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# PHYSICOCHEMICAL PROPERTIES AND SENSORY ACCEPTABILITY OF ICE CREAM PREPARED WITH DIFFERENT RATIOS OF DAIRY WHIPPING CREAM TO TOMATO PUREE

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**Abstract:** Ice cream is a popular dairy product consumed by people of all ages. However, commercial ice cream is high in fat and calories, and it frequently uses synthetic colorants. Therefore, the aim of this study is to determine the effects of tomato puree addition on the physicochemical properties and sensory acceptability of ice cream. Five formulations of ice cream were prepared with dairy whipping cream to tomato puree ratios of 100:0, 90:10, 80:20, 70:30 and 60:40. Physicochemical analyses were carried out in triplicate, which involved colour profile, pH and moisture levels, as well as ash, fat and protein content determination. The sensory attributes of colour, odour, hardness, creaminess, flavour, aftertaste and overall acceptability of the ice cream were evaluated by 50 untrained panellists using a 7-point of hedonic scale of acceptance test. The results showed that decreasing the percentage of dairy whipping cream and increasing the percentage of tomato puree enhanced the a* value and ash content of the ice cream, while decreasing the b* value, pH, and fat contents. However, the L* value, and moisture and protein contents were not significantly ($p$>0.05) affected by the different ratios of dairy whipping cream to tomato puree. The sensory acceptability for all ice cream attributes increased significantly ($p$<0.05) with the addition of tomato puree and decrease of dairy whipping cream in the formulations. This study suggests the incorporation of tomato puree of up to 40% has a good potential in giving ice cream an attractive colour and improving its nutritional and sensory qualities.

Keywords: Functional food, natural colorant, flavor enhancement, fat reduction, lipid-based matrices.

## Introduction

Ice cream is one of the most popular dairy products that is consumed by people of all ages across the world, and it is typically made with a combination of milk, sugars, emulsifiers, stabilisers, and flavouring ingredients (Erkaya *et al.,* 2012). Ice cream is a rich source of energy that provides 180 to 250 kcal/100 g (Patel *et al.,* 2009) and contains three times more fat and slightly more protein than milk due to the addition of emulsifier and egg yolk in its formulation. Dairy whipping cream highly contributes to the increase in fat and calorie contents of ice cream, as it is 30% to 40% milk fat (Ghribi *et al.,* 2021), which can increase the risk of health failures if consumed in large amounts. In addition, commercially available ice cream in the market is generally inadequate in natural colorants, vitamins and antioxidant properties (Pinto & Dharaiya, 2014). The use of plant-based ingredients, with beneficial health effects, can potentially improve the nutritional values and sensory properties of ice cream, especially in terms of colour and flavour enhancement, as well as fat reduction, as previously reported on applications of green coconut pulp (Igutti *et al.,* 2011), soybean milk and watermelon seed milk (Bisla *et al.,* 2012), carrot and pumpkin pulps (Hassan & Barakat, 2018), persimmon (Karaman *et al.,* 2014) and tomato peels (Rizk *et al.,* 2014).

Tomato (*Solanum lycopersicum* L.*)* is one of the most popular produced and extensively consumed vegetable crops in the world and is the basic ingredient in a large variety of raw, cooked or processed food. Recent studies have shown that a diet rich in tomatoes and tomato products will bring potential health benefits.

Tomatoes have been gaining attention due to its benefits in terms of preventing several diseases. Tomato fruit contains bio-accessible provitamin A of carotenoids (lycopene and β-carotene), which are good for the heart and eyes (Rizk *et al.,* 2014). Besides having a good flavour and aroma characteristics, tomatoes are also a good source of vitamins A and C, and they contain minerals and have a low amount of fat (Akanbi & Oludemi, 2004). Ripe tomatoes rich in lycopene have an attractive and strong red colour (Rizk *et al.,* 2014). Being a climacteric and perishable fruit, tomatoes have a very short lifespan, which is usually only up to two to three weeks (Haile, 2018). Depending on the humidity and temperature, tomatoes in tropical countries ripen faster, ultimately resulting in them being of poor quality as the fruit become soft and unacceptable. Tomatoes have the strong potential of being used as an ingredient in functional food products with good benefits for human health, and this could elongate their shelf-life.

Digestion of high lipophilic carotenoids and vitamin A incorporated in lipid-based matrices like ice cream may promote high absorption by the human body compared with other food applications. Therefore, this study aims to determine the effects of different ratios of dairy whipping cream to tomato puree on the physicochemical properties and sensory acceptability of ice cream.

## Materials and Methods

### *Raw materials*

Fresh ripe tomatoes (*Solanum lycopersicum* L.) were purchased from Mydin Mall, Kuala Nerus, Terengganu, while other ingredients, such as dairy and non-dairy whipping cream, castor sugar, fresh milk and maltodextrin as stabilisers, were purchased from a donut bakery shop in Kuala Nerus, Terengganu.

