Note

ELEMENTAL CONTENTS IN EXOTIC BRAZILIAN TROPICAL FRUITS EVALUATED BY ENERGY DISPERSIVE X-RAY FLUORESCENCE

Alessandra Lopes de Oliveira[1]*; Eduardo de Almeida[1]; Fernanda Bevilácqua Rodrigues da Silva[1]; Virgílio Franco Nascimento Filho[2]

[1]*USP/FZEA, C.P. 23 - 13635-900 - Pirassununga, SP - Brasil.*
[2]*USP/CENA, C.P. 96 - 13400-961 - Piracicaba, SP - Brasil.*
**Corresponding author <alelopes@usp.br>*

ABSTRACT: The exotic flavor of Brazilian tropical fruits led to increased consumption. Consumers awareness regarding balanced diets, makes necessary determining nutritional composition - vitamins and minerals – of the fruits ordinarily consumed. This study contributed to the evaluation of macro (K, Ca) and microelements (Mn, Fe, Cu, Zn and Br) in eight exotic Brazilian tropical fruits: "abiu" (*Lucuma caimito* Ruiz & Pav.), "jenipapo" (*Genipa americana* L.), "jambo rosa" (rose apple, *Eugenia Jambos* L.), "jambo vermelho" (*Syzygium malaccence* L., Merr & Perry), "macaúba" (*Acrocomia aculeata* Jacq. Lood. Ex Mart.), "mangaba" (*Hancornia speciosa*), "pitanga" (Brazilian Cherry, *Eugenia uniflora* L.), and tamarind (*Tamarindus indica* L.), using the Energy Dispersive X-Ray Fluorescence (EDXRF) technique. "jambo vermelho" and "macaúba" presented the highest values of K concentrations, 1,558 and 1,725 mg 100 g^{-1}, respectively. On the other hand, Ca concentrations were highest in "macaúba" (680 mg 100 g^{-1}) and "jenipapo" (341 mg 100 g^{-1}). The microelemental concentrations in these eight fruits ranged from: 0.9 to 2.0 mg 100 g^{-1} for Mn, 3.9 to 11.4 mg 100 g^{-1} for Fe, 0.5 to 1.0 mg 100 g^{-1} for Cu, 0.6 to 1.5 mg 100 g^{-1} for, Zn and 0.3 to 1.3 mg 100 g^{-1} for Br. The amounts of macro and microelements in the eight fruits analyzed were compared to other tropical fruits and it was found that some of them could be classified as rich sources for these macro and microelements.
Key words: EDXRF, microelements, macroelements, chemical analyses.

COMPOSIÇÃO MINERAL DETERMINADO POR FLUORESCÊNCIA DE RAIOS-X DISPERSIVA DE ENERGIA DE FRUTOS EXÓTICOS TROPICAIS BRASILEIROS

RESUMO: O sabor exótico dos frutos tropicais brasileiros vem contribuindo para o aumento de seu consumo. Ao se considerar a busca por uma alimentação balanceada, por consumidores cada vez mais exigentes, o conhecimento da composição de vitaminas e sais minerais dos frutos que compõe a dieta se faz necessário. Desta forma o presente trabalho vem contribuir com a determinação da concentração de macro (K e Ca) e microelementos (Mn, Fe, Cu, Zn e Br) em oito frutos tropicais exóticos brasileiros: abiu (*Lucuma caimito* Ruiz & Pav.), jenipapo (*Genipa americana* L.), jambo rosa (rose apple, *Eugenia jambos* L.), jambo vermelho (*Syzygium malaccence* L., Merr & Perry), macaúba (*Acrocomia aculeata* Jacq. Lood. Ex Mart.); mangaba (*Hancornia speciosa*), pitanga (Brazilian Cherry, *Eugenia uniflora* L.) e tamarindo (*Tamarindus indica* L.) através da técnica de fluorescência de raios X por dispersão de energia. Jambo vermelho e macaúba apresentaram altas concentrações de K, 1.558 e 1.725 mg 100 g^{-1}, respectivamente. Por outro lado, as concentrações de Ca foram maiores na macaúba (680 mg 100 g^{-1}) e jenipapo (341 mg 100 g^{-1}). As concentrações em microelementos nestes oitos frutos variaram: de 0,9 a 2,0 mg 100 g^{-1} para Mn, de 3,9 a 11,4 mg 100 g^{-1} para o Fe, de 0,6 a 1,5 mg 100 g^{-1} para o Zn e de 0,3 a 1,3 mg 100 g^{-1} para o Br. As quantidades destes elementos nos oito frutos analisados foram comparadas com outros frutos tropicais e pode-se constatar que alguns deles podem ser classificados como fontes ricas em minerais.
Palavras-chave: EDXRF, microelementos, macroelementos, análise química

