ELSEVIER

Food Chemistry 73 (2001) 205–208

Food Chemistry

www.elsevier.com/locate/foodchem

# Effect of exposure to light on the solanine content of two varieties of potato (*Solanum tuberosum*) popular in Jordan

M.S.Y. Haddadin [a,*], M.A. Humeid [a], F.A. Qaroot [a], R.K. Robinson [b]

[a] *Department of Nutrition and Food Technology, University of Jordan, Amman, Jordan*
[b] *School of Food Biosciences, University of Reading, Reading RG6 6AP, UK*

Received 11 July 2000; received in revised form 14 September 2000; accepted 14 September 2000

**Abstract**

An analysis of random samples of potatoes (*Solanum tuberosum*) from local markets in Jordan showed that many whole tubers had solanine contents above the recommended level of 20 mg/100 g (fresh weight) of potato, while the maximum level in the skins was 128 mg/100 g. Exposure of two local varieties, Draga and Sponta, to direct or diffuse sunlight generated comparable levels over a 3-week period, but differences between the varieties were significant. It is suggested that growers in countries with Mediterranean climates should select varieties that generate low levels of solanine, remove the tubers from the field immediately after harvest and store the crop in the dark. 

## 1. Introduction

The potato (*Solanum tuberosum*) can be grown in a wide variety of soils and climates and, as a consequence, it has become one of the major food crops in many parts of the world. The tuber is an excellent source of carbohydrates but, in addition, it makes a significant dietary contribution in terms of protein, minerals and vitamins (Smith, 1984). On the negative side, potato tubers may contain high levels of α-solanine and α-chaconine, two glyco-alkaloids which occur together and are usually discussed under one blanket heading, solanine. The usual concentration of solanine in market potatoes is 2–15 mg/100 g (van Gelder, 1984), but it is important that solamne is toxic to humans at levels above 20 mg/100 g of fresh tuber (Plhak & Sporns, 1992).

The comparatively minor change in concentration from 'normal' to 'toxic' means that potatoes must be handled carefully after harvest, for mechanical damage, temperature stress or exposure to light can all initiate solanine synthesis (Dao & Friedman, 1994; Friedman & Dao, 1992; Mondy & Seetharaman, 1990; Percival, Dixon & Sword, 1996; Thomson & Sporns, 1995). Smith (1984) observed levels of 10–40 mg/100 g in apparently healthy potatoes in Germany, but Woolfe (1987) suggested that levels in some varieties could be much higher. As the skin contains the maximum concentration of solanine, peeling can prove beneficial, but any subsequent exposure of the peeled potatoes to light can lead to renewed synthesis of the alkaloids. Domestic processes such as boiling, baking or frying do not destroy solanine and, as chlorophyll and solanine synthesis in potatoes are not necessarily linked, the 'traditional' advice to discard 'green' tubers does not offer the consumer any real protection (Smith, 1984). Consequently, the most reliable method of protecting consumers from solanine poisoning is to improve handling practices and reduce the risk of alkaloid synthesis taking place.

In Jordan, the most potentially damaging practice is that of leaving the harvested potatoes exposed to direct sunlight in the fields or on market stalls, and hence the aims of this study were: (1) to check the solanine contents of a random selection of potatoes from a local market; and (2) expose tubers from two local varieties of potato to different degrees of sunlight, and follow the build-up of solanine over a period of several weeks.

## 2. Materials and methods

The market survey involved buying batches (20 kg) of mature potatoes, during early spring, from 20 individual traders operating around Amman.

* Corresponding author.

