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Modification of vitamins B_1 and B_2 by culinary processes: traditional systems and microwaves

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Abstract

Loss of thiamin and riboflavin is studied in Swiss chard and green beans. The processes of boiling and boiling and frying lightly in two systems, traditional and microwaves, both cause loss of these two vitamins, but vitamin B_1 shows a higher loss in traditional boiling. Leaching of both vitamins into the boiling water occurs and, in general, Swiss chards show higher leaching losses, mainly in the traditional system.

Keywords: Swiss chard; Green beans; Thiamin; Riboflavin

1. Introduction

Modern cooking practices can cause partial or total loss of essential micronutrients (Colastra, 1989; Garcia Rollán, 1990; Robinson, 1991; Rozo & Mamone, 1986)

Water-soluble vitamins, and particularly vitamins B_1 and B_2, undergo important losses in culinary processes, depending on their intrinsic stability and on the type of processing. (Goldoni, Bossani & Cosceicao, 1983; Greenway & Ongomo, 1990; Klein, 1981; Klein, Kuo & Boyd, 1981)

Cooking by traditional methods causes a higher percentage of loss than the microwave, technique which, besides being fast, needs less water to boil the food, a lower temperature and less time, these factors being very positive when preparing these products (Meredith, 1989).

To quantify the losses of these two vitamins, Swiss chard and green beans, are examined as the raw product and after a boiling process or boiling and frying lightly. These techniques are the usual ones for preparing these two products.

2. Materials and methods

Vitamins B_1 and B_2 were determined in three samples of Swiss chard and three of green beans which were obtained in supermarkets. Determinations were on raw product and boiled, (microwaves and in pressure cooker) and also in the boiling water. Afterwards, a part of the boiled product was subjected to frying lightly in a traditional way or in microwaves immediately preceding analysis.

For identification "CH" was used for Swiss chard and "GB" for green beans, in the following way:

- From CH.1 to CH. 3: Swiss chard samples
- From GB.1 to GB. 3: Green beans samples

Before analyzing for vitamins B_1 and B_2, the samples were extracted and subjected to an enzymic hydrolysis with acetate buffer and an enzymic solution of papain and diastase for 24 h at 37°C.

Both vitamins were then determined by a fluorimetric technique. The method for vitamin B_1 is based on its oxidation to thiochrome with potassium ferricyanide in an alkaline environment and subsequent interpretation by $\lambda_{emission} = 435$ nm and $\lambda_{excitation} = 365$ nm.

The method for vitamin B_2 is based on its oxidation with potassium permanganate and elimination of its excess with peroxide. The interpretation of the spectrofluorimetry used the following wavelengths: $\lambda_{emission} = 565$ nm and $\lambda_{excitation} = 440$ nm (AOAC, 1995).

3. Results and discussion

Tables 1 and 2 show the contents of vitamins B_1 and B_2 found in Swiss chard and green beans, respectively.

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Tables 3 and 4 show the reliability levels, obtained by an analyisis of the variance (Anova test) (Dixon, 1993), applied to our experimental data.

Fig. 1 shows the average percentages of loss of vitamins B_1 and B_2 in Swiss chard and green beans, boiled and fried lightly by the traditional process and by microwaves. Fig. 2 shows the thiamine and riboflavin leached into the boiling water.

3.1. Vitamin B_1

The highest content of thiamine appears in Swiss chard (near 0.050 mg/100 g). It is less in green beans, i.e. 0.026 mg/100 g in sample number 1.

