INTERNAL CAN CORROSION DUE TO HIGH NITRATE CONTENT OF CANNED VEGETABLES

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ABSTRACT

Tomatoes from four areas and green beans from a fifth area in Florida were examined for their nitrate content and its effect on internal can corrosion in the processed product.

Floradel tomatoes from Bradenton canned during May and June of 1965 were examined after one year storage. Little detinning was evident from these fruits which had a nitrate content of 7 ppm. Similar results were obtained with fruit from the Immokalee and Ft. Pierce areas, which were processed and stored for six months.

Tomatoes from the Homestead area, which were grown on plots to which above normal nitrogen fertilization was added, were high in nitrate content. Levels of 53 to 78 ppm nitrate were detected in the fruit. Extensive detinning was evident in the can after 3.5 to 4 months storage.

Green beans from the Belle Glade area had nitrate levels of 425 to 800 ppm in the raw pod. After a water blanch process, this value dropped to less than 26 ppm. Some detinning was evident but not excessive after 1.5 months storage.

Internal can corrosion was measured by a photometric procedure.

INTRODUCTION

Inasmuch as vegetable growers are employing high rates of fertilization, and sporadic detinning not clearly related to nitrogen fertilization is extant, this study was undertaken to determine what the relationship might be between vegetable nitrate content and tinplate corrosion.

In 1953 Strodtz and Henry (4) reported that nitrates in vegetables were corrosive to internal tinplate below a pH of approximately 5.5 but that corrosion also depended on the commodity. In 1943 Wilson (5) reported a nitrate content of several hundred ppm in the expressed sap of most of the vegetables examined while many had in excess of 1000 ppm. Griffith and Johnson (2) found the nitrate levels of rape and kale to be related to the nitrogen soil fertility but variable with maturity and with the portion of the plant used for the test.

In south Florida some economic losses have occurred due to corrosive canned vegetables.

MATERIALS AND METHODS

Tomatoes—Floradel tomatoes were grown at the Gulf Coast Experiment Station. Three levels of nitrogen fertilization were used but later soil analyses (several weeks prior to harvest) indicated nitrogen and potassium deficiencies. Three harvests were obtained on May 17 and 26 and June 9, 1965. The fruit was transported to the Department of Food Science at Gainesville for processing. After being steamed and peeled the tomatoes were canned whole with extracted juice from fruit of the same lot. A $CaCl_2$-NaCl tablet was added to each can. Processing was for 45 minutes at 212 F.

Grothen's Globe and Homestead 24 varieties of tomatoes such as those available for commercial processors were obtained from the Imokalee area. Both juice and whole tomatoes were packed on December 29, 1965. From the Ft. Pierce area, Homestead 24 variety commercial fruit were obtained. These tomatoes were processed on January 6, 1966. The above fruit were also processed at Gainesville.

An acre plot of commercially grown Homestead 24 tomatoes was contracted in the Homestead area. Normal fertilization was permitted and additional nitrogen fertilizer was added (Table I) to subplots by Dr. P. G. Orth of the Subtropical Station. A severely defoliating frost on January 31, 1966, destroyed most of the foliage but did little damage to the more mature fruit. This fruit was harvested and processed on February 26 and March 12, 1966 at a commercial plant in Princeton. Processing was accomplished in a rotary cooker for 12.25 minutes followed by air cooling. A few samples were cooled immediately after processing by dry ice to approximately 0 C before being transported to Gainesville for analysis. They were then kept

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Table 1. Fertilizer treatments of Homestead tomatoes

	Pounds nitrogen per acre					
Treatment	30 Dec	20 Jan	23 Jan	12 Feb	Total added	Nitrate found[2]
						ppm
1	0	0	0	0	328[1]	39
2	40	0	40	0	408	57
3	80	0	80	0	488	97
4	40	40	0	40	448	86
5	80	80	0	80	568	144

[1] 328 lbs of nitrogen were added by grower to all plots.
[2] Average of soil analyses at the time of harvests 26 Feb. and 12 March.

frozen until analyzed and the results reported as initial nitrate content.

