Use of Salt and Sodium Metabisulfite Dips Prior to Sun-Drying Tomatoes

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Abstract

Two pre-drying treatments, i.e. 1) salt and 2) sodium metabisulfite dips were evaluated on sun-dried tomatoes by assessing moisture content, color, rehydration ratio, mold and yeast count, sulfur dioxide content, an/or salt content. There were significant differences in rehydration ratio, yeast count, and salt in the salt dipping pretreatment. The most effective conditions from the salt dipping pretreatment was using a concentration of either 10% or 15% salt for 5 minutes. There were significant differences in rehydration ratio, yeast count, color and sulfur dioxide in the sodium metabisulfite dipping pretreatment. Dipping tomatoes in either 6 or 8% sodium metabisulfite for 5 minutes resulted the best red color.

INTRODUCTION

U.S. production of sun-dried tomatoes in 2001 was about 2,721 metric tons valued at $16 million (W. Traina, pers. commun., 2001). In the same year the U.S. imported about the same amount of sun-dried tomatoes (2,622 metric tons) valued at almost half the price ($8.1 million) (G. Lucier, pers. commun., 2002). Among the major producers are: California, Turkey, Morocco, Mexico, Spain, and Italy. The largest volume originates from Turkey, e.g. an estimated 55 % of the total volume imported in 2001 (Food Institute Report, 2002).

The standard practice in the U.S. is to sun-dry tomatoes after a pretreatment with gaseous sulfur dioxide. Sulfur dioxide is either burned, or introduced via a gas cylinder. In other countries, sodium metabisulfite dips are common, these may have advantages such as: decreased sulfuring time, avoidance of air pollution, better control of the sulfuring process, and safer conditions for the workers (Stafford and Bolin, 1972; Rosello et al., 1993).

Consistent production of high quality sun-dried products is limited by color degradation, poor rehydration, microbial growth, and nutritional losses. Scientific literature on methods for improving the quality of sun-dried tomatoes is limited and variable. Therefore the objective of this study was to evaluate two different pretreatments used prior to sun drying on various quality and safety parameters, including: final moisture content, color, rehydration ratio, mold and yeast count, sulfur dioxide content and/or salt content. These pretreatments were: 1) dipping in salt and 2) dipping in sodium metabisulfite.

MATERIALS AND METHODS

Raw Materials and Pre-Drying Treatments

Approximately 160 kg of ripe Halley 3155 tomatoes (Orsetti Seed Co., Hollister, CA) were obtained from the Campbell Soup Supply Company (Dixon, CA). The tomatoes were transported to the UC Davis Food Processing Laboratory, where they were sorted and washed with chlorinated (5ppm) water at 25°C. After washing they were cut into half perpendicularly with a stainless steel knife. The 160 kg batch was divided randomly into 2 groups of 60 kg to which the following pre-drying treatments were applied:

1. Salt Dipped. Dividing the first 60 kg batch of tomatoes randomly into 13 batches was necessary in order to meet all possible combinations of salt dipping for 0, 2.5, 5 or 7.5 minutes in 0, 10, 15 or 20% salt. Thirteen batches were sufficient for the 4 (dipping times) x 4 (salt concentrations) design rather than 16 batches, since it was only necessary to do one control batch without dipping (time 0 x 0 salt concentration) for the remaining 3 concentrations. The tomato to dipping solution ratio was 1:3. Continuous mixing was used during the dipping time, following which tomato halves were drained, spread in a single layer on 24 x 48 inch wooden trays, and weighed.
2. Sodium Metabisulfite Dipped. Dividing the second 60 kg group of tomatoes randomly into 13 batches was necessary in order to meet all possible combinations of dipping for 0, 2.5, 5 or 7.5 minutes with 0, 4, 6, or 8% sodium metabisulfite. The tomato to dipping solution ratio was 1:3. The same process as outlined above was followed for mixing, draining and weighing the tomatoes.

Sun Drying

All the trays from the pre-drying treatments were placed on the roof of the Food Processing Laboratory within approximately one hour and exposed to direct sunlight. The outside temperature and relative humidity were monitored with an Omega data logger (Omega Technologies Co., Model OM-550, Stamford, Connecticut).

Dried tomatoes were packed into polyethylene-sealed bags and stored at -20ºC until analyzed. The whole sun drying experiment was carried out 3 times. The end of each drying trial was determined based on previous investigations, and approximately the same number of days (7-8 days) was used for each trial.