On comparing the average values of thiamine in the raw Swiss chard and green beans with those that appear in the Tables of Food Composition (Souci, Fachmann

Table 1
Vitamin B_1 and B_2 content in Swiss chard, subjected to culinary processes: traditional and microwaves[a]

Samples	Vitamin B_1					Vitamin B_2				
	Raw product	Traditional		Microwaves		Raw product	Traditional		Microwaves	
		Cooked	Cooked + dressed	Cooked	Cooked + dressed		Cooked	Cooked + dressed	Cooked	Cooked + dressed
CH.1	0.056	0.013	0.012	0.025	0.023	0.084	0.040	0.021	0.077	0.060
CH.2	0.047	0.005	0.005	0.017	0.019	0.085	0.048	0.042	0.073	0.076
CH.3	0.051	0.002	0.005	0.026	0.012	0.076	0.040	0.046	0.071	0.047
$\bar{x} \pm \sigma$	0.051±0.005	0.007±0.006	0.007±0.004	0.023±0.005	0.018±0.006	0.081±0.005	0.042±0.005	0.036±0.001	0.074±0.0003	0.061±0.015

[a] Results expressed in mg/100 g product.

Table 2
Vitamin B_1 and B_2 content in green beans, subjected to culinary processes: traditional and microwaves[a]

Samples	Vitamin B_1					Vitamin B_2				
	Raw product	Traditional		Microwaves		Raw products	Traditional		Microwaves	
		Cooked	Cooked + dressed	Cooked	Cooked + dressed		Cooked	Cooked + dressed	Cooked	Cooked + dressed
GB.1	0.026	0.014	0.015	0.020	0.020	0.049	0.024	0.030	0.029	0.036
GB.2	0.018	0.007	0.009	0.012	0.014	0.025	0.022	0.017	0.015	0.014
GB.3	0.019	0.009	0.006	0.014	0.012	0.071	0.059	0.027	0.028	0.028
$\bar{x} \pm \sigma$	0.021±0.004	0.010±0.004	0.010±0.005	0.014±0.004	0.015±0.004	0.048±0.023	0.035±0.021	0.025±0.007	0.024±0.008	0.026±0.011

[a] Results expressed in mg/100 g product.

Table 3
Analysis of variance related to the comparison of Swiss chard and green beans subjected to culinary processes: traditional and microwaves

Treatment	Vitamin B_1				Vitamin B_2			
	Levene F	Pooled test	Separate test	Mann–Whitney test	Levene F	Pooled test	Separate test	Mann–Whitney test
Raw product	0.8993	0.0011	0.0011	0.0495	0.1920	0.0702	0.1231	0.0495
Traditional								
Cooked	0.6185	0.0087	0.0102	0.0495	0.0432	0.1673	0.2241	0.2752
Cooked + dressed	0.2393	0.0195	0.0349	0.0495	0.8089	0.4808	0.4817	0.2752
Loss	0.2739	0.4414	0.4614	0.5127	0.3328	0.0172	0.0333	0.0495
Microwaves								
Cooked	0.3371	0.0053	0.0127	0.0495	0.0686	0.0062	0.0216	0.0495
Cooked + dressed	0.6189	0.0072	0.0079	0.0495	0.8536	0.2316	0.2341	0.2752
Loss	0.4280	0.0757	0.0835	0.1266	0.2944	0.9534	0.9548	0.0495

Table 4
Analysis of variance related to the comparison between the applied culinary techniques: traditional system and microwaves

Treatment	Vitamin B_1				Vitamin B_2			
	Matched test (P value)	Wilcoxon test (P value)	Correlation (means)	Spearman (rank)	Matched test (P value)	Wilcoxon test (P value)	Correlation (means)	Spearman (rank)
Cooked	0.0000	0.0313	0.9923 (0.0001)	1.0000 (0.0028)	0.5843	0.5625	−0.7061 (0.0897)	−0.4286 (0.3965)
Cooked + dressed	0.0005	0.0313	0.9482 (0.0026)	0.9429 (0.0048)	0.1785	0.1563	0.0217 (0.9635)	−0.0286 (0.9572)
Loss	0.2905	0.3750	0.7631 (0.0576)	0.7714 (0.0724)	0.0182	0.0313	0.3940 (0.3921)	0.2571 (0.6228)

