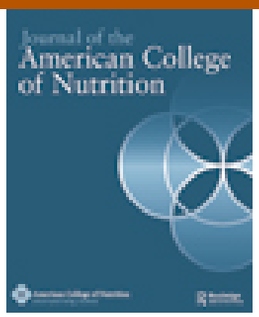

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ORIGINAL ARTICLE

Influence of Avocado Purée as a Fat Replacer on Nutritional, Fatty Acid, and Organoleptic Properties of Low-Fat Muffins

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ABSTRACT

Objective: The feasibility of developing reduced-fat muffins with avocado is investigated by preparing muffins with 25%, 50%, 75%, and 100% avocado purée as a fat (butter) replacer.

Methodology: The resulting products were compared to the control muffin, which was made with 100% butter. Muffins were analyzed for nutritional content, fatty acid profiles, and sensory acceptability.

Result: Muffins incorporated with avocado purée revealed a significant increase ($p < 0.05$) with respect to moisture, ash, and carbohydrate in comparison with the control sample. However, no significant changes ($p > 0.05$) were detected in all muffin formulations for protein and dietary fiber content. Both fat content and caloric value of muffins incorporated with avocado purée were significantly decreased ($p < 0.05$). The fatty acid profile showed that there was an increment in the monounsaturated fatty acids (MUFA) content by 16.51% at full-fat substitution. The sensory evaluation test demonstrated that muffins had acceptability at up to 50% substitution. Fat substitution at higher than 50% lead to undesirable flavor and aftertaste, which was significant ($p < 0.05$) to the panelists.

Conclusion: The findings indicated the feasibility of avocado purée in fat-reduced muffin preparation with an optimal level of 50% avocado purée substitution.

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KEYWORDS
Fat replacer; muffin; avocado purée; nutritional content; hedonic study

Introduction

Avocado (*Persea americana*) is a tropical fruit that originated from Mexico, and the majority of the avocados available worldwide are from Hass avocados. Avocado is classified as a functional food due to the nutraceutical components in the fruit (1,2). The avocado pulp contains antioxidant phytochemicals and other bioactive substances, including carotenoids, lutein, β-sitosterol, and potassium, which have anticancer properties, have a lipid-lowering effect, and improve blood pressure (3,4,5).

Besides, avocado contains a substantial amount of lipid, mainly composed of monounsaturated fatty acids (MUFA; about 66.67%), followed by saturated fatty acids (SFA) and polyunsaturated fatty acids (PUFA), present at 14.29% and 12.24%, respectively (6). Considering the high MUFA content, researchers suggested avocado consumption for glycemic control in diabetic patients (7). However, to reap the benefits of avocado on human lipid profile, substituting saturated fats proportion in dietary fats with avocado was recommended, rather than adding avocado in the daily diet (8).

It is recommended that the daily fat consumption should not exceed 30% of the total calories (9). However, regardless the quantity of fat intake, the quality of fat is more important (10). High intake of SFA and TFA leads to hypercholesterolemia and coronary heart disease. TFAs elevate low-density lipoprotein (LDL) and reduce high-density lipoprotein (HDL), which lead to greater risk of coronary heart diseases (11).

Nutrition and health awareness leads consumers to choose reduced- or low-fat/-calorie foods. Over the years, low-fat and low-calorie food products have been continuously studied and developed in the baking industry to meet consumer demands for healthier food choices (12). The applications of fat replacers have successfully formulated low-fat and low-calorie food products without compromising consumers' preference. Mung bean paste, okra gum, rice starches, Yuja pectin, and cocoa fiber, as well as fruit and vegetable purées such as prune purée, squash, and cantaloupe, are the examples of fat replacers used in baked goods (13–19).

Muffins, classified as quick breads, are popular for breakfast and afternoon snacks in some countries. They are characterized as a soft spongy product with porous crumb structure and high volume. Muffins and other sweet baked goods are usually rich in fat and sugar, which are avoided by health-conscious consumers. Fats in bakery products entrap air into batter or dough to develop crumb and leaven the baked goods (20,21), as well as contributing to flavor and taste of the final products. Thus, fat replacement during muffin preparation can negatively affect both crumb texture and the organoleptic property.

