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TIMING OF CALCIUM TREATMENT ON RESISTANCE OF RAW AND CANNED DICED TOMATOES TO MECHANICAL ABUSE

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Accepted for Publication February 28, 2005

ABSTRACT

Tomato dices are typically treated with calcium (Ca) to increase firmness and resistance to mechanical abuse. However, studies have not examined when the application of Ca would provide the greatest protection and result in the greatest firmness. Tomato (cv. P696) dices were dipped in a 600 mg/L calcium chloride (CaCl$_2$) solution either before or after undergoing mechanical abuse for 0–240 s in a rotary drum. The drained weight and firmness, which were measured using a Kramer shear cell (Instron Corp., Canton, MA), did not depend on whether Ca was added before or after the mechanical abuse. However, sensory evaluation showed that the panelists preferred the diced tomatoes that were dipped in Ca before undergoing mechanical abuse. These tomato dices appeared to have a larger percentage of undamaged dices, while those that were mechanically abused before dipping in Ca appeared ragged and mushy because of a collapsed structure. Therefore, although there was no significant difference in the drained weight or texture obtained by instrumental measurement, dices that are dipped in Ca before undergoing mechanical abuse appear less damaged to consumers.

INTRODUCTION

The tomato (Lycopersicon esculentum) is the second largest crop in terms of dollar value and is consumed all over the world. Two-thirds of the total world production of tomatoes is processed (Johannessen 1993). The total world production of processed tomatoes exceeds 24 million metric tons, and
more than 50% of that is produced in the U.S.A. (Thakur et al. 1996). Among all of the processed tomatoes that are consumed in the form of processed products, diced tomatoes have gained much focus since salsa replaced ketchup as the top-selling condiment in the U.S.A. (Poole 1992).

The mechanical abuse of tomatoes results in product breakdown. During the initial handling and delivery, the tomatoes are subjected to different forms of stress that damage the tissues. Heat processing further destroys tissue rigidity. The transportation of canned tomatoes also causes damage, decreasing drained weight and increasing the percentage of damaged tomatoes.

Treatments with divalent cations have been shown to improve the texture of processed tomatoes (Gould 1992). Firmness and resistance to softening induced by divalent Ca ions have been attributed to the formation of calcium pectate or pectinates by binding pectin methylesterase – demethoxylated pectate chains, which increase the rigidity of the middle lamella and cell wall (Grant et al. 1973). This creates a more stable three-dimensional (3D) network that imparts additional firmness to the tissue as a result of the formation of a calcium pectate gel. This also causes an increased resistance to polygalacturonase attack of the pectic substances of the middle lamella, cell wall and the pericarp tissue in general (Buescher and Hobson 1982). As approved by the Food and Drug Administration (FDA 2003), purified calcium chloride (CaCl2), monocalcium phosphate (Ca(H2PO4)2·H2O), calcium sulfate (CaSO4), calcium citrate (C12H10Ca3O14) salts or any two or more of these in concentrations not to exceed 800 mg/kg of product can be used as firming agents.

Kertesz et al. (1940) first showed that Ca treatment provides a definite protection and increases the ability of the tomato fruit to withstand mechanical damage. A standard shaking machine was used to simulate the actual transportation that canned tomatoes are exposed to. The samples of canned tomatoes with Ca added showed a higher drained weight and retained a higher percentage of whole tomatoes than the samples without Ca added.

Another study transported whole tomatoes canned with different CaCl2 concentrations in trucks for 250 miles (Godfrey 1940). He found the drained weight for the Ca-treated samples decreased by 0.63% while the samples without Ca showed a decrease of 2.7%.

These early studies showed that whole canned tomatoes that had been treated with Ca better resisted mechanical damage during transportation, giving higher drained weight and percentage of whole tomatoes compared to samples without Ca. However, studies have not been done on when, during the process, Ca should be added to best resist mechanical damage. Typically, tomatoes are treated with Ca early in the process line, right after being washed and peeled, before they are sent to different lines for further processing. Increasing the firmness early in the process may increase the damage that occurs during abuse or may prevent damage. The objective of this study was
to determine whether Ca treatment should occur early or late in the process to produce the best product.

MATERIALS AND METHODS

Tomatoes (cv. P696) were mechanically harvested in Fremont, OH and transported to Columbus, OH, then processed the following morning. The tomatoes were soaked in an air-agitated washer, lye peeled with 18% sodium hydroxide (NaOH) and 0.1% Faspeel (wetting agent) for 30 s at 87.8°C, followed by a rotary revolving rubber disk belt under a low-pressure water spray to remove the peel. The tomatoes were diced into 1.27-cm cubes. A second harvest was performed a few days later so that the entire experiment was done twice.

CaCl₂ was used to produce a 600 mg/L calcifying solution. The tomato dices were dipped in 7 L of the calcifying solution for 5 min at 24°C, and then drained for 1 min. A fresh solution was used for each dip. A tumbling drum (Master Series™ Tumble Drum, Spray Dynamics, Ltd., St. Clair, MO) that runs at a speed of 12.25 rpm was used to simulate the mechanical abuse of the product. Two batches of dices were dipped, so that the dipping was done twice.

