Comparison the Effects of, Modified Ultra Filtered Cheese Whey, Whey Concentrate and Milk powders on the Rheological and Sensory Properties of Dough and Taftoon Bread

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ABSTRACT

In order to explore the possibility of using dairy ingredients as a functional ingredient in Iranian bread (Taftoon), investigations were made to study the effect of replacement of wheat flour with 5% Non Fat Dry Milk (NFDM), Whey Protein Concentrates (WPC) and Ultra Filtered cheese Whey Powder (UFWP) on extensograph and farinograph parameters of wheat flour, staling rate and sensory evaluation of Taftoon. Dairy ingredients decreased water absorption of dough in almost all cases. Heat treatment of NFDM, WPC and UFWP at 85°C for 1hr increased the mixing time of dough. Heat treatment in slightly alkaline pH counteracted the deleterious effects of adding untreated UFWP and NFDM in Taftoon. Heat-treated UFWP had the best effect on lowering the staling rate in bread and got the best scores in sensory evaluation.

Key words: Bakery product, Ultra Filtered cheese Whey Powder, Non Fat Dry Milk, sensory evaluation

Introduction

Dairy ingredients such as nonfat dry milk (NFDM), whey protein concentrates (WPC) and ultra filtered cheese whey powders (UFWP) are widely used in the preparation of bakery products. The nutritional, organoleptic and some functional properties of bread enriched by dairy products are improved. Reducing of staling rate, increasing of crust color and spongy tissue are some of advantages of dairy ingredients in bread baking. On the other hand, dough slackening and volume-depressing effects with no heated dairy fractions have been reported frequently. The performance of dairy ingredients in baking has been the subject of many publications, and almost every milk fraction has been described as loaf volume-depressing. Such fractions include whey proteins (powders or concentrates), casein, and lactose (Harland et al. 1943, Larsen et al. 1949, Ashword and Kruger 1951, Gordon et al. 1954, Swanson and Sanderson 1967, Zadow 1981, Harper and Zadow 1984).

In the context of dairy ingredient performance in baking, several conclusions emerge from the published data. First, the interaction patterns between dairy ingredients and characteristics of wheat flour components depend on the dairy fractionation method and wheat flour. Second, the functionality of a dairy ingredient or product is impressed with its individual components and its production conditions (Claypool 1984). Third, some baking parameters such as mixing time and water absorption control the performance of a particular dairy ingredient in final product. Dairy products, such as none fat dry milk and cheese whey protein powders or concentrates vary in general composition and the extent of denaturation. These variations in starting materials combined with variations in functionality and performance in different foods make it difficult to classify the dairy products in a simple and straightforward manner (Kinsella 1984). The complexity of the bread baking system, including several stages of processing and interaction among the components, makes it very difficult to predict the performance of a particular dairy product based on its behavior in a model system. Thus, the performance of a dairy ingredient may vary with flour composition and strength, presence of additives, bread baking system (straight or sponge; fixed or optimized), and tested parameter (dough development time, mixing tolerance, fermentation and oxidation requirements, loaf volume, and crumb grain firmness). In order to remove the defects caused by the addition of unmodified dairy ingredients in the formula and increase the shelf life of bread several modifying techniques have been developed (Thompson and Backer 1982, Erdogru-Amoczky et al. 1996, Kenny et al. 2001, Hudson et al. 2000, Krešić et al. 2008, Asghar et al. 2009) That in this study thermal modifying method was used (Resch and Daubert 2002). This method is used with the assumption that the thermal modification counteracts disturbance effects of thiol bonds of dairy protein compound in gluten network and cheese whey proteins while being denatured, may form polymer and gel and even increase their water holding capacity (Bryant and Mc Clements 2000, Marangoni et al. 2000, Britten and Giroux 2001, De Kruijf et al. 2003). For ternary starch – sugar – water systems, Slade and Levine presented linear relationships for the dependence of gelatinization temperature on the amount of sucrose and the inverse molecular weight of the
co-solvent (water + sugar) using a series of sugars as co-solvents. With a series of 1:1:1 sugar–water–starch mixtures, the gelatinization temperature increased in the following order: water alone < galactose < xylose < fructose < mannose < glucose < maltose < lactose < maltotriose < DE10 maltodextrin < sucrose. Sugars and polyhydric alcohols, in general, have long been known to impede granule swelling, raise the temperature of gelatinization and elevate the temperature of viscosity rise (pasting). Hydrophilic solutes such as sucrose, glucose and sucrose syrups compete for water, and can delay and inhibit starch swelling if present in adequate amounts. Sugars and oligosaccharides influence gelatinization onset temperature in relation to their impact on water activity and water volume fraction. Van Soest has recently proposed that sugars act as cross linking agents stabilizing the polymer chains in the granular structure via intermolecular hydrogen bonding. Katsuta et al. and Miura et al. argued that the ability of sugars to impede retrogradation is related to the mean number of equatorial hydroxyl groups, i.e. sugars with large numbers of equatorial — OHs were more effective in stabilizing the amorphous and entangled matrix of starch chains in the gel. Also sugars such as lactose are humectants and can absorb moisture from environment. Proteins can compete for water, delaying cooking and increasing the pasting temperature, but proteins and starch interact in ways that are more specific and profound. When starch and milk protein are cooked together, the resulting viscosity may be greater than if they are cooked separately and mixed (Be Miller and Whistler 2009).

