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# Determining Experimental Conditions for Soybean analysis by Neutron Activation Analysis

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## 1. Introduction

Soybean occupies major space in the Brazilian economy – according to the Brazilian ministry of agriculture, in 2021, soybean reached 51.7% of total exportations of the agribusiness.

The most used techniques for the soil preparation employ chemical fertilizers, sewage sludge and pesticides [1, 2] that, eventually, can increases levels of Cd, Pb and Hg, which are toxics for human, in addition As, Cu, Fe and Zn which can became toxics for human in elevated concentrations [3,4]. Therefore, out of control use of these chemicals, aside from elevating their concentrations in the soil, and hence in the plant, can promote their insertion on the human food chain.

An alternative method, which has been studied for soybean growth is biological control. This methodology uses biological agents, like specific bacteria cultures, which promote solubilization and fixation of the micro and macro elements essential for the plant growth [4-8]. Some studies relate that elevated microbiological activities can increase micro and macro nutrient concentrations important for the plant growth in the soil and the soil solution [7, 8, 9].

Considering the potential use of biological agents in plant growth some companies started to study the effectiveness of this methodology in different cultures [10]. Brazilian Agricultural Research Corporation (EMBRAPA) foresees, in case of Brazil, a growth of 20% per year for the use of biological agents in the initial stages of the plantation [11].

Although this methodology has been used with effectiveness in soybean cultures there are no studies about elemental composition in soybeans growth with biological approach. Some elements are present in soybean with known levels, about ppm or even ppb, therefore it is necessary the use of analytical techniques with great sensibility. In this context Instrumental Neutron Activation Analysis (INAA) can be applied for this kind of study.

INAA is recognized as an analytical technique capable of dealing with low levels of concentration in different kinds of matrices, between them soybean samples. This technique has been used at Neutron Activation Laboratory (LAN) at Energy and Nuclear Research Institute (IPEN) in different kinds of matrices, however soybean samples have never been analyzed at LAN. Therefore the aim of this study

was to determine the best condition of soybean samples preparation for INAA. After determining the best experimental sample conditions, growth by traditional means and biological means will be analyzed to check differences in terms of ratios of micro and toxic elements.

## 2. Methodology

The soybean samples were previously crushed using a blender with Ti blades. After this initial grinding process, the samples were macerated in an agate mortar until reaching the appropriate particle size. The quartile method was used to ensure sample homogenization. Subsequently, aliquots of approximately 200 mg were used for moisture content determination. For this determination, the samples were dried in an oven at 80ºC until reaching a constant mass.

For elemental determination, aliquots of approximately 120 mg were irradiated for periods ranging from 8 up to 16 hours in the IEA-R1 reactor, under a neutron flux around $10^{12}$. The identification of radioisotopes present in the samples was performed by gamma spectroscopy using a Hyperpure Germanium (HPGe) detector.

## 3. Results and Discussion

Results presented in Table I pointing out the presence of the following essential elements Mg, Zn, and Mn indicating their absorption for the plant. On the fourth column of Table I are presented the concentration values reported in the literature by [table 1], which indicate that INAA (Instrumental Neutron Activation Analysis) can be applied in a future stage for the determination of these elements in samples cultivated through biological management and traditional agricultural cultivation methods in soybean.

Table I: Elements determined in soybean samples

| Radioisotope | Energy (keV) | CPS*±U* | Concentration(ppm) |
|---|---|---|---|
| $^{72}$Mg | 1014 | 50.0±6 | 3100±200 |
| $^{56}$Mn | 847 | 66.2±1.1 | 38±3 |
| $^{28}$Al | 1780 | 9.0±3 | 4±1 |
| $^{90}$Mo | 140 | 0.475±0.030 | 2 |
| $^{92}$Zn | 1115 | 0.075±0.019 | 52±6 |
| $^{24}$Na | 1368 | 13.18±0.03 | - |
| $^{30}$Co | 1332 | 0.428±0.003 | 0.24±0.02 |
| $^{140}$La | 487 | 0.046±0.005 | NI*** |
| $^{46}$Sc | 1121 | 0.018±0.001 | <0.01 |
| $^{59}$Fe | 1099 | 0.053±0.002 | NI*** |

*CPS=Counts per Second; **U=Uncertainty ; ***NI= Not Informed.

## 4. Conclusions

The results obtained demonstrate that INAA (Instrumental Neutron Activation Analysis) has sufficient sensitivity to determine the concentration of elements present in soybeans. The comparative table presented in this study shows that even elements present in low concentrations were detected following the analysis protocols developed in this study.

The methodologies developed in this study will be applied in a subsequent stage to determine the concentration of the elements listed in Table I in samples cultivated through biological management and conventional farming, which are already available for analysis. However, it is necessary to conduct comparisons and methodological studies with soybeans from biological management, as these analyses have not yet been carried out.

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