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RESEARCH ARTICLE

# Process optimization and characterization of spice oleoresins infused ice cream for enhancing its functional attributes

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**Abstract**: Different spice oleoresins, such as black pepper (0.15, 0.20, and 0.25% w/w), ginger (0.10, 0.15, and 0.20% w/w), and turmeric (0.02, 0.05, and 0.07% w/w), were added at specific concentrations to make the spice-flavored functional ice cream. The effects of concentration of oleoresin on the physico-chemical, biochemical, microbiological, and organoleptic attributes of the spice-flavored ice cream was evaluated. Addition of 0.20% black pepper oleoresin obtained the highest overall acceptability score of 8.5, having an overrun of 33.64%, melting rate of 0.85g/min, total solids of 43.86%, fat content of 12.33% and total phenol content of 393.72 mg GAE/ml and ranked first. This was followed by ginger flavoured ice cream with the concentration of 0.15% with overall acceptability score of 7.7, overrun of 30.53%, melting rate of 0.87 g/min, total solids of 43.82%, fat content of 12.53% and total phenol content of 384.57 mg GAE/ml. Among the three spice oleoresins added, turmeric oleoresin at the concentration of 0.05% had the lowest overall acceptability score of 7.3, overrun of 29.63%, melting rate of 0.87g/min, total solids of 48.93%, fat content of 12.66% and total phenol content of 378.47 mg GAE/ml. The addition of oleoresin enhanced the total phenol content in the ice cream which could provide therapeutic benefits to consumers.

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## Introduction

Ice cream is a frozen dessert made from pasteurized mixture of milk, milk solids, sugar or corn syrup, flavourings, stabilizers and emulsifiers, with or without eggs. Ice cream is the most popular dairy product, loved by people of all ages (Goff and Hartel, 2013). Due to the low storage temperature, ability for stabilizing ingredients, and widespread consumer appeal, frozen dairy desserts act as excellent carriers for nutrients fortification. Therefore, ice cream can be successfully employed to provide consumers with special added ingredients and therapeutic benefits in addition to the basic nutrition. In order to attract consumers who are health-conscious, new ice cream flavours with functional properties are being developed.

Spice components give food its distinctive flavour, aroma, piquancy, and colour. These possess functional properties like anti-oxidative, anti-inflammatory, anti-diabetic, anti-hypertensive, and antibacterial activities (Srinivasan, 2005). Spices contains flavonoids, phenolic compounds etc. which have an intrinsic ability to protect products by inhibiting microbial growth, oxidation and enzymatic reactions in food (Torre et al. 2017). Flavors of spices are due to these phenol compounds. Eugenol, apiol, sufranol, vanillin, piperine, beta caryophyllene, alfa pinene, carvacol, thymol, sabinene, cinnamaldehyde, and gingerol are a few significant chemical constituents for the flavouring potential of spices (Torre et al. 2017). Spices can also be used as a flavouring to ice creams (El-Sayed & Youssef, 2019). Pinto et al. (2004 and 2006) developed ginger ice cream adding ginger juice in ratios of 3, 4, 5% and ginger pieces at 4, 6, 8% levels of ice cream mix and compared with vanilla as the control. The optimum concentration of curcumin to add to ice cream as a natural colouring agent, according to Manoharan et al. (2012), was 0.5% by evaluating the sensory properties of ice cream. David (2014) found that ice cream incorporated with 4% ginger juice was the most acceptable in terms of sensory and microbiological analysis. Gabbi et al. (2018) has manufactured ice cream with ginger juice, paste, candy and powder. According to Chamchan et al. (2017) ice cream with 15% ginger extract or lemon grass extract infused with 90% xylitol was found to be the most acceptable in terms of microbiological, chemical and physical properties. Vedashree et al. (2020) prepared ice cream with freeze-dried ginger extracts at different concentrations, and analyzed its physico-chemical and microbial qualities. The effect of cinnamon and black pepper powders addition on the sensory and physico-chemical characteristics of ice cream was investigated by Aumpa et al. (2022). Various spice powders such as fenugreek, coriander, black pepper and cinnamon were added to ice cream by Dhanavath et al. (2022) at various, concentrations, viz. 1%, 1.5%, and 2%. The spice powders with a 1.5% incorporation level showed a higher level of acceptance. In order to investigate the effect on the chemical and physical characteristics of ice cream, MacÝt et al. (2017) used spice essential oils (coconut, lemon bark, clove, and cinnamon) in two different concentrations (0.2% and 0.4%).

Although researchers have tried to create ice creams with spice flavours using spice powders and other related forms, there are no reports on ice creams with spice oleoresin infusions. No research has been done on the effect of spice oleoresin addition on the physico-chemical, bio-chemical, and sensory attributes of ice cream. Oleoresins serve as an alternative to synthetic additives and contribute to flavour, aroma, colour and therapeutic properties like anti-inflammatory, antioxidant, antimicrobial, and anticancer properties, besides additional health benefits (Habashy et al. 2018). The use of oleoresins is preferred for the food industry because it has a specific flavor and aroma. Oleoresins offer better heat stability and flavour compared to spice powders and essential oils (Shahidi and Hossain, 2018).

