Canning of Yams: Absorption and Removal of Sulfur Dioxide During Processing[1]

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ABSTRACT

Habanero yams (*D. rotundata*) chunks were dipped in 4,000 p/m sulfur dioxide solutions at different pH levels for various periods of time. The absorption and removal of sulfur dioxide was determined at different canning processing steps. Sulfur dioxide absorption tended to increase as dipping time increased. Higher absorptions were obtained in samples dipped in solutions of pH 3.0.Nevertheless, sulfur dioxide content after heating in water at 200° F for 10 min was reduced, in all cases, to just 1.61 p/m. Brine pH, acidity and turbidity, and color and acidity of yam chunks were measured 15 days after being processed. The average brine pH and turbidity were 5.51 and 35.75 respectively. Acidity was higher in yam chunks than in brine. Lightness in color of canned yam chunks after being boiled in water for 10 min was less than that of yams taken fresh from the can.

INTRODUCTION

Yams (*Dioscorea rotundata*) of the variety locally known as Habanero are the most extensively cultivated in Puerto Rico. The total production of yams (including all varieties) for the fiscal year 1975–76 was 282,000 cwt. with a cash value of \$6.2 million (3).

In Puerto Rico, yams are generally eaten boiled in salt water. They are in great demand in both rural and urban areas. They are cultivated mainly to supply the fresh market, but due to yam's seasonal behavior, supplies are greater from October to January, there being practically none from February to September. This situation warrants the establishment of a yam canning industry to alleviate the scarcity of this produce during the off-season period.

For processing, fruits and vegetables are generally peeled with a hot lye solution (2, 10). In the case of Habanero yam, this treatment activates the enzyme system, rendering the yams unfit for canning if proper measures are not taken to inhibit that system.

The major enzymes involved in the browning discoloration of yams are phenolases (9). Some fruits also suffer discoloration following mechanical or physiological injury involving the enzyme-catalyzed oxidation of phenolic compounds by polyphenoloxidase. Weaver and Charley (13), working with bananas, found a significant correlation between the concentration of ascorbic acid and both the initial brownness and susceptibility to

[1] Manuscript submitted to Editorial Board October 16, 1978.

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discoloration. Both increased as ascorbic acid decreased in individual ripening bananas.

Sulfite solutions are generally used to inhibit enzyme activity in processing fruits and vegetables. Sulfur dioxide is used as an antioxidant and as an inhibitor of enzyme-catalyzed oxidative discoloration and of non enzymic browning during preparation, storage, or distribution of many food products (6).

Sulfuring of apricots before sun drying is an established practice. Stafford and Boling (12) found a linear relationship between the concentration of the bisulfite dip solution and the sulfur dioxide content of the treated fresh apricots. They also found an increasing absorption rate of bisulfite into apricots that were dipped into progressively lower pH solutions.

Amla and Francis (1) found that the optimum pH range for sulfur dioxide solution stability and the quality of potatoes was 5.0 to 6.0. They also demonstrated that potatoes treated with 4000 p/m sulfur dioxide at various pH levels showed no discoloration, but the optimum pH of the dipping solutions for prepeeled potatoes was in the range of 5.5 to 6.5. Moreover, they found that the residual sulfur dioxide increased in the strip of potatoes with the increasing strength of solution but not with increasing time of immersion (4). Working with corn, Hayes et al. (5) found that a pH of 5.0 appears to be the optimum for the greatest uptake of sulfite from solutions.

Finally, it is recognized that residual sulfur dioxide in canned products is a problem due to the interaction of the sulfur dioxide with the tin plate (6). Although the desirability of the removal of sulfur dioxide has been recognized, this removal is never complete. This paper reports studies on the absorption and removal of sulfur dioxide of yams during processing for canning.

