Evaluation of the Potential of Brazilian non-conventional edible plants (NCEP) as Sources of Mineral Elements. Development of sample preparation methods and it's application.

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RESUMO

Some Brazilian plant species with food and nutritional potential are still little known or studied. NCEP (non-conventional edible plants) are important examples of these plants, as they are easy to cultivate. In this sense, NCEP have aroused interest as potential sources of minerals, capable of supplying macro and/or micronutrients, such as Calcium and Iron. Therefore, this study proposes the determination and quantification of Ca and Fe contents in the following NCEP: Xanthosoma sagittifolium (Taioba), Basella alba (Bertalha), Amaranthus viridi (Caruru), Stachys byzantina (Peixinho da Horta) and Pereskia aculeata (Ora Pro Nobis), using Flame Atomic Absorption and Emission Spectrometry (F AAS and F AES). For this purpose, a design experiment was applied to optimize the sample preparation and analysis using a 2^{5-1} fractional factorial design. To obtain results that effectively represent the best experimental conditions, the investigated factors were: [1]Ultrasonic-Assisted Extraction (UAE) Time, [2]Heating, [3]Reagent Mixture, [4]Presence of Chelating Agent, and [5]Spectrometric Technique. The established method was validated for Ca quantification and studied for Fe determination under the same extraction conditions. Additionally, UAE was compared with samples subjected to calcination in a muffle furnace (reference method), showing good agreement. The fractional factorial design indicated that the interaction between Extraction Time and Heating had the most significant effect, positively influencing Ca extraction. The obtained results for this analyte ranged from 46.60 to 59,60 mg/100g of Ca, suggesting that these samples may serve as a source of this mineral.The proposed method proved to be effective for extraction and quantification of macroelements (Ca), and can also be applied for analysis of microelements (Fe), obtaining values between 3.06 to 13.76 mg/100g of Fe. Furthermore, complementary studies on antinutrient levels, such as oxalate, are being conducted to better evaluate the nutritional potential of these plants.

Palavras-chave: NCEP, Quantification, Mineral Elements, Atomic Spectrometry, Sample Preparation, Experimental Design.

Introdução

Brazil has a wide plant biodiversity, including species that have not been explored by their nutritional potential, such as Non-Conventional Edible Plants (NCEP)(1,2). In addition to contributing to food security, these species can be affordable alternatives to supply deficiencies of essential minerals, such as calcium (3,4), whose inadequate intake affects a large part of the Brazilian population (6-9). Difficulties such as lactose intolerance, cost, and eating habits limit the consumption of traditional sources of this mineral (10-12). However, in addition to the presence of calcium, it is necessary to evaluate compounds that may interfere with its absorption, such as oxalates (13). In this scenario, the need for robust and optimized analytical methodologies to determine these constituents in NCEP stands out, such as the use of factorial design and chemometric tools (14-16). Thus, this work aims to develop an analytical method for quantifying the content of calcium, a macroelement, and subsequent use also for analysis of microelements, such as iron, in five NCEP species, namely Xanthosoma sagittifolium (Taioba), Basella alba (Bertalha), Amaranthus viridis (Caruru), Stachys byzantina (Peixinho-da-horta) and Pereskia aculeata (Ora-pro-nóbis) using spectrometric techniques, with optimization of preparation conditions through fractional factorial design 2^{5-1}.

Experimental

Sample preparation followed a protocol optimized by fractional factorial design 2^{5-1}, in which five variables (spectrometric technique, extraction time, heating, reagent mixture and use of chelating agent) were evaluated at two levels of variation. The samples were oven-dried, pulverized and weighed as a pre-treatment. Subsequently, the samples were subjected to ultrasound-assisted extraction with the reagent mixture, time, chelating agent and heating already defined by the fractional factorial design. Finally, the extracts were filtered and analyzed according to the previously established technique.

Resultados e Discussão

The calcium levels determined in the analyzed plant samples varied from 40.60 to 59.60 mg/100 g, with the species Pereskia aculeata (Ora-pro-nóbis) presenting the highest average content, demonstrating itself as a potential alternative source of this mineral. As for iron, the concentrations ranged from 3.06 to 13.76 mg/100 g, with Amaranthus viridis (Caruru) standing out as the species with the highest content of the element, which corroborates its relevant nutritional potential. These results between species are systematized and visually compared in Figure 1. The efficiency of sample preparation by Ultrasound-Assisted Extraction (UAE) was evaluated through a comparative study with the classical method of calcination in a muffle furnace, traditionally used for the complete mineralization of plant samples. The calcium concentrations obtained by both approaches presented similar values, with the average content obtained from the ashes being 39.38 mg/g, while the UAE method resulted in 35.41 mg/g. Despite this small difference, the statistical analysis performed by the t-test for independent samples indicated that such variation is not statistically significant at the 95% confidence level ($p = 0.0031 <$ critical t), demonstrating the equivalence of the methods in terms of extraction efficiency. The Ultrasound Assisted Extraction (UAE) sample preparation methodology demonstrated satisfactory performance, presenting calcium recoveries between 87% and 109%, with relative standard deviations (RSD) below 5%, values that meet the criteria established in the literature for robust and reproducible analytical methods. It is also worth noting that the ultrasound-assisted procedure has significant operational advantages, such as shorter preparation time, reduced energy consumption and less exposure of analytes to extreme temperature conditions, factors that make the method more attractive from a technical, economic and environmental point of view.

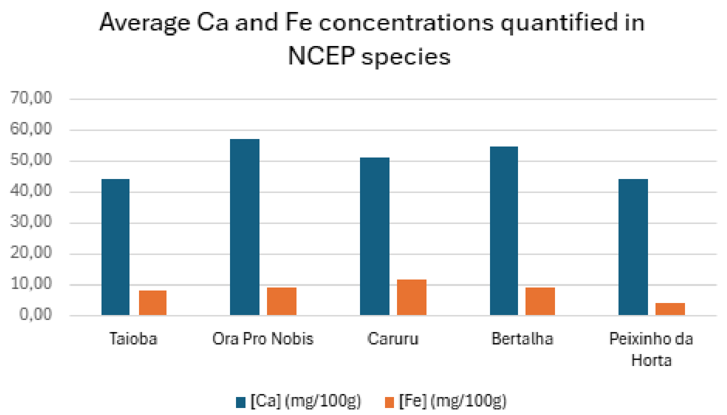

Figure 1. Average Calcium and Iron concentrations quantified in NCEP species

Conclusões

The results demonstrate that UAE is an efficient and reliable alternative for preparing plant samples for calcium quantification, meeting the precision and accuracy requirements required for analyzing macronutrient minerals. Furthermore, it is possible to expand the application of this method to trace elements such as iron.

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