TEXTURE AND COLOUR KINETICS OF CHANGE IN BLANCHED CARROTS

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Resumen

Five Isothermal heating experiments, at different temperatures and at predetermined time intervals, were carried out on diced carrots. The objective of this study was to determine the degradation kinetics of colour (*a* and *a/b* parameters) and texture (*work* and *maximum force)* along blanching. The best model to fit the degradation kinetic data was the fractional conversion and the temperature effect was well described by the Arrhenius equation. The $k_{80°C}$ and E_a values were 0.2, 0.05, 0.5 and 0.05 min^{-1} and $12x10^3$, $18x10^3$, $49x10^3$ and $192x10^3$J/mol, respectively for *a, a/b, maximum force and work.*

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INTRODUCTION

The blanching process is a thermal treatment that is needed to extend the self-life of frozen vegetable products. The process should ensure the required reduction of enzymes and the removal of intercellular gases. Since blanching is a thermal treatment, it may result in some microbial load reduction, as well. Blanching may induce both textural and colour changes, depending on process time and temperature, and type and state of the vegetables. These changes are a result of heat, that has a pronounced effect on the cell structure and leaching of soluble constituents. Since texture and colour are the major, if not the most important, sensory characteristics in determining product acceptability, it is of critical importance for the food industry to prevent, or at least minimise, its degradation.

MATERIALS AND METHODS

Samples Preparation and Blanching Treatments

Carrots (Daucus carota), variety "Nantes", were purchased from a local supermarket. They were sliced, 0.5 cm thick, and cylindrical samples, with 2 cm diameter, were cut.

Thermal Treatment

Blanching was conducted in water, at controlled temperature, using a circulating water bath with 10 liters. The samples were blanched at different temperatures and times (table 1). For each blanching treatment 12 samples was used for texture and colour analysis. Twelve samples were not treated and were evaluated in the raw state, for control.

Table 1. Temperatures and corresponding blanching times.

Temperature (°C)	Time (minutes)
70	2, 5, 10, 15, 20, 30, 40, 50
75	2, 5, 10, 15, 20. 30. 40, 50 60
80	2, 5, 10, 15, 20. 25, 30
85	2, 5, 10, 15, 20, 25, 30
90	2, 5, 10, 25, 35

Texture and Colour Measurement

Texture analysis were carried out in a Texture Analyser TA-Hdi. The *maximum force* (breaking load) and *work* (area below the curve) were measured using a knife/guillotine blade.

Objective colour measurements were made with a triestimulus colorimeter (Minolta CR-300). The apparatus was calibrated with a standard white plate (*L*=97.10, *a*= +0.08, *b*=+1.80) and the *a* and *a/b* values were measured taken for the twelve samples from each treatment.

Data Analysis

To quantify the kinetics of change, a non-linear regression to all the data was done for each parameter, using the software STATA.

Two models were tried, the first-order (Equation 1) and the fractional conversion model (Equation 2)

$$\frac{C}{C_0} = \exp(-kt) \tag{1}$$

$$\frac{C - C_{eq}}{C_0 - C_{eq}} = \exp(-kt) \tag{2}$$

where C_o is the initial value of concentration, k the temperature dependent reaction rate constant (min^{-1}), C the value of the concentration at any time, t, and C_{eq} the value of concentration at the equilibrium.

Texture and colour degradation rates have been described with respect to temperature by the Arrhenius relationship:

$$\ln k = \ln k_{ref} - \left[\frac{Ea}{R}\left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right] \tag{3}$$

where k is the rate constant at temperature T (K), Ea the activation energy (cal/mol) and R is the universal gas constant (1.987 cal/(mol K)).

RESULTS AND DISCUSSION

A non-linear regression to all data, using a fractional conversion and a first-order model, was carried out. We found out that the fractional conversion model of data was the best fit .The results obtained in the experiment for degradation of colour (value *a*), as a function of heating time, at 70°C are presented in Fig.1.

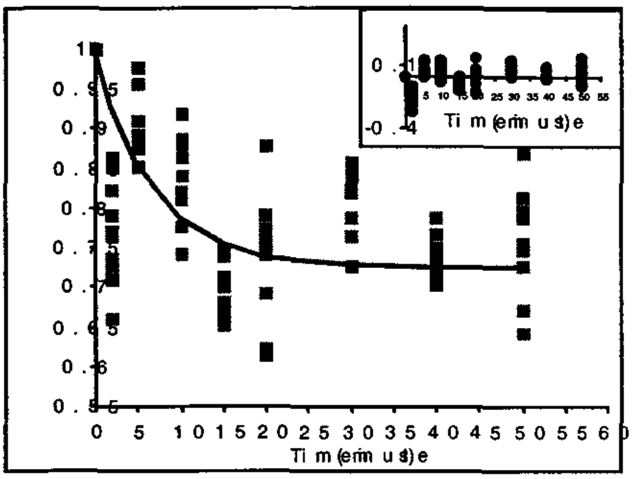

FIGURE 1. Degradation of a/a_o value in diced carrots (◆) modeled using a fractional conversion model (–) at 70°C. Values of residues obtained in the model applied.

In Figure 2 the mean values for colour degradation (value *a/b*) in experiments at 80ºC and 90ºC are presented.

