

The Physicochemical and Sensory Attributes of Watermelon Rind Flour Incorporated Steamed Cupcake

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ABSTRACT

This study aim to investigate the physicochemical and sensory attributes of watermelon rind flour incorporated steamed cupcakes. The produced watermelon rind flour using hot-air drying at 40, 60°C and freeze drying were substituted for plain flour at 10% level to produce CR40, CR60, and CRFD, respectively. Steamed cupcake without watermelon rind flour served as control (CCONT). Proximate results showed that composite steamed cupcakes had significantly ($p < 0.05$) higher ash, crude fat, and crude fibre contents but lower crude protein, total carbohydrate, and calorie values than control. CRFD steamed cupcakes showed lighten crust and crumb and greater volume and specific volume. However, it shows harder texture but springier crumb than the CCONT. Sensory evaluation results showed that all steamed cupcakes with or without containing 10% watermelon rind flour were considered acceptable by the panellists. It can be concluded that watermelon rind flour dried using freeze drying method improved the nutritional quality and texture properties of steamed cupcakes.

Keywords: Watermelon rind flour, physical properties, chemical composition, sensory attributes, steamed cupcake

ABSTRAK

Kajian ini bertujuan untuk mengkaji sifat-sifat fiziko-kimia dan deria kek cawan kukus yang dimasukkan tepung kulit tembikai. Tepung kulit tembikai yang dihasilkan melalui pengeringan udara panas pada suhu 40, 60°C dan pengeringan beku telah menggantikan dengan tepung biasa pada tahap 10% untuk menghasilkan masing-masing CR40, CR60, and CRFD. Kek cawan kukus tanpa tepung kulit tembikai digunakan sebagai kawalan (CCONT). Hasil proksimat menunjukkan bahawa kek cawan kukus komposit mempunyai ketara ($p > 0.05$) lebih tinggi abu, lemak mentah dan serat kasar tetapi lebih rendah protein mentah, jumlah karbohidrat, dan nilai kalori daripada kawalan. Kek cawan kukus CRFD menunjukkan kerak dan serdak lebih cerah dan lebih besar isipadu dan isipadu tertentu berbanding kawalan. Walau bagaimanapun, ia memperlihatkan tekstur serdak yang lebih keras tetapi lebih elastik daripada CCONT. Hasil penilaian sensori menunjukkan bahawa semua kek cawan kukus dengan atau tanpa mengandungi 10% tepung kulit tembikai dianggap diterima oleh panel. Dapat disimpulkan bahawa tepung kulit tembikai yang dikeringkan menggunakan kaedah pengeringan beku meningkatkan kualiti nutrisi dan sifat tekstur kek cawan kukus.

Kata Kunci: Tepung kulit tembikai, Ciri-ciri fizikal, Komposisi kimia, Atribut sensori, Kek cawan kukus

INTRODUCTION

Watermelon (*Citrullus lanatus*) consists of three main components which are the flesh, seed, and rinds; representing 68, 30, and 2%, respectively of its total weight (Kumar, 1985). Recently, watermelon rind has been identified to contain good amount of antioxidant activities, dietary fibres, and richest source of citrulline (Perkin-Veazie and Collins, 2004; Rimando and Perkins-Veazie, 2005; Oseni and Okoye, 2013; Al-Sayed and Ahmed, 2013; Yadla et al., 2013). However, there are wastes created when only the flesh is consumed and the rind is usually discarded, applied to feeds or fertilizer. According to Larrosa et al. (2002), agricultural and industrial residues are attractive sources of natural antioxidants and dietary fibre. Therefore, it may be used as a good source of the dietary fibre and macro- and micro-nutrients in food product development.

Water is the most important factor in accelerating food deterioration process and microbial spoilage (Sewald and DeVries, 2015). Bad handling of watermelon by-product after fruit processing may cause the fresh watermelon rind to deteriorate and resulted in large physical damage and loss in a short period of time. Hence, processing of watermelon into flour by reducing the water content is needed for extension its shelf life. Drying, is a method used for food preservation may be a suitable method to be practice when commercialize the fresh watermelon rind. Drying process can slow down the growth of microorganisms and prevent increase of certain biochemical reactions resulted to an increase in nutrient. However, drying process accelerate some biochemical activity leading to change in product appearance and aroma which resulted from losses in volatiles or the formation of new volatiles due to the esterification or oxidation reactions (Hossain et al., 2010).

