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IMPACT OF GREEN TEA EXTRACT ADDITION ON OXIDATIVE CHANGES IN THE LIPID FRACTION OF PASTRY PRODUCTS

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ABSTRACT

Background. Alongside flour, fat is the key ingredient of sponge cakes, including those with long shelf lives. It is an unstable food component, whose quality and nutritional safety depend on the composition and presence of oxidation products. Consumption of fat oxidation products adversely affects the human body and contributes to the incidence of a number of medical conditions. Qualitative changes in fats extracted from thermostat sponge cakes with and without antioxidant additions were determined in this study.
Material and methods. In the study, two types of antioxidant were used: natural – green tea extract in three doses (0.02%; 0.2% and 1.0%) and synthetic BHA (0.02%) and 100%, solid bakery shortening. Sponge-cakes were thermostatted at temperatures 63°C after twenty-eight days. In this study, the quality of the lipid fraction was analyzed. The amount of primary (PV) and secondary (AnV) oxidation products was determined, and a Rancimat test was performed.
Results. Adding antioxidants to fats varied in the degree to which oxidation processes of lipids fractions were inhibited. The peroxide value after twenty-eight days of thermostatting ranged from 3.57 meq O/kg (BHA) and 11.14 O meq/kg (extract content – 1%) to 62.85 meq O/kg (control sample). In turn, the value of AnV after the storage period ranged from 4.84 (BHA) and 6.71 (extract content – 1%) to 16.83 (control sample).
Conclusion. The best protective effects in the process of oxidation was achieved by BHA. The longest induction time and the lowest peroxide value and anisidine value were obtained for this antioxidant. It was achieved after twenty-eight days of fat thermostatting. Nonetheless, the results demonstrated it is possible to use the commercially available green tea extract to slow the adverse process of fat oxidation in sponge cake products.

Keywords: sponge cakes, oxidation products, green tea extract, oxidative stability

INTRODUCTION

Consumer choice of food products is guided not only by their sensory properties but also, increasingly, by the weight attached to health aspects and the nutritional value of products (Krystyjan et al., 2015; Onacik-Gür

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et al., 2015; Żbikowska et al., 2015). Bakery products are very popular, because they are easy to eat. These kind of products could be a great carrier of substances increasing the nutritional value of a product. Other authors proposed to increase the nutritional value of sponge cakes with fruit pomaces as a source of polyphenols (Górnaś et al., 2016; Mildner-Szkudlarz et al., 2016). The high quality of baked food is of great importance, since these products are often used and stored at room temperature for a certain time before consumption (Al-Bandak and Oreopoulou, 2011). The quality of raw materials and storage conditions influence the quality of pastry products, among other factors. Fat, which fulfils a range of functions, is a major ingredient of such products. It has a positive impact on such characteristics as taste, humidity, elasticity, hardness or aeration (Laguna et al., 2013; Seker at al., 2010; Żbikowska, 2010). However, fat is an unstable component as it is subject to oxidation processes. The quality and safety of fat are affected by its composition (Mensink et al., 2003) and the presence of products rsulting from its degradation. The quality of shortenings is reduced by elevated content of saturated fatty acids (FA) and trans FA isomers. Secondary lipid oxidation products are the main results of fat degradation. Many of them are involved in the oxidative damage to cell structures and in the toxicity process that leads to cell death (Dianzani and Barrera, 2008). Moreover, lipid peroxidation can have deleterious consequences for the overall retinoid homeostasis in the cells (Lee et al., 2008).

Fatty acid (FA) composition, storage time and temperature, availability of oxygen and light have a considerable impact on the intensity of oxidative changes in food lipids (Mohsen et al., 2009). Synthetics, e.g. antioxidants, are used industrially to prevent deterioration of fat quality. These are disliked by both consumers and nutritionists, who prefer natural antioxidants.

Addition of an appropriately selected, particularly natural, antioxidant determines the durability, quality and safety of food in storage (Kozłowska et al., 2014). It is therefore important to determine the potential for applying natural antioxidants in order to extend the life of fats in sponge cakes.

