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Removal of a pharmacological undesirable compounds from potato tuber

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ABSTRACT

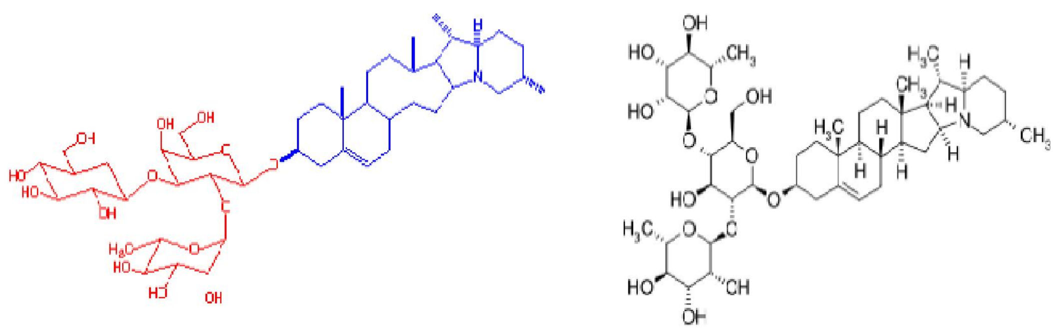
Potatoes contain natural nerve toxins called glcoalkaloids compounds. The two major glycoalkaloids in domestic potatoes are α-chaconine and α-solanine. Unlike other toxins, α-solanine and α-chaconine does not dissolve in water, nor is it destroyed by heat. Therefore, any present on the potato tubers will still be there after it is cooked. Thus the aim of this study was to reduce toxic glycoalkaloids content in potato tuber by the addition of sulfur containing compounds. Free sulfhydryl groups in sulfur compounds have been reported to act directly on glycoalkaloids to reduce their toxicity. Garlic bulb and sodium bicarbonate were added to potato as a safe sulfur-containing source. Glycoalkaloids content in potato tubers were analysed for α-solanine and α-chaconine before and after the treatment with garlic and sodium bicarbonate by high performance liquid chromatography with UV-detection at 205 nm. Experiments were carried out at different temperature, time, garlic weight and pH to determine the optimum removing conditions. The results obtained indicated that the content of glycoal-kaloids in peeled potato tubers subjected to the garlic treatment decreased to 85–90%, compared to the level of glycoalkaloids before treatment. The results obtained showed that potato /garlic/ sodbicarbonate mixture had the lowest amount of total glcoalkaloids (10.455 mg/kg),) in 120 min. at 90^{o} C and pH 8

KEYWORDS

Glycoalkaloids reduction;
α-solanine;
α-chaconine;
Garlic bulb.

INTRODUCTION

As one of the major agricultural crops, the cultivated potato is consumed each day by millions of people from diverse cultural backgrounds. A product of global importance, the potato tuber contains toxic glycoalkaloids (GAs) that cause sporadic outbreaks of poisoning in humans, as well as many livestock deaths. Recent research has found that GAs are responsible for increasing the risk of brain, breast, lung and thyroidcancer[1]. The toxicity of glycoalkaloids at appropriately high levels may be due to such adverse effects as anticholinesterase activity on the central nervous system[2,3], induction of liver damage[4] and disruption of cell membranes adversely affecting the digestive system and general body metabolism[5]. The concentration of GAs in potatoes destined for human consumption in many countries, 200 mg / kg which is generally accepted as a 'total alkaloid taste standard' – has a 'zero' safety threshold[6]. A several studies were studied the distribution of Glycoalkaloids in Whole Tubers[1]. The majority of glycoalkaloids in the potato tuber are located within the first 1 mm from the outside surface and decrease toward the center of the tuber,[1]. Tubers of several cultivars showed an uneven distribution of α -chaconine and α -solanine, with the highest levels around the eyes of the outer layer (periderm, cortex, and outer phloem)[7]. Peeling of the tissue 3-4 mm from the outside before cooking removes nearly all of the glycoalkaloids. Both rates and patterns of accumulation. as well as α -chaconine to α -solanine ratios during tuber growth and development are strongly influenced by genotype[8]. Total levels generally decrease with increasing tuber size. The most pronounced increases in glycoalkaloid levels during storage °C occurred in the outer tuber layers. There appears to be variability among cultivars in their susceptibilities to light-induced glycoalkaloid synthesis[9]. Figure 1 show that α -chaconine is composed of a branched β -chacotriose (bis- α -L-rhamnopyranosyl- β -D-glucopyranose) carbohydrate side chain attached to the 3-OH group of the aglycon solanidine, whereas α -solanine has a branched β -solatriose (α -L-rhamnopyranosyl- β -D-glucopyranosyl- β -galactopyranose) side chain also attached to the 3-OH group of the same aglycon. The trisaccharide chains of both glycoalkaloids can be sequentially cleaved by acid or enzyme hydrolysis to form the aglycon solanidine. TABLE 1 contains a survey of glycoalkaloid content in potatoes analyzed using the high performance liquid chromatography. technique[10]. Garlic has a high concentration of sulfur-containing compounds[11]. The thiosulfinates, including allicin, appear to be the active substances in garlic. Allicin is formed when alliin, a sulfur-containing amino acid, comes into when raw garlic is chopped, crushed, or chewed. The main objective of this thesis is to use garlic bulb as a sulfur containing compound in order to beneficial effects and reduce the toxic glycoalkaloids contents.



