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ANALYSIS OF SULFUR IN DRIED FRUITS USING NAA

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ABSTRACT

In this study the amount of elemental sulfur in some dried fruits, available commercially, was analyzed using INAA. Apple, apricot and raisin (dried fruits) were investigated due the application of sulfur dioxide for keeping the color and to protect the flavor from oxidation. The samples of dried fruits (apple, apricot and raisin) that are consumed by local population were obtained from the supermarket of São Paulo city (SP, Brazil). The sulfur concentration values for apple (0.32 ± 0.04 gkg^{-1}) and raisin (0.30 ± 0.08 gkg^{-1}) are similar but they are significantly lower when compared with the apricot (1.55 ± 0.12 gkg^{-1}). This analysis is important due to an increase in the consumption of dried fruit by Brazilian population and also for its nutritional relevancy.

1. INTRODUCTION

The importance of sulfur in nutrition is not well known, but it is present in every cell of our body, especially in the skin, hair and nails, which represents approximately 0.25% of our weight. The sulfur in body participates in the repair and construction of tissues and cells, the formation of several vitamins and proteins also helps to combat the microbes and parasites. Particularly, the amount of sulfur required per day is unknown to the general population, but the recommended value, from United States Department of Agriculture: Nutrient Database Laboratory [1,2], ranges from a minimum of 100 mg to a maximum of 850 mg.

Nowadays, agribusiness is one of the most dynamic segments of the Brazilian economy, accounting for a significant portion of its exports. The industry already leads the statistics of employment generation and number of industrial establishments. In the production of dried fruit, Brazil is one of the three largest world producers with a production exceeding 34 million tonnes and generates more than 4 million direct jobs [3]. Dried fruit processed products stand out because they are easy to obtain, maintain the characteristics of the natural product, reduces transportation costs and are less susceptible to microbes than fresh fruit. Although the market for dehydrated foods in Brazil is still concentrated in urban centers, consumption of these foods is common among people of all ages and social classes, and what varies is the frequency.

Among the dried fruits consumed by the Brazilian population stand out: apple, raisin and apricot. While the grape and apple dehydrated already have economic expression in Brazil, the cultivation of apricots on a commercial scale is practically nonexistent. The consumption of fresh apricot is not very popular in Brazil, being more common the consumption of dried fruit and in the jellies. According to Philippi [4], dried fruit has a higher concentration of nutrients and therefore calories. But this is no problem when the consumption is moderate. Yet, some investigations emphasize that the sulfite-based preservatives in some dried foods, mainly apricots, can cause allergic reactions or asthma attacks in susceptible people [5].

On average, one fresh unit of apricot contains 33g while the dry unit reaches a maximum of 25g. Its composition also changes [6-8] (see Table 1).

Table 1. Nutritional composition apricot

Mass g/unit	Carbydrates g	Lipids g	Proteins g	Fibers g	Ca mg	Fe mg	K mg	P mg
33 (fresh)	4.6	0.2	0.3	0.4	10	nd	nd	11
25 (dried)	15.5	0.1	0.92	1.9	nd	1.2	344.5	nd

nd: not determined

Considering also that, for Brazilian population the intake of sulfur is not well established the interest in its evaluation becomes relevant due to use of elemental-S as a fertilizer in tropical soils [9,10] as well as the application of sulfur dioxide in these fruits for keeping the color and to protect the flavor from oxidation [11].

Recently, an investigation of mineral characterization of the ration administrated in horses indicated the presence of S at high level (a factor of 100 above nominal specification) [12], emphasizing the relevance to investigate sulfur levels in Brazilian foods.

Based on this facts, this paper describes the application of Neutron Activation Analysis to determine sulfur concentration in some available commercially dried fruits (apple, apricot and raisin) consumed by local population at São Paulo city (SP, Brazil).

2. EXPERIMENTAL PROCEDURE

To perform these measurements, brands of dried fruits (ten of apple and raisin and eight of apricot) that are consumed by local population were obtained from supermarket of São Paulo city (SP, Brazil).

Each dried fruit was mixed and homogenized in a domestic blender coated with Teflon equipped with titanium blades. This was necessary to avoid any contamination from metallic parts during this step. After, each sample (prepared in duplicate) was weighed (200.0 ± 0.4 mg) and transferred polyethylene tube. Aliquots of standard solutions of S were pipetted onto 1cm^2 of Whatman N$^{\underline{0}}$ 41 filter paper and evaporated to dryness under an infrared lamp. Samples and standards were irradiated at a thermal neutron flux of about 7.7 10 ^{12} n cm^{-2} s^{-1} at the IEA-R1 nuclear Reactor at IPEN (2-4MW, pool type) facility. For ^{37}S ($T_{1/2}$~5 min, E_γ =3104 keV) determination sample and standard were irradiated for 2 minutes and after a decay time of 30 seconds they were counted by 5 minutes. The precision and the accuracy were examined by analyzing replicate samples.

A γ- spectrometer system with an ORTEC detector (Model GEM-60195, FWHM=1.89 keV), calibrated for energy through the measurements of standard sources of Co^{56} and Eu^{152}, coupled to a MCA ORTEC Model 919E and connected to a PC, were used to measure the induced gamma-ray activity. The elemental concentration of sulfur was calculated using in-house software [13]. The quality of analytical results was evaluated by analyzing the NIST 1573a Tomato Leaves standard reference material. The polyethylene tube (blank) was also analyzed using the same irradiation conditions for checking sulfur impurities.

3. RESULTS AND DISCUSSION

The accuracy evaluation by Z-score for NIST 1573a Tomato Leaves standard reference material indicate that our results are satisfactory and are within the range of certified data at 95% confidence level. Related to blank analysis, only impurities of Al and Mg were identified in the polyethylene tube, but they do not interfere.

