# EFFECT OF HOMOGENIZATION PRESSURE ON CONSISTENCY OF TOMATO JUICE[1]

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Accepted for Publication October 25, 1994

## ABSTRACT

*Pressurized homogenization of tomato juice at room temperature (28C) leads to an increased consistency and reduced serum separation in the juice. Percentage increase in consistency (as measured by Libby's tube) of hot processed juice from different cultivars ranged from 95±3 to 282±13 s. The magnitudes of change in consistency and serum separation of cold processed juice due to homogenization were smaller than those for hot processed juice. Increases in consistency of cold processed juice ranged from 42±4 to 213±10 s. Consistency in all the samples increased with increasing pressure of homogenization up to a pressure of 3000 psi, above which it became constant. Homogenization of juice at higher temperature resulted in a very small increase in consistency. However, the magnitude of increase in consistency decreased with increasing temperature. Serum separation slightly increased at higher pressure of homogenization, after reaching a minimum with increasing pressure initially. In general, the juice with higher initial efflux and serum viscosities showed a larger increase in consistency and greater reduction in serum separation.*

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Journal of Food Quality **18** (1995) 389-396. 

## INTRODUCTION

Consistency plays an important role in determining the quality of tomato products (Kertesz and Loconti 1944; McColloch and Kertesz 1949). Organoleptic qualities of some of the products such as tomato juice, paste and puree depend upon their consistency, and products with low consistency may be sold at lower prices or even graded unacceptable (Kertesz and Loconti 1944; Crandall and Nelson 1975). It is important to the processors, Federal Grading Agencies and especially for consumer acceptance (Gould 1978). Tomato juice consists of disintegrated cells of the pericarp mixed in a clear serum (Becker *et al.* 1972; Hand *et al.* 1955). In addition to pectins, the amount and configuration of cell walls is reported to influence the consistency of tomato products (Whittenberger and Nutting 1958). Sheetlike or rodlike walls or wall fragments offer more resistance to flow than round shaped walls, causing an increase in the consistency of the tomato products. Homogenization changes the configuration of the cell walls (Whittenberger and Nutting 1957) which results in increased consistency. It is generally used for cold break juice in the range of 1000-1500 psi pressure and at a temperature of 66C. This reduces settling in the product and gives a thick bodied juice (Gould 1992). There is little information on the effects of homogenization at higher pressures and temperature. This paper reports the effect of homogenization at different pressures and temperatures on the consistency, serum viscosity, and serum separation of tomato juice from different cultivars with varying initial consistency.

## MATERIALS AND METHODS

Uniformly field ripened, fresh and healthy tomatoes were brought to the Purdue University, food science pilot plant, sorted and washed under running tap water. The washed tomatoes were processed into juice by cold and hot break methods. In the cold break method of juice processing, a small commercial extractor (Langenkemp Co. Model 185S) was used to crush and express the tomatoes through a 9.5 mm screen. The product was passed through a small laboratory finisher fitted with a 0.56 mm screen to remove the skin and seeds. The juice was canned in 303 x 406 enameled cans. The cans were sealed and heated for 20 min in a boiling water bath, cooled under running tap water and stored at 4C.

In the hot break method, the macerated product was continuously heated to 88C in an open steam jacketed kettle and passed through the finisher. The juice canning procedure was the same as that for the cold break method.

Both cold and hot break processed juice samples were subjected to homogenization at different pressures and temperatures using a two stage pressure homogenizer (APV Gaulin Inc. Model 15, 15MR-8TBA Wilmington, Massachusetts, U.S.A.).

The consistency of the control and the homogenized juice was measured at room temperature (28C) by determining their efflux viscosity (EV) using a standard Libby's pipette for tomato juice. Juice serum was obtained by centrifugation of the juice at 12,800 x g (12,000 rpm) at 4C. Serum viscosity was measured, using a 7 ml sample, with a capillary viscometer (size 100 Cannon-Fenske) after sample has equilibrated to 25C in a constant water bath. The standard flow time for 7 ml of water at 25C was $64.6 \pm 2.3$ s. Precipitate weight ratio (PPT) was determined by method of Takada and Nelson (1983) while serum separation (SS) was measured using the procedure of Caradec *et al.* (1985). All the readings are the mean of a minimum of five values.

