SciVerse ScienceDirect

Procedia Food Science 1 (2011) 1026 – 1030

Procedia Food Science

11th International Congress on Engineering and Food (ICEF11)

Kinetic of white chocolate color loss

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Abstract

Quality loss of white chocolate, considered the main reaction which limits the shelf-life, is caused by loss of white color during its storage. The main objective of this research was to determine the kinetic data of transformations that entail loss of quality in white chocolate, providing information about the degradation over time. For the kinetic study the samples were stored at approximately 82% RH to accelerate the reaction, at 10, 20 and 30 °C. Three formulations were made: with whey (Formulation 1), with skim milk (Formulation 2) and with Globe™ Chocosystem (Formulation 3). The Formulation 3 maintained the white color longer compared to Formulations 2 and 3, according with the values of Ea (kcal/ gmol.K), and Q_{10} obtained.

Selection and/or peer-review under responsibility of 11th International Congress on Engineering and Food (ICEF 11) Executive Committee.

Keywords: white chocolate; color; kinetic; Q_{10}.

1. Introduction

White chocolate has in its basic formulation, sugar, cocoa butter, milk solids (e.g., whole or skimmed powder milk, whey and lactose, soya lecithin and vanilla flavor) [1]. Quality loss caused by yellowing (loss of white color, darkening or browning) during its storage and marketing is considered the main reaction which limits the shelf-life of this product [2]. The system sugar, fat and milk is susceptible to browning reactions, mainly by Maillard reaction, especially because of the sugars and amino acids in the composition. The occurrence of reaction depends on the conditions of humidity and temperature, as well as on changes to these conditions, during chocolate storage. The kinetics data (constant and order of reaction, activation energy (E_a) and factor Q_{10}) give information about the loss of quality.

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2211–601X
Selection and/or peer-review under responsibility of 11th International Congress on Engineering and Food (ICEF 11) Executive Committee.
doi:10.1016/j.profoo.2011.09.153

In the literature there are few articles about white chocolate despite its importance and presence in the market. Some ingredients of the white chocolate formulations can accelerate the loss of color and others can decrease it. One ingredient, recently made available to the industries, by Corn Products Company, called GlobeTM Chocosystem, is offered as an inhibitor of the browning in white chocolate.

The main objective of this research was to determine the kinetics data of transformations that entail loss of quality in white chocolate, being color the attribute chosen, to be studied over time or the shelf-life. Three basic formulations were studied, including whey and Globe Choco System® as ingredients.

2. Materials & Methods

For the kinetic studies three formulations were prepared: WCh1 containing whey in the formulation, WCh2 containing skimmed milk and WCh3 containing Globo Choco System®, as shown in Table 1.

Table 1. White chocolate (WCh) formulations

Ingredients	**WCh 1** (%)	**WCh 2** (%)	**WCh 3** (%)
Sugar	47.0	47.0	47.0
Cocoa butter	27.4	27.4	27.4
Skimmed powdered milk		**9.0**	
Whole milk	16.0	16.0	16.0
Demineralized whey	**9.0**		
Globe^{TM} Chocosystem			**9.0**
Soya lecithin	0.3	0.3	0.3
PGPR (polyglycerol polyricinoleate)	0.2	0.2	0.2
Vanilla Flavor	0.1	0.1	0.1
Carbohydrates	60.2	58.3	62.3
Proteins	5.0	7.1	4.0

(*)From Corn Products supplier

White chocolate samples were produced in the pilot-plant following the conventional steps: mixing, refining, conching and tempering. The ingredients were selected, weighed and mixed until a mass was formed with ideal plasticity to pass through the refiner. Conching was performed at 60°C for 12 h. Tempering parameters (time and temperature) were determined for each sample. The chocolates were placed in preheated moulds and the air bubbles were removed. After cooling, the chocolates were properly packaged and stored in a dry place, at temperature around 21°C.

2.1. Color

Instrumental analyses were made according to the Instruction Manual of the portable colorimeter, model Chroma Meter CR-400/410, brand Konica Minolta [3], obtaining the L*, a* and b * values of the Cielab System, at 25°C.

2.2. Temper Index

After the production of samples and before the kinetic experiment, they were tempered and the Temper Index was determined using a device (Tempermeter Sollich E3).