The objective of the current study was to develop functional foods by incorporating spice oleoresins such as black pepper, ginger and turmeric into ice cream. The study was carried out to investigate the physico-chemical and bio-chemical properties of spice oleoresin-flavored ice cream as well as the optimization of spice oleoresin concentration for the production of spice-flavored ice cream.

## Materials and methods

### Selection of ingredients

Both dairy and non-dairy products were used for the preparation of ice cream. All the dairy and non-dairy products (Fresh cream, Toned milk, Skim milk powder, Sugar, Stabilizer-emulsifier blend (premitex), Spice oleoresins (Naturalich: Ozone Naturals), Natural colour (Symega food ingredients Pvt. Ltd.)) were procured from the local market at Kozhikode, Kerala, India.

### Formulation of ice cream

The percentage composition of each ingredient used in the preparation of ice cream mix was calculated using Algebraic method as described by De (1980). The composition of each ingredient is estimated as toned milk – 31.10, cream - 46.65, sugar – 15.55, skim milk powder – 6.22 and stabilizer-emulsifier – 0.46 (%, w/w). The ice cream was made by the following procedures provided by De (1980), with some minor modifications made to fit the conditions in the laboratory.

### Optimization of ice cream mix and ice cream

The ice cream mix was prepared by mixing all liquid ingredients and dry ingredients separately. All liquid ingredients such as toned milk and cream were mixed and blended thoroughly in a stainless-steel vessel. The dry ingredients such as sugar and skim milk powder were added to the liquid mix. After proper stirring, the ice cream mix was heated. When the temperature attained 50°C, the stabilizer and emulsifier was added. The mixture was further heated to pasteurization temperature (80°C). The temperature was maintained at 80°C and held for 5-8 mins. After pasteurization, the ice cream mix was cooled immediately to 3-4°C by placing the stainless-steel vessel in the chilled water for 20mins. At this stage, the required concentration of spice oleoresin was added to obtain the spice flavour and aroma. The different spice oleoresins used for the preparation of ice cream was black pepper (0.15, 0.20 and 0.25% w/w), ginger (0.10, 0.15 and 0.20% w/w) and turmeric (0.02, 0.05 and 0.07% w/w). The concentration of oleoresin in the ice cream mix was decided based on the preliminary trials. The mix was homogenized using an electric blender (iBELL hand mixer IBL HM 390L, 200 W) for 5 min. Additionally, the mix was kept for aging at 5 °C for 4 hours to enhance the whipping ability, texture, and overrun. The aged mix was frozen in an ice cream maker (kitchenif automatic digital ice cream maker,1.5L) for 20 minutes at a speed of 55 rpm. After freezing mix to semi-solid consistency, it was drawn directly into the ice cream cup and covered. The containers were then transferred to the freezer for hardening at a temperature of -18ºC or below for 12 h. After the ice cream was hardened, it was subjected to the physical, biochemical, microbial and sensory analysis.

### Analysis of physical characteristics of ice cream mix and ice cream

The physical properties studied were acidity, pH, melting rate, overrun and colour. The method outlined in IS: 1166 - 1960 was used to determine the titratable acidity of the ice cream samples. The results were expressed as a percentage of lactic acid equivalent. The specific gravity of ice cream was measured using a pycnometer (Standard Specific Gravity Bottle) as per the AOAC procedure (AOAC 925.22 1925). The method described by Rajor and Gupta (1982) was used to assess the melting rate of ice cream. A long stem glass funnel was used to hold 30 g of ice cream that had been spread on a wire mesh measuring 2 sq. inch. Over a 100ml measuring cylinder, the funnel with wire mesh carrying the ice cream slice was placed. The weight of the melted ice cream for the first 10 min was recorded and further measured at every 5 min until the ice cream melted completely. The melting rate was measured as:

$$\text{Melting rate (g/min)} = \frac{\text{weight of melted ice cream (g)}}{\text{time (min)}}$$
(1)

The overrun of ice cream was determined according to the method described by De (1980). Known volume of ice cream mix was taken in a pre-weighed 200 ml glass beaker before ageing. Similarly, after freezing the mix in the ice cream maker, the partially frozen ice cream was immediately drawn and filled into the same beaker, and the initial and final mass was recorded. The overrun was determined by using the formula:

$$\text{Overrun, \%} = \frac{\text{weight of unit volume of mix} - \text{weight of unit volume of ice cream}}{\text{weight of unit volume of ice cream}} \times 100$$
(2)

The pH of ice cream was determined using a digital pH meter (Eutech Instrument pH tutor) according to the method described by Dhanavath et al. (2022).

Colour of sample was determined by the method outlined by Kwon et al, (2019) using colour meter (Color Flex EZ, Hunter Lab). Spice flavoured ice cream was filled to half the volume of the sample cup and it was placed on the instrument. Digitally, the sample's colour was represented as L*, a*, and b* by the International Commission of Illumination. The L* measures brightness from 0 (black) to 100 (white). The values of a* and b*, which correspond to the two chromatic components of green to red and blue to yellow, respectively, range from -120 to 120. Triplicate readings for each sample were taken.

