International Journal of Engineering & Technology, 7 (4) (2018) 3687-3689

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET
doi: 10.14419/ijet.v7i4.15157
Research paper

Numerical performance of healthy processing for HMF content in honey

Norma Alias [1], Koo Suey Ching [1] *, Alyani Nazeeha Ab Karim [1], Waleed Mugahed Al-Rahmi [1], Qusay Al-Maatouk [2]

[1] *Ibnu Sina Institute for Scientific &Industrial Research (ISI-SIR), Faculty of Science, Universiti Teknologi Malaysia, 81310, UTM Skudai, Johor, Malaysia*
[2] *Faculty of Engineering, Computing and Technology, Asia Pacific University of Technology & Innovation (APU), Technology Park Malaysia, Bukit Jalil-57000 Kuala Lumpur, Malaysia*
**Corresponding author E-mail: norma@ibnusina.utm.my*

Abstract

The objective of this study is to develop a kinetic model correlating the effect of heating temperature and the duration of thermal treatment on HMF formation for different types of honey from different geographical locations. In this study, the experimental data from previous re-search papers for European and Asian honey was collected from year 1999 to 2012. The data was analysed and performed visually in graphical representation to draw the relationship between the factors. Then, a descriptive mathematical model was developed by using Math Work to correlate the parameters and the model was validated based on the data from Malaysian and European honey samples. The study showed that both heating temperature and duration could accelerate the production of HMF content in honey. The formation of HMF con-tent is proportionally increased with the increase of heating temperature and duration.

Keywords: Numerical Performance; Healthy Processing.

1. Introduction

Honey processing frequently requires heating both to reduce viscosity, and to prevent crystallization or fermentation (Singh et al., 1988). Honey consistency is changed and de-crystalized through heat treatment for the following reason (Justina, 2010):

1) To prepare a consistency (liquid, soft, creamy etc.) attractive physical appearance for customer.
2) To prevent or stop fermentation process of honey with moisture content exceeds 18% by pasteurization and at the same time reduce moisture content to 17.1%. (Justina, 2010).
3) To facilitate packaging of honey stored in large wholesale containers into small cruets 150-1500g in volume.
4) To destroy the micro-organisms to avoid honey contamination.

During heating, two stages can be identified: the transitory or transient stage, and isothermal stage. The transient stage corresponds to an increase in temperature, starting from its initial value and reaching the treatment temperature, followed by the isothermal stage, in which temperature remains constant at the obtained value. In the transient stage, duration of heating depends on the system properties and heat flow. In the isothermal stage, time is generally fixed according to the purpose of heating. It is important to develop a thermal process capable of achieving pasteurization and stabilizing the crystallization phenomenon in a single operation for the production of honey (Tosi et al., 2001).

2. Honey thermal processing

Honey processing frequently requires heating both to reduce viscosity, and to prevent crystallization or fermentation (Singh et al., 1988). Honey consistency is changed and de-crystalized through heat treatment for the following reason (Justina, 2010):

1) To prepare a consistency (liquid, soft, creamy etc.) attractive physical appearance for customer.
2) To prevent or stop fermentation process of honey with moisture content exceeds 18% by pasteurization and at the same time reduce moisture content to 17.1%. (Justina, 2010)
3) To facilitate packaging of honey stored in large wholesale containers into small cruets 150-1500g in volume.
4) To destroy the micro-organisms to avoid honey contamination.

During heating, two stages can be identified: the transitory or transient stage, and isothermal stage. The transient stage corresponds to an increase in temperature, starting from its initial value and reaching the treatment temperature, followed by the isothermal stage, in which temperature remains constant at the obtained value. In the transient stage, duration of heating depends on the system properties and heat flow. In the isothermal stage, time is generally fixed according to the purpose of heating. It is important to develop a thermal process capable of achieving pasteurization and stabilizing the crystallization phenomenon in a single operation for the production of honey (Tosi et al., 2001).