Previous studies have shown the feasibility of avocado purée as a fat replacer in oatmeal cookies and butter cake at up to 50% avocado substitution for butter (22,23). However, the potential of avocado purée as a fat replacer in muffins has not been tested. In view of the preceding, this study was conducted to develop fat-reduced muffins while determining the

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nutritional characteristics of muffins incorporating avocado purée. Sensory quality and acceptability of muffins were also assessed to determine the optimum level of avocado substitution in muffin formulations.

Material and methods

Materials

The ingredients used in muffin production were multipurpose flour (Blue Key Brand, PPB Group Bhd., Kuala Lumpur, Malaysia), low-fat milk (Dutch Lady, Dutch Lady Milk Industries Bhd., Selangor, Malaysia), unsalted pure butter (Anchor, Fonterra Ltd., Hamilton, New Zealand), granulated sugar, one whole egg, baking powder, and salt. All ingredients were purchased from local markets.

Avocado used in muffin formulations was obtained from a local orchard in Negeri Sembilan, Malaysia. The ripe avocado fruit was chosen from physical observation on the firmness and color of the fruit, which was soft when pressed and had black/purplish skin color. The fruit was cut in half and the seed was removed. The avocado flesh was scooped out using a spoon and blended into a purée. The purée was then kept in a freezer until further use. The nutritional composition of avocado purée per 100 g is: moisture (85.35%), ash (1.28%), protein (1.98%), fat content (11.37%), total dietary fiber (1.15%), carbohydrate (0.15%).

Sample preparation

The muffins were prepared using flour (200 g), milk (160 mL), sugar (80 g), butter (70 g), whole egg (60 g), baking powder (12 g), salt (2 g), and vanilla essence (24). All dry ingredients were sifted together into a bowl, and a well was made in the middle. The egg was beaten in a separate bowl before adding milk and butter (and/or avocado purée). Avocado purée was incorporated by replacing butter in the formulation at 0% (control, M0), 25% (M1), 50% (M2), 75% (M3), and 100% (M4). The mixture was mixed thoroughly and poured into the well in the dry ingredient bowl, prior to mixing.

Approximately 50.0 ± 1.0 g of batter was poured into each muffin cup and baked for 20 minutes at 200°C in a preheated oven (Zanussi ZCG 841 W). After a 5-minute setting period, muffins were removed from the pans and allowed to cool at room temperature for 1 hour before storage. Finally, all muffin samples were kept in airtight containers at room temperature until further use.

Throughout this study, all muffins were analyzed on a dry basis except for the sensory evaluation. The homogenized muffin sample was dried in a drying oven (Memmert model 100–800, Germany) for 3 consecutive days at 60°C. The ground samples were stored in a labeled air-tight plastic container at room temperature.

Proximate analysis of muffins and avocado purée

Proximate analyses of samples, including moisture, ash, fat, and protein, were determined in triplicate (25). The nitrogen conversion factor used for crude protein calculation was 6.25, while the available carbohydrates were calculated by difference: carbohydrate $(\mathrm{g}) = 100 - (\%\ \text{moisture} + \%\ \text{protein} + \%\ \text{fat} + \%\ \text{ash})$. The total dietary fiber of muffins was analyzed by digesting the sample with enzymes, as described in the Association of Official Analytical Chemists (AOAC) method (25).

Calorific value

The determination of calorific value was performed by indirect calorimetry: calorific value $\left(\frac{\text{kcal}}{100\text{g}}\right) = (\%\ \text{Fat} \times 9) + (\%\ \text{Protein} \times 4) + (\%\ \text{Carbohydrate} \times 3.75)$ The energy conversion factors applied were 9 kcal/g for fats, 4 kcal/g for protein, and 3.75 kcal/g for carbohydrate, as reported in Metric Units, Conversion Factors and Nomenclature in Nutritional and Food Sciences (1972) (26). The percentage reductions of fat and caloric value were calculated by using formula; $[(V1 - V2)/V1] \times 100$, where V1 is the value of control sample, M0, and V2 is the value of the test sample.

