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Influence of Corn and Millet Starches as Fat Substitutes on Cake Quality

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Abstract: Current dietary guidelines focus on lowering dietary fat and increasing complex carbohydrate intake. In the present study, two grain starches corn and millet were used to produce resistant starch (RS) and used as partially fat replacer (at 12.5, 25, 37.5 and 50%) in cakes. The effect of the level of fat substitution on the physicochemical and sensory properties as well as starch digestibility and shelf life of the cakes were investigated. The study showed that moisture content of the products was increased by increasing the level of fat substitution. The caloric values of produced cakes were lower than that of control. The specific volume of cakes were higher at 12.5 and 25% fat replacement levels. In contrast, cake density decreased by increasing shortening replacement level up to 25%, it was lower and reached 0.38g cm^{-3} in relative to control (0.41g cm^{-3}). TPA values cleared that cake prepared with 12.5 and 25% substitution levels were less hardness. Increasing the replacement level more than 25% increased the cake hardness, gumminess and chewiness. Results of color analysis showed a significant increase in L value and a decrease in b value. The highest decrement in starch digestibility was observed at 50% replacement level. The use of (RS) does not change the taste and improve sensory properties of produced cakes. The shelf life based on the microbial examination of the cake for all samples and control recorded 2 weeks.

Keywords: Corn, Millet, RS, Fat, Calorie, TPA, Analysis, Shelf Life

1. Introduction

In a report of a Joint FAO/WHO Expert Consultation, resistant starch is defined as dietary fiber as well as resistant starch that escapes digestion in the human small intestine appears to have a unique combination of physiological and functional properties compared to traditional types of fiber. Namely, the consumption of high amount of resistant starches may improve glucose and lipid metabolism, can reduce the risk of diabetes mellitus type 2, coronary, and heart diseases as well as colorectal cancer and other gastrointestinal disorders [1].

Resistant starch has been classified into four general subtypes called RS1, RS2, RS3 and RS4 [1]. In a study on humans. The consumption of resistant starch type III (RS3) resulted in lower serum glucose and insulin levels than obtained with other carbohydrates [2]. The study also showed that food containing RS decreased postprandial blood glucose and might play a role in providing improved metabolic control in type II diabetes [3]. Most rich food is characterized and dominated by the high-glycemic effect, which has been associated with an increased risk of chronic disease like obesity, cardiovascular disease and some kind of cancers [4]. A reduction in the glycemic response of carbohydrate food appears to be accompanied by a higher content in resistant starch [5], and RS type III promotes slow to moderate post-prandial glucose and insulin response [6].

RS3 refers to non-granular starch-derived materials that resist digestion. Starch granules are disrupted by heating in an excess of water in a process commonly known as gelatinization, which renders the molecules fully accessible to digestive enzymes.

However, if these starch gels are then cooled (retrogradation), they form starch crystals that are resistant to enzymes digestive. It may formed in cooked food that are kept at low or room temperatures, therefore, most moisture heat treated foods contain some RS3 [1]. RS3 is of particular interest, because of its thermal stability [7, 3, 1].

Additionally, resistant starches have desirable physicochemical properties making it useful in a variety of foods. Moreover, resistant starches do not significantly influence the sensory properties of starch-based products (bread, pasta, cookies, pudding, yoghurt etc.). The demand for the application of resistant starch as a functional ingredient is growing. Thus, the analysis of its structural, thermal, rheological and digestibility properties have a great importance [1].

Fat is one of the important ingredients influencing the sensory characteristics of baked products. Attempts have been done to replace the fat with other food components in baked products to reduce the total calories as well as to enhance nutritional properties. Among the substituting materials, carbohydrates are widely used in baked products, partly because they have economical advantages over many other fat substitutes [8].

The optimum conditions of moisture content, pH, temperature, duration of heating, repeated heating–cooling cycles, etc., make the content of RS may reached as much as 30%. RS is shown to improve eating qualities [9]. The physical properties of resistant starch, particularly its good water-holding capacity, make it a functional ingredient that provides good handling and improves texture in the final product [10].

There is also an increasing interest in using resistant starch (RS) to lower the energy value and available carbohydrate content of foods [11]. Resistant starch provides many technological properties, such as better texture appearance and mouthfeel than conventional fibers [12].

