



## Effect of pH Reduction on the Color of Cakes

Susan Mathew, Sonu<sup>1,2,3</sup>, Loisel, Catherine<sup>2,3</sup>, Jagannathan Rangarajan<sup>1</sup> and Le- Bail, Alain<sup>2,3\*</sup>

<sup>1</sup>IIFPT, Thanjavur, India

<sup>2</sup>ONIRIS, BP 82225, 44322 Nantes, – France

<sup>3</sup>ONIRIS, UMR GEPEA CNRS 6144 - 44322 Nantes, – France

\*Corresponding Author E-mail: [alain.lebail@oniris-nantes.fr](mailto:alain.lebail@oniris-nantes.fr)

Received: 2.07.2019 | Revised: 11.08.2019 | Accepted: 16.08.2019

### ABSTRACT

*Appearance is one of the sensory attributes that give first impression regarding a product to the consumers. Color plays a major role in determining the overall quality of the product. Acidic cakes like lemon cakes are unique in taste and flavor. In this study, changes in color of cakes were analyzed and the effect of pH and sugar on color was evaluated. Cakes were baked at similar processing conditions. Lemon juice and maltitol were added in different proportions by varying water and sucrose respectively with other ingredients. Color of crust and crumb were evaluated on the second day of baking using colorimeter. A significant color difference was observed between samples. Crust color become darker and color intensity of crumb increased on increasing the amount of lemon juice. Reducing sugars produced due to acid hydrolysis of sucrose promotes browning. Maltitol didn't contribute significantly to the browning reaction.*

**Keywords:** Pound cake, Lemon juice, Maltitol, Color

### INTRODUCTION

Cakes were generally classified as layer cakes, foam cakes and pound cakes, based on the methods used to produce it (Miller, 2016). The main ingredients using for cake baking include all-purpose flour, eggs, sugar and fat. Each ingredient contributes significantly to the characteristic properties of cakes. Sucrose reduction is gaining popularity in food industry due to the increase of lifestyle diseases like diabetes, obesity and teeth problems (Ortiz, 2016). Polyols or sugar alcohols are widely used in bakery products as sugar replacer due to their low energy

compared to sucrose. Among polyols, maltitol is the most common as its sensory properties are similar to sucrose (Nourmohammadi & Peighambaroust, 2016, Struck et al., 2014, Jia et al., 2008). Use of polyols in formulation results in lighter colored baked products, as it is not actively participating in Maillard reaction (Ronda et al., 2005).

Color is an important attribute that give first impression to the customers regarding the product (DuBose et al., 1980). Food colors are depending upon their composition and structure (Barbosa-Canovas et al., 2009).

**Cite this article:** Susan Mathew, S., Loisel, C., Jagannathan, R., & Le- Bail, A. (2019). Effect of pH Reduction on the Color of Cakes, *Ind. J. Pure App. Biosci.* 7(4), 255-260. doi: <http://dx.doi.org/10.18782/2320-7051.7709>

The variations in color can be observed during baking, if any changes in temperature occur. High temperature baking will lead to darker color and low temperature baking leads to pale color (Sani et al., 2014). The browning of cakes take place due to non-enzymatic browning reaction called Maillard reaction.

Along with emulsification, foaming and coagulation (Bennion & Bamford, 1997), eggs also contribute to the sensory properties like color, taste, aeration and structure to the product (Cauvain, 2003). Fat gives soft, smooth and shiny outer layering to the baked cake along with its primary functions like aeration and tender structure formation (Wilderjans, 2013). Lemon contain high amount of citric acid (49.2g/kg) compared to other citrus fruits (Poerwono et al., 2001). In this study, the effect of pH reduction on the color of baked cakes was evaluated.

## MATERIALS AND METHODS

**2.1 Materials:** The main ingredients used for baking of cake include type 45 wheat flour, whole egg powder, Corman fat, crystal sugar, maltitol powder, sodium bi carbonate, Sodium Acid Pyro Phosphate 10 (SAPP 10) and lemon juice.

Wheat flour of type 45 was supplied by Giraudineau (France) with 14.8% water content, 10.7% protein, 0.2% fat, 66.8% starch and 0.42% ash. Whole egg powder was supplied by Ovobio (France). It is composed of 48% protein, 38% fat and less than 5% moisture. Fat composed of rapeseed oil (70%) and high melting anhydrous milk fat (30%) is a ready to use blend supplied by Corman (Belgium). Crystal sugar (mean diameter 100 µm particle size) and crystalline maltitol (Maltilite P 200) was supplied by Tereos (France). Baking powder (sodium bicarbonate) and SAPP 10 (Sodium Acid Pyrophosphate 10, leavening acid) used in this formulation were supplied by Buddenheim. Lemon juice was purchased from Lea Nature, Jardin Bio (France). 100 mL of Jardin Bio lemon juice contains 36 mg of vitamin C, 1.7 g carbohydrates, 0.8 g fat, 0.2 g saturated fat, 0 g protein and remaining water. The total energy per 100 mL is 133 kJ.