Hot air-drying is one of the commonly used drying methods in food industry due to its relatively cheaper (Hsua et al., 2003). Among the various drying processes, freeze-drying provides highest product quality but the relatively high production cost is a major drawback of the process (Mohan et al., 2016).

A major food component in the international market and widely consumed food are bakery products (Kotsianis et al., 2002). Cupcakes are made from wheat flour is rich of carbohydrate but poor in nutritional qualities such as fibre and essential minerals. Hence, the effect of large consuming of wheat-based products is tends to malnutrition. According to Eswaran et al. (2013), lack of dietary fibre in human food intake is often related with the diseases such as obesity and constipation. Therefore to meet the sufficient intake of dietary fibre in human daily diet, the innovation of enriched wheat-based product such as steamed cupcakes is necessary to be developed. Cupcakes can be baked or steamed; steaming is a moist-heat cooking technique that employs hot steam to conduct the heat to the food item. Steaming often results in a light, tender, and very moist crumb than a baked cake (French, 2015). According to Yuan et al. (2009), steaming has minimal effects on chlorophyll, soluble proteins and sugars, and vitamin C. Thus, it is an alternative method to retain nutrients that are otherwise lost in the baking process.

Watermelon rind flour could be a potential source in providing a novel fibre in foods especially in steamed cupcakes. This is because the application of watermelon rind flour in steamed cupcakes has not been investigated. Hence, based on these, the present study was conducted to develop new composite steamed cupcakes incorporated with watermelon rind flour obtained through different drying condition (hot-air drying at 40 and 60 °C, and freeze drying). The effects of partial replacement of red-fleshed watermelon rind flour for wheat flour on the physicochemical and sensory attributes of steamed cupcakes were also investigated.

MATERIAL AND METHODS

Materials

The red-fleshed watermelon (*Citrullus lanatus*) was purchased from local retailer in Besut, Terengganu, Malaysia. The ripe watermelons with yellowish-cream ground spot, dispersed stripes, shining skin, and producing hollow sound when flicked (Sapii and Muda, 2005) were used for this study. The steamed cupcakes making ingredients such as plain flour, castor sugar, egg, cake stabilizer, double action baking powder, fresh milk, and corn oil were purchased from a local supermarket (Supermas Supermarket) in Besut, Terengganu, Malaysia. All chemicals used in this study such as petroleum ether (40-60 °C boiling point) was purchased from R & M Marketing (Essex, UK). Sulphuric acid (H₂SO₄) and sodium hydroxide (NaOH) were purchased from Merck (Darmstadt, Germany). Ethanol was purchased from Qrec Asia (Selangor, Malaysia). Bromocresol green and methyl red dyes were purchased from Sigma-Aldrich (Missouri, USA) whereas Kjeltabs was purchased from Foss (Hillerød, Denmark). All of the chemicals used are of analytical reagent (AR) grade.

Methods

Watermelon rind flour preparation

The watermelon was washed under running tap water to remove dirt and soil. The peel was then removed and the melon was cut transversely between blossom and stem ends. Flesh, rind, and seeds were separated. The rind which is white area part was sliced into thin pieces (2 mm) using industrial fruit slicer (Santos Vegetable Slicer 48, Lyon, France) prior drying in laboratory dryer (Tech Lab, FDD-720, Selangor, Malaysia) for overnight at 40 and 60 °C. To prepare freeze dried red-fleshed watermelon rind flour, the sliced watermelon rind was frozen overnight at -18 °C and lyophilized in freeze dryer (SP Scientific, 25 L Genesis SQ Super ES-55 Pilot, Pennsylvania, USA) for 2 days. The dried watermelon rind was ground using a stainless steel grinder (Waring Commercial Blender, 7011HS, Osaka, Japan) and sieved into fine flour by using mechanical sieve shaker (250 µm). The watermelon rind flour was kept in airtight plastic container and stored at ambient temperature prior to use.

Preparation of steamed cupcakes

Plain flour without replacement of watermelon rind flour served as control steamed cupcake. Plain flour was substituted by watermelon rind flour produced from different drying conditions; hot-air drying at 40 and 60 °C, and freeze drying at the level of 10% for the preparation of CR40, CR60, and CRFD, respectively (Table 1).

