Effect of Cooking on the Total Glycoalkaloid Content of Potatoes

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The effect of different cooking methods on the total glycoalkaloid (TGA) content of three potato cultivars was studied. The cultivars, Katahdin, Chipbelle, and Rosa, were baked and fried and compared with fresh controls. Tubers were separated into cortex and pith tissues and analyzed separately. The ranges in TGA content of baked cortex were 25–76 mg/100 g dry weight and of the corresponding pith 5–12 mg/100 g dry weight, fried cortex 27–72 mg/100 g dry weight, and fried pith 3–10 mg/100 g dry weight. In all cultivars baking and frying of potato tissues decreased the TGA content significantly ($p < 0.05$). The cortex had significantly higher ($p < 0.01$) TGA content as compared to that of pith. Varietal differences were also observed. Katahdin and Chipbelle were significantly higher in TGA content than Rosa.

The potato (*Solanum tuberosum* L.) is considered as a major vegetable crop in the United States with an annual per capita consumption of 120 lb (USDA, 1982). It is also widely used in many parts of the world as a staple food for man. The potato is classed among the foods that are valued for protein, mineral, and vitamin content (Talburt and Smith, 1975). However, under certain conditions the naturally occurring toxic compounds known as glycoalkaloids can be produced in excessive amounts. Two of the chief glycoalkaloids, α-solanine and α-chaconine, are potent cholinesterase inhibitors. Serious illness and death in humans and farm animals have been attributed to high glycoalkaloid content (>30 mg/100 g fresh weight) of potato tubers (Bömer and Mattis, 1924; Willimott, 1933; McMillian and Thompson, 1979). Because of possible toxic effects, the total glycoalkaloid (TGA) content of 20 mg/100 g fresh weight is considered as the upper limit of safety for food, but levels as low as 14 mg/100 g fresh weight can impart a bitter flavor (Jadhav and Salunkhe, 1975; Sinden and Deahl, 1976).

Glycoalkaloids occur in potato tubers in various amounts depending on the cultivar, stage of development, environmental factors, and stress conditions (Sinden and Webb, 1974). These compounds are concentrated in the periderm and cortex, including eye regions, with the concentration decreasing from outside to inside (Wolf and Duggar, 1940; Lampitt et al., 1943).

Limited data are available regarding the stability of glycoalkaloids under various cooking methods. Steaming, boiling, and conventional and microwave baking of potatoes did not significantly alter glycoalkaloid content, although values reported for cooked potatoes were lower than the corresponding raw potato (Baker et al., 1955; Bushway and Ponnampalam, 1981). These authors reported that cooking lowered the glycoalkaloid content slightly but did not carry out statistical analysis of the data. Solanine decomposes at 260–270 °C, which is 70–80 °C above normal frying temperatures (Porter, 1972). Frying has been found to concentrate TGA content in potato chips and peels (Sizer et al., 1980; Bushway and Ponnampalam, 1981).

Toma et al. (1979) reported that potato peels, a byproduct from the potato industry, should be considered a substitute for dietary fiber in bread since it lacks the unfavorable high phytate content found in wheat bran, but the TGA content in these peels was not considered. Augustin et al. (1979) reported that whether raw or cooked and regardless of the cooking methods used tuber peel contained significantly higher amounts of ash, crude fiber, protein, and riboflavin but less thiamine than the corresponding flesh. Fried potato peels and french fries are commerically produced for human consumption. This study was undertaken to determine the effect of home cooking, as well as commercial processing, on TGA levels of potato products.

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MATERIALS AND METHODS

Three cultivars, Katahdin, Chipbelle, and Rosa, were used in this study. Katahdin and Chipbelle were grown at the Cornell Vegetable Research Farm at Riverhead, Long Island, NY, and Rosa was grown at the Cornell Research Farm at Freeville, NY, during the 1981 growing season. The tubers were stored for 4 months at 5 °C until analyzed.

Potatoes of medium size and uniform shape were selected from each variety in order to limit variations from size differences. Thirty potatoes from each variety were baked at 400 °F in two conventional ovens (15 in each oven) for 1 h. All potatoes were allowed to cool but were still warm when each was cut. Each tuber was cut longitudinally from bud to stem end in order to include both sections, and slices were subsequently separated into cortex (including the periderm) and pith sections. The proportion of cortex tissue to pith tissue varies from variety to variety but the percentage of cortex comprises approximately 40% of the whole tuber by weight. Since in commercial practice the cortex tissue is baked and frozen before frying, a similar procedure was followed in this study. The baked cortex tissue was frozen and fried in 100% vegetable oil at 350 °F for 3–4 min by using a Sunbeam Fryer. Wedges of raw pith were fried in a similar manner. The moisture content of raw, baked, and fried cortex and pith was determined by using a Stokes freeze-dryer. Results are reported on a dry weight basis in order to eliminate differences in dehydration. Crude lipid content was determined in fried tissues by using the method described in AOAC (1975).