### *Preparation of tomato puree*

The tomatoes (1 kg) were cleaned and blanched in hot water for 2 minutes at simmer temperature (75-80$^{o}$C) before the skin is peeled. They were then cut into small pieces and blended to produce puree with a smooth and fine texture. The tomato puree was first sieved to ensure that all the seeds have been removed. The moisture content of the tomato puree was checked using a moisture analyser (Radwag Wagi Elektroniczne, Poland) before being stored in a freezer at -18$^{o}$C until further use.

### *Preparation of ice cream incorporated with tomato puree*

Five ice cream formulations with different ratios of dairy whipping cream to tomato puree were prepared; 100:0, 90:10, 80:20, 70:30 and 60:40 according to the basic formulation of ice cream (Table 1). The proportion of dairy whipping cream to tomato puree is shown in Table 2. Ice cream with no tomato puree addition was used as a control sample. The ice cream was prepared by mixing sugar and maltodextrin using a whisk for 2 minutes. Then, other ingredients, included dairy whipping cream, non-dairy whipping cream and fresh milk, were heated at 80$^{o}$C and continuously stirred to avoid the milk from coagulating. When the temperature of the mixture reached to 80$^{o}$C, it was held for 15 seconds before it was taken off from heat. The hot mixture was then poured into the sugar mixture and continuously stirred for 5 minutes using a hand mixer. The ice cream mixture was placed in a chiller for 2 hours before being put under the aging process in a blast freezer for 15 minutes. The ice cream mixture was then introduced to an ice cream maker (GELATO-Pro 3000, Italy), followed by the tomato puree. Once finished, the ice cream was moved out from the ice cream maker, placed in a container and submitted to a normal freezer for the hardening process for 3 hours.

Table 1: Basic formulation of ice cream

| Ingredients | Quantity (g) | Percentage (%) |
|---|---|---|
| Non-dairy whipping cream | 500 | 71.4 |
| Dairy whipping cream | 78 | 11 |
| Maltodextrin | 42 | 6 |
| Castor sugar | 40 | 5.7 |
| Fresh milk | 40 | 5.7 |
| **Total** | **700** | **100** |

Table 2: Proportion of dairy whipping cream (DWC) to tomato puree (TP) in the formulation of the ice cream

| Formulation | DWC(g) | Percentage (%) | TP (g) | Percentage (%) |
|---|---|---|---|---|
| Control (A) | 78 | 100 | 0 | 0 |
| B | 70.2 | 90 | 7.8 | 10 |
| C | 62.4 | 80 | 15.6 | 20 |
| D | 54.6 | 70 | 23.4 | 30 |
| E | 46.8 | 60 | 31.2 | 40 |

* The 100% value of dairy whipping cream uses 78 g from the total weight of ice cream formulation as reference

### *Physicochemical analysis*

The physical properties of ice cream as affected by different ratios of dairy whipping cream to tomato puree were evaluated in terms of colour profile and pH. The colour profiles of L*, a* and b* values were measured as indicators of lightness, redness and yellowness, respectively, using a colorimeter (Minolta Chromameter model CR-310, Japan). A calibrated pH meter was used for the measurement of the pH level. The chemical composition of moisture, ash, fat and protein were performed according to the AOAC (2000) method. All analyses were carried out in triplicate.

### *Sensory evaluation*

The sensory evaluation of the ice cream prepared with different ratios of dairy whipping cream to tomato puree involved 50 untrained panellists of students and staff members of Universiti Malaysia Terengganu. A 7-point hedonic scale of acceptance test, with 1 referring to dislike extremely and 7 like extremely, was used to evaluate the sensory attributes of the ice cream in terms of colour, odour, creaminess, hardness, taste, aftertaste, flavour and overall acceptability according to the modified method of Choo *et al.* (2010). Five samples labelled with 3-digit random numbers and randomly permutated were presented to each panellist in an air-conditioned room.

### *Statistical analysis*

The statistical analysis was carried out using the Minitab software (version 18) and all data were analysed by one-way analysis of variance, followed by a post-hoc test of Fisher's least significant difference at $p<0.05$.

## Results and Discussion

### *Chemical properties of the ice cream*

The chemical composition of the ice cream prepared with different ratios of dairy whipping cream to tomato puree is shown in Table 3.

