

# *Effects of corn resistant starch on physicochemical properties of cake*

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**Abstract**— The present study focused on partial replacement of wheat flour with corn resistant starch (RS) at 10%, 20%, 30%, 40% and 50% levels in cake and its modification by gluten. Obtained results showed that it is possible to develop high quality cakes when adding up to 20% of RS. Higher levels of RS decreased the density and viscosity of batter and consequently decrease cake volume, height and textural parameters. Therefore gluten was added to improve its quality. Cakes with substitution of up to 40% of the wheat flour with RS in combination with gluten added on 10% RS weight basis, received high sensory scores.

**Keywords**- Resistant starch, cake, Batter, Gluten, Physicochemical properties

## I. INTRODUCTION

The concept of resistant starch includes starch and starch degradation products which withstand digestion in the small intestine of healthy individuals [3]. RS has been categorized into four types according to resistance properties. RS1: enzyme inaccessible starch; RS2: ungelatinized starch granules; RS3: retrograded gelatinized starch; RS4: chemically modified starch.

Resistant starch (RS) as a source of dietary fiber has attracted considerable attention during the last two decades due to its physiological functions [13]. Resistant starch decreases the risk of colon cancer, improves cardio-vascular health, prevents diabetes type II, lowers plasma triglyceride and cholesterol level, positively influences the operating of the gastrointestinal tract, and assists in the control of obesity. In addition to its beneficial impacts on human health, RS has functional advantages over traditional fiber sources. It has lower effect on the sensory properties of food, offers good water-binding capacity, viscosity, swelling power and gel formation, which make it find application in a variety of foods. [4, 5, 12].

The use of resistant starch in bakery products has been studied in bread, spaghetti, cakes, muffins, biscuits and battered fried products .

There have been large amounts of research on addition of different fiber sources to cakes such as oat and rice bran, corn bran, wheat bran, oat bran and cellulose microcrystalline, apple pomace. However, a few papers studied RS supplementation of cakes and have incorporated relatively low levels of RS.

The objective of this study was to incorporate high levels of RS in cake and investigate the physicochemical and sensory

changes that take place when flour is replaced by RS and modification of these changes by addition of gluten to the formulation.

## II. MATERIALS AND METHODS

### • Materials

Wheat flour, white fine sugar, low fat milk, sunflower oil, baking powder, vanilla and fresh whole eggs were purchased from the local market; gluten was obtained from Fars-Glucosin

Co., Marvdasht, Iran and corn resistant starch was supplied by Caren Food Ingredient Co. Tehran, Iran. The basic control layer cake has the following formulation: 320g flour, 240g sucrose, 180g whole eggs, 100g oil, 200g low fat milk, 10g baking powder, 1.5g vanilla

For RS enriched cakes 10%, 20%, 30%, 40% and 50% levels of wheat flour was replaced by RS. Gluten (10% of RS weight) was also added to formulations containing 30% or more RS.

### • Methods

#### A. Batter preparation

Egg, vanilla and sugar were whipped in a kitchen mixer (Moulinex, Model HM 1010, Beijing, China) at medium speed, for 2 minutes then milk was added and mixed for another 5 minutes, baking powder was mixed well with wheat flour and passed through a stainless steel screen (ASTME:11, Iran) and added gradually to the mixture. Finally the oil was added to the recipe and gently mixed.

#### B. Batter consistency

100 g of the batter at ambient temperature ( $20\pm 0.5^{\circ}\text{C}$ ) was poured in the reservoir of a Bostwick consistometer and allowed to stand for 2 minutes and then released to run along

the leveled trough. The results were reported as distance (cm) the front moved during 30 seconds. The higher values indicate lower batter consistency [11].

#### C. Batter density

Batter density was measured by dividing the weight of a standard container filled with batter to the weight of the container filled with an equal volume of distilled water [10].

#### D. Baking of cake

250 g of cake batter were placed into rectangular metallic pans (80mm width, 175 mm length and 50 mm height), and were baked in an electric oven (Nanerazavi Industrial, I.R.

Iran) for 35 min at 180°C. After baking, cakes were removed from the pans and left at room temperature for 1 h to cool down. Then, they were placed on polyethylene pouches and sealed to prevent drying.

### E. Cake height and volume

The cake height was measured using a digital caliper. Cake volume was determined using rapeseed displacement method 1 hour after removing from the oven as described by the Approved Methods of the AACC (2000) (Method No.10-10-B).