2.3. Calculation of kinetic parameters

For the kinetics study the samples (Table 1) were stored at 10, 20 and 30°C and 82% RH to accelerate the reaction. For kinetic data it was monitored the variation of color (values L*, a*, b*). For kinetic parameters calculation first was determined the order of reaction, by charts of the constant **k** reaction. The values of ln k were plotted as a function of inverse temperature (Arrhenius chart). Through the values of the slope of the straight line, the activation energy (Ea) was determined. The calculation of Q_{10} was done according to the Ea as shown in $Q_{10} = 10$ ((E_a/(0.46 x T ^ 2)).

3. Results & Discussion

The Temper Indexes for the samples WCh1, WCh2 and WCh3 were 4.8, 6.0 and 4.0, respectively. Those values showed the samples had a sufficient quantity of crystals to ensure their stability. Initially, the water activity (at 25 °C) of samples was around 0.40 and at the end it was around 0.70. It suggests there was water uptake, change of physical state and loss of quality. The results were obtained over time with the three formulations of white chocolate stored at 10, 20 and 30°C and 82% RH.

3.1. Color

The results of L*, a* and b * parameters are showed in the Figures 1, 2 and 3 for 10, 20 and 30°C, respectively.

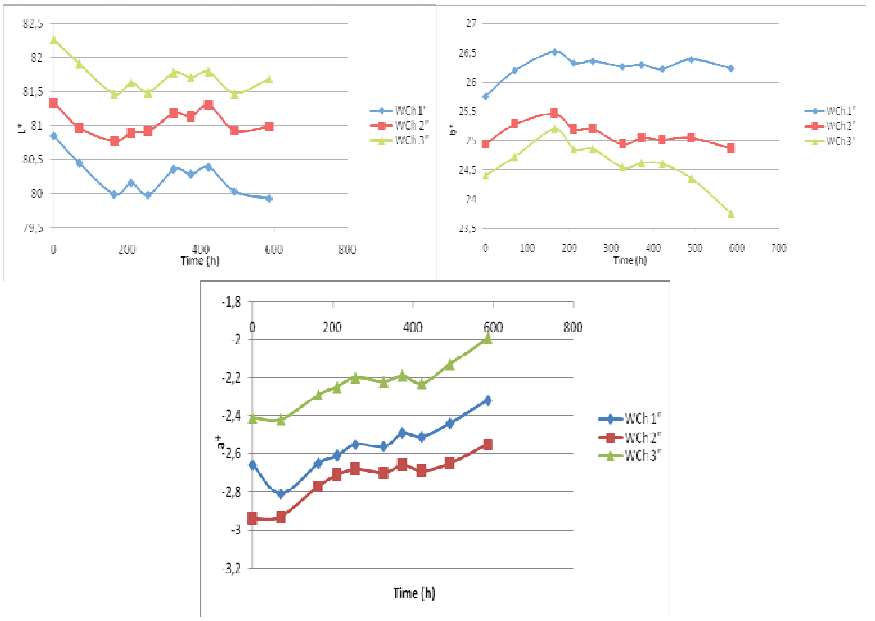

Fig. 1. Values of L*, a* and b* parameters of white chocolates (WCh1, WCh2 and WCh3) stored at 10 °C and 82% RH, over time