0308-8146/01/$ - see front matter 
PII: S0308-8146(00)00279-X

A 20 g sub-sample of diced whole potato, or one of the component fractions (skin, cortex or medulla), was macerated with a pestle and mortar in acidified alcohol [ethanol (96%) with 5% glacial acetic acid] for 10 min. After filtering through Whatman No. 1 filter paper, the filtrate was heated in a water bath at 70°C for 30 min. On cooling, ammonium hydroxide (N) was added until the pH of filtrate reached 10 and the glycoalkaloids precipitated (Harborne, 1973). The filtrate was centrifuged at 5000 rpm for 5 min, and the precipitate was washed with $NH_4OH$ (N/100) (Bushway, Barden, Bushway & Bushway 1980). After recentrifugation, the precipitate of crude glyco-alkaloids was dried to constant weight. Taking the molecular weight of solanine as 868 (Harborne, 1973), enough of the crude mixture of glyco-alkaloids was dissolved in a mixture (1:1) of 96% ethanol and 20% $H_2S0_4$ to give a concentration of alkaloids of 0.2–0.3 mM. From this latter solution, duplicate aliquots (1 ml) were mixed with 5 ml of 60% $H_2SO_4$ and, after 5 min, 5 ml of formaldehyde (0.5% in 60% $H_2SO_4$) were added.

After standing for 3 h, the absorbance of the test solutions was measured at 565–570 nm using a spectrophotometer. The total level of glyco-alkaloids was recorded as solanine equivalent (mg/100 g fresh weight) by reference to a standard curve of pure solanine; the use of the term 'solanine' in this paper refers to these values for total glycoalkaloids and not to α-solanine alone.

The results were analysed using the SAS Statistical Package (SAS, 1987), and an analysis of variance (ANOVA) with LSD was performed to confirm the significance of any differences between the results of each treatment (Steel & Torrie, 1980).

For the trial exposure to sunlight, two popular local varieties of potato, namely Sponta and Draga, were purchased from a local farm (A1-Ghadeer Company, Al-Modawara, Jordan) immediately after harvest, and batches of 30 kg were taken to the laboratory in double-walled paper sacks. After removal of any damaged material, tubers of roughly similar sizes were arranged on wooden trays. The trays were then placed in one of three locations: an open yard with direct exposure to sunlight, under cover but exposed to sunlight reflecting off surrounding structures, and in complete darkness in a large, sealed cupboard. At weekly intervals, 10 tubers of each variety were removed from each of the three locations and analysed in the manner of the market tubers.

## 3. Results and discussion

The results of the market survey are shown in Table 1. The average solanine content for the whole tubers was 19.5 mg/l00 g, but it was notable that 40% of the samples gave values above 20 mg/100 g, i.e. above the upper safe level for solanine (Sizer, Maga & Graven, 1980). Equally notable was the fact that the values for the skins ranged from 25.8 to 128 mg/100 g with an average of 67.7, so that peeling to a depth of more than 1 mm would remove around 80% of the total solanine present.

Table 1
Mean solanine contents (mg/100 g fresh weight) in the 20 samples of potatoes collected from different markets around Amman; each value is an average of the results for two sub-samples

| Sample | Whole tuber | Skin | Cortex | Medulla |
|---|---|---|---|---|
| 1 | 13.7 | 45.2 | 9.1 | 0.7 |
| 2 | 16.9 | 70.0 | 14.4 | 1.2 |
| 3 | 13.8 | 55.8 | 12.3 | 0.5 |
| 4 | 16.7 | 73.1 | 14.9 | 1.2 |
| 5 | 16.9 | 69.7 | 15.2 | 1.4 |
| 6 | 12.7 | 44.9 | 10.6 | 0.8 |
| 7 | 18.1 | 79.2 | 16.3 | 2.4 |
| 8 | 26.8 | 96.4 | 22.1 | 3.4 |
| 9 | 15.4 | 58.9 | 12.3 | 2.3 |
| 10 | 16.3 | 70.0 | 14.1 | 2.0 |
| 11 | 28.4 | 118 | 24.6 | 4.1 |
| 12 | 22.7 | 81.7 | 19.2 | 2.8 |
| 13 | 17.1 | 66.1 | 13.3 | 2.2 |
| 14 | 29.7 | 128 | 25.6 | 4.3 |
| 15 | 25.4 | 92.8 | 22.6 | 3.6 |
| 16 | 14.3 | 47.2 | 9.4 | 1.8 |
| 17 | 9.4 | 25.8 | 5.2 | 0.2 |
| 18 | 21.2 | 78.5 | 17.3 | 2.4 |
| 19 | 23.4 | 84.3 | 19.6 | 2.7 |
| 20 | 32.3 | 107 | 27.2 | 3.1 |

