Food Development & Production

Process optimization and shelf-life determination of processed food. Review of same case studies.

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Introduction

Consumers expect processed foods to be safe and have sensory and nutritional quality characteristics similar to fresh products. Food processing has three main objectives: a) to make food safe; b) to provide products with high-quality attributes, transforming them into more convenient or attractive forms for consumption, and c) to extend their shelf life. Food processes, which involve thermal treatments (e.g., blanching, pasteurization, sterilization, or drying), and storage that resort to the use of temperatures such as freezing and refrigeration, are processes that depend on the applied temperature-time binomials [1]. Different mathematical models that describe and/or predict changes in the characteristics of processed foods under constant real or dynamic conditions are fundamental tools in the development of new products, process optimization, and determination of the lifetime of these foods in different scenarios.

Objectives

In this study, the quality of certain vegetables (carrots, pumpkin, broccoli) was modelled as a function of specific temperature profiles to which they were subjected. Optimisation of the blanching operation according to different quality attributes, inactivation of peroxidase activity [2, 3], and determination of their shelf life during frozen storage under isothermal and non-isothermal conditions will be presented and discussed [4, 5].

Case I - Methodology to otimize the blanching operation

Objectives

Otimized processing conditions (OPC) conjugate:
- inactivation of POD enzymes
- maximisation of physical and organoleptic attributes
- maximisation of nutritional content

Produts / Determinations / Time-Temperature range

Pumpkin – Blanched in water (75-95°C; 0-50 min)
- Peroxidase
- Vitamin C
- Texture
- Colour

Broccoli – Blanched in water (70-90°C; 0-40 min)
- Peroxidase
- Vitamin C
- Total phenolic content
- Texture
- Colour
- Sensorial evaluation

Carrots – Blanched in water (75-95°C; 0-40 min)
- Peroxidase
- Total phenolic content
- Texture
- Colour

Kinetic models

Isothermal conditions

$$C = C_0 - \left(k_{ref} \exp\left(-\frac{E_a}{R}\left(\frac{1}{T}-\frac{1}{T_{ref}}\right)\right)t\right) \quad \text{zero-order}$$

$$C = C_0 \exp\left(-k_{ref} \exp\left(-\frac{E_a}{R}\left(\frac{1}{T}-\frac{1}{T_{ref}}\right)\right)t\right) \quad \text{first order}$$

$$C = C_{eq} + (C_0 - C_{eq}) \exp\left(-k_{ref} \exp\left(-\frac{E_a}{R}\left(\frac{1}{T}-\frac{1}{T_{ref}}\right)\right)t\right)$$

fractional conversion model

t – storage time | T – temperature | R – universal gas constant
C – quality attribute (0 and eq indicates initial and equilibrium values)

model parameters
E_a – activation energy | k_{ref} – reaction rate at a given temperature T_{ref}

Non-isothermal conditions

$$C = C_0 - \left[k_{ref} \int_0^t \exp\left[-\frac{E_a}{R}\left(\frac{1}{T(t)}-\frac{1}{T_{ref}}\right)\right]dt\right]$$

$$C = C_0 \exp\left[-k_{ref} \int_0^t \exp\left[-\frac{E_a}{R}\left(\frac{1}{T(t)}-\frac{1}{T_{ref}}\right)\right]dt\right]$$

$$C = C_{eq} + (C_0 - C_{eq}) \exp\left[-k_{ref} \int_0^t \exp\left[-\frac{E_a}{R}\left(\frac{1}{T(t)}-\frac{1}{T_{ref}}\right)\right]dt\right]$$

Integration of time effects

Case II - Methodology to otimize the storage conditions

Objectives

- To improve the overall quality and determine the shelf-life of vegetables during frozen storage under isothermal and non-isothermal conditions