α- solanine α- chaconine

Figure 1 : Chemical structure of α-solanine and α-chaconine

TABLE 1 : Glycoalkaloid Content of Extracts of Potato Flesh, Peel and Whole Potatoes[1].

sample (dehydrated powder)	mg/kg		
	α-chaconine (A)	**α-solanine (B)**	**Total (A+ B)**
Atlantic potato peel	59.4	24.4	83.8
Atlantic potato flesh	22.6	13.9	36.5
Russet Narkota potato peel	288	138	425
Russet Norkota potato flesh	3.7	2.7	6.4
Dark Red Norland potato peel	859	405	1264
Dark Red Norland potato flesh	16.0	6.1	22.1
Snowden potato peel	2414	1112	3526
Snowden potato flesh	366	226	591
Russet whole potatoes	65.1	35.0	100
White whole potatoes	28.2	15.3	43.5
Benji whole potatoes	70.7	27.6	98.3
Lenape whole potatoes	413	216	629

ANALYTICAL METHODS

Materials

Sod bicarbonate was supplied by Aldrich Chemical Co. (Gillingham, Dorset, UK). The two glycoalkaloids, á-chaconine and á-solanine were from Sigma (St. Louis, MO, USA). Potato tuber and garlic bulbs were purchased from a local food market in Buriydah, Saudi Arabia.

Preparation of the samples

Weighed samples (1000 g) of Freeze dried peeled potato tubers were ground into fine powder with a mill. In addition, 100 g fresh garlic were cut into pieces to study the effect of thiol on the glycoalkaloid contents. The dried mixture was homogenized in a one liter solution of 1N sod bicarbonate. The mixture was stirred at

95°C for 360 minutes and the suspension was centrifuged and the supernatant was filtered into a volume flask. The concentration of selected glycoalkaloids and total phenolic compounds were detected at all stages of assay. The optimized factors TABLES 2-6 were used for the removal of solanine and chaconine in potato mixture

Analysis and quantification

The concentration of glycoalkoliods, α-solanine and α-chaconine were reported in mg/ kg of sample (dry weight basis). High Performance Liquid Chromatography methods uv detector at 205 nm, array detection for determination of glycoalkaloids were optimized with the aid of a Hitachi liquid chromatograph model. The total glycoalkaloid concentration of freeze dried potato tubers powders in these experiments was at an acceptable level (under 200 mg/k g of FW) in the all samples. The standards were a mixture of 0.888 mg / ml solanine and 0,976 mg/ml chaconine with 95 % purity, standard were purchased from sigma chemical co., st. Lous, MO. For the sulfur analysis, total thiols were measured using the 2-nitro-5-thiosulfobenzoate NTSB method[12]. and free thiols were measured by the 10 mM 5,5 dithiobios 2-nitrobenzoic acid DTNB method[12]. Disulfide bonds were calculated as the difference between total thiols and free thiols.