Fatty acid profile

The extracted oil of muffin samples obtained from Soxhlet extraction method was derivatized into fatty acids methyl esters (FAMEs) (25). A volume of 20 μL of oil was solubilized in 1 mL of toluene. After adding 2 mL of 1% H_2SO_4, the solution was kept in water bath at 50°C overnight. Next, 2 mL of 5% NaCl and hexane was added. The mixture was shaken until two separate layers were formed. By using a micropipette, the upper layer was collected and transferred into vials. Approximately 10 μL of the FAME was injected into gas chromatography instruments (Varian CP3800, USA) fitted with a flame ionization detector (GC-FID) for further analysis on the fatty acid profile.

The analysis was operated under the following conditions; capillary column CP-Sil 88 for FAME (CP 7489) (Varian, Netherlands) 100 m × 0.25 mm, 0.2 μm thickness; column temperature 160°C; detector temperature 300°C; and a carrier gas, helium at a flow rate of 25 mL/min. The peaks generated from the GC-FID instrument were identified by comparison with a FAME standard (Supelco, Bellefonte, PA). Results were reported as a percentage of individual fatty acids.

Sensory evaluation

The sensory evaluation on muffins was carried out by 67 untrained panelists, (ages 18 to 42 years), who were recruited among students and staffs of Health Campus, Universiti Sains Malaysia. The samples were prepared the day before testing. The muffin samples were cut into 2-cm cubes and packed into the sealed plastic bag, respectively. In total, five muffin samples were presented simultaneously on a serving plate. Each sample was coded with a 3-digit random number. In order to prevent positional bias and contrast effect, samples were presented in randomized order. Drinking water was provided for palate cleansing and to eliminate the carryover taste from the previous sample. The evaluation was conducted in a day, under the condition of ambient temperature and fluorescent light.

The assessment was made on six sensory attributes, including the crumb appearance, color, moistness, tenderness, mouth feel, and overall impression based on a 9-point hedonic scale (1 = extremely dislike; 5 = neither like nor dislike; 9 = extremely like). Muffin samples were considered acceptable if their mean values were above 5. Overall acceptance and purchase intent were also rated using binomial scale (yes or no) (27).

Statistical analysis

The SPSS statistical package (Version 16.0, SPSS, Inc., Chicago, IL) was employed for statistical analysis. The data were analyzed by using one-way analysis of variance (ANOVA) test for the assessment of the effect of avocado purée incorporation on the nutritional content and sensory evaluation of muffins. Comparison of means was conducted using Tukey's least significant difference test with 5% significance level ($p = 0.05$).

Result and discussion

Proximate analysis

Avocado purée incorporation into muffins significantly affected the nutritional content, as summarized in Table 1.

Moisture content increased significantly ($p < 0.05$) in muffins incorporating avocado purée as compared to M0. At full substitution, M4 showed the highest moisture content. This can be explained by the high moisture content of avocado purée when used as a substitute for butter. Similar trends were observed for incorporation of peanut butter in biscuits (28).

With respect to the control muffin, total ash increased with the incorporation of avocado purée, with a significant increment ($p < 0.05$) showed in M3 and M4. Likewise, the incorporation of cantaloupe and squash into Madeira-type cake (19) also increased the ash content of final products as compared to the control cake.

Protein content in muffins showed an insignificant increment ($p > 0.05$) with the incorporation of avocado purée, ranging from 10.16% to 11.61%. Previous studies confirmed a similar trend in which incorporation of a fat replacer increased the protein content of baked goods, either significantly or insignificantly (19,29).

Total dietary fiber showed fluctuation among samples, but there were no significant differences ($p > 0.05$) for all formulations, ranging from 2.03% to 3.55%, with M0 having the highest dietary fiber content. The fat content of muffins decreased significantly ($p < 0.05$), from 14.85% to 2.41%, with increment in avocado purée incorporation. Previous studies also showed a similar trend, in which fat replacement reduced the fat content progressively in baked products (14,29).

Carbohydrate content significantly increased ($p < 0.05$) following the increment of avocado purée incorporation, ranging from 67.83% to 77.85%. Avocado purée incorporation contributed to the increase in carbohydrate content in muffin formulation since other ingredients were kept at a constant amount. Caloric values of muffins decreased significantly ($p < 0.05$), owing to the reduction in fat content in muffins. This is because fat contributes the highest caloric value (9 kcal/100 g) as compared to protein and carbohydrate. Thus, reducing the fat content will simultaneously reduce the caloric value.

