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Influence of emulsifiers on the changes of sponge cakes during storage

KEYWORDS: sponge cake, emulsifiers, storage, crumb moisture, structural and mechanical properties of cake crumb

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ABSTRACT *The present research investigated the effect of three types of emulsifiers on the changes of sponge cakes during storage. The following 4 samples were examined – control sponge cake, prepared by traditional recipe, sponge cakes with added 1% of one of the following emulsifiers - modified inulin palmitate ester (HP-25), sucrose stearate ester (E473) and polyglycerol monostearate ester (E475). The changes flowing during storage at 18 °C and 75% relative humidity are investigated. This approach evidenced that the evolution of the sponge cakes freshness closely depends on the dynamic of the water in the crumb during storage. The amount of water in crumb cakes reduced during the storage process. It was proved that, simultaneously with the changes of the water in the crumb cake during storage, the qualitative characteristics (structural and mechanical properties) of the crumb of sponge cake had also changed. The kinetics investigations on crumb moisture showed that use of emulsifiers has preserved the sponge cake freshness up to the sixth day of storage in comparison with control cake. That visible effect in cakes with 1% sucrose stearate ester and with 1% modified inulin palmitate ester. The moisture loss in the crumb of these sponge cakes was lowest during storage. Higher values of shrinkage and springiness of cake with 1% sucrose stearate ester were read on the first and on the third day of storage.*

Introduction

Sponge cakes are high ratio, low fat, foamed type of cakes that rely on incorporated air for volume and texture. The egg white is whipped to form a foam and then other ingredients like flour, sugar, yolk are gently folded in. The egg protein matrix with its air incorporation forms the structure of the cake as it bakes. The high-quality sponge cakes have various attributes, including a good volume with a uniform crumb structure, tenderness and the ability to retain the crumb softness during storage (6) that could be achieved by applying different types of emulsifiers. It has been reported that emulsifiers increase air incorporation, decrease specific gravity, produce a finer fat dispersion and as a result increase the final cake volume (11, 14). A number of different emulsifiers like mono- and diglycerides, sucrose esters, polyglycerol esters, propylene glycolesterq polysorbate–60 and sodium steroyl lactylate have been used in cakes (5, 7, 9, 10, 11, 12, 14). The most important factor which affects on the function of an emulsifier is its physical state. The emulsifiers used for cake baking should be in the α-gel state to create a stabilizing film to cover the bubble surfaces (7). In the cake batter, all α-gel emulsifiers decrease density and increase incorporation of air into the batter (10). In fact, hydration of powdered emulsifiers by dispersion in hot water before use, results in the formation of functional α-crystalline form (7). This alpha-gel configuration allows easier distribution of the emulsifier to the interface resulting in maximum functionality (10).

An emulsifier functions in two ways. It aids in the incorporationof air and disperses the shortening in smaller particles to give the main number of available air cells (10, 11). Aside from emulsifying action, emulsifiers have anti-staling characteristics.Their anti-staling characteristics are explained by their ability to form insoluble complexes with amylose, their limited reaction with amylopectin, and their strengthening effects on doughs by interaction with flour proteins, and also maximize the inclusion of moisture (12). Glycerol mono-stearate (GMS) has a long history of use as a anti-staling agent and is able to form complexes with the starch, which slows down the retrogradation process in the baked product during storage (4). Lecithin has also been used in the food industry since the 1930s (13). Sorbitan fatty-acid esters are sorbitol derived analogs of mono- and diglycerides that are slightly more water soluble. These emulsifiers can be used in emulsions where enhanced aeration properties are desired (8).

The objective of this work was to study the effect of different emulsifiers on the changes of the water and texture crumb sponge cake during storage, and potential these emulsifiers use as an anti-staling agent in sponge cake.

Materials and methods

Preparation of sponge cakes

Standard raw materials: wheat flour of type 500 - ash 0.5% (GoodMills, Bulgaria EAD), granulated sugar (Zaharni zavodi AD), eggs (local market), glycerol, water and emulsifiers used in the current study are authorized by the Ministry of Health as manufactured in Bulgaria. Three different emulsifiers (food surfactants or surface active agents) are considered as optional additives and are used as batter and cake improvers: polyglycerol monostearate E475 (Radiamuls Poly 2248K) (*Oleon Group, Belgium*), sucrose stearate E473 (Sisterna SP70-C) (*SISTERNA*, Netherlands) and modified inulin palmitate (HP-25), produced by University of Food Technologies, Department of Organic Chemistry and Microbiology, Bulgaria. A control cake was also prepared, following a traditional technology and formulation (1). Ingredients based on flour weight: egg yolk - 43.23%, egg white - 96.77%, sugar - 83.87, wheat flour - 100.00%. In particular, a double mixing procedure was applied by partitioning whipping of whites and egg yolks. The batter with the addition of surfactant as an emulsifier gel is prepared by a single-bowl mixing process of the components. Emulsifiers are added to the formulation at 1% (amount based on the batter).