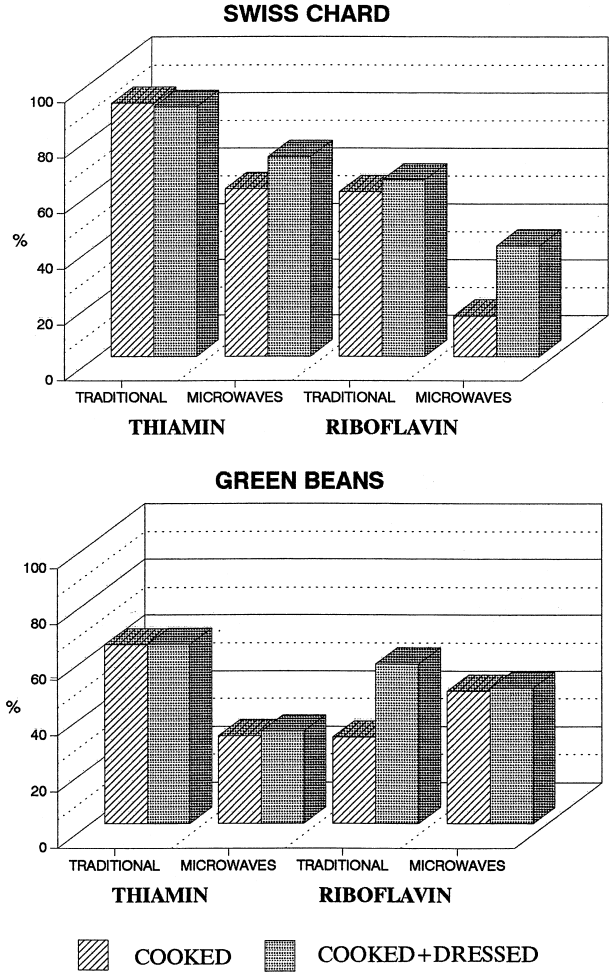

Fig 1. Percentage loss of vitamin B_1 and B_2 in Swiss chard and green beans, in traditional seasoning and microwaves.

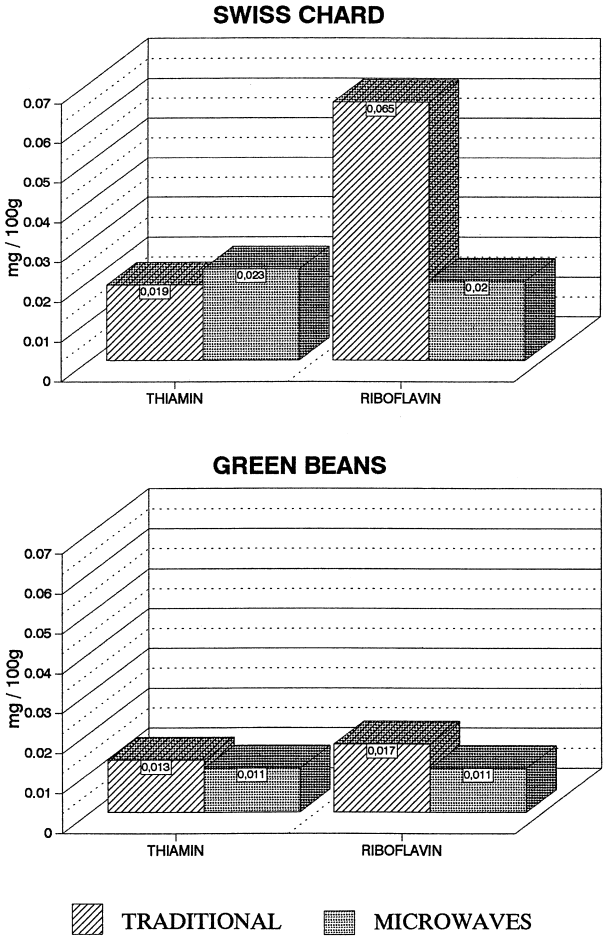

Fig. 2. Content in vitamin B_1 and B_2 transfered to boiling water per 100 g of Swiss chard and green beans by traditional methods and microwaves.