Bakery products constitute one of the most consumed foods in the world. Among them, cakes are popular and are associated in the consumer's mind with a delicious sponge product with desired organoleptic characteristics [13].

The butter cake is a complex fat and water emulsion system containing flour, sugar, fat, eggs and baking powder. A proper combination of these ingredients could give a high quality cake product with desirable flavor and texture [14]. However, due to its high glycemic index, over-consumption may contribute to chronic diseases. The glycemic indices of cake products vary continuously from about 67 to 87% [15]. In addition the baking industry has responded to the demands of consumers by developing low- or reduced-fat products. Low-fat products normally contain fat substitutes and are produced using formula or processing modifications [16].

The objective of this study is to investigate the impact of partially fat substitution of cake by corn and millet resistant starch (RS) on physicochemical and sensory attributes in the tasted cake samples.

2. Materials and Methods

2.1. Materials

Wheat flour, white fine sugar, skim milk, shortening, baking powder, vanilla and fresh whole eggs were purchased from the local market. The corn starch was obtained from Egyptian company of Starch and Glucose, Turra factory, Cairo, Egypt. Organic white creamy millet grain produced in USA.

2.2. Methods

2.2.1. Isolation of Millet Starch

Millet starch was isolated according to the method of Bhupender *et al*., (2013) [17]. Briefly, Millet grains were steeped in distilled water (w:v, 1:2) at 4°C for 24 h. The excess water was decanted and the steeped and washed grains were ground in a Warning blender with sufficient water. The slurry was sieved on 85 mesh nylon bolting cloth. The left-overs (hulls, germ and endosperm) were reslurried with sufficient water to float off the germ and hulls. The grinding, sieving and regrinding for the left over endosperm particles was repeated until the left-overs were essentially free of starch. The starch-protein slurry was centrifuged at 2000 rpm for 20 min. The supernatant was discarded and the protein layer on top of the starch removed with spatula. The starch was repeatedly washed by re-dispersing inadequate distilled water amounts and centrifuging until it became clean. The cleaned starch was air-dried on a glass plate for 12 hr, re-dispersed in water and wet-sieved through 100- mesh screen. The starch passing through the screen was recovered by centrifugation (2000 rpm, 20 min; and dried in hot air oven at 40°C.

2.2.2. Resistant Starch Preparation (RS)

Corn and millet starch are used to produce RS. The method of RS prepared was adapted according to Sievert and Pomeranz (1989) [18]. Starch sample (200 g) was weighed into a 1, 000-ml beaker and mixed with 700 ml of distilled water. The starch-water suspension was autoclaved at 20 psi (125 C) for 1 hr. After autoclaving, the sample was cooled to room temperature. After three autoclaving-cooling cycles, RS stored overnight in a refrigerator at 4 ± 1C. (Lin Po-Ying *et al*., 1994) [19].

2.2.3. Cake Preparation

Cakes were prepared according to the formula of Lin Po-Ying *et al*., (1994) [19]. The cake formula is listed in Table (1). The control cake was prepared by mixing the sugar and shortening were creamed for 3 min at speed 5 in an kitchen aid mixture. The whole eggs were added and mixed in at the same speed for 2 min. The flour, baking powder and skim milk were add and the batter was mixed for 4 min. at speed 2. To prepare the replacer cakes the shortening (fat weight basis) in the formula was replaced with corn and millet RS (0, 12.5, 25, 37.5 and 50%). Cake batter was placed in cupcake model and was baked in an electric oven for 35 min at 180°C. After baking, cakes were removed from the pans and left at room temperature for 1 hr. to cool down. Then, were placed on polyethylene pouches and sealed to prevent drying.