In this study the effects of UFWP (8-11% protein), WPC (80% protein), and NFDM (34% protein) in both modified and unmodified states, on physical properties of yeasted dough, and staling rate of bread in straight dough system of Iranian bread (Taftoon) (AACC 2000) in level of 5% based on weight of flour with 14% moisture was investigated. Modifying was in both acidic (3.35) and slightly alkaline (7.5) pH. The effects of treatments were compared in terms of dough rheology, reducing the rate of bread staling, bread texture, flavor and color.

Materials and methods

Modifying of dairy compounds by heat treatment:

NFDM and UFWP were prepared from Solarec Company of Belgium and Caseinate-Iran Company of Iran respectively. First each dairy powders (10%w/w) was dispersed in the deionized water to form protein solution and allowed to stir for about 1 h. After that acidic treatments pH was set by HCl 6 N on 3.35 and slightly alkaline treatments pH was set by NaOH 6 N on 7.5. Then heat modification was carried out in water bath equipped with shaker. The solutions temperature was increased to 85 ºC at approximately 5 ºC/min and held at 85 ºC with constant agitation for 1h. After thermal modification, solutions were placed at 5 ºC for at least 24 h. Frozen solutions were dried in a MR-TR Mechanically Refrigerated Freeze-Mobile freeze dryer with tray drying chamber (Hetoholten, Denmark). The dryer operated at a condenser temperature of -30 ºC and a pressure of 1 hecto pascal while the shelf temperature was slowly increased from -30 ºC to -20 ºC over a drying period of about 40 h.

Chemical analysis:

Wheat flour obtained from Jor-e flour plant was used for this study. The characteristics of the flour such as moisture, ash, dry gluten and Zeleny’s – Sedimentation value were determined using AACC methods (2000). WPC, UFWP and NFDM were analyzed for moisture, ash, protein and fat according to AOAC methods (2000). The carbohydrate content was expressed as percent and calculated by subtracting the sum of moisture, protein, crude fiber, fat and total ash from 100.

Ingredients:

Sodium chloride, yeast powder and malt powder were used in this study.

Rheological characteristics:

Effect of replacement of wheat flour with 0 and 5% modified and unmodified WPC, UFWP and NFDM on farinograph, extensograph and universal testing machine characteristics were studied using standard AACC methods (2000).

Taftoon making characteristics:

Wheat flour and modified or unmodified dairy compound (wheat flour/WPC, UFWP or NFDM) in the ratios of 100.0 and 95.5 w/w, salt (1%), yeast powder (1%) and malt powder (1.5%) were mixed together. Then
adequate water was added. Taftoon dough was prepared using optimized straight dough method (AACC 2000). Bread was packed in polyethylene for farther tests.

**Farinograph test:**

Rheological measurements of undeveloped doughs with the addition of modified and unmodified NFDM, UFWP or WPC were tested on a farinograph to determine the mixing behavior of wheat flour according to the method number 54-21 of AACC (2000).

**Extensograph test:**

Resistance to stretching and extensibility measurements of undeveloped doughs with the addition of modified and unmodified NFDM, UFWP or WPC were tested with a universal testing machine (UTM) according to the method number 54-10 of AACC (2000).

**Puncture test:**

The puncture test measures the force required to push a punch or probe into bread that is a criterion to determine the bread staleness. It was tested with a UTM according to the method number 74-09 of AACC (2000).

