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THE EFFECT OF AVOCADO PUREE AS FAT REPLACER ON THE PHYSICAL QUALITY OF MUFFIN

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ABSTRACT

Avocado (*Persea americana*) is a medium energy dense fruit with buttery puree texture. Avocado is high in monounsaturated fatty acids (MUFAs), which can promote healthy blood lipid profiles and regulates blood glucose levels. This study was performed to study the effect of avocado puree as a fat replacer on the physical quality of fat-reduced muffins. During the muffin-making, butter was replaced with avocado puree at a level of 25% (M1), 50% (M2), 75% (M3) and 100% (M4) whilst muffins with 0% addition of avocado puree were used as a control (M0). The effect of butter replacement on the muffin volume, moisture content, muffin texture profile analysis (TPA) and crumb colour were measured. The results showed that addition of the avocado puree has no significant difference ($p>0.05$) on the weight and height of the M1, M2, M3 and M4 compared to M0. 100% avocado-replacement produced significantly ($p<0.05$) springy muffin while the hardness, cohesiveness and chewiness of M1, M2, M3 and M4 showed no significant difference ($p>0.05$) compared to M0. Muffin-added avocado (M1, M2, M3 and M4) also showed to have darker colour of muffin crumb compared to the control muffins. In conclusion, utilization of avocado puree as a fat replacer in reduced-fat muffins production had not significantly ($p>0.05$) affected the physical properties of muffin. Therefore, avocado can be a natural ingredient for butter replacer in bakery products.

Key words: Avocado puree, Fat-reduced muffins, monounsaturated fat, texture profile analysis (TPA), crumb colour

INTRODUCTION

Avocado (*Persea americana*) is a tropical fruit originated from Mexico. Majority of the avocados available worldwide are Hass avocados. Although avocado is largely produced and consumed in Mexico, at least ten other countries have been producing high yield of avocado annually, including Chile, Dominic Republic, and Indonesia. Avocado, besides being consumed as a fresh fruit, it is also suitable for salad fruit, sandwich spread, and guacamole (Yahia & Woolf, 2011). In contrast to typical sweet and acidic fruits, avocado has a buttery and smooth texture that makes it suitable as a potential fat replacer. Moreover, it contains high level of fat; 66.67% of monounsaturated fatty acid (MUFA), 14.29% of saturated fatty acid (SFA) and 12.24% of polyunsaturated fatty acid (PUFA), as recorded by Gillingham *et al* (2011). In addition, avocado is also known as a medium energy dense fruit as approximately 80% of the edible part of avocado consists of water (72%) and dietary fiber (6.8%) (Dreher & Davenport, 2013).

Fat plays important roles in food systems. In bakery products such as muffins, cakes, and breads, fat entraps air during mixing to incorporate air bubbles into the batter or dough to produce porous crumb texture (Dwyer & Gallagher, 2001) and leaven the final products (Matsakidou *et al.,* 2010). Besides the importance of fat in bakery industry, types of dietary fats affect differently on health. For a healthier lifestyle, trans fatty acids (TFAs) and saturated fatty acids (SFAs) should be avoided.

High intake of SFAs and TFAs lead to hypercholesterolemia and coronary heart disease, while TFAs increase the risk of coronary heart disease due to increase of low-density lipoprotein (LDL) and lower high-density lipoprotein (HDL) (Zock & Katan, 1997). Butter and margarine, which are commonly used in bakery products, are high with these types of fats. Thus, there is a need to find fat replacers to substitute the use of these fats in baking. Fat replacement in foods, however, poses a

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complex problem because fat contributes to both sensory and physiological characteristics such as flavour, mouth feel, taste, and texture. As the public demands for reduced-fat food products without compromising the good taste still remains high, many studies have been conducted to make acceptable low-fat food products with the utilization of natural ingredients as fat replacers. These include the mung bean paste (Adair & Knight, 2001), pawpaw fruit puree (Wiese & Duffrin, 2003), avocado puree (Wekwete & Navder, 2008), cocoa fiber (Martinez-Cevera *et al.,* 2011) and apple sauce (Hayek & Ibrahim, 2013).

In many countries, muffins are popular for breakfast and afternoon snack. Consumers of all age groups appreciate muffins for the good taste and tender crumb, among other types of bakery products. Classified as ready-to-eat food, muffin is also consumed for convenience. Due to the hectic lifestyles nowadays, people tend to choose ready-to-eat foods. Apart from that, people have started to change from traditional foods to a more convenient and healthier food due to health awareness.