**Determination of physico-chemical and biochemical properties**

Ice cream's total solid content was calculated using the method outlined in Indian Standard Procedure IS: 1479-1961 (PARTII). Fat content was estimated by Gerber method as outlined in AOAC 2000.18, 2002. The protein content was estimated using the Kjeldhal method, as mentioned in AOAC 930.29, 2005. The ash content of ice cream was calculated by dry ashing method as outlined in AOAC method (AOAC 930, 2005). The sucrose content in ice cream was determined by the difference between the total reducing sugar and reducing sugar. The total reducing sugar and nonreducing sugar was determined by anthrone method and Nelson-Somogyi method, respectively as described by Sadasivam and Manickam (2008).

With some minor modifications, the Folin-Ciocalteu method reported by Perera and Perera (2021) was used to estimate the total phenol concentration. 0.1ml of sample was taken in an ambered test tube and dissolved in 7ml of distilled water and mixed thoroughly. 0.5ml of Folin-Ciocalteu reagent was added (1:1 v/v water) and mixed well, then incubated the test tubes for 8 min at room temperature, followed by the addition of 1.5ml of 2% sodium carbonate and 0.9ml of distilled water. The sample was stored at room temperature for 2 hours in the dark. At 765 nm, absorbance was measured using a blank. The calibration curve was prepared using gallic acid, also referred to as phenolic acid from spices, as a standard. The calibration curve was used to calculate the sample's total phenolic content, and the results were represented as milligram of gallic acid equivalent/g of sample (mg/GAE/ml).

**Microbiological analysis**

The total plate count of ice cream was analyzed by the Indian Standard procedure described in IS: 1166 – 1986 with slight modification. 10g ice cream was sampled in a bottle that has been sterilized, and it was tempered in a water bath at 40°C. 1ml of ice cream sample was transferred to 9ml of sterile water and then subsequent serial dilutions were made up to $10^{-8}$ for each sample. 1ml from $10^{-5}$, $10^{-6}$, $10^{-7}$ and $10^{-8}$ dilution was plated in sterile petri dish using nutrient agar media. The plates were further incubated for 24 h at 37°C (IG216IC: IGENE LABSERVE, Delhi).

**Sensory evaluation of ice cream**

The sensory evaluation of ice cream was performed using 9-point hedonic scale. The ice cream cups were served immediately after withdrawing from the freezer (after hardening) and promptly offered to the panelists. The serving sequences were totally randomized, and the samples were coded with three-digit random numbers. Sensory evaluation for spice flavoured ice cream was conducted by 10 trained panel members (Isleten and Karagul-Yuceer, 2006) and the attributes evaluated were colour, flavour, taste, texture and overall acceptability.

**Statistical Analysis**

A single factorial completely randomized block design (CRD) was followed to determine the effect of addition of each oleoresin in the spice flavoured ice cream. Experiments were conducted by adding each oleoresin (black pepper, ginger and turmeric) at three different levels (black pepper - 0.15, 0.20 and 0.25% (w/w), ginger - 0.10, 0.15, 0.20% (w/w) and turmeric - 0.02, 0.05, 0.07% (w/w)). Three replicates of each treatment were taken for the evaluation of its physical, biochemical, microbiological and organoleptic qualities. The quality parameters of spice flavoured ice cream developed for different concentrations of oleoresins were analyzed using R Studio (R version 4.2.1, R Core team 2022) statistical software.

**Results and Discussion**

**Effect of addition of spice oleoresin on the qualities of ice cream**

Experiments on effect of addition of spice oleoresin for production of spice flavoured ice cream were done for varying concentrations *viz.*, Black pepper (0.15, 0.20,0.25%), Ginger (0.10, 0.15, 0.20%) and Turmeric (0.02, 0.05, 0.07%). The spice flavoured ice cream was evaluated for its physical, biochemical, microbial and organoleptic characteristics.

**Effect of addition of oleoresin on the physical qualities of ice cream mix**

The ice cream mix was analyzed for acidity and specific gravity. The acidity of ice cream mix remains constant for all the concentrations of oleoresins added and the value corresponded to 0.18% (Table 1). The specific gravity of ice cream mix varied from 1.090 to 1.099 (Table 1) as the concentration and type of oleoresin was varied. The ANOVA indicated that specific gravity was significantly influenced ($p \leq 0.001$) by the addition of oleoresin. Oleoresins are thick, resinous substance with a flavour that is five to twenty times stronger than that of the corresponding spice. Because of resinous nature it is dense and vicious. Sp gravity of pepper oleoresin ranges from 0.86 to 0.88, turmeric oleoresin from 0.916 to 0.936, and that of ginger oleoresin from 0.862 to 0.878. The increase in sp. Gravity ice cream may be attributed to the increased specific gravity of oleoresins. But however, in black pepper and turmeric oleoresins, it was found that an increase in oleoresin there is a decrease in specific gravity.