**Evaluation of Taftoon:**

Taftoon were evaluated for physical characteristics like texture, color and flavor. The scores for each characteristic were between +4 and -4. The best sample got the score +4 and the worst sample got the score -4. The results got from ten trained panelist, then statistical analysis carried out.

**Statistical analysis:**

The data obtained from the empirical rheological values from different treatments of wheat flour with and without the addition of modified and unmodified NFDM, UFWP and WPC were subjected to statistical analysis to determine the analysis of variance and level of significance for different treatments and the differences in their mean values were determined by Duncan’s multiple range test.

**Results and Discussion**

**Farinograph results:**

Because desirable consistency of dough affects quality of bread, therefore studying of farinogram properties of dough formula before baking bread are of particular importance. Farinogram properties of dough treatments are given in Table 1. The most important data of dough farinogram are water absorption, dough development time and dough stability, the results showed that heat treatment of dairy ingredients, regardless of protein content and pH adjusted, increased all three mentioned data. But addition of modified WPC at slightly alkaline pH (mWPC1) was not so, that it’s justified so that heat treatment caused many chemical linkages, but in spite of modified WPC in acidic pH (mWPC2), protein hydrolysis was not occurred. Therefore addition of mWPC1 disturbed gluten network and decreased dough development time and dough stability. It seems that modification of dairy ingredients in acidic pH in compare with slightly alkaline modification had negative effect on water absorption. Of course this effect in addition of mWPC2 was not dominant maybe because of high protein content, but mentioned effect in addition of UFWP2 was dominant and counteracted the effect of heat treatment in compare with unmodified one. It seems that protein content of modified treatments had direct relationship with dough water absorption. Also protein content of unmodified treatments had direct relationship with dough development time. It seems that considerable decrease of water absorption when unmodified or modified UFWP was added had positive effect on dough development time and dough stability.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>control</th>
<th>UFWP0</th>
<th>NFDM0</th>
<th>WPC0</th>
<th>UFWP1</th>
<th>NFDM1</th>
<th>mWPC1</th>
<th>mUFWP2</th>
<th>mWPC2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water abs. (%)</td>
<td>63.6*</td>
<td>56.5*</td>
<td>61.3*</td>
<td>60.1*</td>
<td>57.0*</td>
<td>61.7*</td>
<td>65.0*</td>
<td>56.4*</td>
<td>64.9*</td>
</tr>
<tr>
<td>Dev. time (min)</td>
<td>3.0*</td>
<td>2.9*</td>
<td>3.0*</td>
<td>3.2*</td>
<td>3.8*</td>
<td>3.5*</td>
<td>1.5*</td>
<td>3.8*</td>
<td>3.5*</td>
</tr>
<tr>
<td>Stability (min)</td>
<td>2.0*</td>
<td>2.6*</td>
<td>2.0*</td>
<td>2.8*</td>
<td>3.0*</td>
<td>2.9*</td>
<td>1.7*</td>
<td>3.1*</td>
<td>3.5*</td>
</tr>
</tbody>
</table>

0: unmodified treatment, 1: slightly alkaline treatment, 2: acidic treatment, Values with the same letter in a column are not significantly different at a P ≤ 0.05 level.
Extensograph results:

Three data of dough resistance (Rmax), dough extensibility (E) and coefficient of resistance (D) are derived from extensogram curve. Strengthening or weakening of glutenin or gliadin affect Rmax and E value and thus affect D value. For comparison of extensograph properties D value is more suitable criterion. The results showed that all treatments had positive effect on D value in compare with blank treatment. Heat treatment, high content of protein and high content of lactose had the most effect on increase of D value. High content of protein and particularly high content of casein had the least effect on increase of D value because of disturbance in gluten network.

Table 2: Effect of modified and unmodified dairy ingredients on the extensograph characteristics of wheat flour.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>treatments</th>
<th>mWPC2</th>
<th>mWPC1</th>
<th>UFWP2</th>
<th>NFDM1</th>
<th>UFWP2</th>
<th>UFWP0</th>
<th>WPC0</th>
<th>NFDM0</th>
<th>control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rmax(g)</td>
<td></td>
<td>211.80</td>
<td>136.53</td>
<td>169.28</td>
<td>108.37</td>
<td>115.51</td>
<td>133.50</td>
<td>54.86</td>
<td>26.90</td>
<td>30.64</td>
</tr>
<tr>
<td>E(mm)</td>
<td></td>
<td>82.22</td>
<td>81.11</td>
<td>142.78</td>
<td>128.33</td>
<td>143.33</td>
<td>192.22</td>
<td>130.00</td>
<td>131.11</td>
<td>161.67</td>
</tr>
<tr>
<td>D(g/mm)</td>
<td></td>
<td>2.58a</td>
<td>1.68b</td>
<td>1.19</td>
<td>0.84</td>
<td>0.80d</td>
<td>0.69a</td>
<td>0.42f</td>
<td>0.21e</td>
<td>0.19g</td>
</tr>
</tbody>
</table>

