Effect of DATEM and fat reduction in semi-hard biscuits using RSM

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ABSTRACT

The effect of diacetyltartaric esters of monoglycerides (DATEM) on fat reduction of semi-hard biscuits has been studied. Decreasing the amount of fat in 5 levels (5.37-50.63 percent) showed significant variations in most studied characteristics (p < 0.05). Addition of DATEM in 5 levels (0.42-0.99 percent) had significant variation in some characteristics such as thickness, density, texture and color, but it didn't have much correlation with width, length and weight. Results which were analyzed by response surface method (RSM) showed that biscuits with 26.23 percent fat reduction and 0.81 percent DATEM addition have the most desirability. Also 35 consumers evaluated appearance, flavor, texture, color and general acceptance of biscuits and the result was in conform to RSM results.

Key words: Biscuit, DATEM, Fat reduction, RSM

Introduction

Fat is an essential ingredient in biscuit manufacture and is the largest component after flour and sugar [11]. Fat in a biscuit formulation has a multifaceted function [13]. It performs shortening and textural functions in biscuits. During mixing of biscuit dough, fat acts as a lubricant; it also competes with the aqueous phase for the flour surface and prevents the formation of a gluten network in the dough [11,10]. It also interacts with other ingredients to develop texture, mouth feel and overall sensation of lubricity of the product [12]. By using small amounts of emulsifier the fat phase is spread more uniformly over the hydrophilic ingredients such as flour, sugar, etc., in the dough [9].

High fat intake is associated with various health disorders such as obesity, cancer, high blood cholesterol, and coronary heart disease. This awareness has prompted consumers about the amount of fat in their diet [13]. In this regard, the American Heart Association suggested limiting fat consumption to ≤ 30% of kilocalorie and several researches have attempted to reduce the fat content of baked products [13,4,5,7,8,15].

Innovation of new products and exploitation of alternative raw materials to reduce production costs are also important for biscuit manufacturers [14].

The incorporation of emulsifiers with fat has been proposed to reduce the interfacial tension and increase the effectiveness of the fat, allowing less to be used [7,1]. Sai Manohar et al. have reported that the level and type of fat as well as emulsifiers changed the rheological characteristics of biscuit dough and quality of biscuits. They have clearly shown the beneficial effect of using emulsifiers in producing a soften dough with improved machinability and better textural characteristics of biscuits [11].
Traditionally, lecithin has been used across the range of biscuit types. It aids the dispersion of the fat in semisweet doughs and improves the emulsification during cream up in short doughs. Monoglycerides and their derivatives are also the effective emulsifiers. The polar part of the monoglyceride molecule can also be enlarged and made more effective by reacting with a food acid such as lactic, citric, acetic and diacetylated tartaric acid [9]. The latest one leads to an emulsifier name DiacetylTartaric esters of monoglycerides (called as DATEM).

The objective of the present work was to study the effect of DATEM on the quality and also fat reduction of semi-hard biscuit formulation. Also, response surface methodology was used for modeling the best formulation and minimizing the number of baking trials.

Materials and methods

Biscuit Formula and Ingredients:

Biscuit dough was prepared according to the following formula: Flour 100g, sugar 25g, fat 16g (Behshahr Co., Tehran, Iran), non fat dry milk 0.5g (Ramak Ltd., Shiraz, Iran), leavening agents 3g (Kimia Saz Ltd., Tehran, Iran), lecithin 0.2g (ADM Ltd, Netherlands). For preparation of low fat biscuits, fat content in the biscuit formulation was reduced from 5% to 50%, respectively. The replaced emulsifier was DATEM (Kerry Ltd, Netherlands), which was used from 0.4% to 0.99%, respectively.

Preparation of Biscuits:

Sugar and fat was creamed in a Z-blade mixer for 2 min. at the speed of 70 rpm. After that, milk powder, salt and leavening agents were added and continue mixing for 7 min. to obtain a homogenous cream. Then commercially available wheat flour with sufficient water were added and mixed for 7min. Chemical characteristics of the flour used has given in Table 1. After the preparation of the dough, they were sheeted to a thickness of 2mm, cut to rectangle shape and baked in a tunnel oven for 5min. Then, the baked biscuits were cooled and packed.

It should be noted that the complete experimental design consisted of 14 experimental trials, which included five replications of center points.

Evaluation of Biscuits:

Physical Characteristics:

The average weight and dimension (length, width, and thickness) of 50 biscuits –divided to 5 groups of 10 biscuits- were measured by placing them edge to edge and by stacking one above the other respectively.

Breaking and Compression Strength:

Braking strength of biscuits was measured in a Texture Analyzer (Testometric M350-10CT, UK) according to a triple-beam snap technique –also called three-point break- with a load cell of 50 N, and a crosshead speed of 10 mm/min. The force required to break 5 biscuits individually were recorded and the average value reported

Color:

Surface color of the biscuits was measured using a Hunter lab (Color Flex Model) and the value of color difference (ΔE) was calculated.

