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FACTORS AFFECTING THE SULFUR DIOXIDE UPTAKE IN SULFITED PRE-PEELED POTATOES[1]

L. R. Ross and R. H. Treadway[2]

A number of papers have been published concerning the pre-peeled potato industry, and most of these articles are cited in a recent paper (1). These publications deal with various aspects connected with the processing, packaging, and storage of pre-peeled potatoes. Only limited information has been available on the subject of how such factors as concentration, temperature, and composition of the sulfite dipping solution and time of immersion affect the amount of sulfur dioxide (SO_2) absorbed[3] by peeled potatoes. This dearth of information is largely due to the fact that accepted procedures for determining the SO_2 content of peeled potatoes are rather difficult and laborious to execute. A rapid method for the SO_2 determination was recently presented in this Journal (1). Availability of such a simple procedure has enabled us to appraise the important factors influencing SO_2 uptake.

Materials and Methods

All data on the SO_2 content of peeled potatoes presented in this paper were obtained using the shorter method, designated as the "regular" procedure in the reference cited. The sample of sulfited potato was homogenized in a buffer solution at pH 4.4 to extract the sulfite and other soluble constituents. An aliquot of the filtered extract was then titrated with iodine solution, using starch indicator. The sulfur dioxide content was computed as parts per million of potato. Values for SO_2 content found in one set of experiments may not be strictly comparable with those from another set. However, in any given set of experiments, the SO_2 determinations were made on the same day and all precautions were taken to maintain uniform conditions.

U.S.P. grade sodium bisulfite ($NaHSO_3$) and A.C.S. grade citric acid monohydrate were used as reagents in the dipping bath. Potatoes of a single variety and grown in one area (Long Island Katahdins) were used in order to make the results as comparable as possible. Except for one set of experiments, the raw material was all from the same lot of 1958 crop. Experiments on the temperature effect were made on the 1959 crop.

Whole, peeled potatoes of nearly spherical shape were used in the sulfiting experiments except in a few instances where it will be noted that French-fry slices were employed. Use of peeled potatoes of the same shape, size, and surface area is important when results of SO_2 absorption are to be compared.

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[2]Eastern Regional Research Laboratory, Eastern Utilization Research and Development Division, Agricultural Research Service, United States Department of Agriculture, Philadelphia 18, Pa.

[3]Note: The terms "absorbed" SO_2 and SO_2 "uptake" will denote in this paper the quantity of SO_2 present as indicated by the analytical method. It is recognized that some of the SO_2 taken up from the dipping solution reacts with the reducing substances in potatoes and some is oxidized by air.

In storage tests, in which the sulfited potatoes were analyzed at intervals, it was deemed better from the sampling standpoint to use French-fry slices instead of whole potatoes. A large quantity of sulfited 2 x ⅜ x ⅜-inch slices was put away and 100 grams (approximately 20 slices) removed when desired for the SO_2 determination.

Evaluation of Factors Influencing SO_2 Absorption

It has been found in previous work at this Laboratory and elsewhere that use of an acid such as citric acid in conjunction with the weakly acid salt $NaHSO_3$ provides more effective protection against discoloration of peeled potatoes than is furnished by $NaHSO_3$ alone. Under comparable conditions, more than twice as much SO_2 was absorbed from a $NaHSO_3$-citric acid dip as from one containing the same amount of $NaHSO_3$ but no citric acid. Acidification of $NaHSO_3$, either by addition of an acid or by the acidity of potato juice, liberates SO_2; the extent of sulfite treatment is usually measured in terms of SO_2 concentration present. While it is not unanimous in any sense, it is common for central peeling plants to employ a mixture of $NaHSO_3$ and citric acid. Hence, in these experiments equal amounts of $NaHSO_3$ and citric acid were always used in the dips.

Since the data are readily presented by graphs, it was decided to use this method of presentation instead of tabular style.

Concentration of dip. The concentrations of $NaHSO_3$ and citric acid were simultaneously varied from 0.125% to 1%. As shown in Fig. 1, the SO_2 uptake increased from about 100 to about 275 parts per million (ppm) with corresponding increase in concentration of dip. The peeled potatoes were dipped at room temperature and drained for 1 minute before starting the determination of SO_2.

Time of dip. The immersion time was varied from ½ to 4 minutes, again dipping the peeled potatoes at room temperature and draining for 1 minute before assaying for SO_2. At first the quantity of SO_2 uptake increased rapidly with time, as shown in Fig. 2. However, after about 1 minute's immersion, the rate of uptake decreased to a nearly linear relationship.

Temperature of dipping solution. It is generally accepted that it is good practice in central peeling plants to keep the potatoes cool during processing, to package them in protective bags that seal against entry of outside air, and to store the sulfited potatoes under refrigeration. From the standpoint of SO_2 absorption alone, however, the temperature of the dip seems to exert no great effect. Whole peeled potatoes were dipped for 2 minutes in 0.5% $NaHSO_3$-0.5% citric acid solution, drained 1 minute, and then assayed for amount of SO_2 absorbed. At 40° F., the average value for 2 experiments was 96 ppm SO_2; at 50°, the average value for 2 experiments was 89 ppm; at room temperature (about 75°), the average value for 3 experiments was 108 ppm SO_2 absorbed by the potatoes.