Analyses of fresh tubers were made by using the modified titration method of Bushway et al. (1980) and Fitzpatrick et al. (1978). During frying, water is lost at the same time fat is absorbed. The amount of water lost, as well as the lipid absorbed, was calculated. Work in this laboratory has shown that hydration is necessary for maximum TGA extraction from fried samples. The extraction, cleanup, and quantitation were the same as for fresh tubers except for the fried samples. In these samples partitioning with petroleum ether was used following the method of Bushway and Ponnampalam (1981). Duplicate

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Table I. Total Glycoalkaloid Content of Fresh, Baked, and Fried Potato Tissues[a]

	mg/100 g fresh weight					
	cortex			pith		
variety	fresh	baked	baked and fried	fresh	baked	fried
Katahdin	13.99 ± 0.1	21.68 ± 0.1	43.22 ± 0.3	2.27 ± 0.1	2.70 ± 0.3	4.47 ± 0.3
Chipbelle	18.48 ± 0.3	30.38 ± 0.1	65.17 ± 0.5	2.67 ± 0.2	2.80 ± 0.1	4.15 ± 0.2
Rosa	7.56 ± 0.6	10.17 ± 0.5	24.27 ± 1.0	1.02 ± 0.1	1.27 ± 0.1	1.60 ± 0.2

[a] Mean values and standard deviation of the mean.

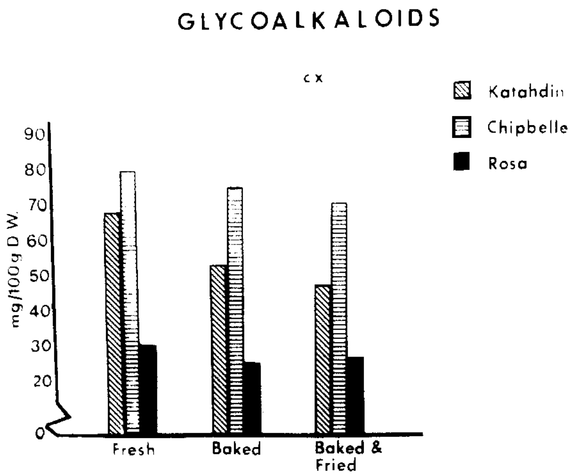

Figure 1. Effect of baking and frying on the TGA content (dry weight basis) of cortex tissue of Katahdin, Chipbelle, and Rosa potatoes.

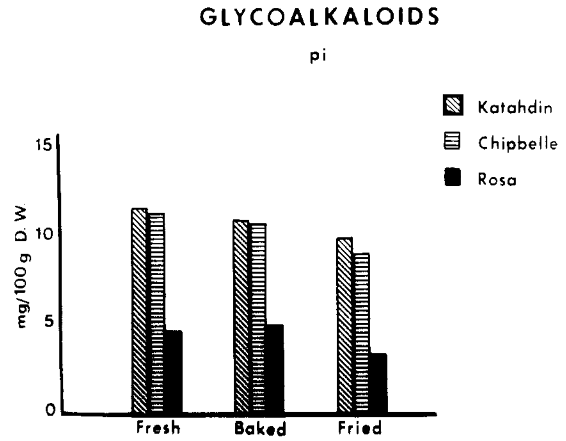

Figure 2. Effect of baking and frying on the TGA content (dry weight basis) of pith tissue of Katahdin, Chipbelle, and Rosa potatoes.

determinations were made on each treatment.

STATISTICAL ANALYSES

Data were analyzed by using three factor analysis of variance and the L.S.D. multiple test which compares all treatments with each other (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Conventional baking and frying of potatoes resulted in significant reductions ($p < 0.05$) in the total glycoalkaloid content (dry weight basis) of cortex tissues (Figure 1). Although slight decreases in TGA content of pith tissue following cooking were observed, these differences were not significant (Figure 2). This may be due to the high percentage of glycoalkaloid associated with the cortex as compared to the pith tissue (Wolf and Duggar, 1946). Zitnak and Johnson (1970) suggested that since solanine has an initial decomposition temperature of 470 °F and melts at 545 °F, it would not be destroyed in most potato preparations involving heat. It is possible that the decrease in TGA content during conventional baking may be due to the difficulty of extracting glycoalkaloids from the cooked tissues. Beaulieu and Hadziyev (1982) had difficulty in extracting BHA and BHT from cooked tissues. The TGA content was lower in fried cortex and pith as compared to the corresponding baked tissues. This decrease may be due to the ease of cell separation of the cooked potato tissue when the temperature is increased (Fedec et al., 1977). The TGA content of Katahdin and Chipbelle baked cortex exceeded the level (20 mg/100 g of potatoes fresh weight) considered safe (Table I), and fried cortex tissues from all three varieties greatly exceeded this critical value. Because of the high TGA content of fried potato peels and the resulting possible toxicity, one should use caution in eating fried potato peels.