Statistical Evaluation:

Results were analyzed statistically following Response Surface Method by the means of Design Expert soft ware version 7.1.6.

Sensory Evaluation:

Biscuits were evaluated by 35 non-trained panelists with the method of ranking (Carpenter et al., 2000). Samples were assessed by their taste, color and texture

Results and discussion

Effect of fat reduction and DATEM addition on physical and rheological properties of biscuits is shown in Table 2.

Biscuit Dimension

Measurement of biscuit thickness showed significant variation (Fig. 1). It was found that by reducing fat and DATEM up to certain amount, the thickness of the biscuits reduced significantly ($p \leq 0.05$). The samples produced with high levels of fat reduction and low levels of DATEM were thinner. This is in agreement with other researches [13] have reported that by reducing fat from 20 to 6 percent of dough weight, thickness of the biscuits increases significantly. That can be due to development of gluten network in the dough. Increasing the elasticity of the dough by fat reduction can be another reason [13].
Table 1: chemical characteristics of flour

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>9.54</td>
</tr>
<tr>
<td>Gluten (%)</td>
<td>23.8</td>
</tr>
<tr>
<td>Protein (% of dry matter)</td>
<td>9.5</td>
</tr>
<tr>
<td>Ash (% of dry matter)</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Rheological

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farinograph water absorption (%)</td>
<td>59.4</td>
</tr>
<tr>
<td>Dough development time (min)</td>
<td>2.3</td>
</tr>
<tr>
<td>Dough stability (min)</td>
<td>2.3</td>
</tr>
<tr>
<td>Farinograph quality number (BU)</td>
<td>34</td>
</tr>
</tbody>
</table>

1including 3 replication for each test

Table 2: Changes of physical and rheological properties of biscuits due to fat reduction and DATEM addition

<table>
<thead>
<tr>
<th>Sample's number</th>
<th>Fat reduction (%)</th>
<th>DATEM (%)</th>
<th>Width (mm)</th>
<th>Length (mm)</th>
<th>Thickness (mm)</th>
<th>Weight (g)</th>
<th>Density (g/cm³)</th>
<th>Texture (N)</th>
<th>Color (ΔE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>28</td>
<td>0.42</td>
<td>4.50</td>
<td>5.56</td>
<td>0.50</td>
<td>3.88</td>
<td>0.31</td>
<td>16.39</td>
<td>28.89</td>
</tr>
<tr>
<td>B2</td>
<td>12</td>
<td>0.50</td>
<td>4.60</td>
<td>5.60</td>
<td>0.57</td>
<td>4.33</td>
<td>0.29</td>
<td>13.87</td>
<td>32.74</td>
</tr>
<tr>
<td>C3</td>
<td>44</td>
<td>0.50</td>
<td>4.40</td>
<td>5.65</td>
<td>0.51</td>
<td>3.77</td>
<td>0.30</td>
<td>16.56</td>
<td>29.18</td>
</tr>
<tr>
<td>D4</td>
<td>28</td>
<td>0.71</td>
<td>4.50</td>
<td>5.70</td>
<td>0.59</td>
<td>3.86</td>
<td>0.26</td>
<td>10.97</td>
<td>31.82</td>
</tr>
<tr>
<td>E5</td>
<td>50.63</td>
<td>0.71</td>
<td>4.50</td>
<td>5.65</td>
<td>0.56</td>
<td>3.70</td>
<td>0.27</td>
<td>12.86</td>
<td>28.08</td>
</tr>
<tr>
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<td>4.50</td>
<td>5.55</td>
<td>0.60</td>
<td>3.80</td>
<td>0.25</td>
<td>11.88</td>
<td>34.00</td>
</tr>
<tr>
<td>G7</td>
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<td>0.71</td>
<td>4.70</td>
<td>5.40</td>
<td>0.54</td>
<td>4.00</td>
<td>0.29</td>
<td>12.26</td>
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<tr>
<td>H8</td>
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<td>4.55</td>
<td>5.55</td>
<td>0.59</td>
<td>3.99</td>
<td>0.27</td>
<td>12.17</td>
<td>32.87</td>
</tr>
<tr>
<td>I9</td>
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<td>4.50</td>
<td>5.57</td>
<td>0.60</td>
<td>3.80</td>
<td>0.25</td>
<td>11.53</td>
<td>34.30</td>
</tr>
<tr>
<td>J10</td>
<td>28</td>
<td>0.71</td>
<td>4.50</td>
<td>5.67</td>
<td>0.60</td>
<td>3.87</td>
<td>0.25</td>
<td>11.16</td>
<td>34.23</td>
</tr>
<tr>
<td>K11</td>
<td>44</td>
<td>0.91</td>
<td>4.50</td>
<td>5.65</td>
<td>0.52</td>
<td>3.63</td>
<td>0.28</td>
<td>10.97</td>
<td>30.57</td>
</tr>
<tr>
<td>L12</td>
<td>12</td>
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<td>4.60</td>
<td>5.60</td>
<td>0.53</td>
<td>4.06</td>
<td>0.30</td>
<td>9.90</td>
<td>34.26</td>
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<tr>
<td>M13</td>
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<td>0.99</td>
<td>4.48</td>
<td>5.75</td>
<td>0.55</td>
<td>3.88</td>
<td>0.27</td>
<td>11.82</td>
<td>33.18</td>
</tr>
<tr>
<td>O14b</td>
<td>-</td>
<td>-</td>
<td>4.50</td>
<td>5.55</td>
<td>0.55</td>
<td>4.15</td>
<td>0.29</td>
<td>16.29</td>
<td>33.84</td>
</tr>
</tbody>
</table>