Composition of the control recipe is 29% wheat flour, 20% fat, 6% egg powder, 1% baking powder, 25% crystal sugar and 19% water. 100 g of the cake from this recipe contains 403.71 kcal energy, 7.94 g protein, 20.27 g fat in which 5.90 g is saturated fat and 47.39 g carbohydrates of which 25.03 g sugars.

**2.2 Cake preparation:** Experimental design was done with the help of Statgraphics Centurion XVII-X64 (France) with two factors, lemon juice and crystal sugar and seven responses. All the dry ingredients and water for mixing were taken at room temperature (22-24°C). Corman fat and lemon juice at 6- 8°C was used for mixing. The dry ingredients given in the formulation were weighed and sieved properly and mixed for a minute at the lowest speed in a mixer (Kitchen aid- St Joseph, Michigan USA, Heavy duty model 5KPM5) with whisk (mixing blade). Then water was added to this and again mixed for a minute at the same speed. Fat was blended into the mixture through three stages of mixing initially for one minute at lowest speed (speed 1), then for 2 minutes at medium speed (speed 6) and at highest speed (speed 8) for 3 minutes. The batter prepared was poured into previously greased baking moulds (300 g in each) and kept for 20 minutes as resting period. Conventional baking was done in a preheated (180°C for an hour) lab model domestic oven at 180°C for 25 minutes.

The trials were encoded X: Y corresponding to their lemon juice: sugar content from LJ:S-0:21 to LJ:S-14:21 by adjusting lemon juice and water content in the control formulation. In the meantime, sugar content was varied from 25% for the control recipe to 17.5% by replacing sucrose by maltitol.

**2.3 Color evaluation:** Color changes in crust and crumb of different cakes were checked using Konica Minolta Colorimeter (CR- 400). The color values are expressed in L\*, a\*, b\* (CIELAB) on the second day of baking and each variable is described (McGuire, 1992) in Table 1. Baked cakes were conditioned in freezer bags to retain moisture and to avoid drying of crust.

**2.4 pH measurement:** pH of the samples was determined using pH meter with electrode (VWR collection- 662-0084) based on AACC Method 02.52.01. 10 grams of powdered cake samples were mixed with 100 mL of distilled water and immediately checked pH of the supernatant.

## RESULTS AND DISCUSSION

Color change was significant in both crust and crumb of all the samples. Figure 2 and 3 show the top view and cross-sectional view of samples respectively.

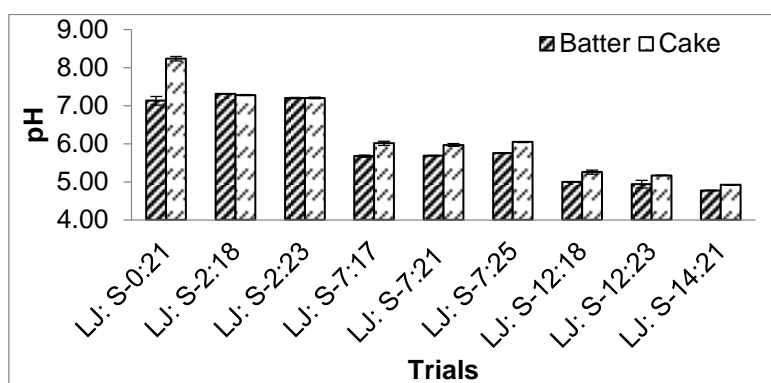
As acidic content of cakes increases (Fig. 1), crust is getting darker even without complete baking. Decrease in  $L^*$  indicates the shift of crust from lighter to darker color, while decrease in  $b^*$  values of crust reveal a decrease of the color saturation (intensity of the color) (Fig. 4a).  $L^*$ ,  $a^*$  and  $b^*$  of crust was decreased from 52.6 to 34.18, 7.06 to 9.35 and 30.99 to 13.41 respectively as referred to the control. Browning of cakes is due to the Maillard reaction of sugars on heating. This reaction get accelerates in the presence of acids. Acids in cake increase hydrolysis of sugars leading to reducing sugar. These ones react with proteins enhancing the browning reaction.

