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Physical and sensory characteristics of sponge cakes containing an additive of modified fructooligosaccharides

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Abstract

The aim of this study was to analyze the possibilities to include modified fructooligosacchararides in recipes for sponge cake with sugar. It was demonstrated that fructooligosaccharides palmitate esters (FOSP) are used as emulsifiers, improving aeration and emulsification of components, technological cutting production time and improve the physical and sensory characteristics of sponge cakes. In the experimental work was used emulsifying gels consist fructooligosaccharides palmitate ester 1-2% of the mass of batter cake. Emulsifying gel with 1% fructooligosaccharides palmitate ester improved the physical properties of the sponge cake batter and cakes. Moreover ithad a positive influence on the quality of the ready final cake compared to the control sample. According to the sensory evaluation of sponge cakes, the sampleswith 1 and 2% fructooligosaccharides palmitate ester characterized with better sensory performance compared with the control cake. The experiments and processed results proved that fructooligosaccharides palmitate esters can be used as emulsifiers to improve the quality of sponge cakes.

Introduction

The quality of the produced food is essential for consumers. This requires the use of a number of additives and modern production methods that ensure consistent quality of food products. Food additives have been the subject of extensive research and confectionery industry (Kaur and Gupta, 2002; Miyamoto *et al*., 2005). An important part of modern industrial production of bread and pastries takes food emulsifiers (Miyamoto *et al*., 2005; Kozak *et al.*, 2012; Rodríguez-García *et al*., 2014), which play an important functional role in the modern food technology. Due to its surface-active properties (Devereux *et al*., 2003; Jakob *et al*., 2012; Kozak *et al.,* 2012), they exhibit the emulsifying and stabilizing properties in various food systems (Khouryieh *et al*., 2005; Rodríguez-García *et al*., 2014). They play an important role in the process of baking, whereby directly involved in the structure formation of bakery product (Rodríguez-García *et al*., 2014). Emulsifiers influence the processes of aeration and foam stabilization in the production of sponge cakes (Khouryieh *et al*., 2005; Miyamoto *et al*., 2005; Kozak *et al*., 2012). The fine distribution of air bubbles results in an improvement of the rheological properties of cake batter, as well as improving texture characteristics of sponge cake (Khouryieh *et al*., 2005; Miyamoto *et al*., 2005). The addition of inulin and its derivatives leads improving in the structural characteristics of the baked goods to improve the texture of sponge cake (Gallagher *et al*., 2003; Van Geel-Schutten, 2006).

Short-chain fructooligosaccharides are considered as prebiotics because they reach colon in the indecomposable form, where they play the role of carbohydrate substrate which is particularly important as enhancement in the process of probiotic bacteria growth (Kaur and Gupta, 2002; Wu *et al*., 2002; Jakob *et al*., 2012). Inulin and fructooligosaccharides) have been reported as potential ingredients to imitate the functional and sensorial properties of fat and sugar, while at the same time provide high-quality baked products with considerably lower calories. Fructooligosaccharides are with sweet taste andact as texture modifier in many food products (Miyamoto *et al*., 2005; Kozak *et al*., 2012; Rodríguez-García *et al.,* 2014). There are conflicting views regarding the effect of inulin with respect to its degree of polymerization on the quality of cakes.

In previous researches fructooligosccharides esters were reported to possess not only promising

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emulsifying capacity (Petkova *et al.*, 2012), but also antibacterial and antifungal activity (Vassilev *et al.,* 2016). These dietary fiber esters (Petkova *et al.,* 2012) could be applied as potential antimicrobial agents and could be successfully used in the preservation of food in medicine and cosmetics (Vassilev *et al.,* 2016). To the best of our knowledge the investigation of the influence of fructooligosacchrides esters on sponge cakes quality was not study in details.

The objective of this study is to investigatef the physical and sensory characteristics of sponge cakes with and without an additive of modified fructooligosaccharides.

Materials and Methods

Sponge cake preparation

The standard raw materials - wheat flour of type 500 - ash content 0.5% (GoodMills, Bulgaria EAD), granulated sugar (Zaharni zavodi AD), eggs (local market), glycerol, water used in the current study are authorized by the Ministry of Health as manufactured in Bulgaria. A modified fructooligosaccharides: fructooligosaccharides palmitate esters (FOSP) - produced and characterized in the laboratory of the University of Food Technologies – Plovdiv, as previously described (Vassilev *et al.,* 2016). A control sample of cake batter was also included in the study. The mixture for the sponge cake batter (batter-control) was prepared following a traditional technology and formulation (Angelov *et al.*, 1974) as double mixing procedure by partitioning whipping of whites and yolks of egg was used. The batter with the addition of FOSP as an emulsifier gel is prepared by a single-bowl mixing process of the components. FOSP is added to the formulation at 1-2% (amount based on the batter). The sponge cakes were placed in a metallic pan containing 120 cm^3 of batter and baked in an electric oven (Rahovetz -02, Bulgaria) for 30 mins at 180^{o}C.

