DETERMINATION OF THE GLYCOALKALOIDS CONTENT FROM POTATO TUBERCULES (SOLANUM TUBEROSUM)

DETERMINAREA CONTINUTULUI DE GLICOALCALOIZI DIN TUBERCULII DE CARTOFI (SOLANUM TUBEROSUM)

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Determinations concerning the glycoalkaloids content were made over four potato varieties (Hansa, Sieglinde, Nicola and Linda) obtained from a private German source, country in which potatoes are cultivated and consumed frequently. Potatoes have been cultivated in classic conditions, as well as in biodynamic conditions. The glycoalkaloids complex and their aglycones had been obtained through a sequence of operations, like extractions with several specific solvents at reflux and in backward flow, hydrolysis, lyophilisation etc. The determinations concerning the glycoalkaloids content of the four studied potato varieties were accomplished comparatively for both culture modes, in classic and biodynamic conditions.

Key words: potato, glycoalkaloids, solanine, chaconine, solanidine, lyophilisation.

Introduction

The most important glycoalkaloids, which are found in the largest amount in potatoes, and which together add up 95% of the total glycoalkaloids content, are α-solanine and α-chaconine. These are steroid glycoalkaloids, both having solanidine for aglycone [Edwards and Cobb, 1996; Olsson, 1989]. Besides these alkaloids, the potato tubercles also contain β-solanine, γ-solanine, β-chaconine, γ-chaconine, in a percentage of 5%. The glucides contained in these alkaloids are [Paseshnichenko and Guseva, 1956]:

- α-solanine: galactose, glucose, rhamnose;
- β-solanine: galactose, glucose;
- γ-solanine: galactose;
- α-chaconine: glucose, rhamnose, rhamnose;
- β-chaconine: glucose, rhamnose;
- γ-chaconine: glucose.

This alkaloids complex of potatoes is known as solanine. All these alkaloids are found in potatoes in form of glycosides, all their aglycones containing molecules of 27 Carbon atoms and one nitrogen atom. All own the cholesterol...
skeleton and an OH group in the third position of it. The solanidine structure had been established by Prelog (1944) and Jacobs (1945) [Nenițescu, 1968; Sândulescu et al., 1973].

In potato plants solanine is found in different percentage. Term mg/100 g dry substance, solanine is contained in the whole tubercle between 20 and 40 mg, in peel between 106 and 270 mg, in marrow between 6 and 40 mg, in cornes between 565 and 4570 mg, in stolons between 25 and 55 mg, in leaves between 510 and 620 mg, in flowers between 105 and 340 mg. In tubercles, solanine is represented in the first 10 cells batches of the peel. The immature tubercles contain more solanine than the mature ones. The amount of solanine increases in mature tubercles while they are greening and germinating, as well as they are exposed to light. This alkaloids complex is very toxic.

The toxic α-solanine dose LD50 for rats is 67 (52.3-85.7) mg/kg, 84 (65.6-107.5) mg/kg for α-chaconine, and in case of the total glycoalkaloids extract it is 60 (35.7-100.8) mg/kg.

Chronic administration in a dose of 40 mg/kg a day of α-solanine, α-chaconine and total glycoalkaloids extract for two days spelled to a death rate of 40% of
unpregnant rat females, and the administration of 20 mg/kg a day for 8 days to a death rate of 42%.

In case of administrating 8 daily α-chaconine injections, 5-29 mg/kg in the days 5-12 of pregnancy spelled to a death rate of 40% of the pregnant female rats, while the administration of 40 mg/kg in the days 5-6 of pregnancy spelled to a death rate of 66%. Administration in the same conditions of α-solanine resulted with the death of 17% of the fetuses, and the administration of total glycoalkaloids extract resulted with the death of 86% of the fetuses.

In case of animals, toxicity behind potato consumption developed such:
- rabbits fed only with potato plants had diarrhea after 6 days; all of them died after 7-17 days;
- concerning sheep, green potatoes in germination phase resulted with their death;
- concerning calfs, toxicity was expressed through narcotic poisoning, sinusitis and absence of the cornean reflex;
- concerning bovines, potato consumption resulted with growth inability, vomit, asphyxia, stopping of lactation, as well as eczema or inflammation of the feet skin
- in case of pigs, burgeoned potatoes, spelled to anorexia, diarrhea, hypothermia and coma after 5 days.