& Kraut, 1994), we find that, in the case of Swiss chard, our average value of 0.05 mg/100 g is higher than the one shown by Souci et al., of 0.02 mg/100 g and lower than the one shown by Mataix Verdú (1995), of 0.07 mg/100 g. On the other hand, the value of 0.021 that appears in green beans is lower than the one given by Souci et al., of 0.08 mg/100 g and Mataix Verdú, of 0.06 mg/100 g.

In the boiled and lightly fried product, Swiss chard is the one that presents more important falls when subjected to boiling with a pressure cooker, with 91.1±6.42%. Loss by microwaves is lower, as shown by the average percentage of 60.1±6.95% (Fig. 1).

Green beans also undergo a decrease in the content of vitamin B_1, after the boiling process, as can be seen from Fig. 1. The decrease is more pronounced in the traditional process than in microwaves.

Nevertheless, in the product which has been fried lightly, both vegetables, show fewer losses compared to the boiled product, than are shown with respect to the raw product. Fig. 1 shows that the thiamin content even rises when Swiss chard is fried lightly by the traditional

process, given the lower percentage of 89.9%, against 91.1%, obtained after boiling this vegetable. This fact could be explained first, by the increase in concentration of vitamin B_1, by evaporation and secondly, because, during this process, garlic is added, and its content of thiamine is 0.16% (Andüjar, Moreiras, Varela & Gil, 1990; Mataix Verdú, 1995), which is considerably higher than the average content of this micronutrient in this vegetable, of 0.051 ± 0.005 mg/100 g.

Green beans also undergo a loss of vitamin B_1, higher in the case of the traditional method. There were practically no differences in the contents of vitamin B_1 between the boiled product and boiled and lightly fried, because the percentages of loss were 64.0% and 64.2%, respectively, for the boiled product and boiled and fried lightly by the traditional method, and 31.2 and 32.8%, respectively, for these same products, processed by microwaves.

Notable is the content of thiamin that remains in the boiled water of these vegetables, which in Swiss chard as in green beans, is very similar in both treatments, the former showing a lower content of thiamine in the water by the traditional system and the latter in the microwave process (Fig. 2).

3.2. Vitamin B_2

The content of riboflavin in these two vegetables is higher than that of thiamin, with contests quite similar for Swiss chard but, on the other hand, quite scattered in the case of green beans, the former showing an average content of 0.081 ± 0.005 mg/100 g and the latter 0.048 ± 0.023 mg/100 g (Tables 1 and 2). These concentrations are higher than those for Swiss chard by Souci et al. (1994) and Mataix Verdú (1995) of 0.06 mg/100 g.

Nevertheless, they are lower in the case of green beans by Souci et al. (1994) — 0.12 mg/100 g and by Mataix Verdú (1995) — 0.10 mg/100 g. The differences between our values and the ones given by these authors, arise because the growing of these two vegetables is conditioned by many factors, among which are the area and the harvest-time, varieties and geographic characteristics in which they are cultivated, which will no doubt affect the vitamin content.

As studied, these green vegetables are consumed boiled, more or less seasoned, and that is the reason why there are important losses of vitamin B_2, due to factors of temperature and boiling time, losses that vary depending on the culinary process that is applied.

As for thiamin, the riboflavin contents found in the boiled product and in the boiled and lightly fried one, are lower in the traditional method, yielding a higher homogeneity of data in the three analyzed samples of Swiss chard, a similarity that does not happen in the case of green beans (Tables 1 and 2).

The losses of vitamin B_2 found in boiled and lightly fried Swiss chard are near 60% in the traditional process, whereas the average losses found in boiled and boiled and lightly fried by the microwave technique, vary substantially between the boiled and lightly fried product, as can be observed in Fig. 1.

In green beans, on the other hand, losses in the boiled and lightly fried product by the microwave technique are similar, about 47%, showing a disparity for the results in the boiled product and in the boiled and lightly fried product by the traditional method, with 30.7 and 57.1% of loss, respectively, for both products in comparison to the raw ones.

