**Effect on oxalate concentration in taro (*Colocasia esculenta*(L.)Schott var. ant quorum) of planting in sandy or clay soils, and of traditional ways of cooking the corms**

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**Abstract**

Corms, petioles and leaves of taro (*Colocasia esculenta* (L.) Schott var. ant quorum) were collected at 9 months growth stage from farmer plots situated in typical “sandy” and “clay” soils in Central-coastal Vietnam.

The levels of total and soluble oxalate in all parts of the taro plant harvested at the tradition age of 10 months were: (i) higher when the taro was planted in clay-rich rather than sand-rich soils; and: ((ii) that these high levels could be reduced substantially by all traditional methods of cooking. There were major differences in the proportion of soluble and insoluble oxalate among the main plant components (corms, petioles and leaves, which appeared to be related to their growth/storage functions.

***Key words:****calcium, harvest, leaves, petioles, solubility, variety*

**Introduction**

Taro (Colocasia esculenta) is a major tropical crop that is widely grown in in central-coastal regions of Viet Nam. It is cultivated in both clay and sandy soils (Hang and Preston 2007). It is a popular plant and the tubers, petioles and leaves have a range of uses.

Our previous studies with this plant have been focused on ways to reduce the content of oxalate salts which decrease the absorption of several essential minerals, especially Ca, Fe and Mg (Noonan and Savage, 1999). This can be done by simple processing techniques such as wilting, soaking and washing in water. Ensiling is especially effective in reducing the soluble oxalate content of leaves and petioles s of taro cultivars (Hang et al 2011; Hang et al 2013).

In view of the range of soil in which taro is grown in Vietnam, the present study was focused on determining possible differences in soluble and insoluble oxalates in taro plants grown on typical “sandy “and “clay” soils where the most popular variety “Mon Quang” is grown in for production of corms for human consumption.

**Materials and methods**

The Mon Quang variety used in this experiment was grown on farms located in Vinh Chap village, Vinh Linh District, Quang Tri Province, Vietnam, and which were representative of “typical” “sandy” and “clay “soil types (Table 1.). At the traditional time of harvesting (9 months after planting) sample were taken of leaves, petioles and corms from plants grown farms located on the typical “clay” and “sandy” soils. Leaves and petioles were dried in at 65°C. The corms were washed and half of them had the skin removed prior to the evaluation for different ways of cooking which were:

Soaking: 1 kg was soaked in 2 liters of water for12 hours

Steaming: 1 kg was steamed for 70 minutes

Boiling: 1 kg was boiled in 1.5 liters of water for 60 minutes

Roasting: 1 kg roasted by dry heat in an oven at 1500C, 15 minutes

The samples were then allowed to cool at room temperature (26 1ᵒC) before preparing for analysis.

There representative samples (30g) of each processing method were dried in the oven at 65ºC, then ground to a fine powder (Sunbeam multi grinder (Model no. EMO 400 Sunbeam Corporation Limited, NSW, Australia) and sealed in plastic bags until analysis. The residual moisture was determined by drying to constant weight in an oven at 105°C.

**Oxalate determination**

The total and soluble oxalate content of the samples was determined in duplicate using the method outlined by Savage et al (2000). Insoluble oxalate (calcium oxalate) was calculated by difference (Holloway et al 1989). Oxalates were extracted from each processed taro samples. Soluble oxalate was extracted with 40 ml nano pure water and incubated in a water bath at 80°C for 15 min, while total oxalates were extracted using 40 ml of 0.2 M HCl at 80°C for 15 minutes. Extracted supernatants were filtered through a 0.45 mm cellulose nitrate filter and chromatographic separation and analysis was carried out using a Rezex ROA ion exclusion organic acid column. All oxalate data are expressed as mean values ± standard error wet matter (WM) basis.

**Calcium determination**

Total calcium content was analyzed using an atomic absorption spectrometer (AOAC, method 945.46). Calibration of the measurements was performed using commercial standards according to AOAC method 991.25. The calcium bound up in insoluble oxalate was calculated assuming that insoluble oxalate was predominantly calcium oxalate and that calcium was 31 % of this molecule.

**Statistical Analysis**

All analyses were carried out in triplicate and the results are presented as mean values ± standard error. Statistical analysis was performed using one-way analysis of variance (Minitab version 16, Minitab Ltd., Brandon Court, Progress way, Coventry, UK)

**Results and discussion**

**Soil characteristics**

As expected, the soils in which the taro plant ere were grown differed  different in physical characteristics. The clay soil was denser and had greater porosity than the sandy soil (Table 1).