## RESULTS AND DISCUSSION

The effect of homogenization on consistency of tomato juice at different pressures is shown in Fig. 1. Homogenization caused a large increase in the consistency of tomato juice, with hot processed juice showing a higher increase than cold processed juice. The percentage increases in consistency of hot processed juice from different cultivars ranged from $95 \pm 3$ to $282 \pm 13$ with pressure of homogenization increasing from 1000 to 3000 psi, above which level no change in the consistency was observed (Table 1). In cold processed juice, the percentage increases ranged from $42 \pm 4$ to $213 \pm 5$ within the same range of pressure of homogenization. In cold processed juice also, no increase in consistency was observed after a pressure of 3000 psi. Pressure of homogenization did not significantly influence the serum viscosity of juice processed by either methods or type of cultivar. As reported earlier, configuration of cell walls present in the juice influence the consistency of juice (Whittenberger and Nutting 1957). Forcing cell walls through a passage of small clearance (pressurized homogenization) or other type of shredding, stirring or breaking action increases the linearity of cell walls and causes a reduction in particle size (Whittenberger and Nutting 1957). Linear shaped cell walls exert more resistance to flow, resulting in an increase in the consistency of homogenized juice. Luh *et al.* (1954), also reported an increase in the consistency of tomato juice due to homogenization. They attributed the increase to reduced particle size, changed shape and increased surface area of the particles due to homogenization. Further, the outer boundary or walls of the cells in tomato juice consist of interwoven cellulose fibrils impregnated with

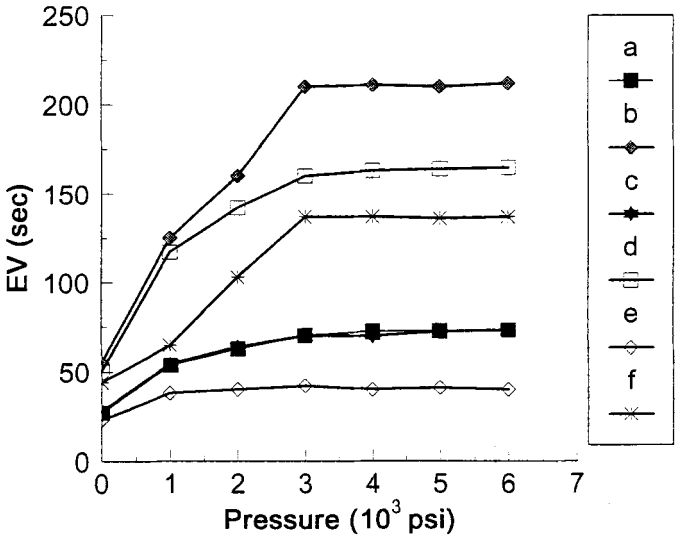


FIG. 1. EFFECT OF HOMOGENIZATION ON EFFLUX VISCOSITY (EV) OF TOMATO JUICE AT DIFFERENT PRESSURES:
a,b,c,d hot processed juice from different cultivars;
e and f cold processed juice from cultivars a and b

TABLE 1.
PERCENTAGE INCREASE IN THE CONSISTENCY OF HOT AND COLD PROCESSED TOMATO JUICE FROM DIFFERENT CULTIVARS

| | Tomato Cultivars | | | | | |
|---|---|---|---|---|---|---|
| Pressure ($10^3$ psi) of Homogenization | a | b | c | d | e | f |
| 1 | 100± 3 | 95 ± 3 | 125± 5 | 134 ± 7 | 42 ± 4 | 105 ± 8 |
| 2 | 135 ± 9 | 129 ± 6 | 188 ± 11 | 185 ± 7 | 68 ± 5 | 136 ± 6 |
| 3 | 165 ± 12 | 159 ± 10 | 279 ± 9 | 208 ± 8 | 83 ± 4 | 211 ± 8 |
| 4 | 169 ± 7 | 159 ± 9 | 281 ± 11 | 224 ± 10 | 81 ± 4 | 211 ± 10 |
| 5 | 170 ± 7 | 160 ± 8 | 280 ± 11 | 225 ± 10 | 80 ± 3 | 213 ± 10 |
| 6 | 171 ± 10 | 160 ± 9 | 282 ± 13 | 225 ± 9 | 80 ± 4 | 213 ± 8 |