Nutritional quality of muffin: Energy and macronutrients

The nutritional quality of muffins from each formulation was evaluated by calculating the nutrient density index per serving for one piece of 60-g muffin, as summarized in Table 2. The energy and macronutrients values were then compared to the recommended intake in terms of Malaysian Nutreint Intake (RNI) (30), with reference to the daily nutrient requirement for adults (males) in the general population: energy intake 2240 kcal/day consisting of 10–20% protein, 50–65% carbohydrate, and 25–30% fat from MUFA (12–15%) and SFA (10%).

It is interesting to note that protein content remained stable in all muffin formulations. The protein contribution from a 60-g muffin is comparable to a 66-g sausage roll (25.2 kcal) or a half cup of chickpeas (28 kcal). As compared to the legumes and baked product, avocado-incorporated muffins provided about the same protein content. Other sources of protein among Malaysians include beef, seafoods, legumes, and milk products.

In terms of fat content, it was expected that the fat content would decrease from sample M0 to M4 since butter content was decreased from M0 to M4. Sample M2 would be a better choice for weight watchers who were only interested in reducing the fat but still wanted to maintain other nutrients such as protein. Sample M2 provided the same amount of protein as the control sample (M0) but with much lower saturated fat (approximately 58% reduction in saturated fat).

The carbohydrate content increased since fruit purée is among the major source of carbohydrates, besides milk products, cereals, and vegetables. Full fat substitution in muffins reduced approximately 41.2 calories. The reduced amount of

Table 1. Mean values of nutritional composition of muffins incorporating avocado purée.

Parameters	M0	M1	M2	M3	M4
Moisture (%)	3.61 ± 0.03^{a}	4.14 ± 0.08^{b}	4.27 ± 0.09^{b}	4.28 ± 0.29^{b}	5.53 ± 0.07^{c}
Ash (%)	2.67 ± 0.08^{a}	2.83 ± 0.10^{ab}	2.69 ± 0.05^{ab}	2.85 ± 0.04^{bc}	3.01 ± 0.02^{c}
Fat (%)	14.85 ± 0.16^{e}	12.12 ± 0.14^{d}	9.18 ± 0.08^{c}	6.10 ± 0.24^{b}	2.41 ± 0.02^{a}
Protein (%)	10.16 ± 0.77^{a}	10.40 ± 0.48^{a}	11.08 ± 0.29^{a}	11.08 ± 0.59^{a}	11.61 ± 0.96^{a}
TDF (%)	3.96 ± 1.66^{a}	2.07 ± 0.17^{a}	3.15 ± 1.05^{a}	2.55 ± 1.15^{a}	3.03 ± 1.73^{a}
Carbohydrate (%)	67.83 ± 1.06^{a}	71.32 ± 0.46^{b}	72.58 ± 1.04^{b}	76.28 ± 1.12^{c}	77.85 ± 0.95^{c}
Caloric value (kcal/100 g)	428.66 ± 3.65^{e}	418.13 ± 0.62^{d}	399.15 ± 2.70^{c}	385.24 ± 3.37^{b}	360.09 ± 4.60^{a}
Fat reduction (%)	—	18.4	38.2	58.9	83.8
Caloric value reduction (%)	—	2.5	6.9	10.1	16.0

*Means across the column with different superscripts are significantly different ($p < 0.05$).

Table 2. Nutritional quality of muffins per piece of 60-g muffin.

Sample	Energy (kcal)	Protein (kcal)	Carbohydrate (kcal)	Fat (kcal)	MUFA (kcal)	SFA (kcal)
RNI requirement (%)	2240 kcal/day	10–20	50–65	25–30	12–15	10
M0	257.20 (11.5)	27.56 (1.2)	152.62 (6.8)	80.19 (3.6)	17.96 (0.8)	9.24 (0.41)
M1	250.88 (11.2)	26.88 (1.2)	160.47 (7.2)	65.45 (2.9)	15.72 (0.7)	6.03 (0.27)
M2	239.49 (10.7)	25.66 (1.2)	163.31 (7.3)	49.57 (2.2)	12.70 (0.6)	3.87 (0.17)
M3	231.14 (10.3)	24.77 (1.1)	171.63 (7.7)	32.94 (1.5)	9.12 (0.4)	1.45 (0.06)
M4	216.05 (9.6)	23.15 (1.0)	175.16 (7.8)	13.01 (0.6)	5.06 (0.2)	0.19 (0.01)

*Values in parentheses note the percentage of each nutrient as compared to the recommended intake.

