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Effect of gamma irradiation on the thiamine, riboflavin and vitamin B_6 content in two varieties of Brazilian beans

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Abstract

The effect of ^{60}Co gamma rays on the content of several B-vitamins in two varieties of Brazilian beans has been studied. Carioca (*Phaseolus vulgaris* L. var. Carioca) and Macaçar beans (*Vigna unguiculata* L. *Walp*, var. Macaçar) were irradiated at doses of 0, 0.5, 1.0, 2.5, 5.0 and 10 kGy, and subsequently stored at ambient temperature for 6 months. The content of vitamin B_1, B_2 and B_6 was analysed by HPLC. In addition, the optimum cooking time was established for each dose and bean variety. A taste panel evaluated sensory properties. Only slight changes were measured for thiamine and riboflavin, whereas a dose-dependent decrease was noted for pyridoxine, which, however, was significant only at the highest doses of 5 and 10 kGy. Cooking time was considerably reduced with increasing radiation dose, but accompanied by a loss of the sensory quality. However, at the disinfestation dose up to 1 kGy, acceptable ratings were obtained for the sensory evaluation. In conclusion, for insect disinfestation of Brazilian beans radiation processing is a promising technology.

Keywords: Food irradiation analysis; Beans; Thiamine; Riboflavin; Vitamin B_6

1. Introduction

In Brazil, beans are an important source of alimentary proteins and nutrients. Cultivation and consumption are locally restricted. The *Vigna unguiculata* (L.) *Walp*, so called North beans, Caupi beans or Macaçar beans are cultivated in the Northeastern part of Brazil. The *Phaseolus vulgaris* L., e.g. Carioca beans, are extensively cultivated in central and South Brazil. These two varieties represent 70% of the Brazilian production of beans, soybeans excluded (Lam-Sanches et al., 1990). Substantial quantities of the beans, produced in Brazil, are affected by insect infestation and efforts to improve the quality for dry beans after storage have included various pre-treatments and treatments, as well as processing by radiation. The extent of post harvest losses is around 30% in Brazil (Farrar and Going, 1994). For insect disinfestation in beans, irradiation may offer an attractive alternative to chemicals. Radiation processing of beans for the purpose of

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insect disinfestation at dosages up to 1 kGy has been shown to be a promising technique for reducing loss during storage of these nutritious foodstuffs (Delincée and Bognár, 1993). Since beans are regarded as an important supply of B vitamins in Brazilian diets (Roncada and Mazzilli, 1989), the effects of radiation processing on the B_1, B_2 and B_6 vitamins are studied here. Studies of the effects of irradiation on vitamins have led to different conclusions depending on whether pure solutions or actual food matrices were investigated (WHO, 1994). Aqueous and other solutions of vitamins are highly sensitive to irradiation, but this is not true of vitamins in food. It is inappropriate to extrapolate data of vitamin losses in solution to food. In the present work, the effect of household cooking and storage after irradiation were investigated by using an optimized analytical method to measure vitamin contents.

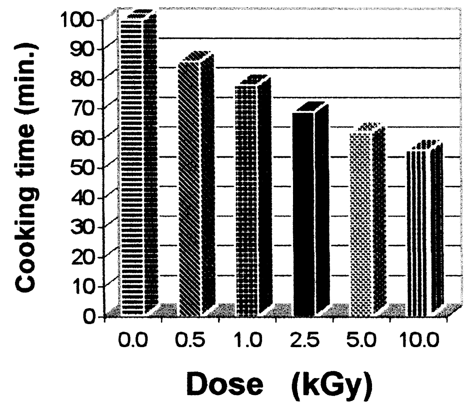

Fig. 1. Carioca beans.

2. Experimental

2.1. Sample material

Brazilian beans, *P. vulgaris* L., var. Carioca and *V. unguiculata* (L.) *Walp*, var. Macaçar, bought in a local market, were used.

2.2. Irradiation

Samples were packaged into plastic bags and irradiated in a Gammacell (AECL) ^{60}Co source (IPEN, São Paulo, dose-rate ~0.44 kGy/h) at doses of 0, 0.5, 1.0, 2.5, 5.0 and 10.0 kGy.

2.3. Storage time

Following irradiation, the beans were stored at room temperature for 3 months in Brazil and then shipped to Germany. There they were stored at 24°C for more 3 months until the tests were made.

2.4. Cooking time

The optimal cooking time was determined for each dose and for each variety. The beans were soaked overnight in distilled water at room temperature, and cooked at 100°C on the following day.

