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Chemical composition, dietary fibre and resistant starch contents of raw and cooked pea, common bean, chickpea and lentil legumes

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Abstract

The chemical composition and the contents of resistant starch and soluble and insoluble dietary fibre of pea (*Pisum sativum* L.), common bean (*Phaseolus vulgaris* L.), chickpea (*Cicer aretinum* L.) and lentil (*Lens culinaris* Med.) legumes, were studied. Raw and freeze-dried cooked samples were used, both in the form of flour. Protein values of the legumes ranged from 18.5 to 21.9 g/100 g for the raw grains and from 21.3 to 23.7 g/100 g for freeze-dried cooked legumes. Chickpea stood out for the highest lipid content ($p < 0.05$), the lowest insoluble fibre values, and soluble dietary fibre not detected. The average content of resistant starch found in the legumes did not differ statistically ($p > 0.05$), being 2.23 ± 0.24 g/100 g for freeze-dried cooked legumes, and showing a slight reduction in comparison to the raw form.

Keywords: Legumes; Chemical composition; Soluble and insoluble dietary fibre; Resistant starch

1. Introduction

Around 20 leguminous species are used as dry grains in appreciable amounts for human nutrition. Among these, pea (*Pisum sativum* L.) is highly consumed in Asian countries, common bean (*Phaseolus vulgaris* L.) in Latin American and African countries, chickpea (*Cicer arietinum* L.) in India and lentil (*Lens culinaris* Med.) in countries of the Middle East (Morrow, 1991).

In Brazil, common bean is the most popular food product, having been considered for a long time as the basic food of the greatest importance for the population, both of the rural and urban areas. Consumption of legumes increases each year; however, winter legumes – pea, lentil and chickpea – are little consumed and the national production is still small; therefore most is imported. The country imports almost all lentil intended for consumption, mainly from Canada, Argentina and the United States. Around 3000 tons of chickpea are annually imported, especially from Mexico and Chile. Up until the 1980s, pea was almost totally imported; nowadays all demand is met by the national production.

In general, legumes are sources of complex carbohydrates, protein and dietary fibre, having significant amounts of vitamins and minerals, and high energetic value (Morrow, 1991; Nielsen, 1991; Tharanathan & Mahadevamma, 2003). Protein contents in legume grains range from 17% to 40%, contrasting with 7–13% of cereals, and being equal to the protein contents of meats (18–25%) (Genovese & Lajolo, 2001). Nevertheless, the low nutritional value of legume proteins represents one of its biggest problems.

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Some studies report low nutritional values for legumes, the protein digestibility having considerable influence on these bad results, due to its chemical structure. Also influential are antinutritional factors, such as protease inhibitors, lectins, phytate, tannin and dietary fibre, including resistant starch. The primary action of fibres in the human organism occurs in the gastrointestinal tract, presenting different physiological effects. Indeed, the physiological effects caused by the fibres, such as alteration of the gastrointestinal transit time, satiety changes, influence on the levels of body cholesterol, after-meal serum glucose and insulin levels, flatulence and alteration in nutrient bioavailability, are due to the physico-chemical properties of the chemical components of which they are composed (Hopwell, Yeater, & Ullrich, 1993; Institute of Food Technologists, 1989; Lajolo, Saura-Calixto, Penna, & Menezes, 2001). Thus, the aim of this study was to evaluate the content of dietary fibre and resistant starch of the cited legumes.

2. Material and methods

2.1. Samples

Grains of pea (*Pisum sativum* L. cv. Maria), common bean *(Phaseolus vulgaris* L. cv. IAC carioca Eté), chickpea (*Cicer arietinum* L.) and lentil (*Lens culinaris* Med. cv. Silvina), deriving from the collection of available grains in the National Center of Vegetable Research of the Brazilian Company of Farming Research (CNPH/EMBRAPA), Brasília/DF, and from The Campinas Agronomic Institute (IAC), Campinas/SP were used.

2.2. Treatment

The grains of the legumes were chosen in order to eliminate external material, immature seeds and damaged grains. Part of the grains of each legume was ground raw into flour, and the rest washed in running water, soaked for a period of 16 h (1:2 w/v) and then cooked with the addition of one volume of water.

Common bean and chickpea grains were cooked in a domestic pressure (14.7 psi) cooker for 20 and 40 min, respectively, measured after the air exhaustion. Pea and lentil legumes were cooked from 20 min at atmospheric pressure (Domene & Oliveira, 1993). The cooked material was frozen, freeze-dried (Virtis, 10–146 MR-BA model) and ground into flour (60 mesh).