After drying, four sets of representative samples were taken randomly from each batch. One set was analyzed for moisture content (10g), a second set for rehydration ratio and color (40g), a third set for mold and yeast count (50g), and a fourth set for storage at 25°C and 30-34% relative humidity for 3 months (100g). Extra sets of samples were taken for sulfur dioxide (50g) and salt content (40g) from the batches that required such analyses. One average tomato half weighed approximately 3.5 g.

Analytical Methods

Moisture content (% moisture w/w) was determined using the vacuum oven method as per AOAC (1984). Triplicate determinations were carried out per sample. The color of the sun-dried tomatoes was measured using a Minolta colorimeter, Model CR-200 (Ramsey, NJ). In the CIE color system “a” describes intensity of red color (a >0); “b” intensity of yellow (b > 0), “L” lightness (black = 0, white = 100); and “hue angle” (Hueº = $\tan^{-1}$ b/a) the hue of the sample (red = 0 yellow = 90). Thirty replicates were carried out per 40g of each sample and color was reported as hue angle. The optimum hue angle for sun-dried tomatoes was considered the value nearest to that hue angle (range 24 to 28) of a fresh tomato.

A representative sample of 50g was selected randomly and placed in a sterile bag and sent to a private laboratory (Silliker Laboratories of California in Modesto), for mold and yeast count according to the reference method of the 7th edition of FDA-BAM, (AOAC, 1988).

Rehydration ratio, sulfur dioxide and salt content were carried out in duplicate. For rehydration ratio twenty grams of dried tomato halves were submerged in distilled water at room temperature (24±2°C) in a product to water ratio of 1:8 (Kareem et al., 1978) for 24 hours (Levi et al., 1988). The samples were drained for 2-3 minutes and the adhering water was absorbed onto tissue paper, then samples were weighed again. The index used to express rehydration of dry plant tissues is a ratio of weight after rehydration / initial weight (Lewicki, 1998). Total sulfur dioxide (ppm dry weight basis) was determined by the modified Reith Williams Method that is described in (FAO, 1986).

Statistical Analyses

Considering that the entire experiment was replicated 3 times (3 drying trials), the mean of the three batch averages was used as the mean value presented in the statistical results.

*Salt dipped and sodium metabisulfite pretreatments***.** An analysis of variance (ANOVA) was performed on each quality parameter: moisture content, rehydration ratio, mold and yeast count, color value, and salt (for salt dipped treatment) or sulfur dioxide content (for sodium metabisulfite treatment). Tukey's test was used for testing significant differences between means with a confidence level of 95%.

Logarithm transformations (log) on mold and yeast count (cfu/g) were necessary in order to achieve a normal distribution (Neter et al., 1996) for the salt and sodium metabisulfite treatments.

All statistical analyses were carried out with the General Linear Model (GLM) procedure of SAS (SAS Institute, Cary, N.C., U.S.A.).

RESULTS AND DISCUSSION

Salt Dip Pretreatment

Effects of salt dipping for 0, 2.5, 5 and 7.5 minutes in 0, 10, 15, 20% salt on moisture content, color value, rehydration ratio, mold and yeast count, and salt content of sun- dried tomatoes was investigated. The analysis of variance shows that the overall test of significance was not significant for moisture content and mold count ($P > 0.05$) (Table 1). Dipping time was not significant as a main effect for color, rehydration ratio, and yeast count ($P > .05$), but was significant for salt content. Concentration of the dipping solution had a significant effect ($P < 0.05$) on yeast count and rehydration ratio.

Dipping in salt solutions prior to sun drying resulted in significant decreases ($P < 0.05$) in the yeast counts of sun-dried tomatoes. Salt is an effective antimicrobial, since it can inactivate enzyme systems vital to the cell, slowing or stopping microbial growth (Robinson et al., 2000). In the untreated sun-dried tomatoes, yeast counts were 4.9 log cfu/g, exceeding the allowable limits (10^3/g) and resulting in off, fermented odors with physical signs of spoilage. Yeast growth was reduced significantly (3.9 log cfu/g) when tomatoes were dipped in a 10% salt solution prior to sun drying. There was an additional decrease, without a significant difference, however, when tomato halves were pretreated in 15 (2.9 log cfu/g) and 20% (2.2 log cfu/g) salt. The 15 and 20% salt treatments did not have fermented odors or show signs of spoilage when compared to either those dipped in 10% salt or the control.

Rehydration may be considered to be a measure of the injuries to the material caused by drying and treatments preceding dehydration (Lewicki, 1998; Okos et al., 1992). Thus, the higher the rehydration ratio, the less damage to the tissues caused by the drying process and the greater the product hydration. There was a significant difference ($P < 0.05$) in the rehydration ratio between treatments and the control. Tomatoes dipped in salt solutions had lower rehydration ratios, implying lower quality than the control.