This study was designed to determine qualitative changes in fat extracted from thermostat sponge cakes with and without the addition of green tea extract.

MATERIAL AND METHODS

Raw materials

The cake mixture was made of Akobake SY shortening (AarhusKarlshamn, Sweden), green tea extract (Danisco, Grindtsted, Denmark) – GT, butylated hydroxyanisole (Hortimex, Mumbai, India) – BHA, and other ingredients purchased in a local market. The control mixture was made of wheat (23%) and potato (6%) flour, shortening (20%), sugar powder (20%), eggs (29%) and baking powder (2%). The other variations were prepared by adding a synthetic antioxidant (BHA 0.02%) and green tea extract (GT) with a content of: 0.02%, 0.2% and 1.0% (according to the amount of shortening added).

Mixture-making procedure (Fig. 1)

A fat base made of shortening and sugar was creamed by a Zelmer 181.7 food processor for 6 min of continuous mixing. Eggs were then added and the mixture blended for a further 2 min. Finally, flour mixed with baking powder was added, followed by mixing for 7 min until the consistency became uniform. Cakes were baked at 160°C for 45 min in a Unox type XBC convection oven (Vigodarzere, Italy).

Methods

Cake samples were thermostatted (ELKON CWE–4a thermostat, Łódź, Poland) to an accelerated storage test which was conducted in a forced-draft oven at 63°C (test Schaala) for up to 28 days (Hu and Jacobsen, 2016). Quality indices were determined in fresh shortening and in an extracted lipid fraction after 7, 14, 21 and 28 days.

Analysis of fresh shortening

Gas chromatography (GC) was used to determine the fatty acid (FA) composition of investigated fats according to the ISO (2000a) standard. Methyl esters were prepared according to ISO (2000b). The composition of FA was expressed as the peak area percentage of total fatty acids. Instrument: HP 6890 GC System with autosampler; SGE Capillary BPX 70, 60 m length column 0.25 mm ID; Oven: temperature program from 160 to 210ºC, rate: 2.5ºC/min; Carrier gas: Helium, Air: 300 ml/min; Injector: Split-Splitless 240ºC; Detector: FID 250ºC; Software: HP Chemstation v. 3.11.