The sponge cakes were baked in a metallic pan containing 120 cm^3 of batter and placed in an electric oven (Rahovetz -02, Bulgaria) for 30 min at 180 °C.

The sponge cakes stored at standard conditions (at temperature of 18 °C and 75 % relative humidity) were investigated up to the sixth day from production date according to standard requirements (3). Humidity and temperature were kept constant by means of desiccator supplied with psychrometer, and put in a thermostat with accuracy of 0.5 deg.

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Water Activity (a_w) and Moisture Content (MC) of cake crumb
The a_w of the crumb samples at different ageing times was measured using Novasina 12 CH-8853 (Switzerland) at 20 °C. Crumbled samples were put in sample cups and hermetically covered before analysis to avoid moisture loss or gain. The a_w-metre was calibrated with a saturated sodium chloride (NaCl) salt solution. The MC of crumb cakes were measured according to BSS 3412-79 (2). The MC of crumb cakes were determined by drying 5 g the samples in an oven at 105 °C up to a constant weight. The data are reported as the mean of three measurements on 1, 3 and 6 days during storage of cakes.

Structural and mechanical properties of the sponge cake crumb
The physical characteristics of sponge cakes were measured 2 h after baking. The indices of the structural and mechanical properties of the sponge cake crumb (shrinkage and springiness) were determined with an automatic penetrometer (model DSD VEB Feinmess, Dresden, Germany). A hemispherical body with a diameter 12.5 mm and total weight 300 g acted on the sectional surface of a sponge cake sample, 40 mm thick, determining the shrinkage at the 5 and 10 s. The relaxation was checked by means of a hemispherical body with a diameter 25 mm and total weight 50 g acting upon a 40 mm thick of crumb cake for 5 s. This procedure was used to determine crumb springiness (15).

Mathematical and staistical methods:
Three repetitions of each measuremen were done depending on the type of studied characteristic. A method with a level of statistical significance $p \leq 0.05$ was used for the evaluation of the results.

Results and discussion
The batter formulations of the control sample and the investigated sponge cakes containing emulsifiers are four types: control sample, sample with 1% modified inulin palmitate ester (HP-25), sample with 1% sucrose stearate ester (E473), sample with 1% polyglycerol monostearate ester (E475).

Water Activity (a_w) and Moisture Content Measurements (MC) of sponge cake crumb
Moisture migration from crumb to crust and moisture redistribution between sponge cakes have significant changes during storage. The measurements of moisture loss in cake crumb were done of 1, 3 and 6 day of storage (Figure 1).

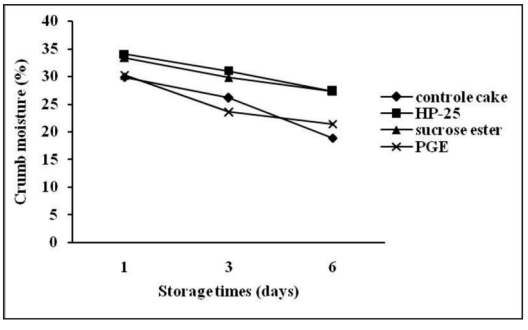


Fig. 1. Crumb moisture of sponge cakes during storage at 18 °C and 75% relative humidity.

Figure 1 shows that moisture loss in the crumb of sponge cakes – control and with 1% polyglycerol monostearate ester, was biggest during storage, while in the sponge cakes with 1% modified inulin palmitate ester and with 1% sucrose stearate ester it has reduced smoothly. For example, the moisture loss measured on the sixth day of storage was 10.96%, 6.68%, 6.05% and 8.84% in the crumb of cakes control, with modified inulin palmitate ester, with sucrose stearate ester, with polyglycerol monostearate ester, respectively. The overall mean crumb moisture content of different cakes showed that control cake has lowest crumb moisture content on the sixth day of storage.