Table 3. The fatty acid profile of avocado purée and muffins.

	Sample and percentage of fatty acids					
Fatty acid	M0	M1	M2	M3	M4	AVOCADO2
C8:0	1.26	1.38	1.14	1.19	0.28	0.24
C10:0	2.95	3.45	2.96	2.74	0.56	0.35
C11:0	0.35	0.33	0.25	0.29	ND	0.01
C12:0	6.34	5.91	4.95	5.51	1.46	3.03
C13:0	0.24	ND	ND	0.14	ND	0.02
C14:0	13.86	13.11	12.56	10.35	2.90	3.76
C15:0	0.61	0.54	0.38	0.27	ND	0.28
C16:0	37.85	34.49	34.98	32.59	31.10	27.77
C17:0	0.78	0.50	0.44	0.37	ND	0.26
C18:0	10.20	12.57	12.09	10.68	5.08	ND
C20:0	3.15	3.70	4.65	8.17	19.72	0.22
C21:0	ND	ND	ND	ND	ND	0.09
C22:0	ND	ND	ND	ND	ND	0.08
C23:0	ND	ND	ND	ND	ND	0.04
C24:0	ND	ND	ND	ND	ND	0.07
C14:1	1.18	0.78	0.78	0.58	ND	0.12
C15:1	ND	ND	ND	ND	ND	0.01
C16:1	2.00	1.98	2.12	2.26	3.29	5.85
C17:1	0.17	ND	ND	ND	ND	0.04
C18:1	19.06	21.27	22.72	24.86	35.62	15.61
C20:1	ND	ND	ND	ND	ND	0.77
C22:1	ND	ND	ND	ND	ND	0.05
C24:1	ND	ND	ND	ND	ND	0.05
∑FA (%)						
∑SFA (%)	77.60	75.97	74.38	72.30	61.09	36.21
∑MUFA (%)	22.40	24.02	25.62	27.70	38.91	22.51
∑SFA (g)	11.52	9.21	7.80	4.41	1.47	4.12
∑MUFA (g)	3.33	2.91	2.35	1.69	0.94	2.56

*ND: not detected.

calories from two pieces of muffins (82.4 kcal) is comparable to a slice of whole-grain bread (70 kcal) or two potatoes (80 kcal).

Fatty acid profile

Since butter was substituted for by unsaturated-fats avocado purée, the fatty acid profile improved as predicted. In general, saturated fats were decreased while monounsaturated fats were increased with avocado incorporation. Table 3 illustrates the fatty acid profile of avocado and muffins incorporating different levels of avocado purée. SFAs in full-fat muffins (M0) are mostly comprised of palmitic (C16:0), stearic (C18:0), myristic (C14:0), and lauric acid (C12:0). These fats were gradually decreased with avocado incorporation. MUFA content in avocado-substituted muffins was basically high in palmitoleic (C16:1) and oleic acid (C18:1).

The total SFA decreased by 21.3% from the M0 (control) to the M4 sample. The total MUFA content, on the other hand, increased by 73.7% from the M0 to the M4 sample. The Academy of Nutrition and Dietetics recommended that 20% to 35% of energy should be obtained from dietary fat with limited intake of SFA and TFA, with increases in PUFA (10). Briefly, it is more important to consider the displacement of the quality of fatty acids than the quantity of the fat intake (31).

Sensory evaluation

The mean scores for sensory evaluation are presented in Table 4. All of the assessed parameters were significantly affected ($p < 0.05$) with the increasing level of avocado purée incorporation in muffins. Concerning the hedonic scale (1 = extremely disliked; 5 = neither liked nor disliked; 9 = extremely liked), muffin samples with a score higher than 5 were considered as acceptable for panelists.

