Steam assisted baking of cookies as compared to convectional baking

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ABSTRACT

Steam assisted baking of foods is a hybrid baking method which produces sharing advantages of steam-baking with natural and/or forced convection baking. It is a healthy cooking method, which provides shorter baking times with constitution of harmful compounds such as acrylamide, at a minimal level.

Steam assisted (steam+forced convection/turbo) baking of cookies at 180 °C for different baking times (15, 20, 25 and 30 minutes) as a comparison to conventional baking was examined in the scope of this study. For the cookies baked at different times at 180 °C, the physical quality (moisture content (w/w, db), colour (browning degree), spread ratio, bulk density (kg/m³), hardness (N), fracturability (mm)) as well as acrylamide content and sensory evaluation were determined. The comparison has been made with the results of natural and forced convection/turbo baking of cookies, statistically.

It was resulted that moisture content of cookies baked in steam assisted oven was higher than that of baked in natural convection and turbo ovens, statistically (p<0.05). The browning degree (BI value) was lower for steam assisted baked cookies (p<0.05). The hardness values of steam assisted oven baked cookies were in the range of 28-54 N, where the values for natural and forced convection oven baked cookies were in between 38-63 N and 36-63 N, respectively. Acrylamide content of the cookies was found to be related to the oven type (p<0.05), the forced convection oven baking resulting to the maximum formation. Steam assisted baking caused a reduction in the acrylamide formation compared to the natural convection and turbo oven baking. The sensory points of the cookies baked by different times was significantly different (p<0.05), for all baking ovens. The ovens were not differentiated from each other in the sense of sensory points of the cookies (p>0.05).

keywords: cookie; steam assisted baking; acrylamide; browning index

INTRODUCTION

Steam assisted baking of foods is a hybrid baking method which produces sharing advantages of steam-baking with natural and/or forced convection baking. It is a healthy cooking method, which provides shorter baking times with constitution of harmful compounds such as acrylamide, at a minimal level. The increase in society’s health standards perspective has resulted in an increase of interest on steam and/or steam assisted baking of foods.

Cookies may be defined as small cake-like products from a dough or batter made from raw materials such as flour, fat, sugar, milk, egg, salt, starch, cocoa, leavening agents, emulsifier, and essences, which is viscous enough to allow the pieces of dough to be baked on a flat surface. They come in an infinite variety of sizes, shapes, texture, composition, tenderness, tastes, and colours [1]. Among the whole production procedure of cookies, baking is the key step that develops the product characteristics, including colour, texture, and flavor. Previous studies have focused on nonenzymatic browning reactions to develop colour and flavor, as well as starch gelatinization and protein denaturation to develop structure and texture. Texture is the key factor effecting the baked product (cookie, cakes, biscuit, .. ) quality. By the study, it was examined the texture of microwave and convective baked cakes; microwave oven baked at 250 W showed improved textural properties (springeness, moisture content, firmness) as compared to baked in the convective oven at 200 °C [2]. In a study on biscuit, indicated that breaking stress, as a textural property, is an indication of the
mechanical integrity of the biscuit [3]. Some researches investigated that the rheological properties (hardness, adhesiveness, cohesiveness) of cookie dough and the physical properties (spread, colour and hardness) of baked cookies formulated with varying levels of tagatose [4]. By the another study, it was observed and contrasted the textural changes of canned biscuit wheat dough in terms of modulus of elasticity, weight loss and density during microwave and convectional oven baking [5]. The best baking conditions were determined in the halogen lamp–microwave combination oven to produce cookies having similar colour and texture properties as conventionally baked ones. Biscuit temperature during baking as well as moisture distribution were thought to be the critical factors in determining checking behavior and mechanical strength [6].

Steam assisted (steam+forced convection/turbo) baking of cookies at 180°C for different baking times (15,20, 25 and 30 minutes) as a comparison to conventional baking was examined in the scope of this study.