2.3. Chemical determinations

The following composition characteristics were determined in the raw and cooked samples: protein (AOAC, 1975), utilizing 5.40 as nitrogen conversion factor for legume protein (Mossé, 1990); total lipids (Bligh & Dyer, 1959); ash (Lees, 1979); crude fibre (Angelucci et al., 1987); moisture (Pearson, 1976); carbohydrate by difference; soluble and insoluble dietary fibre (Asp, Johansson, Hallmer, & Siljestrom, 1983); and resistant starch (Faisant et al., 1995). The results were submitted to analysis of variance (ANOVA) and Tukey's means test, using the SAS Programme – The SAS Systen Institute/USA, considering $p < 0.05$ as the minimum acceptable probability for the difference between the means.

3. Results and discussion

Results from chemical composition analysis of raw and freeze-dried cooked legumes are presented in Table 1. Chickpea was the legume of prominence, presenting lower protein values and total lipid contents, approximately three times higher than the others, both in raw and freeze-dried cooked forms, and differing statistically ($p < 0.05$). Protein values found in the legumes were in agreement with data presented by other authors (Kutoš, Golob, Kač, & Plestenjak, 2003; Ratnayake, Hoover, Shahid, Perera, & Jane, 2001). Carbohydrate, determined by difference, presented similar statistical values,

Table 1
Chemical composition of legumes (g/100 g)

Raw legumes/freeze-dried cooked legumes						
Legumes	Protein[a]	Lipids	Ash	Crude fibre	Carbohydrates[b]	Moisture
Pea	21.9 ± 1.53^{a}/	2.34 ± 0.01^{b}/	3.00 ± 0.03^{cb}/	10.4 ± 2.33^{a}/	52.5 ± 0.04^{a}/	9.88 ± 0.84^{b}/
	23.7 ± 1.58^{a}	2.65 ± 0.07^{b}	3.46 ± 0.24^{b}	8.98 ± 1.37^{a}	58.6 ± 5.21^{a}	2.61 ± 1.34^{b}
Common bean	20.9 ± 1.49^{ab}/	2.49 ± 0.22^{b}/	3.80 ± 0.27^{a}/	8.55 ± 3.31^{b}/	54.3 ± 2.94^{a}/	9.93 ± 0.42^{b}/
	22.1 ± 2.07^{ab}	2.52 ± 0.09^{b}	4.00 ± 0.24^{a}	6.26 ± 0.45^{b}	59.9 ± 0.57^{a}	5.29 ± 1.84^{a}
Chickpea	18.5 ± 1.74^{b}/	6.69 ± 0.56^{a}/	3.15 ± 0.20^{b}/	9.88 ± 2.11^{a}/	54.0 ± 3.30^{a}/	7.79 ± 0.85^{c}/
	21.3 ± 0.73^{b}	6.73 ± 0.63^{a}	3.48 ± 0.03^{b}	8.50 ± 0.55^{a}	57.8 ± 2.11^{a}	2.29 ± 1.09^{b}
Lentil	20.6 ± 0.37^{ab}/	2.15 ± 0.14^{b}/	2.80 ± 0.15^{c}/	6.83 ± 2.42^{c}/	56.4 ± 4.08^{a}/	11.2 ± 0.28^{a}/
	23.44 ± 0.64^{a}	2.36 ± 0.13^{b}	3.12 ± 0.37^{c}	5.69 ± 0.33^{b}	61.8 ± 1.24^{a}	3.63 ± 1.16^{ab}

Different letters in the same column indicate a statistical difference ($p < 0.05$) between legumes in the respective forms (raw or freeze-dried cooked). Data represent means and standard deviations ($n = 6$).

[a] Conversion factor = 5.40.

[b] Determined by difference.

Table 2
Soluble dietary fibre (SDF) and insoluble dietary fibre (IDF) values of legumes (g/100 g)

Raw legumes/freeze-dried cooked legumes	Pea	Common bean	Chickpea	Lentil
IDF	$20.3 \pm 0.40^{a}/22.8 \pm 1.29^{a}$	$19.9 \pm 0.19^{a}/22.6 \pm 0.10^{a}$	$13.9 \pm 0.09^{b}/15.4 \pm 0.18^{b}$	$19.0 \pm 1.27^{a}/21.4 \pm 2.10^{a}$
SDF	$1.73 \pm 0.26^{ab}/2.38 \pm 0.77^{a}$	$2.42 \pm 0.74^{a}/2.60 \pm 0.57^{a}$	$0.00 \pm 0.00^{c}/0.00 \pm 0.00^{b}$	$1.44 \pm 0.11^{ab}/1.37 \pm 0.52^{a}$

Different letters in the same line indicate a statistical difference ($p < 0.05$).
Data represent means and standard deviations ($n = 4$).

accounting for more than 50% of the legume grain composition.

