

Contents lists available at [ScienceDirect](#)

Food and Bioproducts Processing

journal homepage: [www.elsevier.com/locate/fbp](http://www.elsevier.com/locate/fbp)

# Modelling the chemical free neutralization of caustic peeled tomato slurry as a continuously stirred tank

David M. Phinney<sup>a,\*</sup>, John C. Frelka<sup>a</sup>, Dennis R. Heldman<sup>a,b</sup>

<sup>a</sup> The Ohio State University, Department of Food Science & Technology, 2015 Fyffe Ct., Columbus, OH 432210, United States

<sup>b</sup> The Ohio State University, Department of Food Agriculture & Biological Engineering, 590 Woody Hayes Drive, Columbus, OH 43210, United States

## ARTICLE INFO

### Article history:

Received 24 February 2016

Received in revised form 3 August 2016

Accepted 9 August 2016

Available online xxx

### Keywords:

Membrane technology

Waste reclamation

Fruit/vegetable peeling

Neutralization

Process modeling

## ABSTRACT

The purpose of this investigation was to use membrane filtration to neutralize a waste stream from the chemical peeling of tomatoes and to model this process. The waste exiting the peeler/scrubber unit is decanted to separate skins and seeds from the aqueous portion of the waste stream. This aqueous suspension represents the inefficiency in over peeling of tomatoes. Recycling the slurry would reduce waste generated from the peeling operation thereby increasing process efficiency. A constant volume dilution (CVD) membrane filtration process was designed to perform a chemical-free neutralization of the tomato slurry. Through the CVD process, the active alkali of the slurry was reduced from 0.7 to less than 0.01 mol/L and electrical conductivity of the suspension decreased from 27 to less than 0.1 mS/cm. Additionally, electrical conductivity and active alkali were found to have a linear relationship ( $r^2 = 0.9962$ ) showing that one value can adequately predict the other in this system. All of the indicators of neutralization fit log-linear to the derived stirred tank processes model with significant correlation coefficients. This work shows that a CVD process using membrane technology has the potential to reclaim tomato waste from caustic peeling and that the filtration can be adequately modelled.

Published by Elsevier B.V. on behalf of Institution of Chemical Engineers.

## 1. Introduction

The United States tomato industry imported and exported over one billion kilograms of processing tomatoes in 2012 (USDA-ERS, n.d.). As a high value worldwide commodity, research surrounding processed tomatoes has been, and continues to be, extensive. Waste streams generated during tomato processing have been evaluated extensively for recovery of value added components (Dolatbadi et al., 2015; Poojary and Passamonti, 2015; Sabio et al., 2003). What has not been evaluated is the recovery of waste for use other than

extraction of valued components, such as the reintroduction of that recovered product into the processing stream.

The first step in many commercial tomato processes is the removal of the peel. This can be performed by subjecting the whole fruit to either steam or a hot caustic solution to break down the structure of the cells adhering the skin to the mesocarp, allowing for easier removal (Das and Barringer, 2006). Lye peeling is the most commonly used method in the Midwestern United States and is used also, though less frequently, in California (Das and Barringer, 2006; Garcia and Barrett, 2006). Lye peeling is most commonly performed with hot (60 to over

\* Corresponding author. Fax: +1 614 292 0218.

E-mail addresses: [Phinney.14@osu.edu](mailto:Phinney.14@osu.edu), [phinney.david.m@gmail.com](mailto:phinney.david.m@gmail.com) (D.M. Phinney).

<http://dx.doi.org/10.1016/j.fbp.2016.08.004>

0960-3085/Published by Elsevier B.V. on behalf of Institution of Chemical Engineers.

100 °C) sodium hydroxide (NaOH) at concentrations ranging from 2M to 6M or 8 to 25% for a couple minutes (Floros and Chinnan, 1989, 1990). Alternative chemicals, including KOH and  $\text{Ca}(\text{OH})_2$ , have also been evaluated, but NaOH still remains the primary caustic salt used in tomato peeling (Das and Barringer, 2006).

The effluent created from a chemical peeling operation consists of a high-moisture (~95% wet basis) slurry of suspended tomato solids in an alkaline aqueous phase (pH ~12–13). This creates a waste stream that is more difficult and less economic to dispose of (Wongsa-Ngasri, 2004). Research has been performed previously attempting to neutralize this waste stream by various methods including carbonation, coagulation with salts and membrane filtration (Pandurangi and Barringer, 2000). Past attempts at membrane filtration have been unsuccessful, however these have used nanofiltration membranes, which had a pore size too small for the tomato waste, resulting in low flux and a high rate of fouling.

Tomato peeling waste slurry contains the skin portion of the tomato as well as a portion of tomato pulp which is representative of over peeling of the fruit. Recovery of the tomato pulp from the waste stream and re-introduction of that material into the process stream would create an environment where nearly zero losses (product waste) are observed during the peeling operation. The research performed in this study evaluated the use of food grade membrane filtration technology to perform a chemical free neutralization of the caustic tomato slurry to create a suitable product for reintroduction in to the processing stream.