With respect to the color attribute, avocado incorporation lowered the acceptability scores, with M2 and M3 significantly less liked ($p < 0.05$) as compared to the control muffin. However, the scores were still in the acceptable range, which was represented by values higher than 5. M0 was the most while M3 was the least accepted by panelists. M4 also scored lower than M0, but showed no significant difference ($p > 0.05$) among all formulations. A similar result was observed in cake with cantaloupe added as a fat replacer, in which full-fat replacement lowered the acceptance color score as compared to the control product (19). The color of fat replacer used greatly

Table 4. The mean scores of sensorial evaluation of muffins with different levels of avocado purée incorporation.

Attribute	M0	M1	M2	M3	M4	Range **
Color	$6.64 \pm 1.11_{a}$	$6.31 \pm 1.53_{ab}$	$5.90 \pm 1.63_{bc}$	$5.37 \pm 1.83_{c}$	$5.94 \pm 1.46_{abc}$	1.27
Aroma	$6.34 \pm 1.58_{a}$	$6.12 \pm 1.59_{a}$	$5.57 \pm 1.96_{ab}$	$4.87 \pm 1.84_{b}$	$5.72 \pm 1.71_{a}$	1.47
Hardness	$5.72 \pm 1.78_{ab}$	$6.06 \pm 1.49_{a}$	$5.88 \pm 1.77_{ab}$	$5.21 \pm 1.72_{bc}$	$4.88 \pm 2.01_{c}$	1.18
Moistness	$5.37 \pm 2.01_{ab}$	$5.64 \pm 1.82_{a}$	$5.76 \pm 1.63_{a}$	$5.19 \pm 1.75_{ab}$	$4.63 \pm 1.69_{b}$	1.13
Flavor	$6.21 \pm 1.77_{a}$	$5.96 \pm 1.82_{a}$	$5.51 \pm 1.92_{a}$	$4.55 \pm 2.00_{b}$	$4.48 \pm 2.06_{b}$	1.73
Aftertaste	$6.07 \pm 1.78_{a}$	$6.12 \pm 1.80_{a}$	$5.49 \pm 1.97_{a}$	$4.37 \pm 2.12_{b}$	$4.43 \pm 2.12_{b}$	1.75
Overall	$6.03 \pm 1.76_{a}$	$6.12 \pm 1.67_{a}$	$5.64 \pm 1.78_{a}$	$4.63 \pm 1.95_{b}$	$4.64 \pm 1.94_{b}$	1.49

*Tukey. Samples with different letters in the same row differ significantly ($p < 0.05$).
**Range = the highest score minus the lowest score.

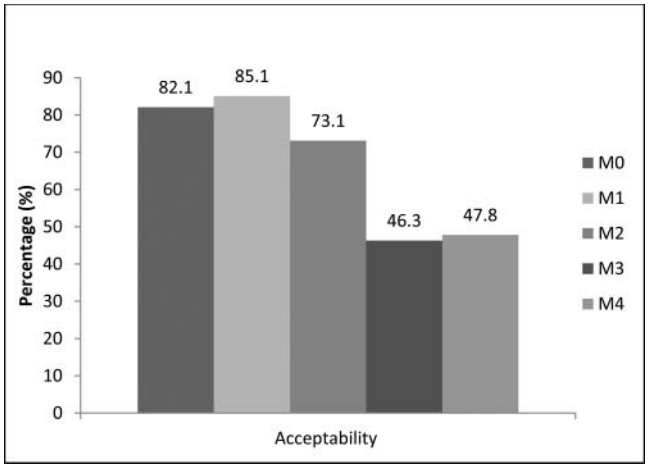

Figure 1. The overall acceptance of muffins among panelists.

affected the crumb color of final products, with color changes either desirable or undesirable to the panelists. In this study, the greenish-yellowish color of avocado purée produced undesirable and detectable color changes in muffins.

In terms of aroma, sample M0 had the highest while sample M3 recorded the lowest score. Avocado incorporation in muffin did not significantly affect ($p > 0.05$) the panelists' acceptance with respect to the aroma, except for sample M3. This is because avocado does not have a strong aroma, and thus it does not affect much the overall aroma of muffin.