Table 1 Formulation for steamed cupcakes

Ingredients	CCONT	CR40	CR60	CRFD
Plain flour (g)	83.3	75.0	75.0	75.0
Watermelon rind flour (g)	-	8.3	8.3	8.3
Egg (g)	106	106	106	106
Castor sugar (g)	70	70	70	70
Cake stabilizer (tsp)	½	½	½	½
Double action baking powder (g)	3	3	3	3
Fresh milk (mL)	25	25	25	25
Corn oil (mL)	9	9	9	9

CR40, CR60, and CRFD were the abbreviations for steamed cupcake incorporated with 10% red-fleshed watermelon rind flour dried using hot-air dryer at 40 and 60°C, and freeze drying, respectively, and without watermelon rind flour (CCONT)

Sugar (106 g), eggs (106 g), and cake stabilizer (1/2 tsp) were mixed until thick using a hand mixer (Philips, HR1456/70, Toa Payoh, Singapore). Then, fresh milk (25 mL) and corn oil (9 mL) were added and mixed for one minute. The pre-sifted plain flour (83.3 g) and double action baking powder (3 g) were then folded gently to the mixture. The batter was then poured into the round paper cup (size of 50 mL) until 1/3 full and steamed on boiling water in a stainless steamer for approximately 10 min. The steamed cupcake was cooled at room temperature for 1 h prior to analysis.

Proximate analyses

The official method of AOAC (1995) was referred to determine the proximate compositions of the steamed cupcakes. Moisture, ash, crude protein, crude fat, and crude fibre contents were analysed according to oven drying (AOAC method 977.11), dry ashing (AOAC method 923.03), Kjeldahl's (AOAC method 955.04), Soxhlet (AOAC method 960.39), and gravimetric (AOAC method 991.43) methods, respectively.

Total carbohydrate and calorie values determination

Total carbohydrate content was calculated by difference [Carbohydrate (%) = 100% - % (moisture + ash + crude protein + crude fat)] (BeMiller and Low, 1998). The caloric value of the steamed cupcake was calculated by multiplied by the factor value (For each gram of crude protein and carbohydrate, 4 kcal of energy is obtained and 9 kcal of energy for 1 g of crude fat) (Nielsen, 1998).

Determination of colour

The colour of the crust and crumb of steamed cupcakes were measured according to the Commission Internationale de l'Eclairage (CIE) $L^*a^*b^*$ scale. Colorimeter (Konica Minolta, Chroma Meter CR-400, Tokyo, Japan) was used to determine the L^* [Lightness ($L^*=0$; black, $L^*=100$; white)], Chroma a^* [green chromaticity (-60) to red (+60)], and Chroma b^* [blue chromaticity (-60) to yellow (+60)] space values.

Determination of weight, volume, and specific volume

The steamed cupcake was weighed using four decimal point analytical balance after 1 h of baking to obtain its weight (g). The volume was expressed in cm^3 and specific volume was expressed in cm^3/g of steamed cupcakes were analysed by using a benchtop laser-based scanner (VolScan Profiler, Stable Micro Systems Ltd, Surrey, UK). A non-contact measurement system was selected in the volume and specific volume measurement with using 3-

dimensional assessment of soft and freshly steamed products. The data were generated using VolScan Profiler Software (Stable Micro Systems Ltd, Surrey, UK).

Texture profile analysis

Texture profile analysis of steamed cupcakes was analysed using a texture analyser (Stable Micro System, TA.XT2i, Surrey, UK). The instrument was equipped with 30 kg load cell and calibrated to a force sensitivity of 1 gram. The test was conducted on crumb (2.5 cm × 2.5 cm × 2.5 cm cube size) cut from the middle of the cupcake. The setting of the analyser was performed according to Method 74-09 (AACC, 2000). The test speed was set at 5 mm/ s at 75% of the original height; the post-test speed was 5 mm/ s, and 5 s interval between the two compression cycles. A trigger force of 5 g was selected. The cubes were compressed twice using a 36 mm diameter aluminium cylinder probe (P/36R) under the force of compression at 75% of the product original height. The parameters of hardness, springiness, cohesiveness, and chewiness were analysed using Texture Expert Version 1.05 Software (Stable Micro System Ltd, Surrey, UK).

