Phytochemistry Letters 23 (2018) 116–119

Contents lists available at ScienceDirect

Phytochemistry Letters

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

Evaluation of new strategies to reduce the total content of α-solanine and α-chaconine in potatoes

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ARTICLE INFO

Keywords:
α-Solanine
α-Chaconine
Glyco-alkaloids
Potatoes
Toxins

ABSTRACT

Potatoes are a staple food for over a billion people worldwide, a primary dietary source of carbohydrates, and a vital crop to the agricultural economy of South America, Africa, East Asia and Central Asia. Potatoes occupy third place (after rice and wheat) on the list of foods on which the world depends for food security. In particular, glyco-alkaloids contents in potatoes are potentially toxic and secondary metabolites such as α-solanine and α-chaconine are reported to be dangerous to human health. This paper describes new methods for α-solanine and α-chaconine reduction in the potato cultivar known as Marabel. The potatoes were incubated at room temperature in the dark for 24 h and the optimal experimental condition was achieved with NaOH solution at pH 12. In the assayed samples, α-solanine and α-chaconine reduction was 43% and 27% respectively. The process proposed here allows to minimize the total content of glyco-alkaloids, with respect to mode of collection, storage and cleaning of Marabel potatoes.

1. Introduction

Potatoes (*Solanum tuberosum* L.), belongs to the Solanaceae family, are native to South America and they were cultivated in the pre-Columbian period, although several wild species were spread in North America. The spontaneous varieties still until now enigmatic. Potatoes are a staple food and the main source of carbohydrates in the diets of hundreds of millions of people, as well as a crop vital to the economy of South America, Africa, East Asia and Central Asia. Potatoes occupy third place (after rice and wheat) on the list of foods on which the world depends for food security. The potato was considered as an ornamental plant and the flowers was used to adorn the hair of fashionable ladies.

Despite the beneficial uses, potatoes contain toxic secondary metabolites to the human health, such as α-solanine and α-chaconine (Yamashoji and Matsuda, 2013), while other glycoalkaloids, α-tomatine, α-solasonine and α-solamargine are present in negligible quantities (Fig. 1). The compounds α-solanine and α-chaconine possess an effective chemical defence against animals, insects (e.g., Colorado beetle), fungi (e.g., potato blight, *Fusarium*, *Alternaria*), worms and bacteria (Andrivon et al., 2003; Friedman, 2006). Certain wild *Solanum* species containing high levels of glycoalkaloids, which are used in reproduction studies to introduce unique features into cultivable species, such as a high resistance to pathogens (Meziani et al., 2015; Nitithamyong et al., 2010). The stressful factors that occur before and after the harvest potatoes could cause a rapid increase the concentration of α-solanine and α-chaconine. Small sized and immature tubers were often associated with high levels of glycoalkaloids. In fact, the levels decrease with growth and maturation of the plant (Senguel et al., 2004). Even post-harvest conditions, such as exposure to light, heat and storage times, are able to influence the levels of glycoalkaloids (Haase, 2010). Prolonged exposure to light rapidly stimulates the production of glycoalkaloids. It has been shown that exposure of the tubers to sodium and fluorescent light increases their concentration (Roch et al., 2015; Romanucci et al., 2016a). These substances, often simply referred to generically as "*solanine*" or, for greater precision, as Total GlycoAlkaloids (TGA), can be considered as a group because of their similar chemical structures are quite similar, and when they are metabolized, they release the same few alkaloids (Mendel et al., 2010). TGA are not evenly distributed in the potato (approximately 10 mg per 100 g) (Romanucci et al., 2016a), but a large portion is concentrated under the skin, and it is preferable to remove it (Friedman and Dao, 1992). Furthermore, these two glycoalkaloids are poorly soluble in water and are not eliminated by normal cooking processes because they are degraded only at temperatures above 243 °C. Baking at 170 °C (as in the case of

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https://doi.org/10.1016/j.phytol.2017.11.024
Received 25 October 2017; Received in revised form 27 November 2017; Accepted 29 November 2017