Table 1. *Cake Formula ingredients.*

Ingredient	Amounts
Wheat flour	100g
Salt	2.0g
Shortening	40-20g
Sugar	90g
Baking powder	5.0g
RS (starch gel)	0-20
Whole eggs	44g
Skim milk	71ml
Vanilla	0.5g

2.2.4. Analytical Methods

The proximate chemical composition, *ie.* moisture, crude protein, total fat and ash of raw materials and cake samples were determined according to AOAC (2005) [20]. Total carbohydrate were calculated by difference. *In vitro* starch digestibility was assessed by following the method of Singh *et al*., (2006) [21]. Total calories of cake were calculated by the following equation as reported by James (1995) [22].

$$Energy\ value\ =\ 4\ (g\ protein\ +\ g\ carbohydrates)\ +\ 9\ (g\ fat)$$

2.2.5. Physical Measurements of Cake

Cake weight (g) was recorded after cooling for 1hr. Cake volume (cm^3) was determined by rapeseed displacement method as described by AACC (2002) [23]. Specific volume (g cm^{-3}) of cake was calculated by dividing volume by weight. Density (g cm^{-3}) was calculated by dividing weight by volume**.**

2.2.6. Texture Profile Analysis (TPA) of Cake

Hardness, cohesiveness, adhesiveness, gumminess and chewiness of cupcakes were measured using Brookfield Engineering Lab. Inc., Middleboro, MA 02346- 1031 USA. The cupcake was sliced in half across its diameter and a 25 mm wide longitude slice was taken from one of the halves. The measurement was taken at three different side points from the left, center and right perpendicular to the slice, with 40% compression based on AACC (2002) [24] method 74-09.01.

2.2.7. Color Evaluation

The color of cake crumb was measured according to the method outlined by McGurie (1992) [24]. Crumb color was measured on opposite sides of cake by using a hand-held tristimulus reflectance Colorimeter Minolta Chroma Meter (model CR-400, Konica Minolta, Japan). The apparatus provided L (lightness with L = 100 for lightness, and L = zero for darkness), a [(chromaticity on green (−) to red (+)], b [(chromaticity on a blue (−) to yellow (+)].

2.2.8. Sensory Evaluation of Cake

Freshly prepared cake samples were organoleptically evaluated immediately after baked for their sensory characteristics. Slice of each cake sample was served to well trained ten panelists on white, odorless and disposable plates. Samples were scored for shape, crust color, crust vision characteristics, crumb color, brightness, crumb texture, softness, taste, odor and total score (sum of all the tested attributes). The evaluation was carried out according to Bennion and Bamford (1983) [25].

2.2.9. Microbiology

The microbiological quality of stored cake for 3 weeks at an ambient temperature was evaluated by determining total fungal count (1gm sample) using malt yeast agar media to be as a good tool to estimate the shelf life according to Mislivec *et al*., (1992) [26] and aerobic plate count using total count media (Swanson *et al*., 1992) [27].

2.2.10. Statistical Analysis

For the analytical data, mean values and standard deviation are reported. The obtained data were subjected to one-way analysis of variance (ANOVA) at $P < 0.05$. It was performed and the results were separated using the Multiple Range Duncan's test using the SAS (1987) [28] statistical software.

3. Results and Discussion

3.1. Proximate Analysis of Cake

The proximate composition of the cake samples replaced with different levels of corn and millet resistant starch (RS) are presented in *Table 2.* Cake samples containing (12.5, 25, 37.5, and 50%) resistant starch were observed to have higher moisture content than the control. Increment resistant starch levels had been shown to increase the moisture content of cake samples, ranged from 25.24 to 28.86 and 29.91% in cake samples replaced with corn and millet RS, respectively. The reason is may be attributed to the good water binding capacity of the resistant starch. These results are agreement with (Majzoobi *et al*., 2014) [29]. Results showed no significant differences in protein content between control and cake samples.

Table 2. *Chemical composition of cake (%dry weight).*

Sample	Moisture%	*Protein%	*Fat%	*Ash%	*T. C%	*Calories
1	25.24 f	11.04b	18.48a	1.60f	68.88h	486.00a
2	25.89 e	11.72a	15.54c	1.83b	70.91g	470.36c
3	28.06d	11.79a	12.72e	1.83b	73.65d	456.23e
4	28.50c	11.19b	11.94fg	1.87a	75c	452.22g
5	28.86b	11.04b	10.89h	1.88a	76.18a	446.89h
6	26.00e	11.04 b	15.94b	1.70d	71.33f	472.88b
7	28.54c	11.10 b	13.93d	1.70d	73.27e	462.79d
8	28.91b	10.89 b	12.21f	1.64e	75.25bc	454.45f
9	29.91a	11.04 b	11.83g	1.75c	75.38b	452.17g

1= un replaced cake, 2=12.5%fat replacement cake with corn RS, 3=25% fat replacement cake with corn RS, 4=37.5% fat replacement cake with corn RS, 5 = 50% fat replacement cake with corn RS, 6 = 12.5% fat replacement cake with millet RS, 7= 25% fat replacement cake with millet RS, 8 = 37.5% fat replacement cake with millet RS and 9= 50% fat replacement cake with millet RS.