Sensory evaluation

The sensory attributes of all steamed cupcakes were evaluated by 35 semi-trained panellists comprising of students and staffs of the Faculty Bioresources and Food Industry, Universiti Sultan Zainal Abidin, Malaysia. The sensory was evaluated using 7-point hedonic scale to determine sensory acceptability by panellists; 1 indicates 'dislike very much' to 7 indicates 'like very much' (Watts et al., 1989). The steamed cupcakes were cut into cubes of 2 cm x 2 cm x 2 cm using clean bread knife. Each sample was coded with different 3-digit numerical codes and then placed onto the paper plate. Each sample was presented to the panellists in the randomized order so that each sample appears in a particular position an equal number of times. Each panellist was served with a tray containing a plate of labelled steamed cupcakes, a cup of 300 mL drinking water, and a sheet of sensory form. They were requested to rate the samples on the scale for each attribute; colour, aroma, hardness, chewiness, springiness, taste, and overall acceptability.

Statistical analysis

Statistical analysis was conducted using Statistical Package for the Social Science (SPSS) 20.0 software (SPSS Inc., Chicago, IL, USA). The obtained results in this study were represented as the mean values of three individual replicates ± the standard deviation. One-way analysis of variance (ANOVA) and Duncan Multiple Range test were used to determine the statistical significance at level $p < 0.05$.

RESULTS AND DISCUSSION

Proximate composition of steamed cupcakes

The results of proximate composition of steamed cupcakes were shown in Table 2. Moisture is an important parameter to be measured for the bakery products as it significantly affects their textural quality, chemical and biochemical reactions, and microbiological spoilage. Moisture content of steamed cupcake was not significant ($p > 0.05$) difference from each other. Results obtained in this study were not in line with the findings from Al-Sayed and Ahmed (2013). The authors reported that cake containing watermelon rind powder showed lower moisture content (23.26-25.24%) than the cake without addition of watermelon rind powder (27.04%). This was attributed to the different cooking methods was used to make the cake, whereby, steaming instead of baking method was applied in the present study. Steaming, resulting in direct contact of batter with moist heat in the form of steam which generated through evaporation of boiling water, therefore causing in a moist texture of the steamed cupcake.

Steamed cupcakes containing the watermelon rind flour dried at different drying conditions (CR40, CR60, and CRFD) were significantly higher ash content than CCONT. The ash content may be associated with the presence of greater ash in the watermelon rind flour (13.09-19.13%) (Ho et al., 2016) than in the plain flour or wheat flour (1.42%) (Noor Aziah et al., 2011). The high ash content of steamed cupcakes containing watermelon rind flour was also corresponded with the presence of a high mineral content (Omotoso and Adedire, 2007) in watermelon rind due to the minerals are less sensitive to heat and has less volatile properties. Lakshmipathy and Sarada (2013) reported that the major minerals present in watermelon rind are sodium, potassium, magnesium, and calcium, and other trace minerals (zinc and iron).

Table 2. Proximate composition of steamed cupcakes

Composition	Types of cupcake ¹			
	CCONT	CR40	CR60	CRFD
Moisture (%)	38.06 ± 0.23 ^a	38.32 ± 0.32 ^a	38.32 ± 0.22 ^a	38.36 ± 0.12 ^a
Ash (%)	1.39 ± 0.05 ^a	2.08 ± 0.01 ^d	1.86 ± 0.00 ^c	1.71 ± 0.02 ^b
Crude protein (%)	12.25 ± 0.06 ^c	12.18 ± 0.14 ^c	11.91 ± 0.12 ^b	11.22 ± 0.08 ^a
Crude fat (%)	9.25 ± 0.14 ^a	9.18 ± 0.10 ^a	9.79 ± 0.31 ^b	9.67 ± 0.09 ^b
Crude fibre (%)	0.31 ± 0.11 ^a	0.74 ± 0.01 ^b	1.07 ± 0.06 ^c	1.03 ± 0.13 ^c
Total carbohydrate (%)	39.25 ± 0.23 ^b	38.01 ± 0.16 ^a	38.27 ± 0.76 ^{ab}	38.99 ± 0.27 ^{ab}
Calorie (kcal/100 g of sample)	288.64 ± 0.42 ^b	283.61 ± 0.98 ^a	287.66 ± 0.55 ^b	288.32 ± 0.88 ^b

Values with different superscripts within the same row are statistically significant from each other ($p < 0.05$)