Finally, Fig. 2, shows the contents of vitamins B_1 and B_2 left in the boiling water after the two treatments: microwaves and conventional. Higher loss occurs in vitamin B_2 by the traditional method, in Swiss chard and in green beans, although this is lower in the latter. This is logical, because the riboflavin is not only affected by heat, but also by the process and thus by volume of water used in boiling these vegetables.

Cooking by microwaves transmits less vitamin B_1 and B_2 to the water, given that, by this process, vegetables are basically steamed, and also need a lower temperature and less time of boiling.

All the variations discussed about the vitamin content in the raw product in the case of Swiss chard and green beans, as well as in the quantity remaining after the boiling process and the boiling and lightly frying are supported by statistics, by the application of an analysis of variance, which appears in Tables 3 and 4. Significance levels are lower than 0.05 in the case of the vitamin B_1, in raw products as in boiled and boiled and lightly fried products by both systems, traditional and microwaves, which shows the different content of vitamin B_1 which is found in Swiss chard and green beans, in the raw product as well as in the cooked one.

For riboflavin, there are less significant diferences, stressing P values 0.0062 and 0.0172, respectively, for the boiling process by microwave and transfer of this vitamin to the boiling water by the traditional pressure cooker method.

Comparing the two culinary processes that have been applied: traditional and microwave process, independently of the vegetable type (Table 4), the treatments are totally different for thiamin, and this is not the case for riboflavin, in regard to transfer of this vitamin to the boiling water by both culinary processes, when we apply the matched test ($P = 0.0182$) and when we apply the Wilcoxon test ($P = 0.0313$).

It is important to note the high correlations, with very low significant levels, that are shown in the case of thiamin in the boiling processes, lightly fried, and transferred, when establishing this correlation for medium values as well as ranks (Table 4).

Loss of vitamins has previously been studied in cabbage and cauliflower (Franco et al., 1995). In those vegetables the greater losses were after cooking with microwave.

Watt and Merrill (1975) studied thiamin and riboflavin in Swiss chards and green beans and showed that losses were greater by the traditional method than by microwave. Augustin et al. (1987) observed losses in vitamin B_2 when vegetables were boiled by the traditional cooking system and microwave, and established that losses were greater by the former. Augustin et al. studied the variation in vitamin and mineral contents of raw and cooked commercial *Phaseolus vulgaris* classes and they showed retentions of thiamin and riboflavin of 73.1 and 76.0%, respectively. These values are higher than those obtained in this study (64.0 and 30.7 for thiamin and riboflavin, respectively).

Anderson, Dibble, Mitchell and Rynbergen (1977) observed losses of around 80% in both vitamins in raw and cooked product, and this percentage is lower in our samples. Klein et al., (1981) analysed thiamin and riboflavin in cabbage and cauliflower and observed that losses were higher by the conventional method than by microwave.

Finally, there are papers on vitamin losses in food of animal origin, also showing that the vitamin loss that is produced by the microwaves is lower than that produced by the traditional or conventional system (Abdulrahman, Al-Khalifa, Abdelbary & Dowood, 1993; Cooksey, Klein & McKeith, 1990; Uherová, Hozora & Smirnov, 1993).

4. Conclusions

Higher average contents of thiamin and riboflavin appear in Swiss chard, with average values of 0.051 ± 0.005 mg/100 g and 0.081 ± 0.005 mg/100 g, respectively. In the case of green beans, there are heterogeneous data, with average contents of 0.021 ± 0.004 and 0.048 ± 0.023 mg/100 g, respectively, for vitamins B_1 and B_2.

After boiling these vegetables, it is established that vitamin B_1, given its thermolability, shows a higher loss, mainly by the traditional system.

Swiss chard and green beans differ in their loss of riboflavin, Swiss chard, giving losses near to 60% by the traditional system and heterogeneous data by the microwaves system; results are the other way round in the case of green beans.