**Effect of addition of oleoresin on the physical qualities of ice cream**

**Variation in overrun of ice cream:** As the oleoresin concentration increased, the overrun value increased from 33.52 to 33.69%, 29.37 to 30.70% and 29.37 to 29.70% for black pepper, ginger and turmeric oleoresin infused ice cream, respectively. Low overrun values are due to the non-inclusion of air during freezing process as it was done in lab scale. The ANOVA indicated that the overrun significantly ($p \leq 0.001$) affected by the addition of oleoresin (Table 2). The yield and profit of ice cream production are directly affected by the overrun, which also affects the product's body, texture, and flavour (Pinto et al. 2004). In the findings of Yeon et al. (2017), ice creams with fermented pepper powder had a significantly lowered overrun than plain ice cream. This may be related to viscosity; if the mixture has a high viscosity, less air will get into the ice cream during production. Ice cream with ginger shreds in it reduced overrun, with higher addition levels having a significantly greater effect (Pinto et al. 2006).

**Variation in pH of ice cream:** For ice cream added with a black pepper oleoresin flavour, the pH ranged from 6.58 to 6.60.

**Table 1:** Physical properties of spice oleoresin flavoured ice cream mix

| Oleoresin | Concentration of oleoresin (%) | Acidity (% as lactic acid) | Specific gravity |
|---|---|---|---|
| Black pepper | 0.15 | $0.18^{a}$ | $1.099^{a}$ |
| | 0.20 | $0.18^{a}$ | $1.095^{b}$ |
| | 0.25 | $0.18^{a}$ | $1.093^{c}$ |
| Ginger | 0.1 | $0.18^{a}$ | $1.097^{b}$ |
| | 0.15 | $0.18^{a}$ | $1.098^{b}$ |
| | 0.2 | $0.18^{a}$ | $1.099^{a}$ |
| Turmeric | 0.02 | $0.18^{a}$ | $1.099^{a}$ |
| | 0.05 | $0.18^{a}$ | $1.097^{b}$ |
| | 0.07 | $0.18^{a}$ | $1.090^{c}$ |

Different letters indicate significant differences at $p \leq 0.001$

**Table 2:** Physical properties of spice oleoresin flavoured ice cream

| Oleoresin | Concentration of oleoresin (%) | Over run % | pH | Acidity (% lactic acid) | Melting rate (g/min) | Colour value L* | Colour value a* | Colour value b* |
|---|---|---|---|---|---|---|---|---|
| Black pepper | 0.15 | $33.52^{c}$ | $6.58^{a}$ | $0.18^{a}$ | $0.83^{b}$ | $87.61^{a}$ | $-4.10^{c}$ | $17.86^{c}$ |
| | 0.20 | $33.64^{b}$ | $6.60^{a}$ | $0.18^{a}$ | $0.85^{b}$ | $87.42^{b}$ | $-4.82^{b}$ | $18.10^{b}$ |
| | 0.25 | $33.69^{a}$ | $6.60^{a}$ | $0.18^{a}$ | $0.97^{a}$ | $85.94^{c}$ | $-6.29^{a}$ | $19.56^{a}$ |
| Ginger | 0.10 | $29.37^{b}$ | $6.41^{b}$ | $0.20^{c}$ | $0.84^{b}$ | $89.42^{b}$ | $-0.65^{c}$ | $21.48^{b}$ |
| | 0.15 | $30.53^{a}$ | $6.47^{b}$ | $0.19^{b}$ | $0.87^{b}$ | $89.67^{a}$ | $-0.87^{b}$ | $21.48^{b}$ |
| | 0.20 | $30.70^{a}$ | $6.54^{a}$ | $0.18^{a}$ | $0.91^{a}$ | $89.73^{a}$ | $-1.21^{a}$ | $22.95^{a}$ |
| Turmeric | 0.02 | $29.37^{c}$ | $6.42^{b}$ | $0.20^{c}$ | $0.85^{b}$ | $90.15^{a}$ | $-5.92^{c}$ | $36.59^{c}$ |
| | 0.05 | $29.63^{b}$ | $6.56^{a}$ | $0.18^{a}$ | $0.87^{b}$ | $88.99^{b}$ | $-6.64^{b}$ | $48.22^{b}$ |
| | 0.07 | $29.70^{a}$ | $6.58^{a}$ | $0.18^{a}$ | $0.99^{a}$ | $87.74^{c}$ | $-6.68^{a}$ | $56.41^{a}$ |
| Control | Nil | - | 6.52 | 0.20 | 0.75 | - | - | - |

Different letters indicate significant differences at $p \leq 0.001$

However, the variation was non-significant. The pH of ginger and turmeric flavoured ice cream varied from 6.41 to 6.54 and 6.42 to 6.58, respectively. The pH of ginger and turmeric flavoured ice cream was significantly influenced ($p \leq 0.01$) by the addition of oleoresin. The pH of the developed ice creams was compared to ice cream available in the market (as control) and the value was found to be 6.52. It is observed that the pH of all concentrations was closer to the market sample. In the study by Dhanavath et al. (2022), the pH of ice cream added with spice powders was found to be in the range of 6.58 to 6.68. As reported by Gabbi et al. (2018), the addition of ginger juice and powder resulted in a notable rise in acidity and fall in pH of the ice cream samples.