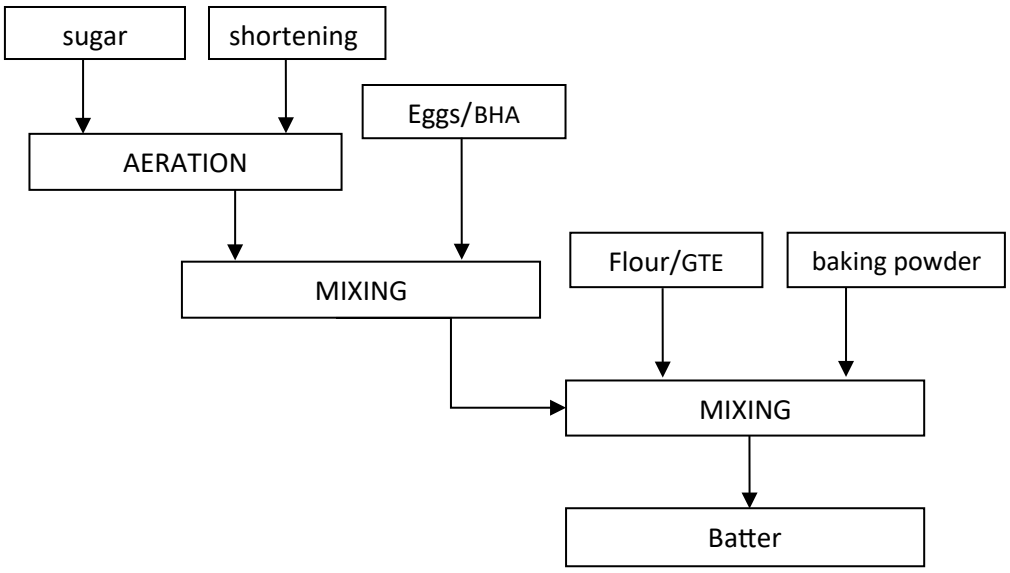

Fig. 1. Diagram of batter preparation

Analysis of lipid fraction

Lipid fraction were extracted with chloroform/methanol (2:1) and the extract was dried over Na_2SO_4. After lipid fraction filtration, the solvent was removed by evaporation under reduced pressure on a rotary evaporator (Bűchi type B – 491). The stability of the lipids extracted was determined by peroxide value, anisidine value and Rancimat analysis.

Peroxide value (PV)

Peroxide value was determined according to ISO 3960:1996. The PV is expressed as milliequivalents [mEq] of active oxygen per kilogram of fat sample.

Anisidine value (AnV)

Anisidine value was determined colorimetrically according to ISO 6885 (2008). Absorbance was measured using a Hitachi U-2000 spectrophotometer.

Totox index

Totox index (PN-93/A 86923) was calculated on the basis of peroxide and anisidine values.

$$Totox = 2 \cdot PV + AnV$$

Rancimat test

Oxidative stability was determined according to PN-ISO 6886:1997. The induction times for oxidation were measured using Methrom Rancimat apparatus model 679 (Herisau Switzerland). Samples were heated to 120°C under an air flow of 20 L/h.

Statistical analysis

The results were subjected to one-way ANOVA. The Tukey test was used to assess the differences between means. A level of $\alpha = 0.05$ was considered significant. The Statgraphics plus 4.0 package (Statistical Graphics Corp., USA) was used for analysis purposes.

RESULTS AND DISCUSSION

The characteristic of raw shortening

The content of primary and secondary lipid oxidation products in the shortening used for the cake production was low. The peroxide value was 1.96 mEq O/kg, while the Polish standard accepts up to 3 mEq O/kg (PN-A-86902, 1997). The anisidine value (AnV) of shortening sample analyzed was 4.19 (Table 1). This probably resulted from a high content of saturated fatty acid (SFA) – 59.1% of total FAs and a low content of PUFA (4.9%) in the shortening (Table 2). Generally, the levels of SFA in this fat are high, which is typical for bakery fats, because SFA are oxidation-resistant and, moreover, they have excellent technological properties (Żbikowska and Kowalska, 2007).

Table 1. Oxidation products in raw fat and in lipid fraction extracted from pastry (after baking)

Parametr	Extracted lipid fraction					
	raw fats	PC	BHA	GT 0.02	GT 0.2	GT 1
LOO	1.96a	2.25a	2.09a	2.11a	2.09a	2.09a
AnV	4.19a	4.20a	4.19a	4.20a	4.20a	4.19a
Induction period, h	13.36a	13.26a	48.01d	25.67b	26.93b	36.90c
Induction period*, h	13.36	18.36	24.10	18.39	19.1	21.92

*After 28 days of storage.
a, b, c – statistically significant differences, $p < 0.05$.
PC – control sample, BHA – sample with BHA, GT 1 – sample with 1% addition of green tea extract, GT 0.2 – sample with 0.2% addition of green tea extract, GT 0.02 – sample with 0.02% addition of green tea extract.

Table 2. Fatty acids composition of raw shortenings

Fatty acids (FA)	Percentage of fatty acids (FA)
Saturated	
C:8	1.28
C:10	1.03
C:12	7.91
C:14	3.18
C:16	3.,53
C:18	12.16
Monounsaturated	
C:18:1	34.04
Poliunsaturated	
C18:2	4.95
C18:3	0.15
Trans isomers	1.77

Furthermore, unsaturated FA are undesirable in bakery fats, because they are not resistant to environmental stress during the baking process (e.g., high temperature). At high temperatures unsaturated FA is the main source of undesirable oxidation products. PUFA oxidizes 100–350 times faster than SFA and 10–35 times faster than monounsaturated FA (Regulska-Iłow et al., 2001).

