

The potential of avocado paste (*Persea americana*) as fat substitute in non-dairy ice cream

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Abstract. Consumer preferences towards plant-based food have shifted significantly due to sustainable and healthy reasons. Dairy products consist of high Saturated Fatty Acid (SFA) and overconsumption of SFA could lead to cardiovascular diseases. Avocado contains high levels of fat dominated by Monounsaturated Fatty Acid (MUFA) and phytosterol that have the potential as a plant-based fat source to substitute dairy-fat in ice cream. The objective of this study was to analyze the physicochemical, rheological and sensorial properties of ice cream substituted with different concentrations of avocado paste ranging from 0%, 25%, 50%, 75% and 100% respectively against dairy fat to produce non-dairy fat ice cream. The physicochemical properties and total fat were determined. Sensorial quality and hedonic attributes of ice cream were investigated using 60 semi-trained panelists. There were significant differences ($p < 0.05$) for overrun, melting rate, and viscosity of the ice cream substituted with avocado paste. The addition of avocado paste led to the increase in viscosity and hardness of the ice cream significantly ($p < 0.05$) while the sensorial properties for airiness and creaminess were perceived the same ($p > 0.05$). The addition of 50% avocado paste was the most preferred among the panelists. Avocado could provide a potential substitution for dairy-fat in ice cream.

Keywords: avocado, ice cream, plant-based food, non-dairy, MUFA

1. Introduction

Consumers prefer plant-based diets [1], which are more sustainable [2] and able to provide better health benefit. The preference towards plant-based diets has significantly increased [3], with the rise of millennial generation who are increasingly adopting vegan and free-lactose diets [4]. It also has been reported that dairy milk sales have decreased globally by 7% in 2015 due to the negative health perception of dairy-based product consumption. Plant-based food diets however have become more inclusive within personalized nutrition plans for more than 70% of consumers [5]. Several factors such as lactose intolerance, gastrointestinal discomfort, and allergies have become the principal reasons for people avoiding dairy-based products [6]. Moreover, the clean label trend has also become one of the major concerns that affect consumer preference towards dairy consumption [7]. Furthermore, traces of antibiotics and hormones potentially carried in dairy and dairy-based products can also contribute to



the harmful effects to the human health if consumed at certain levels [8]. From the healthy aspect, dairy and dairy-based products such as cream and butter provide high SFA (10 g/100 g) and high cholesterol (20 mg/100 g) levels. The overconsumption of SFA and cholesterol increased the risk of cardiovascular diseases [9], [10], [11]. Therefore plant-based alternative ingredients are deemed suitable substitutes in dairy-based products. An investigation is required to answer this challenge.

Fruits and vegetables have been reported as the largest category that can promote plant-based diets [12]. Avocado fruits contain high total fat (15.4 g/100 g) dominated by MUFA (9.8 g/100 g), high in phytosterol (57 mg/100 g) and contain zero cholesterol [13]. It has been reported that people who consumed avocado regularly tended to have a sufficient nutrient supply of dietary fibre, vitamin K, vitamin E, potassium, magnesium, as well as vitamin B complex [14]. These nutrients provide a wide range of potential health benefits such as preventing hypercholesterolemia [15], vascular damage [16], and reduce the risk of atherosclerosis [17]. The consumption of avocado has been investigated to have positive effects on lipid profiles [18] by increasing HDL cholesterol levels, reducing lipid serum peroxidation, and promoting cardiovascular health [19]. Furthermore, phytosterol has also been proven to be an effective compound against type-2-diabetes mellitus, lowering the risk of cardiovascular diseases, and preventing cancer [20].

Avocado has high fat content [13] which is a good source for substituting the milk fat in frozen dairy desserts [21]. Ice cream is one of the most widely consumed foods in the frozen dairy dessert category [21]. A series of different types of non-dairy based ice cream have been developed due to the rise of health concerns associated with milk consumption [9], milk-fat consumption that dominated by SFA [9], [10], [11], and clean label issues [8]. A non-dairy fat source derived from avocado could be a potential alternative in order to create an option for free-dairy fat ice cream as well as provide better health benefits to the consumers. Plant-based fat sources have great potentials to be used as a replacement for dairy-based fat sources in the ice cream formulation. Furthermore, plant-based sources are generally less expensive compared to dairy fat [21] and provide advantages towards health [15], [16], [17], [18], [19]. The objective of this study was to analyze the physicochemical, rheological and sensorial properties of ice cream that have been substituted with different concentrations of avocado paste.