Preparation of emulsifier gels

The emulsifier gels were prepared using powder of fructooligosaccharides palmitate ester suspended in warm water/glycerol. The emulsifiers were melted and glycerin was added with constant stirring. The temperature was maintained at 65°C. The mixture was allowed to cool down until a smooth gel was obtained. In the new method of producing raw materials were mixed in separate whipping eggs, they were added to the cold emulsifier gel at temperature 18-20°C.

Physical characteristics of the batters and cakes

The specific gravity of the sponge cake batter was calculated by dividing the weight of a standard cup of batter to the weight of an equal volume of distilled water according to AACC Method 10-95 (AACC, 1983) at batter temperature (20.0±0.0^{o}C). The physical characteristics of sponge cakes were measured two hours after baking. The volume was determined by small uniform seed displacement method AACC 10-05 2000 (AACC, 2000) and the porosity was evaluated by the method of Yackoby (BSS 3412-79) using a cylinder driller – a device of Zhuravljov (Bulgarian State Standard, 1979). The porosity of sponge cake was defined as the ratio between the volume of the air-pockets in the cake crumb and the volume of the crumb. The specific volume was expressed as the ratio between the sponge cake volume to its weight. The water-absorbing capacity of the sponge cake was measured by the method of determination of biscuits swelling according Bulgarian State Standard 15221-81. Photographs of cross sections of the half-cut cake were done for the determination of the sponge cake structure. The indices of the structural and mechanical properties of the sponge cake crumb such as shrinkage, plasticity and springiness were determined with automatic penetrometer (model DSD VEB Feinmess, Dresden, Germany). The total moisture of the samples was determined after drying of the sample at 105°C until the constant weight according standard method AACC 44-15.02. (AACC, 1999).

Sensory characteristics

The descriptive test for quantitative sensory profiling was used to establish the sensory characteristics (shape, colour, cells size and uniformity, odour, sweetness, aftertaste, crumb tenderness) of the sponge cakes, 6 hours after baking, according Method of ISO 8586:2014 and ISO 13299:2011. A panel of twelve experienced degustatiors was selected to guarantee the evaluation accuracy. The intensity of each sensory characteristic was recorded on a ten-point linear scale after one hour orientation sessions of the panelists where they specified terminology and anchor points on the scale. The coded samples were shown simultaneously and evaluated in random order among panelists.

Mathematical and statistical methods

Depending on the type of the studied characteristic from 3 to 12 repetitions of each measurement were done. For the valuation of results a method with a level of statistical significance $p< 0.05$ was used.

Results and Discussion

The recipe composition of sponge cake batters with an additive of emulsifier gel 1-2% the mass of

Table 1. Sponge cake batters formulations

Ingredients	Amount based on flour weight, %:		
	Control sample	with 1% FOSP	with 2% FOSP
Yolk of egg	43.23	43.23	43.23
White of egg	96.77	96.77	96.77
Refined granulated sugar	83.87	83.87	83.87
Wheat flour type 500	100.00	100.00	100.00
FOSP	-	3.55	7.74
Water	-	19.36	41.94
Glycerol	-	9.68	22.58

Table 2. Physical characteristics of the sponge sucrose-sweetened batters and cakes

Physical characteristics[1]	Sponge sucrose-sweetened cake type:		
	Control sample	with 1% FOSP	with 2% FOSP
Specific gravity (for batter)[2]	0.77±0.01	0.74±0.01	0.64±0.01
Volume, cm^3	268.00± 4.47	277.00±2.24	248.00±4.47
Specific volume, cm^3/g	3.17±0.12	3.57±0.11	3.38±0.11
Porosity, %	67.40±1.66	62.96±0.00	61.47±0.00
Springiness, PU[3]	25.40±0.89	21.20±0.84	34.40±1.67
Shrinkage, PU	69.40±1.14	107.20±2.17	159.20±0.84
Plasticity, PU	44.00±0.71	86.00±2.12	124.80±2.28
Water-absorbing capacity, %	364.20±1.92	384.80±0.35	293.60±2.30
Total moisture, %	25.90±1.15	28.11±0.62	28.97±0.46

[1] The values are mean ± SD ($p \leq 0.05$).
[2] The temperature of the batter is on the average 20.0±0.5°C.
[3] PU - Penetrometer Units.

cake batter was developed. The batter formulations of the control sample and the investigated sponge cakes containing fructooligosaccharides palmitate ester (FOSP) are given in Table 1.

The most accurate evaluation of the merits of the suggested technology can be given by juxtaposing the qualitative characteristics of cakes batter for the control batter-sample and kinds of batter containing an additive of modified fructooligosaccharides, as also juxtaposing the same characteristics of the baked sponge cakes. In this study the sponge cakes batter with emulsifier gels had lesser specific gravity towards the same of the control batter-sample (0.77 ± 0.01) as it is shown in Table 2.