INTRODUCTION

Fruits and vegetables are nutrient suppliers, acting on the metabolism of several functions in the human organism, and their main nutrients (minerals and vitamins) influence the performance of these func-

tions. Hence, studies about the mineral composition of Brazilian foods are relevant, especially those concerning exotic tropical fruits, because of the scarce data on their composition in the literature concerning.

The macro and microelemental composition of well-known tropical fruits such as banana, sweet lime, African pear, orange, passion fruit and others have been reported (Eromosele et al., 1991; Aremu & Udoessien, 1990; Burguera et al., 1992; Oliva & Valdes, 2003; Glew et al., 2003). On the other hand, data on mineral composition of exotic tropical fruits are scarce. A sole example is Marx et al. (1998), who have studied the "Cubiu" (*Solanum sessiliflorum*), a typical fruit from the Amazon region.

The exotic Brazilian tropical fruit market, once restricted to local areas, has increasingly expanded to the metropolitan centers. Thus, information on the nutritional value of these fruits is of great importance, since there is a rapidly growing body of literature covering the role of plant metabolites in food and their potential effect on human health.

Considering that consumers are increasingly aware of the need for a balanced diet, which requires previous information on nutrients, the aim of this study was to determine the macro (K and Ca) and microelemental (Mn, Fe, Cu, Zn and Br) concentrations in eight exotic Brazilian tropical fruits: "abiu", "jenipapo", "jambo rosa" (rose apple), "jambo vermelho", "macaúba", "mangaba", "pitanga" (Brazilian cherry) and "tamarindo" (tamarind), using the Energy Dispersive X-Ray Fluorescence (EDXRF) analytic technique. Although the mineral fruit composition depends on the soil, the aim of this study was to verify the mineral composition of fruits obtained from the largest supplying center of South America (CEASA).

MATERIAL AND METHODS

Sample preparation

Fruits cultivated in different regions of Brazil ("abiu", "macaúba" and "tamarindo" from the State of São Paulo; "jambo rosa", "jambo vermelho" and "pitanga" from the State of Pernambuco; "mangaba" from the State of Mato Grosso and "jenipapo" from the State of Rio Grande do Norte) were obtained from the largest suppling center of South America - Centrais de Abastecimento de São Paulo (CEASA), São Paulo, SP, Brazil. Pulps were separated manually from fruits and frozen at -18ºC, dried in an oven at 80ºC following the Burguera et al. (1992) procedure, and then ground (Bühler-Miag, Germany). One gram of each sample (n = 3) was pressed manually (Parr Instrument Co., USA) in a plastic vial with Mylar (6.3 μm thickness) in the bottom and then analyzed immediately.

Elemental content

The elemental concentration was determined by the Energy Dispersive X-Ray Fluorescence (EDXRF) technique (Nascimento Filho, 1999). The excitation was done with Mo-Kα X-rays (17.44 keV) from a Mo target X-ray tube with Zr filter, operated at 45 kV and 20 mA.

Samples were excited for 200 s and the Kα characteristic X-rays were detected by a multichannel spectrometer, based on a Si(Li) semiconductor detector and conventional nuclear electronics. AXIL software (Van Espen et al., 1977) was used to interpret the spectra, obtaining the characteristic Kα X-ray intensities.