a,b,c,d hot processed juice from different cultivars; e,f cold processed juice from cultivar, a and b

pectic substances. Homogenization increases the surface area of the cell walls and the pectins embedded between cellulose fibrils of cells are exposed (Whittenberger and Nutting 1957). This results in increased water binding, leading to increased consistency. This view is supported by a large increase in the precipitate weight ratio (PPT-weight ratio of precipitate to the initial sample weight after centrifugation) of homogenized juice as a result of increased water binding by the cell walls (Fig. 2). Takada and Nelson (1983) reported a strong correlation between PPT values and efflux viscosity and Bostwick consistency of tomato juice. Higher increases in the consistency of hot processed juice as compared with cold processed juice may be due to the higher pectin content of hot processed juice (data not shown).

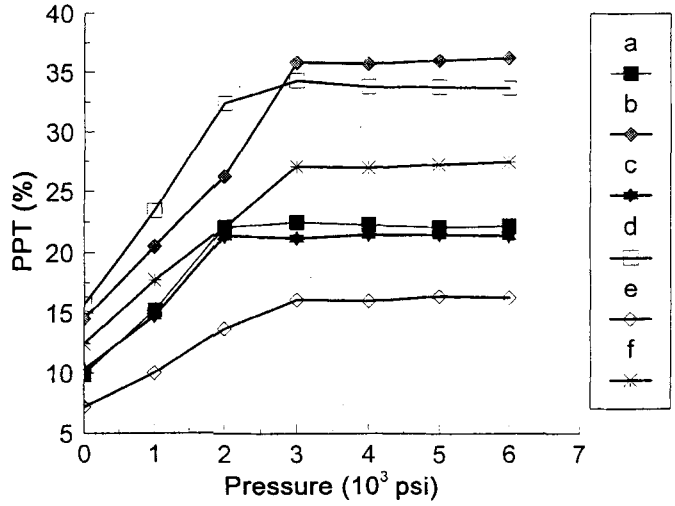


FIG. 2. EFFECT OF HOMOGENIZATION ON PRECIPITATE WEIGHT RATIO (PPT) VALUE OF TOMATO JUICE AT DIFFERENT PRESSURES:
a,b,c,d hot processed juice from different cultivars;
e and f cold processed juice from cultivars a and b

Pressurized homogenization of tomato juice resulted in decreased serum separation (Fig. 3). Serum separation in juice is caused by packing of suspended particles into smaller volumes rather than by simple sedimentation (Robinson *et al.* 1956). Homogenization causes a marked increase in the volume of particles due to rupture of the cellular envelope. The ruptured cells do not settle as compactly as the intact cells (Hand *et al.* 1955), leading to reduced serum

separation in homogenized juice. The effect of homogenization on the shape of the particles is more important than the decrease in their size in reducing serum separation in homogenized juice (Robinson *et al.* 1956).