2.5. Sensory evaluation

This was carried out by a trained panel of six people based on the procedure of 'Official Collection of Testing Methods according to paragraph 35 LMBG 1990'.

2.6. Vitamin determination

This was performed on cooked and lyophilysed samples. Dry matter content was determined gravimetrically by drying at 103°C. Vitamins B_1, B_2 and B_6 were determined in duplicate fluorometrically by high-performance liquid chromatography (Bognár, 1986, 1989). Isocratic elution, nucleosil column 120, C18, 5 μm (Macherey + Nagel).

2.7. Statistical analysis

The homogeneity of groups were analysed by ANOVA (Yaname, 1977). When some difference was detected among the means, Student's *t*-test and the multiple comparison test of Tukey–Kramer were

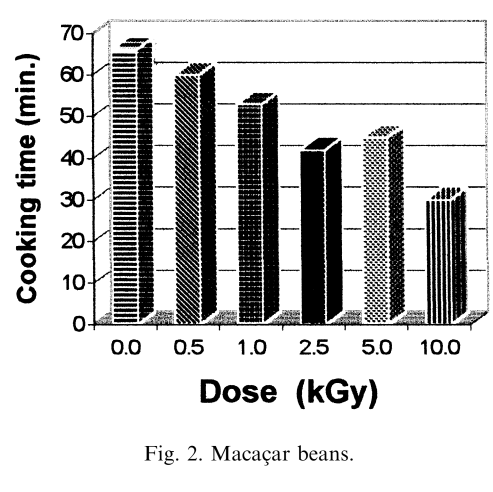

Fig. 2. Macaçar beans.

Table 1
Effect of radiation dose on the content of B vitamins in cooked beans after 6 months' storage[a]

	Content μg/100 g Dry Matter					
			Vitamin B_6			
	Vitamin B_1 total	Vitamin B_2 total	Pyridoxamine	Pyridoxal	Pyridoxine	Total
	x s	x s	x s	x s	x s	x s
Carioca						
0	$560 \pm 45^{**a}$	$248 \pm 8^{**a}$	$162 \pm 8^{**a}$	$12 \pm 2^{**a}$	$318 \pm 10^{**a}$	$492 \pm 12^{**a}$
0.5	569 ± 30^{a}	245 ± 8^{a}	153 ± 3^{a}	12 ± 2^{a}	315 ± 8^{a}	480 ± 8^{a}
1.0	552 ± 26^{a}	242 ± 6^{a}	152 ± 5^{a}	12 ± 2^{a}	316 ± 6^{a}	480 ± 6^{a}
2.5	520 ± 30^{b}	245 ± 7^{a}	146 ± 5^{b}	11 ± 2^{a}	306 ± 9^{b}	463 ± 9^{a}
5.0	$480 \pm 15^{**c}$	$222 \pm 8^{**b}$	$121 \pm 6^{**c}$	$10 \pm 2^{**b}$	$290 \pm 1^{**c}$	$421 \pm 13^{**b}$
10.0	$520 \pm 20^{**b}$	$253 \pm 9^{**c}$	$111 \pm 3^{**d}$	$8 \pm 2^{**c}$	$265 \pm 10^{**d}$	$384 \pm 11^{**b}$
Macaçar						
0	$380 \pm 30^{**a}$	$172 \pm 8^{**a}$	$120 \pm 4^{**a}$	$7 \pm 1^{**a}$	$260 \pm 9^{**a}$	$387 \pm 6^{**a}$
0.5	370 ± 25^{a}	$193 \pm 6^{*b}$	115 ± 5^{a}	4 ± 1^{b}	258 ± 7^{a}	377 ± 5^{a}
1.0	395 ± 20^{a}	209 ± 7^{c}	106 ± 2^{b}	3 ± 1^{b}	270 ± 8^{a}	379 ± 7^{a}
2.5	395 ± 25^{a}	190 ± 9^{b}	107 ± 3^{b}	3 ± 1^{b}	266 ± 10^{a}	376 ± 6^{a}
5.0	$393 \pm 25^{**a}$	$206 \pm 10^{**}$	$104 \pm 6^{**b}$	$1 \pm 1^{**c}$	$261 \pm 12^{*a}$	$366 \pm 7^{**b}$
10.0	$370 \pm 20^{**b}$	$208 \pm 8^{**c}$	$87 \pm 8^{**c}$	$1 \pm 1^{**c}$	$232 \pm 11^{**b}$	$320 \pm 8^{**c}$

[a] * = means ± SD ($n = 4$); ** = means ± SD ($n = 2$). In the same column, means followed by different letters (a,b,c,d) are statistically different ($P < 0.05$).

made, using the program GraphPad Instat, version 2.01, GraphPad Software.