0: unmodified treatment, 1: slightly alkaline treatment, 2: acidic treatment, Values with the same letter in a column are not significantly different at a P ≤ 0.05 level

Staling test results (puncture test):

Tables 3 and 4 represent puncture test 1 hr and 72 hr after baking respectively. High percent of protein and heat modification caused that when mWPC1 or mWPC2 were added, bread texture was more rigid than other treatments 1 hr after baking. Addition of mWPC2 because of large number of chemical linkages between dairy proteins and negative effect of acidic pH represented bread with a texture more rigid in comparison with addition of WPC0. Moreover addition of mWPC1 because of large number of chemical linkages between dairy proteins and higher percentage of protein, represented bread with a texture more rigid in comparison with addition of mNFDM. Also Negative effect of acidic pH on bread texture was observed when mUFWP2 was added in comparison with addition of mUFWP1. After 72h control sample represented a texture more rigid than other treatments because the addition of dairy ingredients protected high content of water in bread texture. Acidic pH of mWPC2 and mUFWP2 had negative effect on bread texture. The mentioned negative effect counteracted after 72h in mWPC2 may be because of high percent of protein and in result protecting more water than UFWP2. High percent of lactose in UFWP treatments caused that binding of lactose and starch increases gelation temperature of starch and in result decreases staling rate of bread after 72h. Acidic pH of UFWP2 counteracted the effect of lactose in bread texture.

Table 3: Puncture test results immediately after baking.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>treatments</th>
<th>mWPC2</th>
<th>UFWP2</th>
<th>mWPC1</th>
<th>NFDM0</th>
<th>UFWP0</th>
<th>WPC0</th>
<th>NFDM1</th>
<th>UFWP2</th>
<th>UFWP0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average(N/mm²)</td>
<td></td>
<td>22.50a</td>
<td>21.97ab</td>
<td>21.29ab</td>
<td>19.81abc</td>
<td>17.21bcd</td>
<td>13.99bcd</td>
<td>11.94cd</td>
<td>10.34d</td>
<td>9.16d</td>
</tr>
</tbody>
</table>

0: unmodified treatment, 1: slightly alkaline treatment, 2: acidic treatment, Values with the same letter in a column are not significantly different at a P ≤ 0.05 level

Table 4: Puncture test results 72h after baking.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>treatments</th>
<th>control</th>
<th>UFWP2</th>
<th>mWPC1</th>
<th>NFDM0</th>
<th>UFWP0</th>
<th>WPC0</th>
<th>NFDM1</th>
<th>mWPC2</th>
<th>UFWP1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average(N/mm²)</td>
<td></td>
<td>35.12a</td>
<td>30.17ab</td>
<td>25.46bc</td>
<td>22.93cd</td>
<td>16.30de</td>
<td>15.08bc</td>
<td>14.98e</td>
<td>14.64e</td>
<td>7.11f</td>
</tr>
</tbody>
</table>

0: unmodified treatment, 1: slightly alkaline treatment, 2: acidic treatment, Values with the same letter in a column are not significantly different at a P ≤ 0.05 level

Sensory evaluation results:

The results showed that addition all types of UFWP treatments and modified milk had the most desirability. The flavor of mentioned treatments got the best scores while all WPC treatments got the least scores. The color of modified WPC treatments got the least scores and differences between two mentioned treatments and the others were quite significant.

Conclusion:

Addition of heat modified UFWP in slightly alkaline pH causes that bread texture remains very fresh and also the sensory properties of that be the most desirable. Of course the nutritional properties of dairy whey proteins are unavoidable and with carrying out the heat modification in suitable pH on whey powder with about 30 percent protein content can get additive with more suitable nutritional aspects besides the rheological effects. Also heat modified NFDM can decrease bread staling better than unmodified NFDM.
References