*Protein, fat, ash, total carbohydrate (T. C) and total calorie content are calculated on dry basise.

Data are averages from three independent trials

Data in the same column with different letters are significantly different ($p<0.05$)

Slight changes were observed in ash content compared with control. Fat content decreased linearly with substitution replacement level. The total carbohydrate content increased significantly with increasing the replacement level. The calories reduced from 486Kcal. in control cake to 456.23 in cake replaced with 25% corn RS, while calories reduced to 462.79Kcal. in cake replaced with millet RS. Thus adding corn or millet RS as fat replacer succeeded to reduce the energy of produced cake which were favorably, compensated the cake product. The use of resistant starch in the diet as a bioactive functional food component is a natural, endogenous way in reducing energy intake, so may be an effective natural approach to the treatment of obesity [30].

3.2. Physical Properties of Cake

Physical Properties of Cake replaced with corn and millet resistant starch as fat replacer are shown in Table 3. It showed that cake in which 12.5% and 25% of shortening was replaced by corn resistant starch had the highest cake volume 145 and 143 cm^3 compared with control cake 135 cm^3. Cake volume decreased as the replacement level increased. Specific volume was also increased at 12.5% and 25% replacement levels, it reached 2.57 and 2.60 g cm^{-3} compared with control 2.40 g cm^{-3}. On contrary the cake density decreased by increasing shortening replacement level up to 25%. The lowest density was observed at the level of 25% corn RS, it reached 0.38 g cm^{-3} compared with control 0.41 g cm^{-3}.

Regarding to millet resistant starch (as shortening replacer) the results revealed that the volume of cake replaced with millet resistant starch increased by increasing the replacement level up to 37.5% which had the highest value 141.33cm^3 compared with 135.67cm^3 in control cake. Similar trend was observed in specific volume, it reached 2.48 g cm^{-3} at 37.5% replacement level then it decreased at 50%. The cake density decreased by increasing shortening replacement level up to 25%. The replaced cake at 25% and 37.5% had the same density 0.40g cm^{-3} compared with 0.41 g cm^{-3} in control.

From above mention data, these results suggested that 12.5% and 25% of corn resistant starch (as shortening replacement) have similar ability to retain air during cake baking while in case of millet resistant starch (as shortening replacement), 37.5% had ability to retain more air during baking.

Table 3. *Physical properties of cake.*

Sample	Volume (cm^3)	Weight (g)	Specific volume (g cm^{-3})	Density (g cm^{-3})
1	135.67d	56.30a	2.40e	0.41b
2	145.67a	56.80 a	2.56b	0.39e
3	142.67 b	54.35b	2.62a	0.38f
4	130.00e	53.94 b	2.40e	0.41b
5	128.67e	54.55 b	2.35f	0.42a
6	136.33d	56.44 a	2.41e	0.41b
7	139.67c	57.12 a	2.44d	0.40c
8	141.33bc	57.09 a	2.48c	0.40c
9	136.33d	56.84 a	2.39e	0.41b

1= un replaced cake, 2=12.5%fat replacement cake with corn RS, 3=25% fat replacement cake with corn RS, 4=37.5% fat replacement cake with corn RS, 5= 50% fat replacement cake with corn RS, 6= 12.5% fat replacement cake with millet RS, 7= 25% fat replacement cake with millet RS, 8= 37.5% fat replacement cake with millet RS and 9= 50% fat replacement cake with millet RS.

Data are averages from three independent trials

Data in the same column with different letters are significantly different ($p<0.05$)

3.3. Texture Profile Analysis (TPA) of Cake

Resistant starch have a good water binding capacity, viscosity, swelling power and gel formation, which make it fine application in a variety of foods [1, 31-32]. It is known that one of the roles of fat in cake is the incorporation and stabilization of air cells [33-34]. So the decrease in cake volume was expected as the more replacement of the shortening was done. The textural parameters analysis from TPA test are presented in Table 4. Cake prepared with 12.5% and 25% corn resistant starch replacer level were more softer (less hardness) than that of control cake. In addition cakes prepared with the replacer at 37.5 and 50% replacement levels were harder than control cake.