Characteristics of lipid fractions of baked pastry and the Rancimat test

Monitoring oxidative changes is highly significant with regard to the health aspects of fat consumption. Although the adverse effects of oxidated fats on the human body are well known, an acceptable content of oxidation products in pastry has not yet been determined (Żbikowska et al., 2015). The maximum content of primary products of oxidation – 3 mEqO/kg – has only been specified for shortenings (PN-A-86902:1997), with the anisidine value of 8 being accepted for refined oil (PN-A-86908:2000).

Statistical analysis has demonstrated that baking temperature does not affect the PV or AnV values of the samples tested (Table 1). Żbikowska and Kowalska (2007) have likewise proven the process of baking short cakes does not increase these parameters to any considerable extent.

The shortening used in this study showed a very long induction period (IP) of 13.36 h, and thus a high oxidation stability. This may be attributed to a high content of oxidation-resistant SFAs (Table 2).

Analysis of the induction periods of fats extracted from cakes immediately after baking has demonstrated a significant impact of antioxidants on IP. The longest IP was exhibited by fat in a cake containing BHA. Applying this antioxidant extended the induction period by 262% over its initial value. The addition of 1% GT extract raised oxidative stability by 178%, from 13.26 to 36.90 h. Adding 0.2% of a GT prolonged the IP by 103%. The period was somewhat lower in fat samples

from cakes with the minimum GT quantities (the IP rose by 94%; Table 1).

Fat extracted from pastry after 28 days in a thermostat also displayed positive effects of oxidative stability additives. Lipid fraction samples from cakes containing BHA and 1% of GT extract presented the optimum protection effects (Table 1).

Quality characteristics of lipid fraction extracted from thermostat cakes

The lipid fraction of products free from antioxidant (PC) additions showed little resistance to oxidation processes. PV in the extracted lipid fraction rose dramatically as early as after the first week of pastry thermostatting, to reach a level as high as 62.85 mEq O/kg after 28 days (Fig. 2).

The antioxidant doses applied substantially inhibited oxidation processes in all the sample variants. Increases in primary oxidation product quantities were shown to vary depending on the types and doses of antioxidants. PV was lowest in pastry samples containing BHA additions regardless of the thermostat time. With regard to products containing GT extract, PV was maximum in the lipid fraction of cakes with a maximum 1% addition of the extract. Likewise, Mildner-Szkudlarz et al. (2009) have demonstrated a high antioxidant activity of a fresh green tea extract produced immediately before their testing.

Quantities of secondary products of oxidation in the lipid fraction extracted from the control cake were found to rise considerably as early as the first 7 days of thermostatting – PC (AnV: from 4.20 to 7.22). AnV continued to grow and reached 16.83 after 28 days (Fig. 3).

Applying a commercially available GT extract slowed the oxidation processes. Following the first 7 days, AnV was in the range 4.23–4.38. BHA displayed maximum protective effects, since LAn was merely 4.84, that is, below 8 (the limit for refined oil – PN-A-86908:2000) after 28 days of testing. Mildner-Szkudlarz et al. (2009) have also proved the synthetic antioxidant, BHA, provides better protection than fresh green tea extract does. Optimum protective effects were provided by the largest dose of the extract (GT1) among the tested samples containing GT additions. After 28 days of thermostatting cakes with 1% GT, their lipid fraction contained low quantities of secondary products of oxidation, and AnV was 6.71. Lower doses of the natural GT extract limited the emergence of secondary products of oxidation to a lesser extent (Fig. 3).