Color values ranged from hue angles of 36.1 to 36.9, with the control having the highest value and the 10% salt dip the lowest, but these differences were not significant ($P < 0.05$). Salt dipping did not improve the color of sun-dried tomatoes and in general these tomatoes appeared to have a darker unattractive color, most likely due to browning reactions that were not prevented as in the other three pretreatments in this study, which employed the use of sulfur dioxide.

Both concentration and time were significant ($P < 0.05$) factors for final salt content of the sun-dried tomatoes. As dipping time and concentration of the salt increased salt uptake also increased. Changes in salt content over time depend on the original concentration of the dipping solution. Sun-dried tomatoes dipped in a 10% salt solution for 2.5 minutes reached a final salt content of 7.5 % after drying. When dipping time was increased to 7.5 min at the same concentration, the final salt concentration in the dried tomatoes increased to 11.1%. When a 15% salt dip was used, the absorption increased from 10.2% to 14.2% when dipping time was increased from 2.5 to 7.5 minutes. The highest absorption of salt was obtained when tomatoes were dipped in 20% salt for either

2.5 or 7.5 minutes, where final salt concentrations reached 14% and 16.1% respectively. The recommended combination of salt concentrations and dipping time to control yeast growth, but minimize the effect on color and rehydration ratio are either 10 or 15% salt for 5 minutes.

Sodium Metabisulfite Dip Pretreatment

Effects of dipping tomatoes in 0, 4, 6 and 8 % sodium metabisulfite for 0, 2.5, 5 and 7.5 minutes on moisture content, sulfur dioxide content, color value, rehydration ratio, mold and yeast count of sun-dried tomatoes was also studied.The analysis of variance shows that the overall test of significance was not significant for mold count ($P > 0.05$) (Table 2). Dipping time was not significant as a main effect for any of the response variables ($P > 0.05$) except for sulfur dioxide content. The concentration of the dipping solution had a significant effect on sulfur dioxide content, color, rehydration ratio, and yeast count.

Time and concentration both had a significant ($P < 0.05$) effect on the sulfur dioxide content of sun-dried tomatoes. As dipping time and sodium metabisulfite concentration increased sulfur dioxide absorption also increased. Changes in the sulfur dioxide content of sun-dried tomatoes over dipping time depend on the original concentration of the dipping solution. Sun-dried tomatoes dipped in 4% sodium metabisulfite for 2.5 minutes reached a sulfur dioxide content of 840 ppm and this content increased about 55% to 1305 ppm when tomatoes were dipped for 7.5 minutes. There was about a 2.5 fold increase in final sulfur dioxide content between dipping in a 6% solution for 2.5 (1936 ppm) and 7.5 minutes (4915 ppm). The highest absorption of sodium metabisulfite obtained was with dipping in an 8% sodium metabisulfite solution. The 2.5 minutes dip resulted in a concentration of, 3106 ppm in the sun-dried fruit; when dipping time was extended to 7.5 minutes this increased about 2.7 fold to 8631 ppm. Pazyr *et al.* (1996) reported that the absorption of sulfur dioxide in sun-dried tomatoes increased as the concentration of the metabisulfite solution and dipping time increased. The quantities of sulfur dioxide content found in this study are similar to those given by Pazyr *et al.* (1996), where tomatoes dipped for 2.5 and 10 minutes had residual sulfur dioxide contents of 2785 and 8395 ppm, respectively, after sun drying. This agrees with the linear relationship between concentration of metabisulfite solution and absorption of sulfur dioxide observed in apricots by Stafford and Bolin (1972) and carrots by Baloch *et al.* (1987).

Significant differences in color were observed between metabisulfite concentrations ($P < 0.05$). As the concentration of sodium metabisulfite increases, the color values (hue°) decrease inferring a redder and more desirable color. It is generally accepted that sulfur dioxide prevents color degradation during drying. Sun-dried tomatoes that had been dipped in an 8% sodium metabisulfite pretreatment had the highest sulfur dioxide content, and thus the best red color (32.2 hue°). This value was significantly different from the rest of the treatments, except for the 6% metabisulfite treatment, which had a hue angle of 32.9.