These results were in agreement with those obtained by Paraskevoulou and Kiosseoghou (1997) and khalil (1998) [35-36] who reported that cakes prepared with fat replacers at

25% level were softer than control.

Table 4. *Texture profile analysis (TPA) of cake.*

Sample	Hardness (kg)	Cohesiveness	Gumminess (kg)	Chewiness (kg)	Springiness
1	0.88[e]	0.61[ef]	0.53[e]	0.45[e]	0.83[c]
2	0.74[g]	0.61[f]	0.45[g]	0.36[g]	0.79[d]
3	0.69[i]	0.61[de]	0.42[h]	0.33[h]	0.79[d]
4	0.96[c]	0.63[b]	0.61[c]	0.48[c]	0.80[d]
5	0.99[b]	0.63[b]	0.63[b]	0.57[b]	0.91[a]
6	0.78[f]	0.61[d]	0.48[f]	0.36[f]	0.75[e]
7	0.72[h]	0.63[c]	0.45[g]	0.33[h]	0.74[e]
8	0.88[d]	0.63[ab]	0.56[d]	0.48[d]	0.85[b]
9	1.1[a]	0.64[a]	0.70[a]	0.58[a]	0.83[c]

1= un replaced cake, 2=12.5%fat replacement cake with corn RS, 3=25% fat replacement cake with corn RS, 4=37.5% fat replacement cake with corn RS, 5= 50% fat replacement cake with corn RS, 6= 12.5% fat replacement cake with millet RS, 7= 25% fat replacement cake with millet RS, 8= 37.5% fat replacement cake with millet RS and 9= 50% fat replacement cake with millet RS.
Data are averages from three independent trials
Data in the same column with different small letters are significantly different ($p<0.05$)

Cohesiveness quantifies the internal resistance of food structure. It is the ability of a material to stick to itself. The TPA results showed no significant differences between control and replaced cake when corn starch resistant (as fat replacer) was used.

Gumminess is determined by hardness multiplied by Cohesiveness. The TPA results showed a decrease in gumminess at 12.5 and 25% replacement levels. While it increased by increasing the level of replacement, the TAP results showed a decrease in cake springiness as the level of fat replacer increased.

Regarding to millet resistant starch (as a fat replacer). The TPA results showed a decrease in hardness at 12.5 and 25% replacement levels, while cake of 37.5% replacement level had a similar hardness to control. In addition, TPA results showed an increase in hardens of cake at 50% replacement level.

The results showed an increase in cohesiveness of cakes with increasing the replacement level. Gumminess Chewiness was decreased at 12.5 and 25% replacement level, then they increased with increasing replacement level.

In general, increasing the replacement level more than 25% caused an increase in hardness, gumminess and chewiness where as the springiness was decreased. No significant differences in cohesiveness of cake replaced with corn resistant starch but it insignificantly increased with increasing the replacement level of millet resistant starch.

3.4. Starch Digestibility of Produced Cake

In vitro starch digestibility of cakes prepared with corn and millet RS (as shortening replacement) are shown in Table 5. As compared with control, cake in which 12.5% of shortening was replaced by corn or millet resistant starch showed insignificant differences on starch digestibility. While increase the replacement level to 25% lowered the starch digestibility from 83.5 to 78.5%. The highest reduction in starch digestibility was observed at 50% corn and millet RS replacement level.

Table 5. *Starch digestibility of produced cake.*

Sample	Starch digestibility %
1	83.50[a]
2	83.00[a]
3	78.50[b]
4	76.25[bcd]
5	74.75[de]
6	82.50[a]
7	78.25[bc]
8	76.00[cd]
9	73.00[e]

1= un replaced cake, 2=12.5%fat replacement cake with corn RS, 3=25% fat replacement cake with corn RS, 4=37.5% fat replacement cake with corn RS, 5= 50% fat replacement cake with corn RS, 6= 12.5% fat replacement cake with millet RS, 7= 25% fat replacement cake with millet RS, 8= 37.5% fat replacement cake with millet RS and 9= 50% fat replacement cake with millet RS.
Data are averages from three independent trials
Data in the same column with different letters are significantly different ($p<0.05$)

Resistant starch could be produced from retrogradation of gelatinized starch and known as a resistant starch type III (RS3) which has been cause a reduction in glycemic response due to possibility to increase the resistance towered digestive enzymes [37-38]. The glycemic indices of cake products vary continuously from about 67 to 87% [15].

