and cooled in a stream of cold air.

The cooking time of fresh vegetables and the time of blanching/cooking frozen vegetables were respectively: spinach – 6 min and 2 min 15 sec/3 min, pea – 8 min and 2 min 30 sec/6 min, broad bean – 12 min and 3 min 15 sec/8 min, French bean – 9 min and 3 min/6 min, New Zealand spinach – 4 min and 2 min/2 min, parsnip – 10 min and 2 min 30 sec/ 4 min 30 sec, red beet – 35 min and 15 min/15 min, celeriac – 8 min and 2 min 3 sec/5 min, Brussels sprouts – 15 min and 5 min/9 min, carrot – 12 min and 2 min 4 sec/6 min, green cauliflower – 6 min and 3 min 15 sec/5 min, broccoli – 5 min and 3 min/4 min, kale – 15 min and 3 min/12 min, white cauliflower – 6 min and 3 min/5 min.

Blanched materials (treatment 2) and boiled ones (treatment 3) were placed on trays and frozen at -40°C in a Feutron 3626-51 blast freezer (Greiz, Germany) for 90 min, this being the time required for the inside temperature to reach -20°C. Frozen vegetables were then packed in 500 g polyethylene bags (0.08 mm thickness) and stored at -20°C for 12 months.

Preparation of frozen products for evaluation

Samples of vegetables blanched before freezing were boiled in 2% brine, the proportion of brine to material being 1:1 (w/w). As with the cooking of fresh vegetables, the frozen product was placed in boiling brine. The boiling time, measured from the moment when the water returned to the boil, was 2–12 min. After boiling, water was immediately drained, and the product was cooled to 20°C and analysed. In the case of vegetables boiled before freezing, 500 g portions were placed in covered heatproof vessels, then defrosted and heated in a Panasonic NN-F621 (Matsushita Electric, UK) microwave oven. The time required for

defrosting and heating the material to consumption temperature was 7 min 45 sec. The samples were then cooled to 20°C and analyzed.

Chemical analysis

In order to determine the concentration of magnesium the material was mineralized in a 3:1 mixture of concentrated nitric(V) and chloric(VII) acids. The blank sample was included in every series of analyses. A 50 g portion of the material and 30 cm³ of the acid mixture were placed into 250 cm³ test tubes of the Tecator Kjeltac Auto Plus II (Tecator, Hoganäs, Sweden) mineralization set. The treated samples were left until the next day, when mineralization was completed. The mineralized samples were diluted with ultra-pure water to a volume of 100 cm³ and filtered into dry flasks. There was no residue left after filtration. The content of magnesium in the solution was determined using a JY 238 Ultrace –Jobin Yvon (Longjumeau, France) inductively coupled argon plasma emission spectrophotometer. The most sensitive wavelength for determining magnesium was 279.533 nm. Operation conditions of ICP equipment were as follows: generator power – 1300 W, the argon flow rate – 15 dm³×min⁻¹, the flow of argon as a secondary gas – 0.2 dm³×min⁻¹, the flow of argon as a gas injection – 0.5 dm³×min⁻¹, sample flow of the pumped plasma during the analysis to 1.50 dm³×min⁻¹. The accuracy of the vegetable analysis method was verified on the basis of certified reference material (GBW 08504 – State Metrology Bureau, Beijing, China) (cabbage), with concentration of Mg – 0.184 µg×g⁻¹. The recovery rate of reference material was 97 to 102%. All glassware and polyethylene flasks were soaked in 10% nitric acid for 24 h and then rinsed with ultra-pure water before use.

Nutrient Density (ND) values and percentages of Recommended Dietary Allowances (RDA) were calculated in order to compare the contribution of various vegetable species to the dietary intake of magnesium (both potential in fresh vegetables and actual in vegetable products prepared for consumption), as well as to determine whether cooking, freezing and preparation for consumption have any nutritional effect on magnesium content. Nutrient density was calculated using the following equation from Renner et al. [28]:

$$ND(\%) = ((Np/Ep)/(Nr/Er)) \cdot 100$$

where Np is the nutrient (magnesium) concentration in the vegetable; Ep is the energy supplied by the vegetable; Nr is the recommended daily intake of nutrient (magnesium); and Er is the recommended energy intake. Data for Ep included both raw vegetables and vegetable products (drained where necessary), and for almost all species were taken from USDA [35] tables; data for broad bean seeds were those given by Kunachowicz et al. [20]. The Ep values applied are presented in Table 1. Data for Er were those given by EFSA [8] for moderately active adults (female – 2100 kcal/d and male – 2600 kcal/d) over the age of 18. Nr values of magnesium was that given by European Commission Directive [10].