Previously, a study had been made to investigate the functionality of avocado as fat replacer in bakery product. However, it focused on the partial replacement of butter fat using two different fat replacers, avocado puree and Oatrim (Wekwete & Navder, 2008). In contrast with this current study, full butter replacement was aimed with the usage of avocado puree as the ingredient of fat replacer. Therefore, the present study is conducted to investigate the effects of avocado puree incorporation as fat-replacer on the physical quality of muffin.

MATERIAL AND METHODS

Muffin ingredient

Multi-purpose flour (Blue Key Brand, PPB Group Berhad, Kuala Lumpur, Malaysia), fresh milk (Dutch Lady Milk Industries Berhad, Selangor, Malaysia), granulated sugar (Gula Prai, MSM Malaysia Holdings, Perlis, Malaysia), unsalted pure butter (Anchor, Fontera Ltd., Hamilton, New Zealand), baking powder (Barkath Food Sdn. Bhd., Seberang Perai Tengah, Malaysia), egg, and salt used were bought from local markets in Kubang Kerian, Malaysia.

Avocado puree preparation

The avocados were obtained from farm in Seremban, Negeri Sembilan, Malaysia. Only ripe avocado (slightly yellow in colour and soft when touched) was chosen based on the physical texture. The fruit was cut in half and the seeds were removed. Avocado flesh was scooped out using a spoon and divided into few portions according to the formulations. The fruit was appropriately handled to maintain the quality of the raw material.

Muffin preparation

Basic muffin recipe was prepared according to Figoni (2008). Five muffin formulations were derived from the original recipe; all-purpose flour (200 g), fresh milk (160 mL), sugar (80 g), butter (70 g), an egg (60 g), baking powder (12 g) and salt (2 g). Each formulation was labelled as M0, M1, M2, M3 and M4. M0 was the control, formulated without butter replacement. For other four formulations, butter was replaced with avocado puree in the following portions; 25% (M1), 50% (M2), 75% (M3) and 100% (M4).

Dry ingredients, wheat flour, baking powder, and salt were sifted together into a bowl, and a well was made in the middle. Sugar and an egg were beaten in a separate bowl. Next, milk and butter were mixed in thoroughly. The wet ingredients were then poured into the well in the dry ingredient bowl. They were mixed until the mixture was just smooth to avoid over-mix. A total of 50.0 + 1.0 g of batter was poured into muffin cups, and baked for 20 minutes at 200ºC in a preheated oven.

After five minutes, muffins were removed from the pans and allowed to be cooled on a wire rack at room temperature for 1 hour. Next, the muffins were packed in a set of three and sealed in plastic bags. Analyses were conducted twice after 24 hours of baking.

Physical measurements of batter and muffins

Batter specific gravity was determined as the ratio of the weight of certain volume of batter to the weight of the same volume of water. The weight and volume of each muffin were measured using an electronic balance and seed displacement method, respectively. Standard ruler was used to measure the cross-section scanned image of the muffin (Rodriguez-Gracia *et al.,* 2014). Specific volume (the ratio of the muffin volume to the weight) and density (the ratio of muffin weight to its volume) of the muffin were calculated while the oven-drying method was used to analyse the moisture content in the muffin. All analyses were done in triplicate.

Texture profile analysis (TPA) studies

Textural properties of the muffin were measured using texture analyzer (TA.XTPLUS, Stable Micro System Ltd., Godalming, UK) provided with the Exponent 32 software (Version 5,1,1,0, Stable Micro Systems Ltd., Godalming, UK). The upper and lower muffin crust was cut horizontally into a cylinder-shaped muffin with a size of 2.5 cm in height and 4.0 cm in diameter. The crumb texture measurement was performed using a 36 mm diameter cylindrical

probe with a test speed of 1.0 mm/s, pre- and post-test speed of 10.0 mm/s. The test distance was 8.0 mm and time was 10 seconds. Each sample was compressed to 25% of the initial height in the double compression test.

Four instrumental parameters were measured in triplicate which was the hardness, cohesiveness, springiness and chewiness. Cohesiveness is defined as the ratio of positive force area during the second compression to the positive force area during the first compression, while the springiness determines the recovery height of food between the end of first compression and the start of second compression. Chewiness, on the other hand, is the product of hardness, cohesiveness and springiness. It indicates the difficulty of chewing before swallowing.

Colour of muffin crumb

The colour of muffin crumb was measured in triplicate using a colorimeter (Minolta CM-3500d, Konica Minolta Sensing Americas, Inc., New Jersey, USA) with D65 illuminant and 10° viewing angle, based on CIELab scale. Colour attributes were recorded with the aid of SpectroMagic software (Version 2.03, USA).

Muffin was cut horizontally into half parallel to its base. The crumb colour was measured at several points on the cut surface. The parameters were L* (L* = 0 is black, while L* = 100 is white), a* (+a* is red), and b* (+b* is yellow).