3. Results and discussion

The effect of radiation dose on cooking time in Carioca and Macaçar varieties is shown in Figs. 1 and 2. The optimal cooking time of Carioca beans, as illustrated in Fig. 1, decreases with increasing dose. Although the var. Macaçar showed a small deviating response to a dose of 5.0 kGy, as noted in Fig. 2, a decrease of cooking time with increasing dose was obvious.

The reduction of cooking time after radiation treatment has been reported for several legumes such as dry beans (Nene et al., 1975; Iyer et al., 1980; Aguilera and Steinsapir, 1985), chickpeas and mungbeans (Nene et al., 1975; Rao and Vakil, 1985; Aurangzeb et al. 1990), lentils (Nene et al., 1975; Ismail et al., 1976; Rao and Vakil, 1985), white beans, lentils and peas (Delincée and Bognár, 1993). Reduction in the cooking time was attributed to some starch fragmentation (Sabularse et al., 1991). An increase of starch solubility was observed after radiation processing by El Saadany et al. (1979).

Immediately after irradiation, a slight off-odour of the raw beans could be noted at doses higher than 2.5 kGy in both kind of samples. After cooking, Carioca and Macaçar beans showed no significant changes in sensory quality up to doses permitted for insect disinfestation, i.e. up to 1.0 kGy. However, at higher doses sensory quality was reduced. Rao and Vakil (1985) have shown that the changes in colour, odour and taste increase as a function of the radiation dose. Delincée and Bognár (1993) reported no significant difference in sensory properties of white beans, lentils and peas after radiation doses of up to 5 kGy; however, some slight differences may occur.

There was only a small effect on the thiamine content in Carioca beans at doses higher than 2.5 kGy. Macaçar beans did not show significant losses (Table 1). These results are in accordance with other studies on the vitamin B_1 content of irradiated food at a dose level of about 1 kGy (Delincée and Bognár, 1993).

After irradiation and 6 months' storage, practically no effects were seen in the riboflavin content of Carioca beans. In Macaçar beans, the riboflavin content mostly increased with increasing dose (Table 1). Our data are in accordance with most of the literature. Adrian and Frayssinet (1975) did not observe riboflavin losses in Macaçar beans at doses of 0.15 kGy. Fonseca et al. (1974) reported a riboflavin loss of 12% immediately after irradiation of kidney beans at 0.15 kGy. However, after 5 months' storage, the loss was only 7% when compared with the controls. No losses of riboflavin have been found in maize, wheat and beans after radiation processing in the dose range of 0.5 to 5 kGy (Badshah and Klopfenstein, 1989).

The total quantity of pyridoxal, pyridoxamine and pyridoxine was analysed in cooked and lyophilysed samples; the influence of radiation dose is shown in Table 1. In Carioca beans, the total B_6 vitamin content was higher than in Macaçar beans. The content of total B_6 vitamin decreased with increasing dose. Losses at 0.5–2.5 kGy were 0–6%, at a dose of 5.0 kGy losses were 1–12% and at 10 kGy, 14–19% were lost. The observed losses in both varieties suggest that irradiation at disinfestation doses of up to 1 kGy produces a minimal effect of losses in total B_6 vitamin content.

Thus, the content of B vitamins is not reduced by appropriate radiation processing, nor is the protein biological value of Carioca and Macaçar beans (Delincée et al., 1998).

4. Conclusion

The cooking time of beans is considerably reduced at doses up to 2.5 kGy, but at higher doses a decrease in sensory quality in both Carioca and Macaçar varieties has been found. In accordance with the sensory parameters used, i.e. colour, odour, taste, shape and texture, it can be concluded that up to doses of 1.0 kGy, good quality similar to that of non-irradiated controls is retained. If the produce is irradiated at doses higher than 5 kGy, changes in sensory properties occur which render the beans inedible. The observed thiamine losses in Carioca beans irradiated at an disinfestation dose of up to 1 kGy are small. No significant thiamine losses have been found for the Macaçar variety. Riboflavin concentration increased with radiation dose, as frequently reported in literature (Kilcast, 1994). At doses up to 1 kGy, B_6 vitamin was not affected. These slight changes in the content of B vitamins suggest irradiation as a good alternative for extending the storage time of beans.

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