Apart from that, both M1 and M2 had similar characteristics to M0 with regard to hardness, flavor, and aftertaste. Panelists did not detect differences in these three attributes for M0, M1, and M2 ($p > 0.05$). However, the scores were significantly lower ($p < 0.05$) for M3 and M4, which revealed that more than 75% avocado substitution negatively affected the sensorial properties. The flavor of muffins was obviously changed since the muffin used in this study was a plain muffin. Usage of other flavor ingredients in bakery products, such as banana, peanut, and chocolate, helped in masking and dominating the flavor of the fat replacer used (14). The aftertaste attribute was noted as a negative quality of avocado purée, and a few panelists

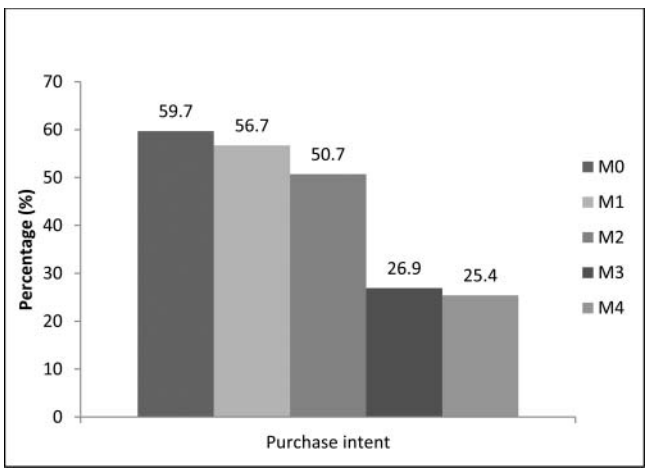

Figure 2. The positive responses (yes) for purchase intent of muffins among panelists.

commented on the strong aftertaste and slight bitterness that coud be detectable as the substitution increased in M3 and M4.

The moistness of M4 was significantly least accepted ($p < 0.5$) by the panelists among all the muffin formulations. This finding agreed with a previous study, which mentioned the commercial full-fat control was preferred to the low-fat control with respect to moistness and softness (32).

In general, M0, M1, and M2 were significantly more acceptable to the panelists as compared to M3 and M4. The changes in M0, M1, and M2 samples were not detectable to panelists with regard to hardness, flavor, and aftertaste. The overall acceptance of muffins was greatly influenced by the crumb hardness, flavor, and aftertaste. Thus, the incorporation of avocado purée up to 50% substitution resulted in acceptable muffins, while more than 50% substitution lowered the preference of muffin among panelists, which indicates that higher avocado substitution negatively affected the sensorial properties. The acceptance of muffins seems to be dependent on the hardness, flavor, and aftertaste parameters, since the pattern of overall acceptance was similar to that of hardness, flavor, and aftertaste attributes.

Amongst the six attributes, flavor and aftertaste parameters noted high mean scores and range. Both flavor and aftertaste were important in determining the acceptance of product, since both parameters showed the relatively highest value amongst the muffin samples. The percentages of overall acceptance and purchase intent of muffins are illustrated in Figure 1 and Figure 2, respectively. The possibility of acceptance or rejection of each muffin sample was interpreted from the percentage of muffin acceptability, where a percentage lower than 50% was considered to be a rejection (33). In this study, the positive (yes) and the negative responses (no) were interpreted as acceptance and rejection, respectively.

Unacceptableness in any sensory parameter cannot be generalized as a rejection of the formulation as a whole. From the findings, samples M0, M1, and M2 were better accepted as compared to M3 and M4. It is interesting to note that sample M1 (85.1%) received higher acceptance than the control sample, M0 (82.1%). This result is also in line with the data from the 9-point hedonic scale. The purchase intent for reduced-fat muffins also agrees with the acceptance pattern, in which M3 and M4 samples were less preferred by the panelists because of the sensorial changes in those samples.

Conclusion

The muffin incorporating avocado purée was accepted up to 50% avocado incorporation, with 38.2% fat reduction and 2.5% lower calorie content compared to the full-fat counterpart. In terms of nutritional aspects, full substitution of avocado purée for butter in muffins produced 83.8% reduced fat and 16.0% lower calorie content. Fatty acid profiles confirmed the reduction in SFAs content with increment in MUFAs. Sensorial studies revealed the acceptability of avocado-incorporated muffins depends on the hardness, flavor, and aftertaste properties of muffins. Therefore, further study must be done to eliminate the aftertaste and unfavorable flavor of avocado purée in muffins at full-fat substitution in order to produce full-fat replacement in a muffin.

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