The Totox index is a parameter that takes into consideration the primary and secondary oxidation

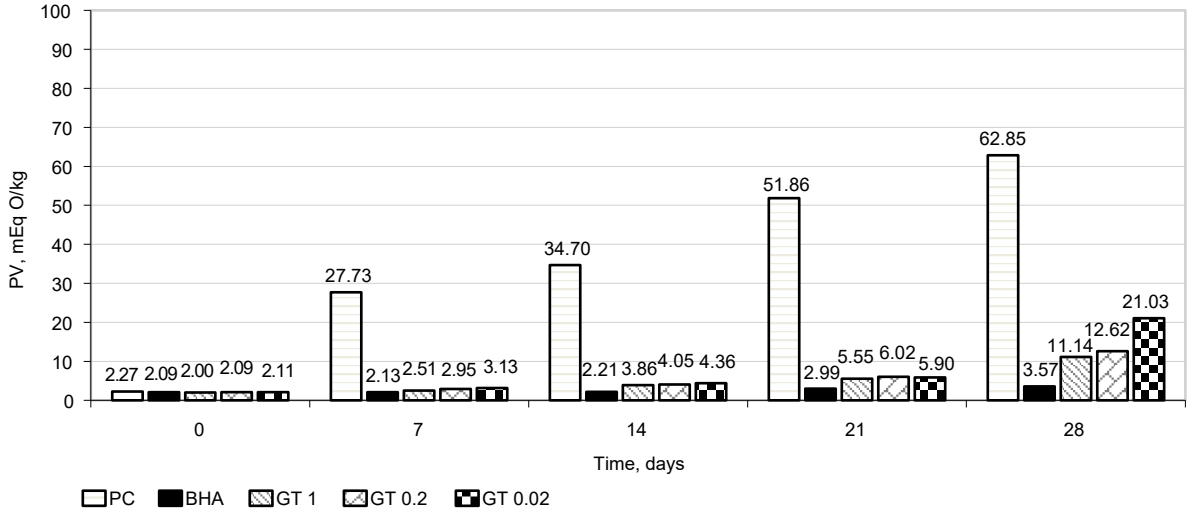

Fig. 2. Peroxide value (PV) in lipid fraction extracted from cakes after 28 days of storage. The designations are identical to those under Table 1 above

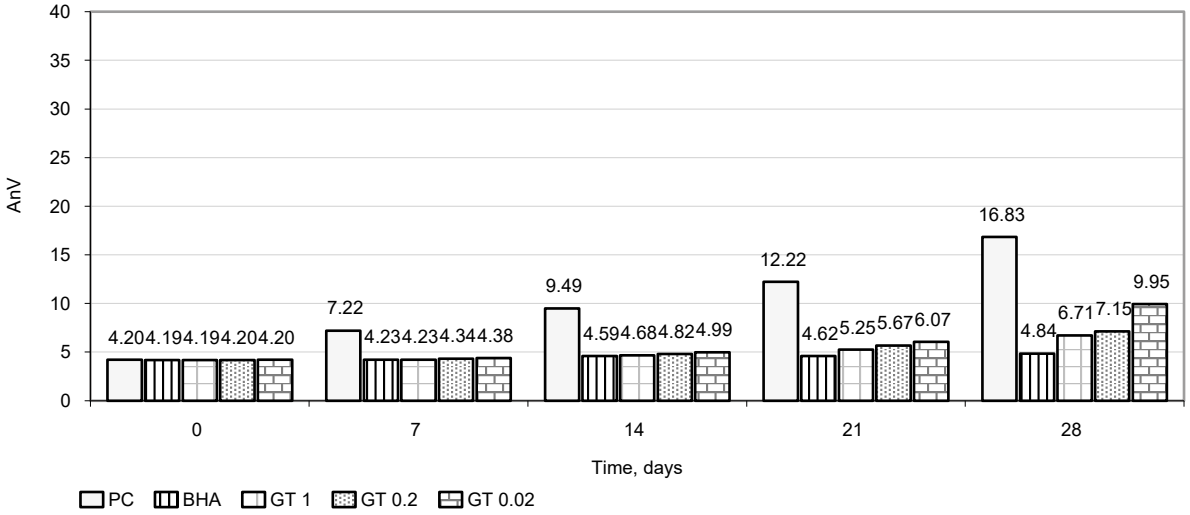

Fig. 3. Anisidine value (AnV) in fat extracted from cakes thermostated during 21 days. The designations are identical to those under Table 1 above