a Including 3 replication for each test
b Data of the last row indicate control sample
c using texture analyzer.

Fig. 1: Effect of fat reduction and DATEM on the thickness of the biscuits (3D and contour plot)

Results showed that the width of the biscuits decreases by fat reduction respectively ($p \leq 0.05$), but DATEM didn’t show significant effect (Fig. 2). However the length of the biscuits didn’t show significant variation and that can be due to machinability effect. Results are in agree with other researches [13,5]. Conforti et al. have reported that fat reduction leads to having a dense texture and also smaller size [5,13] have shown that by decreasing the amount of fat, spread ration and width of the biscuits decreases significantly and this is maybe due to increasing the elasticity of the dough in absence of sufficient fat [13].

As shown in Fig. 3, the weight of the biscuits reduced by fat reduction significantly ($p \leq 0.05$). This may be due to the replacement of water with fat that resulted in harder texture. So it required more force to break the products as measured by three-point break. In comparison with fat, the effect of DATEM was lower in weight changes.

**Biscuit Texture:**

Hardness of the biscuits which was measured by a texture analyzer increased significantly by reduction of fat ($p \leq 0.05$), and more force was needed to crack the biscuits. Many other researches approve this result [13,5,1,2]. In the other word, reducing the fat content increases the fracture stress of the biscuits. In addition, a low amount of fats, or
alternately high water content, makes the dough hard [12]. As fat prevents the formation of a gluten network in the dough, hardness can be due to greater gluten development by decreasing the fat content [11] However, as can be seen in Fig. 5, using higher amounts of DATEM partly covered the effect of fat reduction and resulted in less hardness.

Surface Color:

Surface color, as measured by a Hunter lab was seen to vary significantly ($p < 0.05$). Fig. 6 shows that decreasing the amount of fat results in less color difference and lighter surface color. These observations confirm the results reported by other researchers [11,5]. According to conforti et al. fat can have some roles in the color of the biscuits [5].

Sensory Evaluation:

After taking the taste panel, results were analyzed with SPSS software. Samples with fat reduction of 28 percent and DATEM addition of 0.71 percent were acceptable. Results have shown in Fig. 7.

Desirability:

Calculation of the optimal levels of ingredients to be used was performed using a multiple response method called desirability. This optimization method incorporates desires and priorities for each of the variables. [6]. Biscuits with darker color (in standard range), weight, dimensions, density, and crispiness (in standard range) are preferable. Analyses with RSM have shown that biscuits with 26.23 percent fat reduction and 0.81 percent DATEM addition have the most desirability. The desirability of each response and combined has shown in fig. 8

Conclusion:

Addition of DATEM affected the quality of fat-reduced biscuits. Its role was more significant in some characteristics such as texture which resulted in less hardness. However it cannot be implied that any one single ingredient significantly can affect all of the responses. Results have shown that by choosing 28 percent of fat reduction and 0.71 percent of DATEM, acceptable biscuits can be produced. This was in agreement with the results of taste panel tests.

Fig. 2: Effect of fat reduction and DATEM on the width of the biscuits (3D and contour plot)

Fig. 3: Effect of fat reduction and DATEM on the weight of the biscuits (3D and contour plot)
Fig. 4: Effect of fat reduction and DATEM on the density of the biscuits (3D and contour plot)

Fig. 5: Effect of fat reduction and DATEM on the texture of the biscuits (3D and contour plot)

Fig. 6: Effect of fat reduction and DATEM on the color of the biscuits (3D and contour plot)
Fig. 7: Taste panel results. Samples were evaluated by their taste, color and texture via 35 panelists. Numbers of acceptability are the means of evaluation factors.

Fig. 8: Desirability of responses

References

11. Manohar, R.S. and P.H. Rao, 1999. Effect of emulsifiers, fat level and type on the rheological characteristics of biscuit dough and quality of...