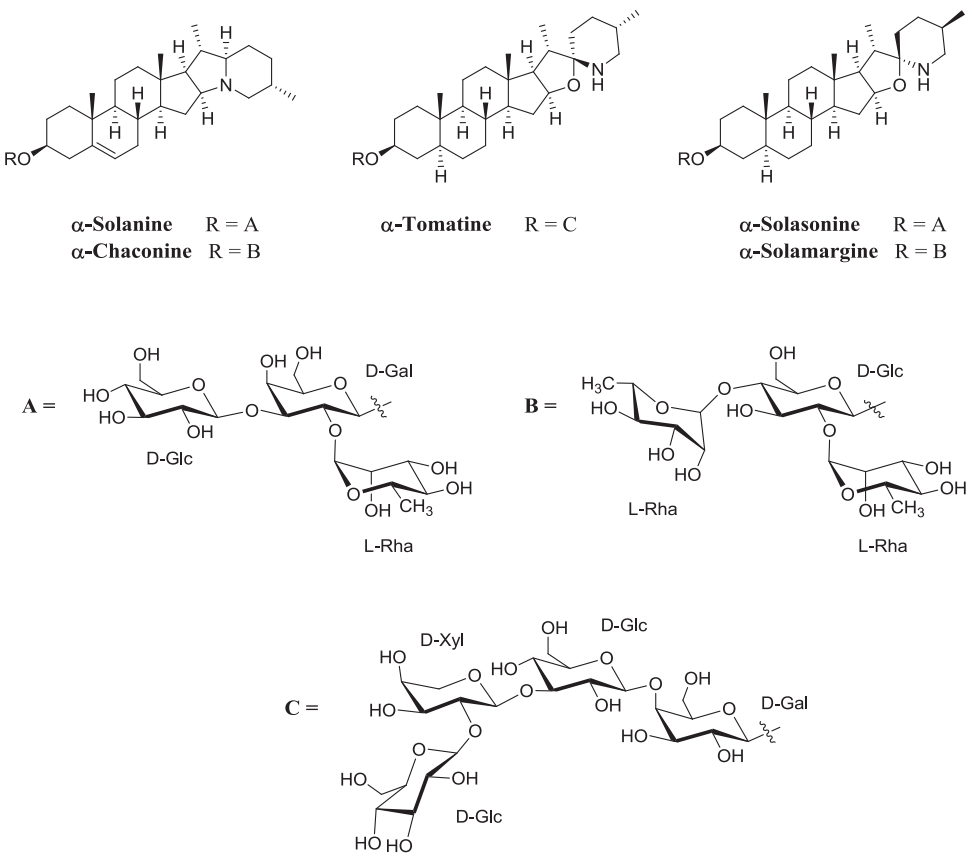

Fig. 1. Chemical structures of glycoalkaloids.

Table 1
Concentrations[a] of α-solanine and α-chaconine of Marabel potatoes.

	Experimental conditions	α-solanine (*α-S*)[a]	α-chaconine (*α-C*)[a]	(*α-S*) + (*α-C*)[a]
A	Potatoes not treated	7.54 ± 0.43	1.20 ± 0.18	8.74
B	Aqueous solution containing the following nutrients: phosphate (10 mg/L), nitrate (10 mg/L), nitrite (10 mg/L), sodium carbonate (10 mg/L)	7.62 ± 0.19	1.45 ± 0.10	9.07
C	Solution of sodium bicarbonate at a concentration of 1.1 g/L	9.39 ± 0.38	1.50 ± 0.32	10.9
D	Solution of sodium bicarbonate at a concentration of 6.5 g/L	11.01 ± 0.56	2.16 ± 0.16	13.2
E	In a nitrogen atmosphere	6.96 ± 0.64	1.16 ± 0.10	8.12
F	At pH 12 for a solution of NaOH 0.1 M	4.27 ± 0.93	0.88 ± 0.10	5.15
G	At pH 3 to a solution of acetic acid	5.50 ± 0.44	1.12 ± 0.10	6.62
H	In a solution of cyanamide at a concentration of 1 mg/L	7.82 ± 0.45	1.50 ± 0.15	9.32
I	In a solution of sodium tartrate and potassium at a concentration of 6.5 g/L	6.70 ± 0.30	1.06 ± 0.11	7.76
L	Potatoes illuminated with a lamp mimicking the conditions to which they are exposed in supermarkets	15.84 ± 0.55	2.36 ± 0.16	18.2

[a] In mg/kg of potatoes.

frying) might reduce the amount of these substances, although it does not completely eliminate them. A recent study showed that daily consumption of potatoes leads to the accumulation of glycoalkaloids. Poisoning by α-solanine and α-chaconine was noted primarily from gastrointestinal disorders and neurological issues. Symptoms include nausea, diarrhoea, vomiting, stomach cramps, burning throat, heart arrhythmia, headaches and dizziness. In severe cases, hallucinations, loss of sensation, paralysis, fever, jaundice, dilated pupils, hypothermia, drowsiness and apathy, confusion, weakness, unconsciousness and death have been reported (Phillips et al., 1996). Severe poisoning can cause paralysis, respiratory failure, heart failure, and coma (Ji et al., 2012; Mendel et al., 2010; Roddick, 1989). In this context, Madiwale G.P. reports some precautions to minimize alkaloid content in potatoes (Madiwale et al., 2012), but a systematic study is still needed. Continuing our studies concerning the characterization (Cutillo et al., 2004, 2006; D'Abrosca et al., 2005; Della Greca et al., 2002, 2003, 2004; Di Fabio et al., 2012; Fiorentino et al., 2007; Romanucci et al., 2014), as well as the analysis of metabolites in staple foodsand nutraceuticals (Romanucci et al., 2016b; Davinelli et al., 2015), the aim of this manuscript is directed to determine some industrial processes which could serve to minimize the content of glycoalkaloids arousing the interest of producers and a wide and safe consumption.

2. Results and discussion

In this study we determine some industrial processes which could serve to minimize the content of glycoalkaloids α-solanine and α-chaconine. For the tests, potatoes were chosen from a single batch (potatoes harvested on the same day, from the same soil, and were transported and stored in the same manner). The potatoes used in the tests were approximately the same size (by weight), and those that were damaged, had green spots on the surface or were shrivelled or sprouted were discarded. All potatoes were cleaned by removing soil residue and were washed and dried before weighing. Ten different tests were