Table 3: Chemical composition (n=3) of ice cream prepared with different ratios of dairy whipping cream and tomato puree

| Formulation | Moisture | Ash | Protein | Fat |
|---|---|---|---|---|
| A | 46.88 ± 2.09[a] | 0.15 ± 0.11[b] | 1.02 ± 0.24[a] | 3.99 ± 1.07[a] |
| B | 44.43 ± 3.43[a] | 0.34 ± 0.06[a] | 0.98 ± 0.09[a] | 2.93 ± 0.30a[ab] |
| C | 44.96 ± 1.28[a] | 0.35 ± 0.02[a] | 0.99 ± 0.18[a] | 3.56 ± 0.41[ab] |
| D | 44.69 ± 0.91[a] | 0.39 ± 0.13[a] | 0.91 ± 0.08[a] | 3.08 ± 0.56[ab] |
| E | 44.82 ± 1.31[a] | 0.41 ± 0.06[a] | 0.78 ± 0.23[a] | 2.78 ± 0.55 [b] |

*Mean values with different superscript letter in the same column are significantly different ($p$<0.05). Ice cream with addition of A) 100% of dairy whipping cream (control sample); B) 90% dairy whipping cream + 10% tomato puree; C) 80% dairy whipping cream + 20% tomato puree; D) 70% dairy whipping cream + 30% tomato puree; E) 60% dairy whipping cream + 40% tomato puree.

There were no significant differences ($p$>0.05) in the moisture and protein contents among all ice cream formulations, ranging from 44.43% to 44.96%, and 0.78% to 1.02%, respectively. The moisture content of the ice cream added with tomato puree was lower than the ice cream added with green coconut pulp (65% of the moisture content) as reported by Igutti *et al.* (2011) as they used of a high amount of water (58%), and no water was added in the tomato ice cream formulation. According to Choo *et al.* (2010), the protein content of ice cream is typically 4% with the presence of an emulsifier. In this present study, the protein content of the ice cream was only contributed by fresh milk and whipping cream. Therefore, the low moisture and protein contents of the tomato ice cream were significant due to the reduction of dairy whipping cream, as well as absence of water and emulsifier in the formulation. As can be seen in Table 3, increasing the percentage of tomato puree and decreasing the percentage of dairy whipping cream in the formulation can increase the ash content of the ice cream. This result is in agreement with the study done on ice cream added with Cape gooseberry (Eryaka *et al.,* 2012) and ice cream added with grape wine lees (Hwang *et al.,* 2009). The increase in ash content was contributed by the high level of potassium (Vallverdú-Queralt *et al.,* 2011) in tomato puree. As expected**,** reducing the amount of dairy whipping cream by 40% decreased the fat content of the ice cream by up to 30% (Table 3). This result was in line with the study by Karaman *et al.* (2014) on ice cream added with persimmon puree.

### *Physical properties of the ice cream*

The physical properties in terms of colour profile of L*, a* and b* values and pH of the ice cream with different ratios of dairy whipping cream to tomato puree are presented in Table 4.

Table 4: Physical properties (n=3) of ice cream prepared with different ratios of dairy whipping cream and tomato puree

| Formulation | L* value | a* value | b* value | pH |
|---|---|---|---|---|
| A | 37.90 ± 2.83[a] | -0.25 ± 0.23[b] | 2.02 ± 0.69[c] | 6.72 ± 0.13[a] |
| B | 37.70 ± 1.60[a] | -0.08 ± 0.49[b] | 4.17 ± 0.66[b] | 6.59 ± 0.27[a] |
| C | 35.92 ± 0.82[a] | 0.73 ± 0.73[ab] | 5.87 ± 1.86[ab] | 6.18 ± 0.17[b] |
| D | 35.75 ± 0.39[a] | 1.02 ± 0.72[a] | 6.87 ± 0.75[a] | 5.99 ± 0.09[bc] |
| E | 36.10 ± 1.18[a] | 1.32 ± 0.65[a] | 6.87 ± 0.91[a] | 5.72 ± 0.08[c] |

*Mean values with different superscript letters in the same column are significantly different ($p$<0.05). Ice cream with addition of A) 100% of dairy whipping cream (control sample); B) 90% dairy whipping cream + 10% tomato puree; C) 80% dairy whipping cream + 20% tomato puree; D) 70% dairy whipping cream + 30% tomato puree; E) 60% dairy whipping cream + 40% tomato puree.