RESULTS

In the present study, degradation of glycoalkaloids was studied using garlic / sod bicarbonate mixture. The high performance liquid chromatography method was successfully applied to the quantitative determination of á-solanine and á-chaconine in freeze dried peeled potato tubers. In addition the factors affects the removal process were also examined as seen in TABLES 2-6 and Figures 2-5. TABLE 2 proves that the degradation was primarily by sodbicarbonate and the glycoalkaloids were degraded within 120 min. at 90 °C. Degradation of the glycoalkaloids, α-solanine and α-chaconine, has been followed for 360 min as shown in Figure 2. Also, TABLE 3 was estimated that the half-lives were in the range 30-40 min. for the two glykoalkaloid at 90 oC. The fastest degradation was observed in first 30 min. Additionally, for the slow process, degradation rates were in the range 60-120 min. and residuals were still present in solution at the end of the experiment (360 min.). Overall, fast degradation was found in both glycoalkaloids at first 30 min. even at low temperatures which estimated also that the optimum temperature at 90 °C. Figure 3 and TABLE 4 contain a glycoalkaloid content in potatoes at different pHs. as increasing pH than value 5.5 the glycoalkaloids content were decrease, but the evaluation in glycoalkaloids was estimated when the pH decreases than 5.5. None of the whole potatoes pH exceeded the 200 mg total glycoalkaloids per kg of potatoes. Also, an increase in batch temperature has shown to cause an increase in thiols liberates from potato garlic mix Figure 5 and TABLE 6a. but no changes in potato thiols were detected TABLE 6b, as well as α-solanine and α-chaconine in tubers reduce. These results proves that it was necessary to use garlic as a sulfur containing compound in order to liberate the thiol species present in garlic. Increasing the batch temperature produced higher glycoalkaloids removals in a manner similar to glycoalkaloids reductions reported with Colorado potato beetle[13].

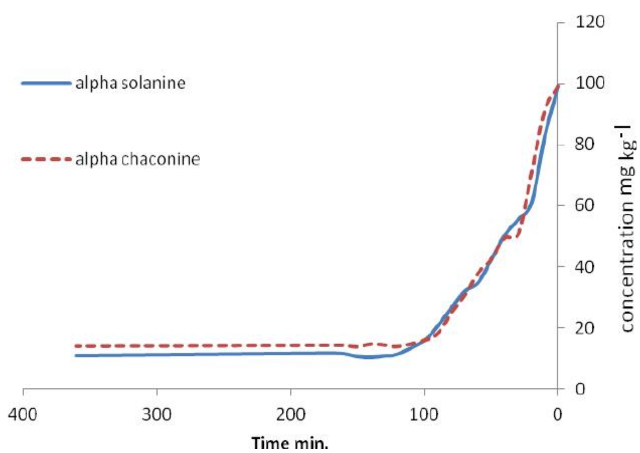


Figure 2 : The effect of time on the degradation of α-solanine and α-chaconine

DISCUSSION

Figures 2-5 estimate that the cleanup of freeze dried potato tubers powders from alkaloids was estimated using a garl/sodbicarbonate mixture at 90 0C, pH 8 and 120 min. as a contact time. Also, it was shown as 100 g garlic in a liter sodbicarbonate (1N) per one kg potato resulted in 90% reductions in glycoalkaloids. Whereas the result obtained from garlic / sodbicarbonate method was higher than those obtained from previous studies that used 3% acetic acid as extractable reagent for glycoalkaloids[10]. TABLES 5a and

5b prove that the extraction of sulfur atom from garlic is the first step in the utilization from the presence of sod bicarbonate on garlic. Whereas during potato-garlic cooking, disulfide bonds were partially detached to form free thiols. the reactivity of thiols my disturb the conformation of both α-solanine and α-chaconine which, in turn, alter their polarity. Reduction in potato toxins may have been influenced by the presence of native free thiols and of added sulfur-containing garlic.