Produts / Determinations / Time-Temperature range

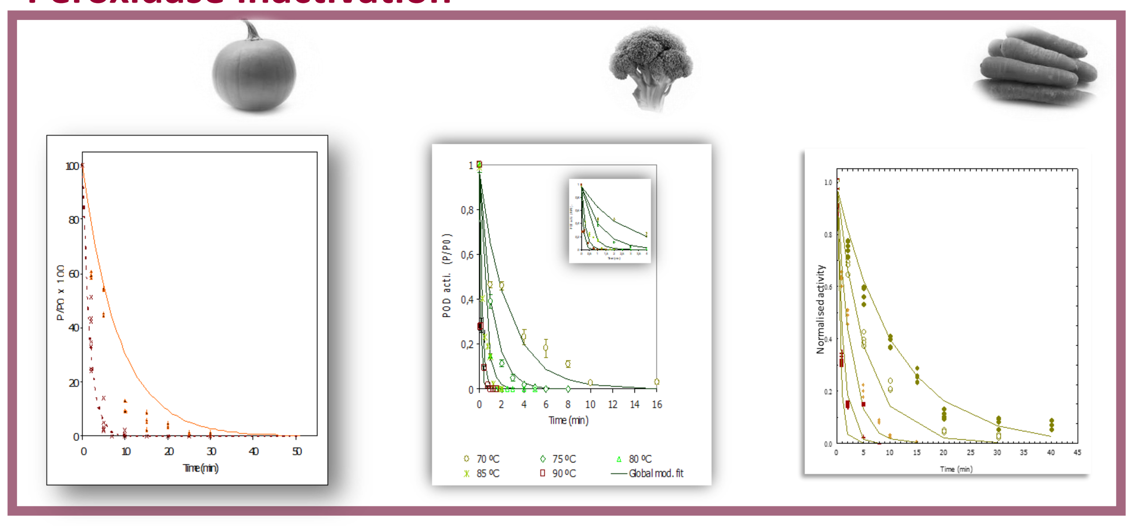
Pumpkin – Isothermal (T(°C)/time(d)): -7, -15, -25/140; Non-isothermal (T(°C)/time(d)): -30/21; -20/16; -10/11; -5/9
- Peroxidase
- Vitamin C
- Texture
- Colour

Broccoli – Isothermal (T(°C)/time(d)): -7, -15, -25/140; Non-isothermal (T(°C)/time(d)): -30/21; -20/16; -10/11; -5/9
- Peroxidase
- Vitamin C
- Texture
- Colour
- Drip loss

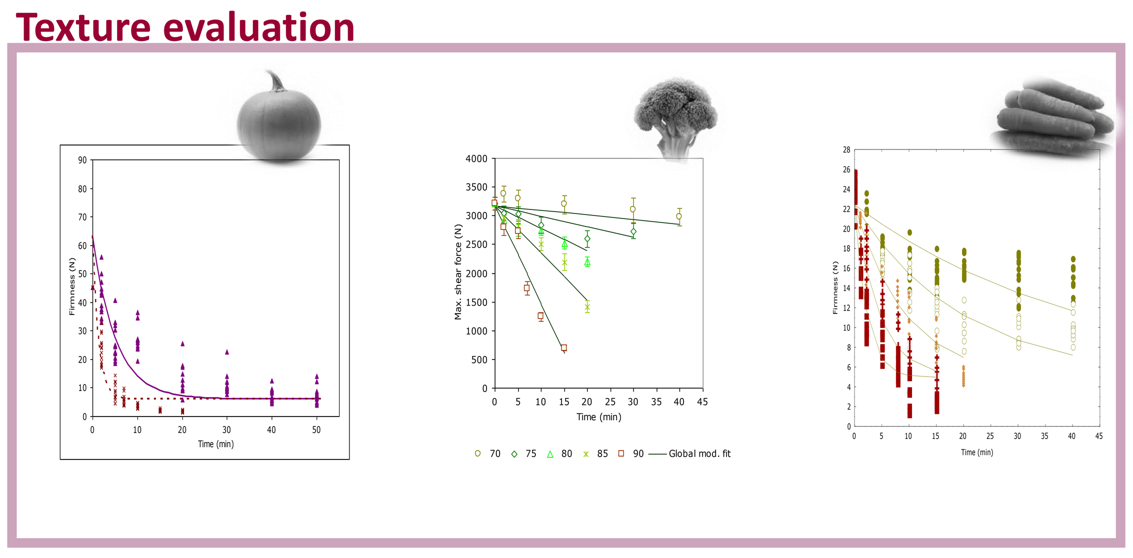
Carrots – Isothermal (T(°C)/time(d)): -7, -15, -25/140; Non-isothermal (T(°C)/time(d)): -30/21; -20/16; -10/11; -5/9
- Peroxidase
- Vitamin C
- Texture
- Colour
- Drip loss

Case I - Results of the otimization of the blanching operation (examples)