Crumbs are more yellowish in acidic cakes.  $L^*$  of crumb was decreased from 59.55 to 54.58 (Fig. 4b). It clearly indicates that crumb also getting darker in color compared to control (cake without lemon juice). The increase in the color intensity of crumb to yellowish shade in visual appearance may due to the addition of yellow color lemon juice to the formulation. The batter also found to be more yellowish as the amount of lemon juice in the batter system increases. Increase in intensity of crumb color according to the visual appearance may be due to the denser structure of the cakes. There were no significant changes in  $a^*$  and  $b^*$  values of crumb.

Even-though the sucrose in cake was reduced with maltitol, it was not completely replaced. So, the remaining sugar can take part in Maillard reaction and it can be catalysed by the acid present in the cakes. The change in color was evident. The color of acidic cake crust was changing even after 15 minutes of baking, So the color of cakes cannot be taken as an indicator of completion of baking in the case of acidic cakes. Baking the cakes more than 25-30 minutes will result in charring of the crust.

**Table 1 : Color characteristics (McGuire, 1992)**

Color characteristics	Description	+ indicates	- indicates
$L^*$	lightness or darkness	lighter	darker
$a^*$	red or green	redder	greener
$b^*$	yellow or blue	yellower	bluer



**Fig. 1: pH of batter and cakes (LJ:S indicates the sample name with lemon juice and crystal sugar ratio 0:21, 2:18, 2:23, 7:17, 7:21, 7:25, 12:18, 12:23 and 14:21 respectively)**

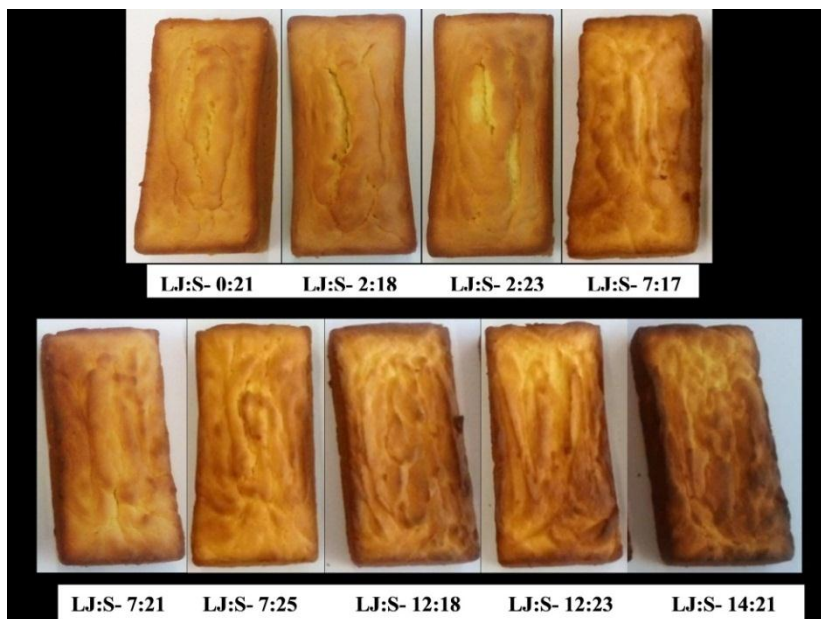


Fig. 2: Top view of trial samples (LJ:S indicates the sample name with lemon juice and crystal sugar ratio 0:21, 2:18, 2:23, 7:17, 7:21, 7:25, 12:18, 12:23 and 14:21 respectively)