2. Material and methods

2.1 Avocado paste

The avocado used in this research originated from Indonesia local horticulture. The avocados were bought in the local market and served at room temperature (25°C) until the desired ripening was achieved. The softness of the avocado fruits indicated the ripeness of the fruits. The fruits that used were soft when lightly touched and does not have a mushy texture. The avocado paste was obtained by separating the flesh of the ripe avocado from its seed. The flesh was then mixed and stored at low temperature (4°C) in a sealed vacuum bag to be used further.

2.2. Ice cream formulation

Preliminary experiments were conducted to determine the optimal formulation of the ice cream. The final ice cream formulation used in this experimentation contained water (48.83%), sugar (12.7%), cream (29.3%), glucose syrups (4.88%), skimmed milk powder (2.93%), egg yolk powder (0.49%), vanilla flavour (0.49%), and stabilizer consisting of carrageenan and xanthan gum (0.20%). All dry ingredients were weighed and mixed with wet ingredients. The mixture was then stirred and pasteurized until 80°C. During pasteurization process the mixture was stirred to homogenize all the ingredients and to distribute the heat evenly. The ice cream mixture was then cooled using a metal basin placed in ice water. The mixture was homogenized again continuously and aging at 4°C for 12 hours then stored at -20°C for hardening process. Five batches of ice cream substituted with avocado paste (AV) concentration with ranges from AV0%, AV25%, AV50%, AV75% and AV100% were

produced and stored at -20°C in a sealed vacuum packaging. The samples were measured and evaluated further for their rheological, psychochemical and sensorial properties.

2.3 *Psychochemical and rheological properties*

The physicochemical and rheological properties of the ice cream mixtures were obtained. Several data such as pH, total solids, overrun, viscosity, moisture, and melting properties were measured. The pH was measured using a pH meter (Benchtop meter Satorius). The total soluble solid (TSS) and moisture content were determined using a moisture analyzer (MB45 Ohaus). The overrun was determined using an exact measurement of volume and weight of the ice cream mixture (g) before and after mixing [22]. The viscosity was measured using Lamy rheology refers to ASTM/ISO 2555 employed ASTM 3 with 40 rpm disc speed [23]. The viscosity measurement was conducted at room temperature (25°C) equipped with the MK-ASTM probe using standard number 3. All measurements were carried out in triplicates. The melting rate was quantified using the dripping method by which a certain amount of ice cream (ml) that was dripped over time (ml/min) at room temperature [24]. A funnel (60 mm) was placed on the top of the measuring cylinder (100 ml) and certain samples were placed inside the funnel. The measurement started from -20°C (from hardening temperature) for 60 minutes that carried out at the room temperature (25°C). The drip was observed every five minutes and pictures of the ice cream sample deformation was taken [24]. The chemical properties such as total fat content were determined using the Soxhlet method. The fat extraction samples were hydrolyzed with 25 ml of 3% HCl solution in Erlenmeyer flask and then heated for one hour until all compound evaporated. The solution was then filtered using filter paper and dried at 110°C. The filter continued to be analyzed through fat extraction using petroleum ether 40–60°C for 2 hour.

2.4. *Sensory evaluation*

The sensory evaluation was conducted using Quantitative Descriptive Analysis (QDA) by 12 trained panelists followed by hedonic testing by semi-trained panelist. The QDA was used to quantify the intensity of ice cream profiles that were substituted with different concentrations of avocado paste. A selection of attributes and terms that were used to determine sensory properties of the ice cream were determined at this section. Nine attributes consist of colour, hardness, melting profile, creaminess, airiness, sweetness, bitterness, taste and overall liking were determined as attributes of investigation. A semantic different scaling was implemented for each attribute. A hedonic test was also conducted in order to evaluate the liking preference of the ice cream. A selection of 60 semi-trained panelist participated in the hedonic evaluation test. They were screened through a two-step process, firstly through a questionnaire, and second through their ability to pass the matching test for the screening evaluation. The potential panelist that had milk allergies, heavy smokers or consumed alcohol frequently, and did not pass the matching test were disqualified.