MATERIALS AND METHODS

Yams used in this study were obtained in the local market. They were brought to the laboratory and stored at ambient conditions until used. Five to 10 lb were used per test. Yams were peeled in a 20% boiling lye solution for 4 min, brushed in a rotary washer provided with water jets and nylon brushes to remove any peel left and the excess lye solution, trimmed and soaked for 5 min in a 4000 p/m sulfur dioxide solution to which the pH was previously adjusted with citric acid to 3.0, 4.0, and 5.0. A control solution (tap water near neutral) without citric acid addition was used. Yams were then cut into chunks of about ½ × ½ × 2 in, and dipped in sulfur dioxide solutions prepared as above for 5, 10, 15 and 20 min. Samples were taken for residual sulfur dioxide analyses after each dipping period. Yams were then blanched in tap water at 200° F (93.3°

C) for 10 min. Samples for sulfur dioxide analyses were also taken at the end of this period. Yam chunks were canned in enameled No. 303 tin cans. They were filled with 8 oz of yam chunks and 1.5% boiling brine solution and 250 p/m of EDTA. Filled cans were passed through a vapor tunnel, sealed, and retorted for 25 min at 15 lb/in^2 and 250° F (121.1° C). After processing, the canned yams were stored at ambient conditions until analyzed.

Sulfur dioxide analyses were performed following the method developed for prepeeled potatoes by Ross and Treadway (11). Turbidity of the brine solution after canning was measured in a Klett-Summerson Photoelectric Colorimeter[3] using a blue glass filter (400–465 nm). The pH of the brine and visual observations of yam chunks were recorded. Color of canned yam chunks before and after boiling for 10 min in water, was determined by a tristimulus colorimeter with a white standard tile (L = 92.8, a = −.5 and b = +2.5). For these measurements, yams were mashed before being placed in the specimen cell holder. Results of this evaluation were submitted to analysis of variance, and the differences among them were judged with Duncan's multiple range test (7, 8).

RESULTS AND DISCUSSIONS

Within the limits of this study, sulfur dioxide content of the yam chunks tended to increase as the dipping time in the potassium metabisulfite solution increased (table 1). At pH 3.0 differences of SO_2 absorption among dipping times were highly significant. At pH 4.0 there were highly significant differences between samples dipped in the solution for 5 min and samples dipped for 15 and 20 min, but no significant differences were found between samples dipped for 5 and 10 min; for 10 and 15 min; and for 15 and 20 min. However, there was a significant difference at the 5% level between samples dipped for 10 and 20 min. At pH 5.0, and when samples were dipped in tap water near neutral there were highly significant differences between samples dipped in solution for 5 min and the other dipping times. At pH 5.0 no significant differences were found between dipping times for 10, 15, and 20 min; however, when tap water near neutral was used as the dipping solution, differences between samples dipped for 10, 15, and 20 were highly significant. No significant difference was found between samples dipped in SO_2 solutions for 15 and 20 min.

Except in dipping time of 5 min, samples dipped in solutions at pH 4.0 absorbed less sulfur dioxide than samples dipped in solutions at pH 5.0.

[3] Trade names in this publication are used only to provide specific information. Mention of a trade name does not constitute a warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

TABLE 1.—*Sulfur dioxide absorption by yam chunks dipped at different time intervals in 4000 p/m sulfur dioxide solution at various pH and turbidity levels, and pH of the brine solution*

pH of SO_2 dipping solution	Dipping time (min)			
	5	10	15	20
		SO_2 absorption (p/m)		
3.00	65.19	105.56	170.32	242.54
4.00	59.03	66.37	73.46	77.00
5.00	50.25	95.01	97.09	99.73
Tap water near neutral	30.07	64.13	77.05	77.71
		Turbidity[1]		
3.00	40.5	43.0	28.0	32.5
4.00	35.0	24.0	34.0	30.5
5.00	41.0	42.5	43.0	42.0
Tap water near neutral	36.0	32.0	35.0	33.0
		Brine pH		
3.00	5.50	5.50	5.50	5.45
4.00	5.65	5.60	5.55	5.55
5.00	5.45	5.50	5.45	5.50
Tap water near neutral	5.45	5.48	5.51	5.48