3. Numerical methods

3.1. Simultaneous equations

In mathematics, simultaneous equations and system of equations are finite sets of equations for those who are looking for common solution. When there are two or more unknown variables and two or more equations relating them are called simultaneous equations. To solve the simultaneous equations, value of the unknowns which satisfy all the given equations at the same time is determined. According to K. Koutsoumanis et al. (1998), Equation (1) the function to relate concentration and temperature can be represent by Concentration = f (time, temperature). In C = αt + bT

Where

a, b = constant

C= HMF concentration (mg/kg)

T= Heating temperature

t = Heating duration

(Math Centre- Simultaneous Linear Equations. Retrieved 4th June 2013, from http://www.mash.dept.shef.ac.uk/Resources/web-simultaneous1.pdf)

3.2. Lagrange interpolation

Interpolation is the process of estimating an intermediate value from a set data. One of the simplest approaches to interpolation is based on the polynomial. Suppose {(x0, y0), (x1, y1), …, (xn,yn)} or {(xi,yi)}ni=0 be the set of (n+1) given data points. The process of finding the value of y corresponding to any value of x=xi between x0 and xn, is called interpolation. The idea behind interpolation is to find a polynomial which agrees with specified data points. We seek a polynomial interpolation Pn(x) of degree ≤n such that Pn(xi) = yi, i=0,1,2,…,n. The polynomial Pn(x) is often said to "interpolate the data". This polynomial can then be used to generate approximate values at other points between x0 and xn.

3.3. Least square regression

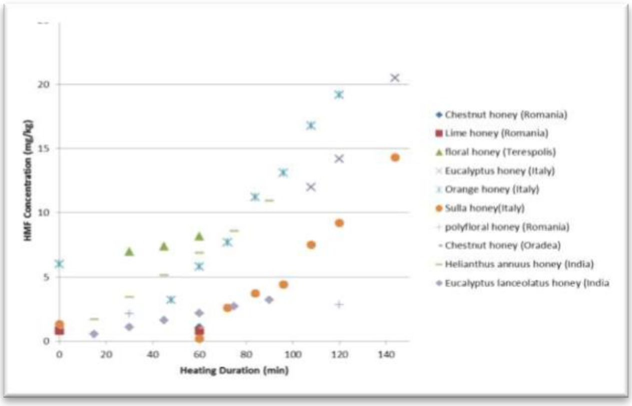
The method of least squares is a standard approach to the approximate solution of over determined systems, i.e., sets of equations in which there are more equations than unknowns. "Least squares" means that the overall solution minimizes the sum of the squares of the errors made in the results of every single equation. The most important application is in data fitting. The best fit in the least-squares sense minimizes the sum of squared residuals, a residual being the difference between an observed value and the fitted value provided by a model. When the problem has substantial uncertainties in the independent variable (the 'x' variable), then simple regression and least squares methods have problems; in such cases, the methodology required for fitting errors-in-variables models may be considered instead of that for least squares.

Least squares problems fall into two categories: linear or ordinary least squares and non-linear least squares, depending on whether or not the residuals are linear in all unknowns. The linear least-squares problem occurs in statistical regression analysis; it has a closed-form solution. A closed-form solution (or closed-form expression) is any formula that can be evaluated in a finite number of standard operations. The non-linear problem has no closed-form solution and is usually solved by iterative refinement at each iteration the system is approximated by a linear one, thus the core calculation is similar in both cases. Least square corresponds to the maximum likelihood criterion if the experimental errors have a normal distribution and can also be derived as a method of moment's estimator. (Wikipedia-The Free Encyclopedia-Least Squares. Retrieved 4th June 2013, from http://en.wikipedia.org/wiki/Least_square)