The S concentration determined dried fruit sample is presented in Table 3. The mean values (MV) with associated error, represented by one standard deviation (1σ), the minimum and maximum values determined, as well as the median and mode were also included. To visualize these data, in figure 1 is showed the sulfur concentration results of all samples analyzed.

Table 2.Results of the present analysis compared to the certified values NIST 1573a Tomato Leaves.

Element, gkg^{-1}	Certified values	NAA	RSD, %	Relative Error,%	| Z score |
Br	1.30^{nc}	1.31 ± 0.10	7.6	0.8	
Ca	50.5 ± 0.9	53.6 ± 3.4	6.3	6.1	0.9

Cl	6.60[nc]	6.56 ± 0.45	6.6	-0.6	
Mn	0.246 ± 0.008	0.245 ± 0.017	6.9	0.4	0.05
K	27.0 ± 0.5	26.9 ± 1.6	5.9	0.4	0.06
Na	0.136 ± 0.004	0.135 ± 0.013	9.6	0.7	0.07
S	9.6[nc]	10.01± 0.11	1.1	4.3	

RSD: Relative Standard Deviation
nc: noncertified value

Table 3. Sulfur concentration in dried fruits using INAA.

S, gkg^{-1}	MV	1σ	Min	Max	Median	Mode
Dried fruits						
Apple *n* = 10	0.32	0.04	0.29	0.38	0.31	0.31
Apricot *n* = 8	1.55	0.12	1.43	1.68	1.45	1.44
Raisin *n* = 10	0.30	0.08	0.18	0.43	0.30	0.30

n: number of brands investigated
min: minimum valued determined
max: maximum value determined

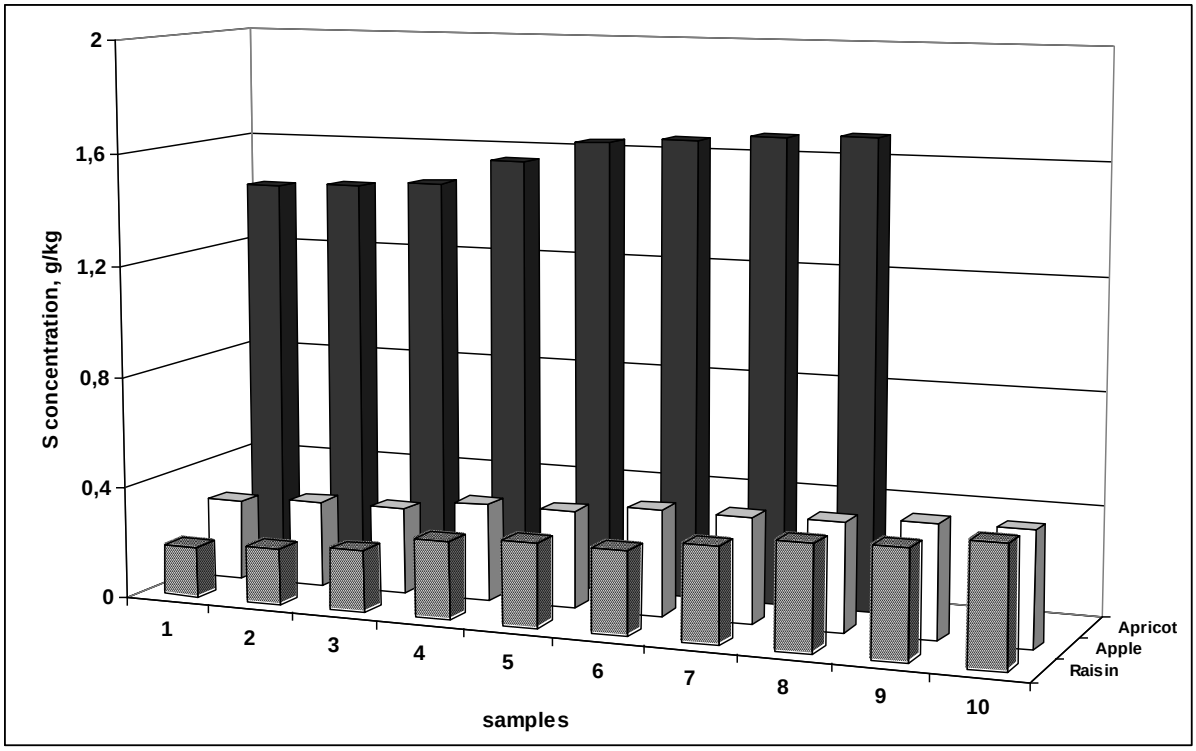

Figure 1. Sulfur concentration in samples of dried fruits

According to Table 3 the S concentration values obtained for apples and raisins are perceptually in agreement, but they are significantly lower (~ factor 5) when compared with the apricot. Whereas the amount of sulfur needed per day is not well established, suggesting a maximum intake of 850 mg [1,2], these results emphasize the need to investigate sulfur levels in Brazilian foods. Moreover, according to Figure 1 no evidence of heterogeneity was observed.

Although the amount of dried fruit consumed per day composes a very small fraction of the Brazilian diet, another aspect to be considered is the intake of other types of dried fruits and also some grains rich in sulfur, highly consumed (mainly rice and beans [11]) emphasizing the need to extend this assessment to other constituents the Brazilian diet.

4. CONCLUSION

This study allowed the sulfur determination in some dried fruits, commercially available in the city of São Paulo. For apples and raisins the sulfur concentrations are significantly lower when compared with the apricots. These results may be useful in other areas of research areas such as health and nutrition and also emphasize the need to check the S levels in Brazilian diet.

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