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The Effects of Applying Wash and Green-A Syrups as Substitution of Sugar on Dough and Cake Properties

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Abstract**—**Usage of different components has been considered to improve the quality and nutritional properties of cakes in recent years. The effects of applying some sweeteners, instead of sugar, have been evaluated in cakes and many bread formulas up to now; but there has not been any research about the usage of by-products of sugar factories such as Wash and Green-A Syrups in cake formulas. In this research, the effects of substituting 25%, 50%, 75% and 100% of sugar with Wash and Green-A Syrups on some dough and cake properties, such as pH, viscosity, density, volume, weight loss, moisture, water activity, texture, staling, color and sensory evaluations, are studied. The results of these experiments showed that the pH values were not significantly different among any of the all cake batters and also most of the cake samples. Although differences among viscosity and specific gravity of all treatments were both significant and insignificant, these two parameters resulted in higher volume in all samples than the blank one. The differences in weight loss, moisture content and water activity of samples were insignificant. Evaluating of texture showed that the softness of most of samples is increased and the staling is decreased. Crumb color and sensory evaluations of samples were also affected by the replacement of sucrose with Wash and Green-A Syrups. According to the results, we can increase the shelf life and improve the quality and nutritional values of cake by using these kinds of syrups in the formulation.

Keywords**—**Cake, green-A syrup, quality tests, sensory evaluation, wash syrup.

I. Introduction

ONE of the most characteristic and unique bakery products made from soft wheat flour is cake. The cake industry has shown developed rapidly in recent years all over the world [2]. Although the functionality of ingredients is known, as several ingredients involve and affect cake texture, it is difficult to determine their specific contributions in complex systems, such as cakes [10]. So, many modifications have been made on cake ingredients in order to improve cake quality [2].

The most common sweetener in the baking industry is sucrose, even though brown sugar, dextrose, maltose, molasses, corn syrup, and invert sugar are frequently used in baked goods [7].

As the functional properties of sucrose, however, are not replaced when high-intensity sweeteners are used as a substitute [13], this article is investigating applying some kinds of sucrose syrups.

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Liquid sugar has many advantages in comparison with dry sugar, such as uniform quality, reduced loss, improved working environment and no packaging handling. It also involves fewer process steps and more automated handling [5].

II. Materials and Methods

A. Cake Ingredients

Flour, sucrose, egg, baking powder, oil, emulsifier and invert sugar were prepared. The syrups were obtained from a sugar factory in Iran. Flour was analyzed for moisture (by moisture meter model OHAUS MB45, Swiss), moist gluten (AACC method 32-12), ash (AACC method 08-01) and protein (AACC method 48-10) [1]. The chemical compositions of the used flour are shown in Table I.

TABLE I
CHEMICAL ANALYSES OF FLOUR

Moisture (%)	Moist Gluten (%)	Ash (%)	Protein (%)
13.87	28.5	0.5	8.5

The syrups were analyzed following the ICUMSA methods for sucrose content (by polarimeter), ash (by conductometer), brix (by refractometer), pH (by pHmeter) and color (by photometer) [6]. The purity of the syrups was also calculated according to (1).

$$Purity = Sucrose\ Content \div Brix \times 100 \qquad (1)$$

These analyses are shown in Table II.

TABLE II
CHEMICAL ANALYSES OF SYRUPS

Syrups / Parameters	pH	Brix	Sucrose Content (%)	Ash (%)	Color (IU)	Purity
Wash Syrup	7	76.4	73.5	0.82	683.625	96.2
Green-A Syrup	6.9	73.2	66.4	1.07	1026.375	90.71

B. Cake Preparation

Sponge cakes were baked according to the formula given in Table III. The formula was modified from a commercial sponge cake formulation.

Cake batters were mixed with a Kitchenaid mixer.

All ingredients were at room temperature. The mixing procedure was a “Single-Stage” method. Batter samples (125 g) were measured into 4.5×5.2×12.5 cm loaf pans and baked in a preheated (180°C) oven for 30 min. After baking, the cakes were cooled 10 min, removed from the pans and stored in zip-keep plastic bags.

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TABLE III
FORMULATION FOR BLANK SAMPLE

Flour	36
Sugar	20
Water	17.5
Egg	11
Oil	8
Invert Sugar	3
Glycerin	2
Emulsifier	105
Baking Powder	1

C. Physicochemical Quality Analysis

- pH: The pH of the batters and cakes were measured using AACC method 02-52 [1].
- Batter Specific Gravity: Specific gravity of cake batter at (28±2℃) was calculated by (AACC method 50-55) [1].
- Batter Viscosity: The viscosity of cake batter was determined using a Brookfield viscometer (model DV-II). The spindle speed was set to 2 rpm and spindle no.6 was used for all experiments. The experiment was run at room temperature (28±2℃).
- Weight Loss: Weight loss was calculated according to [4].

$$\text{Percent weight loss} = \text{A-B/A}\times 100 \quad (2)$$

where A and B were the weights of the batter and the baked cake, respectively.

- Cake Volume: The empty cake pan was filled with rapeseed. The empty cake pan volume (V1) was calculated based on the volume of rapeseed as determined by graduated cylinder. After baking, the rest of the volume of the cake pan (V2) was filled with rapeseed, and the volume of rapeseed was determined by graduated cylinder. Equation (3) was used to calculate the cake volume [12].

$$The\ cake\ volume\ = V1 - V2 \quad (3)$$

- Cake Texture: Cake crumb firmness was measured according to the AACC approved method 74-09 using an Instron Texture Analyzer (model Testometric M350-10CT). Three crustless cake samples 2.5 cm × 2.5 cm × 2.5 cm in size were cut from half cake and compressed individually. A cross head speed of 1 mm/s was applied to the compressed cake cubes to 50% compression. The test was repeated on the remaining half cake after 14 days storage in zip-seal plastic bag at 21±1 °C [8].
- Moisture Content: The moisture contents of cakes were measured by an electronic moisture meter (model OHAUS MB45, Swiss) after one and 14 days of finishing baking.
- Water Activity: The water activity (aw) of the cakes was monitored with a lab master aw device (model Novasina) after one and 14 days after baking.
- Color: Crust and crumb colors of cakes were measured with a hunter lab colorimeter (model Color Flex, America). Lightness (L*), red (+a*) and yellow (+b*) values were recorded after calibrating the instrument by using a white tile [9] and ΔE was calculated according to (4):

$$\Delta E = [(L^*ref - L^*)2 + (a^*ref - a^*)2 + (b^*ref - b^*)2]1/2 \quad (4)$$

- Sensory Analysis: Samples were placed on white plates and were identified, and taste testers were asked to rinse their mouths with water between samples to minimize any residual effects. They were then asked to rate them, for color, texture, flavor, sweetness and odor, based on their degree of liking on a hedonic scale from 1 (dislike extremely) to 5 (like extremely) [12].

III. RESULTS AND DISCUSSION

In terms of the physical properties of cakes and batters, the specific gravity and viscosity of batters and cake volume for each sample are shown in Table IV.

TABLE IV
CHEMICAL ANALYSES OF SYRUPS

Sample	Viscosity (×1000 cp)	Specific Gravity (gr/cm^3)	Volume (cc)
Blank Sample	217.8 ^{ef}	0.874 ^{bc}	344 ^{c}
25% WS	249.9 ^{abc}	0.894 ^{ab}	357 ^{ab}
50% WS	232.9 ^{cde}	0.893 ^{ab}	351 ^{abc}
75% WS	218 ^{ef}	0.891 ^{abc}	348.7 ^{bc}
100% WS	202.3 ^{f}	0.885 ^{abc}	348.3 ^{bc}
25% G-AS	238.9 ^{cd}	0.872 ^{c}	360.3 ^{a}
50% G-AS	258.5 ^{ab}	0.872 ^{c}	359.3 ^{a}
75% G-AS	262.4 ^{a}	0.89 ^{abc}	354 ^{abc}
100% G-AS	264.5 ^{a}	0.9 ^{a}	348 ^{bc}

WS= Wash Syrup; G-AS= Green-A syrup. Values in the same column with the same letter are not significantly different at P< 0:05.

A. Viscosity

There was no significant difference between most of the cakes prepared with Wash Syrup and blank treatment. This result is due to the high purity (Quotient) of the Wash Syrup and the similarity of its chemical analysis to that of granulated sugar.

The viscosity of batters made with A-Green Syrup was increased when the substitution level was increased. This may be because of the high viscosity and dry matter of A-Green Syrup. Moreover, the presence of mineral materials and invert sugar in A-Green Syrup can cause this result.

B. Specific Gravity

There was no significant difference between cakes prepared with Wash Syrup and blank treatment. But the specific gravity of batters made with A-Green Syrup was increased by increasing the substitution level of it, so that the specific gravity of the sample with 100% substitution was significantly increased. This increase in density can be directly related to the decrease in the air volume incorporated in the batter. This fact could be explained by the increase in viscosity. High viscosity will obstruct air incorporation during mixing [11].

C. Cake Volume

Although differences among all treatments are both

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significant and insignificant, all of them had higher volume than the blank one. It can be established that the final volume of studied cakes was not only dependent on the initial air quantity in batter (specific gravity) but also on its capacity of retaining it during baking. The influence of these sweeteners on final cake volumes can be explained by the increase observed in batter viscosity that slows down the rate of gas diffusion and allows its retention during the early stage of baking [11].

D.pH

Table V indicates that the pH values were not significantly different among any of the cake batters and control samples, and also among most of the cakes and the blank one. Moreover, the pH values of all formulations were within the optimum levels of 6.5-7.5 [13]. It is remarkable that these results are justifiable because the pH values of the syrups are within the neutral range.

E. Weight Loss

According to the results listed in Fig. 1, there was no significant difference between the weight loss of most treatments and the blank sample.

F. Moisture Content and Water Activity:

The results for cake moisture and water activity are shown in respectively in Fig. 2 and Table VI.

TABLE V
PH VALUES OF BATTER AND CAKE SAMPLES

Sample	Batter pH	Cake pH
Blank Sample	6.70 ^{abcd}	7.18 ^{bc}
25% WS	6.73 ^{abc}	7.23 ^{b}
50% WS	6.74 ^{ab}	7.19 ^{bc}
75% WS	6.8 ^{a}	7.21 ^{bc}
100% WS	6.66 ^{bcd}	7.16 ^{c}
25% G-AS	6.68 ^{abcd}	7.2 ^{bc}
50% G-AS	6.66 ^{bcd}	7.31 ^{a}
75% G-AS	6.69 ^{abcd}	7.22 ^{bc}
100% G-AS	6.59 ^{d}	7.16 ^{c}

WS= Wash Syrup; G-AS= Green-A syrup. Values in the same column with the same letter are not significantly different at P< 0:05.

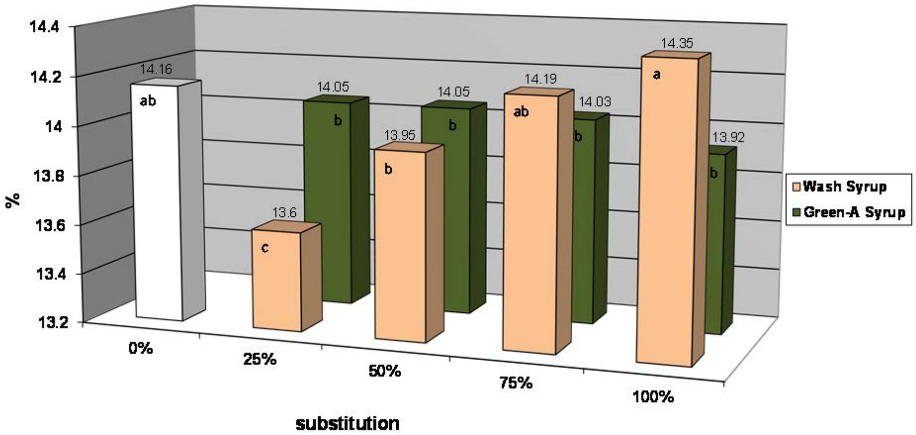

Fig. 1 Weight loss of samples

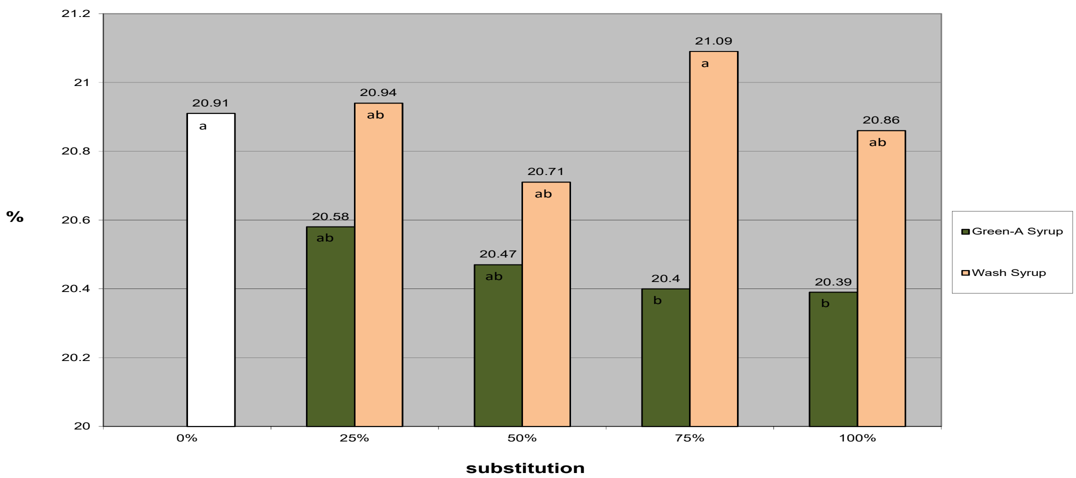

Fig. 2 Moisture content of samples

TABLE VI
WATER ACTIVITY (A_W) OF SAMPLES

Sample	a_w
Blank Sample	0.8 [a]
25% WS	0.81 [a]
50% WS	0.8 [a]
75% WS	0.81 [a]
100% WS	0.81 [a]
25% G-AS	0.81 [a]
50% G-AS	0.81 [a]
75% G-AS	0.8 [a]
100% G-AS	0.8 [a]

WS= Wash Syrup; G-AS= Green-A syrup. Values in the same row with the same letter are not significantly different at P< 0:05.

G. Texture

Although differences among all treatments are both significant and insignificant, most of them had softer texture at one and 14 days after baking (Fig. 3). These results may relate to the presence of invert sugar and some mineral materials which cause more water absorption and also softness in texture [3].

H. Crumb Color

Table VII shows that crumb color was affected by the replacement of sucrose with Wash and Green-A Syrups.

In general, as the usage dosage of these two syrups increased, the crumbs color differences (ΔE) were increased and the lightness of samples decreased. It must be considered that the presence of invert sugar and the pigments in the syrups may cause the darkness [3].

TABLE VII
COLORIMETRIC RESULTS

Sample	ΔE	L^*
Blank Sample	28.40 [b]	80.35 [bc]
25% WS	25.52 [d]	81.43 [ab]
50% WS	28.02 [bc]	80.97 [ab]
75% WS	29.03 [b]	78.91 [cd]
100% WS	32.51 [a]	76.78 [ef]
25% G-AS	26.53 [cd]	82.08 [a]
50% G-AS	27.76 [bc]	80.29 [bc]
75% G-AS	31.68 [a]	77.82 [de]
100% G-AS	31.07 [a]	75.80 [f]

ΔE= Total color difference with blank WS= Wash Syrup; G-AS= Green-A syrup. Values in the same column with the same letter are not significantly different at P< 0:05.

TABLE VIII
SENSORY EVALUATION OF CAKE SAMPLES

Sample	Texture	Color	Flavor	Odor	Sweetness
Blank Sample	4.6 [a]	5 [a]	3.6 [b]	4.6 [a]	3.8 [ab]
25% WS	4.6 [a]	4.8 [a]	4.4 [ab]	4.4 [a]	4.4 [ab]
50% WS	4.6 [a]	4.8 [a]	4.2 [ab]	4.4 [a]	3.6 [b]
75% WS	4.8 [a]	4.8 [a]	4.2 [ab]	4.4 [a]	3.8 [ab]
100% WS	4.6 [a]	4.8 [a]	4.6 [a]	4.2 [a]	3.6 [b]
25% G-AS	3.6 [a]	4.8 [a]	4.2 [ab]	4.2 [a]	4.4 [ab]
50% G-AS	4.6 [a]	5 [a]	4.4 [ab]	4.6 [a]	4.6 [a]
75% G-AS	4.2 [a]	3.2 [b]	4.2 [ab]	3.6 [a]	4.2 [ab]
100% G-AS	4.2 [a]	3.2 [b]	4.2 [ab]	3.6 [a]	4.2 [ab]

WS= Wash Syrup; G-AS= Green-A syrup. Values in the same column with the same letter are not significantly different at P< 0:05.

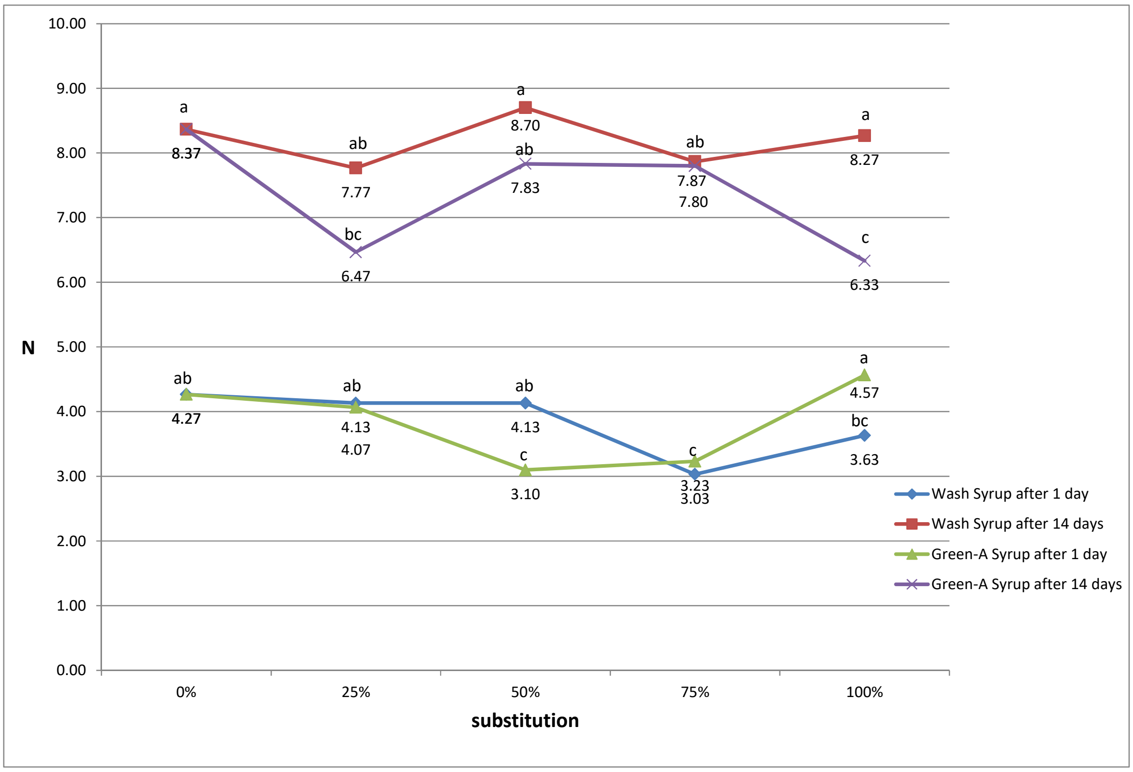

Fig. 3 Firmness of samples at one and 14 days after baking

I. Sensory Evaluation

The test results of the sensory evaluation of the final product for texture, color, flavor, odor and sweetness of samples, which are shown in Table VIII, indicate that the color scores of samples with 75% and 100% Green-A Syrup were lower and the flavor score of the sample containing 100% Wash Syrup was higher than other treatments, significantly ($p>0.05$), while the differences in texture, odor and sweetness of all samples were insignificant ($p>0.05$).

IV. Conclusion

Ingredients modification is one way to improve end product quality. Sugar is about 25% of cake formulation, and therefore, researches on the kinds of applied sweeteners and their effects may be important. Although a number of sweeteners may be used in baked products, none is as versatile as sucrose or can perform all of its important functions. Liquid sucrose has many advantages over granulated sugar in the production process. By using Wash and Green-A Syrups in cake formulations, additional to consuming the by-products of sugar factories, as the results show, the shelf life of cakes can be increased and their quality improved.

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