It is tempting to suggest, therefore, that if potatoes of this type are peeled and then immediately boiled or chipped, the risk to the consumer will be negligible, but two points raise a note of caution. First, many restaurants sell jacket potatoes with a variety of fillings, and the customer will usually eat the entire potato including the skin while, second, pricing practices in the Middle East may discourage caution. Thus, in the morning, the best quality and more highly priced produce will be on display but, as evening approaches and only poor quality and damaged goods remain, prices are reduced. This practice means that low-income groups, who may be loathe to waste the potato peelings, or restaurant owners seeking a bargain, may be eating or serving meals with a high content of solanine.

Consequently, there is a strong incentive to minimise the build-up of solanine in local potatoes in Jordan through improvements in mechanical handling and, more especially, by reducing exposure to light. This latter point was confirmed by the results shown in Figs. 1 and 2. The comparable figures for whole tubers of Sponta were 3.1, 17.8 and 29.4 mg/100 g for the dark, indirect sunlight and direct sunlight treatments, respectively, while the values for whole tubers of Draga were 8.4, 20.9 and 44.5 mg/100 g. Clearly if people were to

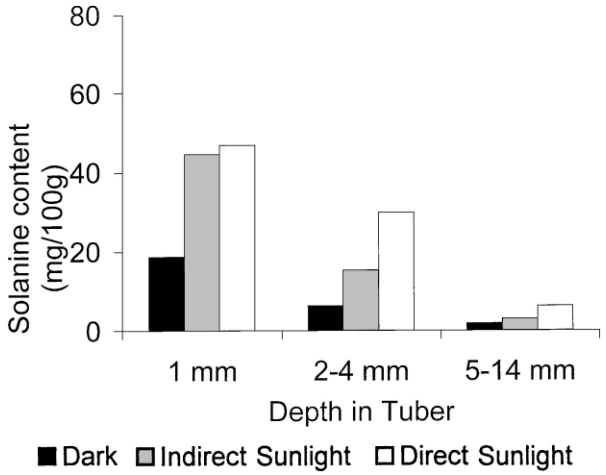


Fig. 1. The solanine contents of samples of potatoes (variety Sponta) following storage for 3 weeks under the conditions indicated. Subsamples for analysis were taken at different depths below the skin.

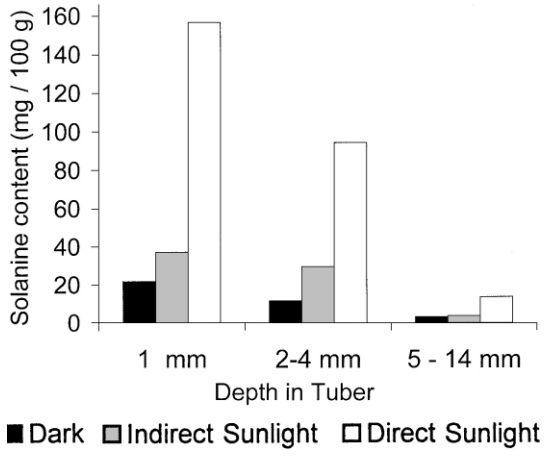


Fig. 2. The solanine contents of samples of potatoes (variety Draga) following storage for 3 weeks under the conditions indicated. Subsamples for analysis were taken at different depths below the skin.

eat the whole tubers of either variety following exposure to sunlight, then their intakes could be above the recommended maximum level of 20 mg/100 g and, with the variety Draga, even diffuse sunlight generated a marginally dangerous level.