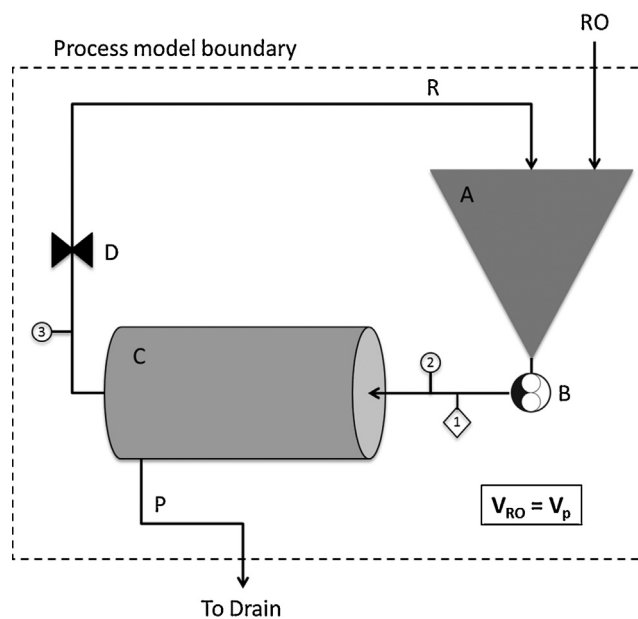
## 2. Materials & methods

### 2.1. Sample acquisition

Commercial caustic tomato slurry was obtained from Hirzel Canning Co. (Ottawa, OH) originating from Roma tomatoes processed through two caustic baths (each at 2% wt./wt. NaOH) followed by a mechanical peeler/scrubber. The material extracted from the peeler/scrubber was further processed using a horizontal decanter creating two streams: the solids fraction, containing seeds and skin and the liquid fraction, containing tomato pulp and caustic salts ( $\text{MC}_{\text{wb}}$  of  $93.3 \pm 0.01\%$ ). The solid fraction was discarded and the liquid fraction was used as the caustic tomato slurry used in these experiments.

### 2.2. Process design

A pilot scale membrane filtration unit (Model BRO/BUF, Membrane Specialists, Hamilton OH) was used to perform the chemical-free neutralization. This was accomplished by designing a constant volume dilution (CVD) process to wash the caustic salts from the slurry with reverse osmosis (R/O) water (Fig. 1). The unit consisted of a Hydra-cell high-pressure pump (Model D15EASTHFEHF, Wanner Engineering, Minneapolis, MN) with a variable frequency drive controller and a downstream pressure controller to modulate target membrane inlet pressure. Eighteen pH tolerant tubular ultra-filters (200 kDa cut-off, FPN-200, PCI Membranes, Hampshire, UK) were fitted into a 1.2m housing (Model B1, PCI Membranes). These high molecular weight (MW) cut-off filters were chosen to retain the suspended tomato pulp (retentate) while allowing the flux of caustic salts and other low MW components (permeate). Membranes were 12.0 mm in diameter



**Fig. 1 – Process design for the completion of the CVD operation used to neutralize the caustic peel tomato waste. Caustic tomato slurry held in the surge hopper (A) is pumped (B) in to the 0.9 m<sup>2</sup> membrane housing (C). The downstream pressure control valve (D) modulates inlet pressure, via an upstream pressure transducer (2), to the membrane housing. The retentate (R) is recycled back in to the surge hopper while permeate (P) is sent to the drain. Reverse osmosis water (RO) was added to the surge hopper to maintain a constant volume throughout the dilution operation. A downstream pressure transducer (3) is used for pressure drop determination across the membrane and a thermocouple (1) is used to monitor temperature during the process. Dashed line surrounding the process represents the boundary line for creating modelling.**

resulting in a 0.9 m<sup>2</sup> surface area. To achieve the CVD the retentate was returned to the product feed tank and R/O water was added to the feed tank at the same rate that the permeate was removed. Samples of the permeate were collected for analysis throughout the process.

Data are presented as a function of volume equivalents removed. In this particular study the initial volume of the CVD was ~19 L. The 19 L level was marked on the inside of the surge hopper containing the caustic tomato slurry and R/O water was added to maintain this level throughout the process.

### 2.3. Analysis

#### 2.3.1. Moisture content

Permeate and retentate moisture content were determined using an oven drying method. Briefly, a small mass of sample (~3 g) was weighed in an aluminum weigh boat and dried at 110 °C for 18 h (Liu et al., 2010). During the drying process, water was driven off and the initial and final mass values could be used to calculate moisture content of the samples.

#### 2.3.2. Active alkali

The active alkali is a titration method very similar to titratable acidity, except the titrant is now an acid rather than a base. It measures the number of free anionic groups in a solution, namely  $\text{OH}^-$  (Mercadé-Prieto et al., 2008; Scandinavian Pulp, 1985). To complete this analysis, approximately 30 mL of sample was aliquoted into a small (50 mL) flask. A drop of indicator

Download English Version:

<https://daneshyari.com/en/article/6488441>

Download Persian Version:

<https://daneshyari.com/article/6488441>

[Daneshyari.com](https://daneshyari.com)