Statistical Analysis

SPSS statistical package (Version 16.0, SPSS Inc., Chicago, USA) was employed for statistical analysis. The data were analysed by using one-way ANOVA test for the assessment of the effect of avocado puree incorporation on the physical quality of the muffins. If the ANOVA test showed significant differences, comparison of means was conducted using Tukey's least significant difference test with 5% significance level ($p<0.05$).

RESULTS AND DISCUSSION

Physical measurements of batter and muffins

Addition of avocado puree in muffin shows no significant difference ($p>0.05$) in the specific gravity of muffin batters, muffin weight and height (Table 1). In general, specific gravity defines the ability of fats in incorporating air into the batters, which indicates the volume development of baked muffins and air cell in crumb structure (Psimouli & Oreopoulou, 2013; Celik *et al*., 2007). Rather than improving the batter aeration, as the effect cocoa fiber in chocolate muffins (Martinez-Cevera *et al*., 2011), avocado has insignificant effect on the muffin batter.

The volumes of M1and M3 are significantly lower compared to M0, M2 and M4. Muffin volume decreases significantly ($p<0.05$) with increasing fat replacement, which is due to low amount of air in baked muffin. Since the specific gravity of all formulation is not significant, this might be explained by the collapse of air membrane in the crumb during baking.

As compared to M0 and M4, the specific volumes of M1, M2 and M3 are significantly decreased ($p<0.05$) while muffin density of M1, M2 and M3 are significantly higher ($p<0.05$). The specific volume affected the volume development and porous crumb texture of the final products (Psimouli & Oreopoulou, 2013).

The moisture content of muffins significantly increased with the addition of avocado. This possibly due to the high content of water derived from avocado puree, which is about 72% of one fruit (Dreher & Davenport, 2013). The water content of

Table 1. Mean values of specific gravity of batter, physical properties and moisture content of muffins

Parameters	M0	M1	M2	M3	M4
Specific gravity	1.10^{a}	1.10^{a}	1.13^{a}	1.11^{a}	1.10^{a}
Weight (g)	41.21^{a}	40.94^{a}	42.71^{a}	42.63^{a}	41.90^{a}
Height (cm)	35.00^{a}	36.20^{a}	38.20^{a}	35.70^{a}	38.80^{a}
Volume (cm^3)	96.40^{b}	75.80^{a}	90.00^{b}	84.00^{ab}	92.60^{b}
Specific volume ($cm^3\ g^{-1}$)	2.34^{c}	1.85^{a}	2.11^{abc}	1.97^{ab}	2.21^{bc}
Density ($g\ cm^{-3}$)	0.43^{a}	0.56^{b}	0.47^{ab}	0.51^{ab}	0.45^{a}
Moisture content (%)	32.92^{a}	36.18^{b}	37.18^{c}	39.81^{d}	40.84^{e}

M0 is control muffin (0% avocado replacement); M1 is muffin with 25% avocado replacement; M2 is muffin with 50% avocado replacement; M3 is muffin with 75% avocado replacement; M4 is muffin with 100% avocado replacement. Numbers with different letters within the same row are statistically different ($p < 0.05$) according to Tukey's test.

Table 2. Mean values for texture profile analysis (TPA) parameters

Formulation	Hardness (N)	Cohesiveness	Springiness	Chewiness (N)
M0 (Control)	1.05^{ab}	0.76^{ab}	0.88^{a}	699.32^{a}
M1	1.19^{b}	0.75^{a}	0.90^{ab}	801.76^{a}
M2	1.04^{ab}	0.73^{a}	0.90^{ab}	679.82^{a}
M3	1.06^{ab}	0.74^{a}	0.90^{ab}	702.97^{a}
M4	0.90^{a}	0.81^{b}	0.94^{b}	676.87^{a}

M0 is control muffin (0% avocado replacement); M1 is muffin with 25% avocado replacement; M2 is muffin with 50% avocado replacement; M3 is muffin with 75% avocado replacement; M4 is muffin with 100% avocado replacement. Numbers with different letters within the same column are statistically different ($p < 0.05$) according to Tukey's test.

avocado puree was higher than water content in butter, which is only about 15%. Besides, fiber content in avocado puree might also affect the water content in muffin as fiber has strong affinity for water (Sadaf *et al*., 2013).

Texture profile analysis (TPA) studies

The parameters shown in Table 2 demonstrate that avocado replacement in muffin did not significantly affect ($p>0.05$) the crumb texture. There was no significant difference ($p>0.05$) between the fat replaced muffins and the control in terms of hardness, cohesiveness and chewiness. However, the springiness was significantly highest ($p<0.05$) in the full-substituted fat muffin, M4.