In the present study, degradation of glycoalkaloids was studied using garlic / sod bicarbonate mixture. The HPLC method was successfully applied to the quantitative determination of α-solanine and α-chaconine in freeze dried peeled potato tubers. In addition the factors affects the removal process were also examined as seen in Tables 2-6 and Figures 2-5. Figures 2-5 estimate that the cleanup of freeze dried potato tubers powders from alkaloids was estimated using a garl/ sodbicarbonate mixture at 90°C, pH 8 and 120 min. as a contact time. Also, it was shown as 100 g garlic in a

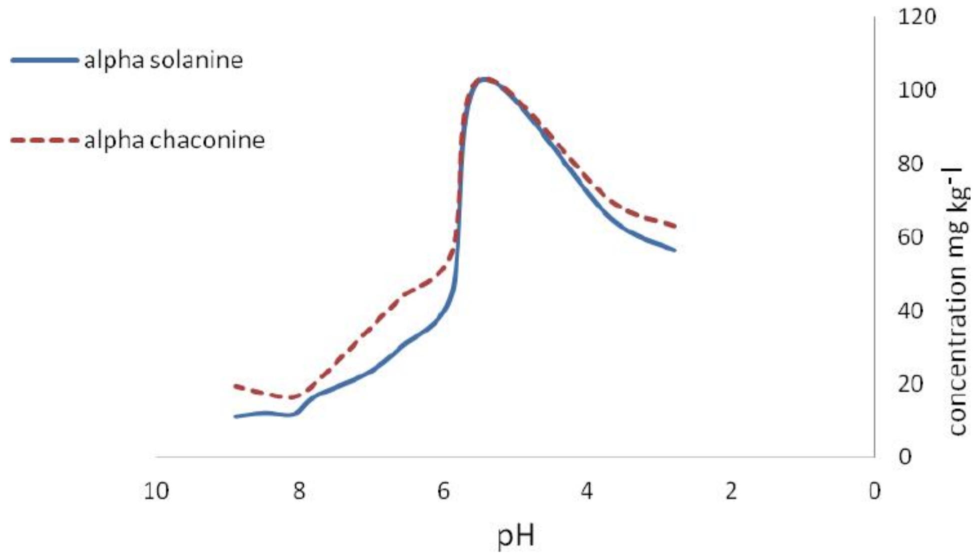


Figure 3 : effect of pH on α-solanine and α-chaconine content when boiling of 1000g potato in 1 L water and 100g garlic

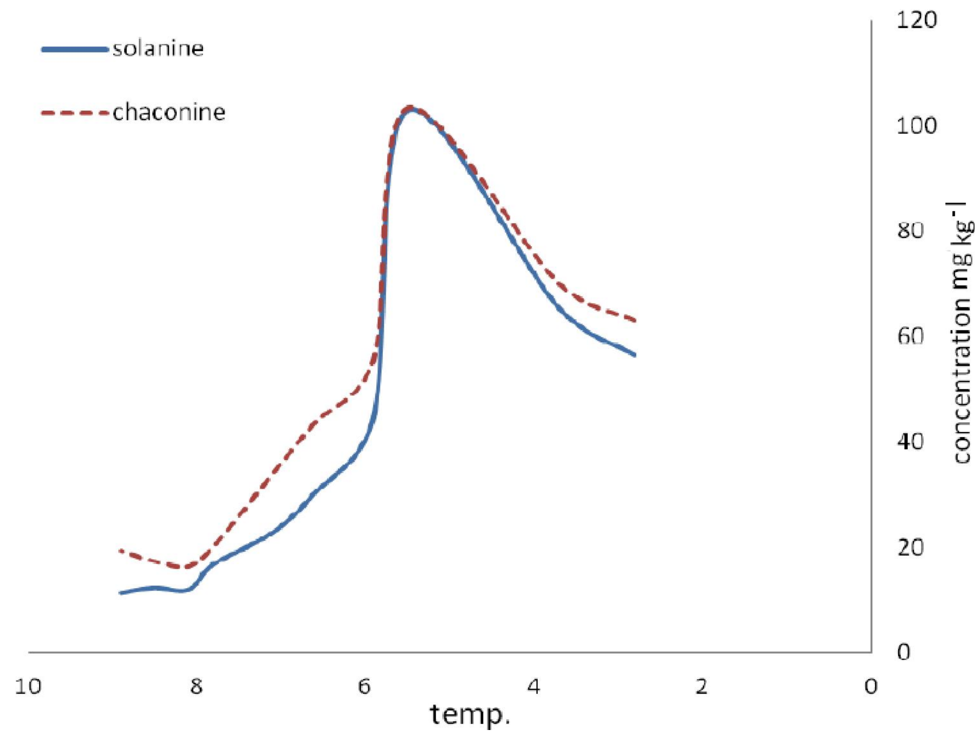


Figure 4 : Effect of temperature on α-solanine and α-chaconine content when boiling of 1000g potato in 1 L water and 100g garlic

