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The effect of genotype and roasting on the fatty acid composition of peanuts

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ABSTRACT

The impact of two factors, genotype (G) and treatment (raw or roasted peanut) (T), on the chemical composition of peanuts was studied using a chemometric method and Tukey's test. The peanut genotypes evaluated were cultivar cavalo vermelho (CCV), cultivar cavalo rosa (CCR) and cultivar tatu (CTA), in both raw and roasted states. The total lipid contents in the CTA and CCR peanuts were 40 and 45%, respectively. These values did not vary significantly ($P<0.05$) after roasting. CCV had the greatest total lipid content, but it decreased significantly after roasting (from 50% to 45%). The variation in the percentage of lipids in the CCV and CCR genotypes was not significant, in contrast to the CTA genotype. The fatty acid (FA) 18:1n−9 predominated in the CCR and CCV samples (50%), without any difference between their raw genotypes. The values for FA 18:1n−9 were lower in the CTA peanut (40%). The second most abundant FA was 18:2n−6 (CCV = 28%, CTA = 38% and CCR = 25%), followed by 16:0 (CCV and CCR = 16% and CTA = 11%). The other FAs found in the peanuts were 18:0, 20:0, 22:0, 24:0, 20:1n−9 and 18:3n−3. The contents of FAs 18:1n−9, 16:0, 20:0, and 20:1n−9 suffered significant reduction after roasting in all genotypes. ANOVA analysis of the influence of the main factors indicated that the contribution of the T variable for the majority of responses was low, being between 0.2 and 13%, except for FAs 16:0 and 18:3n−3 and for the saturated FA summations, which were 38, 60 and 22%, respectively. There was a significant contribution from the G factor for all responses, with values between 17 and 99%. The contribution of the interaction between the T and G factors was greater for the responses n6/n3 (56.6%) and for the FA 16:0 (23%). The other responses had values between 0.02 and 14%.

1. Introduction

The peanut (*Arachis hypogaea* L.), which belongs to the legume family, produces small, bright yellow flowers, and a subterranean pod, the fruit, containing two edible seeds. A large part of the peanut world production is used for human consumption, as a raw ingredient for processed foods, such as peanut butter and savory snacks, and produce oil and flour (Kaya et al., 2009; Nakai et al., 2008; Passone, Funes, Resnik, & Etcheverry, 2008). In Brazil, peanuts are commonly used to produce a variety of sweets and savory snacks (Gorayeb, Casciatori, Del Bianchi, & Thoméo, 2009).

Peanut seeds are of high nutritional and commercial value due to their protein, fatty acid, carbohydrate, fiber contents, besides vitamins, calcium, and phosphorous (Nakai et al., 2008). According to Andersen, Hill, Gorbet, and Brodbeck (1998), this food is made up of 44–56% oils and 22–30% protein, thus being an excellent source of energy (564 kcal/100 g). However, Han, Bourgeois, and Lacroix (2009), reported approximately 40–55% lipid content in peanuts, varying with the genotype and the seasonal conditions under which they were grown.

In addition, there has been a worldwide increase in the search for vegetal protein sources (Aidoo, Sakyi-Dawson, Tano-Debra, & Saalia, 2010) with balanced amino acid profiles (Wu, Wang, Ma, & Ren, 2009). As human beings, as well as the majority of animals, cannot synthesize ten types of amino acids, they must be obtained through the diet (Andersen et al., 1998). The high cost of animal protein is an obstacle to the access to these nutrients by developing countries populations (Wu et al., 2009). Peanuts have high levels of protein that this is more readily available when compared with protein from other sources (Mutegi, Ngugi, Hendriks, & Jones, 2009).

Edible oils and fats are essential nutrients in the human diet and play a vital role in the supply of essential fatty acids and energy. In addition to their nutritional qualities, the oils and fats contribute consistency and specific binding characteristics to the products that contain them. The lipids also affect the structure, stability, taste, aroma, storage quality and sensory and visual characteristics of the foods. Chemically, oils and fats are predominantly composed of triacylglycerols (Ribeiro, Moura, Grimaldi, & Gonçalves, 2007).

The linoleic fatty acids (belonging to the omega-6 family of fatty acids) and α-linolenic fatty acids (belonging to the omega-3 family of fatty acids) are considered essential, as they cannot be synthesized by mammals and must be obtained from food (Moreira & Mancini Filho, 2004). According to Ribarova, Zanev, Shishkov, & Rizov, 2003, polyunsaturated fatty acids must make up 7–10% of the total energy

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ingested for an adequate diet as far the correct ingestion of lipids is concerned.

Furthermore, omega-3 family of fatty acids may have a positive effect in the treatment of depression and schizophrenia (Schram et al., 2007).

Knowing that oily seeds play a role in disease prevention, and considering their nutritional importance, as well as the difference in the composition of nutrients in seeds due to environmental conditions, genotype, and type of treatments (raw or roasted peanut), this study had the objective of investigating the effect of two factors, the genotype and the type of treatments, on the chemical composition of the peanuts, using a chemometric method.

