Journal of Food Composition and Analysis 48 (2016) 34–40

Contents lists available at ScienceDirect

Journal of Food Composition and Analysis

journal homepage: www.elsevier.com/locate/jfca

Original research article

Subtropical fruits grown in Spain and elsewhere: A comparison of mineral profiles

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ARTICLE INFO

Article history:
Received 7 September 2015
Received in revised form 9 December 2015
Accepted 22 December 2015
Available online 3 February 2016

Keywords:
Subtropical fruits
Food analysis
Food composition
Mineral composition
Potassium
Calcium
Sodium
Phosphorous

ABSTRACT

Large quantities of essential minerals are present in subtropical fruits, which constitute a valuable, if relatively unknown, source of dietary micronutrients, and consumption of these foods is tending to increase. Our aim in this study was to investigate the mineral composition (Ca, P, Na and K) of Spanish-grown subtropical fruits in comparison with that of similar fruits sourced elsewhere. The contribution of these fruits to total daily mineral intake per capita in Spain and to mineral intake per regular fruit size was also estimated. The results obtained showed the mineral content of the Spanish-origin samples to be comparable to that of those from other countries, except for avocados, in which the concentrations of P and K were noticeably higher in the non-Spanish fruits (530 *vs.* 196 and 5260 *vs.* 3664 mg/kg, respectively). The contribution of subtropical fruits to daily mineral intake in adults was estimated to be 2–7% for Ca and P, approximately 10% for K and negligible for Na. In conclusion, subtropical fruits of Spanish origin present a balanced mineral composition and the consumption of these fruits is recommended as a means of increasing the intake of essential minerals (especially in a population such as that of Spain, where there is considerable room for improvement in dietary patterns).

1. Introduction

Many studies have demonstrated that the consumption of fruits and vegetables is associated with improved human health. Thus, individuals who eat five or more daily servings of fruits and vegetables have a decreased risk of developing a wide variety of cancer types, particularly those of the gastrointestinal tract (Gescher et al., 1998). Other studies have shown that fruits and vegetables alleviate the effects of Alzheimer's disease (Planas et al., 2004), diabetes, obesity and metabolic syndrome (Devalaraja et al., 2011), due to the bioactive components in these foods. It has also been reported that the consumption of kiwifruit can lower blood triglyceride levels by 15%, compared with a control group (Duttaroy and Jorgensen, 2004). The latter study also reported that consuming two or three kiwifruits per day for 28 days reduces the platelet aggregation response to collagen. Similarly, the consumption of mango, among other fruits, provides significant amounts of bioactive compounds with antioxidant effects (Liu, 2003). In general, exotic fruits have several bioactive components with potential health benefits, including anti-diabetic, anti-obese, anti-oxidant and anti-inflammatory activities (Dembitsky et al., 2011). In this study, therefore, we provide a detailed description of these fruits, as an essential first step in assessing their content of nutrients and bioactive components (Samadi-Maybodi and Shariat, 2003; Montoya et al., 2016).

Mineral micronutrients are involved in numerous biochemical processes and an adequate intake of these minerals is essential to the prevention of deficiency-related diseases (Leterme et al., 2006). The risk of nutritional deficiency, and of associated pathologic conditions, depends on a wide range of factors, including the magnitude of dietary intake, processing practices, the presence of substances that could reduce or increase mineral bioavailability, and the physiologic and health condition of the individual (Barberá et al., 1992). For example, calcium is very important in human nutrition due to its direct relationship with bone mass (Shim and Kim, 2015), while inadequate potassium and sodium intake are both related to the development of hypertension (Perez and Chang, 2014). In this sense, kiwifruit has been demonstrated to decrease bone resoption (Katsumata et al., 2015). Although diets high in fruits and vegetables are rich in vitamins, minerals and dietetic fibre, and are directly linked to a

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http://dx.doi.org/10.1016/j.jfca.2016.02.001
0889-1575/

decreased risk of disease, in the last 30 years their global consumption has decreased (Retamales, 2011). Thus, in Spain, fruit intake per capita (Ministerio de Agricultura, Alimentación y Medio Ambiente, 2014) during 2014 was 284 g/day, well below the 400 g/day recommended by FAO and WHO (FAO/WHO, 2003). Therefore, greater consumption of fruits and vegetables should be encouraged.

Tropical fruits are rich in various mineral species, and so they constitute an important source of these micronutrients (Galán, 2006). Tropical fruit crops are commonly produced in the geographical zone extending from latitudes 30° south to 30° north, where climatic conditions are appropriate, with average temperatures of around 27 °C, low differences in photoperiod and high levels of humidity (Almeida et al., 2009). Subtropical zones, on the other hand, have hotter summers and colder winters, greater differences in photoperiod and less humidity. In Spain, regions such as the Canary Islands and parts of Andalusia fall into this category, where weather conditions are suitable for the cultivation of subtropical fruits (Galán and Ferré, 2005). One such area is that of the "Tropical Coast", which straddles the provinces of Granada and Málaga, and contains the towns of Almuñécar, Itrabo, Jete, Lentejí, Los Guájares, Molvízar, Motril, Salobreña, Otívar, Benaudalla and Vélez (in western Granada province) and those of Algarrobo, Frigiliana, Nerja, Torrox and Vélez-Málaga (in eastern Málaga province) (Diputación de Granada, 2007).

