Effect of Temperature on the Serum Viscosity of Tomato Juice

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ABSTRACT

Tomato juice was canned and exposed to processing temperatures of 82°C, 102°C and 112°C. Serum viscosity was measured after 30, 60, and 120 min at each temperature. Heat treatment affected serum viscosity. A temperature of 82°C applied for 2 hr resulted in a 17–30% loss of serum viscosity depending on the cultivar. Treatment at 112°C applied for 2 hr caused 67–82% loss, again depending on the cultivar.

INTRODUCTION

TOMATOES are one of the most important processed vegetables consumed in the United States. Consistency is one of the quality factors considered by the U.S. Department of Agriculture in their Grades and Standards. Kertesz and Loconti (1944) showed that the gross consistency of tomato juice depended on the suspended solids and on the serum viscosity. Similarly, Foda and McCollum (1970) emphasized the contribution of water soluble constituents to the viscosity of tomato juice.

Processing effects on serum viscosity have been studied (Hand et al., 1955; Luh and Daoud, 1971). Both break method and mechanical treatment were shown to significantly affect the serum viscosity of tomato puree (Crandall and Nelson, 1975). In their extensive study of tomato product consistency, Miers et al. (1967) found that serum viscosity decreased faster at pH 1.5 than at pH 2.5–4.5. An acid-rapid heating procedure showed an increase of serum viscosity over an acid-slow heating procedure.

In some of the large concentration systems used by the industry, the product is held 3–4 hr with temperature variations at different stages of concentration. Evaporators have been noted to reach as high as 110°C (230°F) with product held at that temperature for several minutes. From the hot-break step to the evaporator, the juice is held at a minimum of 93°C (200°F) for several minutes. As a result, the product may be exposed to high temperatures for a long period of time. The effect of this treatment on serum viscosity is not well known (Rica, 1983).

MATERIALS AND METHODS

The three tomato cultivars (Knox, C37, Tipton) used in this study were grown at the Purdue University horticulture farm. Three 9 kg (20 lb) harvests of fully ripened fruits from the same field for each cultivar were processed.

Sample preparation

Juice preparation. Each 9 kg (20 lb) harvest of tomatoes was washed and hot broken in 2.3 kg (5 lbs) batches using a combination microwave-conventional oven (G.E., Model JBV64G). The conventional oven was set at 204°C (400°F) and the microwave oven was at the maximum level for 20 min. After 10 min, the hot broken tomatoes were mashed to assure optimum heat transfer. Immediately after hot breaking, the tomatoes were chopped and seeds and skins removed at the same time in a laboratory size finisher (Langsenkamp, model 17). The juices from the four batches of each cultivar were next blended, and the composite samples were deacicated. The soluble solids of the juice were determined using a refractometer (AO Digital, Model 10450). The Brix level was adjusted as needed to a value between 5.5° and 6.5° by diluting with distilled water.

Heat treatment. The adjusted juice was canned and randomly separated into two batches. Small cans (thermal death time cans, 18 mL) were used to obtain a quick and homogeneous heating of the product. For each batch, approximately one-third of the cans was put in a water bath at 82°C (180°F), a second third was placed in an oil bath at 102°C (216°F) and the remaining cans were put in an oil bath at 112°C (234°F). An untreated control was placed directly in ice-water. After 30 min, cans were taken out of each temperature bath, placed in ice-water, labeled and stored overnight at 4°C (40°F). The same operation was repeated at 60 min and 120 min. The next morning, cans from the same combination (time-temperature) were opened, and their juice was blended for sample analysis.

Sample analysis

Samples were tested for serum viscosity. The serum was obtained by centrifugation of the juice sample at 12,800 x g (12,000 rpm) for 30 min at 4°C followed by filtration of the supernatant through a Whatman No. 1 filter paper. Seven mL of filtered serum were used in the viscometer. The relative viscosity can be calculated based on the efflux time (65 sec) of water at 25°C with the same apparatus. Samples were replicated twice. Absolute viscosity (cps) was computed using the absolute viscosity (0.8931 cps) of water at 25°C.