**Variation in acidity of ice cream:** The acidity ice cream from 0.18 to 0.20% for different concentrations of black pepper, ginger and turmeric oleoresin infused ice creams (Table 2). The addition of ginger oleoresin had a significant effect on the acidity of ice cream. Sagdic et al. (2012) reported that due to the acidic character of phenolic compounds, their addition into ice cream, increased the acidity. When processed amla which is rich in phenolic compounds (Gooseberry) was added, the acidity and pH of the ice cream significantly increased (Goraya and Bajwa, 2015). The acidity of oleoresin infused ice cream was compared to melted market sample (as control) and the value was found to be 0.20%. Dhanavath et al. (2022) reported that ice cream incorporated with various spices powders had an acidity of 0.28% and also stated that titratable acidity of the samples had significantly increased during storage period.

**Variation in melting rate of ice cream:** As the concentration of oleoresin increased, the melting rate of ice cream increased from 0.83 to 0.99 g/min. The addition of oleoresins considerably ($p \leq 0.01$) affected the melting rate. According to Aumpa et al. (2022), the ice cream melted at a rate ranging from 0.23 and 0.52 g/min. The melting rate increased as black pepper powder and cinnamon powder were added. This is due to the use of fibre powder in an ice cream matrix can promote thermal diffusion when the food is heated by the environment. The fat network plays an important role in influencing how quickly ice cream melts (Muse and Hartel, 2004). According to Gabbi et al. (2018), the added solids, including some starch from the ginger, might be the reason why the melting rate decreased as the amount of processed ginger in the ice cream was increased. In accordance with Pinto et al. (2006), the melting resistance of ice cream containing ginger shreds increased with the addition of more shreds.

**Variation in colour value:** Colour value of ice cream prepared for varying concentrations of oleoresin is presented in terms of L*, a* and b* values (Table 2). As the concentration of oleoresin increased from 0.15 to 0.25%, the L* value of for black pepper oleoresin infused ice cream decreased from 87.61 to 85.94. the a* value of colour, which indicates the greenness also decreased from -4.10 to -6.29. The b* value, which indicated the yellowness of ice cream was increased from 17.86 to 19.56. Ice cream's L* value increased from 89.42 to 89.73 as the concentration of ginger oleoresin increased from 0.10 to 0.20%. The a* value reduced from -0.65 to -1.21, while its b* value increased from 21.48 to 22.95 for ginger flavoured ice cream. The L* value for ice cream reduced from 90.15 to 87.74 as the concentration of turmeric oleoresin increased from 0.02 to 0.07%, while the a* value declined from -5.92 to -6.68 and the b* value increased from 36.59 to 56.41. The addition of oleoresin considerably ($p \leq 0.001$) affected the ice cream's colour values L*, a*, and b*. Aumpa et al. (2022) reported that increase in black pepper powder and cinnamon powder resulted in a considerable reduction in the ice cream's L* value while an increase in its a* and b* values. The presence of many pigment molecules in the spices, including the yellow, red, and brown carotenoids and flavonoids, which are responsible for the product's altered colour qualities, caused the alterations in colour intensity. Sagdic et al. (2012) observed that adding phenolic material to ice cream significantly altered its colour qualities. Yeon et al. (2017) reported that L* decreased while a* and b* increased, resulting in a lowering colour value in ice cream containing fermented pepper powder. Pepper powder and cinnamon powder was added to create a lighter shade of brown that produced more redness and yellowness. The colour value L*, a* and b* varied significantly and when ice creams are supplemented with different additives (Akalýn et al. 2008; Hwang et al. 2009; Sagdic et al. 2012).

**Effect of addition of spice oleoresin on physico-chemical and biochemical qualities of ice cream**

Physico-chemical characteristics such as total solids, protein, ash, fat, and sucrose, as well as biochemical characteristics including total phenol content of the oleoresin infused ice creams, were investigated.

**Variation in total solids of ice cream:** Table 3 shows the effect of spice oleoresins on the total solids of ice cream. The total solids had a highly significant ($p \leq 0.001$) effect on the addition of oleoresin. Total solids of ice cream increased significantly with the addition of fig paste, although milk fat levels at various levels had a little impact (Murtaza et al. 2004). According to Gabbi et al. (2018), the total solids of the ice cream significantly decreased as the levels of the ginger juice and paste increased because of the low solid content of those ingredients. On the other hand, due to the high dry matter of candy and powder, total solids increased when they were added.

**Variation in protein content of ice cream:** The protein of ice cream varied from 5.53 to 5.71%, however the variation was non-significant. The protein content of spice oleoresin flavoured ice cream was compared to market sample (as control) and the value found to be 4.9%. It is observed that the protein content of pepper ice cream was higher than that of the control. Perera and Perera (2021) reported that the protein composition of the ice creams did not differ significantly. According to Gabbi et al. (2018), the protein level of processed ginger-infused ice cream was significantly lower except that of ginger powder, which had a comparatively higher protein content than other forms of ginger.

**Variation in ash content of ice cream:** The spice flavoured ice cream's ash content ranged from 0.66 to 1.00%, although the variation was not statistically significant (Table 3). Perera and Perera (2021) found that adding spices in small quantities had no noticeable effect on the amount of ash in spice flavoured ice cream. According to Pagthinathan (2020), ice cream added with ginger paste had a higher percentage of ash content than ice cream with ginger juice added. According to Gabbi et al. (2018), the addition of ginger paste and powder increased the ice cream's ash level; however, the addition of ginger juice and candy decreased the ice cream's ash content.

