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PROTEIN QUALITY OF IRRADIATED BRAZILIAN BEANS

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ABSTRACT

Beans are a major source of dietary protein in Brazil. However, high losses due to insect infestation occur after each harvest. To combat these losses, radiation processing of beans offers promise as an alternative to chemical treatment, provided the nutritional quality of beans is not impaired by the radiation treatment. Conflicting results have been published about the effect of radiation on the biological value of legume proteins. Therefore, two varieties of Brazilian beans were studied: 1) *Phaseolus vulgaris L.*, var. carioca and 2) *Vigna unguiculata (L.) Walp*, var. macaçar. The beans were irradiated with doses of 0, 0.5, 1.0, 2.5, 5.0 and 10 kGy. Since irradiated beans will be consumed after appropriate storage, the beans under study were stored for 6 months at ambient temperature. Protein quality was measured by a biological assay employing the nitrogen balance approach in weanling rats. The animals were fed with optimally cooked beans, which were the only source of protein (~10%). Nitrogen contents of legumes, diets, animal urine and faeces were determined by Kjeldahl analysis. The indices for apparent protein quality: net protein utilisation, digestibility and biological value were not influenced by irradiation. Thus, radiation treatment of Brazilian beans offers considerable promise as an effective insect disinfestation process, without impairing the biological quality of the valuable bean protein.

KEYWORDS

Protein quality; nutritional value; beans; insect disinfestation; food irradiation

INTRODUCTION

Food irradiation is recognized as a safe and effective process for a range of specific applications, among them disinfestation of products such as cereal grains, legumes, fresh and dried fruits, nuts, dried vegetables, dried fish and meat [Moy, 1985; IAEA, 1991; WHO, 1994; Diehl, 1995]. The treatment by ionizing radiation is regarded as a versatile and effective alternative of chemical fumigants to combat insect pests. In Brazil, beans are a major source of dietary protein for the population. Post-harvest losses occur due to infestation by several species of insects during storage. Therefore, irradiation could offer promise to minimize these losses, provided the nutritional quality is not impaired by radiation processing. In general, for a great number of food products no change in the nutritional value has been noted, even not at elevated radiation doses [Diehl, 1995]. However, conflicting results have been published on the effect of radiation on the biological value of protein in pulses, and further research has been recommended [WHO, 1981]. Using chemical assays, only slight changes in amino acid patterns were found in macaçar beans irradiated at 1 and 10 kGy, but feeding tests in growing rats revealed a much lower protein efficiency ratio (PER) for irradiated macaçar beans as compared to non-irradiated beans. This effect was even strongly aggravated by long-term storage (6 months) of the beans [Coelho *et al.*, 1978]. It may be remarkable that also storage of the non-irradiated beans resulted in a large decrease of protein quality. Maybe the rats for some reasons did refuse to feed on both stored diets. In other feeding tests an improved growth of chicks has been reported which were fed with field beans irradiated with the excessive dose of 210 kGy [Reddy *et al.*, 1979]. Similar results with chick growth assays were obtained by Daghir *et al.* (1983), who after feeding of lentils irradiated with 180 kGy, observed either an improvement of the protein quality or no change, depending on the lentil variety. In a recent study using the sensitive rat bioassay for nitrogen balance to measure protein quality in three different kinds of legumes, namely white beans, peas and lentils, no or only slight changes in the indices of apparent protein digestibility, apparent net protein utilisation and apparent biological value were found after irradiation with 10 and 50 kGy [Delincée and Bognár, 1993]. Therefore, these latter studies were all in line with the general view based on many results that the nutritional value of proteins is not impaired by irradiation [WHO, 1994]. In order to further challenge the deviating results obtained by Coelho *et al.* (1978) on macaçar beans, now a long-term storage study using the same variety of beans, namely macaçar beans [*Vigna unguiculata L. Walp.*] was designed using the sensitive nitrogen balance assay in weanling rats. In addition, another variety of beans, namely carioca beans [*Phaseolus vulgaris, L.*] was tested under the same conditions.

EXPERIMENTAL

Sample material

Two kinds of Brazilian beans, macaçar beans (*Vigna unguiculata L. Walp.*) and carioca beans (*Phaseolus vulgaris L.*) were purchased from a local market, São Paulo. These beans in polyethylene bags were irradiated in a ^{60}Co source (IPEN, São Paulo, Gammacell 220, AECL, dose-rate ~0.44 kGy/h) at doses ranging from 0, 0.5, 1.0, 2.5, 5.0 to 10 kGy (nominal values ± 15%). Following irradiation, beans were stored at ambient temperature (24°C) for 3 months in Brazil and then shipped to Karlsruhe, Germany, where storage was continued for another 3 months.

Nitrogen balance trial

Powdered diets for the rat bioassay were prepared to contain about 10% pulse protein (estimation of total protein by N(Kjeldahl) x 6.25 in homogenized freeze-dried pulse material

after optimal cooking). In addition to the cooked, freeze-dried pulse material (40.8% for the macaçar diet and 54.4% for the carioca diet) the diets contained corn oil (4%), saccharose (10%), mineral salts and vitamins (Altromin C-1000, Lage, Germany), and were supplemented with corn starch (37.2% for macaçar and 23.6% for carioca). Since legumes contain antinutritional factors which are destroyed by cooking, rat feeding experiments were only carried out with previously cooked pulses. The optimal cooking time for each legume and irradiation dose was estimated in order not to overcook the material.