### F. Texture analysis

Crumb texture was determined by using a texture analyser (TA-XT2, Stable Micro System Ltd., Surrey, UK) which was interfaced with a computer, to control the instruments and analyses the data, equipped with the software "Texture Exponent Lite". Cake slices (30×30×30mm), were cut from the center of each cake and were placed on the platform of the Texture Analyser. An Aluminum 80mm diameter cylindrical probe was used in a "Texture Profile Analysis" (TPA) test to penetrate to 25% depth, at a pretest speed of 5 mm s<sup>-1</sup>, test speed of 0.25 mm s<sup>-1</sup>, time interval of 10s. Hardness, cohesiveness, springiness, gradient, gumminess and chewiness were calculated from the TPA graphic and taken as indications of texture.

### G. Sensory evaluation

The organoleptic characteristics of cakes were evaluated by 12 panelists (6 males and 6 females, age between 20-30 years). The panelists were asked to evaluate the cakes on the basis of acceptance of their color, texture, taste and overall quality on a 5-point hedonic scale. The scale of values ranged from 5 (like extremely) to 1 (dislike extremely) for each organoleptic characteristic.

### H. Statistical analysis

The experiments were performed in a completely randomized design and performed at least in triplicates. Analysis of variance (ANOVA) was used to study the differences between samples). Duncan's multiple range test (p<0.05) was used to determine the significances within treatments. Statistical analysis of the data was performed using the SPSS software (SPSS, Inc., USA).

## III. RESULTS AND DISCUSSION

### • Batter properties

Batter properties are shown in table 1. Batters incorporating RS showed lower consistencies than the control. By the increase in RS content a progressive decrease in batter consistency was observed. Less consistency indicates less complex batter structure, which may be associated with the dilution of the wheat flour protein in the system. Inclusion of gluten to the formulation increased batter consistency. The adsorption capacity of gluten improves cake viscosity and leads to uniform dispersion of ingredients in the batter [15]. The addition of RS to the batter reduced batter density. Batter density is an indicator of total air holding capacity but does not determine

the bubble size or dispersion [16]. Thus RS may have caused large bubble size in the batter. Large bubbles have low potential for expansion and will burst in the oven and baked cake will collapse [2]. Inclusion of gluten to cake batter increased the density. This behavior might be due to the reduction in air bubble size in presence of gluten.

### • Cake properties

As it is shown in table 1 replacement of flour with RS has caused a decrease in cake height and increased the density. Early gelatinization of starch is the key factor in cake volume and quality [7]. RS is not only resistant to digestion but also most food processing conditions and behaves only as a filler and couldn't be gelatinized during baking [8, 9]. Addition of gluten to the formulations with high levels of RS increased baking performance of cakes. Protein interactions and reactions in cake crumbs provided the cell walls with a resistance to collapse [15]. The volume of cakes with 50% RS and gluten was less than expected. This may be caused by deficiency in gelatinized starch in the cake.

Table1. Effect of RS on properties of batter and cake

Treatment	Bostwick number (cm)	Batter density (g/cm <sup>3</sup> )	Cake density (g/cm <sup>3</sup> )	Cake volume (cm <sup>3</sup> )	Cake height (cm)
control	8.6±0.10 <sup>a</sup>	1.017±0.01 <sup>a</sup>	0.376±0.006 <sup>e</sup>	552.7±2.5 <sup>a</sup>	4.71±0.04 <sup>a</sup>
10% RS	8.9±0.10 <sup>d</sup>	0.937±0.02 <sup>b</sup>	0.39±0.009 <sup>d</sup>	550.66±1.5 <sup>a</sup>	4.6±0.10 <sup>ab</sup>
20%RS	9.4±0.10 <sup>b</sup>	0.847±0.01 <sup>c</sup>	0.394±0.003 <sup>cd</sup>	542.33±2.5 <sup>b</sup>	4.33±0.06 <sup>c</sup>
30% RS	10.1±0.10 <sup>a</sup>	0.773±0.01 <sup>e</sup>	0.406±0.003 <sup>b</sup>	512.1±3 <sup>d</sup>	3.96±0.06 <sup>d</sup>
30% RS+G	9.1±0.20 <sup>cd</sup>	0.813±0.01 <sup>d</sup>	0.393±0.004 <sup>cd</sup>	540 ±3 <sup>b</sup>	4.5±0.10 <sup>b</sup>
40% RS+G	9.2±0.10 <sup>c</sup>	0.77±0.01 <sup>e</sup>	0.402±0.003 <sup>bc</sup>	525.66±1.5 <sup>c</sup>	4.23±0.06 <sup>c</sup>
50% RS+G	10.3±0.1 <sup>a</sup>	0.733±0.02 <sup>f</sup>	0.472±0.007 <sup>a</sup>	447 ±2.6 <sup>e</sup>	2.97±0.10 <sup>e</sup>

The textural parameters calculated from TPA test curves are presented in table 2. A marked decrease in hardness, gradient, springiness, cohesiveness, chewiness and gumminess was observed when wheat flour was replaced by RS and the changes were greater with larger substitution percentages. This behavior is due to RS incorporation and the dilution of gluten from wheat flour, resulting in an undeveloped gluten network; and also lack of gel formation by RS during baking process. Inclusion of gluten to the formulations increased textural parameters as gluten is a determinant of hardness.