Thermal treatment of legumes (as cooking) makes the consumption of these foods possible. The process considerably decreases naturally existing antinutritional factors, increasing the availability of other nutrients, such as protein and starch (Domene & Oliveira, 1993). Freeze-drying, which is based on the dehydration by sublimation of a frozen product, preserves the food for a longer period of time in comparison with other preservation processes, besides providing lower nutritional loss (Ratti, 2001). As shown in Table 1, the thermal treatment, together with the freeze-drying, resulted in a small increase of nutrient amounts, an exception being raw fibre possibly due to its softening, in accordance with data cited in the literature (Sgarbieri, 1989; Tovar & Melito, 1996).

Table 2 shows values of soluble dietary fibre (SDF) and insoluble dietary fibre (IDF) calculated according to the Asp et al. (1983) method. The SDF amount increased in the freeze-dried cooked legumes compared to the raw ones, for the pea and common bean legumes, which agrees with data presented in studies from Kutoš et al. (2003). Vidal-Valverde and Frias (1991), however, suggest that a softening of soluble fibres occurs with the cooking process, reducing its content. Chickpea once again stood out because no soluble fibre was detected, which might be due to the methodology employed.

Insoluble dietary fibre increased for all freeze-dried cooked legumes in relation to the raw samples, but the IDF result was statistically different ($p < 0.05$) only for chickpea (13.9 ± 0.09 and 15.4 ± 0.18 g/100 g, respectively). Bednar and collaborators (2001) analysed the composition of some foods, including legumes, and observed that IDF represented from 92% to 100% of the total amount of dietary fibre for various beans and 99.7% for lentil. The remaining percentage of this value was composed of the soluble fibre, representing a small part (0.0–3.2%) of the total dietary fibre of these legumes. Li, Andrews, and Pehrsson (2002) also found values of SDF below those of IDF in legumes.

The cooking process can change physico-chemical characteristics of legumes, and freeze-drying increases nutrient concentration; therefore, these factors have an effect on the final amounts. Resistant starch (RS) values shown in Table 3 show alteration in the composition of raw legumes in relation to freeze-dried cooked ones and legumes presented lower AR values after thermal treatment, considering that the average value found was 2.23 ± 0.24 g/100 g, not showing statistical difference ($p > 0.05$).

Table 3
Resistant starch (AR) values of raw and freeze-dried cooked legumes (g/100 g)

Raw legume	AR (g/100 g)	Cooked legume	AR (g/100 g)
Pea	2.45 ± 0.30^{b}	Pea	1.89 ± 0.71^{a}
Common bean	3.72 ± 0.79^{a}	Common bean	2.33 ± 1.23^{a}
Chickpea	3.39 ± 0.96^{ab}	Chickpea	2.23 ± 1.15^{a}
Lentil	3.25 ± 0.42^{ab}	Lentil	2.46 ± 0.16^{a}

Different letters in the same column indicate a statistical difference ($p < 0.05$).
Data represent means and standard deviation ($n = 6$).

Kutoš et al. (2003) evaluated common bean (*Phaseolus vulgaris* L.) resistant starch amounts in raw samples submitted to different processing methods and verified that the amount found was almost twice higher in raw samples in relation to the samples submitted to soaking and cooking. Differently, Tovar and Melito (1996), when studying the effect of thermal processing in some varieties of raw and cooked (conventionally and at high pressure) beans, found values of RS three to five times greater in the cooked samples. In the studies of Osório-Diaz et al. (2003); Tharanathan and Mahadevamma (2003) and Ratnayake et al. (2001) it was verified that thermal processing induces an increase in RS values, mainly due to amylose retrogradation. The variation in the results could be attributed to the use of different methods of analysis in each study, which underlines the necessity of methodological standardization for obtaining better uniformity of the data.

4. Conclusions

The results indicate the variety of chemical components of legumes. The raw form was used for comparative purposes but the cooked form, as they are ingested, is far more important.

It was clear that, within the studied legumes, chickpea stood out in relation to the others with lipid values two and a half times higher (6.73 ± 0.63 g/100 g in freeze-dried cooked sample) and smaller IDF contents (15.4 ± 0.18%) in relation to the average amount of 22.3 ± 0.75% for peas, beans and lentils. It was verified that IDF contents represented the greatest part of the total dietary fibre of the legumes, SDF being only a small part of the total. From a nutritional point of view, the four types of studied legumes had good nutrient values, with an approximate protein content of 22%. Data suggest the need for more in-depth studies of nutritional quality of this low cost protein source and of the influence of compounds such as fibre and related substances.

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