**Variation in fat content of ice cream:** As the oleoresin concentration varied, the fat content of the ice cream increased from 12.26 to 12.80%, although the change was not statistically significant (Table 3). According to Akaln et al. (2008), partial coalescence occurred during the freezing process of the ice cream mixture, wherein clumps and clusters of the fat globules form and enclose air to form an inner fat structure or network. According to Perera & Perera (2021), the fat percentages of regular coconut ice cream and spicy coconut ice cream were 11.66% and 11.06%, respectively.

**Variation in sucrose content of ice cream:** The ice cream gets a delightful sweetness from the sucrose. The sucrose content of spice oleoresin infused ice cream ranged from 15.11 to 15.74 %. The sucrose content was influenced ($p \leq 0.001$) by the addition of oleoresin. The sucrose content of the oleoresin infused ice cream complied with ISI requirements.

**Variation in total phenol content of ice cream:** The effect of spice oleoresin on total phenol content (TPC) of ice cream is presented in Table 3. As the pepper oleoresin concentration increased from 0.15 to 0.25%, the TPC increased from 330.42 to 445.33 mg GAE/ml. The TPC was significantly ($p \leq 0.01$) influenced by the addition of oleoresin. The TPC of ice cream rises from 356.02 to 407.54 mg GAE/ml as the ginger oleoresin concentration rises from 0.10 to 0.20%. But the difference wasn't statistically significant. The TPC of turmeric oleoresin infused ice cream rises from 368.81 to 425.16 mg/GAE/ml as the oleoresin concentration rises from 0.02 to 0.07%. The difference wasn't considerable, though. Pepper contains piperine, ginger has gingerol, and turmeric contains curcuminoids as phenolic substances. Perera & Perera (2021) investigated the antioxidant activity of ice cream and the total phenolic content was analyzed. Due to the addition of spices, spice flavoured coconut ice cream had greater levels of total phenol. Aumpa et al. (2022) reported that the difference between black pepper powder and cinnamon powder showed a considerable impact on spice ice cream's TPC and antioxidant properties. The TPC ranged from 216.7 to 484.4 mg of TE/g of sample. Antioxidant activities, which are distinct variables that measure a sample's ability to suppress free radicals and their ability to prevent lipid components from degrading, can also be impacted by polyphenol chemicals. Additionally, adding spices to food increased antioxidant activities, indicating a positive correlation between the antioxidant properties and phenolic content.

**Effect of addition of spice oleoresin on organoleptic characteristics of ice cream**

The black pepper oleoresin flavoured ice cream was evaluated to study the organoleptic properties like colour, flavour, taste, texture and overall acceptability. The effect of addition of oleoresin on the organoleptic characteristics of ice cream is presented in Fig. 1. The results indicated that, as the concentration of black pepper oleoresin increased from 0.15 to 0.25%, the score of colour, flavour, taste, texture and overall acceptability of ice cream was found to increase initially and then decrease. The figure shows that the score of colour, flavour, taste, and texture for ice cream with black pepper oleoresin addition increased from 6.3 to 8, 6.3

**Table 3:** Physico-chemical and biochemical qualities spice oleoresin flavoured ice cream

| Oleoresin | Concentration of oleoresin (%) | Total solids % | Protein % | Ash % | Fat % | Sucrose % | Total phenol content (mg GAE/ml) |
|---|---|---|---|---|---|---|---|
| Black pepper | 0.15 | 43.79$^{b}$ | 5.56$^{a}$ | 1.00$^{a}$ | 12.26$^{b}$ | 15.74$^{a}$ | 330.42$^{c}$ |
| | 0.20 | 43.86$^{b}$ | 5.56$^{a}$ | 1.00$^{a}$ | 12.33$^{ab}$ | 15.55$^{b}$ | 393.72$^{b}$ |
| | 0.25 | 46.20$^{c}$ | 5.53$^{a}$ | 0.77$^{b}$ | 12.53$^{a}$ | 15.11$^{c}$ | 445.33$^{a}$ |
| Ginger | 0.10 | 43.64$^{b}$ | 5.71$^{a}$ | 0.66$^{b}$ | 12.40$^{b}$ | 15.65$^{a}$ | 356.02$^{b}$ |
| | 0.15 | 43.82$^{b}$ | 5.71$^{a}$ | 0.88$^{a}$ | 12.53$^{a}$ | 15.49$^{b}$ | 384.57$^{ab}$ |
| | 0.20 | 53.06$^{a}$ | 5.71$^{a}$ | 1.00$^{a}$ | 12.60$^{a}$ | 15.24$^{c}$ | 407.54$^{a}$ |
| Turmeric | 0.02 | 44.98$^{c}$ | 5.70$^{a}$ | 0.88$^{a}$ | 12.53$^{b}$ | 15.70$^{a}$ | 368.81$^{b}$ |
| | 0.05 | 48.93$^{b}$ | 5.56$^{b}$ | 0.77$^{a}$ | 12.66$^{ab}$ | 15.57$^{b}$ | 378.47$^{ab}$ |
| | 0.07 | 52.06$^{a}$ | 5.53$^{b}$ | 0.66$^{a}$ | 12.80$^{a}$ | 15.36$^{c}$ | 425.16$^{a}$ |