Test modifying a_w of the crumb cakes during storage (Table 1).

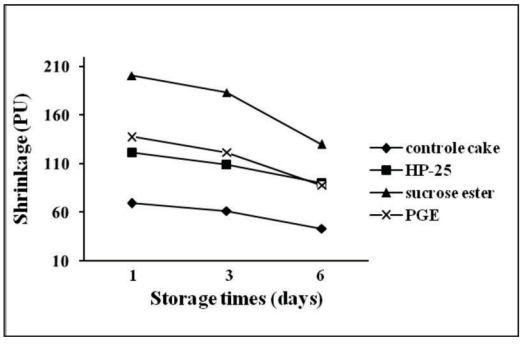
Table 1 Water activity (a_w) of the sponge cakes crumb during storage

Storage	Sponge cake type			
	control sample	with 1% modified inulin palmitate ester	with 1% sucrose stearate ester	with 1% polyglycerol monostearate ester
1 day	0.808 ± 0.001	0.899 ± 0.001	0.898 ± 0.001	0.898 ± 0.001
3 day	0.818 ± 0.002	0.898 ± 0.001	0.894 ± 0.003	0.903 ± 0.002
6 day	0.903 ± 0.001	0.820 ± 0.001	0.833 ± 0.001	0.816 ± 0.002

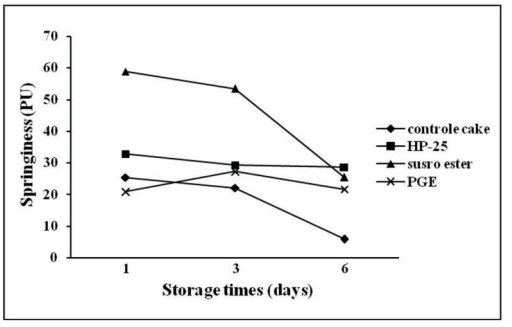
Detected is a difference between a_w of the samples, such as a sixth day of storage highest a_w is control sample, and the lowest - sample with 1% polyglycerol monostearate ester.

On the basis of these data it could be supposed that the water-retaining effect during storage in the cakes with 1% modified inulin palmitate ester and with 1% sucrose stearate ester was highest, which was in correlation with the structural and mechanical properties of sponge cakes crumb.

Structural and mechanical properties of sponge cake crumb
Fig. 1 and Fig. 2 show that the cake with 1% modified inulin palmitate ester had greater percentage retained moisture for first day than all other cakes, which lead to a difference in the indices for the structural and mechanical properties. During the storage of four cakes, the changes in their crumbs were examined by standard physical methods. At the end of storage times (on the sixth day) of cakes, crumbs was observed expressed as decrease of shrinkage and springiness.



a)



b)

Fig. 2. Change of the shrinkage (a) and springiness (b) of sponge cakes crumb during storage for 6 days.

The analysis of the determined structural and mechanical

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characteristics showed that the shrinkage and springiness measured of cake with 1% sucrose stearate ester was reduced to the greatest extent between the third and sixth day of storage (Fig. 2). On the sixth day, the shrinkages of cake with 1% sucrose stearate ester measured higher than that of the on other cakes. By analogy, the springiness of cakes with emulsifiers is higher than that of the control sample on the sixth day of storage. Considerable changes in the springiness changes in control cake, in cake with 1% sucrose stearate ester and in cake with 1% polyglycerol monostearate ester were observed after the third day of their storage. The crumb of sponge cake with 1% modified inulin palmitate ester was characterized with a smoothly reduction of springiness between the first and the sixth day of storage. The cake with 1% sucrose stearate ester on the first and on the third day of storage had a higher shrinkage and springiness than all other cakes. The aspect that most greatly influences the moistness and soft feel of cake is water.

Conclusions

Water plays a major role in both the formation of the initial product structural and mechanical characteristics and the manner in which they change during storage. The results confirm the hypothesis based on molecular mobility of water with sponge cakes crumb during storage. The kinetics investigations on crumb moisture showed that use of emulsifiers has preserved the sponge cake freshness up to the sixth day of storage in comparison with control cake. That visible effect in cakes with 1% sucrose stearate ester and with 1% modified inulin palmitate ester. The moisture loss in the crumb of these sponge cakes was lowest during storage, and the cake with 1% sucrose stearate ester on the first and on the third day of storage had a higher shrinkage and springiness than all other cakes.

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