MATERIALS & METHODS

The cookies were prepared using the following formula: 68.77% (of total weight) Dr. Oetker’s ready dry cookie mix (containing wheat flour, sugar, maltodextrin, corn starch, baking powder, edible salt, vanillin), 7.15 % homogenized whole egg and 24.07% vegetable margarine. Hand kneading method was used to prepare the cookie dough. All ingredients were mixed together for approximately 5 min to obtain homogenous mixture. Then, the cookie dough was cut to form a cylindrical shape (47 mm in diameter and 9 mm in thickness). The initial moisture content of the dough was 0.23 kg water/kg dry solid and kept constant for all experiments.

Baking experiments were carried out in a steam assisted oven (Blomberg) and also in a domestic use electrical convectional oven (Blomberg, BKO 9566). Steam assisted baking oven used in the study is a hybrid oven with 48×43×25 cm dimensions having an inner steam generator mounted at the back panel of the oven. The steam generated from 150-200 g water was injected into the oven cavity in three times during the baking process. The steam injection periods were determined by preliminary experiments as 3, 8 and 16th minutes. For the cookies baked at different times at 180 °C, the physical quality (moisture content (w/w, db), colour ( Browning degree), spread ratio, bulk density (kg/m3), hardness (N), fracturability (mm)) as well as acrylamide content and sensory evaluation were determined. The comparison has been made with the results of natural and forced convection/turbo baking of cookies, statistically.

The moisture content of cookie samples was determined by an infrared moisture analyser (Ohaus, MB45) as two parallel. These results were validated by the standard oven method for total solids and moisture in baked products, as 1 h at 130°C [7]. The surface colour of the cookie samples (browning index (BI) value) was measured by Hunter Colourflex [8]. The browning index (BI) were calculated from following equation;

\[
BI = \frac{[100 \times (\frac{a_t + 1.79L_t}{5.645L_t + a_t - 3.012b_t - 0.31})]}{0.17} 
\]

\( a_t \): a colour value; \( b_t \): b colour value; \( L_t \): L colour value at a definite time (t) of baking

Spread ratio represents a ratio of diameter to height. The bulk densities of baked cookies were calculated by taking the ratio of a known amount of cookie to its volume [9]. The volume of baked cookie samples were determined by the rape seed displacement method [10].

Texture analyses were achieved in texture analyser (TA-XTPlus, Stable Microsystems, Surrey, England) using 3-Point Bending Rig with 30 kg load cell. The test parameters are pre-test speed of 1.0 mm/s, test speed of 3.0 mm/s, post-test speed of 10.0 mm/s, distance of 5 mm and trigger force of 50 g. Fracturability and hardness values were measured in each test. The hardness was determined from the maximum peak force (N), fracturability was determined from the distance at fracture (mm) which the cookie breaks.

Acrylamide content determination method includes extraction with water, addition of D3 acrylamide as an internal standard, bromination and GC-MS analysis in the selected ion monitoring (SIM) mode. Bromination
of acrylamide to 2,3-dibromopropionamide (2,3-DBPA) was achieved using potassium bromide and potassium bromate under an acidic condition. The operating parameters for GC-MS were as follows: oven temperature 65°C (1 min), 15°C/min, 240°C (10 min), injection temperature 250°C and transfer line temperature 240°C. In the SIM mode, m/z 149 for 2,3-DBPA and m/z 153 for internal standard were used for quantification [11].

Sensory evaluation was performed with a 10 semi-trained panel group, using evaluation forms on appearance, texture and flavour of cookies, each out of 5 points.

RESULTS & DISCUSSION

It was resulted that moisture content of cookies baked in steam assisted oven was higher than that of baked in natural convection and turbo ovens, statistically (p<0.05). The moisture contents of the cookies decreased with increasing baking time (Fig 1).