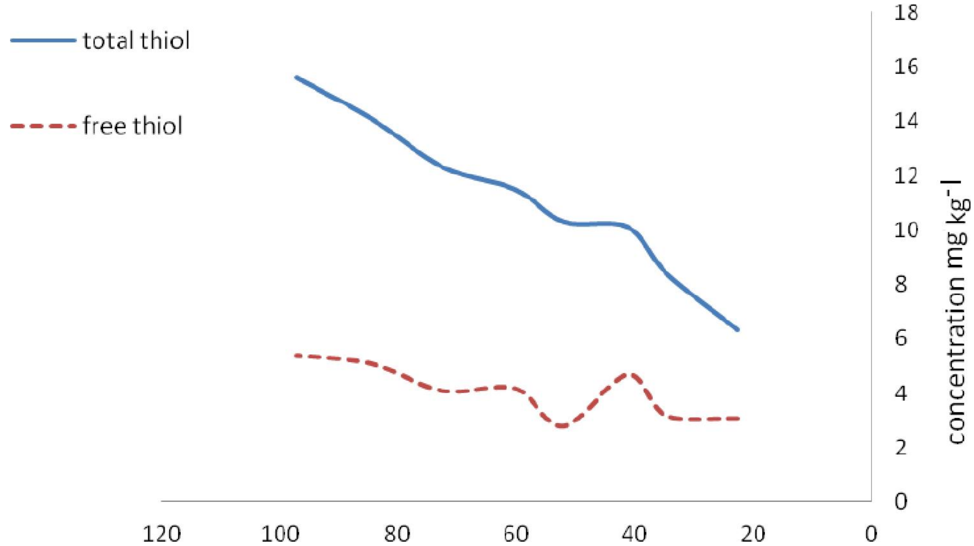


Figure 5 : Effect of temperature on total thiol, free thiol and sulfide

TABLE 2 : Individual and total alkaloid reduction by addition of the garlic / sodium carbonate to potato

Treatment	HPLC detection, mg/kg		summation
	α-chaconine (A)	α-solanine (B)	TGA
Dried potato only before boiling	101.2	98.6	199.8
Boiling of 50 g Potato in 1 L water	101.7	98.2	199.9
Boiling of 50 g Potato in 1L water and 1N sodbicarbonate pH = 8.2	88.9	90.4	189.3
Boiling of 50 g Potato in 1L water and 5 g garlic pH = 5.5	35.8	40.3	76.1
Boiling of 50 g Potato in 1L water and 5 g garlic 1N sodbicarbonate pH = 8.0	11.8	16.4	28.2

TABLE 3 : Effect of time minutes on the removal of alkaloids from potato using garlic salt at pH = 8 and 90°C

Time min.	HPLC detection mg/kg		Summation
	α-chaconine (A)	α-solanine (B)	TGA mg/kg
0	103.1	101.5	204.6
10	82.8	91.3	174.1
20	60.7	73.6	131.3
30	55.3	59.4	105.7
40	50.3	55.4	99.7
50	42.3	50.5	84.5
60	34.7	39.8	72.5
70	29.9	38.5	62.4
80	25.4	29.8	51.2
90	17.6	20.1	38.7
100	13.8	18.8	31.6
120	11.3	16.8	25.1
130	10.7	16.3	25
140	10.2	15.6	24.8
150	10.5	16.7	24.2
160	11.4	16.2	25.6
170	11.6	16.2	25.8
360	10.8	16.9	24.7

