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Polyphenols and antioxidant capacity of *Phaseolus vulgaris* stored under extreme conditions and processed

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Abstract

Phaseolus vulgaris is a foodstuff that not only supplies nutrients, but also bioactive compounds with antioxidant capacity; however, bad post-harvest storage or processing can diminish the antioxidant capacity. In this work, the effect of storage under extreme conditions, of thermal processing and of fermentation on the content of phenolic compounds and their antioxidant capacity (AA) in beans of just harvested *P. vulgaris* were evaluated. Combination of temperatures of 30 and 50 °C and relative humidity of 11% and 80% for 150 days were evaluated. Extreme storage conditions drastically decreased the AA, demonstrating that post-harvest storage at low temperature and humidity preserves the antioxidant capacity of the beans. Regarding processing, cooking decreased the scavenging effect and the AA by 63.5% and 56.8%, while fermentation decreased them by only 14% and 22%, respectively. It was concluded that the loss of antioxidant capacity due to heating is less in fermented beans.

Introduction

Phaseolus vulgaris (*P. vulgaris*) is a functional food because it contains bioactive molecules, such as polyphenols and tannins, which shows antioxidant capacity (Dueñas, Fernández, Hernández,

Estrella, & Muñoz, 2005; Oomah, Cardador, & Loarca, 2005; Parr & Bolwell, 2000). Phenolic compounds not only effectively prevent oxidation in food, but also act as protecting factors against oxidative damage in the human body (Pszczola, 1998).

However, post-harvest storage of the beans, as well as their processing, alters the chemical composition of *P. vulgaris* and consequently their nutritional and functional value.

Regarding post-harvest storage, it has been found that when it is carried out under conditions of high humidity and high temperatures, the Hard-to-Cook (HTC) phenomenon develops a defect that increases bean cooking times and therefore affects their use as human food (García, Filisetti, Udaeta, & Lajolo, 1998; Kyriakidis, Apostolidis, Papazoglou, & Karathanos, 1997).

On the one hand, thermal processing decreases the content of polyphenols and tannins of legumes and modifies their oxidation state (Latha & Daniel, 2001; Rocha, González, Ibarra, Nava, & Gallegos, 2006; Turkmen, Sari, & Velioglu, 2005; Vijayakumari, Siddhuraju, Pugalenthi, & Janardhanan, 1998). Depending on the resulting degree of oxidation, these modifications can decrease or increase the antioxidant capacity. In general, thermal treatment decreases the antioxidant activity (AA) of beans; however, products of the Maillard reactions can also be generated; these products have been identified as excellent antioxidants, particularly as scavengers of free radicals (Kaur & Kapoor, 2002).

On the other hand, natural fermentation, a simple and economical bioprocess that decreases flatulence producing compounds and increases nutritional quality of *P. vulgaris* (Granito, Frias, Doblado, Guerra, & Champ, 2002), reduces polyphenols and tannins of beans (Granito, Torres, Frías, Guerra, & Vidal-Valverde, 2005). However, the effect of fermentation on the antioxidant capacity of legume beans has been little studied. Yung-Ching, Cheng-Tien, and Wen-Wan (2002) reported that the ethanolic extract of *P. radiatus* fermented with *Bacillus subtilis* produced an excellent scavenging effect (86%) compared to that of commercial antioxidants, like butylhydroxy-toluene (BHT) and α-tocopherol, while Berghofer, Gezeskowiak, Mundigler, Sentall, and Walcak (1998) and Hu et al. (2004) reported increases in the antioxidant capacity of soybean and faba bean after fermentation. Considering the importance of legumes in human feeding, in this work it was set as objective to study the variation in the polyphenol content and in the scavenging effect and antioxidant capacity of *P. vulgaris*, after storage under extreme conditions of temperature and relative humidity, and after being subjected to processes of induced fermentation and cooking.

Section snippets

Beans

Freshly harvested black beans of *P. vulgaris* (L-140 variety) from the Instituto Nacional de Investigaciones Agrícolas (INIA), Venezuela, were used. Such crops were handled with high sanitary

controls during and after the harvest to avoid microbial contamination that could alter the samples. To obtain the inoculum used in the induced fermentation, commercial samples of *P. vulgaris* purchased at the local market were used. …

Storage

The selection of the temperatures and relative humidities used during …

Storage effect

In Table 1, the results for the total polyphenols quantified during the 150 days of storage are presented. The initial total polyphenol content found lies within the range reported by other authors for the species *P. vulgaris* (Oomah et al., 2005; Rocha et al., 2006).

During the first 90 days of storage, the total polyphenol content increased significantly ($p \leqslant 0.05$) with respect to the initial value in C2 and C3, the increment being higher for the conditions of high humidity and high temperature …

Conclusion

From the results obtained, it can be concluded that the combination of high temperatures and high humidities during the post-harvest storage of the beans affects negatively the AA of *P. vulgaris*. In contrast, storage at 30% and 11% of relative humidity allows preservation of the functional activity of the beans. Likewise, it can be concluded that fermentation is a process that reduces the losses of the antioxidant activity of *P. vulgaris* associated with cooking, allowing the use of fermented …

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...Furthermore, the waste water used for this process (BW) shows values of polyphenols amounting to about 10% compared to the values found in NS extract, even though they are not directly correlated with the other samples given their different nature. The polyphenol content of NS was lower than others reported, although of the same order of magnitude (Granito et al., 2008; Sang et al., 2002). This difference may be due to several factors, such as cultivar, cultivation practices and peculiar climatic features of the area of origin of the samples examined....

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