Table 1. Nutrient density (ND%) of raw vegetables and vegetables prepared for consumption for two groups of adult (>18) consumers (f – female, m – male)

No	Name of species ([kcal/100 g] raw/cooked)	Raw material		Vegetable prepared for consumption						LSDP < 0.05
				fresh than boiled (treatment 1)	frozen and stored than					
		boiled (treatment 2)			defrosted and heated in micro-wave oven (treatment 3)					
		f	m				f	m	f	
1	Spinach (23/23)	1299 ± 16	1571 ± 203	1077 ± 62	1333 ± 77	888 ± 54	1100 ± 67	1110 ± 103	1374 ± 127	173.0
2	Pea (81/84)	229 ± 21	284 ± 23	191 ± 10	237 ± 12	169 ± 23	209 ± 29	197 ± 27	243 ± 34	34.3
3	Broad Bean (66/63)	286 ± 20	354 ± 25	270 ± 35	335 ± 44	235 ± 26	291 ± 32	274 ± 42	339 ± 52	52.7
4	French Bean (31/35)	532 ± 72	659 ± 89	353 ± 35	437 ± 43	276 ± 26	342 ± 32	364 ± 36	450 ± 44	75.1
5	New Zealand spinach (14/12)	1159 ± 150	1435 ± 186	923 ± 104	1143 ± 129	754 ± 87	933 ± 108	952 ± 88	1179 ± 109	181.6
6	Parsnip (75/71)	205 ± 11	254 ± 14	175 ± 11	217 ± 14	140 ± 11	173 ± 13	180 ± 14	223 ± 18	19.6
7	Red beet (43/44)	282 ± 24	349 ± 30	260 ± 23	322 ± 29	272 ± 30	337 ± 37	261 ± 36	323 ± 44	47.4
8	Celeriac (42/27)	283 ± 28	350 ± 34	348 ± 35	431 ± 43	264 ± 28	327 ± 34	355 ± 29	439 ± 36	49.3
9	Brussel sprouts (43/36)	270 ± 16	334 ± 20	288 ± 17	357 ± 21	184 ± 30	228 ± 37	292 ± 23	362 ± 28	36.3
10	Carrot (41/35)	268 ± 24	332 ± 30	244 ± 27	303 ± 33	198 ± 18	246 ± 23	267 ± 29	330 ± 36	41.0
11	Green cauliflower (31/32)	335 ± 19	414 ± 24	306 ± 13	379 ± 16	190 ± 10	235 ± 13	291 ± 20	360 ± 25	26.4

12	Broccoli (34/35)	296 ± 13	367 ± 16	209 ± 13	259 ± 16	140 ± 9	173 ± 11	225 ± 11	279 ± 14	19.2
13	Kale (50/28)	205 ± 5	254 ± 6	259 ± 30	321 ± 38	250 ± 15	309 ± 18	279 ± 31	345 ± 38	37.6
14	White cauliflower (25/23)	325 ± 50	402 ± 61	292 ± 13	361 ± 16	192 ± 9	237 ± 11	291 ± 29	360 ± 36	48.7

Values in brackets represent energy supplied by the raw/cooked vegetables [Kunachowicz et al., 2005; USDA, 2014]

Statistical analysis

Analyses of magnesium content were carried out in two experimental replications, each in two parallel samples. In the vegetable species investigated, the differences in magnesium content between the samples examined were established using single-factor analysis of variance (ANOVA) on the basis of the Snedecor F and Student's t tests. The least significant difference (LSD) was calculated at the probability level of $p < 0.05$. The Statistica 10 (StatSoft Inc. Tulsa, OK, USA) program was applied.