Experiments were made on variability of sampling, using 8 sulfited whole peeled potatoes. The SO_2 values obtained showed an average deviation of 7% from the mean. This is the magnitude of the difference

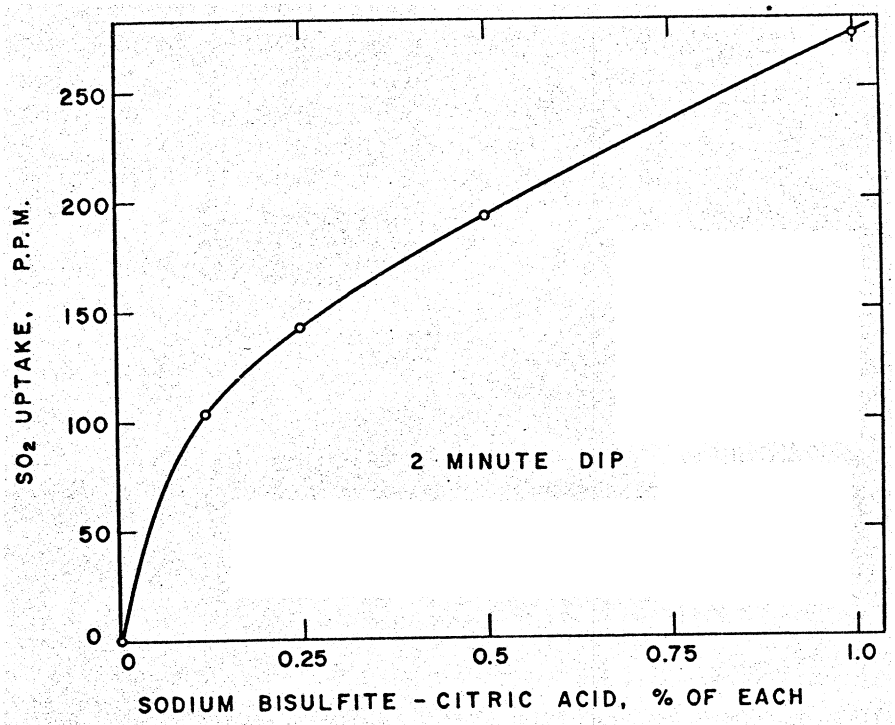

FIG. 1. Effect of concentrations of sodium bisulfite and citric acid on the sulfur dioxide uptake of dipped whole peeled potatoes.

found between the 40° and 50° values. Individual differences due to the tubers themselves can be ruled out only through some system such as quartering the tubers and using one-fourth of each of several tubers to compose the sample to be analyzed. In this study of factors influencing the SO_2 absorption, as these factors interest the processor of pre-peeled potatoes, we are concerned with larger rather than small differences.

Whole vs. sliced potato: Raw and cooked. A comparison was made of the SO_2 absorption obtained with whole potatoes as against French-fry slices 2 x ⅜ x ⅜-inches. In this it was found convenient to use potatoes that were peeled and trimmed to nearly spherical shape and to 107 grams weight. Since this lot of potatoes had a specific gravity of 1.07, the peeled spherical potato samples each had a volume of 100 ml. and a surface area of about 15 square inches. The surface areas of equal weights of whole potato and French-fry slices of the size used bore the ratio of about 1 : 6.

Whole peeled potatoes had an average uptake of 187 ppm SO_2 in this series of experiments. The French-fry slices had an average of 643 ppm SO_2 uptake. Boiling the whole potatoes for 25 minutes reduced the SO_2 content to an average of 75 ppm. French frying the slices reduced their SO_2 value to an average of 147 ppm.