These alkaloids are very toxic also for human, the toxic dose is approximately 2-5 mg/kg body weight [Morris and Lee, 1984; Edwards and Cobb, 1999]. Symptoms appear a few days after consumption, these are: heatburn in the thorax region, vomit, headaches, diarrhea, colic’s, fever, congestion of the face, lips cyanosis, ocular spasms. It is recommended not to consume congealed or dirty potatoes. Consumption of the aerial plant spelled to dermatitis and even death in India [Narayana, 2003]. Consumption of potatoes with high glycoalkaloid content can cause gastro-enteritis and in sever cases it can cause also coma and death. The lethal dose is probably 3-6 mg/kg body weight [Gonomori et al., 1993; Willimot, 1933; Jadhav and Salunkhe, 1975; Fewell and Roddick, 1993]. Solanine is defined by hemolytic properties and antispasmodic effects. It acts over the parasympathetic nervous system and produces the relaxation of the smooth muscles. In low doses it causes pupil dilatation.

Nevertheless, there is known that glycoalkaloids which contain solanidine are able to inactivate several herpes virus types. Glycoalkaloid or solanidine extracts can be used to obtain some preparations having protection effects against skin cancer.

**Materials and Methods**

There were used four potato breeds obtained from a private source in Germany, country in which potatoes are cultivated and consumed frequently:

For the experiments achievement was used following four potato varieties, obtained from a German private source, country were this potato varieties are
frequently cultivated and consumed:

- **Hansa** - ovoid form, shiny yellow peel, yellow pulp resistant to depositing;
- **Sieglinde** - long ovoid tubers, in the kidney form, shiny yellow peel, yellow pulp;
- **Nicola** – oblong ovoid form, dark-yellow pulp, high water content, fine aroma;
- **Linda** – oblong, oval, almost long tubercles, dark-yellow pulp, fine aroma.

The potatoes growing was made in Schöngeising, Germany, at 25-30 km near Munich, on an experimental plot of land with 100 m² surface, on a brown soil with a pH of 6.5-6.7 and with a high content of phosphorus and kalium and a low content of magnesium. The potatoes were seeded in 2005, in the April second decade, and the tubercles were cropped in the September first decade. The atmospheric conditions were unfavourable for the potatoes production: warm and dry weather during almost the whole vegetation period, rain come only in August.

There were used classic cultures as well as biodynamic culture methods. Concerning classic methods, there were used chemical fertilizers from the German „Lebosol“:

- **Aminosol**, a 9% fertilizer solution based on organically fixed nitrogen having amino-acids as nourishing substance;
- **Magphos**, which has 30 % P₂O₅, 3 % N and 7 % MgO in his composition, having phosphorus as nourishing substance;
- **Kalium₄⁵₀**, which contain 3 % N and 31 % K₂O.

These solutions were mixed in 1:5:1 volume reports and were dubbed in quantity of 0.05 l on the classic conditions cultivated potatoes surface.

The biodynamic preparations used for the potato crop were: [Steiner, 1977; Sattler, 2003; Sattler, 2005]:

- **the 500 preparation** obtained by introduction of the cow dung in an cow horn that gave birth to 3 calfs; in 3 September 2005, this cow horn was burying at approximate 50 cm and draw out on 28 February 2006; the horn dung was blended with 12 l of rain water;
- **the wheat straw compost**, blended with vegetal mass (leaves, weeds, young branches); the fermentation period of this biodynamic preparation was of 4 weeks, after which was blended with a small quantity of rain water.

The two biodynamic preparations were mixed together and then scattered on the experimental plot of land after it was ploughed.

For the glycoalkaloids and solanine obtaining were used dry and pulverized potato tubercules.

The glycoalkaloids extraction was accomplished at reflux, using a 50 (v/v) methyl alcohol solution. The extraction time was 60 minutes. The obtaining of glycoalkaloids was accomplished through lyophilisation.

Solanidine was obtained through a method in which the hydrolysis of the glycoalkaloids and the extraction of the aglycone were accomplished in the same step. For this, there was used a backward flow extraction system between two
immiscible liquids. This two phases system’s contain:
- an aqueous phase, built by the methanolic extract which contain the
glycoalkaloids, adding 2% (w/v) chlorhidric acid (for hydrolyzing);
- an organic phase, which is the chloroform.
Solanidine is retrieved in the organic phase. After separating the two phases,
lyophilisation was accomplished, obtaining the aglycone in form of some brown
colored needles [Nikolic et al., 2005; Friedman and McDonald, 1997].