RESULTS AND DISCUSSION

The vegetable species investigated varied significantly in magnesium content (Fig. 1). A more than three-fold difference in magnesium content was found between spinach, which had the highest amount, and white cauliflower, which had the lowest. A group of vegetables with magnesium content of around 30 mg in 100 g of edible parts consisted of pea, broad bean, French bean, New Zealand spinach, and parsnip. With the exception of white cauliflower, magnesium content in the remaining species was in the region of 20 mg/100 g. The above values are within the ranges reported in the literature. However, it should be emphasized that, depending on the source, magnesium content within a particular species can vary widely [9, 15, 17, 30, 32]. However, magnesium contents in the investigated samples were similar to the results shown in works of the authors: Jaworska and Kmiecik [14], Kmiecik et al. [18] and Lisiewska et al. [22, 23, 25]. In our opinion this was due to the fact of obtaining raw materials for research from the same experimental field, using the same cultivation treatments and the same vegetable cultivars.

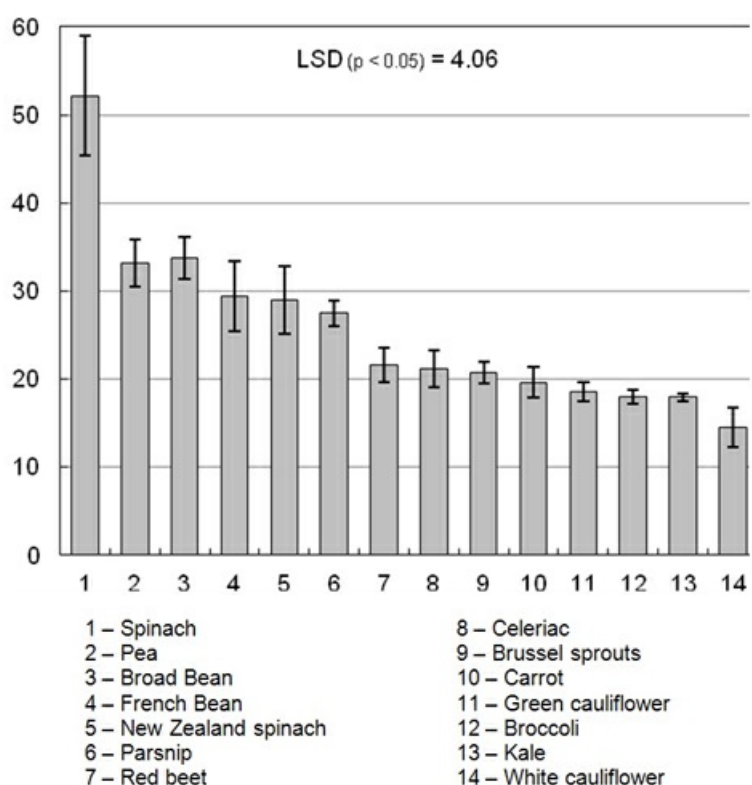


Fig. 1. Magnesium content in raw 14 vegetable species, mg·100 g⁻¹ fresh matter (error bars represent standard deviation)

The content of any component in the raw material is not equivalent to that in the final product. Table 2 illustrates the percentage of magnesium retention in fresh vegetables after cooking (treatment 1) as well as in frozen products prepared for consumption after frozen storage (treatments 2 and 3). Due to changes in water content and therefore dry weight in vegetables during their processing, and especially during heat treatment, the results in Table 2 are presented with respect to fresh and dry matter of the products. Vegetables with a large surface area relative to mass (New Zealand spinach, broccoli, kale) showed the highest magnesium loss (27–32%) during cooking compared with the raw material, whereas the smallest losses (5–8%) were noted in species cooked with the skin left on (e.g., red beet) or in those processed with their seed coat, such as broad bean. Although pea was also cooked with its seed coat, it was not as thick as that of broad bean, resulting in easier leaching of water soluble substances [24]. The significance of the thickness of vegetable tissues is confirmed by the results obtained by different authors. Słupski et al. [33] found a considerably greater loss in blanched dill than Gębczyński [11] did in blanched blades of leaf beet. An important factor in limiting magnesium loss is its content in the processing medium [3]. Magnesium content in tap water with a

hardness of 420–460 mg CaCO₃ dm⁻³, which was used in all operations, was within the range 22–28 mg dm⁻³. Moreover, the degree of magnesium loss is also affected by the level of other constituents present in the medium [16]. Table salt was added to the cooking water to enhance the taste. A weight proportion of vegetables to medium was maintained the same in all samples.