Slowly digestible starch content was increased by autoclaving cooling cycle method. Slowly digestible starch, an important starch derivative could be obtained by modification of starch [39].

3.5. Color of Cake Crumb

Table 6 presents the results of the color of produced cakes. The color of starch affects the color of the finished product. A bright white color starch is more desirable for product development. The L value was a parameter for characterizing starch color, its lightness and it was a direct measurement of its whiteness. The L value close to 100 indicates whiteness. The chromaticity coordinate a, which ranges from -60 (green) to +60 (red), the chromaticity coordinate b, which ranges from -60 (blue) to +60 (yellow) indicated a higher in density of yellow [39]. Color changes gives information about the extent of browning reaction such as carmalization. Millard reaction, degree of cooking and pigment degradation that take place during the starch extraction process [40].Replacement of fat with RS resulted in a significant increase in L values while revealed a decrease in b values, indicating lighter and less yellowish crumb. RS is a white color and hence acts in diluting the pigments components of the cake formulation. Therefore, the lightness of the cake samples increased with increase in the RS level.

Table 6. *Color of cake crumb.*

Sample	L	A	B	Color
1	69. 2^{h}	-4.29^{d}	24.51f^{g}	L. Y
2	74.95^{c}	-3.59^{e}	24.63^{f}	V. L. Y
3	75.02^{c}	-3.42^{f}	27.19^{d}	V. L. Y
4	76.06^{b}	-3.25^{g}	28.62^{b}	V. L. Y
5	77.31^{a}	-3.17^{h}	29.59^{a}	V. L. Y
6	71.52^{g}	-4.68^{c}	27.93^{c}	V. L. Y
7	72.69^{f}	-4.90^{b}	26.74^{e}	V. L. Y
8	73.10^{e}	-4.93^{b}	24.58^{f}	V. L. G. Y
9	74.32^{d}	-5.02^{a}	24.21^{g}	V. L. G. Y

1= un replaced cake, 2=12.5%fat replacement cake with corn RS, 3=25% fat replacement cake with corn RS, 4=37.5% fat replacement cake with corn RS, 5= 50% fat replacement cake with corn RS, 6= 12.5% fat replacement cake with millet RS, 7= 25% fat replacement cake with millet RS, 8= 37.5% fat replacement cake with millet RS and 9= 50% fat replacement cake with millet RS.

L= Degree of whiteness (white + 100 ↔ 0 black); a: Degree of redness (red + 100 ↔ –80 green); b: Degree of yellowness (yellow + 70 ↔ – 80 blue)

L. Y=Light yellow, V. L. Y=Very light yellow, V. L. G. Y=Very light greenish yellow

Data are averages from three independent trials

Data in the same column with different letters are significantly different ($p<0.05$)

Crumb color is affected by constituents in the cake formulation [41]. RS (as shortening replacers) had a white color and hence acts in dilution the pigmented components such as fat and eggs in cake formula. Thus the lightness of cakes increased with increment the shortening replacement level. Similar results also reported by Baixauli *et al*., (2008) [42] related to the resistant starch containing muffins.

3.6. Sensory Evaluation of the Tested Cake

Sensory evaluation score of the tested cakes attributes are illustrated in Table 7. The results showed that there are no significant differences among replaced samples in shape and crust color. There are also insignificant differences between samples and control in crust characteristics, On the other hand, there are no significant differences in crumb color and brightness between samples and control in case of utilization of the corn RS as a replacer. On contrary crust characteristics decrement of the replaced cake was non significantly as increasing the level of millet fat replacer. Crumb texture also showed a non significantly decrease with increasing the level of both type fat replacements. Taste was slightly decreased in replaced cake samples at 37.5 and 50% level compared with control, but there were no significant differences between replaced cake at 12.5 and 25% by the two replacers in relative to control cake. It observed that cakes prepared with 12.5 and 25% fat replacers had higher mean scores for over all acceptability of both the tested replacers.