Different letters indicate significant differences at $p \leq 0.001$

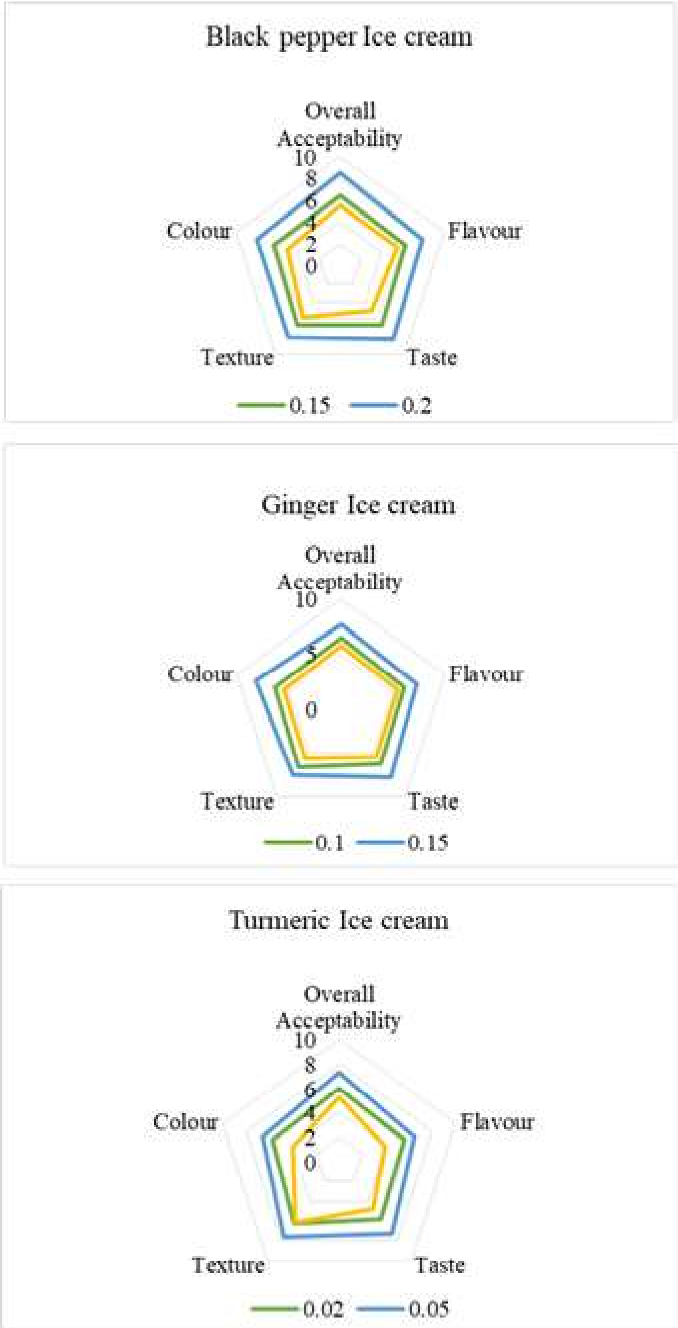


**Fig. 1** Effect of addition of oleoresin on organoleptic properties of ice cream

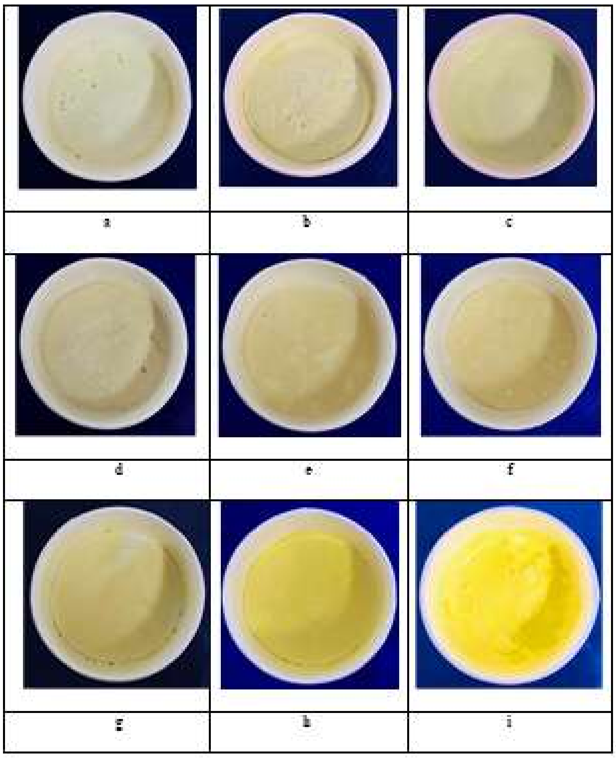


**Fig. 2** Ice cream prepared with black pepper oleoresin at a concentration of a) 0.15%, b) 0.20%, c) 0.25%, ginger oleoresin at concentration of d) 0.10%, e) 0.15 % and f) 0.20%, turmeric oleoresin at a concentration of g) 0.02%, h) 0.05% and i) 0.07%