For the Ca before the mechanical abuse study, a total of 22 kg of tomato dices was used. Two-kilogram batches were dipped into the calcifying solution, then mechanically abused in the tumble drum for 30 s to 4 min, for a total of nine treatments. For the mechanical abuse before the Ca study, 22 kg of tomato dices was mechanically abused in the tumble drum for up to 4 min, for another nine treatments. Two-kilogram samples were collected in 30-s intervals, and immersed in a calcifying bath.

Half the samples for each treatment variable were hand-filled into 300 × 407 three-piece enamel-lined cans with approximately 300 g of dices per can. The cans were solid packed, sealed with steam, retorted at 104.5°C for 30 min, then cooled with cold water to 37.8°C for 30 min. The cans were stored at room temperature for 45 days until analyzed for firmness and drained weight. The other half of the sample was immediately used for firmness testing.

Firmness was measured using a universal traction–compression machine (Instron 5542, Instron Corp., Canton, MA) with computerized data acquisition (software Instron series 9, version 5.23, Instron Corp., Canton, MA) equipped with a 500-N load cell, using a five-blade Kramer shear cell. Measurements were made in triplicate on 100 g of drained product each. A sample compression rate of 60 mm/min and sample thickness of 95 mm were used. The firmness was recorded as the maximum peak force in Newton achieved during
shear compression and extrusion. Firmness was recorded on four samples per treatment.

The drained weight was determined by the method in the Federal Food, Drug and Cosmetic Act 21CFR 155.190 (FDA 2003). The drained weight was measured in triplicate.

A paired preference test was performed by 55 untrained panelists. Each panelist consumed “tomato dices in salsa or other accompaniments” at least once a month, ensuring their familiarity with the product. The samples, which were mechanically abused for 240 s with Ca added either before or after the mechanical abuse, were assigned random numbers. The test was conducted using a combination of natural and halogen lights. The test was replicated so that each panelist had two sets of samples. The panelists were asked to evaluate the samples based on the appearance of the dices and pick the one they preferred. The panelists noted their preference for each replicate.

The analysis of variance (ANOVA) was used to find significant differences in response to treatment. Matched pair analysis was used for comparison of raw versus canned dices and Ca added before or after the mechanical abuse methods. All variables are significant at $P < 0.05$. For sensory evaluation, the frequency of response for each panelist was tabulated and entered into IFPro-grams™, version 7.6 (The Institute for Perception, Richmond, VA). The beta-binomial model was used because over-dispersion was significant.

## RESULTS AND DISCUSSION

The addition of Ca protects tomatoes from tissue breakage and increases the drained weight of tomatoes subjected to mechanical damage (Kertesz et al. 1940). However, studies have not looked at when, during the process, the Ca should be added for maximum effect. In this study, tomato dices were mechanically abused in a tumble drum for various time intervals before or after being treated with Ca to determine the optimum time to add Ca.

There was no significant difference in firmness between the tomatoes that were dipped in Ca then subjected to mechanical abuse and the tomatoes that were mechanically abused then dipped in Ca for either the raw or canned dices (Table 1). The addition of Ca increased the firmness, but the firmness did not change with increasing mechanical abuse. As expected, raw dices were firmer than canned dices. This would indicate that Ca can be added anytime during the process and still would provide a protective effect.

A pair of samples that had been mechanically abused for 240 s, one Ca treated before undergoing mechanical abuse and one treated with Ca after undergoing mechanical abuse, was presented to the panelists in a preference test. The panelists were asked which sample they preferred on the basis of
appearance. The panelists preferred the dices that had been dipped in Ca before being mechanically abused. The dices that were calcified before mechanical abuse appeared to the authors to have a larger percent of undamaged dices, whereas the dices that were mechanically abused before dipping in Ca appeared ragged and mushy because of a collapsed structure. Although there was no significant difference in the texture obtained by instrumental measurement, the dices that were mechanically abused before dipping in Ca showed damage that was visible to the panelists.

Drained weight is another determinant of quality for canned tomatoes because they are marketed, partly based on weight after the packing medium has been drained. It is the second most important attribute for the U.S. standards for grades of canned tomatoes (USDA 1990). The FDA minimum requirement is that the tomatoes must account for at least 50% of the water capacity of the container. Drained weight also gives a gross indication of the textural properties of diced, whole and crushed tomatoes as it measures the weight loss occurring during handling and processing (Barrett et al. 1998).

In this study, there was no difference in drained weight of the dices obtained by the addition of Ca before or after mechanical abuse (Fig. 1). As expected, the drained weight increased with the addition of Ca, and the drained weight decreased or remained constant with increasing mechanical abuse.

<table>
<thead>
<tr>
<th>Bruising time (s)</th>
<th>Maximum peak force (N), raw dices</th>
<th>Maximum peak force (N), canned dices</th>
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TABLE 1. INFLUENCE OF MECHANICAL DAMAGE ON FIRMNESS FOR Ca ADDED BEFORE OR AFTER MECHANICAL ABUSE
Whether Ca is added before or after mechanical abuse does not affect the texture and drained weight of diced tomatoes. Considering that the consumer perception of diced tomatoes is what drives them to buy diced tomatoes, it is better to treat diced tomatoes early in the process to minimize mechanical damage to the tissue that occurs during travel through pumps and pipes.

REFERENCES


