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Journal of Food Engineering 66 (2005) 259–265

JOURNAL OF FOOD ENGINEERING

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Effect of thermal processing on the quality loss of pineapple juice

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Received 24 November 2003; accepted 14 March 2004

Abstract

Three indexes, namely colorimetric Hunter parameters (L, a, b and ΔE), hydroxymethylfurfural (HMF) and brown pigment formation, were monitored to determine the quality loss of pineapple juice at temperatures ranging from 55 to 95 °C. The changes in a and b values followed first order kinetics while ΔE fitted well to a combined model which described both non-enzymatic browning reaction and destruction of carotenoid pigment. For browning indexes, HMF and brown pigment formation increased linearly with heating time and could be explained using zero order reaction kinetics. The results suggested that processing temperature had a significant effect on the color change of pineapple juice. The dependence of the rate constant on temperature was represented by an Arrhenius equation.

Keywords: Color change; Hydroxymethylfurfural; Kinetics; Non-enzymatic browning; Pineapple juice

1. Introduction

Pineapple (*Ananas cosmosus*) is one of the most important commercial fruits of Thailand. The fruit can be consumed fresh or processed in various forms and pineapple juice is a popular product due to its very pleasant aroma and flavor.

Thermal treatment is generally applied to extend shelf life of fruit products. However, heating processes can affect the quality of product which leads to consumer dissatisfaction. Non-enzymatic browning reactions and pigment destruction have been found to be major causes of such problems. Therefore, kinetic studies are required and used to predict quality degradation resulting from process conditions.

Different methods can be used to determine the extent of color change. Color measurement is simple and faster than chemical analysis. The Hunter parameters (L, a, and b) have been proven to be useful for describing visual color change of various fruit products (Avila & Silva, 1999; Garza, Ibarz, Pagán, & Giner, 1999; Ibarz, Pagán, & Garza, 1999). The L value represents the light–dark spectrum, a value is for the green–red spectrum and b value represents the blue–yellow spectrum (Ranganna, 1986). Other assays include the analysis of intermediates and final products of non-enzymatic browning reactions. The measurement of 5-hydroxymethylfurfural (HMF), an important intermediate, is widely used as an indicator of Maillard reactions, i.e. browning development (Bozkurt, Gogus, & Eren, 1999; Cohen, Birk, Mannheim, & Saguy, 1998; Garza et al., 1999).

Kinetic models have been developed to evaluate color degradation and non-enzymatic browning reactions during processing of fruit products such as apple juice (Cohen et al., 1998), pear puree (Ibarz et al., 1999) and peach puree (Garza et al., 1999). For pineapple products, Fontana, Howard, Criddle, Hansen, and Wilhelmsen (1993) studied the effects of additional components, i.e. sugars, organic acids, on the quality deterioration kinetics of pineapple concentrate at 60–80 °C. However, information regarding the changes in quality of pineapple drinks in terms of color change and non-enzymatic browning during heating is unavailable.

This work was aimed at investigating the quality loss of pineapple juice as affected by heat treatment. Visual color, 5-hydroxymethylfurfural (HMF) and brown pigment accumulation were monitored during heating at 55–95 °C. The kinetics of these indicators were also investigated. The information obtained from the study

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doi:10.1016/j.jfoodeng.2004.03.016

could be used as a guideline for designing thermal processes to reduce the quality degradation of the products.

2. Material and methods

2.1. Preparation of pineapple juice

Fresh Smooth Cayenne pineapples were obtained from a local market. After rinsing the fruit in tap water, the shell and core were removed using a stainless steel knife. The flesh was cut into small pieces and the juice was extracted using a hydraulic machine (Sakaya Model 4104, Thailand) to extract the juice. Total soluble solid (TSS) and pH value of the juice were determined in the ranges of 12.2–14.2° Brix and 3.74–4.00, respectively. The prepared juice was then kept at 4 °C until used.

2.2. Thermal treatment

A series of thin wall glass tubes (length 30 cm; inner diameter 5 mm; wall thickness 2 mm) were filled with 8 ml of pineapple juice. The tubes (filled with the juice) were sealed at both ends and then subjected to heat in a water bath (Memmert Model W 600, Denmark) at 55, 65, 75, 85 and 95 °C for 80 min. The come up times for every condition was less than 1 min. The temperature of the juice at the center of a tube was monitored during the experiments using type T thermocouples to an accuracy of ±1 °C. The tubes were removed every 10 min and immediately cooled in an ice-water bath in order to stop the heat accumulation. The control experiments (without heat treatment) were done by the same procedure, filling 8 ml of pineapple juice into the tubes and placing them directly in the ice-water bath. Color change, non-enzymatic browning index and hydroxymethylfurfural (HMF) of pineapple juice were determined using a spectrocolorimeter (JUKI Model JP7100/C, Japan) and spectrophotometer (Shimadzu Model UV-2101 PC, Japan), respectively. All experiments were performed in three replicates.

2.3. Color measurement

Color changes of pineapple juice were analyzed by measuring the transmittance using a spectrocolorimeter. 2° North skylight was used as the light source. The spectrocolorimeter was calibrated against distilled water ($L = 100$, $a = 0$, $b = 0$) before the measurement (according to the equipment instruction manual). A glass cuvette ($3.5\times4\times1.5$ cm^3) containing heat-treated juice was placed in the cell transmittance specimen compartment. The lid of the compartment was closed and the analysis was then conducted. Three Hunter parameters, namely "L" (lightness), "a" (redness and greenness) and "b" (yellowness and blueness) were measured and total color differences were calculated from L, a and b values.

2.4. Determination of non-enzymatic browning index and 5-hydroxymethylfurfural (HMF)

The following assays were performed using the methods as mentioned in Cohen et al. (1998). 5 ml of 95% ethyl alcohol was added to 5 ml of pineapple juice sample. The mixture was centrifuged at 1000*g* for 15 min. The supernatant of the centrifuged sample was separated into two portions. One was taken to measure the absorbency at 420 nm for the non-enzymatic browning index. To determine the HMF content, 2 ml of the other portion was introduced into a 16 ml screw cap tube. 2 ml of 12% w/w trichloroacetic acid (TCA; Sigma, Germany) and 2 ml of 0.025 M thiobabituric acid (TBA; Carlo Erba, Italy) were subsequently added and mixed thoroughly. The tubes with sample were then placed in the water bath (Memmert Model W 600, Denmark) at 40 °C (±0.5 °C). After incubating for 50 min, the tubes were cooled immediately using tap water and the absorbency was measured at 443 nm. A calibration curve of HMF (Aldrich, Germany) was utilized to quantify the HMF concentration.

2.5. Experimental design

The experiments were conducted for five levels of temperatures (55, 65, 75, 85 and 95 °C). A 2-factor factorial design was used in scheduling of the experiments with three replicates in each case.

2.6. Data analysis

The results were reported as an average of three replicates. Analysis of variance (ANOVA) of the two factors and interactions were applied to the different sets of data with a significant level of 0.05 ($\alpha = 0.05$).

3. Results and discussion

3.1. Color change of pineapple juice during heat treatment

The color degradation of pineapple juice as affected by thermal processing was investigated using Hunter parameters (L, a and b). The enzymatic browning reaction was neglected in this study as the enzymes causing browning were susceptible to heat, at temperatures of >50° (Martinez & Whitaker, 1995). Therefore, non-enzymatic browning and pigment destruction were considered as the major causes of color change in pineapple juice.

The results obtained were presented in terms of L/L_0, a/a_0 and b/b_0 when L_0, a_0 and b_0 represented the initial