The aim of this study is to investigate the mineral micronutrient composition of a group of subtropical fruits grown in the above area of southern Spain, and to compare it with the corresponding composition of imported counterparts, marketed in the same region, to determine the influence of the origin and type of fruit in this respect. We also analyse the contribution of the daily consumption of these fruits to overall mineral intake, and the contribution per regular fruit size. Therefore, because of the increased consumption of these fruits in Spain, they become a god source of minerals in the daily diet.

2. Materials and methods

2.1. Sampling

The following fruits were supplied, at the optimal point of maturation, by local farmers: custard apple (*Annona cherimola,* Mill., $n = 17$), avocado (*Persea Americana* Mill., var *Hass,* $n = 10$, and var *Carmero,* $n = 10$), kiwifruit (*Actinidia deliciosa* cv Hayward, $n = 13$), mango (*Mangifera indica* L., $n = 24$), papaya (*Carica papaya* L., $n = 10$), persimmon (*Diospyros kaki* L., $n = 8$) and starfruit (*Averrhoa carambola* L., $n = 8$). These samples were brought to the laboratory on the same day they were harvested. Physical information such as initial weight per piece or length were recorded, and the samples were then stored at 4 °C until the moment of processing. The same types of fruits ($n = 5$ each type), but of international origin (from Brazil, Costa Rica, Ecuador, Colombia and New Zealand), were purchased in local markets along the Granada–Málaga coast, in order to obtain fruits grown in different climatic conditions. The samples were treated in the same way as the local fruits.

2.2. Processing

Each fruit was peeled with a steel knife and voided of all inedible parts (peel and stone); only the pulp was considered for analysis. The pulp of each fruit item was cut into small pieces, frozen to −80 °C, and submitted to lyophilisation (Telstar LYOQUEST −80, Madrid, Spain). The lyophilised fruit was ground and stored at −80 °C until needed for further manipulation.

2.3. Analysis

Analysis was performed in triplicate for each fruit item. All glassware and polyethylene sample bottles were washed with 10 N nitric acid and demineralised water (Milli-Q Ultrapure Water System, Millipore Corp., Bedford, Mass., USA). For the analysis of phosphorus, calcium, potassium and sodium, each sample (0.5 g) was placed in a porcelain crucible and dry-ashed in a muffle furnace (Selecta, Mod.366, Barcelona, Spain) at 450 °C. The white ashes obtained were then dissolved with $HCl/HNO_3/H_2O$ (1:1:2), passed through a Whatman 41 filter and recovered in a 25 mL flask, which was filled to the final volume with Milli-Q water. Total phosphorus was determined colorimetrically at 820 nm in a spectrophotometer (Shimadzu UV-1700, Model TCC-240A, Columbia, USA) by the vanadomolybdate procedure (AOAC, 1990). The remaining minerals were measured by flame atomic absorption spectroscopy in a PerkinElmer Analyst 700 spectrophotometer (Norwalk, Conn., USA). Standard solutions were prepared from Titrisol concentrates (Merck) of calcium (Cl_2Ca in 6.5% HCl, 1000 mg Ca), sodium (NaCl in H_2O, 1000 mg Na) and potassium (KCl in H_2O, 1000 mg K). Lanthanum chloride was added to the samples and standards for calcium measurements, and lithium chloride was added to the samples and standards for sodium and potassium determinations. A final concentration of 0.3%, to avoid interferences, was obtained. In addition, a sample of fruit (mango) was used as an internal control to assess precision. The inter-assay coefficients of variation were 2.07, 1.42, 1.93 and 1.37% for Ca, P, Na and K, respectively. Skim milk powder (certified reference material CRM 063; Community Bureau of Reference, Brussels, Belgium) was used to assess the accuracy of the mineral quantification techniques applied (Table 1).

2.4. Statistical analysis

The statistical significance of the data was tested by one-way analysis of the variance (ANOVA), followed by the Duncan test to compare the means that presented a significant variation ($P < 0.05$). The relationships between minerals were evaluated by computing the Pearson linear correlation coefficient at the $P < 0.05$ confidence level. Multivariate analysis was performed by cluster analysis. In each cluster, the samples that presented an outlier in the parameters addressed (those with a value higher or lower than three times the interquartile range) were removed. The resulting groups were then subjected to principal component analysis. All statistical analyses were performed using Statgraphics Centurion XVI statistical software (2009).

Table 1
Analytical conditions for the analysis of mineral content.

Mineral	Analytical technique	λ_{nm}	Linear range	Certified value (mean ± SD)	Measured value (mean ± SD)	Unit
Na	FAAS	589.0	0.50–2.0 mg/L	4.37 ± 0.03	4.39 ± 0.02	mg/g
K	FAAS	766.5	0.25–1.0 mg/L	17.70 ± 0.19	17.79 ± 0.21	mg/g
Ca	FAAS	422.7	1.0–4.0 mg/L	13.50 ± 0.10	13.47 ± 0.04	mg/g
P	MAE	660.0	1.0–5.0 mg/L	11.10 ± 0.13	11.04 ± 0.03	mg/g

FAAS: Flame atomic absorption spectroscopy; MAE: molecular absorption spectroscopy.