Green Beans.—Green beans from the Belle Glade area were obtained from the Everglades Station. They were grown on muck soil to which no nitrate was added. They were transported to Gainesville and processed. Processing included the following: washing, snipping, cutting into 1½ inch pieces, blanching for five minutes at 200 F, filling with hot (above 190 F) water, addition of 2% salt, and retorting at 248 F for 15 minutes. Analysis for nitrate was made on the raw pods and the processed product.

Nitrates.—The AOAC xylenol method as revised by Henry (1) was used for nitrates. In some early samples of this study the expressed serum of the tomatoes was used instead of an extracted composite as outlined in the procedure. For this reason the initial nitrate content of the Homestead area tomatoes, as reported from the analysis of the frozen controls by National Canners Association, (1) is given for these fruit. Subsequent nitrate analyses were made on the tomatoes which were in the containers whose corrosion color value is reported in Table 4.

Total Acidity and pH—Total acidity and pH were determined with a Beckman Zeromatic pH meter. After the pH was measured on a 10-ml sample diluted with 90-ml of distilled water, the mixture was titrated with 0.1 N NaOH to an endpoint of pH 8.3. Results were reported as per cent anhydrous citric acid.

Internal Can Corrosion Color.—Internal can corrosion was measured by a colorimetric procedure developed by Kattan (3). A can cylinder, open on both ends, is placed vertically on a colorimeter (a Photovolt Model 610 was used) with a standard white plate on the open end. An unused can was the standard of reference, its value being set arbitrarily at 100. A value below 100 indicated corrosion. Normal detinning gave values above 50. Extensive corrosion and internal can blackening gave values of 30 and below.

Results and Discussion

The Bradenton tomatoes cut after a year at ambient temperature showed slight, normal detinning. Low initial nitrate content would suggest little corrosiveness of the container from the processed product in spite of the pH and acidity. Similar low corrosiveness of the containers was obtained with the tomatoes from the Immokalee and Ft. Pierce areas (see Table 3).

Much higher nitrate content was found in the Homestead area fruit (Tables 2 and 4). Since the soil fertilization was high in nitrogen, the carry over to the fruit is reasonable. It is noteworthy that the acidity of the Homestead area tomatoes was higher than those from the other three areas (see Table 2). This increased acidity would not likely have caused the great increase in corrosion. Since the pH of the processed product is below 5.0, tinplate corrosion is logically expected with the higher nitrate levels. As shown in Tables 3 and 4, the internal can color is low as compared with canned tomatoes from the other areas. Detinning with the Homestead area tomatoes was readily evident along the can seams. Considerable corrosion variation within nitrogen fertilization level was

Table 2. Total acidity, pH, and nitrate content of some Florida tomatoes.

Source area	Variety	pH	Total acidity	Initial nitrate Range	Initial nitrate Average
			% citric	ppm	ppm
Bradenton	Floradel	4.4	0.36	2-14	7
Immokalee	Homestead 24	4.3	0.37	5-7	6
Immokalee	Grothen's Globe	4.3	0.37	5	5
Ft. Pierce	Homestead 24	4.3	0.37	3-4	4
Homestead	Homestead 24--1[1/]	4.3	0.46	53-74	63
Homestead	Homestead 24--2[1/]	4.3	0.44	58-78	71

[1/] 1 indicates first harvest; 2, second harvest.

believed due to individual fruit differences. Internal can corrosion color values are an objective measure of corrosive can-blackening. No data is yet available relating internal darkening to tinplate loss. However, darkening of the can interior is a major consideration of food quality to the consumer.

In spite of a year's storage with the Bradenton canned tomatoes and six months's storage with the Immokalee and Ft. Pierce fruit, the containers had high internal corrosion color values. In only four months the tomatoes from Homestead had caused enough detinning to give much lower corrosion color values than those from other tomatoes. As yet no hydrogen swells have been observed with any of the canned tomatoes.

Green bean nitrate content in the raw pods and in the processed product is shown in Table 5. Blanching with hot water instead of steam leached out considerable of the water soluble materials, including nitrates. Some detinning is evident in the can corrosion color but whether this will increase greatly is not evident from the short storage time. The corrosion from the beans was spotty on the tinplate with some cloudiness of the metallic luster. It appeared that some of the spotty corrosion was due to contact of the tinplate with the cut bean pieces.