Male Sprague-Dawly weanling rats (Charles Wiga, Sulzfeld, Germany) with a weight of 40-50g were used for the bioassay. For each legume and radiation dose, a group of 8 rats were assigned, making up a total of 96 rats. After receipt, the animals were kept in Macrolon cages and had free access to standard laboratory chow and tap water for acclimatisation for 2 days. Subsequently, the animals were adapted to their corresponding experimental diet (*ad libitum*) for 4 days. After this adaption period, the rats were weighed and placed into individual metabolic cages with stainless steel bottom screens. They were fed 10 g daily of the experimental diet for 4 days with free access to tap water. Refused food and spill weights were collected and recorded daily. Also faeces and urine were daily collected. At the end of the balance period, the animals were weighed again.

Nitrogen contents of legumes, diets, animal urine and faeces were determined in triplicate by Kjeldahl analysis. The apparent net protein utilisation (NPU), apparent digestibility (D) and apparent biological value (BV) were calculated according to Pellet and Young (1980).

RESULTS AND DISCUSSION

Concerning food intake, the rats consumed most of the total amount of 10 g offered every day, thus no interference of the trial due to large differences in food intake occurred (Table 1). Sensory properties (taste panel consisting of at least six trained assessors) of the unirradiated and irradiated beans were similar up to an irradiation dose of 1 kGy. At higher radiation levels the sensory properties were increasingly impaired, but the test animals did not seem to react upon these changes. Weight gain, therefore, was similar for all radiation doses applied. No large differences in weight gain were observed between animals consuming macaçar or carioca beans.

The indices for protein quality, net protein utilisation, digestibility and biological value were not influenced by irradiation. For this reason results may be pooled over all treatments (grand means in Table 1). However, the digestibility of macaçar beans was slightly higher than for carioca beans, resulting in a lower biological value for macaçar than for carioca beans.

The results confirm to be in line with the general conclusion, that the nutritional value of food proteins is not impaired by irradiation at technologically useful doses.. Legume proteins seem to be no exception. The conflicting results of Coelho *et al.* (1978) are difficult to explain. In our opinion, the option of treating Brazilian beans with ionizing radiation for the purpose of insect disinfestation offers considerable promise. The required low-dose irradiation with doses up to 1 kGy will not lead to a change in sensory properties nor to adverse in protein quality, and will help to prevent post-harvest losses, making more food available.

Table 1. Nitrogen balance study in rats receiving diets with cooked, irradiated beans. Food intake, weight gain, apparent digestibility, net protein utilisation and biological value.

Diet	Food intake (g/4d)	Weight gain (g/4d)	D_{app} (%)	NPU_{app} (%)	BV_{app} (%)
Macaçar					
0 kGy	36.2 ± 2.2	11.5 ± 1.9	74.2 ± 1.3	51.9 ± 2.5	69.9 ± 2.3
0.5 kGy	33.6 ± 3.9	8.4 ± 2.0	70.7 ± 4.4	49.6 ± 4.6	70.1 ± 3.1
1 kGy	37.9 ± 1.7	10.5 ± 2.3	74.9 ± 3.6	56.9 ± 4.0	75.9 ± 2.1
2.5 kGy	38.0 ± 0.8	10.0 ± 3.0	74.1 ± 3.2	55.6 ± 4.5	74.9 ± 3.2
5 kGy	37.1 ± 1.3	9.7 ± 3.0	72.6 ± 4.4	54.4 ± 5.0	74.8 ± 3.4
10 kGy	37.4 ± 1.6	8.4 ± 1.8	70.2 ± 3.0	50.1 ± 3.8	71.4 ± 3.0
Grand means	36.7 ± 2.2	9.8 ± 2.4	72.8 ± 3.4	53.1 ± 4.2	72.8 ± 2.9
Carioca					
0 kGy	35.9 ± 3.9	11.3 ± 1.9	67.0 ± 5.2	56.5 ± 5.2	84.3 ± 2.4
0.5 kGy	35.6 ± 3.0	10.5 ± 2.6	64.0 ± 7.1	54.0 ± 7.6	84.2 ± 3.6
1 kGy	35.4 ± 2.4	10.2 ± 2.3	64.3 ± 6.7	54.2 ± 7.7	84.0 ± 4.0
2.5 kGy	36.5 ± 2.1	12.6 ± 2.3	61.0 ± 5.0	52.1 ± 3.0	85.4 ± 1.4
5 kGy	36.2 ± 3.0	10.4 ± 2.6	63.4 ± 7.3	53.1 ± 7.3	83.5 ± 2.7
10 kGy	36.2 ± 2.0	10.8 ± 2.0	64.7 ± 4.7	55.5 ± 5.0	85.7 ± 1.9
Grand means	36.0 ± 2.8	11.0 ± 2.3	64.1 ± 6.1	54.2 ± 6.2	84.5 ± 2.8

Results are means ± standard deviation, eight rats per treatment;
Grand means over 6 treatment groups, 48 rats totally.

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