The fundamental parameter method was adopted for determining the elemental concentrations, using X-ray intensities and taking into account the matrix effect (Nascimento Filho, 1999). This methodology was validated by analyzing a certified reference sample (hay powder, V-10), produced by the International Agency of Atomic Energy, Vienna.

RESULTS AND DISCUSSION

The K concentrations in the fruits ranged from 691 to 1,725 mg 100 g^{-1}; "jambo vermelho" and "macaúba" presented higher values, 1,558 and 1,725 mg 100 g^{-1}, respectively (Table 1). These fruits can be indicated as K rich food, along with banana (*Musa parasidiaca*) and passion fruit (*Passiflora edulis* f. flavicarpa), with 1,914 and 1,502 mg 100 g^{-1}, respectively (Aremu & Udoessien, 1990; Burguera et al., 1992).

Calcium (Ca) concentration in some tropical fruits from Venezuela range from 400 to 1,200 mg 100g^{-1}, with the highest level attributed to "zapote" (*Colocarpum sapota* Jacq. Merr.) (Burguera et al., 1992). Fig (*Ficus carica* L.) is also considered a Ca-rich fruit and present 133 mg 100 g^{-1} (Zook, 1968). In this study, "jenipapo" and "macaúba" showed elevated Ca concentrations, 341 and 680 mg 100g^{-1}, respectively, which is higher than the fig. Thus, these fruits could be identified as potential sources of calcium in the human diet.

Manganese (Mn) concentrations ranged from 0.9 to 2.0 mg 100 g^{-1} in the eight analyzed fruits, with the highest level attributed to "macaúba". Other tropical fruits, such as star fruit (*Averrhoa carambola* L.), with 4.0 mg 100 g^{-1}, and guava (*Psidium guajara* L.), 3.0 mg 100g^{-1} (Burguera et al., 1992) also present high concentration of this element.

On the other hand, Fe concentrations ranged from 3.9 to 11.4 mg 100 g^{-1}, with "jambo rosa" and "macaúba" showing the highest concentrations, 11.4

Table 1 - Macro and microelemental concentrations (mean ± standard error) in exotic Brazilian tropical fruits, analyzed in triplicate.

Elements	"mangaba"	"menipapo"	"pitanga" (Brazilian cherry)	"tamarindo" (tamarind)	"abiu"	"jambo rosa" (rose apple)	"jambo vermelho"	"macaúba"
---------- mg 100 g^{-1} (edible dry fruit) ----------								
K	1.030 ± 10	1.003 ± 47	806 ± 12	691 ± 13	731 ± 86	803 ± 26	1.588 ± 56	1.725 ± 80
Ca	130 ± 12	341 ± 33	191 ± 14	111 ± 16	107 ± 18	199 ± 42	263 ± 40	680 ± 69
Mn	1.5 ± 0.8	1.0 ± 0.8	0.9 ± 0.4	1.4 ± 0.4	1.2 ± 0.6	1.5 ± 0.6	10.0 ± 5.0	20.0 ± 2.0
Fe	7.9 ± 2.6	7.1 ± 0.3	5.2 ± 0.1	3.9 ± 0.5	5.5 ± 0.7	11.4 ± 0.4	86.0 ± 14.0	101.0 ± 14.0
Cu	0.6 ± 0.0	0.5 ± 0.1	0.6 ± 0.1	0.6 ± 0.1	0.6 ± 0.1	0.5 ± 0.1	8.0 ± 0.0	10.0 ± 3.0
Zn	0.9 ± 0.1	0.7 ± 0.0	1.2 ± 0.1	0.6 ± 0.1	0.8 ± 0.1	0.7 ± 0.2	15.0 ± 1.0	15.0 ± 2.0
Br	0.4 ± 0.1	nd	nd	nd	1.0 ± 0.1	1.3 ± 0.1	3.0 ± 1.0	8.0 ± 1.0

and 10.1 mg 100 g^{-1}, respectively. These levels are similar to those of the African pear (*Pachylobus edulis*), sweet lime (*Citrus aurantifolia)* and orange (*Citrus sinensis*) (Aremu & Udoessien, 1990). Star fruit, guava and "acerola" (*Malpiphia glabra* L.) are also very rich sources of this element (Burguera et al., 1992).