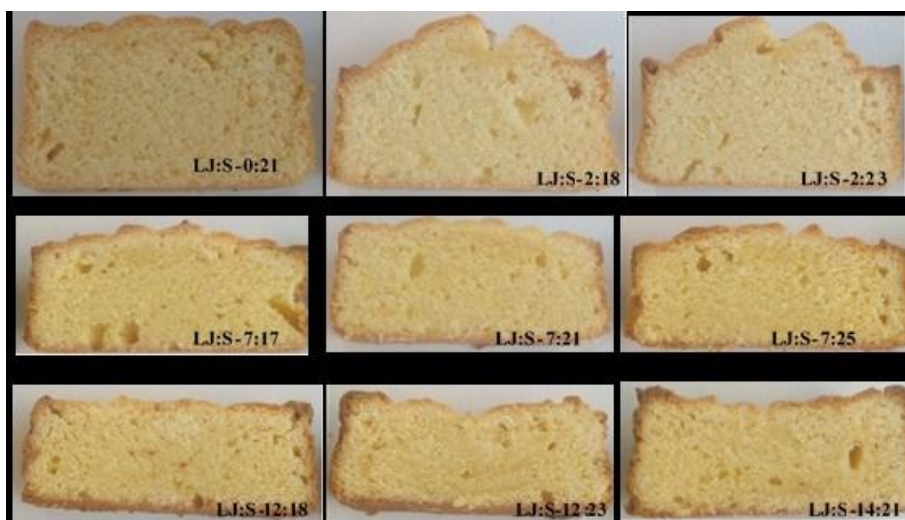
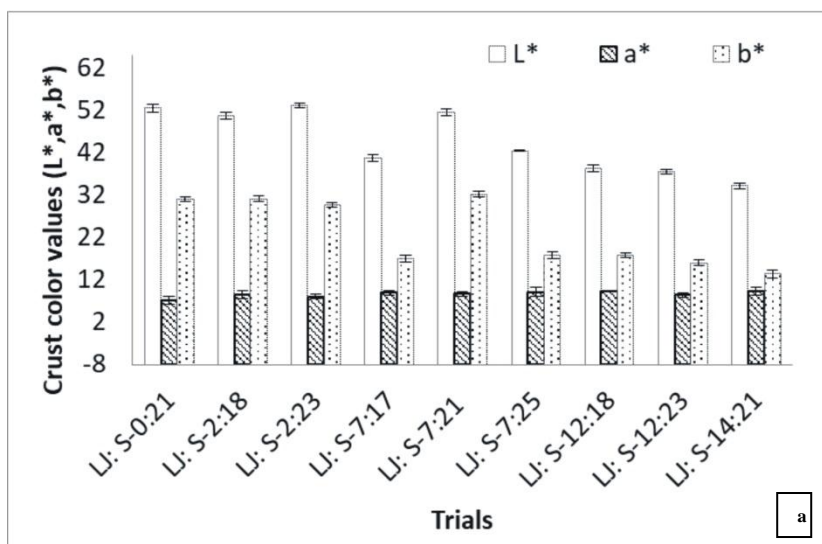


Fig. 3: Crosssectional view of trial samples (LJ:S indicates the sample name with lemon juice and crystal sugar ratio 0:21, 2:18, 2:23, 7:17, 7:21, 7:25, 12:18, 12:23 and 14:21 respectively)



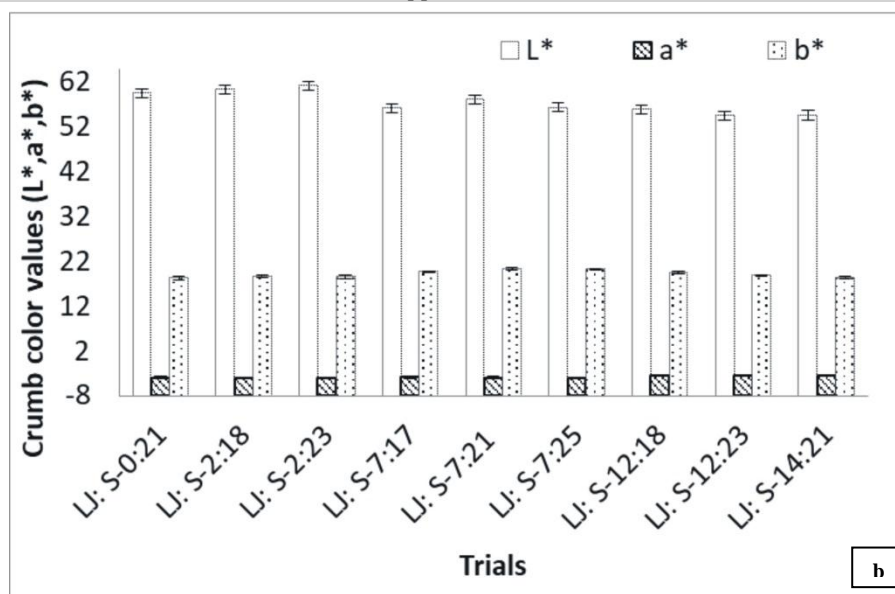


Fig. 4: (a) Changes in color of crust and (b) crumb of samples (LJ:S indicates the sample name with lemon juice and crystal sugar ratio 0:21, 2:18, 2:23, 7:17, 7:21, 7:25, 12:18, 12:23 and 14:21 respectively)

### CONCLUSION

It was concluded that the addition of lemon juice plays a significant role in changing the color of cake along with sugar. Color of crust changed from golden brown to dark brown on increasing acidic content in formulation. Crumb color also became darker. There were no significant changes in  $a^*$  and  $b^*$  values of crumb. Baking at low temperature is recommendable for high acid cakes. Replacing sucrose with maltitol can also be a good solution to reduce darkening of crust. But it may affect other sensory characteristics of cakes.

### Acknowledgments

This study is part of the N3S project (New Sugar Salt Substitutes) supported by the QUALIMENT Carnot Institute, with funding from the French National Agency for Research (ANR). The investigations were carried out during the Masters internship of Miss Sonu Susan Mathew in ONIRIS-Nantes and co-funded by ONIRIS and ANR.

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