2. Material and methods

2.1. Sampling

Samples of peanut of three genotypes with common names cultivar cavalo vermelho (CCV), cultivar cavalo rosa (CCR) and cultivar tatu (CTA) were used. They were grown in the Maringá, Paraná State region in the same period and were purchased on the local market.

About 200 g of peanut samples of each genotype were divided into two equal parts, one was roasted in a domestic oven at 200 °C for 50 min, and the other was kept *in natura*. The skin was retained on the two parts of each genotype. The peanuts were prepared for analysis by grinding 100 g of each sample in a food processor (*Philips — Walita*) until complete homogenization (until obtain homogeneous paste), and then they were vacuum packed and stored frozen in the dark until analysis.

2.2. Lipid extraction

The total lipids were extracted according to Bligh and Dyer (1959), using *ca* 3.50 g of sample, and adding 12.0 mL of water to correct the moisture.

2.3. Fatty acid esterification

The fatty acid methyl esters were prepared as described by Martin, Oliveira, Visentainer, Matsushita, and Souza (2008), and stored at −18 °C for subsequent analysis.

2.4. Chromatographic analysis of the fatty acid methyl esters

The fatty acid methyl esters were separated in a CP-3380 gas chromatograph (Varian, USA) equipped with software Star, flame ionization detector, and fused silica capillary column CP-7420 (i.d., 100 m, 0.25 mm and 0.39 μm 100% bonded cyanopropyl, Varian, USA). The samples were analyzed under the following chromatographic conditions: gas flow rate of 1.4 mL min^{-1} for the carrier gas (H_2); 30 mL min^{-1} for the auxiliary gas (N_2), and 30 and 300 mL min^{-1} for H_2 and the flame synthetic air, respectively. The sample split ratio was 1/80. The injections were performed in triplicate in volumes of 2.0 μL. The fatty acids were identified by comparing the retention times of methyl esters in a standard mixture containing the geometric isomers of linoleic and alpha-linolenic acids (Sigma FAMEs) and the equivalent chain lengths (ECL), following the method described by Visentainer and Franco (2006).

2.5. Quantification of fatty acid methyl esters

Fatty acid methyl esters (FAMEs) were quantified in relation to internal standard methyl tricosanate (23:0), with a concentration of 1.0 mg mL^{-1} in isooctane. The internal standard was added to the esterification tube and the solvent was evaporated under nitrogen flow. The sample was weighed in the same tube. Eq. (1) was used to determine the quantity of the fatty acids identified in the samples, in milligrams $gram^{-1}$ of sample (Visentainer & Franco, 2006):

$$M_X = \frac{A_X \cdot M_P \cdot F_{CT}}{A_P \cdot M_A \cdot F_{CEA}} \quad (1)$$

where:

M_x = Mass of fatty acid X in mg/g of sample.
M_P = Mass of the internal standard in milligrams.
M_A = Mass of the sample in grams.
A_X = Area of the fatty acid X.
A_P = Area of the internal standard.
F_{CT} = Theoretical correction factor.
F_{CEA} = Factor of conversion of fatty acid methyl esters.

2.6. Experimental design

In this study, the influence variables genotype (G) and treatments (T) on the lipid content (% m/m) and the contents of 8 of the 9 fatty acids present in the samples, as well as the summation of monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), saturated fatty acids (SFA), and the ratios PUFA/SFA and fatty acids of the n6 family to fatty acids of the family n3 (n6/n3) were evaluated with a 3×2 factorial design. The three genotype variables were cultivar cavalo vermelho (CCV), cultivar cavalo rosa (CCR) and cultivar tatu (CTA) and the two treatment variables were raw and roasted. Table 1 gives the values of each variable. Six duplicate experiments were conducted, as given in Table 2.

2.7. Statistical analysis

Initially, all variables had their normality and homogeneity of variance assessed by the residual plots. Then, analysis of variance (ANOVA Two-way between groups) and Tukey's test were performed for all the answers. *P*-value below 0.05 was considered significant. To evaluate the effect of independent variables on the responses, the response surface methodology (RSM) was applied. The basic model equation used to fit the data was:

$$E(y) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_{11} x_1^2 + \beta_{22} x_2^2 + \beta_{11} x_1 x_2 \quad (2)$$

where: $E(y)$ is the expected response, β_0 is a constant, β_1, β_2, β_{11}, β_{22} and β_{12} are the regression coefficients, and x_1, x_2 are the levels of independent variables (Granato, Bigaski, Castro & Masson, 2010). The equations for each model along with their coefficients of determination (R^2) are listed in Table 3.

3. Results and discussion

A preliminary test was conducted with raw and roasted CCV peanut, both with and without skin, with the objective of investigating through statistical analysis (Tukey's test) the influence of the peanut skin on the centesimal composition, as well as in its fatty acid profile and contents.

Table 1
Fixed genotype and treatments form.

Factor	Symbol	Levels		
		1	2	3
Genotype	G	CCV	CCR	CTA
Treatment	T	Raw	Roasted	–

G, genotype; T, treatment.
CCV, cultivar cavalo vermelho; CCR, cutivar cavalo rosa; CTA, cultivar tatu.