"Macaúba" had the highest Cu content, 1.0 mg 100 g^{-1}. "jambo vermelho" showed 0.8 mg 100g^{-1}, lower than those reported - 2.0 mg 100 g^{-1} - by Burguera et al. (1992). All exotic fruits studied had lower Cu concentrations than the well-known banana with 2.7 mg 100 g^{-1} (Aremu & Udoessien, 1990).

Zinc (Zn) concentrations ranged from 0.6 to 1.5 mg 100 g^{-1}, with "jambo rosa", "macaúba" and "pitanga" presenting the highest values, 1.5, 1.5 and 1.2 mg 100 g^{-1}, respectively. Other tropical fruits such as "graviola", "acerola" and passion fruit show concentrations from 3.0 to 4.0 mg 100 g^{-1} (Burguera et al., 1992).

The highest Br contents were 1.0 and 1.3 mg 100 g^{-1} from "abiu" and "jambo rosa", respectively. No Br content was detected in "jenipapo", "pitanga" or "tamarindo".

Elements with atomic numbers lower than 19 (K) were not analyzed due to the low energy of their characteristic X-rays and due to strong auto-absorption by the sample and by the air between detector and sample. To determine the elements with Z<19, such as Mg, P, and S, it is necessary to carry out the excitation/detection under either vacuum or He atmosphere.

CONCLUSIONS

The macro (K and Ca) and micro elemental (Mn, Fe, Cu, Zn and Br) content in exotic fruits were within ranges of common tropical fruits. Energy Dispersive X-ray Fluorescence (EDXRF) is a promising technique for the analysis of fruits.

REFERENCES

AREMU, C.Y.; UDOESSIEN, E.I. Chemical estimation of some inorganic elements in selected tropical fruits and vegetables. **Food Chemistry**, v.37, p.229-234, 1990.

BURGUERA, J.L.; BURGUERA, M.; BECERRA, G.M.G. Mineral content of some fruits from Venezuela. **Revista Española de Cincia y Tecnologia de Alimentos**, v.32, p.667-672, 1992.

EROMOSELE, I.C.; EROMOSELE, C.O.; KUZHKUZHA, D.M. Evaluation of mineral elements and ascorbic acid contents in fruits of some wild plants. **Plant Food for Human Nutrition**, v.41, p.151-154, 1991.

GLEW, R.H.; AYAZ, F.A.; VANDERJAGT, D.J.; MILLSON, M.; DRIS, R.; NISKANEN, R. A research note mineral composition of medlar (*Mespilus germanica*) fruit at different stages of maturity. **Journal of Food Quality,** v.26, p.441-447, 2003.

MARX, F.; ANDRADE, E.H.A.; MAIA, J.G. Chemical composition of the fruit of *Solanum sessiliforum*. **Zeitschrift fur Lebensmittel-Undersuchung Und-Forschung A-Food Research and Techonology**, v.206, p.364-366, 1998.

NASCIMENTO FILHO, V.F. Técnicas analíticas nucleares de fluorescência de raios X por dispersão de energia (EDXRF) e por reflexão total (TXRF). Piracicaba: Depto. de Ciências Exatas; CENA, Laboratório de Instrumentação Nuclear, 1999. 32p. Available in: <http://www.cena.usp.br/apostilas/Virgilio/CEN-5723/EDXRF_TXRF.doc>. Accessed: 08 Mar. 2004.

OLIVA, S.R.; VALDES, B. Metal concentrations in Seville orange (*Citrus aurantium*) fruits from Seville (Spain) and Palermo (Italy). **Annales Botanici Fennici**, v.40, p.339-344, 2003.

VAN ESPEN, P.; NULLENS, H.; ADAMS, F.A. Computer analysis of X-ray fluorescence spectra. **Nuclear Instruments and Methods**, v.142, p. 243-250. 1977.

ZOOK, E.G. Mineral composition of fruits. **Journal of The American Dietetic Association**, v.53, p588-591, 1968.

Received October 13, 2004
Accepted December 19, 2005