Table 2. Effect of RS on textural properties of cakes

Treatment	Hardness (kg)	Gradient	Cohesiveness	Springiness	Gumminess(kg)	Chewiness (kg)
control	0.430±0.002 <sup>a</sup>	0.073±0.010 <sup>a</sup>	0.860±0.010 <sup>a</sup>	0.958±0.002 <sup>a</sup>	0.369±0.001 <sup>a</sup>	0.305±0.002 <sup>a</sup>
10% RS	0.310±0.002 <sup>b</sup>	0.057±0.003 <sup>b</sup>	0.83±0.003 <sup>b</sup>	0.948±0.001 <sup>b</sup>	0.258±0.002 <sup>b</sup>	0.204±0.002 <sup>b</sup>
20%RS	0.236±0.001 <sup>c</sup>	0.036±0.001 <sup>c</sup>	0.826±0.001 <sup>b</sup>	0.939±0.002 <sup>c</sup>	0.195±0.001 <sup>c</sup>	0.151±0.001 <sup>c</sup>
30% RS	0.107±0.002 <sup>ef</sup>	0.016±0.001 <sup>a</sup>	0.727±0.001 <sup>d</sup>	0.868±0.002 <sup>e</sup>	0.077±0.002 <sup>e</sup>	0.049±0.002 <sup>e</sup>
30% RS+G	0.160±0.002 <sup>d</sup>	0.028±0.001 <sup>d</sup>	0.746±0.001 <sup>c</sup>	0.933±0.002 <sup>d</sup>	0.120±0.002 <sup>d</sup>	0.083±0.001 <sup>d</sup>
40% RS+G	0.112±0.002 <sup>e</sup>	0.015±0.002 <sup>a</sup>	0.731±0.002 <sup>d</sup>	0.928±0.002 <sup>e</sup>	0.082±0.001 <sup>e</sup>	0.056±0.001 <sup>e</sup>
50% RS+G	0.102±0.002 <sup>f</sup>	0.016±0.002 <sup>a</sup>	0.644±0.002 <sup>e</sup>	0.754±0.002 <sup>f</sup>	0.066±0.001 <sup>f</sup>	0.032±0.001 <sup>f</sup>

Fig. 1 shows the impact of RS supplementation on organoleptic properties of cakes. Addition of RS improved the taste and increased the sweetness of cakes which was loved by consumers. Incorporation of RS imparts softness and tenderness to cake texture which was favorable for consumers. However, inclusion of 30% RS significantly decreased the texture score. Gluten was so useful in texture improvement of cakes containing 30 and 40% of RS but did not modify cakes with 50% RS. Crumb and crust color hardly influenced by addition of up to 40% RS but 50% substitution decreased the color score. Cakes containing up to 40% RS were acceptable for consumer but they did not love cakes with 50% RS

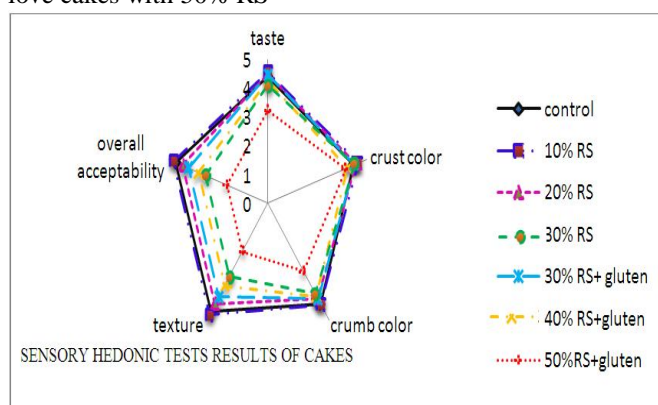


Figure 1. Sensory hedonic test results

#### IV. CONCLUSION

Based on the results obtained, it may be concluded that RS can be used as a dietary fiber in cake formulation due to its physiological effects on human health. However addition of high levels of RS (i.e. more than 30%) has some undesirable effects on physicochemical properties of cake which can be

minimized by addition of gluten to the recipe and it is possible to replace higher levels of flour with resistant starch.

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