As can be seen, the lightness value (L*) was not significantly ($p$>0.05) affected by the different ratios of dairy whipping cream to tomato puree. The range of lightness value for the ice cream was 35.75 to 37.90. In contrast, the a* value (redness) significantly increased and b* value (yellowness) significantly decreased with the increase in tomato puree and decrease in dairy whipping cream. Hwang *et al.* (2009) also found a similar trend in their study of the colour profile of ice cream added with grape wine lees. It is interesting to note that the increase in the tomato puree ratio provided the ice cream with an attractive colour, where it was observed from the increasing trend of the a* value and it is due to high content of the deep red pigment of lycopene (Rizk *et al.,* 2014). Deda *et al.* (2007) also reported a similar effect of tomato paste on the colour of frankfurters. The pH value of the ice cream was significantly ($p$<0.05) decreased with the decrease in dairy whipping cream and increase in tomato puree. Ice cream formulated with 100% dairy whipping cream (control sample) had a pH value of 6.72 and this was significantly higher than ice cream with 40% of tomato puree (pH 5.72) as presented in Table 4. The decrease in pH was due to the existence of various acid compounds (Eryaka *et al.,* 2012) in the tomato puree, such as ascorbic acids, citrate and malice hydroxycinnamic acids (ferulic acid, chlorogenic acid, caffeic acid) and hydroxybenzoic acids (gallic acid, protocatechuic acid) (Jeż *et al.,* 2018). In addition, the pH of tomato pulp is in the range of 4.23 to 4.45 (Akanbi and Oludemi, 2004). Therefore, the addition of tomato puree may increase the acidity of the ice cream.

### *Sensory acceptability of the ice cream*

The mean score of all sensory acceptability attributes, which are colour, odour, creaminess, hardness, aftertaste, flavour and overall acceptability, of the ice cream with different ratios of dairy whipping cream to tomato puree is shown in Table 5.

Table 5: Mean score (n=50) of sensory acceptability of ice cream with different ratios of dairy whipping cream to tomato puree

| Formulation | Colour | Odour | Creaminess | Hardness | After taste | Flavour | Overall acceptability |
|---|---|---|---|---|---|---|---|
| A | $5.68 \pm 1.39^{c}$ | $5.38 \pm 1.18^{c}$ | $5.68 \pm 1.17^{bc}$ | $5.36 \pm 1.38^{b}$ | $5.36 \pm 1.44^{b}$ | $5.32 \pm 1.31^{b}$ | $5.42 \pm 1.26^{b}$ |
| B | $5.88 \pm 1.04^{bc}$ | $5.46 \pm 1.16^{bc}$ | $5.46 \pm 1.39^{c}$ | $5.32 \pm 1.44^{b}$ | $5.30 \pm 1.58^{b}$ | $5.28 \pm 1.50^{b}$ | $5.34 \pm 1.35^{b}$ |
| C | $6.24 \pm 0.85^{ab}$ | $6.02 \pm 0.87^{a}$ | $6.26 \pm 0.90^{a}$ | $5.74 \pm 1.26^{ab}$ | $5.94 \pm 1.06^{a}$ | $6.16 \pm 0.98^{a}$ | $6.16 \pm 0.93^{a}$ |
| D | $6.24 \pm 0.77^{ab}$ | $5.86 \pm 1.05^{ab}$ | $6.12 \pm 0.96^{a}$ | $5.98 \pm 1.10^{a}$ | $5.90 \pm 0.97^{a}$ | $5.84 \pm 1.11^{a}$ | $5.88 \pm 0.92^{a}$ |
| E | $6.28 \pm 0.76^{a}$ | $5.70 \pm 0.93^{ab}$ | $6.02 \pm 1.02^{ab}$ | $5.96 \pm 1.07^{a}$ | $5.76 \pm 1.17^{ab}$ | $5.86 \pm 1.11^{a}$ | $5.94 \pm 1.00^{a}$ |

*Mean scores with different superscript letters in the same column are significantly different ($p$<0.05). Score 1-dislike extremely, score 7- like extremely. Ice cream with addition of A) 100% of dairy whipping cream (control sample); B) 90% dairy whipping cream + 10% tomato puree; C) 80% dairy whipping cream + 20% tomato puree; D) 70% dairy whipping cream + 30% tomato puree; E) 60% dairy whipping cream + 40% tomato puree

It is interesting to note that the mean scores of all the attributes significantly ($p$<0.05) increased with the increase in tomato puree and decrease in dairy whipping cream. Ice cream without addition of tomato puree (control sample) obtained the lowest acceptability score for all sensory attributes. This study indicated that the incorporation of tomato puree has a good potential to increase the sensory qualities of ice cream. Similar trends were also found in ice cream incorporated with persimmon puree (Karaman *et al.,* 2014) and ice cream made with 15% of pumpkin pulp and carrot pulp (Hassan & Barakat, 2018). The sensory analysis revealed that reducing dairy whipping cream by up to 60% and increasing tomato puree by up to 40% in the ice cream formulation promote high sensory attributes, particularly attractive colour and the unique flavour of tomato. These results lead to the ice cream having a marketable value.

## Conclusion

The physicochemical properties and sensory acceptability of ice cream incorporated with different ratios of dairy whipping cream to tomato puree were investigated. Incorporating up to 40% of tomato puree can reduce fat content by 30% and improve the colour quality and sensory aspects, while also increasing the commercial potential of the new flavoured ice cream.

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