There was an increase in rehydration ratio as dipping solution increased. There was a significant difference between treatment concentrations ($P < 0.05$). Sun-dried tomatoes that were dipped in 8% sodium metabisulfite had the best rehydration ratio (3.34) while the control ($P < 0.05$). Sun-dried tomatoes that were dipped in 8% sodium metabisulfite had the best rehydration ratio (3.34) while the control tomatoes had the worst (3.10). Tomatoes pretreated with 4 and 6% sodium metabisulfite had rehydration ratios of 3.24 and 3.26, respectively and did not differ significantly from each other. These results agree with studies reported by Tripathi *et al.* (1989) and Olorunda *et al.* (1990), which have shown that the use of metabisulfite solutions as a pretreatment prior to drying tomatoes improves their rehydration.

Significant differences in yeast count can be observed between the control and pretreated tomatoes ($P < 0.05$). Dipping in sodium metabisulfite decreased yeast growth of sun-dried tomatoes. Untreated sun-dried tomatoes developed an undesirable fermented off-odor and physical signs of spoilage, due to a high yeast count of 4.9 log cfu/g. Sodium metabisulfite treated tomatoes did not show signs of spoilage or off-odors and had lower yeast counts than those sun-dried tomatoes that were not treated or were only dipped in salt.

The recommended combination of sodium metabisulfite concentrations and dipping time to improve color and rehydration ratio and to control yeast growth are 6 or 8% sodium metabisulfite for 5 minutes. Sun-dried tomatoes produced under these combinations had 3168 ppm of sulfur dioxide when dipped in 6% sodium metabisulfite and 5000 ppm of sulfur dioxide when dipped in 8%. Although the limits of sulfite are generally established according to the purchasing company's specifications, studies by Davis *et al*. (1973) recommend that producers of dried fruits should aim for an initial sulfur dioxide content of 3000 mg/kg in order to ensure continuity of supply of acceptable dried fruits form one season to the next.

CONCLUSIONS

Salt dipping was effective in inhibiting yeast growth, but decreased rehydration ratio and color appeared darker than the sulfured, sun-dried tomatoes. The recommended combination of salt concentrations and dipping time are either 10 or 15% salt for 5 minutes. Salt dipped sun-dried tomatoes are a good option for consumers wishing to avoid the use of sulfur dioxide as a preservative. Sodium metabisulfite dipping improved color, rehydration ratio, and decreased yeast growth as compared to the unsulfured, sun-dried tomatoes. The recommended combination of sodium metabisulfite concentrations and dipping time are either 6 or 8% for 5 minutes. The use of sodium metabisulfite dips may offer a safer, more convenient, and more controllable method for producing high quality sun-dried tomatoes.

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Tables

Table 1. Effect of salt dipping concentration on moisture content, color, rehydration ratio, mold and yeast count, and salt content of sun-dried tomatoes.

	Concentration of salt				Overall F Test (P value)
	0%	10%	15%	20%	
final moisture content (% wet weight)[1]	13.1	15.8	16.4	16.4	0.1280
color (hue°)	36.9[a]	36.5[a]	36.4[a]	36.5[a]	0.0016
rehydration ratio	3.11[a]	2.66[b]	2.56[b]	2.50[b]	0.0001
mold log(cfu/g)[2]	1.0	1.0	1.2	1.4	0.2747
yeast log(cfu/g)[2]	4.9[a]	3.9[b]	2.9[c]	2.2[c]	0.0012
salt (% dry weight)	1.2[d]	9.8[c]	12.3[b]	15.2[a]	0.0001

[1]All mean values for parameters measured are based on triplicate values.
[a-c]Means within a row with different letters are significantly different ($P < 0.05$).
[2]Statistical analysis was on log transformed data.

Table 2. Effect of sodium metabisulfite concentration on moisture content, sulfur dioxide content, color, rehydration ratio, and mold and yeast count of sun-dried tomatoes.

	Concentration of sodium metabisulfite				Overall F Test (P value)
	0%	4%	6%	8%	
final moisture content (% wet weight)[1]	13.1[a]	14.0[a]	14.0[a]	14.0[a]	0.0001
sulfur dioxide (ppm dry weight)	21[a]	1044[c]	3340[b]	5579[a]	0.0001
color (hue°)	36.9[a]	33.6[b]	32.9[bc]	32.2[c]	0.0001
rehydration ratio	3.10[b]	3.24[ab]	3.26[ab]	3.34[a]	0.0098
mold log(cfu/g)[2]	1.0	1.4	1.5	1.6	0.1603
yeast log(cfu/g)[2]	4.9[a]	1.8[b]	1.4[b]	1.9[b]	0.0018

[1]All means values for parameters measured are based on triplicate values.
[a-c]Means within a row with different letters are significantly different ($P < 0.05$).
[2]Statistical analysis was on log transformed data.