TABLE 4 : Boiling of 1000g Potato in 1L water and 100g garlic at different pH

Treatment	HPLC detection mg/kg	
	α-chaconine (A)	α-solanine (B)
pH = 2.8 two drops of HCl	56.4	63.1
pH = 3.7 one drops of HCl	65.4	70.1
pH = 5.5 without addition	102.7	103.2
pH = 5.9 0.001N sodbicarbonate	44.5	55.7
pH = 6.6 0.01N sodbicarbonate	30.2	43.6
pH = 7.1 0.3N sodbicarbonate	22.7	33.9
pH = 7.8 0.5N sodbicarbonate	16.7	20.2
pH = 8.1 1N sodbicarbonate	11.8	16.4
pH = 8.5 1.5N sodbicarbonate	12.2	17.4
pH = 8.9 2.1N sodbicarbonate	11.2	18.4

liter sodbicarbonate (1N) per one kg potato resulted in 90% reductions in glycoalkaloids. Whereas the result obtained from garlic / sodbicarbonate method was higher than those obtained from previous studies that used 3%

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TABLE 5 : Effect of temp. on the removal of alkaloids from potato using garlic salt at pH = 8

Temperature °C.	HPLC detection mg/kg		
	α-chaconine (A)	α-solanine (B)	TGA mg/kg
22.6	103.1	101.5	204.6
34.7	98.9	99.8	198.7
41.2	70.3	80.1	166.4
52.1	52.4	60.3	126.7
60.3	42.8	50.1	92.9
72.4	27.2	30.1	57.3
84.6	12.8	15.9	33.7
97.2	10.2	15.6	24.8

TABLE (6a) : The effect of temperature on the sulfur content of Potato only

Temp. °C	Total thiols µ mol/g	free thiols µ mol/g
25.6	0.0122	0.0031
32.4	0.012	0.0031
41.2	0.0124	0.0031
50.7	0.0122	0.0032
64.8	0.0124	0.0033
70.8	0.0121	0.0032
82.3	0.0122	0.0032
90.6	0.0123	0.0031
96.2	0.0121	0.0034

TABLE (6b) : The effect of temperature on the sulfur content of Potato Garlic / sodbicarbonate

Temp. °C	Total thiols µ mol/g	Free thiols µ mol/g	Disulfide bonds µ mol/g
25.6	6.3	3.1	3.2
32.4	8.4	3.2	5.2
41.2	10.1	4.7	5.4
50.7	10.3	2.8	7.5
64.8	11.5	4.2	7.3
70.8	12.3	4.1	8.2
82.3	14.1	5.1	9
90.6	15.6	5.4	10.2
96.2	18.1	6.8	11.3

acetic acid as extractable reagent for glycoalkaloids [10]. TABLE 2 proves that the degradation was primarily by sodbicarbonate and the glycoalkaloids were degraded within 120 min. at 90°C. Degradation of the glycoalkaloids, α-solanine and α-chaconine, has been followed for 360 min as shown in Figure 2. Also, TABLE 3 was estimated that the half-lives were in the range 30-40 min. for the two glykoalkaloid at 90 degrees C. The fastest degradation was observed in first 30 min. Additionally, for the slow process, degradation rates were in the range 60-120 min. and residuals were still present in solution at the end of the experiment (360 min.). Overall, fast degradation was found in both glycoalkaloids at first 30 min. even at low temperatures which estimated also that the optimum temperature at 90°C. Figure 3 and TABLE 4 contain a glycoalkaloid content in potatoes at different pHs. as increasing pH than value 5.5 the glycoalkaloids content were decrease, but the evaluation in glycoalkaloids was estimated when the pH decreases than 5.5. None of the whole potatoes pH exceeded the 200 mg total glycoalkaloids per kg of potatoes. Also, an increase in batch temperature has shown to cause an increase in thiols liberates from potato garlic mix Figure 5 and TABLE 6a, but no changes in potato thiols were detected TABLE 6b, as well as α-solanine and α-chaconine in tubers reduce. These results prove that it was necessary to use garlic as a sulfur containing compound in order to liberate the thiol species present in garlic.

CONCLUSION

The described methods for the treatment of the potato tuber with garlic sod carbonate can lead to decrease in the toxic glycoalkaloids as well as improvements in the precision and reliability of analyses for quality control and for safety of final products. The obtained data indicate that thiols coming from (garlic and sodium bicarbonate mix) played a significant role in reducing the toxic glycoalkaloid (as determined by high performance liquid chromatography method) in potato during cooking. Based on these results, the potato / garlic / sodium bicarbonate mixture became represent a safer and more beneficial spectrum of glycoalkaloids than that found in natural cultivated potato

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