During the sensory evaluation ice cream samples were evaluated in a 50 ml plastic cup served at room temperature and were stored at -12°C before being served to the panelists. The maximum holding time was set at three minutes in order to avoid the samples melting. The samples were served in monadic with 3-digit random code and evaluated by panelists in a random order. The sensory panelists consisted of 30 males and 30 females adults with age range from 18–54 years old. The degree of liking was measured using a 9-point hedonic scale.

Analysis of variance (ANOVA) was performed in order to evaluate the effect of avocado paste substitution against milk fat in different concentrations at a level of AV0%, AV 25%, AV50%, AV75%, and AV100% respectively. The interaction of these parameters towards dependent variables was also analyzed using Duncan test. Significant means will be determined at $\alpha < 0.05$. Statistical analysis was conducted using XLSTAT ver. 2014.5.03 (Addinsoft).

3. Results and discussion

3.1 Value of pH, total solid, and moisture

The pH showed no significant difference between the formulations. However, the trend showed that the addition of avocado paste lowered the acidity level of the ice cream mixture. The acidity level of avocado was between pH 6.2-6.6 depending on the type of cultivar, ripening stage, and maturity of the fruit. The range of the pH from each formulation of AV0%, AV25%, AV50%, AV75% and AV100% demonstrated that they were on the standard acidity level of the ice cream mixture [21]. The acidity of the ice cream mixture is important because it determines the whipping capability that contributes to the stability of the ice cream [21].

Tabel 1. Value of pH, TSS and moisture

Parameter	AV 0%	AV 25%	AV 50%	AV 75%	AV 100%
pH	6.65 ± 0.03	6.56 ± 0.01	6.50 ± 0.01	6.51 ± 0.02	6.29 ± 0.03
TSS	0.32 ± 0.0004	0.33 ± 0.0006	0.31 ± 0.0016	0.33 ± 0.0017	0.32 ± 0.0014
Moisture (%)	65.86 ± 0.014	65.75 ± 0.006	65.39 ± 0.002	64.37 ± 0.004	63.77 ± 0.007

The total solid measurement demonstrated that there were no significance difference between AV0%, AV25%, AV50%, AV75% and AV100% of each formulation. The moisture content also showed similar values. AV100% had the lowest moisture content (63.77 ± 0.007) followed by AV75% (64.37 ± 0.004), AV50% (65.39 ± 0.002), AV25% (65.75 ± 0.006) and AV0% (65.86 ± 0.014) respectively. Ice cream should contain 55-65% water [25]. Ice cream mixture with high water content will resulted in a low total solid content in general and proportionately higher water that available to freeze when hardened at the same temperature compared to the ice cream mixture with low water content and high total solid. This condition will affect the quality of ice cream particularly for texture and hardness [26].

3.2 Viscosity and melting rate

The viscosity showed significant difference ($p < 0.05$) among the formulations. AV100% had the highest viscosity levels (1900 ± 67 m.Pas) followed by AV75% (1065 ± 89 m.Pas), AV50% (1002 ± 55 m.Pas), AV25% (245 ± 30 m.Pas), and AV0% (167 ± 38 m.Pas). The greater the concentration of avocado paste in the ice cream resulted an increase in overall viscosity. The viscosity in the ice cream mixture was particularly affected by the ingredients used as well as type of stabilizer. Carrageenan and Xanthan gum were used as stabilizers for this experimentation. Sugar has also been reported to play a significant role in determining the viscosity profile in ice cream [21]. The higher concentration of avocado paste in the ice cream mixture also directly contributed to the increase in sugar levels that are naturally contain in avocado fruits. This could have resulted the change in the ice cream mixture consistency into a thicker and more viscous [21]. Moreover, avocado contains about 7 grams of dietary fibre (28%) which has the ability as a water binding [13], [28] resulting in a thick mixture and therefore affects the viscosity profile. The avocado paste itself has a viscosity of 1818 m.Pas. The substitution of milk fat with avocado paste contributed to the change of viscosity in ice cream mixture and showed a positive correlation when higher concentration of avocado paste added.