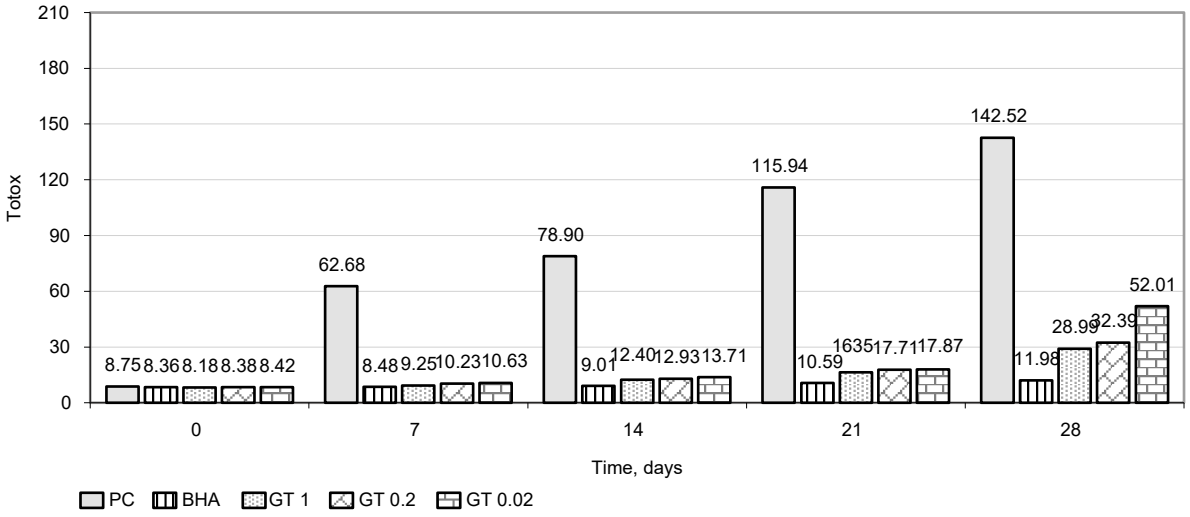

Fig. 4. Variations of Totox index for fat at the time of thermostated of sponge cake products. The designations are identical to those under Table 1 above

products at the same time (PN 93/A 86-926). Its values for fats from cakes containing antioxidants were significantly lower than Totox index values in the control cake (PC). After 14 days, Totox values below 10, which mean good quality fat in a product (Żbikowska and Kowalska, 2007), were only obtained on applying BHA. The lowest Totox index values were also found in the fat of cakes with BHA additions after more weeks of cake thermostatting. When the effects of varying doses of GT extract were compared, the highest dosage, 1%, demonstrated maximum protective action (Fig. 4). Mildner-Szkudlarz et al. (2009) have demonstrated lower Totox index values for fats in thermostat shortbread cakes including additions of

the green tea extract. The improved protective effects shown in that study were most likely the results of using a freshly produced extract. In turn, the results obtained by Kozłowska et al. (2014) from dynamical DSC showed that during storing cookies for 14 days (at 60°C), the addition of thyme extracts was observed to be effective for protecting fat against oxidation. However, after 21 days of storage, the best antioxidant activity was shown by rosemary extracts. The authors stated that aqueous ethanolic rosemary and thyme extracts have potential as ingredients of functional food.

CONCLUSION

No substantial impact of the baking process was found on the quality of the lipid fraction of sponge cake products. The addition of antioxidants, both BHA and green tea extract, inhibited the processes of fat oxidation in the thermostatted cakes. After 28 days of thermostatting, the protective effects were optimum on application of the synthetic antioxidant – BHA. Nonetheless, the results demonstrated that it is possible to use a commercially available green tea extract to slow the adverse process of fat oxidation in sponge cake products.

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