Presented data are mean value of three replications ± standard deviation

¹CR40, CR60, and CRFD were the abbreviations for steamed cupcake incorporated with 10% red-fleshed watermelon rind flour dried using hot-air dryer at 40 and 60 °C, and freeze drying, respectively, and without watermelon rind flour (CCONT)

As shown in Table 2, the crude protein content decreased with substitution of watermelon rind flour for wheat flour in CR60 and CRFD steamed cupcakes making. This was due to the wheat flour contains higher protein content than watermelon rind flour which reduced in the formulation, and thus the protein content was decreased. However, there was no significant difference in the protein content of CR40 and CCONT. Previous work has reported that watermelon rind flour contains 6.02-11.82% of protein (Ho et al., 2016) which is lower than in wheat flour (13.00%) (Angioloni and Collar, 2011). In addition, according to Asif-UL-Alam et al. (2014), prolonged exposures of foods to high temperatures can cause the protein less useful in the diet.

The crude fat content increased significantly with the 10% watermelon rind flour obtained through hot-air drying at 60 °C and freeze drying methods (CR60 and CRFD, respectively) substitution (Table 2). The results of crude fat content obtained in the present study showed compatible with our previous reported results on crude fat content of watermelon rind flour dried using different drying methods; whereby flour dried using hot-air drying at 40 °C has significantly lower crude fat content than hot-air drying at 60 °C and freeze drying methods (Ho et al., 2016).

The replacement of wheat flour with watermelon rind flour at the 10% level significantly ($p < 0.05$) increased the crude fibre content of composite steamed cupcakes (CR60 and CRFD). Naknaen et al. (2016) reported that, wheat flour generally contains low fibre content due to the bran fractions were removed during the milling process, and thus the wheat flour has poor source of fibre. CRFD showed significantly ($p < 0.05$) higher crude fibre content than CR40. This was related to the freeze drying method that applied during flour processing which enhance the crude fibre content by preserving its cellular matrix of the sample. According to Sengkhamarn et al. (2013), the degradation of pectin or other fibre (*i.e.*, cellulose or hemicelluloses) occurred during drying process and hence reduced the crude fibre content of dried sample. The result observed in the present study was in accordance with the study done by Asif-UL-Alam et al. (2014). The authors reported that biscuit made from partial replacement of banana flour dried using freeze drying method showed higher crude fibre content than the biscuit incorporated with banana flour obtained through hot-air drying method.

The steamed cupcake with the 10% watermelon rind flour replacement for wheat flour showed a lower total carbohydrate and calorie values than CCONT. This was associated to a greater fibre and lower fat, protein, and carbohydrate content of the composite steamed cupcake than the CCONT for total carbohydrate and

calories, respectively. Generally, it could be concluded that steamed cupcake containing the watermelon rind flour had a good chemical composition *i.e.*, ash and crude fibre.

Colour of steamed cupcakes

All mean values of colour (expressed as Hunter L^* , a^* , and b^* , indicates to lightness, redness/greenness, yellowness/blueness, respectively) for crust and crumb of all prepared steamed cupcakes are presented in Table 3. The steamed cupcake formulations incorporated with watermelon rind flour with the exception of the CR60 showed significantly ($p < 0.05$) lighter colour for the crust and crumb than the CCONT. The results show a similar trend to the reports from Al-Sayed and Ahmed (2013). The authors reported that the incorporation of watermelon rind powder in cake making yielded in a pale crust colour. The lightness of the composite steamed cupcakes may be resulted to the less protein content, as the wheat flour was replaced with watermelon rind flour at 10%. According to Shin et al. (2007), the crust colour is mainly related with the Maillard and caramelization reactions. Therefore, a decrease in the Maillard reaction occurs during the steaming of the composite cupcakes due to the lower protein (lysine) content compared with the CCONT. In contrast, for the crumb colour of steamed cupcakes, it was not influenced by the temperature but primarily due to the colour of the used substituted ingredients because the temperature reach in the crumb does not as high as the crust (Al-Sayed and Ahmed, 2013). Furthermore, among the composite steamed cupcakes, CRFD showed significantly ($p < 0.05$) higher L^* value than CR40 and CR60. This result was in agreement with the result reported by Ahmed et al. (2010), whereby freeze-dried flour (sweet potato flour) produced higher lightness value than those of dried using hot-air drying method.