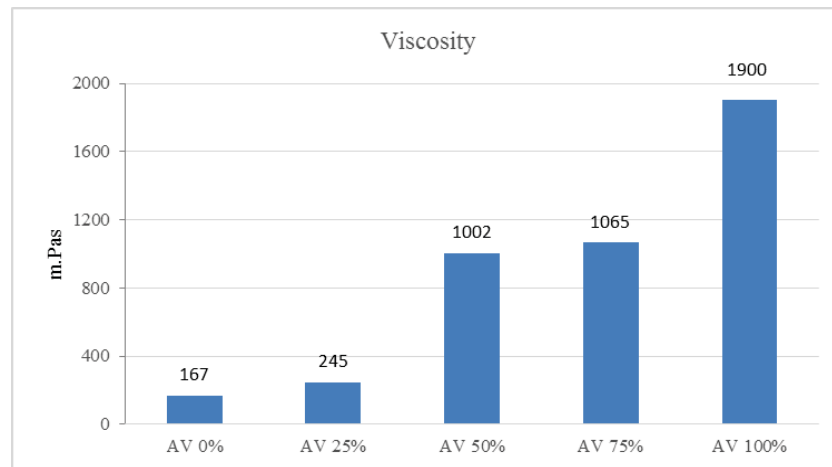


Figure 1. Viscosity (m.Pas) of samples

The melting rate showed significant difference between formulations ($p < 0.05$). It is demonstrated from the **figure 2**, that AV0% has the highest melting rate (36 ml), followed by AV25% (18 ml), AV50% (13ml), AV75% (12ml), and AV100% (4 ml) respectively. The higher concentration of avocado paste resulted in the increase of viscosity of the ice cream mixture followed by decrease in the melting rate as shown in **figure 2**. The fibre content in avocado paste could have affected the melting rate of the ice cream. It has been reported that frozen dairy dessert formulated with dietary fibre could improve the melting quality of the ice cream [27] depending on the type of fibre used [27]. Fibre with high soluble fraction capability such as inulin affects the rheology of the ice cream and could provide in potential cryoprotective action [27]. The result showed that fibre in insoluble compound was able to increase significantly the viscosity and the shear thinning properties of the ice cream mixture [28].

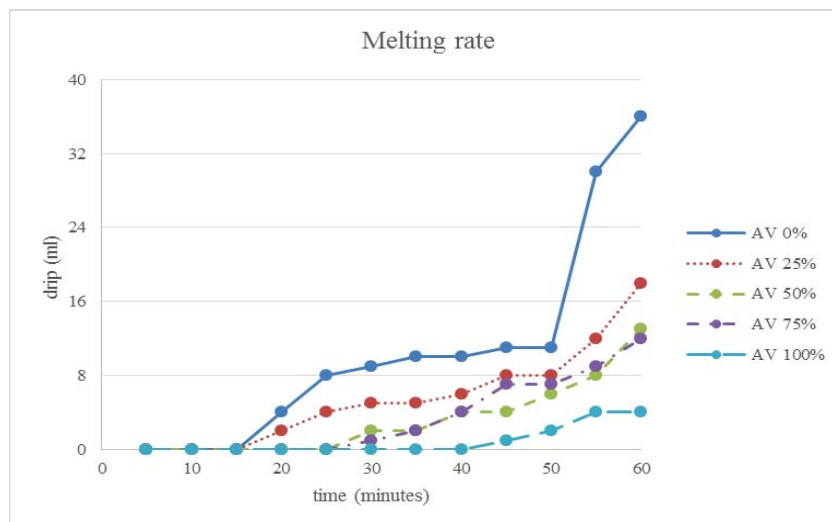


Figure 2. Melting rate (ml/minutes) of samples

Fibre has water binding properties that create a higher viscosity of ice cream mixture due to a reduction in water molecule mobility from the bulk aqueous phase into the ice crystal surface phase [28], [27]. The addition of fibre from fruits such as avocado in the ice cream mixture elevated the viscosity properties of the ice cream [28]. Fibre can contribute to the modification and improvement of

food texture and sensory characteristic due to its water-binding capacity, gel-forming ability, texturizing, and thickening effects [29], [30]. Dietary fibre could promote an effective control of ice crystallization and ice crystal growth during freezing and storage as well as improve the melting and viscosity properties for the ice cream products [28], [29], [30].