Table 2. Percentage content of magnesium in product prepared for consumption; content in raw vegetables 100% ; with reference to: fresh matter of product – fm, dry matter of product – dm

No	Name of species	Frozen and stored than					
		Fresh than boiled (treatment 1)		boiled (treatment 2)		defrosted and heated in microwave oven (treatment 3)	
		fm	dm	fm	dm	fm	dm
1	Spinach	85	70	70	56	91	88
2	Pea	86	70	76	54	92	89
3	Broad bean	92	84	80	59	94	93
4	French bean	75	94	59	62	79	77
5	New Zealand Spinach	68	93	56	93	72	70
6	Parsnip	81	65	65	64	85	83
7	Red beet	95	46	85	41	96	95
8	Celeriac	79	99	60	102	83	81
9	Brussels sprouts	89	82	57	77	93	91
10	Carrot	78	88	63	86	92	85
11	Green cauliflower	89	74	59	62	91	90
12	Broccoli	72	88	49	95	84	78
13	Kale	73	63	70	56	83	78
14	White cauliflower	83	84	54	76	84	83

In traditional frozen products (treatment 2), magnesium content was lower than in cooked fresh vegetables (treatment 1). In 100 g of edible parts, the highest losses due to cooking were recorded in following sequence: New Zealand spinach > broccoli > kale > French bean > carrot > celeriac > parsnip > white cauliflower > spinach > pea > green cauliflower > Brussels sprout > broad bean > red beet. In general, losses were greater in vegetables with a large surface area in relation to their mass and less dense texture. However, it is not always possible to explain this sequence of species in respect of the losses observed. Kmiecik et al. [17] also found that in broad bean losses in magnesium content after cooking were slight, whereas Kawashima and Valente Soares [15] observed lower losses in kale. Santos et al. [29] claimed that losses of magnesium depended on the parameters of water treatment as well as the species of vegetable. In the present study, cooking parameters (see paragraph Preparation of frozen products) were established in order to obtain optimal consumption consistency. In addition, a 1:1 proportion of mass of the medium to that of vegetables was applied, as indicated by Kmiecik et al. [17].

Loss of magnesium content was greater in the traditional frozen product prepared for consumption by cooking (treatment 2) than in cooked fresh vegetables (treatment 1). Compared with the raw material, losses of 15–51% were noted; losses were substantial in New Zealand spinach and broccoli and least in broad bean and red beet.

In frozen products obtained using the modified technology and prepared for consumption by defrosting and heating in a microwave oven (treatment 3), the loss of magnesium in edible parts was approximately half that in samples having undergone treatment 2. Such significant differences may be explained by the fact that samples from treatment 3 were subjected to thermal treatment in water (which results in soluble constituents being leached) only once. According to Bressani et al. [7], prolonging thermal processing in boiling water intensifies the leaching of soluble constituents. However, it should be remembered that losses in soluble substances due to thermal treatment with water can either be real or apparent. It was found that 100 g of edible parts in samples from treatment 3 contained considerably more dry matter than samples from treatment 2 and treatment 1.

Nutrient density (ND) can be a useful evaluation of the nutritional significance of any trace elements [28]. A nutritional density index of 100% or more indicates that the particular food, if consumed in sufficient quantity, contributes substantially to the intake of that particular nutrient. For all the vegetables studied, both raw and prepared for consumption, the percentages were substantially higher than 100% for both males and females (Tab. 1). These results indicate that all the vegetables, raw and processed, are a good source of magnesium. ND values within individual species were highest in fresh vegetables, followed (in descending order) by the modified frozen product (treatment 3); cooked fresh vegetables (treatment 1); and the traditional frozen product (treatment 2), although the value even in this product was still high. Amaro et al. [2, 3] reported that the ND% of magnesium in fresh asparagus was 714 but was lower in frozen products, ranging from 496 to 516. A similar tendency was observed for the vegetables examined in the present work.