The crust and crumb of all steamed cupcake (with or without incorporation of watermelon rind flour) showed negative a^* value ($-a^*$) indicates the presence of green hues colour. However, steamed cupcake incorporated with watermelon rind flour obtained through freeze drying process (CRFD) exhibited highest $-a^*$ value. This was associated to the different drying method was applied during processing of watermelon rind flour. For freeze drying method, heating was not required but drying can be achieved through rapidly freezing the sample and then removes ice by sublimation. Therefore, non-enzymatic browning reaction between reducing sugars and amino acids with the presence of heat was minimized (Kresic et al., 2004).

Table 3 shows the significantly ($p < 0.05$) different crust (with the exception of the CRFD) and crumb yellowness values (positive b^* value) of the various steamed cupcake formulations. The substitution of watermelon rind flour dried using hot-air drying method at 40 and 60 °C resulted in significantly ($p < 0.05$) greater b^* values of the cake crust and crumb than the CCONT and CRFD. This result may be attributed to the green pigment of the flour was deteriorated as it exposures to heat during drying using hot-air dryer. The conversion of chlorophylls to phenophytins occurs during heating and subsequently resulted to the loss of green pigment (Ho et al., 2017). In conclusion, the crust and crumb of CRFD exhibited greater colour quality in terms of more lighten and greener compare to cupcakes made from hot-air dried watermelon rind flour incorporated steamed cupcake.

Weight, volume, specific volume, and texture profile of steamed cupcakes

Results on the weight, volume, specific volume, and texture profile of steamed cupcakes are shown in Table 4. The incorporation of watermelon rind flour did not influence the weight of steamed cupcakes. However, different trend was observed by Al-Sayed and Ahmed (2013), where the average weight of cake was increased as watermelon rind flour substituted for wheat flour in cake preparation. Moreover, El-Badry et al. (2014) also reported that the weight of composite pan bread was increased by substitution of watermelon rind flour for wheat flour as compared with control bread. According to El-Badry et al. (2014), an increased in weight of the composite bakery products was primarily due to the fibre content. However, the results obtained from the present study indicated higher fibre content in composite steamed cupcakes (CR40, CR60, and CRFD) (Table 2) did not influence to the weight of the composite steamed cupcakes.

The incorporation of watermelon rind flour dried using freeze drying method in steamed cupcake (CRFD) significantly ($p < 0.05$) increased the cupcake volume and specific volume. This may be attributed to the loose porosity structure of the produced watermelon rind flour using freeze drying method.

Table 3. Colour of steamed cupcakes

Parameters	Types of cupcake ¹			
	CCONT	CR40	CR60	CRFD
Crust				
<i>L</i> *	70.66 ± 1.00 ^a	84.93 ± 0.58 ^b	71.58 ± 0.96 ^a	93.73 ± 1.55 ^c
<i>a</i> *	-5.74 ± 0.19 ^{bc}	-5.90 ± 0.04 ^b	-5.61 ± 0.16 ^c	-8.56 ± 0.12 ^a
<i>b</i> *	23.84 ± 1.40 ^a	36.98 ± 1.30 ^c	33.17 ± 0.23 ^b	24.46 ± 1.14 ^a
Crumb				
<i>L</i> *	71.96 ± 1.27 ^a	77.41 ± 1.17 ^b	70.85 ± 0.23 ^a	82.12 ± 0.52 ^c
<i>a</i> *	-5.54 ± 0.14 ^c	-5.82 ± 0.13 ^b	-5.13 ± 0.02 ^d	-8.56 ± 0.06 ^a
<i>b</i> *	24.47 ± 0.70 ^b	35.38 ± 0.14 ^d	33.10 ± 0.37 ^c	21.43 ± 0.53 ^a

Values with different superscripts within the same row are statistically significant from each other ($p < 0.05$)

Presented data are mean value of three replications ± standard deviation

¹CR40, CR60, and CRFD were the abbreviations for steamed cupcake incorporated with 10% red-fleshed watermelon rind flour dried using hot-air dryer at 40 and 60°C, and freeze drying, respectively, and without watermelon rind flour (CCONT)

According to Ratti (2012), the solid state of water during freeze-drying preserves the primary structure and the shape of the sample and this can minimize the reduction in volume of the products. The air was incorporated and retained within the loose porous structure during mixing stage. When batter is subjected to heat, the entrapped air within gas bubbles will expand, thereby increasing the volume of the batter. Subsequently, the volume can be maintained due to the coagulation of the egg white and rigidity of egg foam and thus producing high volume cakes (Julianti et al., 2016). Our findings are on par with the reports of Al-Sayed and Ahmed (2013), who reported that cake incorporated with watermelon rind flour had increased both the volume and specific volume. This can be concluded that a good physical quality in terms of high specific volume steamed cupcakes can be produced by incorporation of watermelon rind flour dried using freeze drying method.