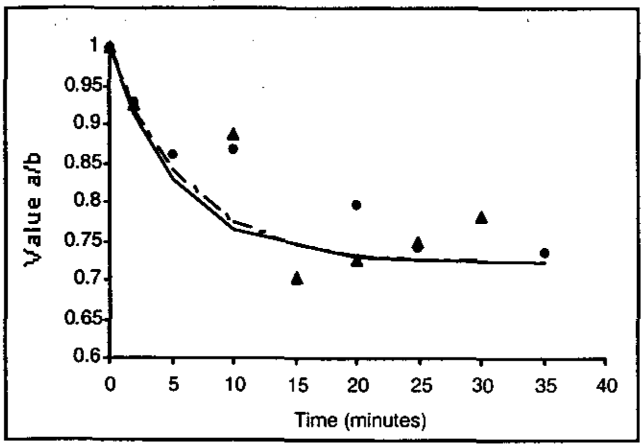

FIGURE 2. Change in colour value, *a/b*, of carrots upon heating, modeled using a fractional conversion model at two temperatures (▲ 80º and● 90ºC).

The reaction rate (*k*) and activation energy (*Ea*) values can be observed in Table 1. The r^2 values obtained from the non-linear regression were satisfactory.

TABLE 2. Kinetic parameters for colour degradation of blanched carrots.

Analysis	Kinetic parameters	Fractional conversion	Std. Err.
Colour (*a* value)	r^2	0.987	
	C_{eq}	0.723	0.008
	E_a (J/mol)	12×10^3	11747
	$k_{80°C}$ (min.-1)	0.2	0.018
Colour (*a/b* value)	r^2	0.987	
	C_{eq}	0.743	0.025
	E_a (J/mol)	18×10^3	10549
	$k_{80°C}$ (min.-1)	0.05	0.011

The same methodology was followed for the degradation of texture. Fig. 3 show the curves for the degradation of texture (*maximum force*) during time for temperature 80° C, using a fractional conversion model.

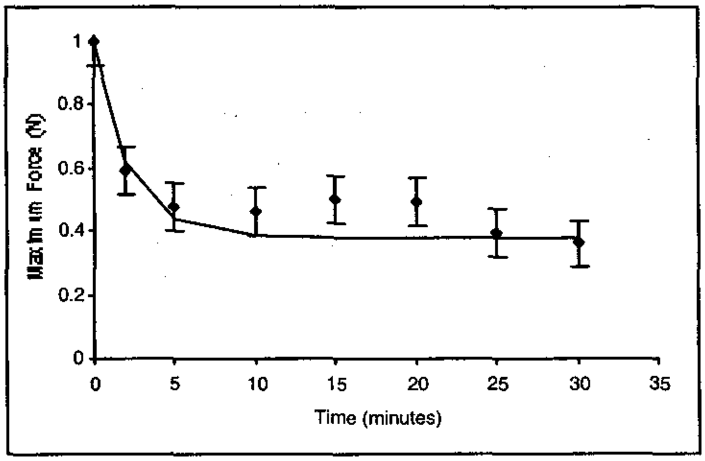

FIGURE 3. Effect of time at 80°C on *maximum force* (♦) of blanched diced carrot modeled using a fractional conversion (—)model.

The change in the *work* value of thermally processed carrot was a function of heating time at the five different temperatures (Fig. 4)

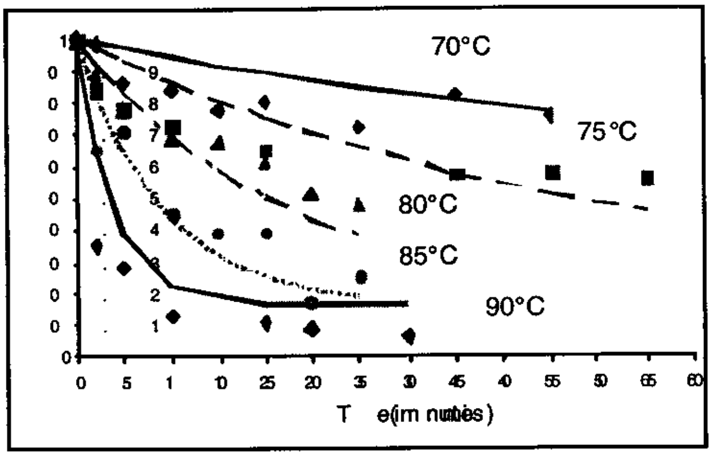

FIGURE 4. Effect of heating on texture (*work*), modeled using a fractional conversion model, at different temperatures.

The reaction rate (k) and activation energy (Ea) values obtained, using the fractional conversion model, can be observed in Table 3.

TABLE 3. Kinetic parameters for texture degradation of blanched carrots.

Analysis	Kinetic parameters	Fractional conversion	Std. Err.
Texture (*work*)	r^2	0.928	
	C_{eq}	0.159	0.027
	E_a (J/mol)	192×10^3	9091
	$k_{80°C}$ (min.-1)	0.05	0.003
Texture (*maximum force*)	r^2	0.957	
	C_{eq}	0.380	0.023
	E_a (J/mol)	49×10^3	29813
	$k_{80°C}$ (min.-1)	0.5	0.108

CONCLUSION

The fractional conversion model fitted well the degradation data for blanching of carrots. As it can be seen in Fig 2, the colour degradation is not dependent on the temperature applied, therefore it is convenient to use high temperatures and short blanching times. The present results are a good tool for optimising carrot blanching process, in terms of maximising its final quality.