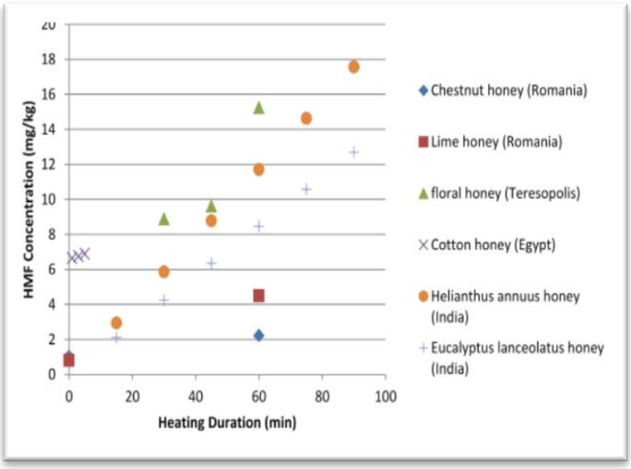
4. Results and discussion

Data from previous studies on European and Asian honey collected from year 1999 to 2012 is represented by graphs; HMF concentration over heating duration at a particular heating temperature (Figure 1) and HMF concentration over heating temperature at a particular heating duration (Figure 1). Figure 1 shows that the HMF concentration is proportional to the heating temperature for low, medium and high temperature. On the other hand, HMF concentration is also showed to be proportional to the heating duration as shown in Figure 1.

(A)



(B)



(C)

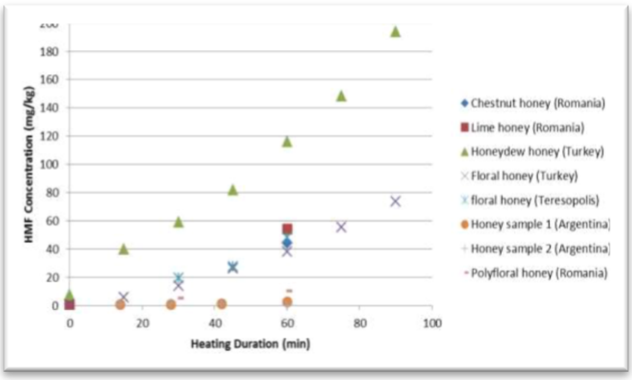
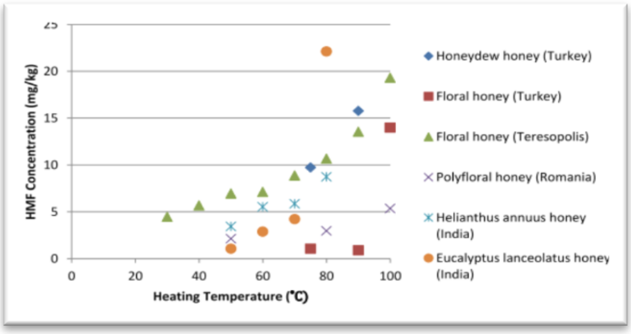
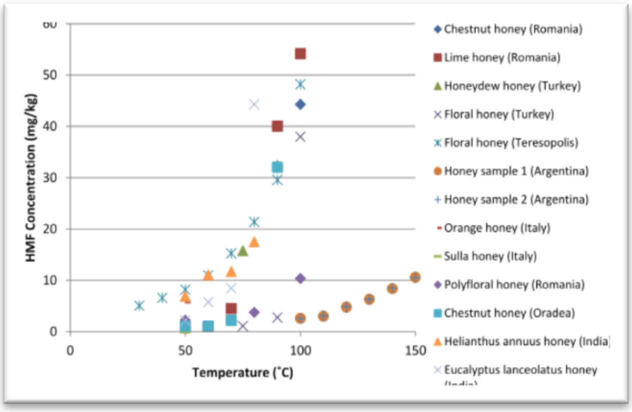


Fig. 1: HMF Concentration over Heating Duration at Low Temperature, 50˚C A), Medium Temperature, 70˚C B), and High Temperature, 100˚C C).

(A)



(B)



(C)

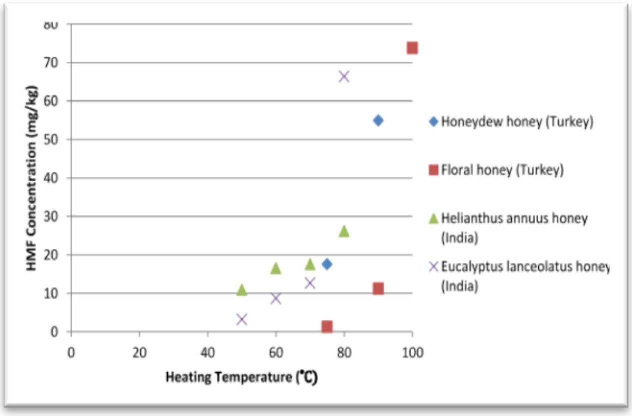


Fig. 2: HMF Concentration at Different Temperature for 30 Minutes A), 60 Minutes B) and 90 Minutes C).