The values of hardness, springiness, cohesiveness, and chewiness for the steamed cupcakes samples are tabulated in Table 4. Crumb hardness was strongly affected by the different processing method for composite flour. The incorporation of watermelon rind flour dried using hot-air dryer at 40 and 60 °C (CR40 and CR60) did not influence the hardness value of the composite steamed cupcakes. However, the significantly ($p < 0.05$) lowest hardness value (soft texture) was found in steamed cupcake containing watermelon rind flour dried using freeze drying method (CRFD). Noor Aziah et al. (2011) reported that texture is likely to be associated to product volume, whereby, the firmness is inversely proportional to volume of the products. These results were on par with the specific volume results, with higher specific volume producing a softer crumb texture.

Significant ($p < 0.05$) difference was found between control and composite steamed cupcakes in springiness values. The springiness of steamed cupcakes was increased by 10% replacement of the watermelon rind flour for wheat flour. This indicates that the composite steamed cupcakes were more rubbery and elastic than the control. The result obtained from the texture analysis for chewiness parameter showed no statistically significant ($p > 0.05$) difference among the samples. The substitution of watermelon rind flour for wheat flour in steamed cupcakes preparation did not influence the masticatory cycle before swallowing. According to Henriques et al. (2012), the chewiness is strongly related to the hardness of the sample. The firmer the crumb texture, the longer time it needs to chew the food. However, although the crumb of CRFD was softer for those steamed cupcakes containing without or with watermelon rind flour dried using hot-air drying method in the current study, it still needs similar period of time to chew the crumb before ready before swallowing.

Table 4. Weight, volume, specific volume, and texture profile of steamed cupcakes

Parameters	Types of cupcake ¹			
	CCONT	CR40	CR60	CRFD
Weight (g)	13.70 ± 0.12 ^a	13.85 ± 0.09 ^a	13.75 ± 0.02 ^a	13.75 ± 0.02 ^a
Volume (cm ³)	34.76 ± 1.74 ^a	35.20 ± 0.32 ^{ab}	34.45 ± 0.38 ^a	36.79 ± 0.58 ^b
Specific volume (cm ³ /g)	2.53 ± 0.12 ^a	2.54 ± 0.02 ^a	2.52 ± 0.03 ^a	2.67 ± 0.04 ^b
Hardness (N)	6.88 ± 0.22 ^b	7.03 ± 0.08 ^b	6.56 ± 0.70 ^{ab}	5.59 ± 1.03 ^a
Chewiness	3.12 ± 0.31 ^a	3.66 ± 0.16 ^a	3.72 ± 0.38 ^a	3.66 ± 0.56 ^a
Springiness	0.72 ± 0.05 ^a	0.85 ± 0.02 ^b	0.88 ± 0.01 ^b	0.86 ± 0.02 ^b

Values with different superscripts within the same row are statistically significant from each other ($p < 0.05$)

Presented data are mean value of three replications ± standard deviation

¹CR40, CR60, and CRFD were the abbreviations for steamed cupcake incorporated with 10% red-fleshed watermelon rind flour dried using hot-air dryer at 40 and 60°C, and freeze drying, respectively, and without watermelon rind flour (CCONT)

This may be attributed to the present of fibrous material (*i.e.*, fibre), coarser particles of watermelon rind flour which cause difficult to swallow.

Sensory evaluation of steamed cupcakes

The sensory evaluation scores for colour, aroma, hardness, chewiness, springiness, taste, and overall acceptability are shown in Table 5. The colour of all formulated steamed cupcakes was rated as 'like slightly' (score ≥ 5 but ≤ 6) by panellists. According to Hathorn et al. (2008), the value of L^* higher than 70 is classified as light colour. Therefore, the present obtained results indicated that panellists may prefer steamed cupcake which would be light in colour (Table 3).