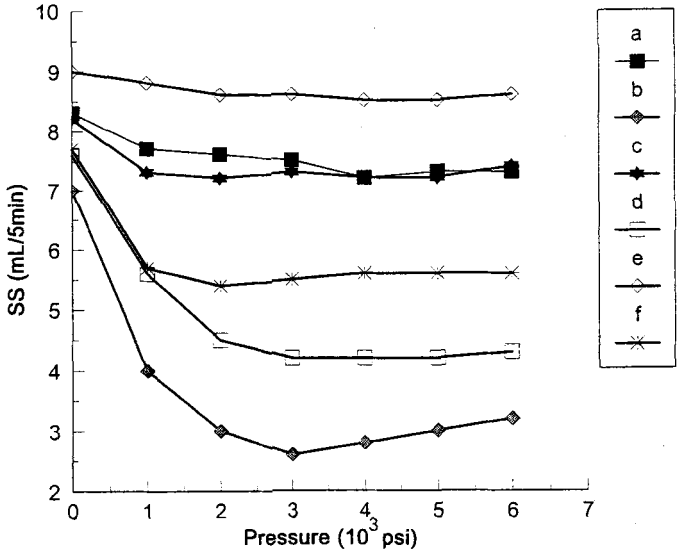


FIG. 3. EFFECT OF HOMOGENIZATION ON SERUM SEPARATION (SS) IN TOMATO JUICE AT DIFFERENT PRESSURES:
a,b,c,d hot processed juice from different cultivars:
e and f cold processed juice from cultivars a and b

Pressurized homogenization (3000 psi) of tomato juice at higher temperatures resulted in a decrease in the consistency compared with that of juice homogenized at room temperature (Fig. 4). As the temperature of homogenization was increased from 28C to 95C (temperature of the juice when added to homogenizer), consistency decreased from $69 \pm 3$ to $31 \pm 2$ s at 3000 psi. This was accompanied by a simultaneous decrease in the PPT value and an increase in serum separation (Fig. 4). Temperature of homogenization had no effect on the serum viscosity of the tomato juice. As evident from decreased PPT values and increased serum separation, at higher temperatures, the water binding capacity of the juice components decreases, resulting in lower consistency.

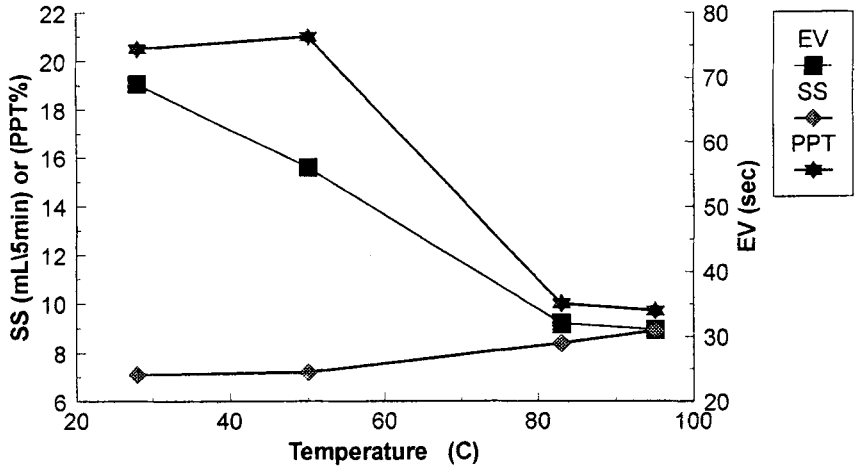


FIG. 4. EFFECT OF TEMPERATURE ON EFFLUX VISCOSITY (EV), SERUM SEPARATION (SS) AND PRECIPITATE WEIGHT RATIO (PPT) VALUE OF TOMATO JUICE (CULTIVAR C) PRESSURE HOMOGENIZED AT 3000 PSI

## CONCLUSIONS

Pressurized homogenization of tomato juice results in a large increase in its consistency. At present the homogenization is carried out at a higher temperature than we employed, but our results show a higher increase in the consistency and reduced serum separation if homogenization is carried out at lower temperatures. A pressure of 3000 psi was found to be the maximum pressure above which no change in the consistency or the serum separation was observed. Therefore, homogenization of juice may be carried out at lower temperatures and at moderate pressures to get a better quality.

## ACKNOWLEDGMENTS

The authors are thankful to Consortium of Plant Biotechnology Research Inc. for the financial support, and Mr. Steve Smith and Ms. Denise Shoaf-Orndorff for their help in the pilot plant.

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