It is difficult to get the sensory properties of fat in low moisture bakery food like cookies, espicially in a final moisture between 3-4%. Normally, increased levels of water are needed to replace high levels of fat, and means of stabilizing the extra water is necessary [16].

Table 7. *Sensory evaluation of the tested cake.*

S	Shape	Crust color	Crust character	Crumb color	brightness	Crumb texture	Softness	Taste	Odor	OAA*
1	9.40^{a}	9.60^{a}	9.60^{a}	9.60^{a}	9.60^{a}	9.20^{a}	9.60^{ab}	14.80^{a}	14.60^{a}	96.00^{a}
2	9.30^{a}	9.50^{ab}	9.60^{a}	9.40^{a}	9.30^{ab}	9.40^{a}	9.50^{ab}	14.60^{ab}	14.40^{a}	95.00^{a}
3	8.90^{a}	9.50^{ab}	9.40^{a}	9.40^{a}	9.10^{ab}	9.50^{a}	9.60^{ab}	14.20^{ab}	14.00^{ab}	93.60^{ab}
4	8.80^{a}	9.20^{ab}	9.40^{a}	9.10^{a}	8.90^{ab}	9.10^{a}	9.00^{bc}	13.80^{ab}	13.40^{ab}	91.00^{ab}
5	8.60^{a}	8.60^{ab}	8.90^{a}	8.60^{a}	8.30^{b}	9.00^{a}	9.00^{bc}	13.40^{b}	13.00^{b}	87.40^{b}
6	9.30^{a}	9.70^{a}	9.20^{a}	9.80^{a}	9.80^{a}	9.20^{a}	9.30^{abc}	14.40^{ab}	14.40^{a}	95.50^{a}
7	9.30^{a}	9.40^{ab}	8.80^{a}	9.50^{a}	9.50^{a}	9.60^{a}	9.60^{ab}	14.10^{ab}	14.00^{ab}	93.60^{ab}
8	9.10^{a}	9.10^{ab}	8.60^{a}	9.40^{a}	9.10^{ab}	9.20^{a}	9.70^{a}	13.90^{ab}	14.00^{ab}	91.90^{ab}
9	9.00^{a}	8.80^{ab}	8.60^{a}	9.00^{a}	9.10^{ab}	8.80^{a}	8.80^{c}	13.60^{ab}	13.80^{ab}	89.50^{ab}

*OAA= Over all acceptability

1= un replaced cake, 2=12.5%fat replacement cake with corn RS, 3=25% fat replacement cake with corn RS, 4=37.5% fat replacement cake with corn RS, 5= 50% fat replacement cake with corn RS, 6= 12.5% fat replacement cake with millet RS, 7= 25% fat replacement cake with millet RS, 8= 37.5% fat replacement cake with millet RS and 9= 50% fat replacement cake with millet RS.

Data are averages from three independent trials

Data in the same column with different letters are significantly different ($p<0.05$)

Cakes prepared by using 25 or 50% fat replacers had higher mean scores for flavor, softness and eating quality than control [36]. The use of resistant starches as food ingredients typically does not change the taste or significantly change the texture, but may improve sensory properties compared with many of the traditionally used fibers, such as bran and gums [3].

3.7. The Microbial Quality of Cake

Post-baking contamination can result in the spoilage of certain baked goods if they are un-properly stored for prolonged time. Molds is one of the most common forms of spoilage for baked goods. Foods are spoiled when they contained more than 10^7 or 10^5 CFU. ml^{-1} or g^{-1} of bacteria or molds, respectively [43].

Table 8 displays the total bacterial count of various concentrations of starch on in cake during storage at room temperature for 3 weeks to be a suitable monitor for the shelf life of the product. It showed an increase in log bacterial count by increasing storage time of all samples. Similar trend was found in control. No significant differences (5% level) in total bacterial count among control and12. 5, 25, 37. 5 and 50% corn RS samples during storage period. The same trend was showed in millet RS replaced samples, where these samples had total bacterial count less than 107 CFUg^{-1}. These results are in agreement with those reported by Bazaraaa *et al*., (2005) [44] who found that, the control samples of cake recorded 5.3 CFUg^{-1} after 3 weeks which was less than in the rejacted values (107 CFUg^{-1}).