The incorporation of watermelon rind flour dried using hot-air dryer at 40 and 60°C into the formulations (CR40 and CR60, respectively) significantly ($p < 0.05$) reduced the score for aroma and hardness values. This can be explained by the strong "earthy" smell from the watermelon rind flour which causes slightly unfavourable by the panellists. In addition, CR40 and CR60 had the lower score (4.74 and 4.69, respectively) for hardness parameter than CCONT. This indicates that the panellists perceived steamed cupcakes as soft texture and reject a harder crumb. This result was on par with the results obtained from texture profile analyser, where CR40 and CR60 had higher hardness value than CCONT (Table 4). However, all formulations were considered acceptable by panellists as they received scores greater than 4.

Steamed cupcakes containing watermelon rind flour (CR40, CR60, and CRFD) exhibited lower score for springiness and chewiness scores than control. Hence, the cupcakes crumbs with more springy was not preferred by the panellists (Table 4). Based on the ANOVA results for sensory evaluation on chewiness parameter, it was observed that the panellists were more sensitive than the used instrument (texture profile analyser) in analysing the chewiness. Panellists were able to detect and differentiate among the sample in chewiness, whereby, they were not prefer to chew the elastic crumb (Table 4) and the crumb containing other foreign material (*i.e.*, fibre) from watermelon rind flour which causes them to take a little bit more time to chew before swallowing. The replacement of watermelon rind flour for wheat flour at the 10% level did not influence the taste attribute. This was attributed to the tasteless of the watermelon rind flour itself.

Table 5. Sensory attributes of steamed cupcakes

Attributes	Types of cupcake ¹			
	CCONT	CR40	CR60	CRFD
Colour	5.74 ± 1.15 ^a	5.37 ± 1.26 ^a	5.17 ± 1.29 ^a	5.69 ± 1.08 ^a
Aroma	5.49 ± 1.29 ^b	5.03 ± 1.50 ^a	5.29 ± 1.20 ^a	5.26 ± 1.36 ^{ab}
Hardness	5.60 ± 1.14 ^b	4.74 ± 1.44 ^a	4.69 ± 1.62 ^a	5.23 ± 1.31 ^{ab}
Springiness	5.80 ± 0.90 ^c	5.14 ± 1.19 ^a	5.26 ± 1.24 ^{ab}	5.37 ± 1.37 ^{ab}
Chewiness	6.09 ± 0.78 ^b	5.43 ± 0.98 ^a	5.06 ± 1.43 ^a	5.37 ± 1.46 ^a
Taste	5.74 ± 1.17 ^a	5.17 ± 1.40 ^a	5.34 ± 0.91 ^a	5.51 ± 0.98 ^a
Overall acceptability	6.03 ± 0.92 ^b	5.31 ± 0.99 ^a	5.23 ± 1.09 ^a	5.43 ± 1.17 ^a

Values with different superscripts within the same row are statistically significant from each other ($p < 0.05$)

Presented data are mean value of three replications ± standard deviation

¹CR40, CR60, and CRFD were the abbreviations for steamed cupcake incorporated with 10% red-fleshed watermelon rind flour dried using hot-air dryer at 40 and 60°C, and freeze drying, respectively, and without watermelon rind flour (CCONT)

According to Noor Aziah et al. (2011), the overall acceptability is vital to access due to it associates to the textural and sensorial properties of the food. As indicated in Table 5, there were significant ($p < 0.05$) reduced in score of overall acceptability by panellists. Panellists rated “like moderately” for CCONT, while recorded “like slightly” for all the composite steamed cupcakes (CR40, CR60, and CRFD). These scores were primarily based on the crumb aroma, hardness, chewiness, and springiness. All formulated steamed cupcakes were acceptable, since they received scores higher than 4, ranging from 5.23-6.03.

CONCLUSIONS

The results from the present findings clearly showed that incorporation of watermelon rind flour dried using different drying method (hot-air dryer at 40 and 60°C and freeze drying) (CR40, CR60, and CRFD, respectively) had significant influence on the physiochemical and sensory properties of steamed cupcakes. Steamed cupcakes incorporated with watermelon rind flour had high ash, high crude fat, and high crude fibre. Watermelon rind flour dried using freeze drying method produce excellent physical quality of steamed cupcake; lighten and greener colour, high volume and specific volume which yielded softer texture as compare to control. In addition, all formulated steamed cupcakes was considered as acceptable by panellists as they received score greater than 4. Watermelon rind flour dried using freeze drying method can be applied for making of other bakery products in order to improve their overall quality. However, its economic interests must be taken into consideration.

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