3.3 Overrun and total fat

The overrun showed significant difference ($p < 0.05$) among the formulations. The data showed that increasing the avocado paste substitution towards milk fat in the ice cream mixture significantly reduce the overrun of the ice cream. The highest overrun achieved by AV0% (56%), followed by AV25% (35%), AV50% (32%), AV75% (17%) and AV100% (16%). Based on Duncan test it showed significant difference between AV0% and AV25% ($p < 0.05$) but no difference between AV75% and AV100% and the other formulations. The overrun data is in line with the melting rate where AV0% had the highest overrun ability followed by rapid melting rate properties. The higher overrun value significantly contributed to the higher melting rate in the ice cream [31], [34]. High overrun levels in ice cream resulted in a high melting rate due to instability of air cells incorporated in the ice cream mixture [34]. This instability is due to the increase in temperature levels when ice cream is unfrozen. Moreover, the overrun also affected the hardness profile of ice cream [31]. Overrun and air cell distribution became critical parameters in the ice cream industry that continuously need to be controlled and monitored. There are numerous factors that could influence the development of air cells and affect overrun in ice cream products such as mixing, freezing, hardening, the use of stabilizers, homogenization, and ingredients used in the ice cream mixture [21], [31]. Air content in the ice cream mixture contributed to the physical properties of the ice cream such as texture, hardness, melting properties and other sensorial characteristics [31]. The amount of air incorporated in the colloidal system in the ice cream mixture influenced the distribution of the air size that could provide melting profile and directly affect the sensory quality parameters of the ice cream [31].

Table 2. Overrun (%) and total fat (%) analysis in samples

Parameter	AV 0%	AV 25%	AV 50%	AV 75%	AV 100%
Overrun (%)	56 ± 1.37	35 ± 0.87	32 ± 0.29	17 ± 0.94	16 ± 1.45
Total Fat (%)	12.28 ± 0.58	11.53 ± 0.25	10.69 ± 0.63	9.75 ± 0.57	8.68 ± 0.84

The presence of air cells in the ice cream mixture is important in determining the texture quality of the ice cream. It has been suggested that the amount of air cells at 70% overrun is enough to prevent collision among ice crystals and the lower the overrun with subsequently create larger ice crystal, thus lead to increase the hardness of ice cream [32]. Air is one of the important ingredients that need to be incorporated in the ice cream mixture. It makes up between 30%-50% of the total volume of the ice cream [34]. It has been reported that the stability of air cells could slow down the melting rate of the ice cream as determined by adding saturated monoglycerides to the ice cream mixture [33].

There was a significant difference ($p < 0.05$) in total fat content for each formulation. The data showed that the highest fat content was obtained by AV0% (12.28%), followed by AV25% (11.53%), AV50% (10.69%), AV75% (9.75%), and AV100% (8.68%). Dairy cream act as one of the base ingredients in ice cream products and contributed up to 35.1% (w/w) of total fat content while avocado fruits contributed around 15.4% (w/w) of total fat including the MUFA and the phytosterol [13]. The differences in fat content of each formulation is due to the reducing fat source from dairy fat particularly from dairy cream that has subsequently substituted with avocado paste. This fat content contributes to the fat crystallization and was able to influence the textural properties of the ice cream [33].