4.1. Combination of equations

Combining both of the models, HMF Concentration = (Heating Duration, Heating Temperature) A kinetic model to correlate the concentration of HMF upon heating duration and heating temperature is:

$$y = (6.06\times10^{-4} t^2 + 0.265 t - 4.088) + (0.076T^2 - 11.183T + 426.434)$$
$$= 0.076T^2 + 6.06\times10^{-4} t^2 - 11.183T + 0.265 t + 422.346 \quad (4.25)$$

Where

y = HMF concentration of honey (mg/kg)

t = Heating duration (minutes)

T = Heating Temperature (˚C)

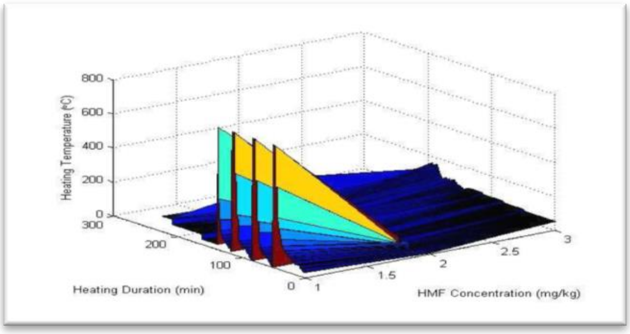


Fig. 3: Three-Dimensional Graph Relating HMF Concentration, Heating Duration, and Heating Temperature.

5. Conclusion

In this study, the heating temperature and duration of thermal treatment is proportional to the amount of HMF formed. In this research, a kinetic model is developed to predict the amount of HMF formed in honey at a particular heating temperature and time. It is important to control the heating temperature and time, so that the HMF produced is at the range of 80mg/kg (tropical honey). The model is also used to validate data from local honey samples. However, the HMF concentrations stimulated via the kinetic models yields high percentage error and do not fits the local honey samples well. This is because the data used for model construction is not sufficient. Furthermore, most of the data collected are from European and Asian countries. The limitation of worldwide data for HMF upon heating caused the large variance of model. The objective of this study was achieved in which a model is developed to establish the relationship between the effect of heating temperature and the duration of thermal treatment in HMF formation for different types of honey from different geographical locations. The kinetic model represents the HMF concentration of honey in relation to heating temperature and heating duration is:

$$y = 0.076T^2 + 6.06\times10^{-4} t^2 - 11.183T + 0.265 t + 422.346 \quad (5.1)$$

Where

y = HMF concentration of honey (mg/kg)

t = Heating duration (minutes)

T = Heating Temperature (˚C)

References

[1] Singh, N., Singh, S., Bawa, A. S., & Sekhon, K. S. (1988). Honey-its food uses. Indian Food Packer, 42, 15-25.

[2] Justinas Kretavicius, Bogumila Kurtinaitiene, Jurgis Racys, Violeta Ceksteryte (2010). Inactivation of glucose oxidase during heat-treatment de-crystallization of honey. Zemdirbyste Agriculture, 4, 115-122.

[3] Tosi, E. Ciappini, M. Re, E. Lucero, H. (2001). Honey thermal treatment effects on hydroxymethylfurfural content. Food Chemistry, 77, 71–74. https://doi.org/10.1016/S0308-8146(01)00325-9.

[4] Koutsoumanis et al. (1998), modelling the effectiveness of a natural antimicrobial on Salmonella enteritidis as a function of concentration, temperature and pH, using conductance measurements. Journal of Applied Microbiology, 84, 981–987. https://doi.org/10.1046/j.1365-2672.1998.00433.x.

[5] Math Centre- Simultaneous Linear Equations. Retrieved 4 June 2013, from: http://www.mash.dept.shef.ac.uk/Resources/web-simultaneous1.pdf).

[6] Wikipedia-The Free Encyclopedia-Least Squares. Retrieved 4 June 2013, from http://en.wikipedia.org/wiki/Least_squares.