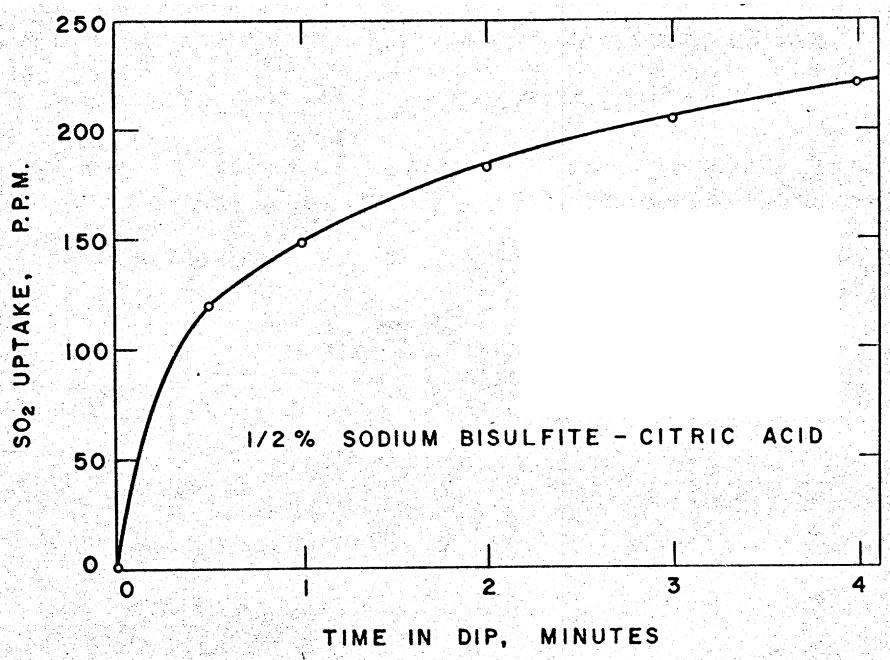

FIG. 2. Effect of immersion time on the sulfur dioxide uptake of dipped whole peeled potatoes.

SO_2 Retention in Storage

French-fry slices were dipped in 0.5% $NaHSO_3$-0.5% citric acid solution for 2 minutes at room temperature, drained 1 minute, and then stored in a polyethylene bag in a refrigerator (37° F.). As Fig. 3 shows the SO_2 loss was more rapid at first and then assumed nearly a linear rate after about 2 days' storage. Although the SO_2 content of the potato slices at the end of the storage period (more than 15 days) was considerably lower than the original value, no measurable discoloration occurred at this low temperature with the protective packaging used.

Summary and Conclusions

A study was made of certain factors that influence the SO_2 uptake of sulfited pre-peeled potatoes. Use of a $NaHSO_3$-citric acid dip instead of $NaHSO_3$ alone greatly increased the absorption of SO_2. Upon increasing $NaHSO_3$ and citric acid in the dip simultaneously from 0.125% to 1%, SO_2 uptake regularly increased from average values of 104 to 274 ppm. With 0.5% each of $NaHSO_3$ and citric acid in the dip, SO_2 uptake increased regularly from 122 to 222 ppm as dipping time was increased from ½ minute to 4 minutes.. Temperature apparently has little effect on the quantity of SO_2 absorbed by peeled potatoes within the limits of 40° to 50° F., the range in which it is common to chill the dipping bath in a central peeling plant. At room temperature, i.e. about

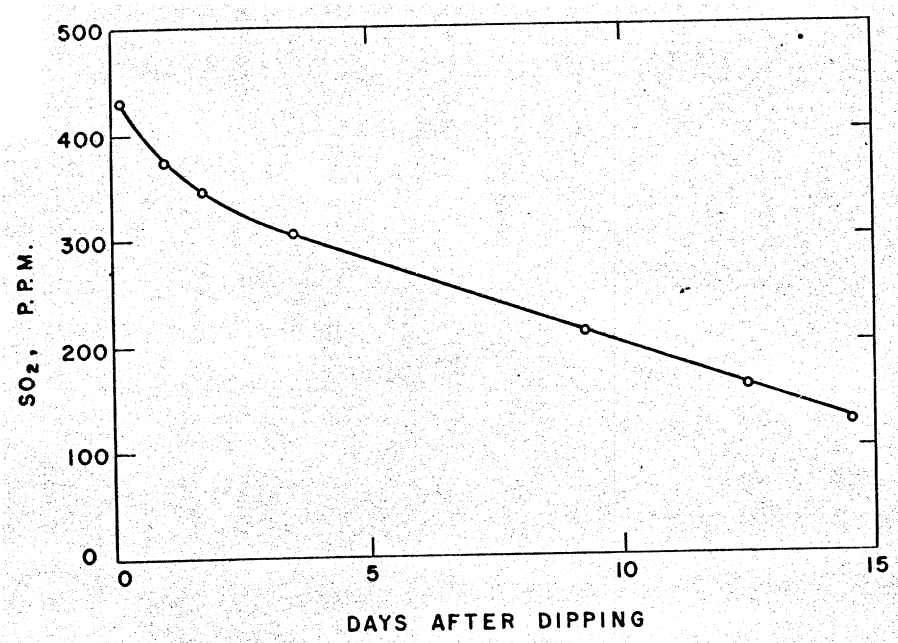

FIG. 3. Effect of 37° F. storage on the residual sulfur dioxide content of sulfited French-fry slices.

75°, somewhat more SO_2 was absorbed during a 2 minute immersion in 0.5% $NaHSO_3$-0.5% citric acid solution than under the same conditions of time and dip concentration in the lower temperature range.

Whole peeled potatoes absorbed less than one-third as much SO_2 as did French fry slices under comparable conditions. Boiling the whole potatoes reduced the SO_2 content to less than one-half the value in the raw state, and French frying the slices reduced the SO_2 content to less than one-fourth the former value.

During cold storage (37°F.), raw French-fry slices lost SO_2 fairly rapidly for the first few days and then at a slower, nearly constant rate such that an appreciable quantity of SO_2 remained even after 2 weeks.

LITERATURE CITED

1. Ross, L. R. and Treadway, R. H. 1960. A rapid method for the determination of sulfur dioxide in sulfited pre-peeled potatoes. Am. Potato J., 37, 102-107.