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| **Table 1.** Mean values for density, bulk density and porosity of sandy soil and clay soil | | |
|  | **Sandy soil** | **Clay soil** |
|  | | |
| Density (g/cm3) | 2.72 | 2.56 |
| Buck density (g/cm3) | 1.4 | 1.1 |
| Porosity (%) | 49 | 57 |
|  | | |

The differences in structure were reflected in concentrations of oxalate salts which were higher in plants grown on clay soils (Table 2). This was true for both soluble and insoluble from of the salts and was as consistent in all the parts of the plant.

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| --- | --- | --- | --- | --- |
| **Table 2.** Mean values (mg/100gDM) of soluble and insoluble oxalate in corms, leaves and petioles of Mon Quang taro, harvested 10 9 months after planting) | | | | |
|  | **Sandy soil** | **Clay soil** | **SEM** | ***p*** |
|  | | | | |
| **Corms** | | | | |
| Total | 897±48 | 988±22 | 21.8 | 0.04 |
| Soluble | 689±45 | 732±49 | 27.1 | 0.33 |
| Insoluble | 208±27 | 256±30 | 12.7 | 0.06 |
| **Petioles** | | | | |
| Total | 11865±663 | 13551±417 | 320 | 0.02 |
| Soluble | 9170±328 | 9514±248 | 18.7 | 0.27 |
| Insoluble | 2695±180 | 4037±159 | 139 | 0.02 |
| **Leaves** | | | | |
| Total | 3572±340 | 4504±406 | 129 | 0.04 |
| Soluble | 2041±125 | 2418±284 | 249 | 0.34 |
| Insoluble | 1531±90 | 2087±87 | 73 | 0.006 |
|  | | | | |

There were differences in the proportions of soluble and insoluble oxalates according to the main plant fractions (Figures 1-3). In the corms and petioles (Figures 1 and 2) the soluble form of the oxalate predominated while the exact opposite was he the for the leaf fraction (Figure 3). It would seem that the predominance of the insoluble form in the leaves was related to this being the active growth region of the taro plant.

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| --- | --- | --- |
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| **Figure 1.**Effect of soil type on the balance of soluble, insoluble oxalate in the corms | **Figure 2.** Effect of soil type on the balance of soluble, insoluble oxalate in the petioles | **Figure 3.** Effect of soil type on the balance of soluble, insoluble oxalate in the leaves |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Table 3.** Mean values (mg/100 g DM) for calcium present as insoluble oxalate in the corms, petioles and leaves of Mon Quang taro harvested at 9months after planting | | | | |
| **Corms** | **Sandy soil** | **Clay soil** | **SEM** | ***p*** |
|  | | | | |
| Total Ca | 181±3.2 | 194 ±9.4 | 2.11 | 0.01 |
| Ca insoluble | 65±2.4 | 80±4.9 | 3.97 | 0.05 |
| % Insoluble/Total | 33.5 | 44.3 | 2.6 | 0.02 |
| **Petioles** | | | | |
| Total Ca | 1726±156 | 1886±123 | 10.9 | 0.001 |
| Ca insoluble | 843±23 | 1263±59 | 42.7 | 0.002 |
| % Insoluble/Total | 48.9 | 67.0 | 3.76 | 0.007 |
| **Leaves** | | | | |
| Total Ca | 1885±98 | 2036±106 | 24.97 | 0.013 |
| Ca insoluble | 497±12 | 652±66 | 22.8 | 0.006 |
| % Insoluble/Total | 25.4 | 32.1 | 1.24 | 0.019 |
|  | | | | |

All the processing methods reduced the soluble oxalate levels in the corms of Mon Quang taro (Table 4).

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| **Table 4.** Effect traditional processing methods on oxalate concentration in corms of Mon Quang taro | | |
| **Processing methods** | **Soluble oxalate (mg/100gDM)** | **Reduction** **(%)** |
|  | | | |
| Whole corm | | |  |
| Initial | 573 ± 48 |  |  |
| Soaking | 509 ± 26 | 12.0 |  |
| Streamed | 391 ± 22 | 32.0 |  |
| Boiled | 324 ± 18 | 43.0 |  |
| Roasted | 380 ± 13 | 34.0 |  |
| Corm minutes the kin | | |  |
| Initial | 440 ±19.3 |  |  |
| Soaking | 363 ± 16 | 17.0 |  |
| Streamed | 248 ± 13.2 | 44.0 |  |
| Boiled | 220 ± 14 | 50.0 |  |
| Roasted | 279 ± 17 | 37.0 |  |
| Fried | 216 ± 13 | 51.0 |  |
|  | | | |

**Conclusions**

* The levels of total and soluble oxalate in all parts of the taro plant harvested at the tradition age of 10 9 months were: (i) higher when the taro was planted in clay-rich rather than sand-rich soils; and: ((ii) that these high levels could be reduced substantially by all traditional methods of cooking.
* There were major differences in the proportion of soluble and insoluble oxalate among the main plant components (corms, petioles and leaves, which appeared to be related to their growth/storage functions.

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