Ice cream contains at least 10% of dairy fat, 20% of total milk solid and able to establish a certain percentage of overrun, which is increasing in volume by whipping air into the ice cream mixture [21], [34], [36]. The percentage of fat, total solid and overrun are important factors in ice cream quality [21]. It has been demonstrated that the increase in dairy fat and total solids lead to higher costs in ice

cream products, since dairy fat is considered as an expensive ingredients. However, this ingredient is the main structure in constructing sensorial properties and determines quality of the ice cream [35]. The role of fat, particularly milk fat in ice cream is important to act as an air stabilizer during the freezing process which creates a dispersed phase of air bubbles [21]. During the freezing process the crystalized fat and partially coalesced fat globule stabilize the air bubbles of the ice cream mixture and provide the desired foamy texture which contributes to the hardness quality of ice cream [21]. Milk fat acts as a thermal insulator which affects the melting properties of the ice cream [25], [37]. Ice cream with high milk fat content can retain its shape and take longer time to melt. In this experiment the substitution of milk fat with avocado paste proportionally at 0%, 25%, 50%, 75% and 100% resulted in reducing the amount of total fat content and retain the melting rate as shown in **figure 2**. This substitution of dairy-fat into plant-based fat from avocado was able to lower the total fat content of the ice cream mixture and lowered the melting rate of the ice cream. This might be due to the fibre content in avocado paste that has the ability to lower the water mobility in the ice cream [27], [28], [29], [30].

3.4 Sensorial properties

The QDA showed that there were significant differences between the formulation for colour ($p < 0.01$), hardness ($p < 0.01$), sweetness ($p < 0.01$), bitterness ($p < 0.01$), and taste ($p < 0.01$). It has been shown that the colour of each formulation showed significant difference towards green colour intensity. The higher substitution of avocado paste lead to the higher intensity of green colour. Based on pairwise multiple comparisons the texture of AV0% was perceived as the most hardest compared to the other formulations ($p < 0.05$). The amount of fat in AV0% affected the crystallization of fat and fat globules that contribute to the hardness and texture quality of ice cream [21]. Ice cream with a higher fat content will be able to retain its shape and able to stabilize the fat crystal [33], [35]. This condition creates a positive influence on the textural properties of ice cream [37].

Table 3. QDA¹ for each samples

Properties	AV 0%	AV 25%	AV 50%	AV 75%	AV 100%
Colour	1.43 ^a	2.97 ^b	5.13 ^c	5.90 ^c	7.27 ^d
Hardness	6.17 ^a	4.83 ^b	4.37 ^{bc}	3.37 ^c	4.73 ^b
Melting profile	5.00	5.60	5.53	5.27	4.73
Creaminess	5.47	6.27	6.07	6.60	5.90
Airiness	4.93	4.63	4.90	4.13	4.27
Sweetness	6.23 ^{ab}	6.43 ^a	6.27 ^{ab}	5.33 ^b	3.67 ^c
Bitterness	1.87 ^a	2.23 ^b	3.47 ^c	5.83 ^d	7.73 ^d
Taste	4.77 ^d	5.23 ^c	5.57 ^b	5.73 ^a	6.23 ^a

^{a,b,c,d} different alphabets in one row showed significant different ($p < 0.05$) for selected attributes

¹ sensory evaluations scores for intensity: 1 = not to, 9 = very

Melting properties ($p > 0.05$), airiness ($p > 0.05$), and creaminess ($p > 0.05$) were perceived the same. Although the overrun, melting rate, viscosity and total fat content showed significant difference in the rheological properties, however this result did not affect the sensorial properties towards melting profile, airiness, and creaminess of the ice cream. These results showed that avocado paste could be a potential plant-based substitution to milk fat in the ice cream products in terms of organoleptic since the important textural properties of the ice cream such as melting, creaminess, and airiness were perceived the same by the panelist.

It has been reported that the fat replacement in ice cream should be effectively replaced in order to match the texture, mouthfeel, and functional properties of fat. Moreover, it also should convey the desired flavour profile [38]. The amounts of fat will affect the size of fat globules, and dairy fat is an important determinant of the texture and body of ice cream [39]. The textural properties in ice cream

such as creaminess are one of the desirable attributes determined by milk fat [39] since there was no significant difference for creaminess between the formulations it indicate that substituting milk fat with avocado paste could maintain the same creaminess properties as ice cream formulated with milk fat. This showcased that avocado paste could replace the fat properties of milk fat and able to maintain the creaminess profile of ice cream. This is also followed by airiness and melting profile that showed the same trends.