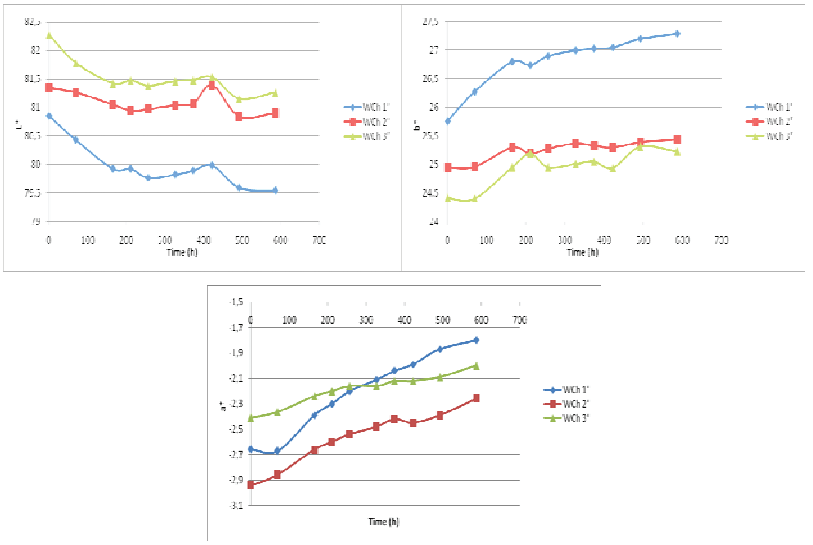

Fig. 2. Values of L*, a* and b* parameters of white chocolates (WCh1, WCh2 and WCh3) stored at 20 °C and 82% RH, over time

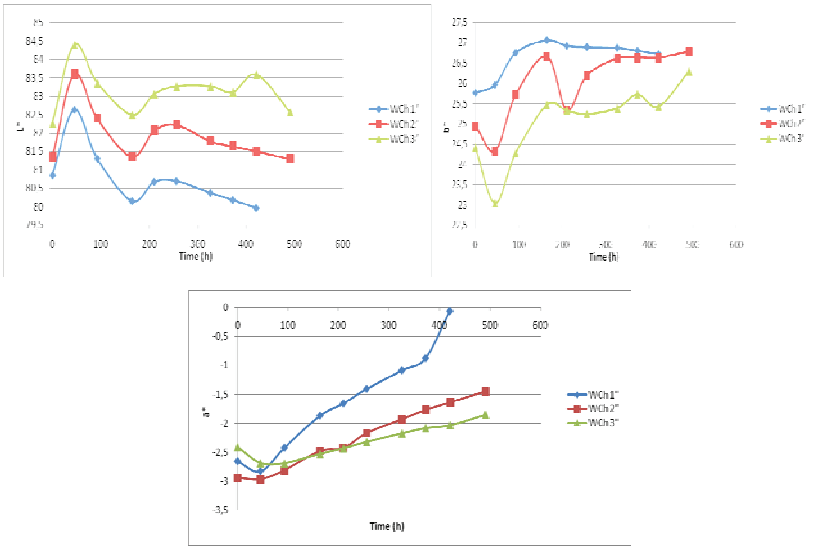

Fig. 3. Values of a* and b* parameters of white chocolates (WCh1, WCh2 and WCh3) stored at 30 °C and 82% RH, over time

3.2. Kinetic Parameters

"a*" values were selected for kinetic study. The order of reaction was determined as 2nd order. Values of R^2 and equations, activation energy and Q_{10} for the formulations (WCh1, WCh2 and WCh3) were presented at Table 2.

Table 2. Values of R^2 and equations, activation Energy (Ea) and Q_{10} for the formulations (WCh1, WCh2, WCh3), for lost of color of white chocolate

T (°C)	R^2	Equation (y)	E_a (kcal/ gmol.K)	Q_{10} *
WCh1			25.43	4.0
10	0.856	-0.0001x-0.3618		
20	0.989	-0.0003x-0.3655		
30	0.918	-0.002x-0.2619		
WCh2			38.27	9.3
10	0.863	-0.00008x-0.3439		
20	0.965	-0.0002x-0.3447		
30	0.958	-0.0007x-0.2964		
WCh3			9.25	2.0
10	0.866	-0.0001x-0.4116		
20	0.952	-0.0001x-0.4199		
30	0.837	-0.0003x-0.3641		

*$Q_{10}=10^{((Ea/(0.46 \times T^2))}$

If the activation energy and Q_{10} increase, the monitored transformation of the food will accelerate [4]. The Table 1 and the results of Table 3 showed the formulation WCh3 (prepared with Globe^{TM} Chocosystem, without skimmed milk or whey) had more stability related to color, followed by formulation WCh1 and WCh2.

4. Conclusion

It can be concluded that white chocolate containing Globe^{TM} Chocosystem can maintain the white color longer compared to formulations containing whey and even more in those containing skimmed milk.

Acknowledgements

We do hereby thank CNPq [Conselho Nacional de Desenvolvimento Científico e Tecnológico] and CornProducts Brasil - Ingredientes Industriais.

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Presented at ICEF11 (May 22-26, 2011 – Athens, Greece) as paper MFS124.