Significant varietal differences ($p < 0.05$) in TGA content was observed (Figures 3, 4, and 5). In all three varieties the cortex tissue was significantly higher in TGA content ($p < 0.01$) than the pith tissue. Katahdin and

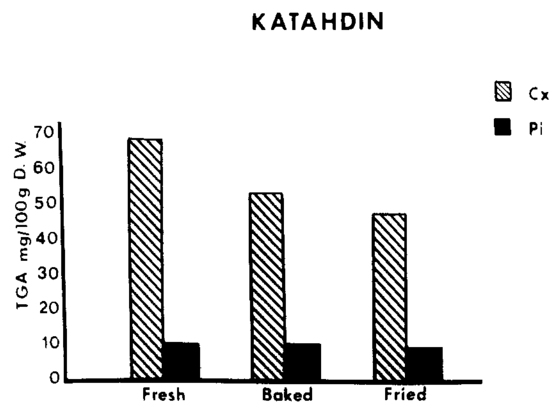

Figure 3. Comparison of TGA content (dry weight basis) in cortex and pith tissue of Katahdin potatoes after baking and frying.

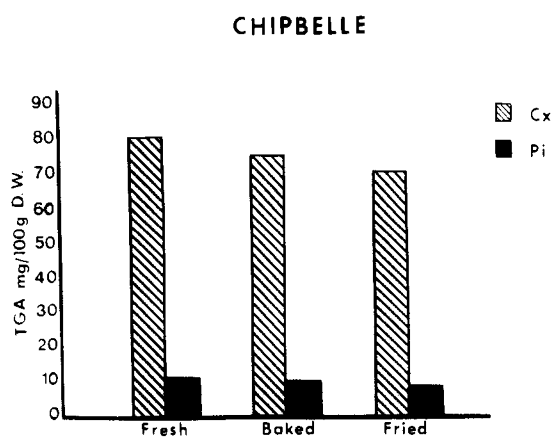

Figure 4. Comparison of TGA content (dry weight basis) in cortex and pith tissue of Chipbelle potatoes after baking and frying.

Chipbelle varieties were significantly higher in TGA content ($p < 0.05$) than Rosa in both cortex and pith tissues.

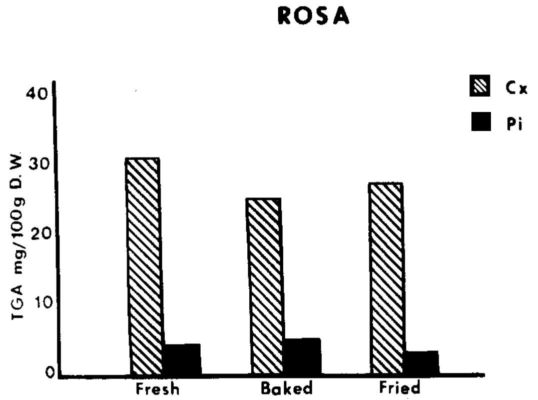

Figure 5. Comparison of TGA content (dry weight basis) in cortex and pith tissue of Rosa potatoes after baking and frying.

Table II. Moisture Content of Fresh, Baked, and Fried Potato Tissues[a]

	% moisture					
	cortex			pith		
	raw	baked	baked and fried	raw	baked	fried
Katahdin	81.4	59.8	10.0	82.2	79.8	55.8
Chipbelle	77.3	45.1	8.5	76.7	74.5	54.8
Rosa	77.2	52.0	11.8	81.0	75.2	53.8

[a] Mean of three trials.

Table III. Crude Lipid Content of Fried Potato Tissues[a]

	% lipid	
	cortex	pith
Katahdin	34.16	9.84
Chipbelle	34.12	9.95
Rosa	31.54	10.50

[a] Mean of two trials and the results are given on a dry weight basis.

The moisture content of raw, baked, and fried cortex and pith tissues is given in Table II. During conventional baking greater water loss occurred in the cortex than in the pith region. Frying greatly decreased the moisture content.

In all three varieties the cortex tissue was significantly higher in crude lipid ($p < 0.05$) than the pith tissue (Table III). The crude lipid content of fried cortex tissues is comparable to that of potato chips reported by Sizer et al. (1980). Although the fried cortex tissue had significant amounts of glycoalkaloids (on fresh weight basis) the taste was not as bitter as would be expected. Perhaps the bitterness was masked by the lipid. In the fried cortex tissue the danger of possible toxicity is increased since the bitterness is not noticed by the consumers.

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