Peroxidase inactivation



Texture evaluation



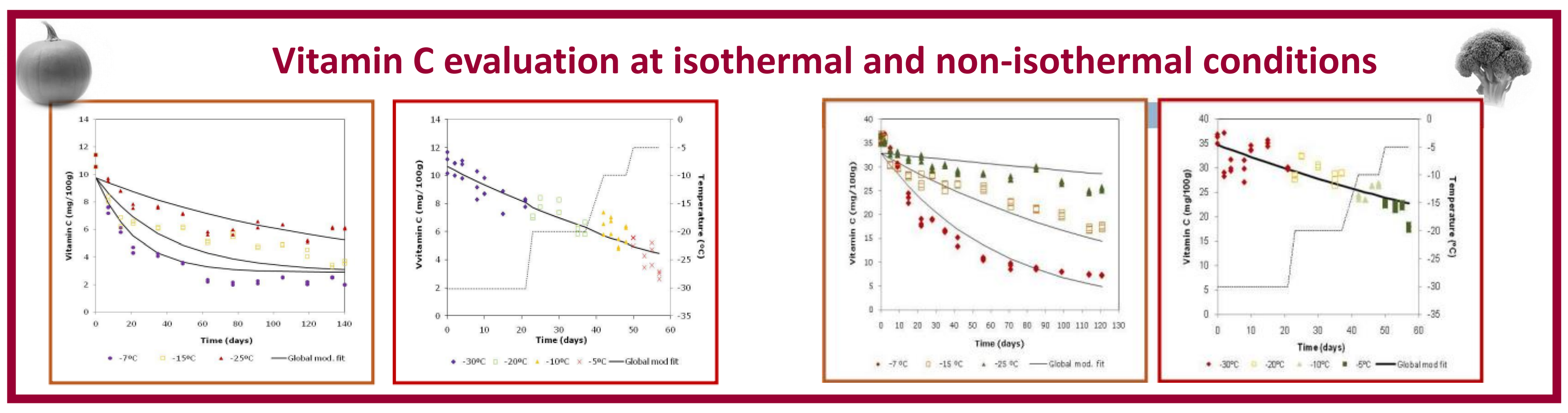
Pumpkin: Texture was the "reference parameter". OPC: 95 ºC – 3.9 min

Broccoli: Colour was the "reference parameter". OPC: 70 ºC – 6.5 min

Carrots: Phenolic content was the "reference parameter"". OPC: 80 ºC – 6.0 min

Case II – Results of the otimization of the storage conditions (examples)

Vitamin C evaluation at isothermal and non-isothermal conditions



Kinetic model + 50% of vitamin c reduction + -18ºC = Shelf life

Pumpkin: Prediction: 61 days

Broccoli: Prediction: 125 days

Carrots: Prediction: 118 days

Conclusion

Because food quality is highly valued by consumers, changes may be understood and controlled during processing. The presented studies revealed that temperature-sensitive parameters during thermal treatment operation like blanching, are dependent on the type of vegetable. Modelling the kinetics of POD inactivation and attribute changes of vegetables during blanching will allow processes optimization and simultaneously, minimization of important quality losses. Frozen storage of vegetables, under isothermal and non-isothermal conditions, affected vegetable quality. Furthermore, the developed kinetic models maybe used to predict vegetable quality behaviors and determine their shelf life along the frozen storage. The accelerated life test method used was a good tool for studying kinetics of quality changes.

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References
[1] Essentials of thermal processing. Turcker, G., Featherstone, S. (Eds). Pndicherry, Blackwell Publishing Ltd, 2011. [2] Gonçalves, E.M., Pinheiro, J., Abreu, M., Brandão, T.R.S., Silva, C.L.M. Journal of Food Engineering, 97 (2010) 574. [3] Gonçalves, E.M., Pinheiro, J., Abreu, M., Brandão, T.R.S., Silva, C.L.M. Journal of Food Engineering, 81 (2007) 693. [4] Gonçalves, E.M., Pinheiro, J., Abreu, M., Brandão, T.R.S., Silva, C.L.M. International Journal of Refrigeration, 34 (2011) 2136. [5] Gonçalves, E.M., Pinheiro, J., Abreu, M., Brandão, T.R.S., Silva, C.L.M. Journal of Food Processing and Preservation, 44 (2020) e14953.