Results and Discussions

The glycoalkaloids and solanidine content of the four potato breeds was
studied and comparatively pursued for the classic farming mode as well as for the
biodynamic one. All values are related to dry vegetal material.
The obtained results are given in table 1.

<table>
<thead>
<tr>
<th>Soiluri de cartofi</th>
<th>Glycoalkaloids and solanidine content, µg/g</th>
<th>(\mu g/g)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Glycoalkaloids</td>
<td>Solanidine</td>
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<td>classic biodynamic</td>
<td>classic biodynamic</td>
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<tr>
<td><strong>Hansa</strong></td>
<td>245.14</td>
<td>110.31</td>
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<tr>
<td><strong>Sieglinde</strong></td>
<td>315.30</td>
<td>142.88</td>
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<tr>
<td><strong>Nicola</strong></td>
<td>138.48</td>
<td>65.28</td>
</tr>
<tr>
<td><strong>Linda</strong></td>
<td>111.36</td>
<td>50.05</td>
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</tbody>
</table>

The potato tubercules **cultivated in classic conditions** contain glycoalkaloids
between 111.36-315.30 \(\mu g/g\), the results obtained for the breeds **Hansa, Sieglinde**
and **Nicola** being similar to those described in the studied special literature, which
are also valid for other potato breeds [Lachman et al., 2001; Maga, 1994; Duke,
1992a; Duke, 1992b]. Therefore, these breeds can be used in the food industry. The
weakest values had the breed **Linda**.

Concerning **potatoes cultivated in biodynamic conditions**, here can be
observed a significant growth of the active principle content, the obtained values
being higher on an average with about 5-15 % for the glycoalkaloids content as
well as for the solanidine content. The explanation is that through the use of
biodynamic preparations detrimental agents were removed out of the present
chemical or ecological agriculture, and there was accomplished a living soil with
extra energy and protection, as well as true natural conditions, in which potatoes
could develop healthy, with an increased vitality unlike potatoes cultivated in
chemical conditions. These potatoes become more able to fight against detrimental
agents and are more storage resistant.
Conclusions

The fertilizers used to increase potato growth represent an ecological risk because they penetrate potato tissues, they affect their metabolism and change the chemical composition of the tubercles, reducing the content of their active principles.

Bio-dynamic agriculture appeared at the beginning of the 20th Century as a result of anthroposophic activities through which Rudolph Steiner tried to limit the hazard represented by the negative effects of using chemicals in excess in agriculture on the different components of the biosphere.

As a result of this beneficial dynamisation, one can get economically efficient crops while the soil becomes healthier for the cultivation of the plants both men and animals need.

The results that biodynamic agriculture can be practiced on no matter what type of soil (about 15 years ago, they have reclaimed from the Egyptian desert 60 ha of land that was turned into agricultural land using biodynamic methods).

The secret of this type of agriculture resides exactly in this dynamisation and it depends on cosmic and earthy factors, on plant preparations and, last but not least, on the state of mind and soul of the practitioner, on its mind, subtle feelings, and wisdom with which he manages all the preparing phases concerning soil, compost, seeds, natural preparations for the spraying of the plants, the way they are applied, etc. Maybe it is also due to this that biodynamic agriculture is practiced by a limited number of individuals, even at world level.

Avoiding the disadvantages of the potatoes cultivated in classical conditions can be done by cultivating potatoes in biodynamic conditions, when the changes of the content of studied active principles as a result of exposing tubers to stress are completely insignificant, even if initial values are high. This shows the fact that biodynamic agriculture ensures resistance and stability of the active principle content, even if the potatoes are exposed to different stress conditions.

Plants cultivated in bio-dynamic conditions have an increased vitality, unless plants cultivated in chemically treated conditions. By using bio-dynamic preparations, we eliminated noxious factors of the present agriculture, be it chemically treated or ecological, and it was practiced on a living soil with a surplus of energy and protection, and in truly natural conditions in which potatoes could develop healthy, unlike potatoes treated chemically. These potatoes become more capable of fighting pests and resist much longer to storage.

Through bio-dynamically cultivated potatoes, we can get healthier alimentary products that can contribute to a normal life in humans, according to present and particularly to future requirements. This food transmits to those consuming it more vitality and the opportunity of knowing the unimaginable vibration-energetic beneficial dimension of the nutrients.

For this farming mode is necessary to take size in the future, so that biodynamic farming should become a true salvation for the human of the 21st Century.