to 7.9, 6.6 to 8.3, and 6.6 to 8 accordingly, when the concentration of oleoresin increased from 0.15 to 0.20%. Further increase in concentration of oleoresin to 0.25% decreased the score of colour, flavour, taste and texture to 5, 5.6, 5.5, 7 respectively. A key consideration in the organoleptic evaluation of black pepper oleoresin ice cream is the overall acceptability. For ice cream with black pepper oleoresin, as the amount of oleoresin increased from 0.15 to 0.20%, the overall acceptability increased from 6.5 to 8.5. For the corresponding oleoresin concentration increased to 0.25%, overall acceptability score reduced to 5.5. The addition of oleoresin had significant effects on the overall acceptability ($p \leq 0.001$).

The ice cream with ginger oleoresin was evaluated for its organoleptic properties, including colour, flavour, texture, and overall acceptability. Fig. 1 depicts how the addition of oleoresin affected the organoleptic properties of ice cream. From the figure it was observed that for ice cream with ginger oleoresin addition, as the concentration of oleoresin increased from 0.10 to 0.15%, the score of colour, flavour, taste and texture showed an increase from 6.3 to 8.2, 6.1 to 7.3, 6.2 to 7.8, 6.6 to 7.5 respectively. Further increase in concentration of oleoresin to 0.20% decreased the score of colour, flavour, taste and texture to 5.5, 5.5, 5.5, 5. 6 respectively. The overall acceptability of developed ice cream increased initially and then decreased. For ice cream with ginger oleoresin, as the amount of oleoresin increased from 0.10 to 0.15%, the overall acceptability increased from 6.5 to 7.7. For the corresponding oleoresin concentration increased to 0.20%, overall acceptability score reduced to 5.7. The overall acceptability was significantly influenced ($p \leq 0.001$) by the addition of oleoresin.

a b c

**Fig. 3.** Microbiological analysis of a) black pepper, b) ginger and turmeric oleoresin flavoured ice cream

The turmeric flavoured ice cream was evaluated to study the organoleptic properties like colour, flavour, taste, texture and overall acceptability. Fig. 1 shows the effect of oleoresin addition on the organoleptic properties of ice cream. The findings showed that the colour, flavour, taste, texture, and overall acceptability of ice cream increased first and then decreased as the concentration of turmeric oleoresin increased from 0.02 to 0.07%. As the concentration of oleoresin increased from 0.02 to 0.05%, the score of colour, flavour, taste and texture showed an increase trend from 5.7 to 6.6, 5.6 to 6.5, 5.8 to 7.3, 6.2 to 7.6 respectively. Further increase in concentration of oleoresin to 0.07% decreased the score of colour, flavour, taste and texture to 4, 4, 4.7, 6.1, respectively. For ice cream with turmeric oleoresin, as the amount of oleoresin increased from 0.02 to 0.05%, the overall acceptability increased from 6 to 7.3. For the corresponding oleoresin concentration increased to 0.07%, overall acceptability score reduced to 5.3. The overall acceptability was significantly influenced ($p \leq 0.001$) by the addition of oleoresin.

**Optimization of Spice Flavoured Ice cream**

The most acceptable spice oleoresin was chosen based on the overall acceptability of the ice cream as a whole. Ice cream with 0.20% black pepper oleoresin obtained maximum overall acceptability of 8.5. Ice cream with 0.15% ginger oleoresin obtained maximum overall acceptability of 7.7. The overall acceptability of the ice cream that was made with 0.05% turmeric oleoresin, was 7.3.

**Microbiological Analysis**

Ice cream with spice oleoresins were subjected to a microbiological analysis. The standard plate count was found to have a low microbial load after 24 hours. The increased level of spice oleoresin incorporation in the ice cream revealed a low microbial count. The antibacterial and antifungal activities spices could be the reason for the low microbial load in the spice flavoured ice cream. The plating results of $10^{-5}$ dilutions were shown in Fig. 3.

**Conclusions**

Different spice oleoresins, such as black pepper (0.15, 0.20, and 0.25% w/w), ginger (0.10, 0.15, and 0.20% w/w), and turmeric (0.02, 0.05, and 0.07% w/w), were added at variable quantities in order to make the spice-flavored functional ice cream. With a total solids content of 43.86%, a fat content of 12.33%, and a total phenol content of 393.72 mg GAE/ml, the addition of 0.20% black pepper oleoresin had the greatest overall acceptability score of 8.5 and was ranked top. Ginger flavoured ice cream with the concentration of 0.15% with overall acceptability score of 7.7, overrun of 30.53%, melting rate of 0.87 g/min, total solids of 43.82%, fat content of 12.53% and total phenol content of 384.57 mg GAE/ml. The turmeric oleoresin had the lowest overall acceptability score of 7.3, overrun of 29.63%, melting rate of 0.87g/min, total solids of 48.93%, fat content of 12.66%, and total phenol content of 378.47 mg GAE/ml among the three spice oleoresins infused ice creams. Taking into account the overall acceptability of the finished product, the most palatable spice oleoresin was selected.

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