Table 8. *Total bacterial count in fat replaced cake during storage at room temperature.*

Sample	0 time	1 week	2 week	3 week
1	1.89^{ad}	2.97^{ac}	4.90^{ab}	5.87^{ba}
2	1.87^{ad}	2.87^{ac}	4.90^{ab}	6.23^{aba}
3	1.86^{ad}	3.00^{ac}	5.10^{ab}	6.23^{aba}
4	1.87^{ad}	2.97^{ac}	5.00^{ab}	6.13^{aba}
5	1.89^{ad}	3.01^{ac}	5.03^{ab}	6.22^{aba}
6	1.88^{ad}	2.89^{ac}	4.93^{ab}	6.25^{aba}
7	1.85^{ad}	3.00^{ac}	5.03^{ab}	6.26^{aba}
8	1.82^{ad}	2.97^{ac}	4.97^{ab}	6.25^{aa}
9	1.83^{ad}	2.80^{ac}	4.93^{ab}	6.32^{aa}

1= un replaced cake, 2=12.5%fat replacement cake with corn RS, 3=25% fat replacement cake with corn RS, 4=37.5% fat replacement cake with corn RS, 5= 50% fat replacement cake with corn RS, 6= 12.5% fat replacement cake with millet RS, 7= 25% fat replacement cake with millet RS, 8= 37.5% fat replacement cake with millet RS and 9= 50% fat replacement cake with millet RS.
Data are averages from three independent trials
Data in the same column with different small letters are significantly different ($p<0.05$)

Table 9 showed the log fungal count in fat replaced cake during storage for 3 weeks at room temperature. Data showed the count was increased by increasing storage period (3 weeks) in all samples.

Table 9. *Log fungal count in fat replaced cake during storage at room temperature.*

Sample	0 time	1 week	2 week	3 week
1	0.48^{ad}	1.95^{ac}	4.40^{ab}	7.32^{aa}
2	0.48^{ad}	2.00^{ac}	4.47^{ab}	7.67^{aa}
3	0.47^{ad}	1.90^{ac}	4.67^{ab}	7.31^{aa}
4	0.47^{ad}	2.00^{ac}	4.43^{ab}	7.23^{aa}
5	0.47^{ad}	2.00^{ac}	4.57^{ab}	7.37^{aa}
6	0.47^{ad}	1.95^{ac}	4.69^{ab}	7.44^{aa}
7	0.47^{ad}	2.00^{ac}	4.71^{ab}	7.62^{aa}
8	0.47^{ad}	1.97^{ac}	4.58^{ab}	7.28^{aa}
9	0.47^{ad}	1.97^{ac}	4.64^{ab}	7.32^{aa}

1= un replaced cake, 2=12.5%fat replacement cake with corn RS, 3=25% fat replacement cake with corn RS, 4=37.5% fat replacement cake with corn RS, 5= 50% fat replacement cake with corn RS, 6= 12.5% fat replacement cake with millet RS, 7= 25% fat replacement cake with millet RS, 8= 37.5% fat replacement cake with millet RS and 9= 50% fat replacement cake with millet RS.
Data are averages from three independent trials
Data in the same column with different small letters are significantly different ($p<0.05$)

From the obtained results, it could be observed that, the control sample was spoiled when stored for 3 weeks, where total fungal count recorded 7.32 CFUg^{-1}. Same result were recorded for other samples. So, the shelf life of the cake for all samples and control recorded 2 weeks where these samples had total fungal count less than 10^5 CFUg $^{-1}$.

4. Conclusions

Fat in cake formula can be partially replaced with corn and millet resistant starch (RS) up to 25% to produce high quality low caloric cake. The caloric values of produced cakes were reduced by increasing levels of replacement. White creamy millet succeeded to produce modified starch with light color that suitable to produce high quality cake similar to corn starch. It is recommended to increase the cultivation in light color millet cultivars in Egypt to be introduced in food industry development. Low starch digestibility and low calorie content of produced cakes have a positive effect for people with obesity, type II diabetes and cardiovascular problems. Thus it is recommended that the resistant starch (RS) could collaborate with bakery products to improve public health.

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