By the application of an analysis of the variance, we observe that Swiss chard and green beans differ in their contents of vitamin B_1 in the raw, and processed products, whereas in the case of vitamin B_2, only low levels appear in the raw product or that boiled in microwaves and leached into water by pressure cooker, which shows the different behaviour of this vitamin in the two vegetables.

By the analysis of variance, applied to check the similarities and/or differences between the traditional cooking system and microwaves, it is established that differences do exist for vitamin B_1, but, in the case of vitamin B_2, Statistical differences due only shown for leaching into the boiling water of both vegetables.

References

Abdulrahman, S., Al-Khalifa, Abdelbary, A., & Dawood (1993). Effects of cooking methods on thiamin and riboflavin contents of chicken meat. *Food Chemistry, 48*, 69–74.

Anderson, M. P. H., Dibble, R. D., Mitchell, A. B., & Rynbergen, B. S. (1977). *Nutrición humana. Principios y aplicaciones*. Barcelona: Bellaterra, SA.

Andujar, M. M., Moreiras, Varela, O., & Gil, E. F. (1990). *Tablas de composicion de alimentos*. Madrid: C.S.I.C.

Augustin, J., Johnson, S. R., Teitzel, C., True, R. H., Hogan, J. M., Toma, R. B., Shaw, R. L., & Deutsch, R. M. (1987). Changes in the nutrient composition of potatoes during home preparation II. Vitamins. *Am. Potato J., 55*, 653–662.

AOAC (1995). *Official methods of analysis*. (16th ed.). Arlington, VA: Association of Official Analytical Chemists.

Colastra, J. (1989). *Las vitaminas. Guía de los buenos nutrientes*. Madrid: Heptada, Majadahonda.

Cooksey, K., Klein, B. P., & McKeith, F. K. (1990). Thiamin retention and other characteristics of cooked beef loin roast. *Journal of Food Science, 55*(3), 863–864.

Dixon, W. J. (1993). *BMDP Statistical software manual*. Los Angeles: University of California Press.

Garcia Rollan, M. (1990). *Las vitaminas*. Zaragoza: Acribia.

Goldoni, J. S., Bossani, I. A., & Cosceicao, F. A. D. (1983). Estudio comparativo en vitamina C de cultivares de repolho, antes e depois de seu processamento em chucrute. *Archivos Latinoamericanos de Nutrición, 33*, 45–55.

Greenway, G. M., & Ongomo, P. (1990). Determination of l-ascorbic acid in fruit and vegetables juices lig flow inyection with immobilisep ascorbate oxidase. *Analyst, 115*(10), 1247–1299.

Klein, B. P. (1981). Effect of processing on nutritive value of food: microwave cooking. In: *Handbook of nutritive value of processed food,* (Vol. 1) (pp. 209–231).

Klein, B. P., Kuo, C. H. V., & Boyd, S. (1981). Folacin and acid ascorbic retention in fresh raw microwave, and conventionally cooked spinach. *Journal of Food Science, 46*, 640–641.

Mataix Verdú, J. (1995). *Tabla de Composición de Alimentos Españoles* (2nd ed). Granada: Servicio de Publicaciones de la Universidad de Granada.

Meredith, R. J. (1989, February): Principios e importancia del tratamiento por microondas de alimentos con particulador. Alimentación, equipos y tecnologia (pp. 147–150).

Robinson, D. S. (1991). *Bioquimica y valor nutritivo de los alimentos*. Acribia, S.A.

Rozo, C., & Mamone, M. (1986). *Vitaminas. Agentes nutritivos y terapéuticos*. Barcelona: Doyma, SA.

Souci, S. W., Fachmann, W., & Kraut, H. (1994). *Food composition and nutrition tables*. Stuttgart: Medpharm, Scientif Publishers.

Uherová, R., Hozorá, B., & Smirnov, V. (1993). The effect of microwave heating on retention of some vitamins. *Food Chemistry, 46*, 293–295.

Watt, B., & Merrill, A. (1975). *Composition of food*. Washington: Agricultural Research Service.