It is obvious from the data in Table 2 that the specific weight of the batter cake decreases in direct proportion by increasing the amount of additive. In the control sample, the specific weight of the batter is 0.77±0.01 whiles cake batter of additive with 1% FOSP is 0.74±0.01. With addition of 2% FOSP it reduced significantly to 0.64±0.01. Higher amount of added FOSP in the form of emulsifier gel led to increasing capacity retentive air on batter cake. The sponge cake with 1% FOSP has the biggest volume and specific volume than the control sample and the cake at 2% FOSP, respectively physical charactersitics of porosity for cakes with FOSP was lower than those of the control sample. The results showed that the sponge cake with 2% FOSP has higher values of structural and mechanical properties – springiness, shrinkage and plasticity (Table 2). Shrinkage of cake with 2% FOSP increased by 80%, compared to the control sample. Springiness of the swamps by 2% FOSP increased by 35%, compared to the control sample. With the significant water absorption was evaluated the cake with 1% FOSP (384.80±0.35%), contrary to the cake with 2% FOSP. Sponge cake with 2% FOSP showed the lowest water absorption capacity (293.60±2.30%), compared to the control sample (364.20±1.92%). By increasing the amount of emulsifier increases the value of total moisture. This tendency was confirmed by structural and mechanical properties of cakes samples.

During our investigations it was found that the control sample and the cakes with addition of FOSP had similar shapes (Figure 1).

Sample with 1% FOSP characterized with softer crumb and crust, more evenly colored crust and crumb, more evenly distributed air cells in crumb than the control sample and cake with 2% FOSP. Air cells of the cake with a 1% FOSP were finer and thin-walled in comparison to the control sample. In both variants with the addition of FOSP was observed fine and uniform distribution of the air cells down the better structural and mechanical properties of the cakes compared with those of the control.

After the sensory evaluation of cakes it was found that new cakes with FOSP received high score for shape (Figure 2).

The sample with 1% and 2% FOSP were coloured intensively compared to the control sample. The colour of the crust of the cake with a 1% FOSP was saturated and free of cracks. The crust of the cakes with the addition of FOSP was smooth without large cracks. The photographs and graphics on the touch profile of the sponge cakes have small and uniformly distributed in the crumb air cells (Figure 1 and Figure 2). This determined the best sensory charactersitics of new products, taste and crumb tenderness. Samples with addition of FOSP don't have odour and aftertaste of eggs, in contrast to the control sample.

a) b) c)

Figure 1. Photographs of cross sections of sucrose-sweetened sponge cakes:
a) Control cake-sample;
b) With an additive of 1% of FOSP;
c) With an additive of 2% of FOSP.

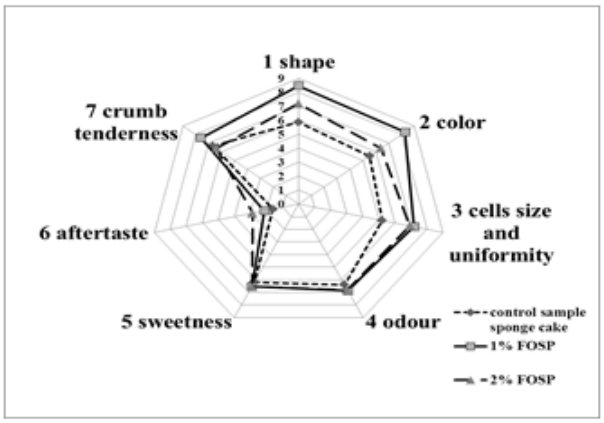

Figure 2. Sensory profiles of sucrose-sweetened sponge cakes (1 shape, 2 colour, 3 cells size and uniformity, 4 odour, 5 sweetness, 6 aftertaste, 7 crumb tenderness)*
*A scale from 0 to 9 was used to evaluate sensory characteristics. Nine is ideal for the third sensory characteristic when the cells are small and equal in size

The tenderness of the cakes is well pronounced in the sample with 1% FOSP. The sweetness of the samples is comparable.

Conclusion

Application of the fructooligosaccharides palmitate esters for the preparation of sponge cakes assisted in optimization of the technological process of production. The addition of modified fructooligosaccharides in gel emulsifier improved the physical characteristics of the cake batter and cakes. The use of 1% FOSP emulsifier gel by mass of sponge batter improved structural mechanical and sensory characteristics of sponge cakes. Through the use of fructooligosaccharides palmitate ester in the form of gel emulsifier improved the mixing of the components in the formulation, the simultaneous fine dispersion of air bubbles and the formation of stable foam. Fructooligosaccharides palmitate ester used in gel form creates conditions for stability of the batter after kneading, and optimum air expansion of the air bubbles without tearing of the films allows some air bubbles. The use of fructooligosaccharides palmitate bring to the finest aeration, emulsifying and foam stabilizing properties of cakes. The addition of 1% fructooligosaccharides palmitate in the formulation of sponge batter as emulsifier improved the quality of the sponge cakes.

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