Fat substitution, either partially or fully, usually produces harder and springier baked products (Martinez-Cervera *et al*., 2013). This has been proved by some previous studies on the incorporation of fat replacers including the studies that used sesame oil in cakes, peanut butter in biscuits, and extra virgin olive oil as margarine substitute in cakes (Sowmya *et al*., 2009; Sadaf *et al.,* 2013; Matsakidou *et al*., 2010). However, in the present study, avocado incorporation into muffin produced softer texture though not significantly different. This is in line with the application of Nutriose as fat replacer in Spanish muffins, the combination of sesame oil, hydrocolloids, and emulsifiers (HPMC, hydroxypropylmethylcellulose; SSL, sodium steoryl-2-lactylate; and GMS, glycerol monostearate), and the flour-oil composite in low-fat cake mixes (Martinez-Cervera *et al*., 2013; Sowmya *et al*., 2009; Singh, 2012).

Martinez-Cevera *et al* (2013) mentioned that muffin hardness is inversely related to its volume. Hence, smaller volume of muffin will produce harder muffin. This is in accordance with the results obtained in the study in which the volume of both M1 and M3 were lowered and hardened in texture compared to the control muffin. As cohesiveness depends on hardness, it showed a similar hardness tendency (Matsakidou *et al.,* 2010).

Full-fat substitution, M4, exhibited the softest and springiest texture. High water content in muffin produces softer crumb. Springiness parameters, also noted as elasticity, revealed to be significantly higher ($p<0.05$) than M0. This reflects the high ability of the muffin to go back to its original shape after the deforming force is removed (Szczesniak, 2012). However, the parameter appeared to be ingredient specific, in which a fruit's dietary fiber does not influence muffins' springiness while other types of ingredients do influence the springiness of crumb (Acosta *et al*., 2011).

Colour of muffin crumb

Avocado puree was found to significantly influence ($p<0.05$) the colour of the muffin crumb, as presented in Table 3. The control sample, M0, exhibited the lightest crumb colour (highest L* value) as compared to avocado-incorporated muffins. As the percentage of avocado substitution increased, the muffin crumb colour became darker. Avocado replacement of 25% showed no significant difference ($p>0.05$) in the L* values. However, higher avocado substitution (M2, M3, and M4)

Table 3. Mean values of color components for muffin crumb

Formulation	L	a *	b *
M0 (Control)	64.33^{c}	2.55^{b}	28.87^{b}
M1	61.72^{bc}	2.90^{b}	29.09^{b}
M2	59.01^{ab}	0.87^{a}	26.44^{a}
M3	56.04^{a}	1.42^{a}	26.23^{a}
M4	58.18^{a}	0.83^{a}	26.31^{a}

M0 is control muffin (0% avocado replacement); M1 is muffin with 25% avocado replacement; M2 is muffin with 50% avocado replacement; M3 is muffin with 75% avocado replacement; M4 is muffin with 100% avocado replacement. Numbers with different letters within the same column are statistically different ($p < 0.05$) according to Tukey's test.

demonstrated to have significant difference ($p<0.05$) compared to M0 and M1.

In addition, a* (red component) and b* (yellow component) values for M0 and M1 were significantly higher ($p<0.05$) than M2, M3 and M4. The three muffin crumbs were greener and lesser in yellow colour component. The colour variation of the muffins might be due to the pigments content in avocado puree; the carotenoid (especially lutein) and chlorophyll (Ashton *et al.,* 2006). In addition, natural enzymatic browning that forms brown pigments of polymerized quinones in the avocado flesh also contributed to the dark colour of avocado-treated muffin samples (Gómez-López, 2002). According to Al-Sayed and Ahmed (2013), Maillard reaction and caramelization were not happening since the crumb part does not reach 100°C. Therefore, the crumb colour is the result of the ingredients and their interaction during baking.

Avocado substitution over 25% showed significant difference ($p<0.05$) in the L*, a*, and b* values of muffin colour components. The muffin crumbs were darker, lower in redness and yellowness than the muffins with avocado substitution below 25%.

CONCLUSION

From this study, it can be concluded that avocado puree is suitable to be used as a fat replacer in muffins production as the addition of avocados showed no significant difference in muffins' weight and height as compared to the control muffin. Crumb muffin with avocado incorporation was softer and springier compared to control muffin. Moreover, muffin crumb appeared to be darker, greener, and less in yellow colour component as compared to control muffin. However, future work should focus on studying the shelf life properties of avocado-incorporated muffins. Sensorial study should also be done to investigate the acceptability of the products.

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