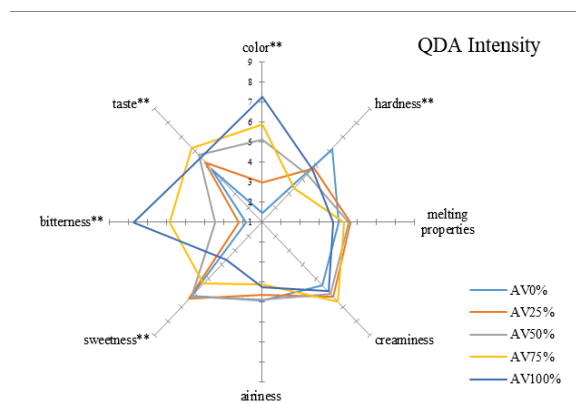


Figure 3. QDA test

*significant difference at $p < 0.05$

**significant difference at $p < 0.01$

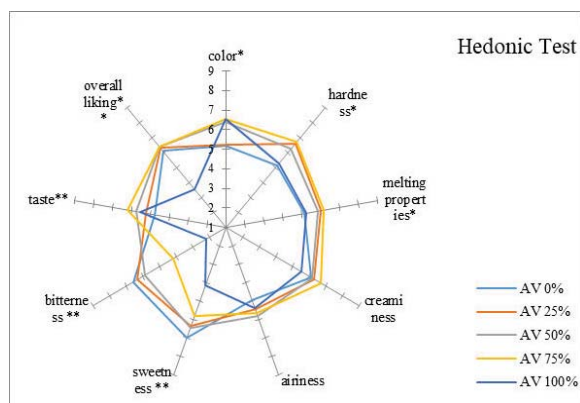


Figure 4. Hedonic testing

*significant difference at $p < 0.05$

**significant difference at $p < 0.01$

Bitterness and taste were perceived significantly difference ($p < 0.05$). The strong bitterness flavour was perceived at AV100% ($p < 0.05$). The higher avocado paste substitution could contribute to the bitterness flavour of ice cream that resulted in the low preferences of consumers as demonstrated in the **figure 4**. Bitterness has been reported as a natural flavour that aversive by consumers. This flavour has been removed from any food because could lead to human rejection [40]. The sweetness perceived as a reverse of the bitterness. The higher the sweetness intensity lead to the lower bitterness perception. The taste also perceived significant difference ($p < 0.05$) due to different intensity of sweetness, bitterness and avocado flavour that has developed in line with the higher substitution of avocado paste.

The bitterness flavour in ice cream could be developed from avocado paste. Avocado flavour compounds derived from 4-keto-2-hydroxyl-1-acetate, 1,2-dihydroxyl-4-acetoxy compound, and 1,4-dihydroxyl-2-acetoxy are present naturally in fruits and vegetables [41] including in avocado, these compounds contribute to the bitterness flavours [41] and commonly found in unripe fruits. Fresh fruit also contains large amounts of degradative enzymes such as lipase, lipoxygenase, polyphenoloxidase, and methyl pectinase that are also able to produce bitterness [42]. Moreover, incorrect preparation and processing from fresh avocado paste could lead to the development of bitterness [42], [43]. For example, the treatment of fresh avocado using antioxidants and citric acid have been reported to suppress the bitter taste in freshly cut avocado [43] whereas the avocado paste used in this experimentation was processed without any addition of antioxidants and used minimal heating process.