Percentages of recommended dietary allowances (RDA) were determined for a theoretical average consumption of 100 g per serving. 100% availability of magnesium was assumed, although availability is affected by a number of factors, including other components in the vegetable, all of which can also impact on RDAs (Tab. 3). The values for raw vegetables varied from 3.9%

to 13.9%. There was an almost four-fold difference in values between the species. Amaro et al. [5] found that RDA provided by asparagus depended on both the cultivar and the thickness and part of the spear. The RDA of all the final products examined was lower than in the raw material. The decrease was smallest in the modified frozen product and slightly greater in cooked fresh vegetables. Among these products, broad bean, red beet, Brussels sprouts and green cauliflower did not significantly differ from the raw materials. A much larger decrease was found in the traditional frozen product; of all the species investigated, the greatest decrease was observed in broccoli (51%), and the smallest in broad bean and peas (22 and 24%). In red beet the decrease was insignificant. Such diversity in RDA values was also observed by Adepoju et al. [1] during the processing of cassava by various methods.

Table 3. Percentages of Recommended Daily Allowances (RDA) per 100 g of raw vegetables and vegetables prepared for consumption. Recommended Daily Allowances in 100 g servings for adult (>18) consumers

No	Name of species	Raw material	Vegetable prepared for consumption			LSDP < 0.05
			fresh than boiled (treatment 1)	frozen and stored than		
				boiled (treatment 2)	defrosted and heated in microwave oven (treatment 3)	
1	Spinach	13.9 ± 1.8	11.8 ± 0.7	9.7 ± 0.6	12.2 ± 1.1	1.78
2	Pea	8.8 ± 0.7	7.7 ± 0.4	6.8 ± 0.9	7.9 ± 1.1	1.05
3	Broad beans	9.0 ± 0.6	8.1 ± 1.1	7.1 ± 0.8	8.2 ± 1.3	1.49
4	French bean	7.9 ± 1.1	5.9 ± 0.6	4.6 ± 0.4	6.1 ± 0.6	1.09
5	New Zealand spinach	7.7 ± 1.0	5.3 ± 0.6	4.3 ± 0.5	5.4 ± 0.5	1.28
6	Parsnip	7.3 ± 0.4	5.9 ± 0.4	4.7 ± 0.4	6.1 ± 0.5	0.63
7	Red beet	5.8 ± 0.5	5.5 ± 0.5	5.7 ± 0.6	5.5 ± 0.8	ns
8	Celeriac	5.7 ± 0.6	4.5 ± 0.5	3.4 ± 0.4	4.6 ± 0.4	0.68
9	Brussel sprouts	5.5 ± 0.3	4.9 ± 0.3	3.2 ± 0.5	5.0 ± 0.4	0.60
10	Carrot	5.2 ± 0.5	4.1 ± 0.4	3.3 ± 0.3	4.5 ± 0.5	0.67
11	Green cauliflower	4.9 ± 0.3	4.7 ± 0.2	2.9 ± 0.2	4.4 ± 0.3	0.63
12	Broccoli	4.8 ± 0.2	3.5 ± 0.2	2.3 ± 0.2	3.8 ± 0.2	0.29
13	Kale	4.8 ± 0.1	3.5 ± 0.4	3.3 ± 0.2	3.7 ± 0.4	0.48
14	White cauliflower	3.9 ± 0.6	3.2 ± 0.1	2.1 ± 0.1	3.2 ± 0.3	0.53

CONCLUSION

1. The loss of magnesium content during cooking fresh vegetables depended on the species. The highest loss (27–32%) showed vegetables with a large surface area in relation to their mass (New Zealand spinach, broccoli, kale), whereas the smallest losses (5–8%) were noted in species cooked with the skin left on (red beet, broad bean).
2. The loss of magnesium content in products obtained using the traditional technology of freezing (blanching before freezing and then cooking after frozen storage) was greater than in cooked fresh vegetables. The loss of magnesium content in products obtained using the modified technology (cooking before freezing and after frozen storage prepared for consumption by defrosting and heating in a microwave oven) was approximately half that in samples obtained using the traditional technology.
3. Nutrient density (ND) for all the vegetables studied, both raw and prepared for consumption, was substantially higher than 100% for both males and females. Nutrient density values within individual species were highest in fresh vegetables, followed by the product obtained using modified technology; cooked fresh vegetables; and the traditional frozen product.
4. The recommended dietary allowances (RDA) of all the final products examined was lower than in the raw material. The decrease was smallest in the product obtained using modified technology, slightly greater in cooked fresh vegetables and a much larger was found in the traditional frozen product.

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