Modeling of the break process to improve tomato paste production quality

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Abstract

The pectic enzyme, Pectinmethylesterase (PE) and Polygalacturonase I and II (PGI and PGII), in the tomato fruit released after crushing during tomato processing reduce the viscosity of tomato paste by breaking down the insoluble pectin in the cell wall. To achieve higher viscosity tomato paste, the cold break (<60°C) or hot break (>60-95°C) processes can be used to inactivate the pectic enzyme and to achieve higher viscosity tomato paste.

The study of tomato solids and PG enzyme activity showed that the levels of insoluble solids, total solids, pectin, and °Brix in Ferry Morse tomatoes were independent of fruit ripeness. The amount of PG enzymes was high in orange and dark red tomatoes and the activity of PG enzymes increased as a function of ripeness, from green to dark red. In the dark red tomato, the inactivation of PG enzyme activity was required to retain the level of pectin. Cold break temperatures below 60°C can not inactivate the PG enzyme activity. The PG enzymes started to be denatured when the hot break temperature was above 65°C and be completely destroyed when the break temperature was above 80°C.

A mathematical model of the break process was formulated and Matlab programme was used to predict the effect of break temperatures on the pectin and PG enzyme concentration of the tomato pulp in the break tank for any inputs of feed rate (the flow rate to the break tank), feed ripeness, and residence time. The model was used to demonstrate the understanding and the optimisation of break process performance. Longer residence time of dark red tomato pulp in the break tank can decrease pectin fraction residual and increase enzyme inactivation in the tank temperature range 40 to 60°C. The pectin fraction remaining increased when the tank temperature was above 60°C because of the inactivation of PG enzymes. At 80°C there was no effect of residence time, the pectin fraction residual increased and reached 90% and enzyme fraction residual decreased to 10%.

The effect of mixed tomato ripeness between the ripe fruit (orange and dark red) with the unripe fruit (green, breaker, and turning), the level of PG enzymes in the break tank decreased and affected on the higher pectin fraction remaining. Lower break temperature can be therefore used in this process to inactivate the low amount of PG enzyme and to achieve the same extent of pectin hydrolysis.

The interruption of the feed coming into the break tank during tomato processing can increase the pectin fraction remaining and the enzyme fraction remaining in a new steady state when the feed was turned on.

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Project Overview

1.1 Problem definition

The tomato is an important ingredient in the present food industry. It can be consumed as a fresh fruit or processed to form tomato pulp, tomato juice, tomato puree or tomato paste. Tomato paste or concentrated tomato is widely used by food manufacturers as a starting material for a wide range of tomato products. The paste imparts viscosity, colour and flavour to formulated products. Concentrated product enables storage for long periods of time for use outside the tomato growing season.

Heinz-Watties Australasia Ltd., Hastings produces a wide range of tomato products such as soups, sauces, baked beans, spaghetti and pasta sauces for several different brands including Watties, Oak, Heinz, Weight Watchers. Tomato paste is used as the base ingredient for many of these products. Tomato paste processing comprises many stages including washing, crushing, evaporating, sterilising and packaging.

Campbell (2002) found that the viscosity of tomato puree after crushing was not uniform and that affected the subsequent viscosity of tomato paste. This was due to the activity of pectinmethylesterase (PE) and polygalacturonase I and II (PG I and II) enzymes (pectic enzymes). These enzymes breakdown the insoluble pectin in the cell wall and as a result, the viscosity was reduced. The hot break process is designed to keep the temperature greater than 80°C to help inactivate both enzymes and achieve the higher viscosity.

Campbell (2002) also showed that the ratio of soluble solid to total solids of paste produced at Heinz-Watties was variable. These findings were assumed to be due to the changing residence time in the break tank resulting in variable pectic enzyme inactivation and therefore varying the degree of the conversion of insoluble pectin into soluble sugars and organic acids. It was therefore assumed that tomato pulp with a short residence time in the break tank may result in high IS/total solid ratios, whereas tomato puree with a long residence time may achieve lower IS/total solid levels.

The aim of this work was to develop a model for the break process to allow process optimisation and thereby providing a more consistent tomato paste for Heinz-Watties. This involves characterisation of the kinetics of pectin hydrolysis and PG enzyme destruction in the process and the modelling of temperature and reaction in the break tank.

1.2 Project Aims

The intermediate aims to achieve these goals are;

- To measure the kinetics of PG enzyme activity.
- To measure of the kinetics of PG enzyme inactivation due to heat processing of tomato fruit at the temperature range 25 to 80°C.
- To mathematically model the break process to allow the prediction of break tank temperature, extent of pectin hydrolysis and enzyme inactivation as a function of time and temperature in the break process.
- To use the model to suggest strategies for the better control of tomato paste quality.