The hedonic evaluation showed that there were significant differences for colour ($p < 0.05$), hardness ($p < 0.05$), melting profile ($p < 0.05$), sweetness ($p < 0.01$), bitterness ($p < 0.01$), and overall taste ($p < 0.01$). These results were in line with the profile intensity from QDA except for melting profile ($p < 0.05$). Based on pairwise comparison using Duncan test the difference was found between AV0% and AV75% ($p < 0.05$) and no significant difference was found between the other formulations for the melting profile. The panelist preference towards colour showed an increase according to the higher percentage of avocado paste substitution as shown in **figure 4**. AV100% was the most

preferred due to its green colour intensity based on colour preferences. Sample AV75% was the most preferred for the hardness while the preference of AV100% was dropped for this attribute. This could be happened due to the higher polysaccharides and fibre content in the AV100% that affect the textural characteristic especially the hardness and the melting profile of the ice cream [13], [21], [28]. Creaminess and airiness were perceived the same ($p > 0.05$) among the formulations which in alignment with the QDA as shown in **figure 3**. The liking towards sweetness were showed in opposite with bitterness as AV0% was the most preferred in terms of sweetness and this preference of liking decrease with the incremental substitution of avocado paste which lead to the bitter taste. Bitterness could lead to human rejection due to unpleasant taste [40]. The avocado itself naturally contains natural compounds that contribute to the bitter flavour [41], [42] coupled with incorrect avocado processing techniques which could have resulted in the development of a strong and unpleasant bitter taste [42], [43]. The overall liking showed that AV50% was the most preferred (6.38). There were significant differences ($p < 0.01$) between formulation for the overall liking, pairwise comparison test using Duncan showed that the differences was in AV100% which showed low preference compared to AV0%, AV25%, AV50%, and AV75% respectively. This was due to the strong bitterness that leads to consumers disliking the samples.

Table 4. Hedonic test of samples

Properties	AV0%	AV25%	AV50%	AV75%	AV100%
Colour	5.17 ^a	5.23 ^a	6.40 ^b	6.57 ^b	6.57 ^b
Hardness	5.17 ^a	6.60 ^c	6.23 ^{bc}	6.70 ^c	5.30 ^{ab}
Melting profile	5.13 ^a	6.03 ^{ab}	5.87 ^{ab}	6.17 ^b	5.23 ^a
Creaminess	6.10 ^{ab}	6.27 ^{ab}	6.20 ^{ab}	6.70 ^a	5.53 ^b
Airiness	4.97 ^a	5.47 ^{ab}	5.83 ^b	5.63 ^{ab}	5.37 ^{ab}
Sweetness	7.00 ^a	6.47 ^a	6.33 ^a	5.83 ^b	4.17 ^c
Bitterness	6.57 ^a	6.33 ^a	5.90 ^a	4.20 ^b	2.20 ^c
Taste	4.77 ^a	5.23 ^a	5.73 ^a	6.23 ^b	5.57 ^{ab}

^{a,b,c,d} different alphabets in one row showed significant different ($p < 0.05$) for selected attributes

¹a-9-point hedonic scale: 1 = dislike extremely to 9= like extremely

4. Conclusion and recommendation

The substitution of milk fat with avocado paste in ice cream formula could decrease the overrun and total fat content in ice cream. However it was demonstrated that the avocado paste could retain the melting rate of the ice cream due to polysaccharides and natural dietary fibre content in the avocado. Higher concentration of avocado paste in the ice cream formula provides more hydrocolloids from the dietary fibre and thus influences the viscosity properties and contributes to the stabilization of air during aeration. The substitution of avocado paste at 0%, 25%, 50%, 75% and 100% against milk fat did not showed significant difference in creaminess, airiness and melting profile based on QDA while the bitter taste strongly developed from the higher concentration of avocado paste that could lead to rejection from consumers. While colour, hardness, bitterness, sweetness and taste were perceived differently, the important parameter of ice cream such as creaminess, airiness and melting profile were perceived the same. This indicated that avocado could be a great potential as a substitute for milk fat. There were no significant differences in overall liking between samples with 0%, 25%, 50% and 75% avocado paste concentration, while the concentration of 100% fat from avocado paste showed a significant difference ($p < 0.01$) compared to other formulations and 50% substitution was the most preferred. The processing of avocado paste was not thoroughly investigated in this research. It is recommended to investigate the post-harvest condition and assess the ripening stage of avocado fruits used in the experimentation since avocado is a sensitive climacteric fruits and the ripeness state of avocado could affect the properties and characteristic of avocado paste.

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