The likely effect of peeling is evident from the figures, but it was noticeable that even a quite generous removal of peel (1–2 mm) might not have rendered safe the exposed tubers of Draga; in the case of Sponta, only direct sunlight raised the solanine level in peeled potatoes above the 'safety' zone. These differences between the varieties were significant at the 5% level, and it could be concluded that, if other factors such as yield or resistance to disease are comparable, farmers in Mediterranean countries should select varieties with limited capacities to synthesise glyco-alkaloids.

Table 2
Changes of solamine in potatoes over 3 weeks

| Time (weeks) | Variety | |
|---|---|---|
| | Sponta | Draga |
| 0 | 2.0 | 4.1 |
| 1 | 13.6 | 19.0 |
| 2 | 29.4 | 44.5 |

Rapid removal of the tubers from the field is important as well. Thus, between week 3 (data shown in Figs. 1 and 2) and week 6, the increases in solanine content were not significant but, over the first 3 weeks, the figures (mg/100 g) for whole tubers exposed to direct sunlight revealed the pattern shown in Table 2.

The trends in solanine generation in both skins and cortex were similar, so that, clearly, it is in the interest of consumers in Jordan that: (1) all varieties of potato are removed from the field as soon as possible after harvesting and (2) the tubers are stored in the dark. Obviously these conclusions could have been predicted on the basis of previous studies, but the fact that some of the market samples were unsafe suggests that direct evidence of the problem merits further publicity.

## Acknowledgements

The authors wish to thank Dr. M.M. Shabana of the Faculty of Pharmacy, Cairo University for providing the pure sample of solanine.

## References

Bushway, R. J., Barden, E. S., Bushway, A. W., & Bushway, A. A. (1980). The mass extraction of potato glycoalkaloids from blossoms. *Amer. Potato J., 57*, 175–180.

Dao, L., & Friedman, M. (1994). Chlorophyll, chiorogenic acid, glycoalkaloid and protease inhibitor content of fresh and green potatoes. *Journal of Agricultural and Food Chemistry, 42*, 633–639.

Friedman, M., & Dao, L. (1992). Distribution of glycoalkaloids in potato plants and commercial potato products. *Journal of Agricultural and Food Chemistry, 40*, 419-423.

Harborne, J. B. (1973). *Phytochemical methods*. London: Chapman & Hall.

Mondy, N. I., & Seetharaman, K. (1990). Effect of irradiation on total glycoalkaloids in potatoes. *Journal of Food Science, 55*, 1740–1742.

Percival, G., Dixon, G. R., & Sward, A. (1996). Glycoalkaloid concentration of potato tubers following exposure to daylight. *J. Sci. Food Agric., 71*, 59–63.

Pihak, L. C., & Sporns, P. (1992). Glycoalkaloid concentration of potato tubers following exposure to daylight. *Journal of Agricultural and Food Chemistry, 40*, 2533–2540.

SAS (1987). *SAS user's guide in Statistics*. Cary, NC: SAS Institute.

Sizer, C. E., Maga, J. A., & Graven, C. J. (1980). Total glycoalkaloids in potatoes and potato chips. *Journal of Agricultural and Food Chemistry, 28*, 578–579.

Smith, O. (1984). *Potatoes: production, storing and processing*. Westport, CT: Avi Publishing Co.Inc.

Steel, R. G. B, & Torrie, J. H. (1980). *Principles and procedures in statistics*. New York: McGraw-Hill Book Co.

Thomson, C. A., & Sporns, P. (1995). Fluorescence polarization immunoassays for potato glycoalkaloids. *Journal of Agricultural and Food Chemistry, 43*, 254–260.

van Gelder, W. M. J. (1984). A new hydrolysis technique for steroid glycoalkaloids with unstable aglycones from *Solanum* spp. *Journal of Science of Food and Agriculture, 35*, 487–494.

Woolfe, J. A. (1987). *The potato in the human diet*. Cambridge, UK: Cambridge University Press.