RESULTS & DISCUSSION

ANALYSIS by the Duncan range test (Anon, 1983) revealed that C37 and Tipton had similar serum viscosities for any given

![Fig. 1-Heat treatment effect on the serum viscosity of tomato juice.](image-url)
EFFECT OF HEAT ON TOMATO SERUM VISCOSITY...

Table 1—Percent loss from initial serum viscosity for C37, Tipton, and Knox

<table>
<thead>
<tr>
<th>Temperature</th>
<th>C37 30 min (%)</th>
<th>Tipton 30 min (%)</th>
<th>Knox 30 min (%)</th>
<th>C37 60 min (%)</th>
<th>Tipton 60 min (%)</th>
<th>Knox 60 min (%)</th>
<th>C37 120 min (%)</th>
<th>Tipton 120 min (%)</th>
<th>Knox 120 min (%)</th>
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<tr>
<td>82°C</td>
<td>8.1</td>
<td>6.4</td>
<td>7.1</td>
<td>11.9</td>
<td>12.2</td>
<td>17.1</td>
<td>17.5</td>
<td>20.3</td>
<td>29.2*</td>
</tr>
<tr>
<td>102°C</td>
<td>18.3</td>
<td>21.8</td>
<td>28.4*</td>
<td>33.8*</td>
<td>38.4*</td>
<td>55.4*</td>
<td>47.7*</td>
<td>61.8*</td>
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<td>112°C</td>
<td>30.9*</td>
<td>34.5*</td>
<td>52.6*</td>
<td>57.9*</td>
<td>73.2*</td>
<td>67.1*</td>
<td>66.7*</td>
<td>82.4*</td>
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</tr>
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</table>

* significance at 0.05 level

heat treatment (Fig. 1). Those two cultivars produced juices showing initial "low" serum viscosities of 308 sec (4.2 cps) for C37 and of 335 sec (4.6 cps) for Tipton. Even after 120 min, the 82°C treatment did not lower the serum viscosity substantially. Thirty min of treatment at 102°C did not lower the serum viscosity dramatically; however, 60 and 120 min of treatment at that temperature lowered serum viscosity. Treatment at 112°C lowered the serum viscosity by approximately 30% after 30 min and by 68% after 2 hr (Table 1).

Knox produced a juice showing an initial "high" serum viscosity of 590 sec (8.1 cps). Although the drop in serum viscosity was significantly after 30 min of treatment at 82°C, it represented only a loss of 7.1% which was comparable to the losses reported for C37 and Tipton for the same treatment. The loss in serum viscosity increased to 30% for 82°C treatment when applied for 2 hr. Treatments at 102°C and 112°C resulted in dramatic losses in serum viscosity. Only 30 min of 112°C treatment caused a loss of 52.8%. A 75.8% loss was found after 2 hr of treatment at 102°C and up to 82.4% loss occurred when 112°C treatment was applied for 2 hr (Table 1).

However, for the 82°C treatment, viscosity of the three cultivars appeared to converge. The serum viscosity values reached the same level after 2 hrs at 102°C treatment or after 1 hr at 112°C treatment. This level was approximately 100 sec (1.4 cps). An additional hour of treatment at 112°C did not lower the serum viscosity any further. This value of 100 sec seemed to become constant and independent of heat treatment.

The above observations demonstrate that heat treatment of tomato juice dramatically affected serum viscosity. Although the losses in serum viscosity for C37 and Tipton seemed smaller than for Knox, both had values of 100 sec when high temperatures were applied for 2 hr. This observation leads to the possible hypothesis that the following two fractions may make up the soluble material: (1) a heat sensitive component present in various concentrations that is dependent on cultivar, seasonal variations, and others; and (2) a possible heat stable component of a constant concentration responsible for the lowest level reached after long heat treatment. Chemical determination of the two components and study of possible variations in their concentrations could be an interesting challenge. Protein, pectin and probably an interaction between these two fractions have been suggested to play a role in the soluble fraction viscosity. However, it is important to remember that the apparent viscosity of the whole product (i.e., tomato juice) is not solely determined by the viscosity of the soluble fraction alone.

REFERENCES

Stockton, CA.

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