It would appear from the above information that Florida vegetables do accumulate nitrates depending upon the fertility practice and/or the area in which they are grown. Corrosiveness to tinplate was readily apparent with Homestead area tomatoes which contained 53-78 ppm nitrates.

Table 3. Internal corrosion color value of tomato containers from some Florida areas.

Source area	Variety	Storage time	Corrosion color value[2/]
		days	
Bradenton	Floradel	390	66
Immokalee	Homestead 24	182	58
Immokalee	Grothen's Globe	182	63
Ft. Pierce	Homestead 24	174	62
Homestead	Homestead 24--1[1/]	120	25
Homestead	Homestead 24--2[1/]	105	27

[1/] 1 indicates first harvest; 2, second harvest.
[2/] average value; lower value indicates more corrosion.

Table 4. Nitrate content and internal corrosion color values from Homestead area tomatoes

Treatment	Initial[1/] nitrates	Nitrates after 4 months[2/]	Corrosion color value[3/]
	ppm	ppm	
		First harvest	
1	53	11	29
2	66	21	23
3	60	16	26
4	62	23	20
5	74	30	17
		Second harvest	
1	58	11	39
2	78	11	21
3	72	15	26
4	72	21	30
5	77	11	23

[1/] Average of five cans, NCA data.
[2/] Average of two cans.
[3/] Average of three cans; lower value indicates greater corrosion.

Table 5. Nitrate content of Belle Glade green beans related to internal corrosion color value.

Variety	Nitrate content Raw	Nitrate content Processed	Corrosion color value[1/]
	ppm	ppm	
Kn-4-33	800	---	---
Blue Lake #274	555	16	83
Provider	426	26	90
Idelight	670	24	83
Harvester	444	16	91
Gallatin	---	22	77

[1/] Stored ambient 50 days; average of two cans.

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THE EFFECT OF SOME PREDRYING TREATMENTS ON THE REHYDRATION OF CELERY

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ABSTRACT

The effect of predrying treatment on rehydration varies somewhat, depending on the method of rehydration. The best rehydration was obtained when dried celery was shaken in cold water, regardless of pre-drying treatment. Rehydration by boiling was usually better than by soaking in cold water. All of the pre-drying treatments studied inhibited rehydration by soaking in cold water.

Blanching, freezing, and puffing, when applied separately as the only treatment before drying, each inhibited rehydration in boiling water. Blanching and puffing, when applied separately as the only treatment before drying, inhibited rehydration by the cold shake method.

Freezing before drying markedly increased rehydration by cold shaking. It would be the preferred treatment when speed of rehydration was not essential because of the simplicity of the process, high yield of dried product, and better flavor retention.

The best rehydration in boiling water was with celery that had been blanched, frozen, pressed and puffed before drying. Celery prepared in this way also rehydrated well by the cold shake method.

[1]U.S. Fruit and Vegetable Products Laboratory, Winter Haven, Florida, one of the laboratories of the Southern Utilization Research and Development Division, Agricultural Research Service, U.S. Department of Agriculture.
References to brand names do not indicate endorsement.

INTRODUCTION

Studies in this Laboratory on processes for preparing dehydrated celery with improved rehydrating characteristics and better texture have been reported (1, 2). A predrying treatment that involved blanching, freezing and thawing, and explosion puffing was found necessary for best rehydration in boiling water. This paper describes further studies on improving the rehydrating characteristics of dried celery.

The poor rehydration of some of the individual pieces in dried celery prepared by the improved process detracted from its appearance. Lack of uniformity in moisture content of the partially dried celery going into the puffing gun appeared responsible for the uneven rehydration. Uniform partial drying is not practical by conventional methods when individual piece size varies as much as cross-cut celery ribs. Pressing the blanched, frozen and thawed celery in a rack-and-cloth press was studied as a method for obtaining a uniform, optimum moisture content for puffing. Cold water leaching was also included as a predrying treatment.

Variations in solids content between different lots of celery and losses in soluble solids during predrying treatments have a pronounced effect on rehydration. For example, a celery that originally contained 4 percent total solids would, when dried, have to absorb half again as much water as celery that originally contained 6 percent total solids if the two samples are to achieve the same degree of restoration during rehydration· Similarly, losses in soluble solids