[1] Units

TABLE 2.—*Lightness measurements of canned yams taken fresh from the can and being boiled for 10 min in water and measured with a tristimulus color instrument*

pH of dipping solution	Lightness (L) measurements							
	Dipping time (min)							
	5		10		15		20	
	A[1]	B[2]	A	B	A	B	A	B
3.00	74.68	68.54	71.78	71.06	75.40	68.68	76.10	70.84
4.00	71.54	66.48	70.02	68.42	69.70	64.90	69.22	67.98
5.00	72.18	65.14	56.40	57.66	73.22	65.62	70.14	58.38
Tap water near neutral	71.12	60.48	72.60	61.84	72.82	63.68	68.76	63.08

[1] Yams fresh from the can.
[2] Canned yams after boiling for 10 min.

Also, except in samples dipped in solutions at pH 4.0, the others absorbed more sulfur dioxide as pH decreased. Thus, higher absorptions were obtained in samples dipped in solutions of pH 3.0 while lower values were obtained in samples dipped in the control solutions. There was a highly significant difference between samples dipped in solutions of pH 3.0 and samples dipped in the other solutions. Samples dipped in solutions of pH 5.0 were significantly different from control samples and samples dipped in solutions of pH 4.0. No significant difference was observed between the control samples and the samples dipped in solutions of pH 4.0.

Sulfur dioxide content of samples after blanching at 200° F for 10 min in a water bath was the same for all samples (1.61 p/m). Thus, blanching removed almost all sulfur dioxide irrespectively of the dipping time and pH of the dipping solutions. The average turbidity of the brine (table 1) was 35.75 units, ranging from 43 to 24 units. This shows that dipping time in sulfur dioxide solutions at the different pH levels and the blanching procedure have a small effect in softening or loosening yam pulp. The average brine pH obtained was 5.51, ranging from 5.65 to 5.45 (table 1).

Table 2 shows the results of the color determinations. Neither yellowness (−a) nor redness (+b) showed definite trends. On the other hand, lightness (L) of samples tended to be higher in samples taken fresh from the can. However, there were no significant differences due to the dipping times and pH of the dipping solutions. Nevertheless, some significant differences were found among samples dipped at different pH levels after boiling for 10 min. Thus, samples dipped in solutions at pH 3.0 and 4.0 had significantly higher L values than samples dipped in solutions of pH 5.0 and control samples. No significant differences were found among samples dipped in solutions of pH 3.0 and 4.0 nor among samples of pH 5.0 and the control samples. The length of dipping time apparently had no effect in color lightness of yam chunks.

RESUMEN

Se estudió la retención de bióxido de azufre (SO_2) por el ñame Habanero (*Dioscorea rotundata*) en las distintas etapas del enlatado de este vegetal. El bióxido de azufre se usa comúnmente para inhibir el pardeamiento, tanto en frutas como en hortalizas mientras se elaboran. Se utilizó una solución de 4000 ppm en la cual se sumergieron los pedazos de ñame a diferentes niveles de pH y períodos de immersión. Se encontró que la absorción de SO_2 aumentó al prolongar la inmersión. La absorción fue mayor cuando el pH de la solución fue de 3.0. Sin embargo, el nivel de SO_2 bajó considerablemente luego de escaldar los pedazos de ñame a 200° F (93.3° C) por 10 min. El ñame fue enlatado en salmuera y examinado para acidez y color 15 días después. Tambien se determinaron la acidez, turbidez y pH de la salmuera. La acidez de los pedazos de ñame fue más alta que la de la salmuera. Los ñames enlatados tendieron a oscurecerse cuando se hirvieron en agua por 10 min. Los valores medios de pH y de turbidez fueron de 5.51 y 35.75 respectivamente.

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