![Fig 1. Moisture content of cookies (dry basis) baked at natural, forced convection and steam assisted oven.](image)

Colour change of samples baked in natural and forced convection was higher than that of baked in the steam assisted oven. This result indicated that radiation mechanism was more responsible for colour change in convection baking. This result was supported by BI values of cookies baked in natural, forced convections and steam assisted oven which are illustrated in Figure 2. The browning degree (BI value) was lower for steam assisted baked cookies (p<0.05).

![Fig 2. Browning Index value of cookies baked at natural, forced convection and steam assisted oven.](image)

The hardness values of steam assisted oven baked cookies were in the range of 28-54 N, where the values for natural and forced convection oven baked cookies were in between 38-63 N and 36-63 N, respectively (Fig 3). The fracturability values of cookies at three different baking conditions (natural, forced convection and...
steam assisted) are significantly same (p>0.05) (Table 1). Briefly, it is possible to obtain less rigid and less brittle cookies with steam assisted baking.

![Figure 3. The hardness values of cookies baked at natural, forced convection and steam assisted oven.](image)

**Table 1. Fracturability values (mm) of cookies baked at different ovens (p>0.05)**

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Natural Convection</th>
<th>Forced Convection</th>
<th>Steam Assisted</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>46,825 (±0.179)</td>
<td>47,502 (±0.240)</td>
<td>46,04 (±0.088)</td>
</tr>
<tr>
<td>20</td>
<td>47,449 (±0.469)</td>
<td>48,142 (±0.330)</td>
<td>46,190 (±0.046)</td>
</tr>
<tr>
<td>25</td>
<td>48,751 (±0.116)</td>
<td>48,774 (±0.564)</td>
<td>46,414 (±0.375)</td>
</tr>
<tr>
<td>30</td>
<td>48,524 (±0.556)</td>
<td>47,970 (±0.300)</td>
<td>46,630 (±0.270)</td>
</tr>
</tbody>
</table>

Acrylamide content of the cookies was found to be related to the oven type (p<0.05), the forced convection oven baking resulting to the maximum formation. Steam assisted baking caused a reduction in the acrylamide formation compared to the natural convection and forced convection oven baking (Fig 4).

![Figure 4. The acrylamide content of cookies baked at natural, forced convection and steam assisted oven.](image)

Spread ratio is defined as a ratio of width (mm) to thickness (mm) of cookies. The spread ratios of the cookies baked in a steam-assisted oven were higher than those of conventionally baked cookies and this difference is significantly important when compared to forced convection oven (p<0.05) (Table 2). Higher spread ratios are desirable and represent a better quality of cookie.
Table 2. Spread ratio values of cookies baked at different ovens

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Natural Convection</th>
<th>Forced Convection</th>
<th>Steam Assisted</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>3.18 (±0.03)</td>
<td>3.14 (±0.03)</td>
<td>3.45 (±0.05)</td>
</tr>
<tr>
<td>20</td>
<td>3.23 (±0.09)</td>
<td>2.94 (±0.06)</td>
<td>3.34 (±0.02)</td>
</tr>
<tr>
<td>25</td>
<td>3.31 (±0.10)</td>
<td>3.09 (±0.01)</td>
<td>3.40 (±0.02)</td>
</tr>
<tr>
<td>30</td>
<td>3.30 (±0.09)</td>
<td>3.04 (±0.05)</td>
<td>3.47 (±0.05)</td>
</tr>
</tbody>
</table>

The bulk density values of cookies in natural, forced convection and steam assisted oven were in the range of 479–657 kg/m³, 526-581 kg/m³ and 576-649 kg/m³ respectively.

The sensory points of the cookies baked by different times were significantly different (p<0.05), for all baking ovens. The higher points achieved at a definite baking time indicated the best baking time according to the panel. On the other hand, the ovens were not differentiated from each other in the sense of sensory points of the cookies (p>0.05).

CONCLUSION

Steam assisted oven baking can be concluded as a good choice for cookie baking, because of the implications observed, i.e. lower acrylamide content and lower BI, high spread ratio as a quality criteria and hardness values when similar eating tastes were reached with conventional methods.

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REFERENCES: