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EFFECT OF GLUTEN -FREE COMPOSITE FLOUR ON THE QUALITY PROPERTIES OF CUPCAKE

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ABSTRACT: *Composite flours were formulated from 53.5-54.5% rice flour, 25% corn starch, 10% chickpea flour and 10% defatted soy bean flour with 1% carboxy methyl cellulose (CMC), or 1.5% CMC or 0.25 xanthan + 0.25% CMC or 0.25% guar gum + 0.25 CMC. Batter properties and cupcake quality of wheat flour and composite flours were evaluated. Mixolab profile, Mixolab simulator mode, chemical composition, physical properties, crust color, crumb color, alkaline water retention capacity and sensory properties of cupcakes were evaluated. Composite flours had higher water absorption and dough stability than control flour. Dough development time and dough weakening values of composite flour were so close to wheat flour. The C1 and C2 values were not affected by replacing wheat flour with composite flours. The C3, C4 and C5 values of wheat flour were higher than composite flours. Composite flour cupcakes had higher crude protein and total ash contents and lower carbohydrates content than control cupcake. Weight of all cupcakes did not differ. Specific volumes and height of composite flour cupcakes containing 1 and 1.5% CMC were higher than control cupcake and other composite flour cupcakes. Composite flour cupcakes had lighter crust color than control cupcake. Composite flour cupcake containing 1.5% CMC had the darker crumb color among all cupcakes. The other composite flour cupcakes had lighter crumb color than the control cupcake. Composite flour cupcakes had lower alkaline water retention capacity than control cupcake. Alkaline water retention capacity of cupcakes was decreased by increasing storage period. Overall acceptability of control cupcake had rating score described as like extremely. Composite flour cupcakes containing 1.5% CMC, 0.25 xanthan + 0.25% CMC and 0.25% guar gum + 0.25 CMC had rating score described as like very much. The produced cupcake from gluten free flour was as good as the wheat product.*

Key words: *Mixolab profile, Mixolab simulator mode, Crust and crumb color, Alkaline water retention capacity and sensory properties.*

INTRODUCTION

Wheat is an important part of the daily diet of peoples. The gluten fraction was reported to be responsible for coeliac disease and later on food allergy (Larré *et al*., 2011). It may be defined as an inflammatory disease of the small intestine triggered by the storage (gluten) proteins not only from wheat but also from rye, barley and possibly, oats (Gessendorfer *et al.,* 2010). An immune reaction in the small intestine damages the mature absorptive epithelial cells and results in diarrhoea, abdominal pain, and growth disorders (Gallagher *et al.,* 2004 and Moore *et al.,* 2006). The need for gluten-free products is increasing since the prevalence of celiac disease has increased over time (Lohi, *et. al.*, 2007).

Since the diet of Celiac patients must be completely free from any gluten, so all the products from wheat, rye, barley and oat must be replaced with gluten free flours such as rice flour, corn flour, sorghum flour corn starch, potato starch, and pseudo cereals or appropriate mixtures (Alvarez-Jubete, *et.al.* 2010, Ranjbar *et al.,* 2012 and Hussein *et al.,* 2012). Legumes and oilseed proteins were used for fortification of bakery products by improving their protein quality, mechanical behavior and storage life (Sanchez *et al.,* 2004 and Hegazy *et al.,* 2009). Hydrocolloids (pectin, hydroxyl propylmethyl cellulose, carboxy methyl cellulose, guar gum, xanthan gum, and locust bean gum) are added to naturally gluten-free flours to mimic the viscoelastic properties of gluten and to improve structure, sensory attributes and shelf-life of these products (Kotoki and Deka, 2010 and Correa, *et.al.* 2010).

When gluten-free flour is mixed to form dough, it does not form a continuous phase or dough structure and consequently fails to produce good quality bread (Ranhotra *et al*, 1975). Therefore, this study was aimed to evaluate the Influence of gluten-free flours (rice flour, corn starch, defatted soybean flour and chickpea flour) and hydrocolloids (1% CMC, 1.5% CMC, 0.25% xanthan gum + 0.25% CMC and 0.25% gar gum + 0.25% CMC) on the quality properties of cupcake.

MATERIALS AND METHODS

Materials:

Wheat flour for cake (72% extraction), was obtained from the Five star flour Mills Company, Giza, Egypt. Chickpea (Giza, 195), rice (Giza, 151) seeds and defatted soybean flour were obtained from Agricultural Research Center, Ministry of Agriculture, Giza, Egypt. Corn starch, compressed yeast, skim dry milk, sugar, corn oil, vanilla and baking powder were obtained from local market Giza, Egypt.

Formulation of composite flours

Composite flours were formulated as shown in Table (I).

Table (I): Formulation of composite flours

	Rice flour (%)	Corn starch (%)	Defatted soybean flour (%)	Chickpea flour (%)	Gums (%)		
					Guar	xanthan	CMC
1	54.0	25	10	10	-	-	1.0
2	53.5	25	10	10	-	-	1.5
3	54.5	25	10	10	0.25	-	0.25
4	54.5	25	10	10	-	0.25	0.25

Methods:

Preparation of cupcake:

Cupcake was prepared according to Khalil (1998) using the following recipe, 760g soft wheat flour (72% extraction), 380g sugar, 380g corn oil, 380g fresh whole egg, 26.6g skim dry milk, 22.8g baking powder and 1.0g vanilla. To prepare the control cupcake, the sugar and corn oil were creamed for 3 min at speed 5 in an Oster Kitchen Center mixer (Model 972-26 H, Sunbeam Corporation, Milwaukee, Wisconsin, USA). The whole eggs were added and mixed in at the same speed for 2 min. The flour and baking powder were added and the batter was mixed for 4 min at speed 6. After scraping down the bowl the batter was mixed for an additional 1 min at speed 6. To prepare the composite flour cupcakes, the wheat flour in the formula was replaced by composite flours (Table I). The same order of mixing as described for the control was followed. Cake batter (50g) was poured into paper baking cups. Cupcake batters were baked at 180°C for 45 min. After 5 min, the cakes were removed from the pans and cooled for 60 min.

Proximate composition

Moisture, crude protein, crude fat and total ash for cupcake were determined according to the methods described in AOAC (2005). Total carbohydrates were calculated by difference.

Physical properties

The average weight (g) of cupcake was determined individually within one hour after baking. The volume (cm^3) of cupcake was determined by TexVol Instruments AB Box 45, 260 40 Viken, Sweden. Specific volume was calculated according to the method of (AACC, 2000) using the following equation:

Specific volume = Volume (cm^3) / Weight (g)

Color

Crust and crumb color were measured using the color profile system of lightness (L*), redness (a*) and yellowness (b*) which was measured by a reflectance colorimeter (Minolta Spectrophotometer CM-3500d, Japan).

The total (ΔE) color difference from the control calculated as the following:

$$\Delta E = \sqrt{(L_o^* - L^*)^2 + (a_o^* - a^*)^2 + (b_o^* - b^*)^2}$$

Where: 0 = color reading of control

Alkaline water retention capacity (staling rate)

Alkaline water retention capacity of cupcake was determined according to the method of Kitterman and Rubentholar (1971). Alkaline water retention capacity of cupcake was determined during storage at room temperature (~25°C) for 6 days.

Sensory properties

Sensory properties were carried out by ten-trained panellists who represented graduate students and staff members in the Department of Food science and Technology, Faculty of Agriculture, Menoufia University, Shibin El-Kom, Egypt. Randomly coded samples were served to panellists individually. Six sensory attributes were evaluated (appearance, crust color, crumb color, taste, aroma, and overall acceptability) using nine-points hedonic scale for each trait where 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much and 1 = dislike extremely.

Statistical analysis:

Proximate composition, physical properties and sensory properties data of cupcake were analyzed by one-way analysis of variance. Alkaline water retention capacity data were analyzed by two-ways analysis of variance. An analysis of variance was conducted using Costat version 6.311 (Copyright 1998-2005, CoHort software). When a significant main effect was detected, the means were separated with the Student Newman Keuls test. The predetermined acceptable level of probability was 5% ($P \leq 0.05$) for all comparisons.

RESULTS AND DISCUSSION

Mixolab profile

Composite flours had higher water absorption and dough stability than control flour (Table 1) and Fig (1). Usually, increased water absorption and dough stability indicate stronger dough. The increase of water absorption and dough stability of composite flour dough might be due to the presence of hydrocolloids. Similar results were reported by Hegazy *et al* (2009) for gluten-free bread. The C1 and C2 values were not affected by replacing wheat flour with composite flours. Aly-Aldin (2016) reported that C1 and C2 values of wheat flour replaced with different levels of flaxseed flour were so close to wheat flour. The C3, C4 and C5 values of wheat flour were higher than composite flours. Iuliana *et al.* (2008) reported that samples with lower values for C4 and C5 are correlated with higher value of the bread.

Mixolab simulator mode properties

Composite flours had higher water absorption and dough stability than control flour (Table 2) and Fig (2). These results are supported by the results previously reported in Tables 1. Dough development time and dough weakening values of composite flour were so close to wheat flour. Hegazy *et al.* (2009) evidence increase in water absorption, dough development time and dough stability were observed for gluten-free dough as compared with control.

Table (1): Mixolab profiles of wheat flour and composite flours

Mixolab properties	Control	[1]1	2	3	4
Water absorption (%)	55.5	56.2	56.5	57.2	57.6
Dough stability (min)	6.0	9.07	6.22	6.22	6.27
C1 (Nm)	1.12	1.08	1.12	1.10	1.09
C2 (Nm)	0.48	0.42	0.52	0.39	0.38
C3 (Nm)	2.02	1.04	1.26	0.55	1.27
C4 (Nm)	1.64	0.99	1.19	1.01	1.03
C5 (Nm)	2.55	1.24	1.74	1.62	1.62

[1]See Table I

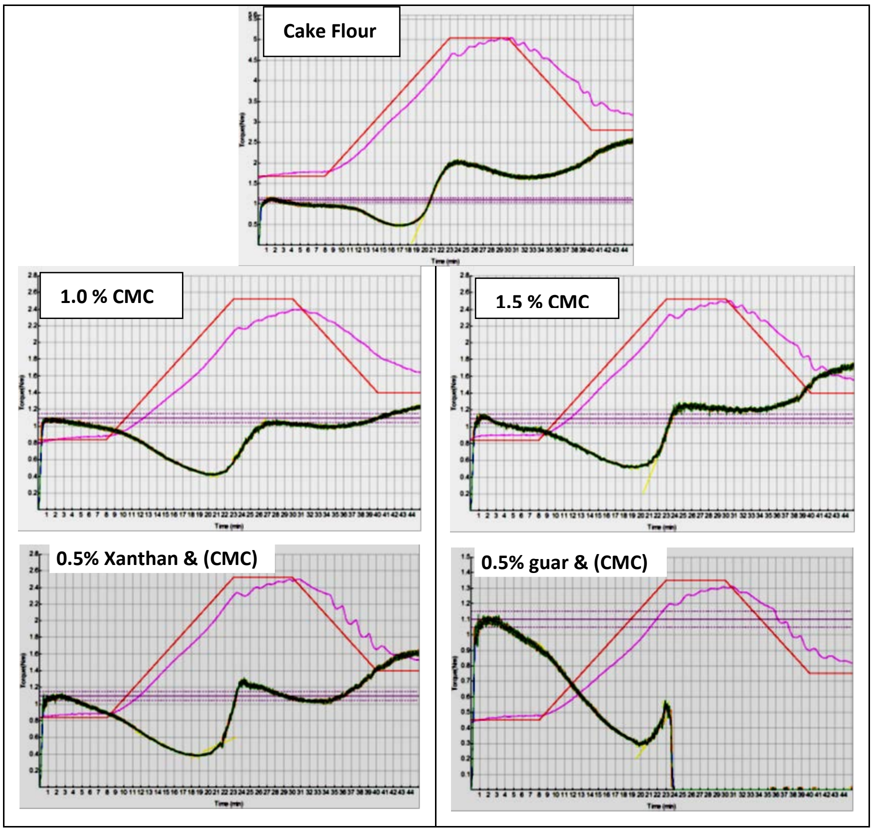

Fig. (1): Mixolab profiles of wheat flour and composite flours

Table (2): Mixolab simulator mode properties of wheat flour and composite flours

Mixolab simulator mode properties	Control	1[1]	2	3	4
Water absorption (%)	56.0	57.9	58.7	58.9	59.0
Dough development time (min)	2.5	2.5	3.0	3.0	2.5
Dough stability (min)	1.5	6.5	7.5	4.0	5.5
Dough weakening (Nm)	0.15	0.16	0.17	0.22	0.24

[1]See Table I

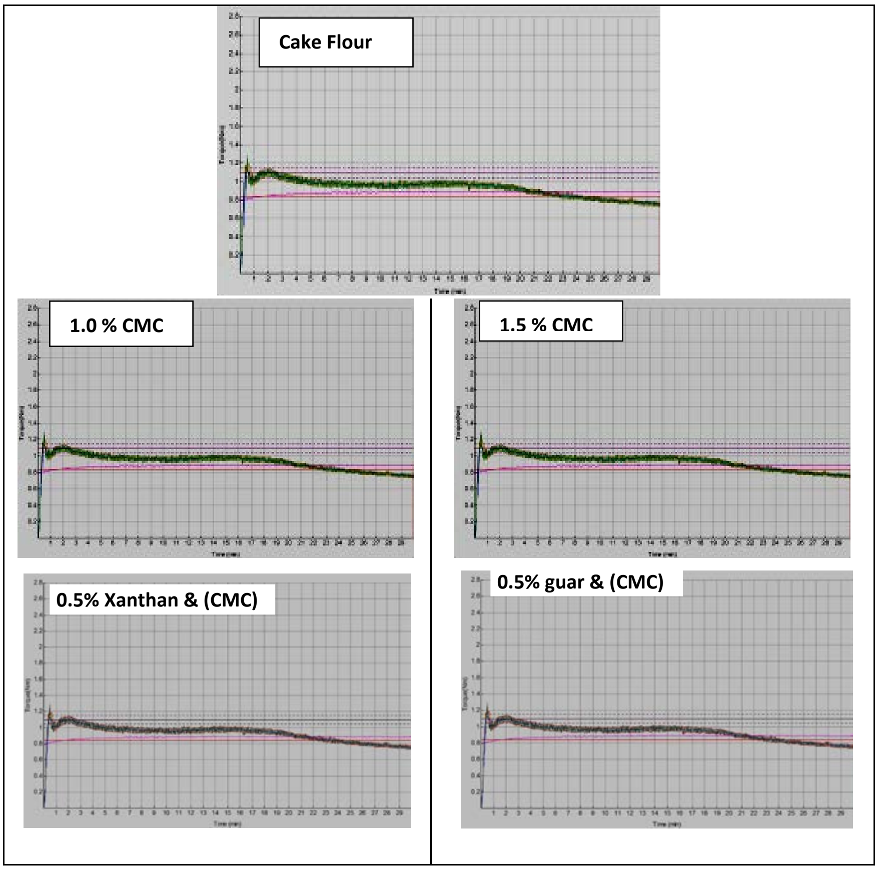

Fig. (2) Mixolab simulator mode properties of wheat flour and composite flours

Proximate composition:

There were no significantly ($p > 0.05$) differences in moisture and crude fat contents among all cupcakes (Table 3). Composite flour cupcakes had higher ($p \leq 0.05$) crude protein and total ash contents than control cupcake. However, control cupcake had higher ($p \leq 0.05$) carbohydrates content than composite flour cupcakes. In general non-significant ($p > 0.05$) difference in proximate composition was observed among composite flour cupcakes. These results are in agreement with those reported by Faheid and Hegazy (1991) who used soybean flour, chickpea flour and lupine flour to replace wheat flour in cookies. Results indicated that protein and ash contents of supplemented cookies were higher than of control.

Table (3): Proximate composition of cupcake prepared from wheat flour and composite flours

Treatment	[1]Moisture (%)	Crude protein (%)	Crude fat (%)	Total ash (%)	Carbohydrates (%)
Wheat flour	$19.31^{a}\pm0.11$	$4.32^{b}\pm0.09$	$30.99^{a}\pm0.12$	$0.60^{c}\pm0.02$	$64.09^{a}\pm0.16$
[2]1	$18.40^{a}\pm0.40$	$5.26^{a}\pm0.17$	$30.74^{a}\pm0.27$	$1.01^{a}\pm0.02$	$62.99^{b}\pm0.14$
2	$18.94^{a}\pm0.12$	$5.23^{a}\pm0.11$	$30.73^{a}\pm0.50$	$0.88^{b}\pm0.05$	$63.16^{b}\pm0.64$
3	$19.22^{a}\pm0.22$	$5.26^{a}\pm0.15$	$30.74^{a}\pm0.26$	$1.01^{a}\pm0.03$	$62.99^{b}\pm0.11$
4	$19.42^{a}\pm0.12$	$5.27^{a}\pm0.11$	$30.77^{a}\pm0.27$	$0.88^{b}\pm0.03$	$63.08^{b}\pm0.43$
LSD	0.93	0.23	0.56	0.06	0.65

[1]Means in the same column with different letters are significantly different ($p \leq 0.05$)
[2]See Table I

Physical properties

Non-significant ($p > 0.05$) difference in weight was observed between composite flour cupcakes and control cupcake (Table 4). Composite flour cupcakes containing 1.5% CMC (1385.3 cm^3) followed by containing 1% CMC (1355.6 cm^3) had higher ($p \leq 0.05$) volume than other cupcakes. Control cupcake had higher ($p \leq 0.05$) volume (1276.7 cm^3) than composite flour cupcake containing 0.25% xanthan + 0.25% CMC (1219.6 cm^3) and composite flour cupcake containing 0.25% gaur gum + 0.25% CMC (1165.2 cm^3). The specific volume of cake (relates with good texture) indicates the amount of air that can remain in the final product. A higher gas retention and higher expansion of the product leads to a higher specific volume (Gomez et al., 2008). Specific volumes of composite flour cupcakes containing 1% CMC (2.16) and 1.5% CMC (2.20) were significantly ($p \leq 0.05$) higher than control (2.02) and composite flour cupcakes containing 0.25% xanthan + 0.25% CMC (1.94) and 0.25% gaur gum + 0.25% CMC (1.86). Control cupcake had higher ($p \leq 0.05$) specific volume than composite flour cupcakes containing 0.25% xanthan + 0.25% CMC and 0.25% gaur gum + 0.25% CMC. Height of cupcakes had a similar trend of specific volume. Yaseen *et al.* (2010) reported that loaf volume and specific volume were improved upon the addition of gums arabic and pectin.

Crust color

In general, a lower L* value indicates a darker crust, a* positive value is associated with crust redness, whereas a higher b* value leads to higher crust yellowness. Composite flour containing 0.25% gaur gum + 0.25% CMC had the highest crust lightness (69.14), yellowness (37.02) and ΔE (11.59) and the lowest redness (10.54) as compared with other cupcakes (Table 5). Control cupcake had the lowest lightness (58.0) and the highest redness (13.47) among all cupcakes. In general, composite flour cupcakes had lighter crust color than control cupcake. This could be attributable to the effect of hydrocolloids on water distribution, which impact on maillard reaction and caramelization. Mezaize *et al.* (2009) reported that breads made with xanthan gum and CMC had lighter crust color.

Table (4): Physical properties of cupcake prepared from wheat flour and composite flours

Treatment	[1]Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)	Height (cm)
Wheat flour	632.03^a±11	1276.70^c±24	2.02^b±0.08	4.00^b±0.15
[2]1	627.60^a±12	1355.60^b±31	2.16^a±0.09	4.15^a±0.15
2	630.60^a±11	1385.30^a±33	2.20^a±0.10	4.22^a±0.12
3	628.40^a±12	1219.60^d±22	1.94^c±0.07	3.30^c±0.11
4	625.50^a±13	1165.20^e±19	1.86^d±0.07	3.40^c±0.09
LSD	7.22	19.37	0.06	0.13

[1]Means in the same column with different letters are significantly different ($p \leq 0.05$)
[2]See Table I

Table (5): Crust color of cupcake prepared from wheat flour and composite flours

Treatment	L*	a*	b*	∆E
Wheat flour	58.00	13.47	35.72	0.00
[1]1	68.40	11.30	34.00	10.76
2	67.48	11.34	33.00	9.69
3	65.73	13.20	36.92	7.83
4	69.14	10.54	37.02	11.59

[1]See Table I

Crumb color

Composite flour cupcake containing 1.5% CMC had the highest crumb redness (1.91) and ∆E (6.61) and the lowest lightness (74.62) and yellowness (23.86) as compared with other cupcakes (Table 6). This indicated that composite flour cupcake containing 1.5% CMC had the darker crumb color among all cupcakes. This might be due to the increase of CMC ratio (1.5%) in the sample. Sciarini *et al.* (2010) found that a darkening of the bread crust color with carrageenan addition. The other composite flour cupcakes had lighter crumb color than the control cupcake and composite flour containing 1.5% CMC.

Alkaline water retention capacity

Water retention capacity of cupcakes was significantly ($p \leq 0.05$) affected by the type of flours and storage period (Table 7). Alkaline water retention capacity of composite flours cupcakes was significantly ($p \leq 0.05$) lower than control cupcake. Alkaline water retention capacity of cupcake was significantly ($p \leq 0.05$) decreased by increasing storage period. These results are in agreement with those reported by Aly-Aldin (2016) for flat bread prepared by replacing wheat flour with different levels of germinated flaxseed flour.

Table (6): Crumb color of cupcake prepared from wheat flour (72 extraction) and composite flours

Treatment	L*	a*	b*	∆E
Wheat flour	75.92	-0.66	29.81	-
[1]1	78.00	1.00	27.30	3.66
2	74.62	1.91	23.86	6.61
3	80.28	-1.15	30.50	4.40
4	80.28	-0.98	28.93	4.46

[1]See Table I

Table (7): Alkaline water retention capacity of cupcake prepared from wheat flour (72 extraction) and composite flours during storage at room temperature (~25°C) **for 6 days.**

Treatment	Storage period (day)				Means[1]
	0	[3]1	3	6	
Wheat flour	261.14±0.24	255.27±0.94	255.18±0.40	252.58±0.42	256.05[a]
1	223.54±0.54	214.91±0.09	210.74±0.26	199.19±0.30	212.10[e]
2	224.95±0.95	218.31±0.41	214.23±0.30	200.32±0.39	214.45[d]
3	232.24±0.76	226.91±0.91	218.27±0.32	202.51±0.61	222.45[b]
4	231.99±1.01	225.70±0.75	221.85±0.50	210.25±0.70	219.93[c]
Means[2]	234.77[a]	228.22[b]	224.06[c]	212.90[d]	

[1]Means in the same column with different letters are significantly different (p≤ 0.05), LSD 0.51
[2]Means in the same row with different letters are significantly different (p≤ 0.05), LSD = 0.46
[3]See Table I

Sensory properties

Control cupcake had higher ($p \leq 0.05$) rating scores of all sensory properties than composite flour cupcake (Table 8). Control cupcake had higher ($p \leq 0.05$) rating scores of appearance, crumb color, crust color, taste and aroma than composite flour cupcakes. Non-significant ($p > 0.05$) differences in appearance and crumb color were observed between control cupcake and composite flour cupcakes containing 1.5% CMC and 0.25% gaur gum + 0.25% CMC. Non-significant (p > 0.05) difference in overall acceptability was observed between control cupcake and composite flour cupcakes containing 1.5% CMC, 0.25% xanthan + 0.25% CMC and 0.25% gaur gum + 0.25% CMC. Overall acceptability of control cupcake had rating score described as like extremely. However, composite flour cupcakes containing 1.5% CMC, 0.25% xanthan + 0.25% CMC and 0.25% gaur gum + 0.25% CMC had rating score described as like very much. Although composite flour cupcake containing 1% CMC had lower ($p \leq 0.05$) sensory properties than control cupcake, it had rating scores described as like slightly. Ranjbar *et al.* (2012) reported that rice cakes containing CMC had better sensory properties than control rice cake.

Table (8): Sensory properties of cupcake prepared from wheat flour and composite flours

Treatment	Appearance	Crust color	Crumb color	Taste	Aroma	Overall acceptability
Wheat flour	9.00^{a} ±0.03	9.00^{a} ±0.03	9.00^{a} ±0.03	9.00^{a} ±0.03	9.00^{a} ±0.03	9.00^{a} ±0.03
[1]1	6.00^{cd} ±0.50	6.00^{c} ±0.50	6.00^{b} ±0.50	6.00^{cd} ±0.50	6.00^{cd} ±0.50	6.00^{b} ±0.50
2	8.00^{ab} ±0.05	7.50^{b} ±0.57	8.00^{ab} ±0.10	8.00^{b} ±0.50	7.75^{b} ±0.50	8.00^{a} ±0.10
3	7.00^{bc} ±0.10	8.00^{b} ±0.50	7.25^{b} ±0.95	7.50^{b} ±0.57	7.25^{bc} ±0.95	8.00^{a} ±0.50
4	8.00^{ab} ±0.50	7.50^{b} ±0.57	7.75^{ab} ±0.10	7.00^{bc} ±0.80	7.75^{b} ±0.50	8.00^{a} ±0.50
LSD	1.09	0.80	1.27	0.89	0.87	1.0

Means in the same column with different letters are significantly different ($p \leq 0.05$)
[1]See Table I

CONCLUSION

Composite flours had higher water absorption and dough stability than control flour. Dough development time, dough weakening, C1 and C2 values did not differ among all cupcakes. Composite flour dough had lower C3, C4 and C5 values than wheat flour dough. Composite flour cupcakes had higher crude protein and total ash contents and lower carbohydrates content than control cupcake. Specific volumes of composite flour cupcakes containing 1 and 1.5% CMC were higher than control cupcake and other composite flour cupcakes. Composite flour cupcakes had lighter crust color and crumb color than control cupcake except for composite flour cupcake containing 1.5% CMC which had the darker crumb color among all cupcakes. Composite flour cupcakes had lower alkaline water retention capacity than control cupcake. Alkaline water retention capacity of cupcakes was decreased by increasing storage period. There was no difference in overall acceptability between control cupcake and composite flour cupcakes containing 1.5% CMC, 0.25 xanthan + 0.25% CMC and 0.25% guar gum + 0.25 CMC. Therefore, it is possible to produce cupcake of high and good quality properties from composite flour free of gluten.

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تأثير الدقيق المركب خالي الجلوتين علي خواص وجودة الكيك

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الملخص العربى

تم أعداد الدقيق المركب من دقيق الأرز بنسبة 53.5- 54.5% 25٪ نشا الذرة و10٪ من دقيق الحمص و10٪ من دقيق فول الصويا منزوع الدهن مع 1٪كربوكسي ميثايل سليلوز أو 1.5 كربوكسي ميثايل سليلوز أو0.25٪ زانثان +0.25 كربوكسي ميثايل سليلوز أو 0.25٪صمغ الجوار+0.25 كربوكسي ميثايل سليلوز تم تقيم خصائص الخليط وجودة الكب كيك من دقيق القمح والدقيق المركب القيم المتحصل عليها من المكسولاب بروفيل والمكسولاب سيموليتر والتركيب الكيماوي والخصائص الفيزيائية ولون القشرة واللبابة والقدرة علي الاحتفاظ بالماء والتقييم الحسي للكب كيك. حصل الدقيق المركب علي أعلي نسبة امتصاص وثباتية يليه الدقيق الكنترول كان وقت تطوير العجين ودرجة ضعف العجينة للدقيق المركب قريبة جدا من دقيق القمح ولم تتأثر قيم C2,C1 باستبدال دقيق القمح بالدقيق المركب وكانت قيم C5,C4, C3 لدقيق القمح أعلي من الدقيق المركب وكانت نسبة البروتين ومحتوي الرماد الكلي أعلى للدقيق المركب ومحتوي الكربوهيدرات أقل من الكب كيك الكنترول، لايوجد اختلاف في وزن الكيك والحجم النوعي والارتفاع لكيك الدقيق المركب المحتوي علي 1 إلي 1.5٪ كربوكسي ميثايل سليلوز أعلى من كيك الكنترول وكيك أصناف الدقيق المركب الأخرى لون القشرة للدقيق المركب أكثر بياض من كيك الكنترول الدقيق المركب المحتوي علي 1.5٪كربوكسي ميثايل سليلوز لون اللبابة مظلم أو قاتم من بين كل الكب كيك لأنواع الدقيق المركب الأخرى يحتوي علي لون لبابه ناصع أو فاتح ثم يليه الكب كيك الكنترول، الكب كيك للدقيق المركب أقل قدرة علي الاحتفاظ بالماء من الكب كيك والقدرة التخزينية تنخفض بزيادة فترة التخزين. التقبل العام لكيك الكنترول تحصل علي أعلى درجة قبول من التقييم الحسي وكيك الدقيق المركب المحتوي علي 1.5٪ CMC و0.25٪ زانثان +0.25٪كربوكسي ميثايل سليلوز و0.25٪ جوار +0.25 كربوكسي ميثايل سليلوز تحصل علي درجة تقيم حسي مقبول جداً.

الكلمات الدالة (key words): مكسولاب بروفيل والمكسولاب سيموليتر، لون القشرة واللبابة القدرة علي الاحتفاظ بالماء والخصائص الحسية.